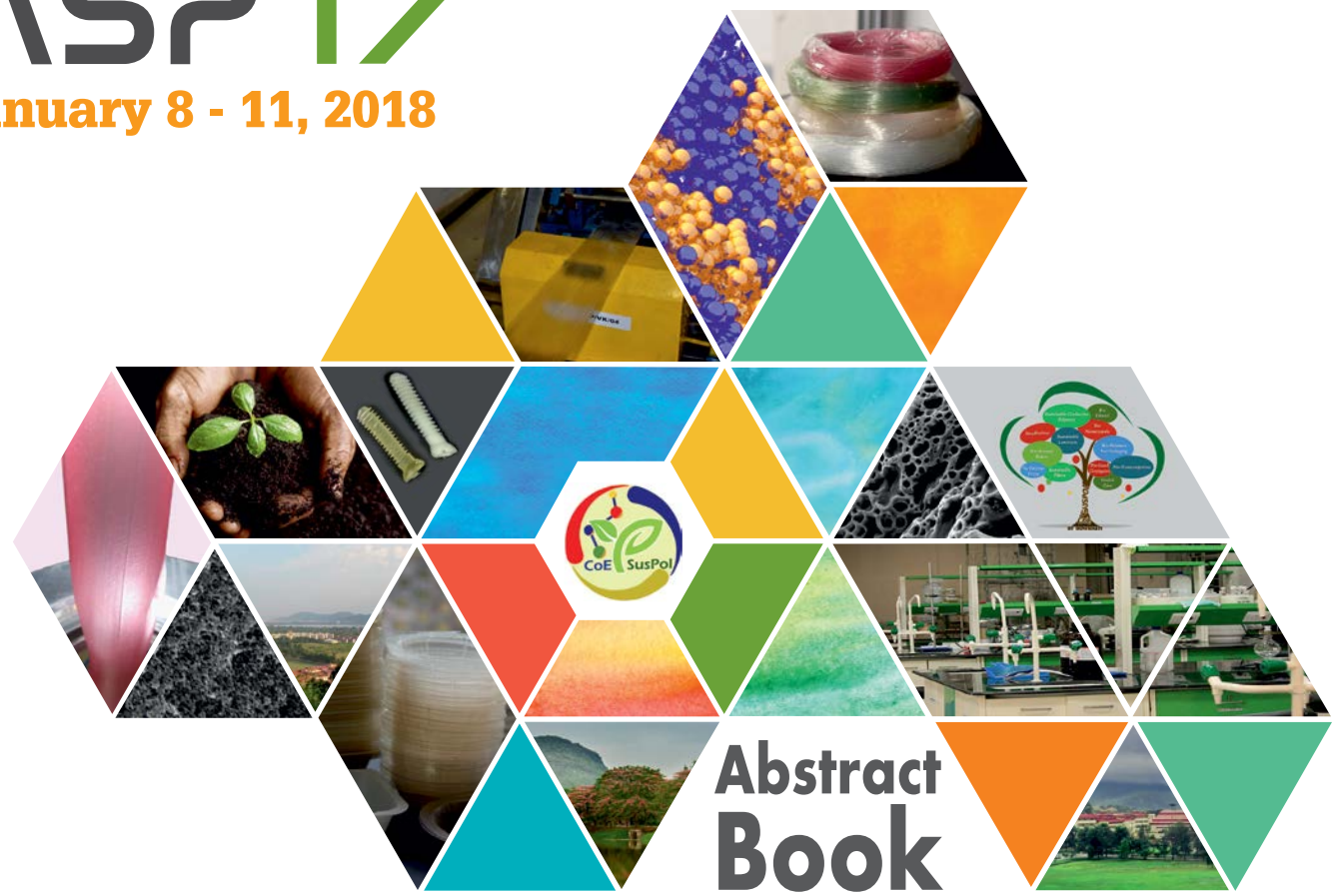
Fourth
International Symposium on

Advances in Sustainable Polymers

ASP 17

January 8 - 11, 2018



Abstract Book

Jointly Organized by

Centre of Excellence for Sustainable Polymers
Department of Chemical Engineering
Indian Institute of Technology Guwahati, India
&
Polymer Processing Academy, India

Indian Institute of Technology Guwahati

An Insight

Indian Institute of Technology Guwahati (IITG), the sixth member of the IIT fraternity was established in 1994 with its academic sessions commencing from 1995. Often surveyed as one of the most scenic campuses in the country and beyond; it is located near the banks of the mighty and majestic Brahmaputra in North Guwahati, Assam. The campus sprawls over 285 hectares and currently houses 11 departments, 5 interdisciplinary academic centers and 5 extramural centers covering all the major engineering, science and humanities disciplines offering a plethora of courses. Keeping in view with its short span, IITG has already established itself as a center of excellence with its world-class infrastructure and state of the art research facilities. In 2017, IITG has been ranked 7th in the Engineering category by the MHRD-NIRF ranking. IITG has already made its mark amongst the top 100 young dynamic university rankings in 2014 as per the Times Higher Education Magazine.

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Supported by

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सत्यमेव जयते

प्रो. आशुतोष शर्मा
Prof. Ashutosh Sharma

सचिव
भारत सरकार
विज्ञान और प्रौद्योगिकी मंत्रालय
विज्ञान और प्रौद्योगिकी विभाग
Secretary
Government of India
Ministry of Science and Technology
Department of Science and Technology

29th December, 2017

MESSAGE

I am glad to know that the Centre of Excellence for Sustainable Polymers, in the Department of Chemical Engineering at the Indian Institute of Technology Guwahati is organizing the Fourth International Symposium on Advances in Sustainable Polymers (ASP-17) during January 08-11, 2018. With distinguished experts from several countries attending ASP-17, the symposium is truly international in nature. I believe that the event will help in raising awareness about the new developments in the field of sustainable polymers. I hope that ASP-17 will provide a platform for young researchers to interact and share knowledge in the field of sustainable polymers and related areas with eminent researchers and scientists from India and abroad.

I extend my heartiest congratulations to the organizing Chair of ASP-17 for arranging this Symposium, and wish the event a great success.

(Ashutosh Sharma)

Technology Bhavan, New Mehrauli Road, New Delhi - 110016
Tel: 00 91 11 26511439 / 26510068 • Fax: 00 91 11 26863847 • E-mail: dstsec@nic.in • website: www.dst.gov.in

राजीव कपूर
सचिव
RAJEEV KAPOOR
Secretary

भारत सरकार
रसायन और उर्वरक मंत्रालय
रसायन और पेट्रोरसायन विभाग
कक्ष संख्या 501, 'ए' विंग, शास्त्री भवन
डॉ राजेन्द्र प्रसाद रोड, नई दिल्ली – 110 001
Government of India
Ministry of Chemicals & Fertilizers
Department of Chemicals & Petrochemicals
Room No. 501, 'A' Wing, Shastri Bhawan
Dr. Rajendra Prasad Road, New Delhi - 110 001
Tel.: 23384196/ 23382467/Fax : 23387893
E-mail : sec.cpc@nic.in

Message

I am delighted to know that the Fourth International Symposium on Advances in Sustainable Polymers (ASP-17) is being organized by the Centre of Excellence for Sustainable Polymers (CoE-SUSPOL) in the Department of Chemical Engineering at the Indian Institute of Technology Guwahati during January 08-11, 2017. It is indeed admirable that CoE-SUSPOL, established through funding from the Department of Chemicals and Petrochemicals, Ministry of Chemicals and Fertilizers, Government of India, is conducting this international Symposium. ASP-17 will help to disseminate knowledge on sustainable polymers in line with the current global emphasis on environmental sustainability. The Symposium will also provide a platform for eminent academicians, researchers, scientists and other professionals to deliberate and discuss the technologies related to development and widespread adopt on of sustainable polymer based products for specific application.

I congratulate the organizing team of ASP-17 for taking the initiative to organize this Symposium and wish the event a grand success.

(Rajeev Kapoor)

भारतीय प्रौद्योगिकी संस्थान गुवाहाटी
Indian Institute of Technology Guwahati

Prof. Gautam Biswas
FNA, FASc, FNAE, FNASc, F-ASME, FIE
Director and J. C. Bose National Fellc

गुवाहाटी-781 039, भारत
Guwahati-781 039, India

January 1, 2018

Director's Message

It is a great pleasure that Department of Chemical Engineering at the Indian Institute of Technology Guwahati is organizing the Fourth International Symposium on Advances in Sustainable Polymers (ASP-17) during January 08-11, 2018. I welcome all the eminent speakers and delegates from India and abroad visiting IIT Guwahati on this occasion. It is highly appreciable that Department of Chemical Engineering of IIT Guwahati is organizing this event to disseminate knowledge on sustainable polymers and build a platform for the scientific community to create an eco-friendly society. I believe that this Symposium will provide an opportunity for eminent academicians, researchers, scientists and policymakers to deliberate and discuss the issues towards development and widespread adoption of sustainable polymer based products and technologies.

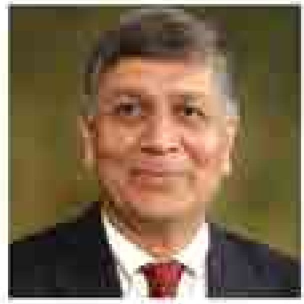
This event will act as a catalyst towards enriching the research knowledge on sustainable polymers amongst the research scholars, young professionals and students.

I congratulate the Organizing Team for making this event happen and wish a grand success to the event.

Gautam Biswas
(Gautam Biswas)

Phone: +91-361-2690401
+91-361-2582005
Fax: +91-361-2692321
+91-361-2690762
Email: director@iitg.ernet.in
gtm@iitg.ernet.in
gtm@iitk.ac.in

POLYMER PROCESSING ACADEMY



Message – Symposium on Advances in Sustainable Polymers

I am delighted that the Indian Institute of Technology Guwahati (IITG) has taken a lead in initiating academic activities in the important area of Polymer Science and Engineering, an area that is very close to my heart. I congratulate the Department of Chemical Engineering and Polymer Processing Academy for jointly organizing the Fourth International Symposium on **Advances in Sustainable Polymers** (ASP-17) during January 8-11, 2018. The theme is significant as the use of sustainable polymeric materials is widespread; however the resources available to prepare them are coming under scrutiny. The majority of traditional resources to prepare the conventional polymers are finite and their limited availability in the future is a cause of concern. Further, this will put a significant cost pressure on the polymers prepared from the dwindling resources. In view of this, there is now a growing shift to developing polymeric materials from renewable sources. Significant research is ongoing to develop new or improved products as well as develop polymerization processes based on sustainability. I am very happy to see that the ASO-17 plans to bring together international researchers from Academia, Research Laboratories, Industry and the Government to present and share recent state-of-the-art technologies in the area of Sustainable Polymers.

I congratulate the organizers for arranging the Symposium and for their enthusiasm in putting together an excellent programme with leading scientists as speakers. I wish ASP-17 all the success and look forward to the deliberations.

(Ashok Misra)
Founder President, Polymer Processing Academy
NASI Distinguished Professor, IISc Bangalore
Former Director, IIT Bombay

Professor Dr. Vimal Katiyar
Coordinator, CoE-SusPol
Department of Chemical Engineering
Indian Institute of Technology, Guwahati
Guwahati, Pin-781039, Assam, India

Dear Vimal

On behalf of participants from Kyoto institute of Technology (KIT), I congratulate all the organizers and the Center of Excellence for Sustainable Polymers (CoE-SusPol) at the Department of Chemical Engineering, Indian Institute of Technology Guwahati (IITG) on the successful preparation for the 4th Symposium on Advances in Sustainable Polymers (ASP-17) as well as for the 3rd Bilateral Meeting of IITG and KIT.

Since Paris Agreement went into effect on 4 November 2016, big impact has been made on global communities, because the agreement enforces us to change our energy and materials sources from fossil resource to sustainable resource. This enforcement will not become weaker in the future in spite of the recent negative movement led by a few political leaders having minority opinion. The current trials to replace oil-driven cars with electric cars will also critically lead the reduction of use of petroleum as energy source. These trends may provoke a possibility of turning petroleum 'a stranded asset" as coal has been and ought to urge the world chemical industry to seek a new route to securing their raw materials other than fossil resource. In consequence, much attention is now paid to biomass resource, and the development of "Sustainable Polymeric Materials" from renewable biomass feedstock has become one of the most important topics of the current science and technology. Total development of these newly emerging polymeric materials is necessary for decreasing the environmental impact as well as for achieving their better performance and specialty.

It has also been convinced that the efficient use of nonedible biomass is essential in reducing the total cost of biobased chemicals and polymers without affecting the food supply chain. For this purpose, the three components of biomass, lignin, hemicellulose, and cellulose, must effectively be separated and totally utilized. While the utilization of cellulose has greatly advanced with the progress of its breakdown technology, efficient use of lignin components has not been achieved at all. Although the break-down of lignin is extremely difficult, the new conversion technology will make it possible to break lignin down into its elemental units such as coniferyl, sinapyl, and coumaryl alcohols by bacterial or enzymatic processes. These aromatic chemicals derived from lignin must open a new window in the utilization of biomass-originated chemicals. With these chemicals as building blocks, various biobased polymers can be synthesized to establish a new platform that ought to be different from the current platform of oil-based polymers. Since such challenges must be done by exchanging various ideas of scientists and engineers of different expertise, the present symposium ASP-17 will afford a best opportunity for mixing the researchers coming from different countries and for allowing them to exchange information and ideas. I therefore hope that ASP-17 will be a real step in enhancing the activities in this field and contribute to the development of the science and technology of sustainable polymeric materials.

Finally, I hope that the all the participants in this symposium will actively perform their own contribution and enjoy fruitful discussion. I'm looking forward to fruitful discussion in the successful symposium and related meetings.

Best regards.

Yoshiharu Kimura
Emeritus Professor
Center for Fiber and Textile Science
Kyoto Institute of Technology
Hashigami-cho, Matsugasaki, Kyoto 606-8585
Japan
E-mail: ykimura@snr.kit.ac.jp

UNIVERSITY of GUELPH

BIOPRODUCTS DISCOVERY & DEVELOPMENT CENTRE

January 2, 2018

A PERSONAL MESSAGE FROM PROF. AMAR MOHANTY

Dr. Vimal Katiyar, PhD
Coordinator, CoE-SusPol
Department of Chemical Engineering
Indian Institute of Technology Guwahati, Guwahati -781039, Assam, India

Dear Dr. Katiyar,

As Director of Bioproducts Discovery & Development Centre (BDDC), University of Guelph, ON, Canada, I am delighted to congratulate all the organizers and the Center of Excellence for Sustainable Polymers (CoE-SUSPOL) at the Department of Chemical Engineering, Indian Institute of Technology Guwahati (IITG) on the successful preparation of the Fourth International Symposium on Advances in Sustainable Polymers (ASP 17). This very timely international conference has attracted delegates from more than 10 countries to IIT-Guwahati to discuss the sustainable future of polymeric materials for the growing low-carbon economy.

The fluctuating cost of petroleum, its dwindling nature, and the growing climate change concern worldwide have drawn the attraction of plastic industries in adapting towards sustainability. The key is to develop biobased alternatives that present an impending engine for our economic growth. A culture of innovation through disruptive R&D can help to achieve a sustainable low-carbon economy.

Your dynamic leadership will assemble international scientists and experts at IITG to explore innovation and possible commercialization opportunities. ASP 17 will be a fantastic venue for sharing the exciting new developments and breakthroughs in sustainable materials. CoE-SUSPOL has played a vital role in bringing together research professionals, industry leaders and government personnel, along with students to foster collaboration. This will facilitate the innovation needed for bringing forward new sustainable biobased materials to the marketplace. Your strong leadership and this event are magnificent examples of translating knowledge discovery and research into societal benefits.

Congratulations!

I very much look forward to a successful symposium.

With best and sincere regards,

Amar Mohanty

Amar Mohanty

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Amar K. Mohanty, PhD
Director, Bioproducts Discovery & Development Centre (BDDC)
Premier's Research Chair in Biomaterials & Transportation
University Research Leadership Chair
Professor, Department of Plant Agriculture & School of Engineering

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Bioproducts Discovery and Development Centre
Crop Science Building, University of Guelph
50 Stone Road East
Guelph, Ontario, Canada N1G 2W1
T 519-824-4120 x56664
mohanty@uoguelph.ca
uoguelph.ca

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Patrons

Prof. Gautam Biswas
Director
IIT Guwahati, India

Prof. Ashok Misra
Founder President
Polymer Processing Academy, India

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Dr. Vimal Katiyar
Coordinator CoE-SusPol,
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Dr. Ashok K Dasmahapatra
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Dr. Raghvendra Gupta
IIT Guwahati, India

Fourth Symposium on Advances in Sustainable Polymers (January 8 -11, 2018)

Day 0: January 07, 2018 Welcome Party (19:00 Hrs-22:00 Hrs)			
Day 1: January 08, 2018			
Registration of ASP-17 (08:00 Hrs-09:00 Hrs)		**Venue: Conference Center; IIT Guwahati**	
Inauguration of ASP-17 (09:00 Hrs-10:00 Hrs)		**Venue: Dr. Bhupen Hazarika Auditorium; IIT Guwahati**	
Talk	**Time**	**Title of Expert Lecture**	**Speaker**
PL-01	10:00-10:50 Hrs	Recent advances in the synthesis of biobased chemicals and polymers: From aliphatics to aromatics	Yoshiharu Kimura, Kyoto Institute of Technology, Japan
10:50-11:10 Hrs High Tea/Group Photo Session			
PL-02	11:10-12:00 Hrs	Circular Economy: A Sustainable path forward for Bioplastics and Biocomposites Innovation	Amar K. Mohanty, University of Guelph; ON, Canada
PL-03	12:00-12:50 Hrs	Sustainable Polymers : Challenges and Opportunities	S. Sivaram , INSA Senior Scientist, IISER, Pune, India
KL-01	12:50 -13:20 Hrs	Sustainability of Polymers : A Reality Check in India	Vijay G. Habbu,Senior Vice President,Reliance Industries Ltd.,India
13:20-14:15 Hrs Lunch Indo-Taiwan Bilateral Symposium Session I [Conference Hall 2]			
Inaugural Ceremony	14:15-14:25 Hrs	Opening Speech	Professor Gautam Biswas (President)
	14:25-14:35 Hrs	Opening Speech	Official representative from Taiwan
	14:35-14:50 Hrs	Progress of Indo-Taiwan cooperative project (Taiwan)	Ching Tsang Wang
	14:50-15:05 Hrs	Progress of Indo-Taiwan cooperative project (India)	Amaresh Dalal
	15:05-15:15 Hrs	Ceremony of signing MOU	
15:15-15:30 Hrs		**Break**	
KL-02	15:30-15:50 Hrs	Effect of calcination of Fe_2O_3 on degradation performance of organic wastewater in a novel Bio-electro-Fenton Microbial Fuel Cell	Chen-Hao Wang, National Taiwan University of Science and Technology, Taipei, Taiwan
KL-03	15:50-16:10 Hrs	Experimental study on the emission of diesel engine with hydrogen syngas	Jer-Huan Jang, Ming Chi University of Technology, Taiwan
KL-04	16:10-16:30 Hrs	Potential study of electricity generation in an anodic anaerobic bacteria and cathodic microalgal microbial fuel cell	Chyi-How Lay, Feng Chia University, Taichung, Taiwan
KL-05	16:30-16:50 Hrs	Continuous Flow Process: A New Paradigm in Materials Syntheses	Anil Kumar, IIT Bombay, India
Polymer Composites [Conference Hall 1]			
KL-06	14:15-14:45 Hrs	Application based development of Poly Lactic acid Technologies	Ian K.W. Toh, Director, Natureworks, USA.

IL-01	14:45- 15:10 Hrs	Polyurethanes and their nanocomposites from Biobased Polyols: Efficient and environment friendly alternative	Anupama Kaushik Sharma, Panjab University, India
IL-02	15:10-15:35 Hrs	Anisotropic designer particles	Sampa Saha, IIT, Delhi, India
IL-03	15:35-16:00 Hrs	Properties Enhancement of Biocomposites	Utai Meekum, Suranaree University of Technology, Thailand
16:00-16:20 Hrs Tea & Networking Break			
Polymer Characterization I [Conference Hall 1]			
KL-07	16.20-16.50 Hrs	Design of Sustainable Packaging: some thoughts	Debkumar Chakrabarti, IIT Guwahati, India
KL-08	16.50-17.20 Hrs	Leading the Blueprint for Improved Sustainability in Plastics Through Industry Collaboration	Han Zhang, Dow Chemical International Pvt Ltd., Singapore.
KL-09	17.20-17.50 Hrs	EnviroESCA™ – The beginning of a new era	Felix Leyssner, SPECS, Germany
IL-04	17.50-18.15Hrs	Twin Drive RheoMicroscopy	Dharmesh Gala, Anton Paar, Austria.
IL-05	18.15-18.40 Hrs	Sustainable Polymer Processing Techniques	Manoj Bansal, Thermo Fisher, USA
Indo-Japan Bilateral Symposium Session I: Synthetic Biodegradable Polymers [Conference Hall 3]			
16:20-16:40 Hrs	INAUGURATION Address by- Professor Gautam Biswas and Prof. Ashok Misra		
KL-10	16:40-17:10 Hrs	Sustainable Materials in the Polymer Industry	Anil K. Bhowmick, IIT Kharagpur, India
KL-11	17:10-17:40 Hrs	DSC and WAXS Studies on the Effects of Silk Nanocrystals on Crystallization of Poly(L-Lactic Acid)	Shinichi Sakurai, KIT Japan
IL-06	17:40-18:05 Hrs	Poly(lactide) Suprastructures: Structural Reorganization of Stereocomplex Nanoparticles	Susheela B. Idage, NCL Pune, India.
IL-07	18:05-18:30 Hrs	Stereocomplexation of the segmented PLLA/PDLA blend melt-spun fibers	Masaki Yamamoto, KIT Japan
Polymers for Biomedical Applications I [Conference Hall 4]			
KL-12	16:20-16.50 Hrs	Sustainable Development of Controlled Drug Delivery and Implants using Biodegradable Polymers	Pralay Maiti, IIT BHU, India
IL-08	16.50-17.15 Hrs	Biomedical devices and implants at Biomedical Devices Lab in IIT Guwahati	S Kanagaraj, IIT Guwahati, India
IL-09	17.15-17.40 Hrs	Polysaccharide induced hybrid polymers for drug delivery application	Sarat K Swain, Veer Surendra Sai University of Technology, India
IL-10	17.40-18.05 Hrs	Biocompatible electrospun nanofiber scaffolds for antibacterial and sustained drug release	T. Umasankar Patro, Defence Institute of Advanced Technology, Pune, India
Student Presentations for Oral Awards I [Conference Hall 2]			
OP-01	16:50-17:05 Hrs	Recyclable Polylactic Acid grafted Cellulose Nanocrystal Films through Reactive Extrusion Approach	Prodyut Dhar, IIT Guwahati, India
OP-02	17:05-17:20 Hrs	Shape memory polymer nanocomposites for biomedical application	Arpan Biswas, IIT BHU, India

OP-03	17:20-17:35 Hrs	Lactic Acid Oligomer (OLLA) Grafted Gum Arabic Conjugates: A Bio-based Adhesive for Structural Applications	Neelima Tripathi, IIT Kanpur, India
OP-04	17:35-17:50 Hrs	Evaluation of silk fibroin/Xanthan biopolymeric blends using FTIR imaging and DTA analysis	Shailendra Singh Shera, IIT BHU, India
OP-05	17:50-18:05 Hrs	Aggregation ehavior of non-ionic twinned amphiphiles and their application as biomedical nanocarriers	Abhishek K. Singh, University of Delhi, India
OP-06	18:05-18:20 Hrs	Rheological, Mechanical and Barrier Studies of Chitosan-graft-Lactic Acid Oligomer Reinforced Poly(Lactic Acid) Bionanocomposite Films	Akhilesh Kumar Pal, IIT Guwahati, India
OP-07	18:20-18:35 Hrs	Polymer brushes for tuning the spatial arrangement of nanoparticles in polymer nanocomposite films	Kishore Kumar Sriramoju, B.V. Raju Institute of Technology, Telangana, India
Poster Session (18:30 Hrs-19:30 Hrs) Cultural Program and Conference Dinner (19:30 Hrs-22:00 Hrs)			

Poster No: PPC 02, PPC 03, PPC 04, PPC 05, PPC 06A, BPS 07, BPS 08, BPS 09, BPS 10, BPS 11, BPS 12, BPS 12A, PNC 13, PNC 14, PNC 15, PNC 16, PNC 17, PNC 18, PNC 19, PNC 20, PNC 21, PNC 22, PNC 23, PNC 24, PNC 25, PNC 26, PNC 27A, SPT 30, SPT 31, SPT 32, SPT 34, SPT 37, SPT 37A, PHA 38, PHA 39, PHA 41, PHA 42, PHA 43, PHA 44, PHA 46, PHA 46A, PMS 47, PMS 48.

Day 2: January 09, 2018			
Talk	**Time**	**Title of Expert Lecture**	**Speaker**
PL-04	09:00-09:50 Hrs	What makes a polymer sustainable? Discussions around bioplastics, biobased, biodegradable-compostable, and the circularity model as metrics for sustainable polymers	Ramani Narayan, Michigan State University, USA
PL-05	09:50-10:40 Hrs	A bacterium that degrades and assimilates poly(ethylene terephthalate) and its enzymes involved in the degradation	Kohie Oda, KIT, Japan
10:40-11:00 Hrs	**Tea Break Biopolymers [Conference Hall 2]**		
KL-13	11:00-11:30 Hrs	Bacterial Cellulose based bioplastic hydrogel film : an exotic and competitive biomaterial for sustainable food packaging	Nabanita Saha, University Institute, Tomas Bata University in Zlin, Czech Republic
IL-11	11:30-11:55 Hrs	Characterization and Application of Cellulose Nano Crystal Incorporated Polylactic Acid Films for Low Temperature Preservation of Prawns (Metapenaeus Dobsoni)	Bindu J, ICAR- Central Institute of Fisheries Technology, Cochin, India
IL-12	11:55-12.20 Hrs	Amino Acid/Peptide Containing Alternating Copolymers	Priyadarsi De, Indian Institute of Science Education and Research Kolkata, India

IL -13	12:20-12.45 Hrs	Self-Healing and Durable Bio-mimicked Interfaces	Uttam Manna, IIT Guwahati, India
Polymers for Advanced Applications [Conference Hall 3]			
KL-14	11:00-11:30 Hrs	Sustainable polymeric nanocomposites for multifaceted advancwed applications	Niranjan Karak, Tezpur University, India
IL-14	11:30-11:55 Hrs	Characterization of polymers -biopolymer using Small angle scattering techniques	Narayan Ch. Das, IIT Kharagpur, India
IL-15	11:55-12.20 Hrs	Depth-Resolved Structure Analysis of Polymer Thin Films by Grazing-Incidence Small Angle X-ray Scattering utilizing of Tender X-rays	Katsuhiro Yamamoto, Nagoya Institute of Technology Japan
IL-16	12:20-12.45 Hrs	Innovative Treatment Technology for Improving the Quality of Plastic Granules Produced from Recycled Waste Plastics	Deepali Jadia, Enviro Remediation & Research Laboratory (ERRL), Mumbai, India
Functional Polymers Interfaces [Conference Hall 4]			
KL-15	11:00-11:30 Hrs	Block Copolymers Functionalized Carbon Nanotubes and their Sensing Applications	Kailash C. Gupta, IIT Roorkee, India
IL-17	11:30-11:55 Hrs	Color Tolerances /Pass Fail Methodology and Appearance	Mr. Subhash Naik, Datacolor Solutions Pvt. Ltd. Mumbai, India
IL-18	11:55-12.20 Hrs	Glycopolymer Grafted Nanoparticles: A Step towards the Development of Vaccine	Tushar Jana, University of Hyderabad , India
IL-19	12:20-12.45 Hrs	Starch and cellulose based films for food packaging and drug delivery applications	R. Anandalakshmi, IIT Guwahati, Assam, India
13:00-14:15 Hrs Lunch Indo-Japan Bilateral Symposium Session II: [Conference Hall 2]			
KL-16	14:15-14:45 Hrs	Effect of water on the mechanical properties of DNA-derived films	Takashi Aoki, KIT Japan
KL-17	14:45- 15:15 Hrs	Sustainable Polyolefin Materials and its Technology: Directions for Designed Polyolefins for 3D Printing Technology	Virendra Kumar Gupta, Reliance Industries Limited, India.
KL-18	15:15-15:45 Hrs	CO_2 Separation by Different Facilitated Transport Polymer Membranes from Binary and Ternary Gas Mixtures	Bishnupada Mandal, IIT Guwahati, India
IL-20	15:45-16:10 Hrs	Synthesis and characterization of functional polylactides consisting of L-lactyl and D-lactyl segment	Kazunari Masutani, KIT, Japan
Polymers for Biomedical Applications II [Conference Hall			
KL-19	14:15-14:45 Hrs	Engineering of Biopolymers for Smart Healthcare	Bhuvanesh Gupta, IIT Delhi, India
KL-20	14:45- 15:15 Hrs	Polymer technologies for developing medical devices	Dr. Prashant Jha, Fellowship Director, Biodesign School, AIIMS, New Delhi, India

IL-21	15:15-15:40 Hrs	Fabrication of nanostructures through self-assembly of non-ionic amphiphiles for biomedical applications	Sunil K. Sharma, University of Delhi, India
IL-22	15:40-16:05 Hrs	Nano-bio interactions dependent optimization of polymeric nanoparticle design for PLK1 siRNA delivery	Neetu Singh, IIT Delhi, India
16:05-16:20 Hrs Tea			
Indo-Japan Bilateral Symposium Session III: [Conference Hall 2]			
KL-21	16:20-16:50 Hrs	Effect of the block length on the physical and structural properties of the multi-stereoblock poly(lactic-acid)s	Hideki Yamane, KIT Japan
KL-22	16:50-17:20 Hrs	Electrical functions expressed via orientation control by mechanical processing of cellulose derivatives	Yoshikuni Teramoto, Gifu university, Japan
IL-23	17:20-17:45 Hrs	Conversion of Paper Industry Fibrous Waste to Value added Sustainable Polymers	Umesh Bhardwaj, Bank Note Paper Mill India Pvt. Ltd., India
IL-24	17:45-18:10 Hrs	Dyeing Fabrics by Using Extracts from Mulberry Branch/Trunk	Hidekazu Yasunaga, KIT Japan
IL-25	18:10-18:35 Hrs	New Generation Polymer Composites	Kuruvilla Joseph, IIST, Trivendram, India.
Indo-Taiwan Bilateral Symposium Session II [Conference Hall 3]			
KL-23	16:20-16:50 Hrs	A microcosm emergy applied in microbial fuel cell systems: the synergy of energy power generating and wastewater treatment for energy-nutrient-water nexus	Ching-Tsang Wang, National Chung Hsing University, Taiwan
KL-24	16:50-17:20 Hrs	Using carbon dioxide (CO_2) as the sole driver for low-energy desalination and decontamination of impaired water sources.	Arup SenGupta, Lehigh University, USA.
IL-26	17:20-17:45 Hrs	Polymeric Organic Framework as Potential Toxicant Remover from Drinking water	Raja Shunmugam, IISER Kolkata, India
IL-27	17:45-18:10 Hrs	Microfluidics based fuel cells for low power applications	Ravi Kumar Arun, CSIR-CMERI, Durgapur, India
IL-28	18:10-18:35 Hrs	Water and salt dynamics in multilayer graphene oxide (GO) membrane: role of lateral sheet dimensions	Anki Reddy Katha, IIT Guwahati, India
Poster Session: 18:30-19:30 Hrs			
Dinner (19:30 Hrs-21:00 Hrs)			

Poster No: PPC 01, PPC 06, PNC 27, SPT 29, SPT 35, SPT 36, PHA 40, PHA 45, PMS 49, PMS 49A, PDD 50, PDD 51, PDD 53, PDD 54, PDD 55, PDD 55A, PDD 56, PDD 57, PDD 58, ECA 59, ECA 60, ECA 61, ECA 61A, PDW 62, PDW 63, PDW 64, PDW 65, PDW 66, OT 68, OT 69, OT 70, OT 71, OT 72, OT 73, OT 74, OT 75, OT 76, OT 77, OT 78, OT 79, OT 80, OT 81.

Day 3: January 10, 2018			
Talk	**Time**	**Title of Expert Lecture**	**Speaker**
PL-06	09:00-09:50 Hrs	Control of Network Microdomain Morphology of Block Copolymer Systems	Prof. Hirokazu Hasegawa, Ex Professor, Kyoto University, Japan
PL-07	09:50-10:40 Hrs	Low Carbon Advanced Materials and Energy	Mohini Sain, University of Toronto, Canada
10:40-11:00 Hrs		**Tea Break [Conference Hall 2]**	
KL-25	11:00-11:30 Hrs	Ionic Liquids in Polymer Synthesis; A Sustainable Process	Nikhil K. Singha, IIT Kharagpur, India
IL-29	11:30-11:55 Hrs	Thermo responsive Imidazolium Compounds: Synthesis and Applications in catalysis	Debasis Samanta, CLRI, India
IL-30	11:55-12.20 Hrs	Aerobic Composting of Bioplastics- A Laboratory Scale Study	Harsh Jadia, Enviro Remediation & Research Laboratory (ERRL), Mumbai, India
IL-31	12:20-12.45 Hrs	Learning from Nature: Producing synthetic biomimetic membrane with water transporter protein from salt tolerant mangrove trees	Prakash P. Kumar, National University of Singapore, Singapore
Indo-Taiwan Bilateral Symposium Session III [Conference Hall 3]			
KL-26	11:00-11:30 Hrs	Graphene Nanocomposites: creating a sustainable polymer framework	Sandip Ghosh, Tata Steel, India
KL-27	11:30-12:00 Hrs	Performance evaluation of an up flow microbial electrolysis coupled anaerobic digestion (ME-AD) reactor	Thangavel Sangeetha, National Taipei University of Technology, Taipei, Taiwan
IL-32	12:00-12:25 Hrs	Simulation studies on Microbial Fuel Cells	Saksham Sharma, IIT Guwahati, India
[Conference Hall 4]			
KL-28	11:00-11:30 Hrs	Biodegradable Star Shaped Poly(lactide)s for Biomedical Applications	Bhaskar B. Idage, NCL pune, India
IL-33	11:30-11:55 Hrs	Rotary Drum Composting of Vegetable Waste Followed by Biodegradation of PLA	Ajay Kalamdhad, IIT Guwahati, India
IL-34	11:55-12.20 Hrs	Laser Surface Bio-Coating of Functionally Graded TiO_2-HAp on Textured Ti Alloy for Enhancing Bioactivity and Cell Proliferation	Mamilla Ravi Sankar, IIT Guwahati, India
IL-35	12:20-12.45 Hrs	Polymers in stimuli responsive membranes	M K Purkait, IIT Guwahati, India
13:00-14:15 Hrs Lunch Student Presentations for Oral Awards II [Conference Hall 2]			
OP -08	14.15-14.30 Hrs	Synthesis of Non-ionic Bolaamphiphile and Study of its Self-assembly and Transport Behaviour for Drug Delivery Applications	Rashmi, University of Delhi, India

OP -09	14.30-14.45 Hrs	Synthesis of nanocomposite hydrogel using modified carboxymethyl cellulose and AuNPs: A transdermal drug carrier	Barun Mandal, IIT (ISM) Dhanbad, India
OP -10	14.45-15.00 Hrs	Paper based biofuel cell with photosynthetic microbial anode and air breathing enzymatic cathode	Sharbani Kaushik, IIT Guwahati, India
OP -11	15.00-15.15 Hrs	Studies on Silk-based Bionanocomposites	Rahul Patwa, IIT Guwahati, India
OP -12	15.15-15.30 Hrs	Gelatin crosslinked nanoparticles for controlled release of silibinin and lipoic acid	Plabita Gogoi, Tezpur University, India
OP -13	15.30-15.45 Hrs	Synthesis and Characterization of Cardanol based Polybenzoxazine-Epoxy Copolymer for Anti-Corrosive Coating Application	Deepak Patil, Institute of Chemical Technology, Mumbai, India
OP -14	15.45-16.00 Hrs	Sustainable Tough Waterborne Hyperbranched Polyester Nanocomposite using Carbon dot and its Nanohybrid through a Greener Approach for Multifaceted Applications	Deepshikha Hazarika, Tezpur University, India
Indo-Nepal Bilateral Symposium Session I [Conference Hall 3]			
14:15-14:45 Hrs:	**Inaugural Speech: By Prof. Gautam Biswas, Director, IIT Guwahati**		
KL-29	14:45- 15:15 Hrs	Biomass Based and Biodegradable Polymer Composites: Structure, Properties and Applications	Rameshwar Adhikari, Tribhuvan University, Nepal
KL -30	15:15-15:45 Hrs	Economy and Conversion Potential of Plastic Wastes of Kathmandu Valley into Fuel through Pyrolysis Process for Waste Management and Fuel Complements	Rabindra Prasad Dhakal, Nepal Academy of Science and Technology, Nepal
IL-36	15:45-16:10 Hrs	Biodegradable Copolyester Composites Reinforced by Wheat Stalked Micro crystalline Cellulose	Jyoti Giri, Tribhuvan University, Kathmandu, Nepal
Student Presentations for Oral Awards III [Conference Hall 2]			
OP -15	16.20-16.35 Hrs	Plastic waste management based on blending of different (Waste Electrical and electronic equipments) WEEE's and their characterization	Jaidev K, CIPET, Bhubaneswar, India
OP -16	16.35-16.50 Hrs	Optimization of waste cooking oil lubricant base stock synthesis via epoxidation using homogeneous acidic catalyst	Atanu Kumar Paul, IIT Guwahati, India
OP -17	16.50-17.05 Hrs	Sustainable-resource-based tough hyperbranched polyurethane nanocomposites with different carbon based metal nanohybrids: Perspective as multifunctional smart materials	Rituparna Duarah, Tezpur University, India
OP -18	17.05-17.20 Hrs	Developement of Wood Polymer Nanocomposites Based on Modified Soybean Oil and Rosin Derivative	Zakaria Halim, Tezpur University, India

OP -19	17.20-17.35 Hrs	Biopolymer from Oily Bilge Water using Mixed Bacterial Culture	V. Uma, NIT Trichy, India
OP -20	17.35-17.50 Hrs	A Novel Approach in Development of Bio Based Foam from Biomass Waste	Anil Kumar, Institute of Wood Science and Technology, India
OP -21	17.50-18.05 Hrs	Rheological behaviour of composite propellant suspension containing aluminium nanoparticles	Rohit Lade, VNIT, Nagpur
OP -22	18.05-18.20 Hrs	Poly Lactic acid/ nano Hydroxyapatite based resorbable composites: Device to fix Podietry fixations	Arbind Prasad, IIT Guwahati, India
OP-23	18.20-18.35 Hrs	Kinetics of thermal degradation of plastic waste and their conversion into liquid fuel by slow pyrolysis	Pallab Das, IIT Guwahati, India
OP-24	18:35-18:50 Hrs	Multifunctional Nano-Hydroxyapatite promoted Toughened High Molecular Weight Stereocomplex Poly (lactic acid) based Bionanocomposite	Arvind Gupta, IIT Guwahati, India
Indo-Nepal Bilateral Symposium Session II [Conference Hall 3]			
KL-31	16.15-16.45 Hrs	Ultrasound-Assisted Synthesis and Characterization of Polymethyl Methacrylate/Reduced Graphene Oxide Nanocomposites	V. S. Moholkar, IIT Guwahati, India
IL-37	16:45-17:05 Hrs	Nano-finishing of Bio-Implants using Polymer Rheological Abrasive Complex Suspensions	Mamilla Ravi Sankar, IIT Guwahati, India
IL -38	17:05-17:25 Hrs	Compatibilizer Effect on Morphological Thermal, Mechanical and Water Absorption Behaviour of Natural Fiber Based Polymer Composites	Netra Lal Bhandari, Tribhuvan University, Kirtipur, Kathmandu, Nepal
IL-39	17:25-17:45 Hrs	Correlative Characterisation of Imidazole 2-Carboxaldehyde Thiosemicarbazone Chitosan, Thiophene 2-Carboxaldehyde Thiosemicarbazone Chitosan and their Copper(II) Complexes	Hari Sharan Adhikari, Tribhuvan University, Kirtipur, Kathmandu, Nepal.
IL -40	17:45-18:05 Hrs	Removal of lead (II) Ions from Aqueous Solution by Hydroxyapatite Biosorbent Prepared from Ostrich Bone Waste	Komal Prasad Malla, Tribhuvan University, Kirtipur, Kathmandu, Nepal
IL -41	18:05-18:25 Hrs	Tuning Morphology and Mechanical Properties in Styrenic Block Copolymer Modified Nanostructured Epoxy Resin	Rajesh Pandit, Tribhuvan University, Kathmandu, Nepal
IL-42	18:25-18:45 Hrs	Flexible Conducting Polymer Nanocomposites using Multiwalled Carbon Nanotubes in Biodegradable Polymer Matrix	Kedar Nath Dhakal , Tribhuvan University, Kirtipur, Kathmandu, Nepal
Dinner (19:30 Hrs-21:00 Hrs)			

Day 4: January 11, 2018			
Talk	**Time**	**Title of Expert Lecture**	**Speaker**
PL-08	09:15-10:05 Hrs	Development and Global Applications of Hybrid Ion Exchange Nanotechnology (HIX-Nano): From Decontamination to Desalination	Arup K. SenGupta, Lehigh University, Bethlehem, USA
KL-32	10:05-10.35 Hrs	Biodegradable Polymeric Nanomaterials for Commodity, Engineering and Biomedical Applications	Vimal Katiyar, IIT Guwahati, India
10:35-11:00 Hrs		**Tea Break [Conference Hall 2]**	
KL-33	11:00-11:45 Hrs	Making of a Compleat Professional: Some ideas and useful tips	R. P. Chhabra, IIT Kanpur, India
IL-43	11:45-12:10 Hrs	Comparison of promising pretreatment technologies for lignocellulosic biomass	Vaibhav V Goud, IIT Guwahati, India
IL-44	12:10-12.35 Hrs	Framework for Designing Sustainable Polymers: An Environmental Perspective	Reddithota J. Krupadam, National Environmental Engineering Research Institute, Nagpur, India
IL-45	12:35-13.00 Hrs	Columnar self-assembly of shape-anisotropic molecules and their applications in organic electronics	A. S. Achalkumar, IIT Guwahati, India
IL-46	13:00-13.25 Hrs	Designing with Bio-composite for Sustainable Development	Amarendra Kumar Das, IIT Guwahati, India
11.00 AM-1.00 PM Indo-Taiwan Bilateral Symposium Session IV Panel Discussion on Challenges and Opportunities on Microbial Fuel Cell Technologies [Conference Hall 3]			
13:30-14:30 Hrs Lunch			
02.30-3.30 PM Panel Discussion on Development of Biodegradable Plastics under Make in India Policy: Challenges and Opportunities [Conference Hall 3] 03.30-4.30 PM Valedictory Session			

PL: Plenary Lecture; KL: Keynote Lecture; IL: Invited Lecture; OP: Oral Presentation

Speakers Profile

Plenary Speakers

Emeritus Prof. Dr. Yoshiharu Kimura graduated in 1971 from Kyoto University with a BS degree in Chemistry. His interest in polymer science was extended through his study in the Graduate School of Kyoto University. He finished his PhD program in 1976. After working as a postdoc in University of Iowa, he was appointed Assistant Professor of Fiber Chemistry at Kyoto Institute of Technology (KIT) in 1981. He became a Professor of Polymer Science and Engineering in 1990. He retired from his position in 2013, and is now serving as an emeritus professor at the Center for Fiber and Textile Science, KIT. He has published 300 papers and has been the author or co-author of many books. For his research activity, Dr. Kimura has received Awards from the Society of Fiber Science and Technology, Japan and The Society of Polymer Science, Japan. Recently, he was nominated as an honorary member of the Society of Fiber Science and Technology, Japan. He is also working as a governing board member of The University of Shiga Prefecture. His current research interests include biobased and biodegradable polymers, hybrid materials, and biomaterials.

Prof. Amar Mohanty, Professor and Ontario Premier's Research Chair in Biomaterials and Transportation at the University of Guelph, and formerly professor at the Michigan State University, is an international leader in the field of biomaterials with a focus in engineering new sustainable materials. Prof. Mohanty's research interests are focused on the bioeconomy related to biobased materials, biofuels and biorefinery. He has around 740 publications to his credit, including 315 peer-reviewed journal papers, five edited books, 25 book chapters, and 51 patents awarded/applied. Prof. Mohanty received the Lifetime Achievement Award from the BioEnvironmental Polymer Society (BEPS) in 2015. The Lifetime Achievement Award is the highest recognition from BEPS to a member who has made "outstanding contributions to scientific advancement and made phenomenal scholarly accomplishments and impact in the field of biopolymers, bio-based materials and/or bioplastic/materials related bioenergy systems". In July 2017, Prof. Mohanty received one of University of Guelph's new Research Leadership Chair awards. This award is for well-established faculty who have demonstrated excellent scholarly output, research-related knowledge mobilization and training of highly qualified personnel. Prof. Mohanty is an accomplished researcher and was the holder of the prestigious Alexander von Humboldt Fellowship at the Technical University of Berlin, Germany. He received the Andrew Chase Forest Products Division Award in 2006 from the Forest Products Division of the American Institute of Chemical Engineers, of which he is one of the Directors. He received the Jim Hammer Memorial Service Award from the BioEnvironmental Polymer Society (BEPS) in 2011. Prof. Mohanty serves as Editorial Board Member for seven international journals. Prof. Mohanty has a strong track record in working with industries. His R&D excellence has helped in developing a number of industrial products and more recently his research innovations have brought a number of new bio-based product platforms to the marketplace.

Dr. S. Sivaram is presently an INSA Senior Scientist and Honorary Professor at the Indian Institute of Science Education and Research, Pune, India. Prior to this he held the position of CSIR Bhatnagar Fellow (2010-15) and J.C. Bose National Fellow of the Department of Science and Technology (2007-15) at CSIR-NCL. He served as the eighth Director of National Chemical Laboratory (NCL) from 2002-10. An alumnus of IIT-Kanpur, he received his PhD in Chemistry from Purdue University, USA. He was a Research Associate at the Institute of Polymer Science, University of Akron, USA before returning to India to pursue his professional career. Dr. Sivaram is

Plenary Speakers

a highly decorated scientist with numerous awards to his credits. He is a recipient of the Vishwakarma Medal (INSA), Silver Medal of the Chemical Research Society of India, Millennium Medal of the Indian Science Congress Association, Distinguished Alumnus Award of IIT, Kanpur, Professor S.R. Palit Memorial Award of the Indian Association for Cultivation of Science, Kolkata, K.G. Naik Gold Medal of M.S. University, Baroda, FICCI Award in Physical Sciences, Om Prakash Bhasin Award, Goyal Prize in Applied Sciences, Distinguished Material Scientist of the Year Award, 2011 bestowed by Materials Research Society of India and the Lifetime Achievement Award of the Indian Chemical Society, 2015. The President of India recognized him with the award of Padma Shri in 2006. Purdue University, USA conferred on him the DSc degree in 2010 for his exceptional attainment and merit. Dr. Sivaram is an elected Fellow of all the learned academies of science and engineering in India. He is also an elected Fellow of the Academy of Sciences for the Developing World, Trieste, Italy (TWAS), Fellow of the International Union of Pure and Applied Chemistry (IUPAC) and Royal Society of Chemistry, UK. He has lectured widely around the world and has been a Visiting Professor at the University of Bordeaux, France, Free University of Berlin, Germany, Indian Institute of Technology, Mumbai, King Abdulla University of Science and Technology, Saudi Arabia and H.A. Morton Distinguished Professor of Polymer Science at the University of Akron, Ohio, USA. He has mentored the Ph.D. thesis of 36 students, over a dozen post-doctoral fellows and published over 210 papers in peer reviewed scientific journals. He is cited as an inventor in 49 granted European and US as well as 52 Indian patents. He has edited two books and authored one book. Dr. Sivaram is a member of the Scientific Advisory Boards of several companies in India and also serves on the Management Boards of five listed and one unlisted company in India. Dr. Sivaram's research interest concerns polymer synthesis, surface chemistry of polymers, porous polymers for energy related applications, biodegradable polymers, organic-inorganic hybrids, nanocomposites and structure-property relationship in polymers.

Prof. Ramani Narayan is a University Distinguished Professor at Michigan State University in the Department of Chemical Engineering & Materials Science. He has received the Governor's (State of Michigan) University Award for commercialization excellence, Michigan Green Chemistry Governor's Award for developing biodegradable packaging and insulation foams, 2011, University Distinguished Faculty Award, 2006, Withrow Distinguished Scholar award, 2005, Fulbright Distinguished Lectureship Chair in Science & Technology Management & Commercialization (University of Lisbon, Portugal), DuPont's Packaging Award for excellence in Innovation & Sustainability, 2010 as part of the Coca Cola Plant bottle team. Prof. Narayan is a Fellow of the U.S. National Academy of Inventors and ASTM International. He is a recipient of the ASTM award of merit-the highest award given by the society to an individual member and the first recipient of the William N. Findley Award from ASTM Committee D20 on Plastics. He has received the James Hammer Memorial Lifetime Achievement Award, 2006 and the Life Time Achievement Award, 2010 from the BioEnvironmental Polymer Society (BEPS). He is technical advisor to many organizations and groups such as WWF Bioplastic Feedstock Alliance, U.S. Department of Agriculture biopreferred program etc. and serves on the Coca-Cola's Plant Bottle Advisory Board. Prof. Narayan is Scientific Chair of the Biodegradable Products Institute (BPI), North America and Director to Society of Plastic Engineers Bioplastics Special Interest Group (SPE-BioSIG). He has 200 refereed publications, 29 issued patents, and has graduated 20 Ph.D and 25 Master's students. His research encompasses design & engineering of sustainable, biobased and biodegradable plastics and its monomer precursors, biofiber reinforced polymer matrix composites, reactive extrusion polymerization and processing of polymers. He has developed and commercialized several technologies related to biodegradable polymers such as poly(lactic acid) technology for Cargill Inc., biodegradable starch polyols

Plenary Speakers

& starch-biopolyesters graft copolymers thermoplastics etc. He is the founding President and CEO of start-up company BioPlastics & Polymers LLC, founding member of Lions Adhesives Inc. (now EcoSynthetix Inc.) and co-founder of BioPolymer Innovations.

Prof. Kohei Oda obtained his M.S. degree from the University of Osaka Prefecture (UOP) in 1969, and his Ph.D. in the field of Agricultural Chemistry in 1975. He worked at UOP first as an Assistant (1969-1978), then Assistant Professor (1978-1985), and finally an Associate Professor (1986-1991). In 1992 he moved to the Kyoto Institute of Technology (KIT) where he held a position of Professor until his retirement. His principal scientific fields of interest are Applied Microbiology and Applied Biochemistry. In 2007, KIT awarded him the status of Professor Emeritus. Since that time, he worked as a Visiting Professor at the Universidad Federal de Sao Paulo, Brazil (2007, for 6 month), and at Khon Kaen University, Thailand (2009, for one year). In 1997, he received an Award from Nikkei Business Publications, Inc. (Medical field). His main contributions to this research field are discoveries of serine carboxyl peptidase family (sedolisins) [S53-family of serine peptidase], and the 6th family of peptidases, glutamic peptides G1 family (eqolisins). His ongoing interests are not only sedolisins and eqolisins, but also microbial hydrolytic enzymes, particularly those involved in degradation of polyethylene terephthalate (PET).

Prof. Hirokazu Hasegawa did his Ph.D. and M.S. in Macromolecular Science at Case Western Reserve University, Cleveland, Ohio, USA and B.E. in Polymer Chemistry, Kyoto University, Kyoto, Japan. His professional experience includes Senior Fellow, Center for Fiber and Textile Science, Kyoto Institute of Technology, Director/Senior Research Administrator, Research Administration Center, Graduate School of Engineering, Kyoto University, Chairman of Department of Polymer Chemistry, Graduate School of Engineering, Kyoto University, Japan. He has been visiting Scientist in National Bureau of Standards, Gaithersburg, MD, USA. He has been part of the Editorial Advisory Board of Macromolecules (published by ACS). He has received several awards and honors which include SPSJ Award (The Society of Polymer Science, Japan), 30th Oens Lager Award (The Society of Rubber Industry, Japan). He is member of The Society of Rubber Industry, Japan, The Society of Polymer Science, Japan and The American Chemical Society (USA).

Plenary Speakers

Prof. Mohini Sain is Professor, and former Dean of the Faculty of Forestry, at the University of Toronto. Dr. Sain specializes in low carbon and advanced manufacturing and his research combines advanced manufacturing with machine learning and artificial intelligence, advanced nanocellulose technology, biocomposites and bio-nanocomposites at the University of Toronto. He is cross-appointed to the Department of Mechanical and Industrial Engineering, Department of Chemical Engineering and Applied Chemistry and is a Professor of Faculty of Forestry and School of Environment . He is a fellow of Royal Society of Chemistry, U.K. and a fellow of the Canadian Academy of Engineering. Prof. Sain is globally known for his pioneering work on the Biocar Initiative. Dr. Sain holds several awards; a few recent ones are the Canadian Entrepreneurship award 2017, Plastic Innovation Award and the KALEV PUGI Award for innovation and contribution to industry. He is the author of more than 400 peer-reviewed papers with more than 600 publications, over 40 patents and has co-authored 7 books. He is designated as a highly-cited researcher. His google citations is over 14,000 and h-index is over 50. Prof. Sain has hugely contributed to society at large by translating research into commercialization. He has several start-up companies that are spin-offs from his research findings. A few examples are: Greencore Composites Inc., Natures Affinity Inc. and GreenNano Technologies Inc. To date he has made more than 40 technology transfers to industries and has helped create new companies for making products ranging from packaging to automotive to building construction materials. He is also the co-author of the world's first book on cellulose nanocomposites and has also co-edited a number of books. He is involved in many global strategic research policy developments, standardizations and research-funding strategic councils in an advisory role. He is a highly acclaimed engineering consultant in materials engineering and works with almost 100 companies worldwide. Prof. Sain is a leader in creating non-profit organizations that are highly meaningful to society at large. He is the founding member of the Canadian Natural Composites Council, the Ontario BioAuto Council, the Ontario-Jianshu Nano-Innovation Centre in Suzhou, China and many more. He has championed the global WPC industry by actively pursuing his global vision for this important and emerging green industry. He has chaired many global committees and has helped grow this industry to over a one-billion-dollar mark.

Prof. Arup K. SenGupta is currently the P.C. Rossin professor of the Department of Civil and Environmental Engineering and the Department of Chemical Engineering at Lehigh University in Pennsylvania, USA. He received his BS in chemical engineering in 1972 from Jadavpur University in Kolkata, India and PhD in environmental engineering in 1984 from the University of Houston, TX, USA. Prof. SenGupta authored the book 'Ion Exchange in Environmental Processes' by Wiley & Sons. He is the recipient of 11 US patents and his research in environmental processes and sustainable materials has received recognition from national and international organizations. Some of the notable awards that Prof. SenGupta has received include 2009 Astellas Foundation Award from the American Chemical Society (ACS), 2009 Lawrence K. Cecil Award from the American Institute of Chemical Engineers (AIChE), 2007 Grainger Challenge Award from the National Academy of Engineering and 2012 Intel Environmental Award for Technology Benefiting Humanity among others. Prof. SenGupta has co-founded three social enterprises to address global water related issues: Tagore-SenGupta Foundation; Technology with a Human Face and DrinkWell.

Keynote Speakers

Dr. Vijay G. Habbu is a Gold medallist chemical technologist from UDCT, Mumbai (now called ICT) at his BScTech and MScTech. He did his PhD from the Univ. of Leeds, UK in polymer science and post-doctoral research at the Univ. of Illinois at Urbana-Champaign, USA conducting research in high performance materials. He is Chartered Colourist & a Fellow of Society of Dyers and Colourists (UK)-CCol, FSDC. Dr. Habbu is a member of various professional bodies such as the Society of Dyers & Colourists (UK), Materials Research Society, Society for Surface Science and Technology, and Textile Association of India. He is also on the Editorial boards of the Journal of Packaging Technology & Research and Colourage. Dr. Habbu is a Past President of the UDCT Alumni Association (UAA). He has had a chequered career spanning Research, Technical and QC/QA, primarily in the polymers/plastics/fibre/composites field, working at Suhrid-Geigy (Mumbai), National Chemical Laboratory NCL (Pune), Synergy Polymers (Daman) and Reliance Industries Ltd. (Navi Mumbai). Dr. Habbu has published papers on high performance polymers, has patents granted on plastic composites and has developed several novel products and processes in polyester/ plastics. He is currently Distinguished Fellow of Polymer Science at ICT, a consultant Sr. VP at Reliance Industries Ltd. on Sustainability and Product Safety compliance, a technical advisor to PET industry associations (PACE and PCMA) and an expert member on several Governmental committees (e.g. Indian Pharmacopoeia, FSSAI. BIS).

Prof. Ching-Tsang Wang graduated from the Department of Aeronautics and Astronautics, National Cheng Kung University, Taiwan with BS, MS and PhD qualifications undertaken between 1992 to 2000. He currently works at National I Lan University, Taiwan. As for his present areas of study related to green technology, innovative biometric flow design, micro fluidic devices, optimal flow slab design of fuel cells, microbial fuel cells and bio-energy are the major fields. There are about 102 journal papers, 12 patents, 2 book chapter author and 1 book editor contributions that can be attributed to his research performance to date. In addition, Professor Wang was awarded the honor of University Distinguished Professor in 2011 and presented with a National Academic Award in 2013.

Prof. Debkumar Chakrabarti is currently Professor of Department of Design, Indian Institute of Technology Guwahati and Director (Officiating), Central Institute of Technology Kokrajhar, Assam. He has worked at the National Institute of Design, Ahmedabad, India, as a faculty member, for around 12 years prior to joining IIT Guwahati and has around 35 years of experience, since 1981 in various capacities covering various aspects of Ergonomics/Human Factors and Design at various levels (UG, PG and PhD). His research interest includes ergonomics and human factors fundamentals, usability and human compatibility factors, design ergonomics and human- product-environment interface system, cognitive perception and interaction ergonomics, occupational health and safety, and participatory ergonomics and training. He has around 130 publications/ reports, which includes journals, conferences, technical reports and books. He has worked on several sponsored and consultancy projects.

Dr. Han Zhang is the Sustainability and Advocacy Leader for Dow Packaging & Specialty Plastics Asia Pacific. He is responsible for driving Dow's 2025 Sustainability Goals

Keynote Speakers

for P&SP and developing strategies to grow business value by leveraging Dow's sustainability expertise. Dr. Zhang will establish the agenda and key programs addressing critical business issues such as marine debris, recycling and driving a circular economy, together with various value chain partners and industry associations throughout Asia. Dr. Zhang joined Dow in 2013 as a Sustainability Manager in the Sustainability Program Office. In this role, he was responsible for Dow's sustainability reporting, including Dow's Annual Sustainability Report and Dow's annual submission to the Dow Jones Sustainability Index. Dr. Zhang also conducts life cycle assessment projects and assists in the efforts to define Dow's next-generation approach to sustainability. In 2015, he assumed the role as Sustainability and Advocacy Manager for Dow Packaging & Specialty Plastics North America. Prior to joining Dow, Zhang held various positions at ConocoPhillips and ExxonMobil as life cycle assessment analyst and engineer. Dr. Zhang earned his doctorate degree in the School of Natural Resources and the Environment from the University of Michigan in 2009. He received his bachelor's and master's degrees in Thermal Engineering from Tsinghua University. Dr. Zhang also received a certificate in MBA Essentials and Entrepreneurship from U-M's Ross School of Business (2009) and a Rackham certificate of graduate studies in Spatial Analysis (2009).

Prof. Anil Kumar Bhowmick is currently Professor in Rubber Technology Centre at IIT Kharagpur. His research interests include: Polymer Nanocomposites and Nanomaterials, Thermoplastic Elastomers and Polymer blends, New Polymer from Renewable Sources, Polymer Modification, Rubber Technology, Failure and Degradation of Rubbers, Adhesion and Adhesives, Waste Rubber Recycling. He has received several awards and honours including Chemistry of Thermoplastic Elastomers Award by the Amercan Chemical Society, Commonwealth Award by the Association of Commonwealth Universities, UK, George Stafford Whitby Award from the American Chemical Society, JSPS Award by the Japan Society of Promotion of Science, K. M. Philip Gold Medal Award by All India Rubber Industry, Khwarizmi International Award for Science by Iranian Research Organisation on Science & Tech., MRF Award by the Indian Rubber manufacturer's Association, NOCIL Award by IRMRA-NOCIL and Stanton-Redcroft-Itas Award by the Indian Thermal Analysis Society. He is a member of several professional bodies and a fellow of National Academy of Engineering, Indian National Science Academy, West Bengal Academy of Science & Technology and Indian Rubber Institute. He has worked on several sponsored and consultancy projects and has 1 patent. He is the member of editorial boards of 7 national and international journals.

Prof. Shinichi Sakurai did his graduation (1984), master's (1986) and Ph.D. from Kyoto University. His doctoral thesis was on "miscibility and phase transitions of polymer blends and block copolymers". He is currently working as Professor at Kyoto Institute of Technology in Department of Biobased Materials Science, since 2010. His work experience includes: Assistant Professor at Kyoto Institute of Technology in Department of Polymer Engineering and Science (1989), Associate Professor at Kyoto Institute of Technology in Department of Polymer Engineering and Science (1998). He was Guest Scientist at National Bureau of Standards, USA, with Dr. Charles C. Han during 1986-1987, and at National Institute of Standards and Technology, USA, with Dr. Charles C. Han during year 1988. He has received several prestigious awards including Award from The Society of Fiber Science and Technology, Japan (2006), Award from SAS2006 conference for the outstanding service (2006), 8th The CERI Best Presentation Award (The Society of Rubber Science and Technology, Japan) (2011). He was Editorial Advisory Board member of Polymer, Elsevier (2000-2012). His research interests include Polymer Physics, Synchrotron Small-Angle X-ray Scattering, Small-Angle Nuetron Scattering, Pattern Formation, Dissipative Structures in Polymer System (convection), Multiphase Polymeric Materials, Biobased Materials, Structure and Properties Relationship, Small-Angle X-ray Scattering. He has 141 refereed publications and 2 book chapters. He is currently working on 5 ongoing projects.

Keynote Speakers

Prof. Pralay Maiti is Professor and Coordinator of the School of Materials Science and Technology, IIT (BHU) Varanasi. Dr. Maiti has received Master's in Chemistry from Indian Institute of Technology Kharagpur in 1991 and a Ph.D. in Polymer in 1996 from Indian Association for the Cultivation of Science (Jadavpur University). He was COE Researcher and Lecturer at Venture Business Laboratory, Hiroshima University, Japan (1997-1999) and was post-doctoral fellow at Toyota Technological Institute, Japan (1999-2001). He was Visiting Scientist at Cornell University, USA from 2002 to 2004. He was Quick Hire Fellow at Central Leather Research Institute, Chennai before joining the School of Materials Science and Technology in December 2004. His research interests are in the areas of nanocomposites of polymers, biomaterials, self-assembly, biodegradable polymers, polymer for renewable resources, radiation resistant polymer, fuel cell membrane and polymer electronics. He has received several honors and awards for his contribution in these areas.

Prof. Nabanita Saha did her B.Sc. (Hons) and M.Sc. in Lifescience (Botany) at Visva Bharati, Santiniketan, West Bengal, India. She carried out her Ph.D. work in Microbial biotechnology at Indian Institute of Technology Kharagpur. She is currently associate professor in Polymer Center at Tomas Bata University in Zlin, Czech Republic. She is working on several projects and is member of several societies, including Life member, Bioenergy Society of India (BSI), India, Life member, Renewable Energy Forum of India (BEFI), India, Member, Society of Plastic Engineers (SPE), USA, Member of Polymer Processing Society (PPS), USA, Member of Polymer Modification, Degradation and Stabilization (MoDeSt), EU, Board member of European Medical Polymer Division, Society of Plastic Engineering (since 2009). Dr. Saha's research interests include biomaterials and medical polymers for healthcare, bioconversion/ biodegradation of organic material, environment friendly biodegradable polymer/ plastic, isolation/ identification/ improvement of microflora for biodegradation and production of biopolymers, microbial production of biomaterials and biodegradable polymers. She has several patents and publications.

Prof. Niranjan Karak is a Professor of Polymer Science and Nanomaterials of Chemical Sciences Department (former HoD) and present Head, Sophisticated and Analytical Instrument Center (SAIC) of Tezpur University. Prof. Karak has published 202 research papers including review articles and authored six books, as well as written seven chapters in different edited books including two encyclopedias. He has supervised sixteen Ph.D. students and is presently supervising many more students along with two post-doctoral fellows. Dr. Karak has also filed five patents on his innovative works. His fields of research interest are mainly based on bio-based high performance hyperbranched polymeric nanocomposites as multifaceted sustainable materials including biomaterials. Prof. Karak has received eight national awards from different learned academic societies including The President of India and Ministry of Fertilizer and Chemicals, Government of India. He has also gained international recognition as one of the most highly prolific authors for ACS Sustainable Chemistry & Engineering in the world for his outstanding contribution in the field.

Keynote Speakers

Prof. K. C. Gupta obtained D.Phil Degree in Chemistry from University of Allahabad in 1984 on Polymer Chemistry and has been awarded fellowships by Govts. of France, USSR, Denmark, Poland and Japan under cultural exchange programs of Govt. of India. Prof. Gupta has been a Professor at IIT Roorkee since 2004. He received prestigious National Khosla Research Award in 2002 from IIT Roorkee for surface modification of biomaterial using binary methods of graft copolymerization. He was adjudged institute's high performer in 2004 for his contributions in teaching and research. Prof. Gupta's research interests include synthesis and characterization of functional biomaterial for controlled and sustained drug delivery and biomedical applications, and synthesis of well-defined polymers for sensing and separation processes. Prof. Gupta also worked as visiting Professor in South Korea where he was involved in teaching and research on tissue engineering. Currently he has developed liquid crystal biosensors for the detection of cancer cells and other biological molecules. Prof. Gupta has published more than 125 research articles in international journals of polymer science and actively guiding Ph.D and M.Tech students from various streams. He has also supervised research projects funded by various agencies like DST, CSIR, UGC and AICTE, New Delhi, India. Prof. Gupta served as member on editorial board of national and international journals of polymers and chemistry. He is a member of several international scientific societies including American Chemical Society, Washington, USA. He has delivered several invited talks and chaired sessions in national and international conferences in India and abroad.

Prof. Takashi Aoki began his academic training under the mentorship of Prof. Naoya Ogata in Sophia University, where he received his B. Sc. and M. Sc. in chemistry in 1986 and 1988, respectively. He went to Sagami Chemical Research Center as a researcher in 1988 and to Kanagawa Academy of Science and Technology as a researcher in 1990. He joined Prof. N. Ogata laboratory of Sophia University as a research associate in 1991 and receive his Ph.D. degree from Sophia University in 1997. The topic of his doctoral research was "Molecular design of stimuli-responsive polymer complexes for biomedical applications". He thereafter moved to Kyoto Institute of Technology in 2000 as an associate professor. At present he is an associate professor in the Department of Biobased Materials Science, Faculty of Fiber Science and Engineering, Kyoto Institute of Technology. His research interests are novel biobased materials and blood- and bio-compatibility of biomaterials.

Dr. Virendra K. Gupta did his Ph.D. in Chemistry from Banaras Hindu University, Varanasi. Currently he is Head of R&D Polymer, Reliance Industries Limited, Navi Mumbai. He previously worked at Gharda Chemicals, Indian Petrochemicals Corporation Limited, University of Alabama at Birmingham, USA. His has total professional experience of 33 Years in science, technology and management. His research interests include material science & technology, catalysis and performance materials including polyolefin, engineering thermoplastics, elastomers and biopolymers. He is first in India to develop and commercialize high performance Ziegler Natta catalysts for production of polyolefin and polyolefin catalyst precursor technology-"First to World". Dr. Gupta is co-inventor of patents with Prof Robert

Keynote Speakers

Grubbs, Nobel Laureate in the area of polyolefin. He has 150 patents and 60 research publications in peer- reviewed journals; 70 invited and contributed presentations in international and national conferences. 25 million ton polypropylene grades for different applications have been commercially produced so far using four generations of in house developed and produced catalyst by Reliance Manufacturing PP Plants based on patented technology co invented by Dr. V K Gupta. 15 technologies and their products have been commercialized for polypropylene, polyethylene, polyethersulfone and polysulfone grades and composites. He has been awarded 20 national and international awards for technologies co-invented and commercialized by him. He is member of various scientific societies, and is a visiting scientist at IIT Roorkee. He is Executive Council member of Central University of Haryana.

Prof. Bhuvanesh Gupta is a Professor in the Department of Textile Technology at Indian Institute of Technology Delhi, India working in the field of fiber and polymer science. He is the President of several international bodies such as Asian Polymer Association, Society of Biomaterials Artificial Organs India (Delhi), Society of Tissue Engineering & Regenerative Medicine, India and Indo-Italian Forum on Biomaterials & Tissue Engineering. Dr. Gupta did his PhD from IIT Delhi and spent a couple of years as post-doc in Paris. Subsequently, he worked for eight years in France, Sweden and Switzerland in different capacities in several laboratories. Dr. Gupta initiated research career in the field of polymer functionalisation, biomaterials and tissue engineering. Dr. Gupta had brief assignment as Director (Research) at Sikkim Manipal University Gangtok and is back to IIT system as professor of polymers and biomaterials. Dr. Gupta has been awarded medals at the University Level and has been granted several Visiting Fellowships in different European countries involving Sweden, Switzerland and France. He has been the member of DBT talk force of Government of India. He is on the editorial board of several journals. Dr. Gupta is the winner of several awards and medals, and has about 200 publications in international journals and more than 300 conference presentations in India and abroad along with 25 patents to his credit. Dr. Gupta has authored eight books published by international publishers and has been invited by several laboratories across Europe for delivering talks. Prof. Gupta's group is engaged in research in different areas of biomaterials and biomedical engineering.

Dr. Prashant Jha is the Fellowship Director of the BioDesign program at the School of International Biodesign which is administered as a collaboration between Stanford University, IIT Delhi, the All India Institute of Medical Sciences (AIIMS) and Queensland University of Technology. Dr. Prashant graduated in Medicine & Surgery (MBBS) from Patna Medical College and later pursued Family Medicine for his Post-Graduation from Royal College of General Practitioners (London). Along with a clinical career in Internal Medicine he took up research in Bioengineering at IIT Kanpur and for his MS worked on a collaborative project between IIT Kanpur, CDRI Lucknow, Tata Memorial Hospital and International Cancer Genome Consortium (ICGC) to develop a bioengineered construct for personalised cancer chemotherapy. Some of the medical devices he has innovated over the last few years include BRUN: a Feto-Maternal wellness monitor for resource constrained settings, Neurokeeper: a device to detect Stroke during sleep in at-risk patients at home; d.Steth: a redesigned stethoscope with SoC; Lev8: a device to help women manage Stress Urinary Incontinence. Dr. Prashant has authored a series of medical handbooks for undergraduate & postgraduate medical students and has mentored students from various IITs, IIMs & Tata Memorial Hospital ACTREC. He has worked with Apollo Hospitals Group where he trained physicians in the areas of Emergency medicine, intensive care, diabetology & family medicine.

Keynote Speakers

Prof. Chyi-How Lay is an Assistant Professor of Master's Program of Green Energy Science and Technology, Feng Chia University, Taiwan. He received his Ph.D degree from Feng Chia University in 2011. Prof. Lay is expert in anaerobic bio-hydrogen production, microbial fuel cell and microalgae. He is also the Chief of Division of Human Resource in Green Energy Development Center at Feng Chia University, Taiwan and a researcher in APEC Research Center for Advanced Biohydrogen Technology. Prof. Lay was a postdoctoral researcher at Tampere University of Technology in Finland during February 2012 to January 2013. He has authored over 40 peer-reviewed publications and book chapters and served as a peer reviewer for SCI Journals and more than 100 conference papers as well as 10 patents.

Prof. Chen-Hao Wang is the Associate Professor in Department of Materials Science and Engineering at National Taiwan University of Science and Technology. His research is currently focused on fuel cell, supercapacitor, redox flow battery and photocatalyst. He has received more than ten awards of thesis competition since 2010. In 2015, he received the Junior Research Investigators Award from Ministry of Science and Technology; he also received the Young Scholar Award from National Taiwan University of Science and Technology in the same year. In 2016, he was granted the Young Scholar Award from Taiwan Association for Coating and Thin Film Technology. He has published over 50 SCI papers in peer-reviewed journals which mostly were published in the high-impact journals, such as Energy Environ. Sci., Adv. Funct. Mater. Nanoscale, J. Mater. Chem., J. Power Sources and so on, and has been granted 8 patents from USA and Taiwan. His research interest includes electrochemistry, nanotechnology, fuel cell and carbon material.

Prof. Nikhil K. Singha is Professor and Chair of the Rubber Technology Centre, Indian Institute of Technology (IIT) Kharagpur. He did his B.Sc. in Chemistry (Main) from University of Calcutta, M.Sc. in Chemistry (Organic) from IIT Kharagpur, India, M.Tech.in Rubber Technology Centre, IIT Kharagpur, India and Ph.D. from IIT Bombay & National Chemical Laboratory (NCL), Pune, India. His research interests include tailor-made functional polymers and elastomers via controlled/living radical polymerization (CRP), preparation of smart self-healing, superhydrophobic and specialty polymeric materials via CRP and "Click Chemistry", preparation of block, graft copolymers, electro-active, bio-active polymers and tailor-made polymer composites via controlled polymerization, polymerization in ionic liquid, and polyurethane-ionic liquid composite. He has received several honours and awards, which include Prof. M. Santappa Award (2014) by Society of Polymer Science India (SPSI), MRSI Medal by Material Research Society of India (MRSI) (2013), Fulbright Senior Fellowship (2013), Fifth Polymer Foundation Award by Prof. Sukumar Maiti Polymer Award Foundation (2012). He was Visiting Scientist in University of Sheffield, UK with fellowship from Royal Society, London, UK (2006), in Institute for Polymer Research, Germany with INSA-DFG & DAAD fellowship (2008 & 2011) & in EPFL, Switzerland with fellowship from Swiss Federal Institute (2009). He is Fellow of Royal Society Chemistry (FRSC), Life member of Materials Research Society of India (MRSI), Society of Polymer science of India (SPSI) and Chemical Research Society of India (CRSI). He is member of editorial board of several peer reviewed journals and has 127 journal publication, 11 patents (one US, one European, eight Indian patents), 5 book chapters and 82 conference proceedings, along with one edited book published by Smithers RAPRA, UK.

Keynote Speakers

Prof. Jer-Huan Jang is currently a professor in the Department of Mechanical Engineering of Ming Chi University of Technology. He is also an adjunct professor in the Department of Mechanical Engineering of Chang Gung University. He received his BS and PhD degree from University of Maryland, USA in 1992. His research interests are in heat transfer, hydrogen production, lithium battery and clean energy.

Dr. Sandip Ghosh currently leads graphene based applications development for polymer composite and protective coatings at Tata Steel. He has done his PhD from School of Chemistry, University of Hyderabad in polymer electrolyte membrane for fuel cell application. A national award for technology innovation winner for his work in innovative polymers, he has 3 patents and 7 publications to his credit in various international and national journals in the field of polymer and material science. Prior to his engagement at Tata Steel Dr. Ghosh worked at Reliance Industries Limited and was responsible for leading the development and execution of high performance thermoplastic polymer synthesis and its application in construction sector . He started his career with Nova Surface Care Center (NSCC) as a technical manager, where he was leading the group for development of new nanotechnology based high performance coatings. Dr. Ghosh has spent 12 years as a polymer scientist in academic and industrial R&D leading projects of strategic intent for the organizations.

Dr. Sangeetha Thangavel is currently Research Assistant Professor in Department of Energy and Refrigerating Air-conditioning Engineering, National Taipei University of Technology, Taipei, Taiwan. She did her post-doctoral fellowship in Environmental Engineering from State Key Laboratory of Urban Water Resources and Environment, Harbin Institute of Technology, Harbin, China. She completed her Doctorate in Environmental Sciences, Diploma in Microbial Biotechnology, Master of Science in Zoology and Bachelor of Science in Zoology from Bharathiar University, Coimbatore, India.

Dr. Bhaskar B. Idage did his Diploma in Web Enabled Technologies (2003) from Centre for Development of Advanced Computing (CDAC), Pune and M. Sc. (1979), Organic Chemistry, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad. He received his Ph. D. (1984) from University of Pune, Pune in Polymer Chemistry. He is currently Scientist at Polymer Science & Engineering Division, National Chemical Laboratory, Pune. His research experience includes: Brain Pool Scientist at Korea Research Institute of Chemical Technology (KRICT), Daejeon, South Korea (2005-2007), visiting Scientist at General Electric Corporate Research & Development Centre (GECRD), Niskayuna, New York, USA (1997-1999), Visiting Scientist, General Electric Company (GE), Cartegena, Spain (1998) and Visiting Scientist, Perkin Elmer, Zurich, Switzerland (1992). He has received several prestigious awards which includes 3 National Awards, 10 Member of Professional Societies awards. He has 135 national & international conference papers, 56

Keynote Speakers

national & international patents and 12 Memo Reports. His research interest are biodegradable polymers, recycling of polymers, high performance polymers, nanomaterials, optical quality materials, telechelic polymers, quality management, laboratory safety.

Prof. Ram Adhikari is a Professor of Chemistry and currently the Executive Director at Research Centre for Applied Science and Technology (RECAST) in Tribhuvan University, Kathmandu, Nepal. Graduated from Martin Luther University Halle-Wittenberg (Germany), he is a Fellow of International Union of Pure and Applied Chemistry (IUPAC), recipient of POLYCHAR International Materials Science Prize, Georg-Forster Fellowship of AvH Foundation and the Technology Award of Nepal Academy of Science and Technology (NAST). He has authored over 120 research papers in peer reviewed journals, and is co-author/editor of 8 books. He has served as visiting professor at Rouen

Dr. Rabindra Prasad Dhakal is a senior scientist at Faculty of Technology, Nepal Academy of Science and Technology, Nepal. He has done his Doctor of Engineering (Dr. Eng.) in Department of Materials Science, Faculty of Science Engineering, Saga University, Saga, Japan, 2005. He worked as JSPS Post Doctoral Research Fellow in the Department of Applied Chemistry, Miyazaki University Miyazaki, Japan (September 2007- September 2009) and UNESCO Research Fellow at Tokyo Institute of Technology, Japan (October 2001- September 2002). He has been awarded Post Graduate Diploma in Chemistry and Chemical Engineering (UNESCO Fellow): Bio-Organic Chemistry, Advanced Research in Chemistry and Chemical Engineering at Tokyo Institute of Technology, Tokyo, Japan (2001-2002). He has also served as Senior Science and Technology Expert to Ex. Prime Minister of Nepal from September 2016 to July, 2017.

Prof. Bishnupada Mandal is currently a Professor and Head in the Department of Chemical Engineering at the Indian Institute of Technology Guwahati. Dr. Mandal has over 14 years of teaching and research experience in IIT Guwahati. He has received B.Sc. in Chemistry (Honours) and B.Tech. in Chemical Engineering from University of Calcutta, Kolkata, M.Tech. in Chemical Engineering from Jadavpur University, Kolkata and Ph.D. in Engineering from Indian Institute of Technology Kharagpur, India. He was Visiting Research Professor in The Department of Chemical & Biomolecular Engineering at The Ohio State Engineering, Columbus, Ohio, USA during May-July 2017. He has served as Vice Chairman, IIT-JEE 2011 as well as Chairman, IIT-JEE 2012 for IIT Guwahati Zone. He had been a recipient of the prestigious BOYSCAST fellow award of Department of Science and Technology (DST) Govt. of India and spent one year (2006-2007) as a visiting scientist at the Ohio State University, Columbus, USA. His research interest includes CO_2 capture by absorption, adsorption, and membrane based processes from flue gas, natural gas and syngas; wastewater treatment using bio-sorption and enzymatic processes; Interfacial reactions; and modeling and simulation of separation processes. He has guided 8 PhD and several MTech as well as BTech students. Currently he is involved in guidance of 13 PhD students. Dr. Mandal published two monographs (Lap-Lambert Academic Publishing, Germany, 2010), three book chapters, 51 research papers in reputed international journals and more than 100 papers in referred conference proceedings. He has over 2150 citations and h-index is 24. Dr. Mandal delivered plenary lectures at several national and international conferences. Currently, Dr. Mandal is serving as the Editorial Board Member of several journals includes Heliyon (Elsevier), American Journal of Modern Chemical Engineering (Columbia International Publishing), etc. He has served as reviewer of more than

Keynote Speakers

40 ACS, Elsevier and RSC journals. He is a life member of Indian Institute of Chemical Engineers (IIChE) and Indian Society for Technical Education (ISTE). He is also a member of American Chemical Society (ACS), North American Membrane Society (NAMS) and The Canadian Society for Chemical Engineering (CSChE). He was the Organizing Secretary of 68th Annual Session of Indian Institute of Chemical Engineers (CHEMCON 2015). He has served as Honorary Regional Secretary, Guwahati Regional Centre (GRC) of IIChE. He is also serving as the Chairman, IIChE-GRC. He has elected as Executive Council Member of IIChE for the years 2016-2019. He is involved in several research/consultancy projects. He has served Oil India Limited (OIL), Duliajan, National Thermal Power Corporation Limited (NTPCL), New Delhi, GAIL (India) Limited and Bharat Heavy Electricals Limited (BHEL), Bangalore as a consultant.

Prof. V. S. Moholkar is a Professor of Chemical Engineering and Head of Center for Energy at Indian Institute of Technology (IIT) Guwahati. He received Bachelors (1993) and Masters (1996) degree in chemical engineering from Institute of Chemical Technology (ICT) Mumbai, followed by Ph.D. from University of Twente in 2002. He has been Head of the Chemical Engineering Department at IIT Guwahati from 2012 to 2015. His main research interests are sonochemistry, cavitation assisted physical, chemical and biological processing, and thermo- and biochemical routes to biofuels. As of June 2017, he has published more than 120 papers in renowned international journals that have received more than 4000 citations (with h-index of 39). He has also filed 2 US patents (in collaboration with CTI Nanotech, CA, USA) on application of hydrodynamic cavitation reactors for biomass pretreatment and bioalcohol synthesis. He has graduated 10 Ph.D. and 24 M.Tech. students. He has been elected as Fellow of Royal Society of Chemistry (FRSC) in July 2016. He was admitted as Senior Member of American Institute of Chemical Engineers (MAIChE (Sr.)) in August 2016. He is a chartered member of Institution of Chemical Engineers, UK, and Chartered Engineer (CEng) registered with Engineering Council of UK.

Prof. R. P. Chhabra is currently Professor in Department of Chemical Engineering, IIT Kanpur. He did his B.E. in Chemical Engineering from Univ. of Roorkee, Roorkee, India, M.E. in Chemical Engineering from Indian Institute of Science, Bangalore and Ph.D. in Chemical Engineering from Monash University, Clayton, Australia. He is Fellow of Indian National Science Academy, New Delhi (elected in 2013), Fellow, Indian Academy of Sciences, Bangalore (elected in 2012), Fellow, National Academy of Sciences, India (elected in 2010), and Fellow, Indian National Academy of Engineering (elected in 2000). He has received several recognitions which include J N Gupta & Smt M D Gupta Chair Professor (9/ 2009 to 9/2012), Professor B. D. Tilak distinguished lecturer, Institute of Chemical Technology, Mumbai (2012-13), CSMCRI Chemcon distinguished speaker award-2011 Indian Institute of Chemical Engineers' Annual Conference, Bangalore (2011), P.D. Verma Memorial Lecture, Department of Mathematics University of Rajasthan, Jaipur (2003), Professor Gopal Tripathi Memorial University Lecture, Banaras Hindu University, Varanasi (2008), Herdillia Award of the Indian Institute of Chemical Engineers for Excellence in Basic Research in Chemical Engineering-1996, Amar Dye-Chem Award of the Indian Institute of Chemical Engineers for Excellence in Research and Development for a Chemical Engineer below the age of 35 years-1988, M.H. Shukla Prize for Best Paper, CHEMCON 2001, Gold Medal for the best design project-1974 and University of Roorkee Award for the second best student-1974. He is member of several societies and on the editorial board of a number of journals. His research interests are in hydrodynamics of non-Newtonian fluid-particle systems including bubbles, drops, particles and fluidization, multiphase (gas/liquid) flow in pipes and in packed beds, interaction between nonlinear properties of fluids and shapes of particles, and modelling of non-Newtonian fluid flow in fibrous media. He has published 7 books, 22 book chapters and 285+ articles in peer reviewed journals.

Invited Speakers

Prof. Anupama Sharma is professor at SSB University Institute of Chemical Engineering and Technology, Panjab University, Chandigarh. Her area of expertise includes polymer composites/nanocomposites, biopolymer synthesis and characterization, polymers for biomedical applications. She has received several honors and awards, which include Young Scientist Award, Asian Polymer Association, 2017, Career Award for Young Teachers (CAYT), All India Council for Technical Education (AICTE), India (2006), Indo Swiss Bilateral Research Initiative (ISBRI) fellowship from the Swiss State Secretariat for Education and Research and DST international division. Prof. Sharma was the Organizing Secretary, Engineering Section, Chandigarh Science Congress (CHASCON), 2008. She is Visiting Scholar to LIPHT, ECPM, Universite de Strasbourg, Strasbourg, France, Akron University, USA, Ecole Polytechnique de Lusanne, Switzerland, Fudan University, Shanghai, China, Universiti Teknologi Malaysia. Her subject expertise includes development and revision of courses on Chemical Engineering and Technology, Rubbers and Plastics, Polymer Science and Technology for Polytechnic Institutes in the States of Punjab, Haryana, Delhi and Uttaranchal by NITTR, Chandigarh. She has delivered invited and keynote lectures in many international conferences and has published more than 50 international journal articles, 10 book chapters, 4 conference proceedings and 2 books.

Prof. Sampa Saha is the Assistant Professor of Centre for Polymer Science and Engineering (CPSE) at IIT Delhi since June, 2015. She has several years of experience in the field of polymer chemistry. After finishing her PhD from Michigan State University, USA and postdoc from University of Michigan, Ann Arbor, USA, she has worked for companies like BASF, Singapore and Prochem, Singapore as team leader. More than 1 million dollar worth research grant was awarded during her work period in BASF, Singapore. Her research area spans from biodegradable polymeric particles (multi-layered and multi-compartmental) to polymer brushes. She has several publications in reputed international journals. She has also written 2 book chapters and filed 2 Indian patents. She emphasizes on multi-disciplinary approach to solve problems and hence believes in strong collaborative efforts.

Prof. Utai Meekum is currently Professor in School of Polymer Engineering, Institute of Engineering, Suranaree University of Technology, Nakorn Ratchasima, Thailand. He did his B.Sc (Hon.) in Chemistry from Department of Chemistry, Chiangmai University, Chiangmai, Thailand and PhD. in Chemistry and Chemical Technology in 1994 from Dept. of Chemical Engineering, University of Bradford, UK. He has 25+ years of industrial and research experience. His principal research work is focused on polymer blends for low surface adhesion applications, high performance engineered woods, crosslinking of PP for high temperature applications, super lightweight concrete/PS foam composite, super durable and lightweight engineered wood foam. He has several patents and publications to his credit and he has received several awards such as Distinguish Innovative Personnel Award from Suranaree University of Technology, 2012 and Distinguish Innovative Personnel Award from Suranaree University of Technology, 2014.

Invited Speakers

Mr. Manoj Bansal is working in Indian subsidiary of Thermo Fisher Scientific Inc. (a USD 17 billion company) as Commercial Leader and heading the Material Characterization business in India, Bangladesh and Sri Lanka. In his role he is responsible for development of strategies and business in these countries. He holds a Master's degree in Experimental Nuclear Physics from University of Delhi and had extensively worked on nuclear instrumentation techniques including material testing. Manoj has 19+ years' experience in the analytical and material characterization instrumentation techniques and business development in various markets such as material science, pharmaceutical, polymer and petrochemicals industries.

Dr. Masaki Yamamoto completed his BS in 2009 at the Faculty of Textile Science, Kyoto Institute of Technology (KIT), Japan. Then he enrolled to receive further education in the Department of Macromolecular Science and Engineering, KIT, where he was awarded his MS in 2011. He worked at a company after graduation and then enrolled to the Department of Biobased Materials Science, KIT. He received the degree of Doctor of Engineering in 2015. He joined the Center for Fiber and Textile Science, KIT as a postdoctoral fellow. He works on the investigation of fiber formation and the structure development of biobased polymers. He is an active member of the Society of Fiber Science and Technology, Japan, and Society of Polymer Science, Japan.

Dr. Susheela Idage is currently a Scientist in Polymer Science & Engineering Division Polymers & Advanced Materials Laboratory, CSIR-National Chemical Laboratory, Pune. Her research interests include biodegradable polymers from renewable resource, materials synthesis of biodegradable polymers for controlled drug delivery, surface modification and characterization of polymers, high performance polymers, optical quality materials and telechelic polymers. She has more than 36 years of experience in the design, synthesis and characterization of polymers. She is member of 5 different societies. She has published 25 articles in international journals, 85 conference papers and 5 patents.

Prof. S. Kanagaraj graduated from Thiagarajar College of Engineering, Madurai, affiliated to Madurai Kamaraj University in 1997. He received his Ph.D degree from Indian Institute of Technology Kharagpur in 2004. He did his post-doctoral fellowship in University of Aveiro, Portugal till May 2008. He has been with the Department of Mechanical Engineering at the Indian Institute of Technology Guwahati since 2008. His research interests include biomaterials, carbon nanotubes based nanocomposites and nanofluids for biomedical applications, assistive technology devices, prosthesis and orthosis, materials characterization. He has received Meritorious Best Paper award in 2003, meritorious scholar award in 2001 and 2002, and best oral presentation award in 2013. He has authored more than 60+ journal and conference papers.

Invited Speakers

Prof. Sarat Kumar Swain is currently working as a Professor of Chemistry and Dean (Post-graduate Studies and Research) at Veer Surendra Sai University of Technology, Burla, Sambalpur, since 2011. He has worked as Post-Doctoral Fellow in Department of Polymer Engineering, University of Akron, OH, USA. He was awarded INSA Fellowship and served as visiting researcher at Indian Association for Cultivation for Science, Kolkata. He was also awarded the JNCASR Fellowship for visiting researcher position at Jawaharlal Nehru Centre for Advanced and Scientific Research, Bangalore. He has published more than 100 research papers in different international journals. So far, he has authored 03 books, 25 book chapters, and has invention of two patents (one USA and one Indian) to his credit. He has received different awards such as BOYSCAST Fellowship, DAE-Young Scientist award, Prof. R K Nanda award and "Samanta Chandra Sekhar Award and gold medal" for various academic achievements.

Dr. T. Umasankar Patro is Assistant Professor at Defense Institute of Advanced Technology (DIAT), Pune. His research area includes polymer composites and nanocomposites, mechanical properties of materials, structure-property relationship, polyurethane foams, layer-by-layer assembly and carbon foams. He has received several awards and honors, which includes UGC JRF & SRF (2000-2005) and Feinberg Postdoctoral Fellow (2008). Dr. Patro is life member of alumni association, IIT Bombay. He has published 9 articles, 5 conference proceedings and 2 patents.

Dr. Bindu J is a Principal Scientist, in Fish Processing Division, ICAR-Central Institute of Fisheries Technology, Cochin Kerala. She has 21 years of experience. Her areas of research include thermal processing high pressure processing, value added fishery products and food packaging. She was awarded the Indo-US Agricultural Knowledge Initiative Borlaug Science & Technology Fellowship and underwent training on "High Pressure Processing" at the Department of Food Science, Ohio State University, Columbus USA in 2008, with a fellowship from USDA. She has published about 40 research papers in peer reviewed journals. She has also conducted numerous seminars, trainings and workshops, edited books, contributed chapters in book and presented numerous research papers in symposiums and seminars. She has independently handled and successfully completed NAIP and DBT funded projects for the Institute.

Prof. Priyadarsi De is currently Assistant Professor at Indian Institute of Science Education and Research Kolkata, India. He did his B.Sc. (Chemistry Honours.) and M.Sc. (Physical Chemistry) from Jadavpur University, Kolkata, India and Ph.D. (Polymer Chemistry) from Indian Institute of Science, Bangalore, India. Prof. De's research interests include controlled/living radical polymerizations [atom transfer radical polymerization (ATRP) and reversible addition fragmentation chain transfer (RAFT) polymerization], water soluble "smart" responsive polymers for drug delivery applications, polymer-drug/bio-active molecule conjugate and their biological evaluations, synthesis and characterization of hybrid materials and nanomaterials, controlled/ Living carbocationic polymerization for macromolecular architecture, combination of living cationic polymerization

Invited Speakers

with ATRP, RAFT, and "click" chemistry to generate novel macromolecular architectures, oxidative polymerization, polymerization of vinyl monomers under high pressure of oxygen. He is reviewer of several journals and visiting scientist at Université Pierre et Marie Curie, Paris, France (2002). He has published 10 patents, 2 book chapters and 54 peer-reviewed publications.

Prof. Uttam Manna is currently Assistant Professor in Department of Chemistry at Indian Institute of Technology Guwahati, India. He obtained M.S. and Ph.D. from IISc Bangalore and worked as a post-doctoral researcher and assistant scientist at University of Wisconsin-Madison, USA before joining IIT Guwahati. He has received several awards and fellowships which include IAAM (Sweden) Scientist Award, 2017, BNRS Young Scientist Research Award, 2017, SERB Young Scientist Research Award, 2015, Toulouse Medal, Best Thesis Award from Indian Institute of Science (IISc), 2013, Post-Doctoral Fellowship, University of Wisconsin-Madison, USA, 2011, and CSIR Junior Research Fellowship, 2008. He has published 34 papers in peer-reviewed journals and has 2 US patents.

Prof. Narayan Chandra Das is currently Associate Professor at Rubber Technology Centre, IIT Kharagpur. His research area includes polymer nanocomposites, conductive polymer/polymer composites and EMI shielding materials, biodegradable polymer and polymer composites, rheology/morphology and phase behaviour of polymer blends, small angle X-ray and neutron scattering (SAXS/SANS) on polymers/nanomaterials/ protein/virus, carbon nanotubes (synthesis/characterization/processing), thermoplastic elastomers, conjugated polymers for renewable energy application, polymer nanocomposites for food packaging, conductive smart textile materials, nanocomposites for sensor and fuel cell and synthesis of graphene and polymer nanocomposites. He is member of member of American Chemical Society, Americal Physical Society, Neutron Scattering Society of America and Sigma Xi: The Scientific Research Society. He is editorial board member of Advances in Nanoparticles. He has published several articles and books.

Prof. Katsuhiro Yamamoto did his Doctor of Engineering from Nagoya Institute of Technology (NIT), Japan in the Department of Materials Science and Engineering. He is currently Associate Professor in NIT, Frontier Research Institute for Materials Science. He received Research Fellow for Young Scientist of Japan Society for the Promotion of Science (1998).

Dr. Deepali Jadia is currently laboratory manager at ERRL since 2016. She worked as Assistant Professor at Department of Life Sciences and Department of Biotechnology, University of Mumbai (2014-2016). She has guided several projects for M.Sc. and Ph.D. students and has operational experience of analytical instruments like HPLC, GC and molecular biology techniques for identification of microorganisms by 16S rRNA gene analysis, genomic DNA library construction. She has received Ph.D. in Life Sciences (environmental biotechnology) from Department of Life Sciences, Kalina, University of Mumbai in 2010 and Post doctorate degree at NCCS, Pune (2011). She has five international and two national papers as well as a bacterium at the NCBI database. She is Assistant Editor of Asian Journal of Microbiology, Biotechnology and Environmental Sciences (AJMBTES), EM international publication, India and also appointed as reviewer for Journal of Hazardous Material, Elsevier Publications. She has published one patent. Her areas of research are environmental biotechnology, phytoremediation, pesticide bioremediation, wastewater treatment and biofertilizer.

Invited Speakers

Prof. Tushar Jana received his Ph.D. in 2001 from IACS-Calcutta and worked as a postdoctoral researcher in USA during 2002-2005. He joined the faculty of the University of Hyderabad (UoH) in 2005 and is serving as a professor of chemistry since 2013. His research interests are focused in three main areas: polymer membranes, polymeric nanoparticles and hydrogels, and polyurethanes. Prof. Jana's achievements have been recognized with awards and honours, including Young Associateship from Indian Academy of Science, Young Scientist Medal from Indian National Science Academy and the Alkyl Amines-ICT Foundation Day Young Scientist Award from Institute of Chemical Technology, Mumbai, India. He is an Associate Fellow of Andhra Pradesh Academy of Sciences. He has been elected as a Fellow of Telangana Academy of Sciences for the year 2015.

Prof. R. Anandalakshmi is an Assistant Professor in the Department of Chemical Engineering, Indian Institute of Technology (IIT) Guwahati. She obtained Ph.D. from IIT Madras and was a post-doctoral research fellow at IISc Bangalore. Her research interests are in the areas of process modelling and simulation, solar thermal energy conversion, microwave assisted material processing and sustainable polymer-based materials for food packaging and drug delivery applications.

Dr. Kazunari Masutani received his MS and Ph.D. degrees in polymer chemistry from Kyoto Institute Technology in 2009 and 2012, respectively. Since 2012, he has worked as a post-doctoral researcher at the Center for Fiber and Textile Science of Kyoto Institute Technology. His current research interests focus on synthesis and characterization of polylactides and the other bio-based polymers derived from renewable natural resources. He also launched a venture company for 3D printing material. Dr. Masutani received GSC Student Travel Grant Awards from Green Sustainable Chemistry Network in 2011, four poster awards in 2010, 2011, 2016 and 2017, Young Researcher Award and the paper award from The Society of Fiber Science and Technology in 2012 and 2016.

Prof. Sunil K. Sharma is a Professor in the Department of Chemistry at the University of Delhi. He obtained BSc (Hons), MSc, and PhD degrees from the University of Delhi. He has Postdoctoral/Visiting Scientist research experience of more than ten years at Freie Universitat Berlin (Germany), Massachusetts Institute of Technology (MIT, USA), University of Massachusetts (USA), Boston College (USA), Copenhagen University & University of Southern Denmark (Denmark), University of Liverpool (UK), and CSIC (Spain). He is a recipient of DBT-CREST Award (2011), DBT Overseas Associate Award (2007), International Authors Award from Royal Society of Chemistry (UK, 1999), and fellowships from University Grants Commission (India, 1986), Spanish Ministry of Education and Science (Spain, 1993), Danish International Development Agency (Denmark, 1996), and NIH (USA, 2000). Prof. Sharma's current research interests focus on organic synthesis, bio-catalysis, responsive polymer-based functional materials and nanotechnology. Prof. Sharma has

Invited Speakers

published over 130 peer reviewed journal papers with total citation of 2500 and an h-index of 27. He has presented more than 95 research papers at various Conferences/ Symposia. Thirteen PhD and two MPhil degrees have been awarded to students under his supervision. He has been granted research projects funded by CSIR, DBT, SERB-DST, DRDO, Government of India, Indo-German Science & Technology Center (IGSTC), Polytechnic University, New York (USA), and University of Delhi. Professor Sharma is having active research collaborations with various National and International (Germany, Italy, USA) groups.

Prof. Neetu Singh obtained her Bachelor's and Master's degrees from University of Mumbai, after which she moved to USA to perform doctoral work in chemistry with Prof. Andrew Lyon at Georgia Institute of Technology, Atlanta. Following her PhD, she moved to Cambridge, MA to pursue her postdoctoral studies at the Harvard-MIT Division of Health Sciences and Technology with Prof. Sangeeta Bhatia. In the Bhatia laboratory, her research efforts were focused on developing nanomaterials for achieving and investigating RNAi therapy. She joined as faculty in the Polymer Sciences and Engineering Division at the National Chemical Laboratory (NCL), Pune in 2012. She then joined as an Assistant Professor in the Center for Biomedical Engineering (CBME), IIT Delhi in April 2014. In her current program at IIT Delhi, she is establishing a research program that explores systematic probing into nanomaterials biological activity and formulates "design rules" for developing biosystem for specific bio-medical & technological applications. Her important scientific contribution in developing strategies for managing cancer got her the Kiran Shaw-Mazumdar International Oncology Fellowship, for establishing cancer-based-research ties with MIT, USA. She is also a recipient of the "Innovative Young Biotechnologist award 2013" by DBT, India.

Prof. Hidekazu Yasunaga did his Masters from Ibaraki University Japan (1990) and received his Ph.D. degree from Tokyo Institute of Technology, Japan in 1994. He served as research associate at Division of Biological Sciences, Graduate School of Science, Hokkaido University, Japan in 1992 and at Department of Chemistry and Materials Technology, Faculty of Engineering and Design, Kyoto Institute of Technology, Japan in 1995. During 1997-1998, he served as post-doctoral research fellow at Institute für Physikalische Chemie Johannes-Gutenberg Universität. In 2004, he joined as part-time lecturer at Kyoto Koka Women's University, Japan and in 2007, he joined as associate professor at Department of Chemistry and Materials Technology, Kyoto Institute of Technology, Japan. Since 2010 he is serving as associate professor at Biobased Materials Science, Kyoto Institute of Technology, Japan. His research interests include hair-dyeing science (dyeing mechanism and inventing new dyeing system), human- and eco-friendly colouring, dyeing and finishing (by using biobased materials), polymer gel (function and structure), NMR analyses (spectroscopy, PGSE, solid state and imaging).

Prof Kuruvilla Joseph is a well-known scientist in the field of nanomaterials, polymers and composites in national as well as international scientific communities. He has headed the Dept of Chemistry at Indian Institute of Space Science and Technology and is presently the Senior Professor & Dean at the institute. He has done post-doctoral, at the

Invited Speakers

Federal University of Paraiba, Brazil and Swedish Institute of Composites (SICOMP), Sweden. He did Ph.D from the Regional research Laboratory, CSIR, Thiruvanathapuram, in collaboration with School of Chemical Sciences, Mahatma Gandhi University, Kottayam. He has more than 8000 citations to his credit. Besides he has authored several academicbooks by international publishers as author / editor and has been invited as speaker for hundreds of National and International Conferences. He has three patents and more than 200 publications in international journals. The academician has produced 18 Ph.Ds and 26 Master Projects so far. Choice of research areas include Nanomaterials and Nanocomposites, Polymer Blends and Composites, Synthesis of polymers from natural resources, Green materials and bio-composites, ageing and degradation and development of biosensors. He is serving member of the Governing Board and Board of management, Indian Institute of Space Science and Technology (IIST), Thiruvanathapuram. He has been deemed worthy of several esteemed awards and honours. A few of them have been enlisted as follows:-Prof.Sivaprasad Award, 2000 instituted by Sivaprasad Foundation, Kollam, for the Best College Teachers in Kerala, The Young Scientist Award`2000, from the Indian Science Congress Association, New Delhi, (Received by the research group), The Mathias Award`95, instituted by All India Association of Christian Higher Education (AIACHE), New Delhi, India, for innovative young college teachers, The Highest Certificate of Merit`94 from the Indian Science Congress Association, New Delhi, for excellence in research, The Young Scientist Award`93, from the Government of Kerala, India are some of them. Prof K. Joseph has also been honoured with the Linnus-Palme Visiting Scientist Fellowship, Sweden, the DST (India)-DAAD(Germany), Visiting Scientist Fellowship, Martin Luther University, Halle, Germany, the Visiting Researcher Fellowship of Swedish Institute of Composites (SICOMP), Sweden, the Visiting Professor Fellowship of the National Council for Scientific and Technological Development (CNPq), Govt. of Brazil, the Visiting Researcher Fellowship of Indian National Science Academy(INSA), New Delhi and the Research Associateship of the Council of Scientific and Industrial Research (CSIR), Govt. of India, New Delhi.

Dr. Ravi Kumar Arun completed his B.Tech-M.Tech (Dual-Degree) from Department of Chemical Engineering, IIT Kanpur in 2009 and PhD from AcSIR. He is presently working as a Scientist in Micro System Technology group of CSIR-CMERI, Durgapur. His area of research included design and development of energy generation and harvesting systems for small to large scale energy storage applications. He has developed paper based membrane less microfluidics fuel cells for low power applications. In continuation with this activity, activity, He is also working in the area of Zinc-Vanadium batteries, Sodium-ion batteries with the focus of "Beyond Li-ion battery technology solutions", "All-Vanadium flow batteries" and "microbial fuel cells". His research interest is also directed towards developing efficient hybrid energy systems where multiple energy sources such as grid electricity, fuel cells, solar, wind, and battery storage are scheduled together to improve the energy efficiency criteria.

Dr. Debasis Samanta was awarded Ph. D. in Chemistry from Jadavpur University, Kolkata, India for his work on organic synthesis and surface functionalization at NCL, Pune (2000-2003) and IACS, Kolkata (2003-2005). After working as Research Associate in NDSU, USA (2005-2006), UMass, Amherst, USA (2006-2009) and IACS, Kolkata, India; he joined CSIR-CLRI, Chennai, India in 2011, where he is currently serving as Senior Scientist and Project Leader. He has published around 40 research papers with citations of around 800.The work by his research group is focused on functionalization of surfaces, synthesis of novel polymers and their applications. He is currently supervising 5 students and co-supervising 2 students for their PhD program registered under AcSIR and Madras University.

Invited Speakers

Dr. Harsh D. Jadia is currently working as Sr. Scientist & Head, Enviro Remediation and Research Laboratory (ERRL), Mumbai. Dr. Harsh completed his Ph.D. in 2009 in Life Sciences (Environmental biotechnology) from Department of Life Sciences, Kalina, University of Mumbai. He worked as an environment scientist for 7 years in UK based MNC, Intertek and completed several projects for international and national clients like including ie.Cairn Energy, Infosys, L&T, SHELL, GE, Vodafone, Thane Municipal Corporation, Indian Oil, Tata chemicals. He has expertise in Plastic biodegradation research and analysis as per ISO 17088, ASTM D 5511 and D6400 for more than 15 clients such as 3M, Uflex, Plastic Waste Solutions, Australia , Cisco Shrilanka, Dino, PT TRIAS SENTOSA, Indonesia, Polynet and Polyplex. He has published research papers in international and national journals of repute with more than 400 citations and filed 3 patents. He is member of New York Academy of Young Scientists, USA and BioVision.Nxt 2007 Fellow (France). His area of research is Environmental Biotechnology, Environmental Nanotechnology, Plastic biodegradation, Plastic recycling, Oily sludge bio-remediation, Phytoremediation, Solid waste, management, Composting and EIA.

Dr. Prakash Kumar is a Professor in Department of Biological Sciences, Faculty of Science at National University of Singapore. Professor Prakash Kumar's early education was from India, and PhD (1988) from Prof Trevor Thorpe's lab at the University of Calgary, Canada. He joined the National University of Singapore (NUS) in 1989, where he is a full professor at the Department of Biological Sciences. He has contributed significantly to plant molecular developmental biology and biotechnology. His current research aims to understand how phytohormones regulate plant development at the molecular genetic level. He has active projects to study salinity tolerance in mangroves, and a rice research program in collaboration with TLL Singapore and IRRI Philippines. Several of his 100 scientific papers are published in prestigious journals. He has supervised 28 PhD students at NUS. He is currently serving as Editorial Board Member of three journals, namely, BMC Plant Biology, Plant Cell Reports and Plant Biotechnology Reports. He has held several department- and University-level senior administrative positions at the NUS and serves on National and International committees, including, the Genetic Modification Advisory Committee, Singapore. He was elected Secretary/Treasurer of Plant Biotechnology Section, Society for In Vitro Biology, USA from 2014 to 2016. He is Singapore's National Correspondent (2012 onwards) for the International Association for Plant Biotechnology (IAPB).

Prof. Ajay Kalamdhad is working as an Associate Professor in Department of Civil Engineering, Indian Institute of Technology (IIT) Guwahati obtained his Bachelor, Masters and Doctorate degrees in Civil and Environmental Engineering from GEC Jabalpur, VNIT Nagpur and IIT Roorkee respectively in the years 2001, 2003 & 2008. Prior to joining IIT Guwahati in 2009, He was an Assistant Professor at VNIT Nagpur (2008-2009) and worked in various projects at RRL, Bhopal (Now AMPRI, Bhopal) and NEERI, Nagpur. He has published more than 62+ international papers in peer reviewed journals and presented his work in more than 80+ national and international conferences/workshops. He has also written one book entitled "High rate composting of municipal solid waste-An option for decentralized composting" on rotary drum composting. He has also associated with Indian Public Health Engineers, India, International Solid Waste Association Italy and National Solid Waste Association of India; and reviewers of 10 international journals. He is a recipient of ISTE- GSITS national award for best research by young teachers (below 35 years) of engineering colleges for the year 2012 and IEI Young Engineers Award 2011-2012 in Environmental Engineering discipline from Institute of Engineers India. Currently he is working on 5 major projects of MoEF, DST (SERC), MDW&S and CSIR, Govt. of India. He is member of editorial board of several journals. He is recipient of "ISTE- GSITS national award for best research by young teachers (below 35 years) of engineering colleges for the year 2012" from Indian Society for Technical Education India, recipient of "IEI

Invited Speakers

Young Engineers Award 2011-2012" in Environmental Engineering discipline from Institute of Engineers India and received CSIR financial assistance for paper presentation in International Conference at Hong Kong and received RTSE (Rural Talent Search Examination) scholarship from 1992-1996.

Dr. Mamilla Ravi Sankar is currently an Assistant Professor in the Department of Mechanical Engineering, IIT Guwahati. He did his B.Tech from Sri Venkateswara University, Tirupati, and M.Tech as well as PhD from IIT Kanpur. His research group is focus on Micro Nano Manufacturing, Biodegradable Polymer Implants, Sustainable Manufacturing, Tribology and Rheology of Polymers. His lab also involves in development of lab scale Innovations to Commercial Manufacturing Products. He has published over 40 research articles in internationally reputed journals, 70 international conferences, 2 Patents, 2 Edited Books and 6 Book chapters. Currently 9 PhD (Going on), 12 M.Tech (Completed), 18 B.Tech (Completed). Currently, MRS lab possess with various funding from BARC, DST, DRDL, IITG of about 20 Million Rupees as Principal investigator and 600 Million Rupees as Co-investigator. He is recipient of prestigious awards such as Institution of Engineers India (IEI) Young Engineers Award-2015 in Production Engineering, Indian Society for Advancement in Materials and Process Engineering (ISAMPE)-2011 and finalist of Indian National Academy of Engineering (INAE) Young Engineer Award-2014. His students received 3 best papers awards in national and international conferences. Apart from academic awards, he has also received Institute Blues (Outstanding Sports Personality) of IIT Kanpur for the year 2009 for his outstanding Games and Sports achievements as well as service.

Prof. Mihir Kumar Purkait is a Professor in the Department of Chemical Engineering at Indian Institute of Technology Guwahatiat (IITG). He became Fellow of Royal Society of Chemistry (FRSC) in 2017 and Fellow of Institute of Engineers (FIE) in 2016. Prof. Purkait has made outstanding contribution in the field of smart membrane fabrication for chemical, biochemical and environmental separation, purification and preconcentration. The development ranges from flat membranes to tubular membranes with various response properties, such as thermo-response, pH-response, glucose-response, molecular-recognition, and dual-/multi-stimuli-response. He has also developed antibacterial and antifouling membranes. Apart from membrane filtration, Prof. Purkait contributed significantly on fruit juice clarification technology, adsorption, electrocoagulation, nanotechnology, catalyst development and electrochemical reduction of CO_2 to various product.

Dr. Krupadam joined as a Scientist in the Department of Environmental Impact & Risk Assessment in October 2000; and reached to the senior level of Principal Scientist at National Environmental Engineering Research Institute (NEERI), Nagpur, India. During his 17 years of service, he worked as Project Leader/EIA Coordinator of 17 EIA projects and contributed as functional area experts/ specialist in 31 projects related to water and solid & hazardous wastes, cost-benefit analysis, pollution control technology evalua-tion and sustainability assessment. In current position, he oversees formulation and implementation of strategy/policy and programs of Water Resources Utilization in Industries and Infrastructure development projects, Environmental Impact Assessment; and Environmental Quality Management Systems of

Invited Speakers

NEERI. During execution of projects as project leader, a team of 15-20 spe-cialists/experts worked under his supervision for each Environmental Assessment pro-ject; and he mobilized funds worth of USD 2.1 billions from industries to the institute as the Coordinator of EIAs. Dr. Krupadam worked extensively on the development of polymers for environmental sensing and remediation, in particular, molecularly imprinted polymers. His current area of research includes development of framework for sustainability assessment of poly-mers and green chemistry approaches for design of sustainable polymers. Dr Krupadam is a National Awardee in the field of "Science & Technology Innovation" (2014) by Government of India and Fulbright-Nehru Academic and Professional Excellence Fel-low (2015); and currently he is member in many professional societies across the world. Dr Krupadam maintains highest ethics, professionalism and discipline in work.

Prof. A. S. Achalkumar did his BSc in SDM College, Ujire, DK District in Karnataka and later on completed his MSc at Mangalore University. This followed a two year stint on the synthesis of pharmaceutical compounds at Syngene International, Biocon Ltd., Bangalore. Later in 2003, he joined the group of Dr. C. V. Yelamaggad at Centre for Soft Matter Research (previously known as Centre for Liquid Crystal Research), Bangalore to pursue his PhD. Here he worked on the synthesis and characterization of Liquid Crystals. After completing his PhD in 2007 he joined the group of Prof. Richard J. Bushby and Prof. Stephen D. Evans in the Centre for Molecular Nano Sciences (previously known as Centre for Self-organizing Molecular Systems) at University of Leeds, UK as a postdoctoral fellow. Here he worked on the self-assembly of lipid bilayers and photopatternable SAMs. After finishing his assignment in UK in 2009, he moved to Bioinspired Materials Team, RIKEN Advanced Science Institute at Wakoshi, Japan. There he worked with Prof. Yasuhiro Ishida and Prof. Takuzo Aida on molecular imprinted polymers and Liquid Crystals chiral reaction media. In 2011, he was appointed as an assistant professor at the Chemistry Department of IIT-Guwahati. He was promoted to Associate Professor position in 2015. His research interests include supramolecular chemistry, Liquid crystals, SAMs, organogels, organic electronics and biomembranes. He has 55 publications and 3 patents so far with citations around 890 and h-index of 19. Two students have completed PhD and presently 5 students are working towards their PhD.

Mr. Subhash Naik is Manager-ISC-PCS in the Datacolor Solutions Pvt. Ltd. Mumbai. He is Working with Datacolor since 1996. After completion of M.Sc. in Physics from ICT (formally known as UDCT), join Bohr industry as Lab officer looking after Color matching for Artificial leather cloth and worked there for two years. Thereafter, he joined with Datacolor Agent, Dr. Gangakhedkar and from there he was directly selected as Datacolor Applications engineer looking after applications support in customers in Indian sub continent. In Datacolor, he worked for various capabilities from textiles and non textiles applications & customer support. In 2010 he was awarded the ASDC, Chartered colourist qualification from SDC, UK .Since 2010, after promotion as Sales Manager, his main target was to developed Datacolor market for Paint & other non textiles industries. During his tenure as Sales Manager, he increased datacolor sales in non textiles market from mare 200K US$ to 800K++ last year.

Technical Session

	Poster Presentation	
Poster No.	**Title of paper**	**Pg.No**
PPC 01	Role of Dicumyl Peroxide as Compatibilizer in Increasing the Thermal Stability and Thermal Degradation Kinetics of Poly (Lactic Acid)/ Coconut Oil Blends, Siddharth Mohan Bhasney, Rahul Patwa, Amit Kumar and Vimal Katiyar, IIT Guwahati, Assam, India.	236
PPC 02	Ionic Liquid as solvent for development of Sulfonated Polyimide-based Polymer Electrolyte Membranes (PEMs), Tushita Rohilla, Narinder Singh and Dhiraj K. Mahajan, Indian Institute of Technology Ropar, Punjab, India.	236
PPC 03	Synthesis, Characterization and Immobilization of DPP-based Click Polymers on ITO and Glass Surfaces, P.Ramar and Debasis Samanta, CSIR-CLRI, Tamil Nadu, India.	237
PPC 04	Sustained Release of Triclosan from Nano Fibrilliated Cellulose and its Prolonged Antibacterial Activity, Srijita Purkayastha, Saikat Biswas and Sampa Saha, Indian Institute of Technology Delhi, Delhi, India.	238
PPC 05	Surface initiated self-healing polymers via Atom Transfer Radical Polymerization from the surface of Graphene oxide, Junali Handique and Swapan Kumar Dolui, Tezpur University, Assam, India.	238
PPC 06	Biodegradable Poly (lactic acid)/Modified Gum Arabic (MG) Based Microcellular Composite Foam: Effect of MG on Foam Properties and Thermal Behaviour, Shasanka Sekhar Borkotoky, Tabli Ghosh and Vimal Katiyar, Indian Institute of Technology Guwahati, Assam, India.	239
PPC 06A	Morphology and crystallinity study of novel polypropylene hybrid composites, Rupam Gogoi, Gaurav Manik, Byravan Arun, Indian Institute of Technology Roorkee, Saharanpur, UP, India.	239
BPS 07	Synthesis of Ethylene Glycol Initiated Poly(ε-caprolactone) [PCL], Purabi Bhagabati and Vimal Katiyar, Indian Institute of Technology Guwahati, Assam, India.	202
BPS 08	Biodegradable cellulose based superabsorbent hydrogels for water conservation in agricultural lands, Dipankar Das and Sachin Bhaladhare, Tripura University, Tripura, India.	202
BPS 09	Waste chicken feather as reinforcement fiber in chemically modified epoxidised soybean oil based composites, Gitashree Gogoi and Tarun K. Maji, Tezpur University, Assam, India.	203
BPS 10	Chitosan Starch Hybrid Biopolymer Reinforced with Banana Fibre, Nithin T James, Rijin Raju, Adarsh Sreekumar and Ambili S Nair, TKM College of Engineering, Kerala, India.	203
BPS 11	Trends in Green Composites - A perspective, Pritam Dey, Srimanta Ray, Chemical Engineering Department, National Institute of Technology, Agartala, India.	204
BPS 12	Renewable resource based smart hyperbranched polyurethane elastomer, Tuhin Ghosh and Niranjan Karak, Tezpur University, Assam, India.	204
BPS 12A	Influence of β-chitin on PVP-CMC and PVP-CMC-CaCO3 hydrogel scaffolds: the bioinspired biomaterials for biomedical applications Vida Čadež, Nabanita Saha, Maja Dutour Sikirić and Petr Sáha, Tomas Bata University, Czech Republic.	201
PNC 13	Development of Chitosan Film Reinforced with Anti-Oxidant Loaded Mesoporous Silica for Active Packaging, P.L. Alagammai, C.K. Bijosh, G. Pugazhenthi and V. Ravi Babu, CSIR – CECRI, Tamil Nadu, India.	228
PNC 14	Study on the properties of nanocomposite based on rice husk and polyvinylchloride, Nipu Dutta and T. K. Maji, Tezpur University, Assam, India.	229
PNC 15	All-Solid-State Flexible Supercapacitor Based on Self Assembled Polyaniline Nanotube/Reduced Graphene Oxide Aerogel, Anindita Bora and Swapan Kumar Dolui, Tezpur University, Assam, India.	229
PNC 16	A Study of Acid red 52 dye removal from an aqueous medium using PANI/PVP/Nd-ZnO polymeric nanocomposite, A. Gouthaman, Raja S. Azarudeen and M. Thirumarimurugan, Coimbatore Institute of Technology, Tamil Nadu, India.	230

PDD 51	Development of a chitosan conjugated 5-Fluorouracil prodrug as a nano-carrier for controlled delivery, Himali Horo, Lal Mohan Kundu and Bishnupada Mandal, Indian Institute of Technology Guwahati, Assam, India.	214
PDD 53	Synthesis, characterization and drug delivery applications of copolymer blend membranes: Kinetics and mechanism of drug release profile, E. Jaisankar, Raja S. Azarudeen and M. Thirumarimurugan, Coimbatore Institute of Technology, Tamil Nadu, India.	215
PDD 54	Injectable and pH-Responsive PEG Hydrogels for Sustained Intra-Tumoral Drug Delivery, Peeyush K Sharma and Yashveer Singh, Indian Institute of Technology Ropar, Punjab, India.	216
PDD 55	Nanobiocomposites - The New Interdisciplinary Field in Case of Drug Delivery, Jyotismita Kalita & Hemantajeet Medhi, Bineswar, Brahma Engineering College, Kokrajhar, Assam, India.	
PDD 55A	Environmental friendly Gold and Silver nanaocomposites bare positive effect on human health, Sarangapani Hazarika & Pranab Dutar Bineswar Brahma Engineering College, Kokrajhar, Assam, India.	
PDD 56	A Review on Thymol Encapsulation in Biodegradable Polymer Shells and its Controlled Release Mechanism, Y. P. Bhalerao, S. J. Wagh and Shroff S. R, Rotary Institute of Chemical Technology, Gujarat, India.	216
PDD 57	PLA/CNC Electrospun Nanocomposite Fiber as a Controlled Release Vehicle for Urea Fertilizer, Narendren S, Prodyut Dhar and Vimal Katiyar, Indian Institute of Technology Guwahati, Assam, India.	217
PDD 58	Synergistic Effect of Curcumin Microcapsule Loaded Anticancer Hydrogel, Prasamsha Panta, Moon Suk Kim, Elina Maharjan, Kamala Panthi and Rameshwar Adhikari, Tribhuvan University, Kathmandu, Nepal.	217
ECA 59	Synthesis and characterization of low cost non-fluorinated aqua-repellent coating, Smruti R. Mohanty, Smita Mohanty and S. K. Nayak, LARPM, CIPET, Orissa, India.	205
ECA 60	Zwitterionic–polyurethane coatings for non-specific marine bacterial inhibition: A nontoxic approach for marine application, Anthony Yesudass S, Smita Mohanty, Sanjay K Nayak and Chandi C. Rath, LARPM, CIPET, Orissa, India.	205
ECA 61	Swelling behavior and surface switchable wettability of perfluorinated imidazolium amphiphilic ionic copolymer, Santosh N. Chavan and Debaprasad Mandal, Indian Institute of Technology Ropar, Punjab, India.	206
ECA 61A	Synthesis and characterization of Itaconic acid based Polyurethane acrylate resin for UV curable coating Application. Ganesh A. Phalak, Deepak M. Patil, S. T. Mhaske, Institute of chemical Technology, Mumbai, India	206
PDW 62	A Study on catalytic co-cracking of waste plastics polypropylene disposal cup and residual fuel oil, Pamreishang kasar and M. Ahmaruzzaman, National Institute of Technology Silchar, Assam, India.	218
PDW 63	Effect of moisture absorption on degradation of FRP composites laminate and durability of FRP laminates exposed with sea water environment, simulate the moisture absorption using FEA analysis, Pitambar Tripathy, Bishnu Panda, Smita Mohanty and Sanjay Kumar Nayak, LARPM, CIPET, Orissa, India.	218
PDW 64	Comparative study of recycled PVC [r-PVC] recovered from waste electrical and electronic equipments (WEEE), Omdeo K. Gohatre, Manoranjan Biswal, Smita Mohanty and Sanjay K Nayak, LARPM, CIPET, Orissa, India.	219
PDW 65	Aerobic biodegradation kinetic study of PLA based biocomposites under composting conditions, Naba Kumar Kalita, Anubhav Sarmah, Ajay Kalamdhad and Vimal Katiyar, Indian Institute of Technology Guwahati, Assam, India.	219
PDW 66	Aerobic biodegradation study of PLA based biocomposites under composting conditions at thermophilic temperature, Naba Kumar Kalita, Ajay Kalamdhad and Vimal Katiyar, Indian Institute of Technology Guwahati, Assam, India.	220
OT 68	Depressurization induced morphology control in microcellular batch foaming process, Indrajeet Singh, Abhishek Gandhi, Smita Mohanty, S. K. Nayak, LARPM, CIPET, Bhubaneswar, India.	207

Plenary Lecture

PL-01: Recent advances in the synthesis of biobased chemicals and polymers: From aliphatics to aromatics

Yoshiharu Kimura
Center for Fiber and Textile Science, Kyoto Institute of Technology
1 Hashigami-cho, Matsugasaki, Kyoto 606-8585, Japan
E-mail: ykimura@snr.kit.ac.jp

Use of renewable natural resources such as biomass has been convinced to be effective for reducing our dependence on fossil resources and for decreasing the environmental impact. Until now, several polymeric materials have been developed by utilizing naturally occurring polysaccharides or their breakdown substances by combining both chemical and biological technologies (white bio-technology). These newly developed polymers are called "bio-based polymers", being superior to the conventional oil-based polymers in reducing the emission of carbon dioxide into the global atmosphere even after their incineration.

Table 1 summarizes the recent development of biobased polymers in the world as a function of their Japanese demands. It is shown that many oil-based polymers such as PET, polyamides, PE, PC, and ABS are produced from monomers of biomass origin. This trend, being more critical in Europe and USA, is based on the rapid development of biobased chemicals including those proposed by DOE (USA) as platform chemicals. They are synthesized from biomass resources, both edible and nonedible, by utilizing new synthetic processes. Table 2 summarizes the development of these biomass-originated chemicals. It is noted that many chemicals needed for synthesizing biobased polymers are awaiting manufacturing. New monomers and polymers that should have specific performance and specialty ought to be more easily prepared from biomass resources to have advantage and competitiveness over the corresponding oil-based polymers. Poly(ethylene furanoate) (PEF) and aliphatic polycarbonate (Durabio®) are now typical candidates in this respect among the newly developed biobased polymers, although their production has remained small.

It has also been convinced that the efficient use of nonedible biomass is essential in reducing the total cost of biobased chemicals without affecting the food supply chain. For this purpose, the three components of biomass, lignin, hemicellulose, and cellulose, must effectively be separated and broken down to valuable chemicals. Particularly, efficient use of lignin components is essential, although its break-down is extremely difficult. At present, several applications of high-molecular-weight lignin are proposed: (1) pyrolysis to carbon products involving carbon fiber, (2) direct use as fillers, and (3) synthesis of thermoset resin replacing formaldehyde resin, in spite of inherent drawbacks of the target materilas in appearance and performance as compared with the conventional products. In the new conversion technology, lignin is thought to be broken down into its elemental units such as coniferyl, sinapyl, and coumaryl alcohols by bacterial enzymatic processes or into more fundamental chemicals such as BTX or substituted phenols by innovative catalytic processes. Although these technologies are under development, the aromatic chemicals derived from lignin must open a new aspect in the utilization of biomass-originated chemicals. We are therefore trying to create new polymer series on this future lignin technology. Different from the currently utilized polyesters such as PET, which consist of aromatic diacids (e.g., terephthalic acid) and aliphatic diols (e.g., ethylene glycol), the new polyesters proposed here consist of aliphatic diacids and aromatic diols, having reversed combination in diacid and diol components. They are accordingly named "reversed polyesters". The components of the reversed polyesters can readily be supplied from the biomass originated resources and have advantages in bio-industrial production over the components of PET. However, the polymerization of the reversed polyesters is not easily accomplished because phenols hardly form ester bonds with carboxylic acids. Here, we demonstrate the synthesis of several reversed polyesters that can be processed into fibers to show a future possibility of the new biobased polyester series involving aromatic monomer units (Scheme 1).

Plenary Lecture

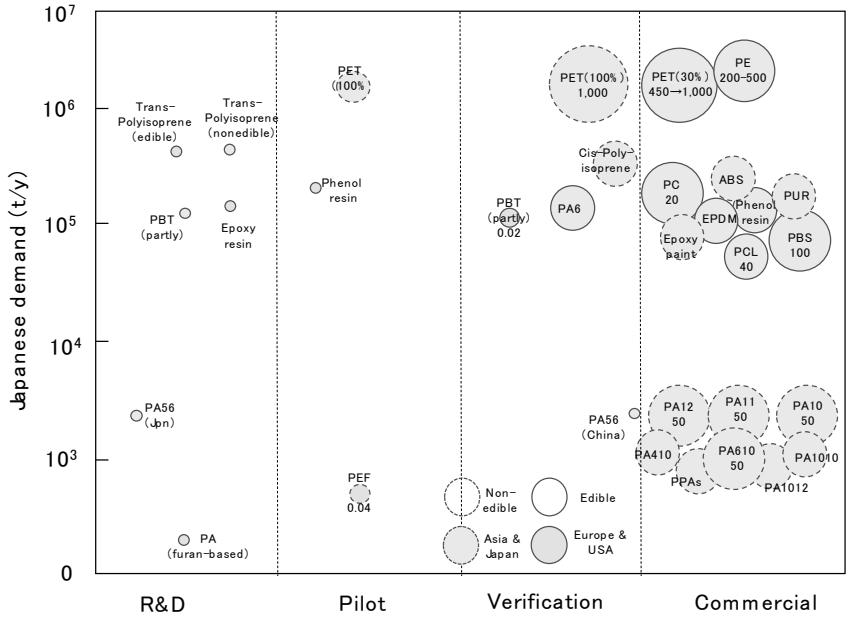


Figure 1. Current development of biobased polymers in the world as a function of their Japanese demands.

[Figures 1 and 2: In reference to the project register for "Technology Development of Manufacturing Processes for Non-edible Plant-derived Chemicals", NEDO, 2017]

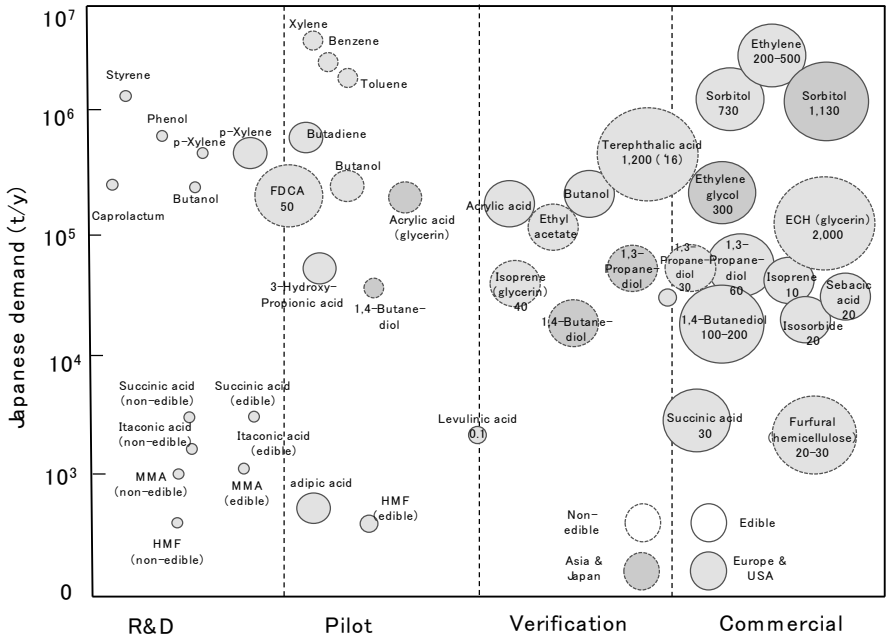
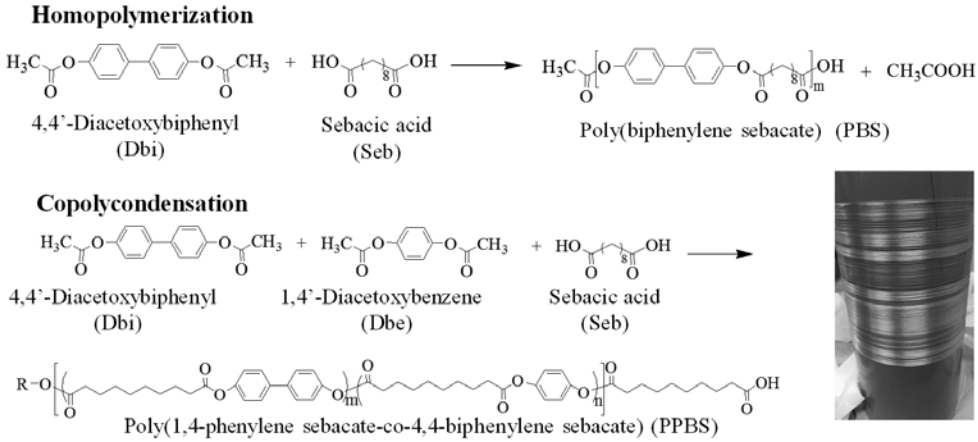


Figure 2. Current development of biobased chemicals and monomers as a function of their Japanese demands.

Plenary Lecture



Scheme 1. Synthesis of reversed polyesters consisting of aromatic diols and aliphatic carboxylic acids.

Plenary Lecture

PL-02: Circular Economy: A Sustainable path forward for Bioplastics and Biocomposites Innovation

Amar Kumar Mohanty

Bioproducts Discovery & Development Centre, Department of Plant Agriculture, School of Engineering, University of Guelph, Ontario, Canada

Circular economy concept targets waste minimization through a closed loop system that helps a sustainable development. Integration of this novel concept to bioplastics and biocomposites can bring a number of innovations to the market place for societal benefit thereby creating new jobs and improved economy. The downstream product of one industry can be used as raw material for another industry thus in finding value-added uses of these coproducts. Bioplastics in general are expensive as compared to traditional plastics. These undervalued coproducts can be used as filler and reinforcement in bioplastics in engineering innovative biobased composites materials for new industrial uses. The downstream products from food processing and pyrolysis industries show immense potential for plastic reinforcements both from supply chain and economical prospective. This presentation will highlight on the recent development of these biobased composite materials for industrial uses in sustainable packaging, ecofriendly consumer products and light-weight automotive parts.

Acknowledgements: *Ontario Ministry of Agriculture, Food, and Rural Affairs(OMAFRA)-University of Guelph Bioeconomy Industrial uses Research Program;; Agriculture and Agri-Food Canada and Competitive Green Technologies through AgriInnovation Program ; the Natural Sciences and Engineering Research Council(NSERC), Canada for the Discovery Grants; and the Ontario Research Fund, Research Excellence Program; Round-7 (ORF-RE07) from the Ontario Ministry of* Research and Innovation (MRI).

***Brief BIO*: Professor Amar Mohanty**, is a Full Professor, Premier's Researcher Chair of Biomaterials & Transportation and Director of Bioproducts Discovery and Development Centre at the University of Guelph and a former Michigan State University professor.

Research publication record:

- More than 750 publications-includes 322 peer-reviewed journal papers (includes accepted), 5 edited books, 25 book chapters and 52 patents (awarded/applied)
- Total citations of his research: 22,787; h-index: 69; i10-index: 236 (Google Scholar).
- ResearchGate (RG) Score: 45.84 (higher than 97.5% of RG members).

Few of his awards include-

- Lifetime Achievement Award from the BioEnvironmental Polymer Society (BEPS), USA
- University Research Leadership Award
- Andrew Chase Forest Products Division Award, from American Institute of Chemical Engineer

A world-renowned researcher in his field, Dr Mohanty is a pioneer in modern biobased materials science and engineering research. His constant innovation has catalyzed changes across several manufacturing sectors, including compostable packaging, environmentally friendly consumer products and automotive parts. His lifelong dedication to improve the environmental impact of plastics has introduced number biobased materials into North American and global markets.

Plenary Lecture

PL-03: Sustainable Polymers : Challenges and Opportunities

S. Sivaram
Indian Institute of Science Education and Research
Dr Homi Bhabha Road, Pune 411008, India
s.sivaram@iiserpune.ac.in

Abstract

Sustainability issues in polymer materials is largely centered around the use of fossil derived feed-stocks as building blocks for synthetic polymers and the issue of persistence of used polymeric material in the ecosphere on account of its durability and non-bio-degradability. Many strategies have been explored for shifting the building blocks of synthetic polymers to more sustainable bio derived feed-stocks. While there has been some success, this area is largely beset with problems of high cost of feed-stocks, low economies of scale and inability to build the kind of diversity in structure and properties that synthetic polymers today are capable of. The issue of persistence of synthetic polymers in the eco-sphere and the growing menace of plastic waste is probably a more relevant and emergent driver of issues related to sustainability of synthetic polymers. Here the demands are more severe since the polymers have to be both bio-derived and bio-degradable and only a few polymers qualify to meet both these requirements.

Unfortunately, the realm of sustainable polymers is at this time passing through a “hype-phase” with inflated expectations. Emerging science in this area is lacking in clarity and purpose and technology is unable to meet the material property envelopes that synthetic polymers have proven to be capable of.

In this lecture, I will question some of the common perceptions about sustainability issues related to polymers and frame the questions afresh so that a more rational and informed approach to R&D in this area can be contemplated. We will examine many current premises, such as, whether bio-derived polymers are green, are environmentally degradable, are inexpensive, that they can co-exist in the ecosphere with fossil fuel derived polymers and will make economic sense, sometime in the future. In the context of burgeoning growth of urban solid wastes, it is pertinent to ask whether bio-derived polymers have the potential to offer a sustainable solution. As the world moves from the concept of “re-cycling” to “” up-cycling” in the context of a circular economy, we need to reassess the definition of sustainability as applicable to synthetic polymers

Plenary Lecture

PL-04: What makes a polymer sustainable? Discussions around bioplastics, biobased, biodegradable-compostable, and the circularity model as metrics for sustainable polymers

Ramani Narayan (narayan@msu.edu)

Biobased Materials Research Group, Michigan State University E. Lansing MI 48824, USA

There is a general understanding of the term "sustainability" but what constitutes a "sustainable polymer"? What are the metrics by which polymer/plastic sustainability should be measured? Polymers form the basis for 322 million tons of plastics in use today (Source: Plastics Europe, 2017) and another 65 million tons used as fibers. Biobased plastics in which the petro-fossil carbon is replaced by biobased carbon offers the value proposition of a reduced carbon footprint and represents an important measure for a sustainable polymer. However, sustainability needs to be documented and accounted for across the entire supply chain from growing the plant-biomass to manufacturing the polymer (resin or finished product). ISO standards specific to biobased plastics based on LCA methodology is in the final stages of approval. This ISO series standard provide guidance on reporting and communicating the carbon and total environmental footprint of biobased plastics.

Environmentally responsible end-of-life for plastics is an important measure for sustainable polymers. Mechanical and chemical recycling of biobased plastics and plastics in general are responsible end-of-life management strategies.

Polymer biodegradability in disposal systems like composting/anaerobic digestion or soil (agriculture) can be a viable and responsible "end-of-life" solution in harmony with the "Circularity Model" (Ellen MacArthur Foundation, in line with circular economy concepts). However, there has been much misuse and abuse of the word "biodegradable. Products abound in the marketplace making unqualified claims of "biodegradable" with little or no supporting data or understanding of the value proposition biodegradability offers. The U.S. Federal Trade Commission (U.S. FTC), the State of California, the European Union Commission report, courts in several countries have all provided clear guidance in this area. ASTM, ISO, and EN standards provide test methods and specifications to measure and report on biodegradability.

This lecture reviews the current state-of-the science and technology in the bioplastics space and the contributory relationship to sustainability and circularity. In particular, we will have a serious conversation about the following:

- Is biodegradability a solution to managing plastics waste and to sustainability? How about marine or landfill biodegradability?
- Can oxo or enzymes or similar additives make hydrocarbon polymers (polyolefins) fully biodegradable-what is the science and hype around it and what does "biodegradable" really mean?
- Is caterpillars & mealworms the next new biodegradable magical solution to plastic waste management?-as reported in literature and extensively covered in print and e-media.

Plenary Lecture

PL-05: A bacterium that degrades and assimilates poly(ethylene terephthalate) and its enzymes involved in the degradation

Kohei Oda

Kyoto Institute of Technology, Kyoto, Japan
e-mail:bika@kit.ac.jp

Abstract: We have developed the following three systems to degrade PET: 1) a microbial consortium system, 2) an *Ideonella sakaiensis* system, and 3) a system utilizing two novel enzymes (Fig. 1). We would like to emphasize that the degradation products are environmentally benign monomers, terephthalate (TPA) and ethylene glycol (EG).

Keywords: Poly(ethylene terephthalate) (PET), Microbial consortium, *Ideonella sakaiensis*, PET hydrolase (PETase), Mono (2-hydroxyethyl) terephthalic acid hydrolase (MHETase).

Plastics with desirable properties such as durability, plasticity, and/or transparency have been industrially produced over the past century and widely incorporated into consumer products. Many of these products are remarkably persistent in the environment because of the absence or low activity of catabolic enzymes that can break down their plastic constituents. In particular, polyesters containing a high ratio of aromatic components, such as poly(ethylene terephthalate) (PET), are chemically inert, resulting in resistance to microbial degradation. About 56 million tons of PET were produced worldwide in 2013. Large quantities of PET have been introduced into the environment through its production and disposal, resulting in the accumulation of PET in ecosystems across the globe. There are very few reports on the biological degradation of PET or its utilization to support microbial growth. Once identified, microorganisms with the enzymatic machinery needed to degrade PET could provide new tools for environmental remediation, as well as a platform for degradation and/or fermentation for biological recycling of PET waste products.

We screened for PET-degrading microorganisms and succeeded in 2001 in isolating a microbial consortium No.46 that degraded amorphous PET-film (1, 2). Subsequently we succeeded in isolating from the consortium No. 46 a novel bacterium, *Ideonella sakaiensis* 201-F6, capable of using PET as its major energy and carbon source (1-3). When grown on PET, this strain produces two enzymes, named PET hydrolase (PETase) and MHET hydrolase (MHETase), capable of hydrolyzing PET and the reaction intermediate, mono(2-hydroxyethyl) terephthalic acid (MHET), respectively. Both enzymes are required to efficiently convert PET into its two environmentally benign monomers, TPA and EG.

Thus we succeeded in developing three novel systems to degrade PET. That is 1) a microbial consortium system, 2) an *Ideonella sakaiensis* system, and 3) PETase/MHETase system (1-3).

We are just at the starting point in creating novel technologies. Possible application aspects are as follows:

1) Screening for another PET-degrading micro- organism(s)
2) Bioprocess production of protocatechuic acid from waste PET in order to synthesize value-added chemicals
3) Treatment of PET-fibers to obtain better textures
4) Additives to detergents
5) Carbon dioxide fertilization
6) Synthesis of bio-degradable PET
7) Recovery of TPA or MHET for re-synthesis of PET

Plenary Lecture

All of them are novel trials on bio-recycling of waste PET, a compound that causes severe environmental pollution. New technologies based on these novel systems have to be established in order to construct an ecological and sustainable society. We would like to carry out this very important task through collaboration with experts in the related fields.

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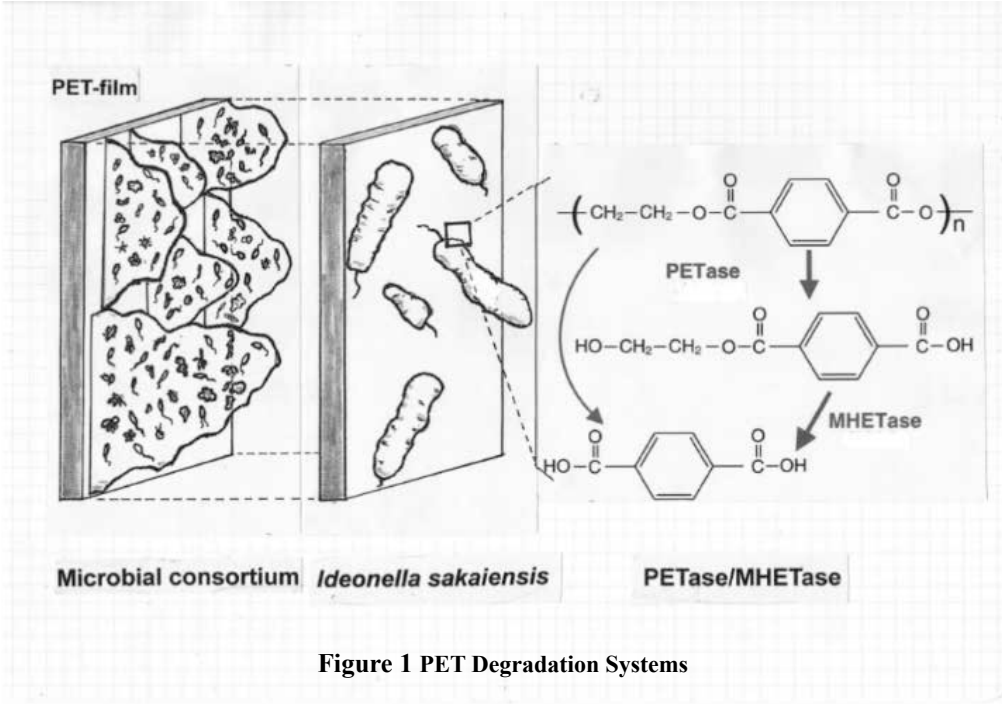

Figure 1 PET Degradation Systems

Plenary Lecture

PL-06: Control of Network Microdomain Morphology of Block Copolymer Systems

Hirokazu HASEGAWA*[1], Yi-Chin WANG[2], Midori WAKABAYASHI[2], Ayano INOUE[2], Mikihito TAKENAKA[2]

[1] Center for Fiber and Textile Science, Kyoto Institute of Technology, Kyoto 606-8585, Japan.
[2] Graduate School of Engineering, Kyoto University, Kyoto 615-8510 Japan
** Corresponding author, e-mail:hasegawa.h0@gmail.com*

Introduction

Block copolymers self-assemble to form highly regular phase-separated structures in nanometer scale and their 2D and 3D patterns are useful for a variety of functional materials for nanotechnology such as nanolithography, photonic crystals, nanoporous membrane, etc. Among different morphologies, 2D and 3D network structures are especially of interest because of the spatial continuity of the microdomains of both components. We explored effective ways to create the network microdomain structures by controlling the ordering in the solution casting processes of block copolymer systems in their strong segregation limit. Not only popular Gyroid networks but also diamond networks were found by investigating the microdomain morphology using 3D TEM tomography as well as SAXS.

Methods and Materials

Network morphology has hyperbolic interfaces and significant variation of microdomain sizes especially at the nodes. In our early publication we pointed out the importance of controlling interface curvature and space-filling of the nodes. [1] Along this line we investigated two systems. One is a bottlebrush-type graft-block copolymer polystyrene-*block*-(poly-4-vinyl- phenyldimethylvinylsilane-*graft*-isoprene) (code:SGI-2). [2] SDI-2 has architecture of a long PS chain (239kD) with ten short PI chains (18kD) at one end. The other is a polystyrene-*block*-polyisoprene-*block*-poly-1,4-dimethylsiloxane (51-64-63 kD) linear triblock terpolymer (code: SID1). [3] The nanostructures of the as-cast films were analyzed by 3D electron tomography (3D TEM) and small-angle X-ray scattering (SAXS) with a synchrotron radiation source (Spring8).

Result and Discussion

A benzene-cast film of SGI-2 was stained with OsO_4 and ultramicrotomed for 3D TEM observation. 2D TEM

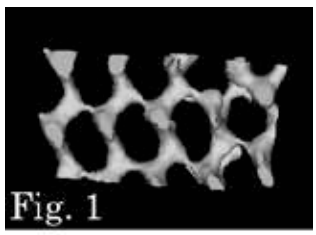

Figure 1 One of the two interwoven PS networks extracted from the reconstructed 3D TEM image of SGI-2.

images exhibit complex regular patterns suggesting network morphology different from Gyroid. [2] The 3D reconstructed image suggests that SGI-2 has double network morphology, i.e., two identical PS 3D networks are interwoven and embedded in PI matrix. Such a situation is unusual because PS is the major component (f_{PS} = 0.54) and normally a major component forms the matrix. We extracted one of the PS networks (Fig.1) and analyzed the 3D structure. It was found that

Plenary Lecture

SGI-2 had all the characteristics of double-diamond network morphology (OBDD), i.e., (1) a double-network structure, (2) 4-fold (or tetrapod) connecting elements and (3) 6-membered rings with every other junction having the connection to the opposite direction. Theoretical studies suggest that Gyroid is more stable than OBDD for diblock copolymers. However, the frustrated PI chains of SGI-2 due to the bottlebrush architecture tend to be stretched along the interface normal and thus changed the phase boundary as well as the relative stability of Gyroid to OBDD.

The second system we investigated was an ABC triblock terpolymer consisting of PS, PI and PDMS (SID1). When it is cast from toluene solution, two-step microphase separation is expected. Since toluene is common good solvent for PS and PI but poor for PDMS, PDMS first segregates from the other two as the solvent evaporates. Eventually, PS and PI microphase separate in the nanospace confined by the PDMS microdomains as further evaporation of the solvent. Therefore, the resulting morphology is affected by the casting process and a nonequilibrium unusual structure might form. Thus, after the structure analyses by 3D TEM tomography and SAXS we found ordered tricontinuous double diamond morphology for the toluene-cast film of SID1, i.e., two interwoven PDMS-PI core-shell diamond networks are embedded in PS matrix. [3] Two-step microphase separation was also confirmed by the SAXS observation of hexagonal-cylinder structure in 37 and 40% SID1 solutions in toluene.

In conclusion, we successfully produced double diamond network morphology by two different approaches.

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Plenary Lecture

PL-07: Low Carbon Advanced Materials and Energy

Mohini Sain

Faculty of Forestry, University of Toronto, Canada.

Currently, there is a strong global interest in low carbon advanced manufacturing. The recent climate change issue has resulted in high demand of lightweight vehicles and low carbon fuels, and since the expenses for conventional materials and manufacturing typically amount to 70% of the total cost of any product, the increased carbon tax prices have impacted or going to impact the manufacturing industry significantly. The prices of manufactured products have not increased accordingly, however, and the net profits of the manufacturing companies have, therefore, decreased appreciably. Presentation will discuss approaches to lowering the material costs entailed by conventional production methods is to develop and popularize an alternative material-a manufacturing process that take advantage of new technologies such as lightweight composite, foamed performance materials, robotics and AI-assisted manufacturing and decision making and low carbon energy systems that retains the integrity and functional characteristics of existing manufacturing but provides a greater realm of growth in precision and complex manufacturing process yet fast enough to be competitive. Members of the manufacturing industry are extremely eager to develop industrial technologies that will produce lighter microcellular plastics with first-rate properties in various manufacturing applications. These traits make low carbon advanced materials an optimal producers, allowing them to manufacture lightweight products that preserve the integrity and desired functionality of the final part. Author will also demonstrate how composites with fiber reinforcement will further enhance the properties while reducing the material usage significantly.

Plenary Lecture

PL-08: Development and Global Applications of Hybrid Ion Exchange Nanotechnology (HIX-Nano): From Decontamination to Desalination

Arup K. SenGupta, P.C.Rossin Professor
Department of Civil and Environmental Engineering
Department of Chemical Engineering
Lehigh University, Bethlehem, USA
e-mail id: arup.sengupta@lehigh.edu

Abstract

Zirconium, the 21st most abundant element in the world, is stable, chemically innocuous and non-hazardous. Nanoparticles of zirconium oxide (ZrO_2) have unique sorption properties to bind a variety of trace contaminants including arsenic, fluoride, phosphate and lead. We have developed a process to disperse ZrO_2 nanoparticles within the gel phase of an anion exchanger with quaternary ammonium functional group. The resulting hybrid ion exchanger, referred to as HIX-NanoZr, is a robust sorbent material that is also amenable to regeneration and reuse (1).

Although unknown nearly twenty five years ago, natural arsenic contamination of groundwater has emerged as a major global crisis affecting over fifty countries including the USA. Nearly 200 million people in Asia and Africa drink groundwater that contains toxic levels of fluoride and arsenic. Both HIX-NanoZr and HIX-NanoFe are now commercial materials and over two million people around the world drink arsenic- and fluoride-safe water through use of these sorbents.

Brackish water desalination plants are mostly located inland and must resort to expensive concentrate disposal methods like deep well injection or evaporation ponds. Increasing the recovery of RO process would obviously reduce the volume of concentrate to be disposed of but cannot be implemented due to scaling of sulfate ($CaSO_4$, $BaSO_4$, etc.) and silica (SiO_2) resulting in fouling of RO membranes. We have developed a hybrid Ion Exchange-Reverse Osmosis (HIX-RO) process where tunable anion exchange resins can eliminate sulfate precipitation (2) and silica fouling without addition of external regenerants or anti-scaling chemicals. Results from the field experiments will be presented.

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Keynote Lecture

KL-01: Sustainability of polymers- a reality check for india

Vijay G. Habbu

Senior Vice President, Reliance Industries Limited, Navi Mumbai

In this address, Dr. Habbu will present the basic framework of Environmental Sustainability and then speak on how the concepts of SUSTAINABILITY are relevant to polymer-based articles, primarily plastics and textiles. In view of their usage in large volumes it is important to understand their fate at the end of their life, hence polymer scientists need to be aware of these issues and get involved in the development of the concepts of Circular Economy.

Dr. Habbu will present a brief overview of the various manifestation of polymers in the real-life usage and home in on the plastics industry, that being the largest usage of polymers. He will present a panoramic perspective of the industry, the regulatory environment in which it operates and the challenges that it faces in view of the ubiquitous nature of plastics, this being veritably the Plastics Age.

Showcasing the versatility of polymers emanating from the unique linkage of structure-property-morphology-properties, he will present an overview of the developments happening to make plastics Sustainable.

A predominant link in Sustainability is Recycling, hence Dr. Habbu will present the framework on the approaches to recycling. He will use the example of PET to demonstrate the phenomenal strides taken in the recycling of PET bottles into a range of alternative products that we commonly use in our daily lives.

Dr. Habbu will also initiate discussions on the important tool of Life Cycle Analysis (LCA) and Eco-footprints for determining the Environmental impacts of various options in the design of articles, primarily in the packaging industry.

Dr. Habbu will sketch the various assaults that the plastics-industry is facing, primarily as a result of ill-informed campaigns from overzealous NGOs. In his appeal to the gathering of polymer scientists assembled, he will present the various areas in which polymer scientist can play a pivotal role in making their products sustainable, educating the Governments and the judiciary on the facts and usefulness of polymers/plastics and striking a balance between their fulfilling human needs and protecting the eco-balance. He will present practical examples of the sterling contributions of scientists/academicians towards creating a Sustainable industry. Towards this, a structure will be seeded for further ruminations at the Symposium.

Keynote Lecture

KL-02: Effect of calcination of Fe_2O_3 on degradation performance of organic wastewater in a novel Bio-electro-Fenton Microbial Fuel Cell

Jung-Chen Wu[1], Wei-Mon Yan[2], Chen-Hao Wang[1,*],Chin- Tsan Wang[3,*], Yi-Hao Pai[4], Sangeetha Thangavel[2]

[1]Department of Materials Science and Engineering, National Taiwan University of Science and Technology, Taipei, Taiwan

[2]Department of Energy and Refrigerating Air-Conditioning Engineering, National Taipei University of Technology, Taipei, Taiwan.

[3]Department of Mechanical and Electro- Mechanical Engineering, National Ilan University, I-Lan, Taiwan

[4]Department of Opto-Electronic Engineering, National Dong Hwa University, Hualien, Taiwan

[*]Email: ctwang@niu.edu.tw ; chwang@mail.ntust.edu.tw

Abstract

Iron oxide (Fe_2O_3) is a renowned photo catalyst and is known to have an effect on the photochemical reaction of catalysts. So, an investigation into the enhancement of the degradation performance of bio-electro-Fenton microbial fuel cells (Bio-E-Fenton MFCs) was carried out at various calcination temperatures of Fe_2O_3 ranging from 500℃ to 900℃. Results show that a suitable temperature for calcination of iron oxide would give a significantly positive effect on the performance of Bio-E-Fenton MFCs. An optimal calcination temperature of 500℃ was observed to produce a maximum power density of 52.5mW/m^2 and a chemical oxygen demand (COD) degradation rate of 99.3% within 1 hour of operation. These novel findings will be useful for the improvement in the performance and applications of BEF-MFCs in the future.

Keywords: *Bio-electro-Fenton microbial fuel cells (Bio-E-Fenton MFCs), Wastewater, Photo catalyst, Calcination.*

Keynote Lecture

KL-03: Experimental study on the emission of diesel engine with hydrogen syngas

Dao-Yi Huang and Jer-Huan Jang

Department of Mechanical Engineering/Battery Research Center on Green Energy
Ming Chi University of Technology, New Taipei City 243, Taiwan
Corresponding author: jhjang@mail.mcut.edu.tw

Abstract

In this manuscript, syngas containing hydrogen was produced by a spark plasma reforming system, which containing three supersonic atomization devices, two plasma generator, and a controlling device, and has been utilized on a diesel engine of motor. In the experiment, the vehicle under testing was a 1997 c.c. 4 cylinder Ford FOCUS with maximum power of 136 hp / 4000 rpm and maximum torque of 32.6 kg-m/2000rpm. The emission test were tested with HAMA LPS 3000 dynamometer and MTG-5. Europe Emission standard cycle (ECE-15) was run for the emission test, constant vehicle speeds of 40 and 60 km/h were also tested. Results show that the emission of HC, CO and CO_2 decrease, while NOx increases with using the spark plug reforming system. In addition, the PM was measured as well. It was shown that the PM concentration is lower with the addition of hydrogen syngas.

Keynote Lecture

KL-04: Potential study of electricity generation in an anodic anaerobic bacteria and cathodic microalgal microbial fuel cell

Chyi-How Lay *[1], Jane-Yii Wu [2], Yi-Cyun Chen[2], Chin-Chao Chen[3]

[1]General Education Center, Green Energy Development Center, Master Program of Green Energy Science and Technology, Feng Chia University, Taichung, Taiwan.
[2]Department of BioIndustry Technology, Da-Yeh University, Changhwa, Taiwan.
[3]Department of Landscape Architecture, Chung Chou University of Science and Technology, Changhwa, Taiwan.
* Corresponding author, e-mail:chlay@fcu.edu.tw

Abstract: Microbial fuel cell (MFC) could remove the pollutant in the wastewater. Moreover, microalgae could utilize organic carbon in the wastewater and carbon dioxide in the biogas to growth. Anaerobic fermentation, MFC and microalgae cultivation would be integrated to develop the anodic anaerobic bacteria and cathodic microalgae microbial fuel cell technology. This study aims to investigate the potential of electricity generation in an anodic anaerobic bacteria and cathodic microalgae microbial fuel cell . This study shows the electricity generation potential in an anodic anaerobic bacteria and cathodic microalgae.

Keywords: *MFC; pig manure; anaerobic bacteria; microalgae*

Introduction

Microbial fuel cell (MFC) is a device which could convert the chemical energy into electricity through the biological catalytic reaction. The organic material could be oxidized to form electron in the anode then transfer to the electron acceptor (ex. oxygen and ferricyanide) through the external loop and combine the proton, which passes through the proton exchange membrane, to form water in the cathode. MFC could be applied in wastewater treatment to remove pollutants and generate the electricity simultaneously. Microalgae could produce oxygen through photosynthesis reaction from light and carbon dioxide. Based on this mechanism, the anodic microalgae MFC was developed. Cui et al. [1] cultivated microalgae using CO_2 (5-14%, v/v) in an anodic microalgal MFC to reach the microalgae biomass content of 1247 ± 52 mg/L. The results also showed that acetate could be utilized without supporting CO_2 un the MFC. He et al. [2] applied immobilized *Chlorella* sp. in an anodic microalga MFC. The results showed that COD removal efficiency could reach 92.1 % and the maximum electrical performance of 2,572.8 mW/m^3 with a coulombic efficiency of 14.1 % could be obtained.

The substrate for MFC is an important issue because of it is the nutrient and energy source for the anaerobic bacteria in the anode. The efficiency of converting chemical energy into bioenergy depends mostly on the substrate composition and the concentration, which influence the electricity performance such as coulomb efficiency and power yields. Many reports studied various kinds of artificial and real wastewaters in MFCs [3]. However, actual wastewater is the most meaningful practical implication for the removal of contaminants with simultaneous electricity generation. Swine wastewater is a kind of high-strength wastewater, which contains high concentrations of organics, nitrates, and phosphorus. This organic wastewater must be treated to meet discharge regulations before being released into the environment to avoid severe environmental pollution from high-strength organic wastewater. Our previous study showed the pollutant removal and electricity generation potential simultaneously in the anodic chamber of a dual-chamber MFC [4]. This study aims to investigate the swine wastewater removal efficiency in both anodic anaerobic bacteria and cathodic microalgae as well as electricity generation potential in this microbial fuel cell.

Methods and Materials

Microalgae collection and algal strain identification Microalgae samples were collected from seawater

around Taiwan, stored in sterile centrifugal tubes and sent to the laboratory within 3 d for algal cell isolation. Walne medium

Keynote Lecture

plates were prepared using full-strength seawater, containing 18 g/L of agar and 1 g/L of glucose. After inoculation, the plates were cultured at 30°C for 2-7 d. Single colonies composed of spherical cells atypical of either yeast, fungi, or bacteria were extracted and carefully transferred to a new plate. Ten *Chlorella* strains (D8-1-1, G29-5, G31-8, O245, Pu10-1, W23-21, W25-381, Y8-1, Z11, and Z16) were isolated and cultivated in sterilized swine wastewater as the medium to investigate the microalgae growth.

Swine wastewater

Swine wastewater was collected from a buffer tank after solid and liquid separate unit in the wastewater treatment plant at a pig farm in central Taiwan. This wastewater was used directly to cultivate ten species of microalgae to investigate the wastewater inhibition on microalgae growth according to the wet biomass estimations using spectrophotometry regarding density (D) at an OD of 650 nm. The raw swine wastewater is characterized as chemical oxygen demand (COD) 6,000 mg/L, pH 7.4, phosphate 43 mg/L, NH_4^+-N 500 mg/L and ADMI 900.

Experiment design

Seven days cultivation was applied to enrich these ten species. These microalgae that could grow at the initial pH 10 and without aeration for extra added carbon source were selected to study the effects of swine wastewater concentration (dilution times of 0, 10, and 100) and sterilization. No additional phosphate and nitrogen sources were added during cultivation. A glass tube with a working volume of 20 mL at 30 °C using an exponentially growing seed culture and 3000 lux of light intensity was adopted. Without aeration (static) were applied during cultivation.

A two-chamber MFC was applied to investigate the electricity generation potential using anodic anaerobic bacteria and cathodic microalgae microbial fuel cell. The enriched microalgae were cultivated in the cathode at pH 7.5 without aeration from 10% diluted swine wastewater (about 600 mg COD/L). The anaerobic sludge collected from the wastewater treatment plant in a food manufactory was seeded into the anode and cultivated with the sample swine wastewater which was used in the cathode. The MFCs operated in a temperature-controlled room (35°C). The MFC reactor was separated into anode (75 mL) and cathode (75 mL) chambers by an anion exchange membrane (AMI-7000, Membranes International, Ringwood, NJ) and the anion exchange membrane contained two sheets of carbon cloth (3 cm x 5 cm). A fixed external resistance (R) of 100 Ω was connected between the electrodes. The detail cultivation conditions in this study are shown in Table 1.

Table 1. Experimental design

Chamber	Anode	Cathode
Inoculum	Enriched pig manure	Enriched microalgae
Carbon and nutrient source	Swine wastewater 600 mg COD/L	Swine wastewater 600 mg COD/L without aeration
pH	7.5	7.5
Temperature	35°C	35°C

Analytical method

Biomass was determined by measuring the OD of each sample at 680 nm (OD680). The dry cell weights of the diluted samples were then detected and measured for plotting the standard curve. The Standard Methods 15 analytical procedures were used to determine pH and COD [5]. The detail information was presented in our previous study [6].

Result and Discussion

Microalgae isolation

The ten enriched microalgae species (D8-1-1, G29-5, G31-8, O245, Pu10-1, W23-21, W25-381, Y8-1, Z11 and Z16) were cultivated at sterilized and unsterilized swine wastewater with various concentrations (dilution rate of 1, 10 and 100 times) at temperature 30°C and 30 rpm for 7 days. The results show that the G29-5, G31-8, O245, W23-21 and W25-381 strains have higher growth rate with the final OD values of 0.782, 1.067, 1.012, 1.055 and 1.02 respectively from sterilization swine

Keynote Lecture

wastewater (Fig. 1 and Fig. 2). While using unsterilized swine wastewater, G29-5, G31-8, O245, W23-21 and W25-381 strains have higher growth rate with the OD values of 0.767, 0.888, 0.871, 0.774 and 0.723 respectively (Fig. 1 and Fig. 2). Peak growth performance was obtained while cultivating the strains of G29-5, G31-8, O245, W23-21 and W25-381 using 10 times diluted swine wastewater (about 600 mg COD/L) as substrate.

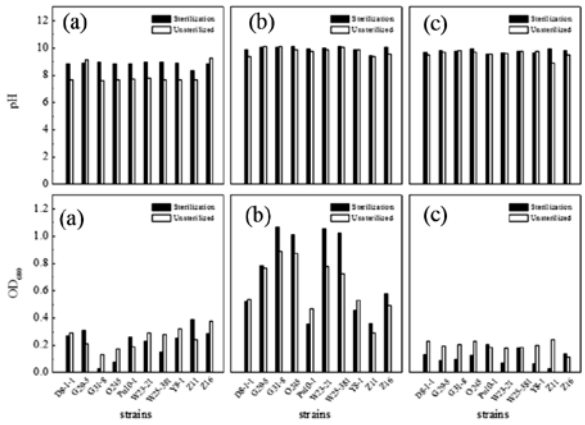

Figure 1 pH variations and microalgae growth performances using sterilized and unsterilized swine wastewater at various dilution times ((a) 0, (b) 10, (c)100)

Sterilization	Sterilized swine WW		Un-sterilized swine WW	
Microalgae	Diluted 5 X	Diluted 10 X	Diluted 5 X	Diluted 10 X
G29-5				
G31-8				
O245				
W23-21				

Figure 2 Photo of microalgae growth performance using sterilized and unsterilized swine wastewater.

Electricity generation in an anodic anaerobic bacteria and cathodic microalgae microbial fuel cell

The enriched microalgae and anaerobic sludge were cultivated in the cathode and anode respectively at pH 7.5 using unsterilized swine wastewater of 600 mg COD/L as substrate. Fig 3 shows the electricity generation using various cathodic microalgae species (G29-5, G31-8, O245, W23-21, and W25-381). Low electricity with peak value ranged from

Keynote Lecture

2 to 8 mV was generated in these anodic anaerobic bacteria and cathodic microalgae MFC. Many reasons might cause the high resistance in the MFC. Capacitance affects the electron transfer capability and related electrolytic proton transfer between the anode and the cathode, which is similar to activation loss. The internal resistance and electronic circuit of MFC are dependent on the anode, cathode, proton exchange membrane, wire, electrolytes, and bacteria in the matrix. High resistance might be occurred because of low activities of anaerobic bacteria and microalgae in this MFC.

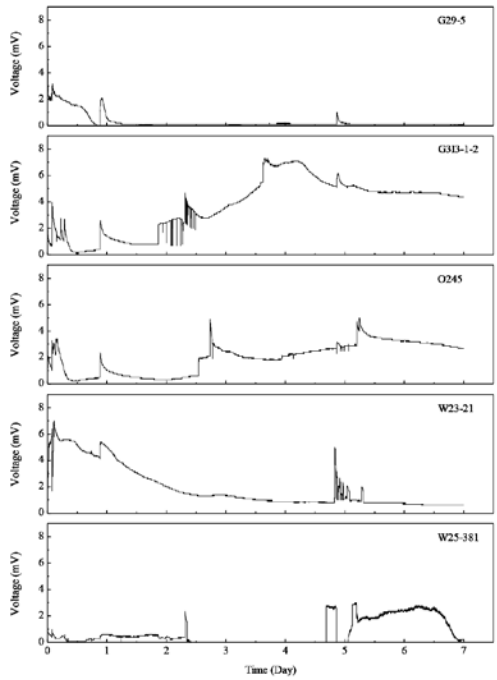

Figure 3 Electricity generation using various cathodic microalgae species.

Conclusions

Then *strains of Chlorella* sp. microalgae could be enriched using swine wastewater with high growth rate. Five of these strains were applied into the anodic chamber in the anodic anaerobic bacteria and cathodic microalgae. The results show low electricity was produced in this MFC. However, further studies on cultivation parameter optimization on pH, nutrient sources, and aeration in anode should be carried out.

Acknowledgements

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Keynote Lecture

KL-05: Continuous Flow Process: A New Paradigm in Materials Syntheses

Anil Kumar

Chemistry Department
Canter for Excellence in Nanoelectronics (CEN)
National Center for Excellence in Technologies for Internal Security (NCETIS)
National Center for Photovoltaic Research and Education (NCPRE)
IIT Bombay
Powai, Mumbai 400076 India

Continuous flow process provides a potential alternative to batch synthesis because of its inherent advantages such as very efficient heat exchange, high batch to batch reproducibility, fast mixing, high throughput, safety, and the ability to do multistep telescoping synthesis. Due to these advantages, these processes have been referred to as the most promising "Green Technology". In fact, continuous flow processes are projected to be the "CHEMICAL FACTORIES" of tomorrow. Continuous flow processes also provide an "On-Demand" synthesis with complete control over reproducibility, size, shape and these parameters can be achieved at various scales (lab synthesis to pilot to bulk production) with excellent reproducibility. This opens up the opportunity for synthetic chemists to prepare materials with precise control over critical molecular design parameters. It also enables one to carry out material synthesis at higher temperatures that were outside the domain of an organic synthetic lab. We have been exploring continuous flow processes for the synthesis of conjugated polymers, nanoparticles and nanofibers, catalysis for heterogeneous processes etc. In this presentation, I will review some of the recent advances in these directions and some results from our laboratory.

Keynote Lecture

KL-07: Design of Sustainable Packaging: some thoughts

Debkumar Chakrabarti
Professor, Department of Design
Indian Institute of Technology Guwahati,
Guwahati 781039, dc@iitg.ernet.in

Abstract

Perception, to a common buyer, of a good design has crossed the boundary of functional reliability for satisfying a need that demands a complete trust. Designing a product, a system must give maximum comfort, efficiency, and safety to its users, taking into account differences in human performance and limitations. Design elements embedded in the packaging should tell about the product usage and anticipates pleasurable utilitarian experience. This deliberation looks into good design elements and concerns that are equally important for good packaging and when these are applied in both the content and the container with proper manner the product gets market, users feel they like it. How people perceive about a good design and what aspects are responsible to? These are universality issues and common perception of good design that conform usability, trust, and sustainability. Packaging itself is a commodity of preference.

Packaging design ideation should balance with characteristics of the product and context of use it is associated with. It demands uniqueness for sustainable existence among varied desirable alternates; how common facilities and different-ness can be made cleaver matching while conceiving design ideation remains a challenge and scope for creative excellence. Design features should relate to the process of acquiring knowledge by the use of reasoning, intuition, and perception. The present discussion focuses on some issues that assist creative vision of conceiving package design and would like designers and manufacturers to explore with care.

Keywords: Design ergonomics, utility and trust, creativity and design ideation

Keynote Lecture

KL-08: Leading the Blueprint for Improved Sustainability in Plastics through Industry Collaboration

Han Zhang

Dow Chemical International Pvt. Ltd., Singapore

Dow is a leader in developing a societal blueprint that integrates public policy solutions, science and technology, and value chain innovation that accelerates our journey towards a more sustainable planet and society. Working collaboratively across our industry, along with ongoing investments and shared knowledge, is key to advancing a circular economy that will result in a more sustainable packaging marketplace and a cleaner, better world. Dow is committed to this important initiative and encourages others to actively support innovations and solutions that can help improve resource efficiency, eliminate waste from industrial processes, and provide the tools and incentives to recover the value of materials we have already created.

Keynote Lecture

KL-09: EnviroESCA™-The Beginning of a New Era

Co-Authors:
Stephan Bahr, Thorsten Kampen, Oliver Schaff, Andreas Thissen

Presenter:
Felix Leyssner (felix.leyssner@specs.com)

Affiliation of all authors:
SPECS Surface Nano Analysis GmbH, Voltastrasse 5, 13355 Berlin, Germany

Abstract:

Since many decades XPS (or ESCA) is the well-accepted standard method for non-destructive chemical analysis of solid surfaces. To fulfill this task existing ESCA tools combine reliable quantitative chemical analysis with comfortable sample handling concepts, integrated into fully automated compact designs.

Over the last years it has been possible to develop XPS systems, that can work far beyond the standard conditions of high or ultrahigh vacuum. Near Ambient Pressure (NAP) XPS has become a fastly growing field in research inspiring many scientist to transfer the method to completely new fields of application. Thus, by crossing the pressure gap, new insights in complicated materials systems have become possible using either synchrotron radiation or laboratory X-ray monochromators as excitation sources under NAP condtions.

Based on this experience SPECS Surface Nano Analysis GmbH has developed a revolutionary tool to realize the long existing dream in many analytical laboratories: reproducible chemical surface analysis under any environmental condition. EnviroESCA™ allows for different applications, like extremely fast solid surface analysis of degassing (but also non-degassing) samples, ESCA analysis of liquids or liquid-solid interfaces, chemical analysis of biological samples, materials and device analysis under working conditions (in situ/in operando studies of catalysts, electrochemical devices etc.).

Discover the new capabilities of EnviroESCA™, a fully automated tool in a new sophisticated and compact design with uncompromising ease-of-use, and explore completely new fields of applications for the established analysis method XPS.

Keynote Lecture

KL-10: Sustainable Materials in the Polymer Industry

Anil K. Bhowmick
Professor of Eminence and INAE Chair Professor
Rubber Technology Center
Indian Institute of Technology, Kharagpur -721302, India.

Abstract

Polymer is one of the most versatile materials having myriad of applications-from niche rubber band and eraser to highly engineered spacecraft seal. Of late, the glittering concept of 'sustainability' has been able to infiltrate within the domain of polymer science and technology to a significant extent-in both academia and industry. This field continues to grow rapidly. Along with polymer, other ingredients that are used to make polymer compounds and products would also be sustainable in future. Sustainable materials may be defined as materials that can be produced without depletion of non-renewable resources and without disturbing the equilibrium between the environment and key natural resource systems. The range of these materials is huge -- from natural rubber , bio-based polymers to recyclable materials etc. The objectives of our research program since the last two decades have been to extract or synthesize polymer and polymer ingredients from natural resources, utilize natural materials in polymer compounds, understand the fundamental science behind new forms of sustainable materials and structure-property relationship, and reduce adverse environmental effects of traditional materials.

In this respect, polymers alternative to hevea brasiliensis have been explored using bio-resources. New polymers having a gradient of polarity have been developed. New materials having dual functionality have been envisaged. The influence of nano- dimensional natural clays, graphene, and silica on the properties of various polymers has been investigated and a few fillers are found to be promising. In order to reduce the environmental hazard of a few polymer chemicals, these are specially activated for use in smaller quantity. New technologies have been developed to utilize waste polymers as sustainable materials. Rubbers have been used in conjunction with plastics for development of recyclable thermoplastic elastomers. In all these areas, structure-property correlation of these sustainable materials would be highlighted.

Keynote Lecture

KL-11: DSC and WAXS Studies on the Effects of Silk Nanocrystals on Crystallization of Poly(L-Lactic Acid)

Amit Kumar Pandey[1], Rahul Patwa[2], Vimal Katiyar[2], Sono Sasaki[1], Shinichi Sakurai[1,*]

[1]Department of Biobased Materials Science, Kyoto Institute of Technology, Kyoto 606-8585, Japan
[2]Department of Chemical Engineering, Indian Institute of Technology Guwahati, India
** Corresponding author, e-mail: shin@kit.ac.jp*
Tel: +81-75-724-7890 Fax: +81-75-724-7547

Introduction

Poly (L-Lactic Acid) (PLLA) is a most frequently used biobased polyester due to its favorable mechanical properties. However, some properties such as slow crystallization rate and low crystallinity restrict its commercial uses. In order to overcome these limitations organic nanofillers can be incorporated into the PLLA matrix. In view of this, the present article has been focused on the non-isothermal cold crystallization behavior of PLLA.

Experimental

PLLA obtained from NatureWorks (code name 2003D) was used as the matrix polymer. SNC used for this investigation was prepared in the laboratory as reported in [1]. PLLA/SNC composites were prepared by melt mixing of PLLA with varying loadings of SNC in co-rotating twin screw extruder.

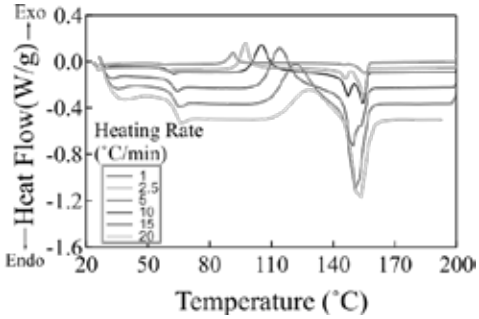

Fig. 1 DSC curves of PLLA/SNC (0.50%) specimen at various heating rates.

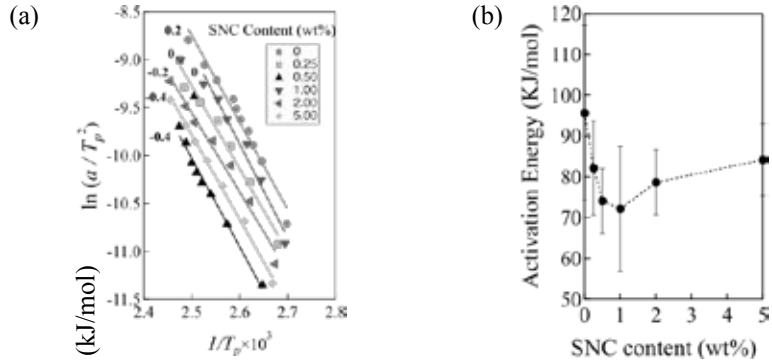

Fig. 2(a) Kissinger plots. In order to avoid overlaps of the plots, each data set is appropriately shifted (the numbers in the graph indicate the extent of the shift according to the ordinate.
(b) Dependence of the activation energy on the SNC content.

Keynote Lecture

Results and Discussion

Fig.1 shows the DSC thermograms for the PLLA/SNC (0.50%) specimen at various heating rates. It can be seen that the exothermic peak shifts to higher temperature with the increase of the heating rate. Kissinger [2] has suggested a method to determine the activation energy (ΔE_a) for diffusion of the polymer chain to the growing surface of the crystallite, by calculating the variation of the crystallization exothermic peak temperature (T_p) with the heating rate (a).

$$\frac{d\left[\ln\left(\frac{a}{T_p^2}\right)\right]}{d\left(\frac{1}{T_p}\right)} = -\frac{\Delta E_a}{R} \qquad (1)$$

Fig. 2(a) shows the plots of ln(a/Tp2) vs 1/Tp (Kissinger plots) and the well yielded linear relationship. The activation energy was calculated from the slopes of the Kissinger plots. Fig. 2(b) shows the dependence of ΔEa on the SNC content. It is found that ΔEa of the SNC loaded PLLA films is lower than that of the neat PLLA. Clearly, the activation energy decreases with small inclusion of SNC (up to 1 wt%) as SNC acted to facilitate the mobilization of PLLA chains. Nevertheless, it was found by the isothermal crystallization DSC measurements at 110˚C that the crystallization rate was decreased with the SNC content (below 2 wt% of the SNC content), as shown in Fig. 3. Thus, the SNC can promote the polymer diffusion but the crystallization rate is decreased. This suggests that the PLLA crystallization is dominated by the polymer chain attachment process on to the growth front of the crystallites.,

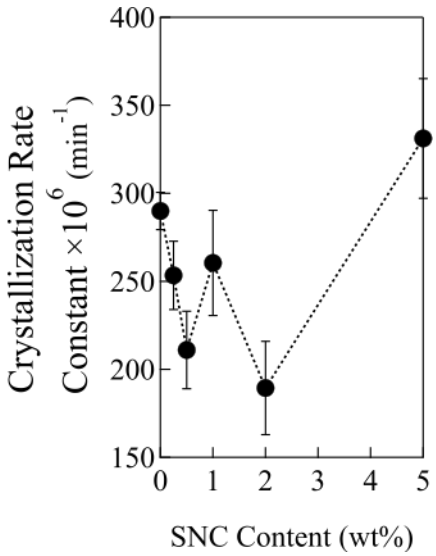

Fig. 3 Plot of the crystallization rate constant (as evaluated by the Avrami analysis based on the DSC isothermal crystallization results.

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Keynote Lecture

KL-12: Sustainable Development of Controlled Drug Delivery and Implants using Biodegradable Polymers

Pralay Maiti, Sunil Kumar, Sudipta Senapati, Arun K. Mahanta, Arpan Biswas, Aparna Shukla

School of Materials Science and Technology, Indian Institute of Technology (BHU), Varanasi 221 005

Email : pmaiti.mst@itbhu.ac.in

Abstract

The challenge remains to design biodegradable alternatives to conventional plastics that combine the mechanical strength and physical properties of the polymer, yet they are susceptible to microbial and/or environmental degradation without adverse effect on the environment. Biodegradable nanohybrids offer the possibility of combining biodegradability with the physical and mechanical properties of polymer typically associated with engineering plastics. Efforts on developing nanohybrids of biodegradable polymer in general with variety of layered nanoparticles emphasizing the processing details and tuned biodegradation will be presented. The effect of polymer intercalation as well as interactions between polymer and nanoparticles on nanostructure and other properties will also be discussed. The application of nanohybrids for its biological use involving animal and clinical studies will be discussed in details with the emphasis of drug delivery and implant materials.

Keynote Lecture

KL-13: Bacterial Cellulose based bioplastic hydrogel film : an exotic and competitive biomaterial for sustainable food packaging

Nabanita Saha*[1], Smarak Bandyopadhyay [1], Petr Saha[1]

[1] Centre of Polymeric Systems, University Institute, Tomas Bata University in Zlin, 76001, Czech Republic

** Corresponding author, e-mail:nabanita@utb.cz*

Abstract: The present study introduces a new generation biodegradable bio plastic hydrogel film for agro food packaging.

A breathable and transparent polyvinylpyrrolidone (PVP)-sodiumcarboxymethylcellulose (CMC)-bacterial cellulose (BC) based hydrogel film is made in response to the environmental problem caused by traditional plastics. The hydrogel film is prepared by solution casting method in a square (25x25cm) plate. The resulting 'PVP-CMC-BC' film is evaluated for enhancing the shelf life of fresh fruits and vegetables. It was evident from the results that 'PVP-CMC-BC' bioplastic hydrogel film can keep table grapes and cherry tomatoes fresh for 30 days without any physiological degradation in their appearance. Thus, 'PVP-CMC-BC' hydrogel films can be considered as an alternative to the conventional plastics

Keywords: *Biomaterial, Bacterial cellulose, PVP-CMC hydrogel, Food packaging, Shelf life.*

Introduction

Sustainable packaging is dignified with improved functional (i.e. product protection, safety, regulatory compliance, etc.) property, cost effective and support long-term human and ecological health. In this respect, biopolymer based biodegradable and breathable food packaging film developed first time by the Czech researcher in 2011, could be a promising food packaging material [1] and meet up certain challenges (raised by environmental pollution created by plastic waste materiasl) to established it as sustainable one. But, Farris et.al (2009) first suggested about this concept i.e. application of biobased polymeric hydrogels in food packaging [2]. Isreal researcher, developed TIPA, a rasin based biodegradable packaging material that automatically "perishs" within 180 days. This innovation provided a 'green' alternative for food and drink industry that still believe on the use of fossil-based plastic [3]. Recently, Penn State researchers also developed a polysaccharide polyelectrolyte complex (carbxymethyl cellulose and chitosan), a new biomaterial which is completely compostable, could replace the use of traditional plastic laminates/eliminate millions of tons of petroleum-based plastic annually [4]. According to an expert from Italian National Research Council, bioplastics may become as competitive as traditional one by early 2020s. It is also pointed out that the on going revolution in packaging is the use of 100% organic materials obtained from the resuduals of agricultural production [5]. It seems development of "Third Generation" of bioplastic is a world wide urge. Hence, effort has been given for the developmnent of bacterial cellulose (BC) based polysaccharide-polyol complex biomaterial: a novel bioplastic was prepared by modifying the existiing polyvinylpyrrolidone-sodiumcarboxymethylcellulose (PVP-CMC) hydrogel film [6-7] and designated as 'PVP-CMC-BC". The paper describe about '*food package prepared with bioplastic hydrogel film'* and its efficiency regarding extension of shelf life of soft & delicate fruits and vegetable (e.g. table grapes and cherry tomatoes).

Methods and Materials

Bacterial Cellulose based bioplastic hydrogel film i.e. 'PVP-CMC-BC' hydrogel film was prepared by solution casting method [6,7]. The polymer solution of 'PVP-CMC-BC' hydrogel film (composition depicted in Table 1) was stirred in sealed glass bottles for 1h and then treated under physical stimulation (120ºC & 15 lbs for 15min). The resulting hot polymer solution (150 ml) was poured into a square (25x25cm) plate and allowed to cool at room temperature (22-25ºC) for 24h. Finally, the food package was prepared by heat sealing using the obtained dry hydrogel film, shown in Figure 1. The performance of the "PVP-CMC-BC" bioplastic hydrogel food package (concerning protection of soft and delicate fruits and vegetables from damage and spoilage) was evaluated by visual observation of their freshness and weight loss. Fresh fruit (table grapes) and vegetables (cerry tomatoes) were examined using above mentioned 'PVP-CMC-BC'

Keynote Lecture

bioplastic hydrogel food package. The effeciency test of this food package was performed at room temperature (20-25 ^{o}C) until 30 days.

Table 1. Composition of 'PVP-CMC-BC' film

Ingradients	Polymer Solution Total: 150 ml
Polyvinylpyrrolidone	0.3gm
CarboxyMethyl Cellulose	1.2gm
Bacterial Cellulose	0.1gm
Polyethelene Gycol	1.5gm
Agar	3.0gm
Glycerin	1.5ml
Water	142.4ml

Result and Discussion

The 'PVP-CMC-BC' bioplastic hydrogel food package is transparent, flexible, breathable, biodegradable as well as sealable [8]. An optical image of 'PVP-CMC-BC' food package prepared with bioplastic hydrogel film is depicted in Figure 1.

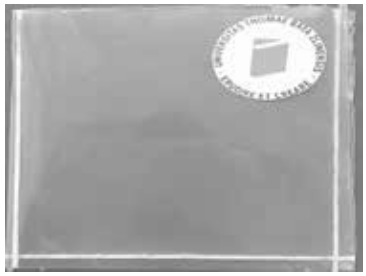

Figure 1 'PVP-CMC-BC' hydrogel food package

Figures 2: represent about the performance of the 'PVP-CMC-BC' hydrogel food package in reference to soft and delicate fruits like 'table grapes' and vegetable like 'cherry tomatoes'. The table grapes (TG) and cherry tomatoes (CT) are selected for performance evaluation of 'PVP-CMC-BC' food package for the following reasons: TG are seedless, with thicker pulp and thinner skins. Moreover, they have less acidity and less sugar compare to wine grapes, more consumable fruits all over the world. On the other hand, CT are juicy, sweet, have thin skins and high water content. Both TG, CT are used regularly by common people during meal and usually store / keep in kitchen at room temperature, hence proper package is essential.

Figure 2 'PVP-CMC-BC' hydrogel food package exibited the shelf life of table grapes and tomatoes

Keynote Lecture

It can be seen from the Figure 2 that both TG and CT are looking quite good in shape until 30 days and protected from early spoilage. This is occured due to in built properties of hydrogel film i.e. 'PVP-CMC-BC' bioplastic package. It is porous in nature which allows to diffuse the residual moisture, generated within the food package due to ocurance of mild respiration within living cells of TG and CT [8]. The invisible crosslinked polymeric structure oriented hydrogel food package protect them from early spoilage and extend the shelf life of these soft and delicate fruits and vegetables. Moreover, the transparent feature of 'PVP-CMC-BC' bioplastic hydrogel film is an advantage to identify the condition of TG and CT without opening the food package.

Conclusions

In conclusion, it can be mentioned as follows:

- The 'PVP-CMC-BC' hydrogel film is a less expensive bioplastic. The composition of the said hydrogel mainly consisted with *polysaccharides* (carboxymethylcellulose, agar and bacterial cellulose which are biopolymer/ biodegradable) and *polyols* (polyvinylpyrrolidone and polyethelenegycol) for its development as one of the nature based *polysaccharide-polyol complex* biomaterial.
- Preparation method of the 'PVP-CMC-BC' hydrogel food package is also inexpensive; as the hydrogel film was prepared by solution casting method where, the polymer solution consisted with water soluble (PVP, PEG, CMC, Agar) and water holding (BC) polymers were treated under physical stimulation (120ºC & 15 lbs for 15min) for the development of a true pseudo-hydrogel having *polysaccharide-polyol complex* within the novel biomaterial.
- Finally, based on its performance in protection of (fresh-soft-delicate fruits and vegetable like: 'table grapes' and 'cherry tomatoes') the 'PVP-CMC-BC' bioplastic hydrogel food package can be recommended as an exotic and competitive biomaterial over the conventional plastic as a sustainable food package.

Acknowledgements

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Keynote Lecture

KL-14: Sustainable polymeric nanocomposites for multifaceted advanced applications

Niranjan Karak

Advanced Polymer & Nanomaterial Laboratory,
Center for Polymer Science and Technology, Department of Chemical Sciences,
Tezpur University, Tezpur 784028, Assam, India

Abstract

The requirements for sustainable polymeric products with high performance are increasing progressively due to ever increasing trend of world population with sophistication and comfort in human life in one end, while depletion of fossil fuel reserves, global warming and environmental issues on other side. Thus the scientists have tried to exploit the naturally renewable bio-resources as the feed stocks for the development of their products for different modern applications. In this milieu, naturally renewable resource-based three dimensional hyperbranched polymers are growing tremendously because of their promising and useful attributes over their synthetic conventional analogs. So, a few industrially important bio-based hyperbranched polymers such as polyurethane, polyester, poly(ester-amide) and epoxy have been developed over the last two decades from Advanced Polymer and Nanomaterial Laboratory of Tezpur University. These novel hyperbranched polymers have been synthesized by using mainly $A_x + B_y$ (x, y $\geq$2) approach with or without solvent to follow the dictates of 'Green Chemistry'. The approach also tries to achieve high 'carbon credit' and maintains the concept of 'triple bottom line'. But, 'virginity is not virtue' in case of polymers is a well-known fact and the conventional filled or composite systems are inappropriate to improve the performance of such bio-based polymers and to meet the service demands of advanced applications. Thus nanotechnology, the most attractive technique in recent times is adopted to develop a variety of nanocomposites of the above sustainable polymers with almost all types of nanomaterials from zero to two including one dimensional. The developed nanocomposites showed significant improvement of almost all desired properties including mechanical, thermal, chemical, biological, optical, electrical, catalytic, etc. along with special properties like antimicrobial, antistatic, fluorescent, shape memory, self-healing, self-cleaning, biocompatibility, etc.; depending on the nature, state of dispersion and interfacial interactions of the nanomaterials in such systems. Brief overview of all such materials including their applications from advanced air cleaning paints to injectable bone tissue scaffold including smart materials will be discussed in this international symposium. The talk will surely address the sustainability issue of the materials in the context of current demands.

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Keynote Lecture

KL-15: Block Copolymers Functionalized Carbon Nanotubes and their Sensing Applications

Kailash C. Gupta

Polymer Research Laboratory, Department of Chemistry,

Indian Institute of Technology Rookee, 247 667 India

Email: guptakc03@yahoo.co.in, Tel: + 91 1332 285325, Fax: + 91 1332 73560

Controlled methods of polymerization have played a significant role in controlling the properties of polymers by controlling their molecular weight and conformations. To obtain block copolymer of controlled size and distribution, consecutive methods of copolymerization are used frequently but these methods have shown deviations when monomers found to be inactive and polymerized using conventional methods of radical polymerization. To overcome these problems, atom transfer radical polymerization has been used to functionalize carbon nanotubes using binary mixture of N-alkylacrylamide and acrylic acid monomers at fixed and variable feed composition. The reactivity of N-alkylacrylamide for graft copolymerization on carbon nanotubes is found to be low but shown significant improvement in presence of acrylic acid as comonomer. The synergistic effect of acrylic acid is found to be useful in controlling the activity of N-alkylacrylamide and also helped in controlling the block size of grafted copolymer. The controlled method of graft copolymerization of N-alkylacrylamide and acrylic acid has produced monodispered graft copolymers at fixed feed molarity and retained monomer-monomer interactions during graft copolymerization. The composition of grafted copolymer on carbon nanotubes is found to vary significantly on varying the mole fraction of N-alkylacrylamide in comparison to mole fraction of acrylic acid in reaction mixture. The role of monomer-monomer interactions and ATRP catalyst has been studied in detail to control the block size and composition of grafted chains on carbon nanotubes. The block copolymer modified carbon nanotubes were characterized for phase transition temperature as a function of composition and conformation of grafted copolymers. The block copolymer modified carbon nanotubes are found to be useful in controlling the selectivity and sensitivity of glassy carbon electrode for detection of biomolecule in presence of other interfering species. The role of cyanocopolymer modified carbon nanotubes in detection of metal ions would also be discussed to provide structure property relationship between polymers and analytes.

Keynote Lecture

KL-16: Effect of water on the mechanical properties of DNA-derived films

Takashi AOKI* and Hidetaka MAKINO
Kyoto Institute of Technology, Kyoto 606-8585, Japan
* Corresponding author, e-mail:t-aoki@kit.ac.jp

Introduction

Plant, insect, and mammalian cells contain genomic deoxyribonucleic acid (DNA) molecules with their characteristic nucleobase sequences to transcript and transfer to amino acid sequences of all proteins required for homeostasis. It is biologically important and essential for genetic information. On the other hand, DNA can be considered to be abundant bio-mass on the face of the earth, since the bodies of all living creatures are constructed with a large number of cells and the genomic DNA is packed into each cell one by one. Accordingly, the biomacromolecules will be industrially important as natural resources like cellulose and chitin/chitosan. To investigate a mechanical property of DNA films and fibers is of interest from the standpoint of novel biobased materials.

DNAs have their unique structures with three inherent constitutions: a phosphate group, a sugar ring, and a nitrogen-containing heterocyclic base. The bases, which are purine derivatives (adenine and guanine) and pyrimidine derivatives (cytosine and thymine), function as hydrogen-bonded donor and acceptor moieties between the polynucleotide and its complementary chain to form double helix structures. However, as the double-stranded DNA molecules are soluble or swollen in water due to the anionic form of phosphodiester bonds on the outer surfaces of the double-stranded structures, the mechanical properties of the films and fibers are remarkably changeable due to water circumstances. They show an elastic property in response to humidity changes [1-3].

In order to obtain stable films derived from DNA, a DNA-cationic surfactant ion complex between anionic DNA and a cationic alkyl compound, tetradecyl- trimethylammonium (TDTMA) chloride was prepared. The DNA ion complexes are insoluble in water and soluble in some organic solvents. We obtained their films by a solvent-casting method and investigated the mechanical property of the films under conditions where temperature and relative humidity were controlled.

Methods and Materials

Fiber-like DNA sodium salts (NaDNA) from salmon sperm and TDTMA (Tokyo Chemical Industry Co., Ltd., Tokyo, Japan) were used without further purification. NaDNA was dissolved in distilled water with stirring gently overnight at room temperature. To an aqueous DNA solution, aqueous TDTMA solution was added dropwise overnight at room temperature. A white precipitate was formed immediately in the mixed solution. The precipitate of DNA-TDTMA ion complexes was collected by filtration, washed with distilled water, and then dried in a vacuum to obtain as a powder. The powder was dissolved in ethanol with stirring gently for one day at room temperature. The solution was poured onto a Teflon plate and left on a lab-bench overnight to prepare transparent and free-standing films, which were peeled off readily from the plate. Stress-strain curves were obtained using SHIMADZU AG-X plus HS (Kyoto, Japan). ATR-FT-IR spectra of the films were collected by 32 scans at a resolution of 4.0 cm^{-1} using a Spectrum GX (Perkin Elmer, Waltham, MA).

Keynote Lecture

Result and Discussion

The stress-strain curves of the DNA-TDTMA as-cast films were obtained at 25˚C under various relative humidity (RH) conditions. The tensile moduli of the films were 500, 182, and 59 MPa under 35, 55, and 75 %RH, respectively: the values decreased with the increasing RH. A DNA film without any cationic surfactants showed the similar tendency of tensile modulus changes against RH, and then it was reasonable that the modulus of the DNA-TDTMA films were generated from that of the DNA molecule itself in the complex films. On the contrary, the increase of stress after yield point was observed in the DNA-TDTMA films, while DNA films did not exhibit elongation. The elongation after the yield points might be due to the entanglement of alkyl chains of the TDTMA electrostaically bound to DNA. Interestingly, the DNA and DNA-TDTMA films show almost same water adsorption behavior based on BET isotherm, while the anionic groups of DNA were consumed by the cationic moieties of TDTMA in the DNA-TDTMA films. In both films, some other polar groups than the anionic groups are found to work as water-binding sites. FT-IR spectra in the regions for the nucleobases slightly shifted to higher wavenumbers in response to the humidity changes. When water molecules interact with polar N-H and C=O groups which do not participate in the base pair formation and expose to major and minor groove spaces, the hydrogen-bonded interaction between the base pairs in double stranded DNA moderately weaken to bring about flexibility of the films. The water modulated brittle-elastic alterations for DNA will be reported in terms of the role of the polar moieties such as the bases on the mechanical properties.

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Keynote Lecture

KL-17: Sustainable Polyolefin Materials and its Technology: Directions for Designed Polyolefins for 3D Printing Technology

Virendra Kumar Gupta

Reliance Research and Development Centre, Reliance Industries Limited, Reliance Corporate Park, Navi Mumbai 400 701 India

Email: Virendrakumar.gupta@ril.com; Mobile: +919998965284

Abstract

Polyethylene and Polypropylene are first two highest produced synthetic plastics materials among different class of polymers. Exponential growth is linked to continuous advancement in technology and tailoring of product characteristics for different applications since discovery of Ziegler-Natta catalysts in 1950,s. This could be possible due to high growth in automobile, infrastructure, packaging and other sectors.

3D printing technology is emerging as frontier among new technologies for novel and designed product applications. Polyolefin have high potential as choice of material due to the possibility of broad range of properties achievable for specific application through synthesis of specialty polyolefin involving homo and copolymerization processes catalyzed by transition metals. Through The present talk presents the development of specialty polyolefin based on homo and copolymers of ethylene as well as propylene using Reliance proprietary RELCAT™ catalyst technology, control of different product characteristics such as molecular weight, thermal, rheological etc. Designed PO can be used for 3D printing technology based on Fused Deposition Methodology (FDM) and Selective Laser Sintering (SLS).

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Keynote Lecture

KL-18: CO_2 Separation by Different Facilitated Transport Polymer Membranes from Binary and Ternary Gas Mixtures by

Bishnupada Mandal

***Other contributors*:** Babul Prasad, Rajashree Borgohain and Mridusmita Barooah

Department of Chemical Engineering, Indian Institute of Technology Guwahati, Guwahati 781039, Assam, India.

Abstract

The research quest in carbon dioxide (CO_2) separation technology through the polymeric membrane is intensive at this time of energy and environmental crisis. But the pursuit of membranes with high selectivity and flux without trading it off for stability still exists as a challenge. We report a novel membrane prepared by rational blending of two biopolymers: chitosan (CS) that acts as a matrix and silk fibroin (SF) that aids chitosan as a carrier for facilitated transport. The separation of binary gas mixture (CO_2/N_2) have been studied at temperature, feed absolute pressure and sweep water flow rate ranging from 60-120 °C, 2- 5.93 bar and 0.01-0.07 ml/min, respectively. The optimum CO_2 permeance of 140 GPU and CO_2/N_2 selectivity of 103 for binary gas were observed at 90 °C and 0.05 ml/min of sweep water flow rate for the membrane. The membrane exhibited CO_2 permeance of 123 GPU and selectivity of 93 and 60 for CO_2/N_2 and CO_2/H_2 respectively, in case of ternary gas mixtures ($CO_2/N_2/H_2$) at the similar operating conditions.

Chitosan is soluble in acidic conditions which leads to protonation of amine group present in it. This can be overcome by modifying chitosan into carboxymethyl chitosan (CMCS) which is water soluble and amine groups are remains active. The confirmation of CMCS is validated by FTIR, NMR, XRD, FESEM and TGA. To increase the concentration of amine group, CMCS has been blended with other amine like piperazine for CO_2 separation from CO_2/N_2 gas mixture. Also the gas permeation study ensures that the proposed modified chitosan membrane can be a potential candidate for flue gas separation.

Another approach for CO_2 separation is achieved by facilitated transport CO_2 by mixed matrix membranes (MMMs). These advanced CO_2-selective membrane materials were developed by embedding silica nanoparticles at different loading into the poly (vinyl alcohol) (PVA)/polyethylene glycol (PEG) matrix using solution casting. In situ sol-gel technique was applied for the synthesis of the hydrophilic SiO_2 nanoparticles. FESEM analysis of the synthesised MMMs confirmed the homogeneous dispersion of the fillers in the polymer matrix. Owing to its good compatibility with PVA/PEG matrix, the inclusion of fillers significantly increased the overall separation efficiency of CO_2 within the membrane. Because of the strong interaction between the polymer matrix and silica filler, the synthesized MMMs exhibited excellent thermal and transport properties for gas separation.

Keynote Lecture

KL-19: Engineering of Biopolymers for Smart Healthcare

Bhuvanesh Gupta, Sadiya Anjum and Surabhi Singh

Bioengineering Laboratory, Department of Textile Technology,
Indian Institute of Technology, New Delhi-110016, India.
Email: bgupta@textile.iitd.ernet.in

Abstract

Hydrogels and hydrocolloids have been an advantage to human healthcare due to their very innovative and beneficial life support features. Hydrogels have excellent biocompatibility, hydrophilicity, processability and sometimes they are bioactive in nature as well. A series of hydrogels based on biopolymers, such as chitosan, pectin and dextran have shown enormous potential in wound care system. These hydrogels may be combined with appropriate ingredients to develop a system which would offer optimum healing to the wound. Herbal bioactive agents have been used for this application. However, the development of such materials requires a close collaboration between medicine, microbiology and materials chemistry.

The development of polymers with bioactive coating is an important area of research focused on solving the problem of contamination by infection in wound care systems. We have observed that a bioactive component may be incorporated within the hydrogel matrix to make it infection resistant. Herbal drugs and essential oils have been incorporated into either natural hydrogels like chitosan, pectin and dextran by blending approach. A wide range of natural bioactive agents such as aloe vera, curcumin, sandal wood oil, clove oil and honey are available to develop excellent materials for wound care. These dressings have been evaluated in wound healing using mouse as the animal model. Excellent healing with minimum scar by hydrogel dressings has been observed.

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Keynote Lecture

KL-20: Technology to Product-Why scientists must solve real world problems

Prashant Jha

Fellowship Director, Biodesign School, AIIMS and IIT Delhi, New Delhi.

As researchers and scientists, we develop technologies after painstaking and expensive research. But what happens to the technology after we have published or patented? Our work must go back to the society as a useful product. I would use examples form my experiences across the world in using technologies for problem solving-from my domain of medical device development.

We use trans-disciplinary knowledge across chemical engineering, computer science, mechanical engineering, polymer and textile engineering to solve unmet clinical needs. In my talk I would be talking about my experiences in developing medical devices for the global needs. I look forward to a wonderful conversation.

Keynote Lecture

KL-21: Effect of the block length on the physical and structural properties of the multi-stereoblock poly (lactic-acid)s

Hideki YAMANE*, Yohanes Windu WIDHIANTO, Masaki YAMAMOTO, Kazunari MASUTANI, Yoshiharu KIMURA

Kyoto Institute of Technology, Kyoto 606-8585, Japan
* Corresponding author, e-mail:hyamane@kit.ac.jp

Introduction

A major obstacle to the practical applications of poly(lactic acid) is a low melting point of its homo-chiral crystal (hc). The fundamental solution to this problem may be a utilization of the stereocomplex (sc) which forms in the equal blend of poly(*L*-lactic acid) (PLLA) and poly(*D*-lactic acid) (PDLA). However, both hc and sc tend to co-exist in the simple blend of PLLA and PDLA. On the other hand, only sc tends to form in the block copolymers of L- and D-lactic acids. In the present study, multi-stereoblock-PLAs (multi-sb-PLAs) with various block lengths were synthesized. The effects of block length and the total molecular weight of multi-sb-PLA on the thermal property and the crystallization behavior were determined.

Methods and Materials

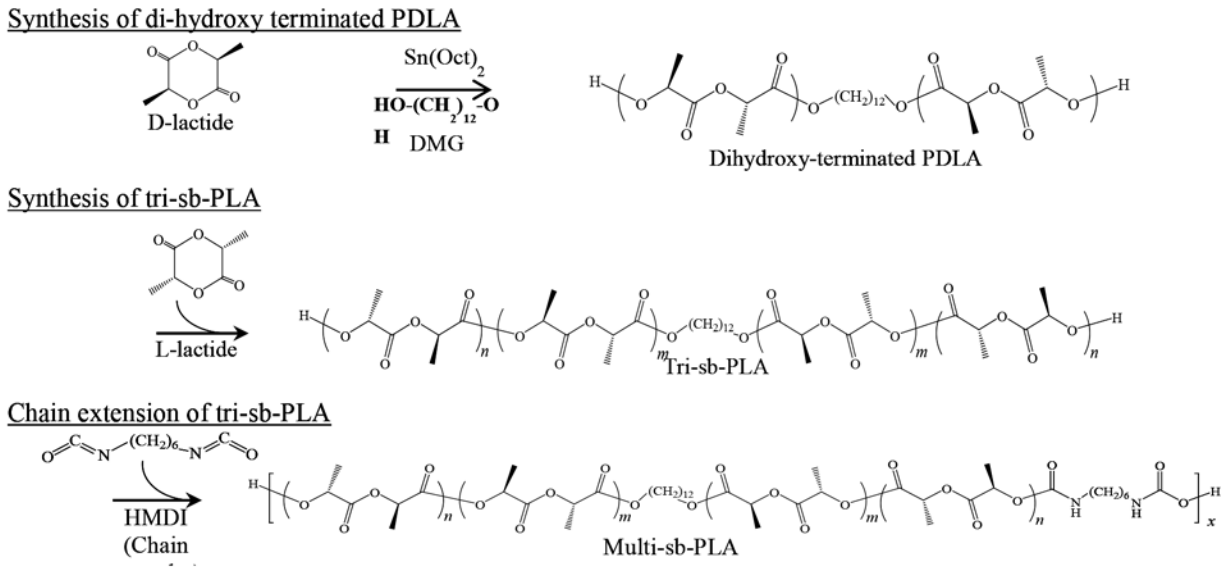
The PDLA prepolymer with Mn = 2500, 5,000, 10,000 and 20,000 were synthesized by the ring-opening polymerization (ROP) of D-lactide using dodecamethlene glycol (DMG) as an initiator. Then tri-sb-PLAs were synthesized by ROP of L-lactide using PDLA prepolymers as macro-initiators. Further the chain extension reaction was performed for these tri-sb-PLAs to obtain multi-sb-PLAs with various block lengths using a hexamethylene diisocyanate (HMDI) as a chain extender. The multi-sb-PLAs with the molecular weights 60,000 and 130,000 were synthesized.

Result and Discussion

DSC analyses revealed that T_g increases with the increase in the block length and the multi-sb-PLA with a lower molecular weight has higher T_g at a constant block length. These are attributable to the higher concentration of DMG and HMDI in the multi-sb-PLA with a shorter block. These multi-sb-PLAs showed only a melting exotherm of sc. T_m increases with the increase in the block length and the molecular weight of multi-sb-PLA. The variation of T_m seems to be attributable to change in the lateral dimension of lamella rather than that of the thickness. T_c in the heating process from the amorphous solid decreases and that in the cooling process from the melt increases with the increase in the block length, indicating that the multi-sb-PLA with a long block has a wider temperature range of the crystallization.

Observation of isothermal crystallization behavior revealed that the multi-sb-PLA with longer blocks and higher molecular weights started the crystallization at a lower temperature within a shorter period of time in a wider temperature range. The crystallization rate increases with increasing block length and the multi-sb-PLA with a longer blocks achieves higher degree of crystal. The multi-sb-PLA with a higher molecular weight forms more complete structure of the spherulite than that with a low molecular weight. Annealing of the amorphous multi-sb-PLA produced sc with two different lamellar thicknesses. One which melts at a higher temperature is a main sc phase with a lamellar thickness merely determined by the block length and the molecular weight regardless of the thermal history. The chains in the amorphous region only crystallized upon annealing and gradually grew with increasing annealing temperature giving some addition to the lamellar thickness of the samples detected by SAXS.

Keynote Lecture



Keynote Lecture

KL-22: Electrical functions expressed via orientation control by mechanical processing of cellulose derivatives

Yoshikuni Teramoto[1,2]

Department of Applied Life Science, Faculty of Applied Biological Sciences,
Gifu University, Gifu 501-1193, Japan
Center for Highly Advanced Integration of Nano and Life Sciences (G-CHAIN),
Gifu University, Gifu 501-1193, Japan e-mail: teramoto@gifu-u.ac.jp

Abstract: This study offers a concept of material functionalization for cellulose derivatives via chemical modification followed by orientation control. Namely, we improved the dielectric properties of cyanoethyl cellulose (CyEC) by a combination of esterification and uniaxial heat-stretching. To this end, we prepared CyEC ester derivatives (C*m*-CyEC: *m* = 3, 4, 5, 8, 12 and 18; *m* is the carbon number of the side chain) with almost no residual hydroxyl groups from CyEC (degree of cyanoethyl substitution = 2.54) in a homogeneous system. Cast films were stretched at temperatures close to the glass transition temperature (T_g) (~150 °C), and different manners of orientation between the original CyEC and C18-CyEC were confirmed by IR dichroism, wide-angle X-ray diffraction and birefringence measurements. The dielectric constant for as-cast films monotonically decreased with an increase in *m*. The constants of the drawn CyEC films also decreased with increasing percent elongation (γ), but those of the C18-CyEC films increased with increasing γ. Such contradictory behaviour may be attributed to a local segmental orientation, which greatly increased the sum of the dipole moments of carbonyl and cyano moieties for C18-CyEC.

Keywords: *Cyanoethyl cellulose; Esterification; Dielectric dynamics; Orientation*

Introduction

A current trend for studies on cellulose derivatives involves relating their microscopic structure to the performances of their bulk materials. For instance, birefringence compensation between the oriented trunk and graft chains can remove the overall birefringence substantially [1].

The present study focuses on the material functionalisation of industrially available cyanoethyl cellulose (CyEC), attainable by combining (1) esterification with (2) molecular and local segmental orientation induced by a uniaxial stretching process. We presumed that esterification would transform the originally high-crystalline CyEC into a less crystalline material and that the increased mobility of the molecular chain segments (with polarised cyano groups) would increase the dielectric constant. In addition, we assumed that uniaxial stretching would cause orientations of overall molecules and local segments, thereby increasing the sum of the dipole moments. We demonstrate a concept of improving dielectric constant via esterification followed by orientation control.

Methods and Materials

Esterified products (C*m*-CyEC; *m* is the carbon number (3, 4, 5, 8, 12 and 18) of the ester substituents) were prepared from commercially available CyEC (DS = 2.54). Esterification to residual hydroxyl group proceeded almost completely, and the total DS (cyanoethyl + ester) of the products was ~3. The esterified products were provided for solution casting and thus obtained films were thermally stretched (γ denotes %elongation). The samples were examined by DSC, TGA, XRD, IR dichroism, birefringence, and dielectric relaxation.

Result and Discussion

As the ester side chain length (*m*) changes, the derivatives show complicated variations in thermal transition behavior and phase structure. C18-CyEC exhibited not only short-range layered hexagonally packed structure of the CyEC chains but also mesomorphic (medium-range) hexagonally ordered structure composed of the cellulosic trunks having long side chains. The derivatives were not amorphized unless long ester side chains are introduced.

Keynote Lecture

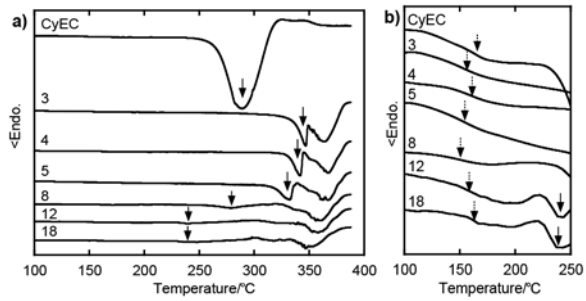


Figure 1 DSC thermograms of CyEC and its ester derivatives in the first heating. Numerals denote the carbon number *m* of ester side chains. Melting points of samples are indicated by solid arrows in (a). Panel (b) presents enlarged thermograms around T_g (indicated by broken arrows).

To enforce an orientation state, the as-cast films were uniaxially stretched at a temperature where their respective glass transitions began to start. The bulky ester side-chains of $m \geq 8$ improve the ductility and thermoplasticity of CyEC.

We compared some effects of the thermal drawing (at the onset T_g) of film on the developments of orientation and higher-order structure therein between the original

CyEC and the derivative C18-CyEC with the bulkiest side chains.

For CyEC, orientation index f_c measured by WAXDreached ~0.6 and leveled off at $\gamma \approx 20\%$; the high orientation capability may be due to not only its crystallite orientation but also intermolecular interactions through the high polar cyano groups. On the other hand, f_c increased more gradually with γ towards a higher maximum than that for CyEC. These results confirm that esterification with higher fatty acids can improve the molecular orientation of CyEC.

IR dichroism revealed that order parameter f_ϕ of C≡N rapidly increased with γ for CyEC whereas that increased more gradualy for C18-CyEC. The f_ϕ of C=O, meanwhile, was negative, indicating that the C=O groups were oriented vertically to the draw direction. these data support parallel alignment of the alkane chains of the ester moiety and the cellulosic main chain.

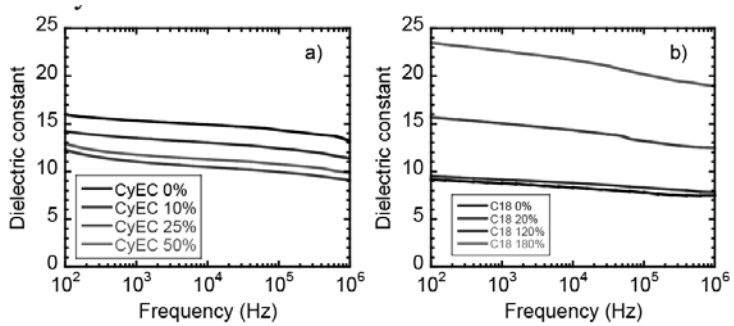


Figure 2 Dielectric constants measured for (a) CyEC and (b) C18-CyEC films with different γ values. Frequency was increased from 100 Hz to 1 MHz at 25 °C.

For dielectric properties, possible influence factors are polarity and activity of the dipoles. The esterification introduced an additional polar group C=O. However, for as-cast films, the increased dipole numbers were virtually insufficient to improve the dielectric constant because non-polar alkane chains as shield were concurrently combined. On the other hand, the dipolar orientation induced by stretching polymer medium reduced the overall dielectric performance in the use of CyEC and improved it in C18-CyEC. That is, the film extension exerted negative and positive effects on the dielectric constants of CyEC and C18-CyEC, respectively. Reasonable explanations for these dielectric behaviours are suggested below:

Keynote Lecture

(a) During stretching, the chains in the amorphous region of CyEC are transformed from a random loose structure to a regular crystalline arrangement. Therefore, by the uniaxial molecular orientation and accompanying crystallisation, the polarity of the C≡N dipoles would be counterbalanced between the neighbouring molecular chains. These two consecutive alterations into a higher-order structure should serve to decrease the dielectric constant.

(b) In the C18-CyEC as-cast films, the mobilities of the C≡N dipoles would be limited by steric hindrance of the bulky ester side chains. Consequently, the dielectric constant was lower in the as-cast C18-CyEC film than in the cast CyEC one. However, under stretching, the fatty acid side chain became aligned parallel to the cellulosic main chain, increasing the active spheres of both the C≡N and C=O dipoles. This rearrangement following the film extension could serve to improve the dielectric constant. In this derivative, however, there was no crystalline development in the drawing process, and, therefore, the inherent spacer effect of the fatty acid side chains on the activity of dipoles still remained, preventing counterbalancing of C≡N dipoles between the neighbouring chains.

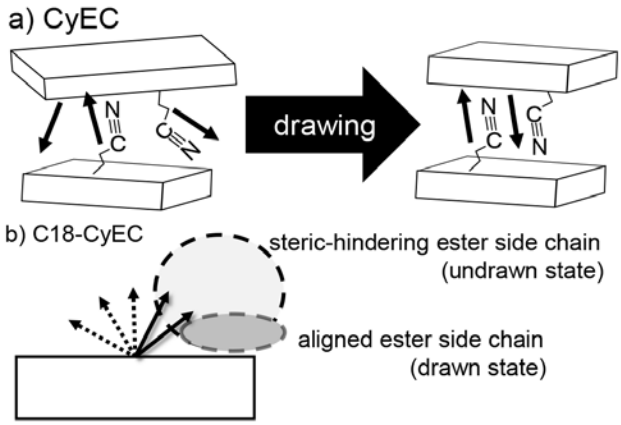


Figure 3 Schematics of dipole moment movements: a) CyEC *per se*; b) C18-CyEC. Arrows indicate dipole moments. Flat plates indicate cellulosic main chains.

Conclusions

To improve the dielectric property of CyEC (DS = 2.54), we esterified the residual hydroxyl groups and performed thermal processing by stretching the film specimens. Thermal drawing induced larger-sized crystallite and local segmental orientations in CyEC and the latter in C18-CyEC, respectively. The local segmental orientation greatly enhanced the dielectric property of C18-CyEC by increasing the active spheres of the polarised carbonyl and cyano moieties. According to our results, the mobility of the dipoles strongly depends on the molecular aggregation structures mediated by crystalline and non-crystalline orientations. This study offers a new method of designing an electrically functionalised cellulosic material from an industrially available one, namely, by using mild chemical modification followed by thermal processing [2].

Acknowledgements

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KL-23: A microcosm emergy applied in microbial fuel cells systems: the synergy of energy power generating and wastewater treatment for energy-nutrients-water nexus

Wei-Shyang Wang[a],Ching-Tsang Wang[b*](王金燦), Fuh-Sheng Shieu[a*]

[a] Department of Materials Science and Engineering,
National Chung Hsing University, Taichung 40227, Taiwan
[b] Department of Mechanical and Electro-Mechanical Engineering,
National I Lan University, I Lan, Taiwan
*Corresponding author: E-mail:ctwang@niu.edu.tw; fsshieu@dragon.nchu.edu.tw;
Fax: +886-4-2285-7017

Abstract

The natural resources are rare and the environmental pollutions are serious today. The wastewater treatment process should make the effluent satisfy environmental discharge criteria and reuse the wastewater for other applications. There are many methods and procedures to improve the economic and environmental performances of the wastewater treatments. The process can be improved by adding energy and material recovery to reduce the amount of emissions that be delivered to environment. Utilizing the MFCs in the wastewater treatment process can use more emergy in wastewater to make the process efficient and come to energy conservation. The reuse of wastewater by MFCs can simultaneously raise environmental and economic performances of the wastewater treatment plant. Increasing the number and efficiency of MFCs in the treatment will raise the energy recycle percent of treatment process and reach the water discharge criteria more easily. MFCs in the wastewater treatment are friendly and sustainable to the environment and will be a novel application to the sustainability of the ecosystems.

Keynote Lecture

KL-24: Using Carbon Dioxide (CO_2) as the Sole Driver for Low-Energy Desalination and Decontamination of Impaired Water Sources

Arup K. SenGupta, P.C.Rossin Professor
Department of Civil and Environmental Engineering
Department of Chemical Engineering
Lehigh University, Bethlehem, USA
e-mail id: arup.sengupta@lehigh.edu

Abstract

Increased population and gradual decrease in fresh water supply are propelling societies globally to produce potable and industrial water supply from impaired sources including treated municipal wastewater. As part of their groundwater replenishment system, Orange County Water District in California treats municipal wastewater with total dissolved solids (TDS) of 600 mg/L prior to pumping it into recharge basins and seawater intrusion barriers. For high recovery, reverse osmosis or RO is used and the process is understandably energy intensive. Many groundwater sources around the world are now contaminated with nitrate and brackish. We have developed a hybrid ion exchange process that is capable of using carbon dioxide as the primary source to remove nitrate and desalinate the groundwater without RO or use of any major chemicals. The process utilizes unique acid-base chemistry of CO_2 where it can serve as both an acid and a base. Ion exchange resins are uniquely designed to overcome intra-particle diffusion resistance and recover nitrate. From a sustainability viewpoint, the process does not produce any secondary waste and consumes miniscule energy compared to RO processes.

Keynote Lecture

KL-25: Ionic Liquids in Polymer Synthesis; A Sustainable Process

Nikhil K. Singha
Rubber Technology Centre
IIT Kharagpur Kharagpur 721302, INDIA

Ionic liquid (IL) is an important class of materials which have an organic cation and an inorganic anion. Most of the ILs are liquid at ambient temperature and are non-toxic in nature. They have low to zero vapor pressure and high thermal stability. They have several advantages over conventional solvents and are considered as 'green' solvents. In polymer science, they are used as solvents for polymerization as well as an additive in polymer processing. In this case, IL was used as the solvent for the polymerization of different acrylates via RAFT process, a method of controlled radical polymerization. RAFT polymerization in IL was remarkably fast. The IL was successfully recovered and reused. Interestingly, IL was used as an additive for the synthesis of specialty polyurethane having interesting properties. This talk will delineate the use of IL in RAFT polymerization of acrylates as well as in polyurethane synthesis.

Keynote Lecture

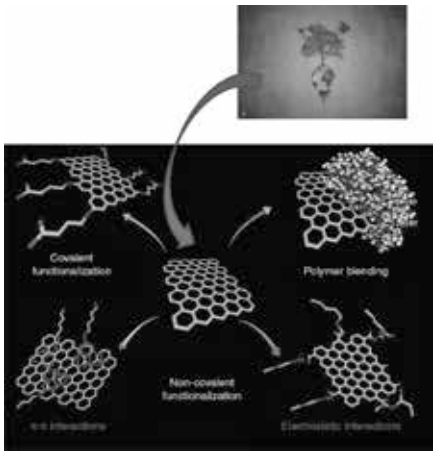
KL-26: Graphene Nanocomposites: creating a sustainable polymer framework

Dr. Sandip Ghosh and Dr. Sumitesh Das
Graphene Business, Tata Steel Ltd.

Carbon-based structures are the most versatile materials used in the modern field of renewable energy and environmental science. However, there is a need and a desire to develop increasingly more sustainable variants of classical carbon materials (e.g., activated carbons, carbon nanotubes, carbon aerogels, etc.), particularly when the whole life cycle is considered (i.e., from precursor "cradle" to "green" manufacturing and the product end-of-life "grave"). Utilization of natural, abundant and more renewable precursors, coupled with simpler, lower energy synthetic processes which can contribute in part to the reduction in greenhouse gas emissions or the use of toxic elements, can be considered as crucial parameters in the development of sustainable materials manufacturing.

Recent sustainable advancement in carbon nanotechnology has further broadened the scope of application of carbon based materials, especially graphene based polymer nanocomposites, in emerging applications. The 'green' nanocomposites that is the subject of investigation in this project are classified as 'sustainable' materials because they are: recyclable, stable in use but can be 'triggered' to biodegrade under composting conditions and environmentally benign. Graphene has been regarded as the next-generation carbon nano-filler for polymer nanocomposites. Owing to its superior physical properties, it produces a dramatic improvement in properties of polymers at very low filler loadings. Graphene has a myriad of unprecedented attributes, any number of which could potentially be used to make extraordinary composites. The presence of graphene can enhance the conductivity and strength of bulk materials and help create composites with superior qualities. Graphene can also be added to metals, polymers and ceramics to create composites that are conductive and resistant to heat and pressure.

Graphene composites have many potential applications, with much research going on to create unique and innovative materials. The applications seem endless, as on one hand-a graphene-polymer composite is light weight, flexible and is an excellent electrical conductor, while on the other hand-dioxide-graphene composite was found to be capable of increased photocatalytic efficiencies. There are many other possible material couplings viz. medical implants, engineering materials for aerospace, renewables which can possibly compliment the challenges facing sustainable polymers include obtaining physical properties (such as toughness, melting temperature, color, and elasticity) that rival traditional polymers and life-cycle assessment should be used to quantify the impact of sustainable polymers to compare them with existing petrochemical benchmarks which will address the needs of consumers without damaging our environment, health, and economy.



Keynote Lecture

KL-27: Performance evaluation of an up flow microbial electrolysis coupled anaerobic digestion (ME-AD) reactor

Thangavel Sangeetha[1*], Wenzong Liu[2], Aijie Wang[2], Chin-Tsan Wang[3], Wei-Mon Yan[1*]

[1]Department of Energy and Refrigerating Air-Conditioning Engineering, National Taipei University of Technology, Taipei 10608, Taiwan

[2] Key Laboratory of Environmental Biotechnology, Research Centre for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China

[3]Department of Mechanical and Electro-Mechanical Engineering, National I Lan University, Yilan 260, Taiwan

Corresponding authors e-mail: geetha.vishnu@gmail.com, wmyan@ntut.edu.tw

Abstract

Bioelectrochemical systems (BESs) are electrochemical transducers capable of converting chemical energy into electrical energy with the aid of microbes. Recently more emphasis is being laid on enhancement of AD (Anaerobic Digestion) by integrating ME (Microbial Electrolysis) with it to convert CO_2 (Carbon dioxide) directly to CH_4 (Methane). This research attempts to shed light on the effects of electrode positioning and arrangement along with hydraulic retention time (HRT), on CH_4 generation, and organic removal in novel microbial electrolysis coupled anaerobic digestion (ME-AD) reactors. However, the positioning and placement of electrodes in a ME-AD reactor have not yet been evaluated. Four reactors (S1, S2, S3 and S4) are designed with different electrode arrangements and run in four different HRTs (12, 18, 24 and 36 h) with beer brewery wastewater as the substrate for treatment. The reactors with electrodes arranged at the bottom are better in performance than the reactors with electrodes placed at the top. They have maximum COD, TOC and Carbohydrate removal efficiencies of 92.1%, 64.2% and 98.9% respectively, high methane production rate (MPR) and methane yield (MY) with 304.5 mLCH_4/Lreactor/day and 275.8 mL/gCOD respectively and a maximum current generation of 10 mA, all at 36 h HRT. Pyrosequrncing revealed that electrode placement also has crucial roles to play in microbial community prevalence on the electrode biofilm of the reactors. Methanogens and electrogens are well enriched on the electrode biofilms of the reactors with bottom positioned electrodes, revealing the basis behind their maximum organic removal, methane production efficiencies and current generation.

Keywords: Integrated reactor; bioelectrochemical system; hydraulic retention time; electrode position; applied voltage; microbial community

Keynote Lecture

KL-28: Biodegradable Star Shaped Poly(lactide)s for Biomedical Applications

Bhaskar B. Idage*[1], Susheela B. Idage[1], S. Sivaram[2]

[1]PSE Division, CSIR-National Chemical Laboratory (NCL), Pune-411 008, India
[2]Indian Institute of Science Education & Research (IISER), Pune-411 008, India
**Email: bbidage@gmail.com*

Abstract

Biodegradable polymers are widely utilized in medical devices for different biomedical applications. This allows to repair, restore or replace damaged or diseased tissue and to interact with biological systems. Poly(lactide) (PLA) and its copolymers are part of a diverse group of poly(α-hydroxy acid)s used in biomedical applications since the 1970's. While initially studied for packaging and agricultural applications these polymers are now mostly used as controlled drug delivery systems in the biomedical and pharmaceutical industries, as well as in the veterinary and agrochemical fields. In this area, active ingredients including proteins, DNA, pesticides, contraceptives, drugs and antibiotics are delivered through sustained release with the ultimate biodegradation of the carrier medium. Although controlled drug delivery has remained the common application of these polymers, surgical fixation devices have also received considerable attention where they are used as resorbable prostheses, sutures and scaffolds for wound dressing, tubular conformations, skin substitutes.

The improvement in synthesis and characterization techniques has allowed the preparation of a wide variety of polymers with architectural diversity and well-defined functionality. The research objectives are focused on the synthesis of star-shaped Poly(L-lactide)s (PLLA)s, Poly(D-lactide)s (PDLA)s and Poly(D,L-lactide)s (PDLLA)s with tailored functionalities. The ring opening polymerization (ROP) of L-lactide, D-lactide and D,L-lactide using multifunctional hydroxyl-terminated initiators and catalyst/initiator systems based on $Sn(Oct)_2$ afforded the preparation of star-shaped, poly(lactide)s (PLA)s of controlled molecular weight, narrow molar molecular weight distribution and well-defined chain end functionality. The different modifications of star-shaped PLA resulted in macromolecules with tailored functionalities for biomedical applications.

In the present work, linear, three and four branched Poly(L-lactide)s (PLLA's) and Poly(L-lactide-co-glycolide) (PLGA) with controlled molecular weight and low polydispersity index (PDI) have been synthesized by ROP of L-lactide using multifunctional initiators namely, Trimethylolpropane (TMP), Pentaerythritol (PET) and tin octoate catalyat. The branched polymers were characterized by solution viscosity, ^{1}H NMR spectroscopy, gel permeation chromatography and ^{31}P NMR spectroscopy.

Keywords: PLLA, PDLA, PLGA, Tin octoate, ROP, IV, GPC, ^{31}P NMR spectroscopy

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Keynote Lecture

KL-29: Biomass Based and Biodegradable Polymer Composites: Structure, Properties and Applications

Rameshwar Adhikari

Research Centre for Applied Science and Technology (RECAST), and
Central Department of Chemistry, Tribhuvan University, Kirtipur, Kathmandu, Nepal
Corresponding author:ram.adhikari.tu@gmail.com

Abstract: The composite materials comprising different polymer matrices (thermosets, rubbers and thermoplastics) were fabricated using natural fibers as fillers. The natural fibers reinforced polymer composites and upcycling polymers as well as agricultural wastes to prepare useful plastics are briefly reviewed. The main focus lies on the compostable polymer composites with lignocelluloses, chitin, chitosan and inorganic wastes as fillers. In particular, the biodegradable polymer, such as poly(butylene adipate-co-terephthalate) (PBAT), has been used as matrix which offered interesting alternative to produce compostable polymer composites. The influence of fiber chemical treatment on the properties of the composites has been studied. It has been shown that morphology and mechanical properties of the composites can be controlled over a wide range.

Keywords: *biopolymer, polymer wastes, polymer composites, electron microscopy*

Introduction

During the last century, plastics materials have emerged as an essential element of human life. Almost every activity of our life is directly or indirectly influenced by their applications. These have made us so dependent that it appears impossible to think about sustaining our contemporary form of society without plastics. However, these materials have posed challenges as well which are not limited to human health alone but are growing as potential risks to the lives of cattle, microorganisms, sea animals threatening simultaneously the growth of several floras. In this context, the attraction towards the use of natural fibers as reinforcing fillers is in rise. It has been deeply realized today that we cannot avoid plastics and we, however, need to develop new plastics on the basis of naturally occurring biomass [1-5]. Several models of such plastics materials have been developed and introduced into the markets.

There is, for todays the polymer scientists, a challenge of developing novel polymeric materials using renewable resources and sustainable technologies as well as for converting wastes into useful and environmentally benign products. In this context, polymer composites utilizing natural fibers and agricultural wastes as reinforcing fillers into various polymeric materials (including compostable biobased and biodegradable polymers) have gained enormous research interest during the last decade. Fibrous fillers such as those obtained from saw dust, flax, sisal, jute etc. may provide renewable resources in plastic industries.

In this paper, we will start with the review of natural fibers reinforced polymer composites and upcycling polymers as well as agricultural wastes to prepare useful plastics. Then, we will focus on the compostable polymer composites with lignocelluloses, chitin, chitosan and inorganic wastes as fillers. The biodegradable polymer, such as poly(butylene adipate-co-terephthalate) (PBAT) as matrix, offered particularly interesting alternative to produce compostable composites materials. Also the influence of fiber chemical treatment on the properties of the composites was studied. It was shown that morphology and mechanical properties of the composites can be controlled over a wide range.

Methods and Materials

Materials: Three different kinds of polymer composites with natural fibers materials were prepared:

a. Composites with polyolefin (PP and PE) *via* melt mixing and compression molding,
b. Composites with natural rubber and epoxy thermosets *via* melt mixing and amine curing, respectively
c. Compostable composites and blends prepared by met mixing and compression molding

Keynote Lecture

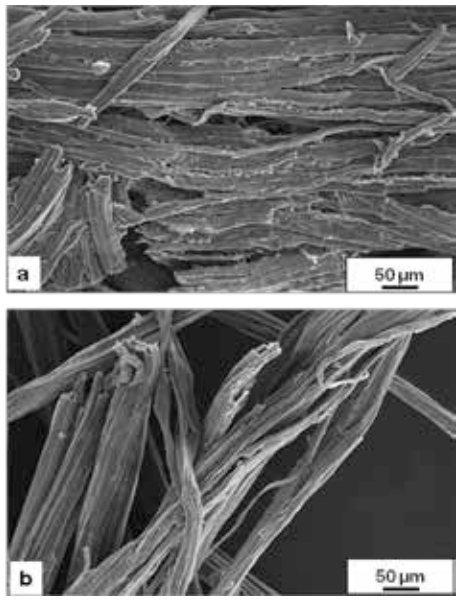

Figure 1 SEM micrographs of bast fiber before (a) and after (b) chemical treatment showing their morphologies.

Characterization techniques: The analytical methods used were scanning electron microscopy (SEM), optical microscopy (OM), tensile testing, dynamic mechanical analysis, Fourier Transform Infrared (FTIR) spectroscopy and microindentation technique.

Results and Discussion

Effect of chemical treatment on fibers morphology: The morphology of the natural fibers is strongly influenced by the alkali treatment due mainly to the removal of loosely bound components such as lignin and hemicellulose. Fig. 1 shows the morphology of the bast fiber before and after alkali treatment. It can be observed that the fibrous crystalline cellulosic framework of the bast becomes more pronounced after the chemical treatment owing to the removal of the amorphous past acting as plastering layers between cellulosic fibers.

Morphology and properties of composites: As a representative example of the composite morphology, an SEM image of natural rubber comprising 50 phr of the neat bamboo flour is presented in Fig. 2.

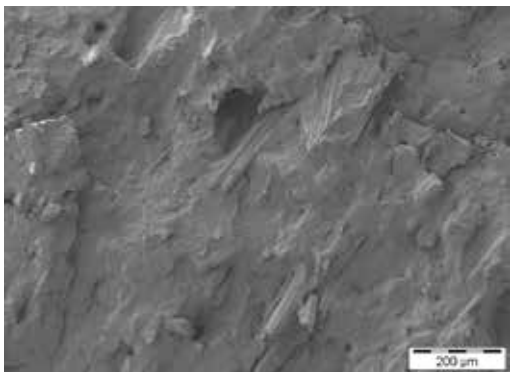

Figure 2 SEM micrographs of a composite of natural rubber with 50 phr of the neat bamboo fiber.

It should be noted that the large amount of the filler was found to disperse quite uniformly and in compatible way in the natural rubber matrix. It can be deduced that such a behavior is favorable for reinforcement of the rubber which was indeed evidenced by dynamic mechanical analysis and tensile testing. We present here only some data from the tensile testing.

Keynote Lecture

The reinforcing effect of the BF into the rubber matrix can be easily observed in Fig. 3. With an increase in the natural fiber content, the strain at break decreases quite significantly. However, the strain at break of > 300% is quite high for several applications.

Similar encouraging results with respect to morphology and mechanical behavior were obtained for the matrix comprising polyolefins, thermosets and biodegradable polymers implying that the products are suitable for low load bearing applications.

Conclusions

The results outlined in this paper have been summarized as follows:

1. Thermoplastics composites: the materials can be highly useful for low load bearing applications. The compatibilization and chemical treatment of filler do not bring much advantage for this application.
2. Rubber and thermoset composites: These have good prospects for future for technical applications. There are several things that can be exercised at the interface in order to control the properties of the composites.
3. Compostable composites: These possess good prospects but there are issues that need to be done during processing. These materials are suitable for low load bearing applications like packaging, trays.

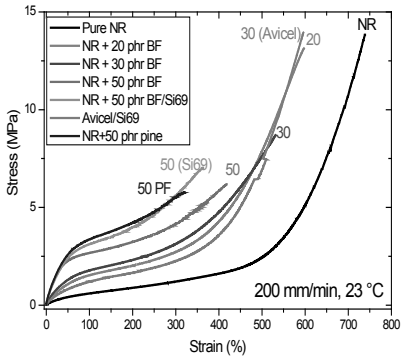

Figure 3 Stress-strain curves of natural rubber composites with various amount of bamboo floor (BF)

Acknowledgements

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Keynote Lecture

KL-30: Economy and Conversion Potential of Plastic Wastes of Kathmandu Valley into Fuel through Pyrolysis Process for Waste Management and Fuel Complements

Rabindra Prasad Dhakal,

Faculty of Technology, Nepal Academy of Science and Technology
GPO Box No. 3323, Kathmandu Nepal

Abstract

The world is fast moving into consuming goods and converting them into huge humps of garbage consisting valuable resources. The energy and materials harness could be the leading research activities in due course of time that may produce substantial research outcome and could easily linked up with the need of society. The scale and size of the equipment, efficiency of the machine, adoptability of the technology, the cost of the processing, the cost incurred otherwise was evaluated of the Kathmandu Metropolitan city. As its fundamental issues, the fuel content, processability of the plastics, quality of the fuel and potential use of fuel has been envisaged, all revealing in positive notes.

Nowadays, waste stream is considered as a valuable resource; and thus appropriate technologies are being adapted that allow more materials to be recovered and add values to them.Therefore, in the context of Nepal, solid waste management could be better regarded as resource management. In this regard, plastic to fuel (PTF) technology offers a greater potential to manage the waste plastics, specifically, by using the pyrolysis process, by converting them into petroleum oils and fuels. The present study focuses on the pyrolysis of different types of scrap plastics together with random sample collected from the Metropolitan city, which include low density polyethylene (LDPE), high density polyethylene (HDPE), polypropylene (PP), and polystyrene (PS). Typically, waste plastics were collected from the different localitiesof Kathmandu Metropolitan and subjected to pyrolysis process in which the plastics are thermally treated in absence of oxygen. The thus obtained oil and leftover were then exposed to different chemical analysis techniques such as Fourier transform infrared (FT-IR) spectroscopy and gas chromatography-mass spectroscopy (GC-MS). Moreover, the yield of oil obtained from different types of plastics was calculated and a subsequent economic analysis of the entire technology was also done. For its economical analysis, the land filling costs was evaluated for the purpose of subsidy determination to process the waste plastics.

Key words: Plastic to fuel (PTF) technology, Waste plastics, Pyrolysis, Petroleum oils, Fourier transform infrared (FT-IR) spectroscopy, Gas chromatography-mass spectroscopy (GC-MS), Economic analysis.

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Keynote Lecture

KL-31: Ultrasound-Assisted Synthesis and Characterization of Polymethyl Methacrylate/Reduced Graphene Oxide Nanocomposites

Vijayanand S. Moholkar

Department of Chemical Engineering and Center for Energy
Indian Institute of Technology Guwahati
Guwahati-781 039, Assam, India

This study reports ultrasound-assisted synthesis of polymethyl methacrylate (PMMA)/reduced graphene oxide (RGO) nanocomposites by in situ emulsion polymerization coupled with in situ reduction of graphene oxide. The thermal degradation kinetics of the nanocomposites was also assessed with Criado and Coats-Redfern methods. Intense microconvection generated by ultrasound and cavitation results in uniform dispersion of RGO in the polymer matrix, which imparts markedly higher physical properties to resulting nanocomposites at low (≤1.0 wt %) RGO loadings, as compared to nanocomposites synthesized with mechanical stirring. Some important properties of the PMMA/RGO nanocomposites synthesized with sonication (with various RGO loadings) are: glass transition temperature (0.4 wt %)=124.5°C, tensile strength (0.4 wt %)=40.4 MPa, electrical conductivity (1.0 wt %)=2×10^{-7} S/cm, electromagnetic interference shielding effectiveness (1.0 wt %)=3.3 dB. Predominant thermal degradation mechanism of nanocomposites (1.0 wt % RGO) is 1D diffusion with activation energy of 111.3 kJ/mol.

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Keynote Lecture

KL-32: Biodegradable Polymeric Nanomaterials for Commodity, Engineering and Biomedical Applications

Vimal Katiyar

Department of Chemical Engineering, Indian Institute of Technology Guwahati, Guwahati, Assam, India. Email: vkatiyar@iitg.ernet.in

Significant efforts have been made worldwide towards development and commercialization of environment friendly sustainable polymers which will help in restoring the environmental damage due to extensive use of fossil fuel based plastics. Biopolymers can be extracted or derived from renewable feedstock such as plants, marine animals, insects, etc. It is noteworthy to mention that so far biopolymers extracted from these sources have limited applications in large scale plastic production. Current research is focused on the fabrication of bionano-fillers from abundantly available biopolymers such as chitosan, cellulose, silk, starch, plant-based polysaccharides gums, etc. with the aim to prove its efficacy in designing new class of superior bioplastics and composites. Conversion strategies of above biopolymers into various bionano-fillers such as amphiphilic nano-chitosan [1], cellulose nanocrystals (CNC) [2], silk based nano-discs, gum based nano-sphares, etc., will be presented.

High molecular weight PLA synthesis is being carried out from biobased precursor lactic acid, through several techniques of melt condensation and ring opening polymerization of lactide followed by solid state polymerization [3]. However, these plastics may not adequate to give desired properties comparable to petroleum derived polymers, therefore, we have examined above bionano-fillers to tune the desired properties of synthetic polymers including PLA, PHAs, PCL, etc., based on their applications. Different approaches like surface modification of the hydrophilic nanofillers (Chitosan and CNCs) have been carried out for better dispersion into the bioplastic matrix. Further, grafting of bio-based nanofillers (Chitosan and CNCs) have been carried out into PLA and PHB, which shows significant improvement in the mechanical, barrier and thermal properties. CNCs are fabricated from different bio based resources through different procedures of acid treatment. Due to hydrophilic nature of these bionanoparticles, dispersion in hydrophobic biopolymers becomes difficult, therefore, we have modified the bionanofillers and subsequently, industrially viable melt extrusion techniques to have been employed for development of high Heat stable PLA stereocomplexes [4].

Novel natural gum based bio-adhesives with extremely high silica binding efficiency have been developed which can be used for various applications in the field of biomedical, structural application, especially in surgical suture because of its biodegradability. Another area which is under investigation is development of cellulose nanocrystals (CNC) based magnetic PLA films which could find their potential application in the field of biomedical, thermally heated packaging, drug delivery and hydrogen storage applications [5].

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Keynote Lecture

KL-33: Making of a Compleat Professional: Some ideas and useful tips

R. P. Chhabra

Department of Chemical Engineering, IIT Kanpur.

Abstract There is no doubt that the professionals (doctors, engineers, scientists, for instance) of the new millennium will be increasingly working in inter-disciplinary settings, both from social and professional viewpoints. The completion of four year studies to earn your BS degree (followed by the graduate studies) is only the beginning of your career. Even if you spend 10 years at the university, it is impossible to prepare you for all situations you are likely to encounter in the real world beyond the academic institutions. Therefore, you need to develop and sharpen a whole range of skills to stay up-to-date and to prosper in your professional and personal life. Hereafter, there will be no one to tell you what you should do! So this is the time when you should take full control of your life. For instance, you must learn to learn on your own the new skills as and when required in your professional life. To quote, Alvin Toffler: the illiterates of the 21st century will not be those who cannot read and write, but those who cannot learn, unlearn and relearn. Also, one needs a whole range of social engineering skills including developing and maintaining inter personal relationships, showing gratitude, acknowledging contributions of the others, maintaining positive outlook, to be able to work in inter-cultural settings, to be compliant with the professional code of conduct and to act in an ethical manner, etc. This talk endeavours to offer some tips on developing and honing such skills thereby enabling you for not only staying at the forefront of yourprofession but also becoming a responsible citizen.

Invited Lecture

IL-01: Polyurethanes and their nanocomposites from Biobased Polyols: Efficient and environment friendly alternative

Anupama Kaushik Sharma

Professor, SSB University Institute of Chemical Engineering and Technology, Panjab University, Chandigarh, India-160014

Phone: 91-0172-2534925 (O), 91-9815177772 (M)

Email: anupamachem@gmail.com, anupamasharma@pu.ac.in

Abstract

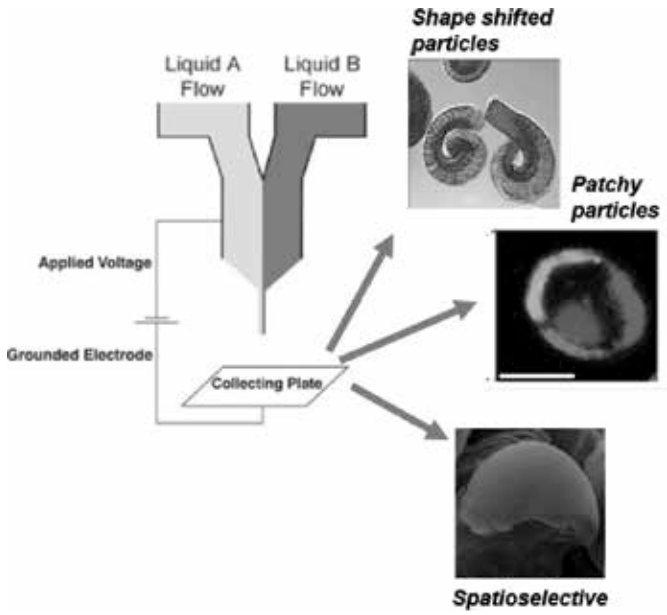
Biodegradable Polyurethanes were prepared from three different biobased polyols namely, vegetable oil i.e. castor oil, lignin based polyols and hydroxyl terminated polylactide diols. Different fillers like organoclay, cellulose nanofibers and modified hydroxyapatite were used as reinforcing agents. In the first study, aromatic and aliphatic segmented polyurethanes were prepared using polylactide diols as soft segment and 4,4-diphenylmethane diisocyanate (MDI)/ hexamethylene diisocyanate (HDI) along with 1,4 butanediol (BDO) as hard segment. Cellulose nanofibers isolated from wheat straw using steam explosion were chosen as nanofillers. These nanocomposities exhibited excellent mechanical, thermal and antimicrobial activities. In second study, polyurethanes were synthesized from oxypropylated lignopolyols and MDI followed by reinforcement of cellulose nanofibrils. The lignin and cellulose nanofibers were derived from waste jute bags. The thermal stability and Young's modulus was best for polyurethanes with 50% hard segment. The polyurethanes showed inconsequential antimicrobial activity but good degradability. In the last study, highly porous castor oil based polyurethane foams were reinforced with hydroxyapatite modified with triethanolamine and etidronic acid. Metabolic activity of cells was measured using cell proliferation measurement by MTT assay. In longer run i.e. beyond a period of 4 days, nanocomposite showed higher proliferation and cell survival than pristine polyurethane foam.

Invited Lecture

IL-02: Anisotropic designer particles

Dr. Sampa Saha,
Centre for Polymer Science and Technology, IIT, Delhi

In recent years, particle technologies have been broadly focused on manipulation of size, shape and surface chemistry. The electrohydrodynamic co-jetting of different polymer solutions leads to a unique design of particles with multiple and distinct surface patterns or nano-compartments. Moreover, the ability to selectively modify individual areas on the surface of a particle, cylinder or a fiber is another important physico-chemical property, which necessitates anisotropic distribution of interfacial binding sides. In this talk, it will be shown how a selective surface modification of individual compartments can yield a novel type of shape shifted microcylinders via surface-selective click chemistry in conjunction with surface initiated ATRP (Atom Transfer Radical Polymerization). Additional examples will be discussed towards microparticles with fully orthogonal surface patches that take advantage of a combination of chemically orthogonal polylactide-based polymers and their processing via electrohydrodynamic co-jetting to yield unprecedented multifunctional microparticles. These and other microstructured particles are highly sought after for their potential to present multiple distinct ligands in a directional manner for targeted drug delivery applications.



Electro hydrodynamic co-jetting-a technique towards anisotropic designer particles

Invited Lecture

IL-03: Properties Enhancement of Biocomposites

Utai Meekum

School of Design Technology, Institute of Engineering, Suranaree University of Technology, Maung, Nakorn Ratchasima,30000, THAILAND.

Abstract: The properties enhancement of the biocomposites based on poly(lactic acid)(PLA) and PLA/poly(butylene succinate(PBS) blends were successfully made. Especially, the service temperature by mean of heat distortion temperature(HDT) above 100°C was accomplished. The natural fibers from the agro industries waste including oil palm empty fruit brunch, bagasse and rice husk were employed as the main reinforcement. The fiber treatments: NaOH, maleic anhydride(MA) and thermal, were explored. Also, the vinyl silane/peroxide macro crosslinking was demonstrated as the effective process to improve the properties of the biocomposites. The compounding of the composites were performed on the twin screw extrusion. The test specimen were obtained by injection molding. The macro crosslink of the silane/peroxide procedure by moisture induction condensation were accelerated the injected samples via the sauna curing. Standard tests; melt flow index(MFI), tensile, flexural, impacts and HDT, were performed. Scanning electron microscopy(SEM) was employed to investigate the fiber/matrix interfacial adhesion.

Keywords: *Biocomposites, Processing and Mechanical and Thermal Properties*

Introduction

One of the main driving economic growth in Thailand is agro based industries. The main industry crops include rice, tapioca, sugar cane, oil palm, etc. In the factory processes of those starting raw materials, the cellulosic fiber is the main by-product waste. They are currently used as the biomass fuel in the power plant. In the environmental term, it is not the kind of "zero" carbon emission waste management. As the country mission as Thailand 4.0 or Industry 4.0 in which innovation is the key succeed for the goal. Bio based industry is one of the clusters that the country is trying to promote. Consequently, the usage of cellulosic fiber waste as reinforcement in biocomposite is not the high value added route but also it is the best technique for waste management. Utilising the natrural fiber by-product in the biocomposite would be one of the "zero" emission management.

Poly(lactic acid)(PLA) reinforced with oil palm empty fruit bunch(EFB) and cotton fibers was successfully manufactured with good mechanical mechanical properties and having the heat distrotion temperature(HDT) above 100°C [1]. It is a promissing material for hot fill packaging. Peroxide/silane crosslinking system were effectively applied onto the biocomposite based on PLA/EFB hybrid system [2]. Again, mechanical performance and HDT were found outstanding. The optimization of the manufacturing methods for producing the best properties of the biocomposite were also concluded. PLA/Poly(butylene succinate(PBS) blends reinforced with rice husk fiber was also studies. Some of the properties enhancement results will presented in this publication.

Methods and Materials

PLA and PBS used are the commercial available grade. They were vacuum dried at 90°C for at least 4 hours before use. EFB was obtained from the local oil palm refinery factory. It was mercerized with NaOH, heat treatment at 170°C and mechanical griding into fine fiber. Rice husk(RH) was available from the local rice mill. It was crushed into fine fiber using the hamer mill machine. Talc, with an average particle size of 1.1 μm, was employed as filler and cost saving. Commercial Irgafos 168/Inganox 1076 was employed as the heat/processing stabilizer. The rest of chemical ingredients were commercial grade and available from its supplier. They were used without further purification. The biocomposites were manufactured using a co-rotating intermeshing twin screw extruder at a screw speed of 15 rpm and melt mixed at 180 °C. The test specimens were fabricated by injection molding at 180 °C. This sauna curing, to accelerates the completion of macro crosslink via the condensation reaction of silane/peroxide system, was perofrmed at 60°C in moisture saturated oven for 12 hours.

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Result and Discussion

Table 1summarizes the tested properties of biocomposites using PLA and PLA/PBS blend as the matrix and EFB and RH as the reinforcement, respectively. The "X" is indicated the crosslink system.

Table 1. Summary the Properties of Biocomposites

Properties	Biocomposites				
	PP	PLA/EFB BioCom.	X(PLA/EFB) BioCom.	PLA/PBS RH BioCom.	X(PLA/PBS) RH BioCom.
MFI(g/10mins) @190/5.0	13.70±0.44	8.44±0.51	3.38±0.22	9.60±0.51	8.75±1.56
HDT(°C) @455 kPa	116.3±1.0	122.1±2.7	128.3±2.9	100.8±1.5	102.8±0.2
Impact: Notched(kJ/m^2)	1.63±0.12	5.69±0.04	7.93±0.33	2.41±0.40	1.74±0.05
Unnotched(kJ/m^2)	41.28±13.75	22.12±4.39	29.81±4.89	7.15±0.86	6.81±1.66
Tensile: Strength(MPa)	31.58±0.43	na	na	23.20±0.38	32.29±0.70
Modulus(GPa)	18.08±0.98	na	na	1.91±0.05	4.19±0.04
Flexural: Strength(MPa)	33.22±0.68	76.39±6.71	83.34±2.97	33.55±0.52	56.12±1.84
Modulus(GPa)	1.10±0.04	2.78±0.35	2.78±0.11	2.29±0.04	4.93±0.05

The properties of injection molding grade of PP is used as the referee material. Regarding to the MFI, it is seen that all of the biocomposites are injectable by the molding process with more carful on the macro crosslink systems. Where the flowability is slightly low, high viscosity. The HDT of the obtained biocomosites are inclusively above 100°C. They manifest that the hot fill packaging applications are feasible for these material. It was also found that the injected product are microwable. For the mechanical properties, especially the toughness, when compare with PP, it is noticed that the biocomposites have lower unnotched impact strength than PP. However, by reinforcing with the cellulosic fiber, the notched impact of the composite materials are typically superior that the PP. The tensile characteristic, in particularly elongation, of the biomaterials show less plasticity in nature than PP. The packaging required more flexibility properties would be limited with the use of biocomposites. The biocomposites show the better flexural properties over PP material. It was observed that adding tougher and greater L/D ratio fiber, such as cotton, had the significant improvement in the toughness characteristic. However, restiction in the flowability must be carefully compomised.

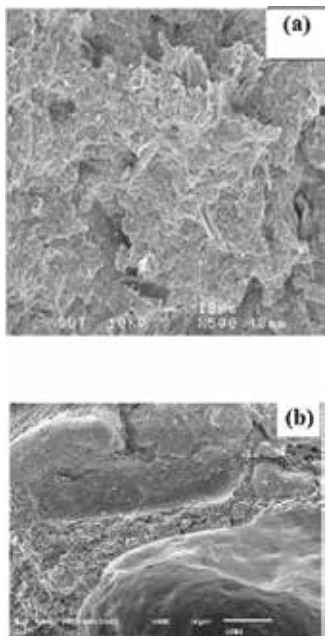

Fig. 1. SEM photo of (a) X(PLA/EFB) and (b) X(PLA/PBS) RH biocomposites

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Fig. 1 show the selected SEM photos of X(PLA/EFB) and X(PLA/PBS)/RH biocomposites, respectively. It is seen that good interfacial adhesion between PLA and EFB after undergoing sauna treatment is apparently observed. Also, the MA treatment on RH fiber show the excellent bonding with PLA/PBS matrix via the silane/peroxide crosslink system. These SEM investigation had confirmed that with beneficial of matrix/fiber adhesion, through the silane/peroxide macro crosslinking, it lead to the properties enhancement of the biocomposites material.

From the preliminary biodegradation testing, it was found that the PLA/EFB biocomposite was bio-degraded with similar manner as PLA. The disintegration of the biocomposite within 6 months was observed.

Conclusions

By using both PLA and PLA/PBS blend as the matrix and EFB and RH fiber as reinforcement, the biocomposites materials with enhancing the mechanical properties and also good thermal properties, HDT above 100oC, were manufactured on the continuous twin screw extrusion process. Silane/peroxide had played the important role in the properties improvement. The obtained biocomposites showed the promissing prospect for the manufacturing of hot fill packaging by injection molding.

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IL-04: TwinDrive RheoMicroscopy

Dharmesh Gala

Anton Paar, Austria

Rheological measurements reveal information about macroscopic material properties, which are strongly dependent on the microstructure. Therefore, in order to understand and customize the behavior of investigated samples under flow conditions, it is necessarily to pay special attention to the structural changes that occur on the microstructural level. One of the most suitable methods for investigating morphology development in the micrometer size during flow is microscopy.

Simultaneous use of rheometric and optical methods has been achieved by developing specialized accessories for rheo-microscopy, which can easily be adapted to the Modular Compact Rheometer (MCR) platform from Anton Paar.

When using microscopy together with a single-drive rheometer, the structures to be investigated are only flowing by. With only a single motor driving, the structure elements of the sample do not remain in the field of view. Thus, it is possible to get general information about structural changes due to rotational or oscillatory movement, but it cannot be quantified optically, for individual structure, particle, or droplet investigation. This disadvantage is eliminated when using the microscopy setup for the TwinDrive™ Modular Compact Rheometer. Due to the counter-rotation drive, a stagnation plane is created, enabling monitoring of size changes, as well as deformation and relaxation of individual droplets or particles in the sample.

Invited Lecture

IL-06: Poly(lactide) Suprastructures: Structural Reorganization of Stereocomplex Nanoparticles

Susheela B. Idage*[1], Bhaskar B. Idage[1], S. Sivaram[2]

[1]PSE Division, CSIR-National Chemical Laboratory (NCL), Pune-411 008, India [2]Indian Institute of Science Education & Research (IISER), Pune-411 008, India *Email: sb.idage@ncl.res.in

Abstract: Star PDLAs were synthesised using different multifunctional initiators by the ring opening polymerization (ROP) using Tin octoate catalyst and characterized by solution viscosity (IV), nuclear magnetic resonance (NMR), gel permeation chromatography (GPC) and thermal analysis. The nanoparticles were prepared by blending the solution of star PDLA and PLLA *via* nanoprecipitation and characterized by particle size analysis (PSA) and Scanning Electron Microscopy (SEM). The SEM morphology shows the formation of seaweed and dendrite type suprastructures. However, the size and morphology of the nanoparticles prepared from the star PLLA shows only sphere type of nanoparticles having the particle size of <150 nm.

Keywords : Poly(L-lactide), Poly(D-lactide), Tin octoate, Ring opening polymerization, Stereocomplex nanoparticles

Introduction

The design and synthesis of nanopaticles with tailored architectures is always intense area of research in polymer science as it offers the platform to address the challenges in the field ranging from nanomedicine, catalysis, electronics and high performance materials. Stereocomplex (SC) formation in polymers is the association of pairs of optically active *S*- or *R*-polymers (L and D- polymer forms) or between optically inactive syndiotactic and isotactic polymers. The stereoselective association depends on structural fitting and the van der Waals forces between polymer chains.

The star polymers differ from linear polymers in that many linear polymers are attached to a core, thus star polymers allow for densely packed architectures with multiple chain ends. Due to their desirable properties, star polymers have been used in number of applications including drug and gene delivery, catalysis, and diagnostics. Additionally, PLA stars exhibit lower hydrodynamic volume and higher viscosity than the linear counterparts in solution. With a dual control over the stereochemistry and topology of the macromolecule, the synthesis of stereoregular star polyesters may provide exciting opportunities for developing new functional polymers with desirable properties for applications in conventional materials and emerging nanotechnologies.

In the present work, we have synthesized star poly(lactide)s using multifunctional initiators namely, trimethylol propane (TMP), pentaerythitol (PET), dipentaerythritol (DPE) and ditrimethylol propane (DiTMP) by ring opening of polymerization (ROP) of D-lactide. The linear polylactide was also synthesized in the same manner. The star PDLAs were synthesised by ROP using different multifunctional initiators and tin octoate catalyst. The PLLA and PDLA were characterized by different techniques namely, solution viscosity (IV) and molecular weights (Mn, Mw and PDI) by gel permeation chromatography (GPC) using different Polystyrene standards in chloroform. The nanoparticles were prepared by blending of star PDLA and PLLA solutions by nano-precipitation method.

Materials and Methods

L-Lactide (Purasorb L) and D-Lactide (Purasorb D) were procured from Purac Biochem, The Netherlands and purified by recrystallization from dry ethyl acetate. Lauryl alcohol, DiTMP, TMP, PETDPE and tin octoate were procured from Sigma-Aldrich, USA and used as such without further purification.

Inherent viscosity (η_{inh}) of polymer solutions (0.5 g/100 mL) was determined using Ubbelhode viscometer in chloroform at 30^{o}C. Mn, Mw and PDI were determined in chloroform using Thermoquest (TQ) SEC equipped with RI detector and column sets of Waters HT 100 to 10^5 A ^{o} using PS standard. DSC was performed with Q10 TA Instruments, USA at a

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heating rate of $10^{o}C.min^{-1}$. CP-MAS ^{13}C NMR spectra were obtained using Bruker Avance 300 MHz solid state NMR spectrometer with 4 mm double resonance MAS probe. All measurements were carried out at a spinning speed of 6.5 kHz. ^{13}C NMR spectra were obtained by Cross Polarization experiment using 2.75 microsecond long proton 90^{o} pulses and cross polarization time of 4 milliseconds. The recycle delay of 5 sec was enough for complete decay of the signal.

The Particle size and distribution of stereocomplex nanoparticles in dilute aqueous solutions was measured by Particle Size Analyzer (90 Plus Zeta Sizer, Brookhaven Instruments Corporation) using Photon Correlation Spectroscopy (PCS) and laser diffraction. A 0.4 % concentration was selected in the working range of Zeta Sizer which has lower limit of 1000 particles in the detection volume. The intensity fluctuation of scattered light arising from Brownian motion of the particles in the detection volume was measured. The rate at which the intensity fluctuation occurs is dependent on the size of the nanocrystal/ nanoparticles.

Results and Discussion

The star-shaped poly(lactide)s were prepared by the ring opening polymerization (ROP) of L-lactide in the presence of multifunctional initiators namely, PET, DPE,TMP and Di-TMP (5 mg each) and 2 g of D-lactide using tin octoate catalyst at $180^{o}C$ for 3 h and characterized by GPC, NMR and DSC. The star shaped poly(D- lactide)s have the number average molecular weights (Mn) in the range of 27300 to 89500 g/mol and and weight average molecular weights in the of 63,500 and 170,000 g/mol, Tm in the range of 168-$173^{o}C$ and Tg in the range of 57 to $59^{o}C$. The linear poly(L-lactide)s have Mn of 66,500 and Mw of 125,000 g/mol, Tm of $178^{o}C$ and Tg of $60^{o}C$. These polymers were used in the ratio of 50:50 for the preparation of stereocomplex nanoparticles.

Preparation of nanoparticles

The solutions of star PDLA and PLLA (10 mg/ mL each) in Tetrahydrofuran were prepared with gentle heating. The solutions were mixed in a three necked R.B. flask equipped with a mechanical agitator. The two solutions were added drop-wise simultaneously at 0-$5^{o}C$ with stirring at 1000 rpm and maintained over 1 h to complete the formation of stereocomplex. This solution (10 mL) was then added drop wise to deionized water (15 mL) at room temperature over 3 h under stirring at 2000 rpm. The turbid solution was filtered through a Millipore Millex-GV PVDF filter (0.22 μm) and the filtrate was used for the particle size determination and studying the SEM morphology.

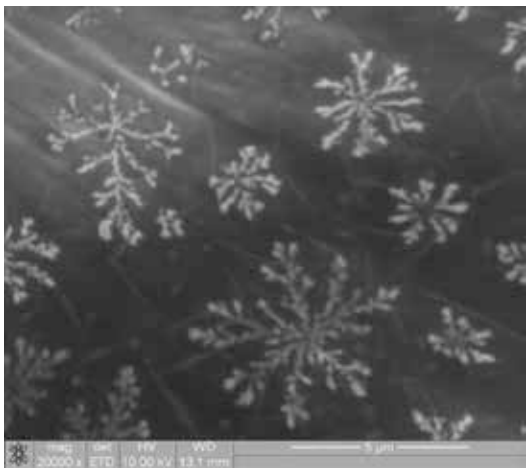

Figure 1 SEM of stereocomplex nanoparticles

(Di-TMP-Star PDLA-linear PLLA)

They crystallize *via* initial formation of a stereoisomeric helical pair prior to nucleation in solution resulting in the growth of nanocrystalline structures. The racemic mixture of PLLA and PDLA forms the stereocomplex nuclei by the alternate packing of β-form 3_1 helices of the opposite absolute configuration (left- *vs* right-handed) side by side facilitated by van der Waals forces and/or intermolecular hydrogen bonds. Stereocomplex nanoparticle formation was confirmed by FTIR,

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^{13}C NMR spectroscopy and DSC. FTIR spectra exhibits characteristic peaks due to PLA stereocomplex formation. The peaks at ~1748 and 908 cm^{-1} are characteristic of stereocomplex (β-crystals) as reported in the literature. The carbonyl vibration band, characteristic of disordered PLA chains in individual solutions of enantiomers at 1759 cm^{-1} gradually disappears and a new vibration band at 1747 cm^{-1} appears. The size and morphology of nanoparticle assemblies formed by combination of molecular weights of PLLA and star PDLA was characterized by SEM. It shows the formation of seaweed and dendrite type suprastructures.

The size and morphology of nanoparticles prepared from the star PLLA is also discussed.

Conclusions

PLLA and PDLA having different molecular weights and polydispersity index were synthesized by the ring opening polymerization (ROP) of L-lactide and D-lactide at 180^{o}C for 1-3h using tin octoate as catalyst and lauryl alcohol as the initiator. Three, four and six branched PDLAs were prepared by the ROP of D-lactide using different multifunctional initiators and 0.05 wt% of tin octoate catalyst at 180^{o}C for 3 h.

Poly(lactide)s synthesised were characterized by different techniques. The molecular weight (M_w and M_n) of the synthesized polymers were determined by size exclusion chromatography using Polystyrene standards. The nanoparticles were prepared and characterized by particle size analysis and scanning electron microscopy. The SEM showed seaweed and dendrimer type of morphology in star PDLA and linear PLLA stereocomplex nanoparticles. The morphology of reorganization of nanostructures in solution switches between three basic patterns (e.g. sphere, dendrites and seaweed) depending primarily on the structural parameters such as the molecular weight and the ratio of enantiomers.

Acknowledgements

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Invited Lecture

IL-07: Stereocomplexation of the segmented PLLA/PDLA blend melt-spun fibers

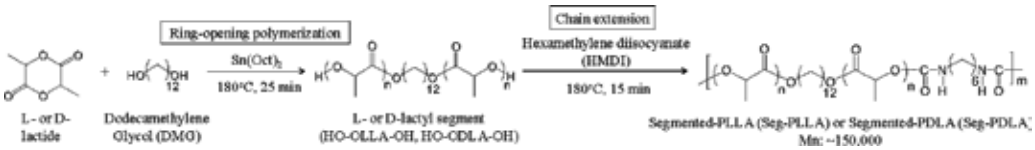
Masaki Yamamoto*[1], Felix Merkord[2], Kazunari Masutani[1], Yoshiharu Kimura[1], Hideki Yamane[3]

[1] The Center for Fiber and Textile Science, Kyoto Institute of Technology, Kyoto, JAPAN.

[2] Institut für Textiltechnik (ITA), RWTH Aachen, Aachen, Germany.

[3] *Department of Biobased Materials Science, Kyoto Institute of Technology, Kyoto, JAPAN*.

* e-mail:myamamoto@kit.ac.jp



Introduction

Segmented PLLA (Seg-PLLA) is obtained by the chain extension of bis-hydroxyl-terminated oligo(L-lactic acid) (lactyl segment) which can be synthesized by the direct polycondensation of L-lactic acid. Seg-PLLA with a short segment hardly crystallizes unless it is annealed and the melting point and the crystallinity of Seg-PLLA were found to decrease with decreasing segment length Stereocomplexation is one of the methods to improve these shortcomings. The stereocomplex crystal (SC) forms in an equal blend of PLLA and PDLA and its melting point is about 50°C higherthan that of the homo-chiral crystal (HC). It is a purpose of this study to determine the physical property of the melt-spun fibers of Seg-PLLA/ Seg-PDLA blend (Seg-(L/D). Seg-(L/D) fibers were drawn and annealed at various conditions and the structure and the thermal property were determined.

Experimental

Scheme shows a synthetic route of Seg-PLLA and Seg-PDLA. L- or D-lactyl segments with various segment lengths were synthesized by the ring-opening polymerization of L- or D-lactide by using dodecametylene glycol (DMG) as an initiator. Then these L- and D-lactyl segments were extended into Seg-PLLA and Seg-PDLA by adding hexamethylene diisocyanate (HMDI). L- and D-lactyl segments with 5,000 and Seg-PLLA and Seg-PDLA with 150,000 in molecular weight were obtained. Equal amounts of Seg-PLLA and Seg-PDLA were melt blended at 170°C and melt-spun into an amorphous fiber. The fiber was drawn and annealed at various temperatures under the tension. Thermal property, the higher-order structure, and the mechanical property were determined by using DSC, WAXD and the tensile tests.

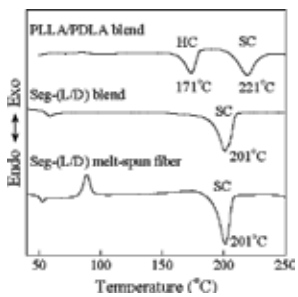


Fig. 1 DSC curves of PLLA/PDLA blend, Seg-(L/D) blend and its drawn fiber.

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Result and Discussion

DSC curves of the melt blended Seg-(L/D) and that of the fibers are shown in Fig. 1. DSC curve of the PLLA/PDLA blend is also shown as a comparison. It should be noted that Seg-(L/D) and its drawn fiber only showed a melting of SC around 201°C. This suggests that the SC was preferentially formed to HC in the Seg-(L/D) and its fiber. On the other hand, both HC and SC were observed for the PLLA/PDLA blend. The lwer melting point of Seg-(L/D) makes the melt spinning possible at a low temperature and the thermal decomposition can be suppressed. WAXD patterns and the equatorial spectra of fiber drawn to x 5 at 70°C and that subseqently annealed at various temperatures are shown in Figs. 2 and 3. Drawn fiber shows a broad and weak peak around 2θ = 16.7º. indicating that the drawing did not promote the crystallization. On the other hand, the fibwer annealed at 120°C shows the arc reflection of HC at 16.7º and that of SC at 12, 20.5, and 24º. The intensity of the reflection of HC decreased and that of SC increased with increasing annealing temperature. In the case of annealed at 160°C, reflection of HC completely disappeared and the strong reflections of SC stayed stronger without relaxing the crystal orientation. These results indicate that the drawn and annealed Seg-(L/D) fiber contains only SC as a crystalline phase.

Acknowledgements: This work was partially supported by Council for Science, Technology and Innovation (CSTI), Cross-ministerial Strategic Innovation Promotion Program (SIP), "Technologies for creating next-generation agriculture, forestry and fisheries" (funding agency: Bio-oriented Technology Research Advancement Institution, NARO).

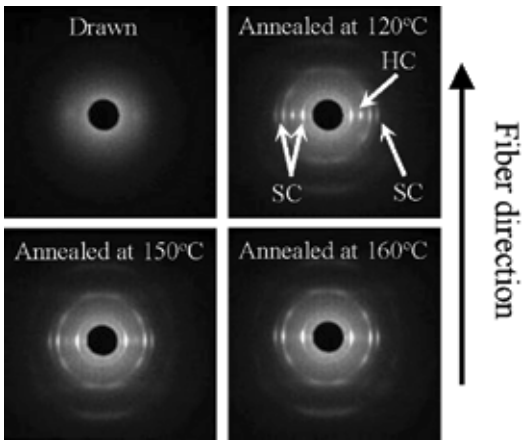


Fig. 2 WAXD patterns of the drawn fiber and the fibers annealed at various temperatures.

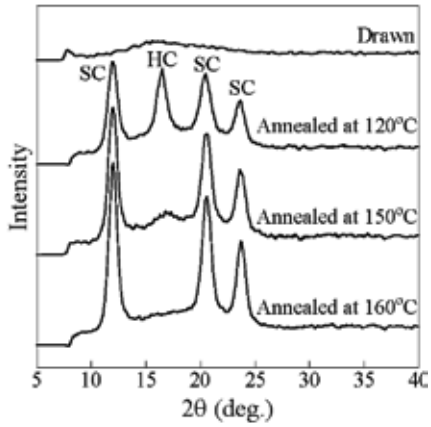


Fig. 3 WAXD equatorial spectra of the drawn fiber and the fibers annealed at various temperatures.

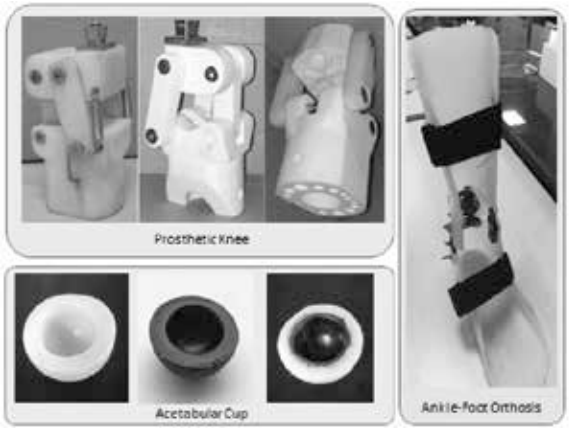
Invited Lecture

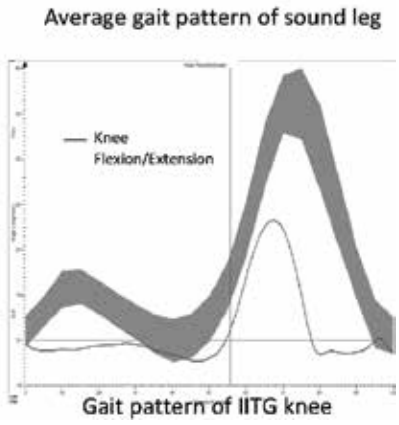
IL-08: Biomedical devices and implants at Biomedical Devices Lab in IIT Guwahati

S Kanagaraj
Department of Mechanical Engineering, Indian Institute of Technology Guwahati, India
kanagaraj@iitg.ernet.in

India is currently importing about 0.65 million USD of different types of medical implants and devices. Most of the imported implants and devices are found to be expensive and not suitable for Indian patients because of their design limitations. Thus, it is very much essential to develop indigenous devices at an affordable cost without compromising their functional activities. In this direction, Maharastra and Andra Pradesh government have started to setup a Biomedical Engineering and Technology Centre and Andhra Pradesh MedTech Zone (AMTZ), respectively in their states to ensure the researchers to actively taking part in the development of biomedical devices. Our objective is to be design and develop patient specific biomedical devices, implants and their testing devices as per ISO/ASTM standards in order to meet their individual requirements. In this direction, the product being developed by our research team has been kept under three different categories namely implants, biomedical devices and testing devices. Under the implant category, the following such as (i) ultrahigh molecular weight polyethylene based acetabular cup, (ii) 3D printed shape memory polyurethane based aneurysm coil, (iii) endotracheal stent, (iv) hemoport device, (v) different types of cerium based anti-scavenging material to absorb the excess reactive oxygen species to preserve the residual hearing after cochlear implant fixation, (vi) in-situ blood pressure monitoring using cardiac implantable devices, and (vii) suture medicated vascular closure device are being developed. In connection with testing devices of implants and devices, the following such as (a) hip joint wear simulator as per ISO 14242, (b) modular version of joint wear simulators, (c) amputee walking simulator, (d) gait lab are being developed. Related to prosthetic and orthotic devices and other assistive devices, (i) polymer based polycentric knee joint, (ii) dynamic foot, (iii) custom made ankle foot orthosis, (iv) anti-prick surgical gloves, (v) assistive device for hearing disabled, (vi) breast screening device to detect the abnormal cells, (vii) analysis of Ilizarov apparatus to increase the tension of wire, (viii) electronic weighing unit to measure the weight of the patient in the bed are being developed.

One of the prosthetic devices namely polymer based polycentric knee joint was designed, developed and made patient trial for 12 trans-femoral amputees. The improved version of the device is being manufactured to fix the same for ~50 amputees within next 2-3 months. The team is also a part of sport and Healthcare Engineering centre, International Centre for 3D Printing Technology for Biomedical Implants, Regenerative Medicine and Devices (3D-BIRD). The gait lab is under developmental stage. Some of the devices are shown here for easy understanding. Our team members work on the requirement of device, design, prototyping, development of functional model for studies and trial at large trial. We have received one US patent, applied two Indian patents. Our motto is to develop different types of biomedical devices and implants which meet Indian requirements as per FDA/MCI regulations.





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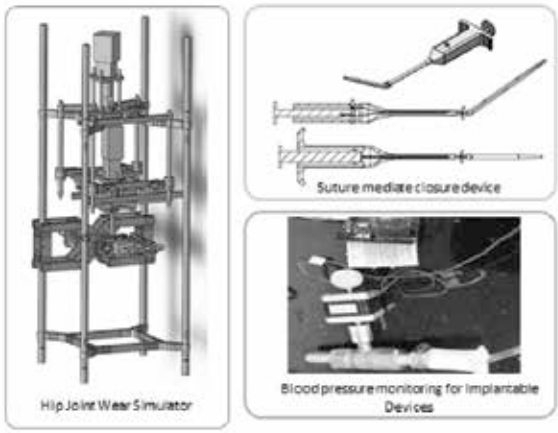

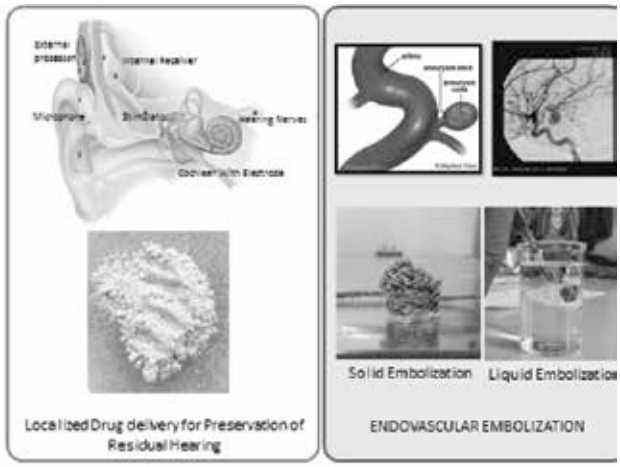

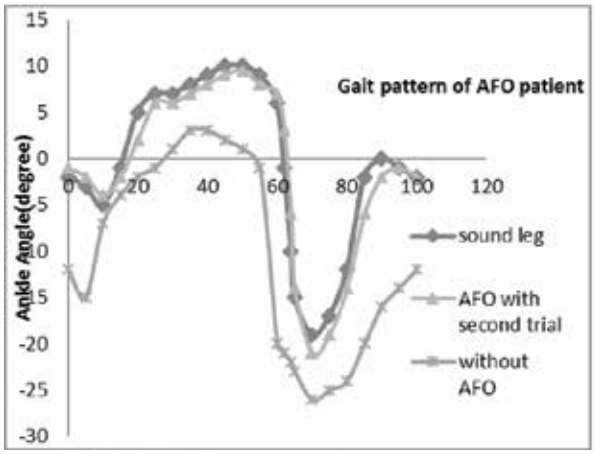

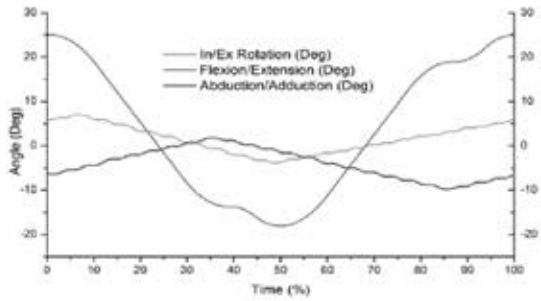

Kinematic pattern of hip joint assembly as per ISO 14242

Invited Lecture

IL-09: Polysaccharide induced hybrid polymers for drug delivery application

Sarat K Swain*

Department of Chemistry, Veer Surendra Sai University of Technology, Sambalpur 768018, Odisha, India

*Corresponding author E-mail: swainsk2@yahoo.co.in, Phone: 91-9937082348

Advances in polymer science have led to the development of several novel drug-delivery systems. A proper consideration of surface and bulk properties can aid in the designing of polymers for various drug delivery applications. Polysaccharides are regarded as key ingredients for the production of biobased materials in life sciences (e.g., food, cosmetics, medical devices, and pharmaceutics). The biodegradability and biocompatibility of these biopolymers, coupled to the large variety of chemical functionalities they encompass, make them promising carriers for drug delivery systems. Biodegradable polymers find widespread use in drug delivery as they can be degraded to non-toxic monomers inside the body. Described herein is a drug delivery system useful to deliver drugs at low dosage levels to patients in a sustainable fashion and at a controlled rate. Attachment of drugs to high molecular weight polymers can significantly improve both tumor targeting and therapeutic efficacy due to the enhanced permeability and retention effect observed in tumor tissue. Polysaccharide based polymeric nanohydrogels are prepared with incorporation of different nanomaterials in polysaccharides matrix for drug delivery applications. In our work, we have designed carbon quantum dot tailored calcium alginate hydrogel for pH responsive controlled delivery of vancomycin. It is observed that, the drug uptake capacity (96%) and lower release rate (56% in 120h) of CA/COD hydrogel film in pH 1.5 with β-CD can be used for its applicability as drug delivery vehicle for controlled release of vancomycin into the stomach region. Moreover, Nano Silver decorated Polyacrylamide/Dextran Nanohydrogels hybrid composites for drug delivery applications have designed. It is interesting to notice that the *in vitro* release rate of ornidazole drug is 98.5% at 6 hr (Figure 1). Nano silver decorated PAM/D nanohydrogels are stable, nontoxic with antibacterial behaviour may be suitable for drugs delivery vehicle.

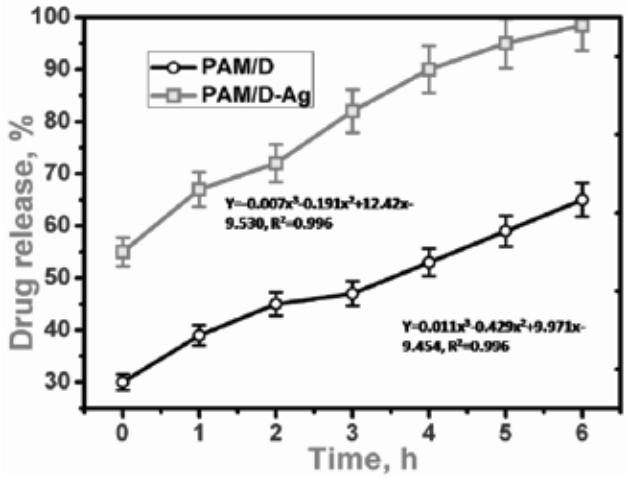

Figure 1: Drug release profile of PAM/D/Ag (filled square) and PAM/D (open circle) hydrogel at 32^0C in buffer capsule using ornidazole (OD) as a model drug.

Invited Lecture

Recent Publications

Prusty K, Swain SK (2017). Nano Silver Decorated Polyacrylamide/Dextran Nanohydrogels hybrid composites for Drug Delivery Applications. *Materials Science and Engineering: C*. (Accepted).

Sethy PK, Prusty K, Mohapatra P, Swain S K (2017) Nanoclay decorated polyacrylic acid/starch hybrid nanocomposite thin films as packaging materials. *Polymer Composites*.DOI:10.1002/pc.24636.

Sarkar N, Sahoo G, Das R, Prusty G, Swain S K (2017) Carbon quantum dot tailored calcium alginate hydrogel for pH responsive controlled delivery of vancomycin. *European Journal of Pharmaceutical Sciences*. *109*: 359-371.

Sahu D, Sarkar N, Sahoo G, Mohapatra P, Swain S K (2017) Nano silver imprinted polyvinyl alcohol nanocomposite thin films for Hg^{2+} sensor. *Sensors and Actuators B: Chemical*. *246*: 96-107.

Sahoo G, Sarkar N, Sahu D, Swain SK (2017) Nano gold decorated reduced graphene oxide wrapped polymethylmethacrylate for supercapacitor applications *RSC Advances*. *7*: 2137-2150.

Prusty K, Swain SK (2016) Nano $CaCO_3$ imprinted starch hybrid polyethylhexylacrylate\polyvinylalcohol nanocomposite thin films. *Carbohydrate Polymers*. *139*: 90-98.

Basiruddin SK, Swain SK (2016) Phenylboronic acid functionalized reduced graphene oxide based fluorescence nano sensor for glucose sensing. *Materials Science and Engineering: C*. *58*: 103-109.

Key words: *Polysaccharide; hybrid polymer; drug delivery*

Invited Lecture

IL-10: Biocompatible electrospun nanofiber scaffolds for antibacterial and sustained drug release

Gajanan K. Arbade and T. Umasankar Patro*

Department of Materials Engineering, Defence Institute of Advanced Technology, Pune-411025, Maharashtra, India

*Correspondence: umasankarp@diat.ac.in, uma.patro@gmail.com

Sustained drug release using biocompatible polymer based nanofiber scaffolds is an efficient way to administer drug molecules to the target for instance in wound and tissue healing [1]. Scaffolds have also been investigated for regeneration of tissue and bone using biodegradable polymers [2-4]. For this, electrospinning is a facile pathway to incorporate various drug molecules into a biocompatible polymer matrix. The technique provides high surface area, 3D network and porosity for controlled drug release, better tissue growth and cell adhesion.

In this talk, a broad overview of our recent efforts on biocompatible polymer based electrospun fibers for antibacterial and drug delivery will be discussed. Polycaprolactone (PCL) was used as a carrier polymer because of its biocompatible and biodegradable properties. Various antibacterial agents; namely, chloramphenicol (CAP), an antibacterial drug and *Emblica officinalis* (EO), extracted from natural product are incorporated into PCL electrospun nanofibers. The fiber diameter was found to be increased with increase in CHL content. The CAP and EO-incorporated PCL nanofiber scaffolds showed more hydrophilic behaviour than their pristine scaffolds, facilitating better cell adhesion. *In-vitro* drug release studies were carried out in phosphate buffer saline at pH~7.4. Both EO and CAP-loaded PCL nanofiber scaffolds showed excellent antibacterial properties against both gram positive as well as gram negative bacterial strains. The composite nanofiber scaffolds were further used for cellular biocompatibility, adhesion, growth and cytotoxicity studies, against HCT 116 cells *in vitro*. Furthermore, efforts were made to increase the hydrophilicity of PCL by blending with polyethylene glycol.

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Invited Lecture

IL-11: "Characterization and Application of Cellulose Nano Crystal Incorporated Polylactic Acid Films for Low Temperature Preservation of Prawns (*Metapenaeus Dobsoni*)".

Bindu J*, Satyen Kumar Panda* and Vimal Katiyar[#]

**ICAR- Central Institute of Fisheries Technology, Cochin, India*

[#]Indian Institute of Technology, Guwahati

Email: bindujaganath@gmail.com

Abstract

Packaging films developed by dispersing 1% and 2% (w/w) cellulose nanocrystals (CNC) in polylactic acid (PLA) matrix along with sulphuric acid, hydrochloric acid and dicumyl peroxide as cross linking agents were evaluated for physical and mechanical properties. The characteristics of six different PLA films with varied combinations of CNC and crosslinking agents and neat PLA were determined. PLA films with 1 and 2% CNC using sulphuric acid and PLA film with 1% CNC with sulphuric acid and dicumyl peroxide (DCP) exhibited higher tensile strength and heat seal strength compared to PLA films manufactured with 1 and 2% CNC and hydrochloric acid. The water vapour transmission rate was higher for PLA/CNC films prepared with sulphur acid when compared to films prepared using HCl. The FTIR spectra and surface characteristics were determined using SEM. For evaluating the films for food packaging, the PLA films were made into pouches and 100g peeled prawns were packed into neat PLA, 6 different types of PLA films and LDPE as control. The packed prawns were stored under chilled (1-2°C) temperature by interlaying with ice in PUF insulated containers. Microbiological and biochemical parameters were estimated at regular intervals of 5 days for shelf life evaluation. The mesophilic count of samples packed in PLA films prepared using HCL and DCP were marginally acceptable up to 20 day of chilled storage whereas PLA films with 2% CNC prepared using sulphuric acid were acceptable even after 20 days of chilled storage. Antimicrobial properties of the films were also estimated against different microorganisms. The total volatile base nitrogen content of the prawns did not exceed limits during the period of storage in any of the films. The changes in free fatty acid content which determine hydrolytic rancidity showed that samples packed in PLA/2% CNC with sulphuric acid and neat PLA exhibited lowest values. The different PLA films were found suitable for storage of peeled prawns and hence can be used for packaging of food products.

Invited Lecture

IL-12: Amino Acid/Peptide Containing Alternating Copolymers

Priyadarsi De[a,b,c]

[a]Polymer Research Centre, [b]Centre for Advanced Functional Materials, [c]Department of Chemical Sciences, Indian Institute of Science Education and Research Kolkata, Mohanpur-741246, Nadia, West Bengal, India

E-mail: p_de@iiserkol.ac.in

Abstract

Alternating copolymers are synthetic macromolecules, where monomer units of different chemical nature are arranged along the polymer chain in an ordered fashion. Monomer sequence is strictly maintained in many biomacromolecules such as DNA, RNA and proteins, thus monomer sequence regulation plays a key role in biology, complex self-assembly, data storage and molecular recognition.[1-3] Recently, efforts have been initiated in developing complex synthetic polymers containing controlled monomer sequence throughout the polymer chain. In this regard, few novel strategies have been proposed in the literature for controlling sequences of monomers in chain-growth and step-growth polymerizations. In chain-growth polymerization, sequence regulation can be attained by using specific comonomer pairs consisting of an electron-donor monomer and an acceptor one. Herein, we have synthesized copolymers composed of *tert*-butyl carbamate (Boc)-protected D-alanine appended styrenic monomer (donor, **1**) and *N*-substituted maleimide monomer bearing L-alanine in the side chain (acceptor, **0**) *via* reversible addition-fragmentation chain transfer (RAFT) polymerization. The RAFT polymerization ensured targeted molecular weight of the polymers, narrow molecular weight distribution (dispersity (Đ)) and precise chain-end functionality. Characterization of the polymers by ^{13}C NMR spectroscopy confirmed that the monomers are copolymerized in an alternating manner to give a **01** sequence, because in these specific combinations of monomers, cross-propagation is favoured over homopropagation.

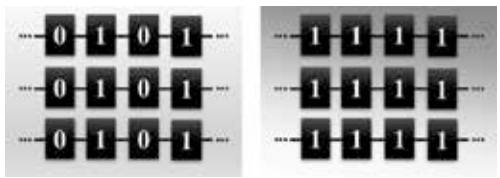

Figure. Precise monomer distribution in the polymer chains. Comonomer pairs (**0** and **1**) arranged in an alternating fashion (left) in the alternating copolymer. Distribution of monomers in homopolymer of styrenic monomer (**1**).

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Invited Lecture

IL-13: Self-Healing and Durable Bio-mimicked Interfaces

Uttam Manna*

Department of Chemistry, Indian Institute of Technology-Guwahati, Kamrup, Assam 781039, India

E-mail: umanna@iitg.ernet.in

Abstract

Bio-inspired (Lotus leaf), non-adhesive superhydrophobicity is well recognized for its ability to repel water extremely (advancing contact angle ≥150°) with a very low roll -off angle (≤10). The appropriate coexistence of chemistry (low-energy surface) and topography (hierarchical rough surface) confers this special wettability to the reported materials in literature. The perturbation in essential chemistry and topography in the artificial superhydrophobic material results in loss of extreme water repellency property. Generally, the hierarchical and rough topography (mostly made out of hydrophilic components) that topped with inert and low surface energy coating—provided the essential metastable trapped air in the synthesized materials to display the desired bio-inspired superhydrophobicity and resulted in the poor interfacial chemical interaction between the hydrophilic hierarchical topography and the top inert coating, and the synthesized materials found to be fragile for common physical manipulations and harsh chemical exposures, and appeared as a potential Achilles' heel of this widely practiced synthetic approach, and eventually restrict such materials from prospective applications at practical settings. To encounter such practical limitations, few elegant strategies are introduced to fabricate highly durable superhydrophobic materials, one of the most tempting approach is—self-healing of the lost wettability in the material on application of appropriate stimuli (heat, humidity etc.) to the damaged materials, mostly through re-association of inert chemical coating on top of hierarchical topography.

However, the attempts to develop material that can self-heal physically damaged interfaces are rare in the literature. In recent past, shape memory polymer was strategically used in recovering the damaged micro/nano features,—but only after application of appropriate external stimuli. In this current work, we have reported a superhydrophobic material—which is highly durable and capable of restoring the lost non-adhesive property through regeneration of essential topography—without requiring any external interventions. The material is developed through facile 1,4 conjugate addition reaction. This chemical approach is of potential interest in many fundamental and applied contexts.

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Invited Lecture

IL-14: Characterization of polymers -biopolymer using Small angle scattering techniques

Narayan Ch. Das*

Rubber Technology Centre, Indian Institute of Technology, Kharagpur, W.B- 721302, India. * Corresponding author, e-mail:ncdas@rtc.iitkgp.ernet.in

Abstract: This talk will be included to basic principle of SAS. We also give a review of application of small angle scatter (SAS), either X-ray or neutron (SAXS or SANS) for structural information's of polymers and biopolymers and phase behavior of polymer blends in the range of 1 nm to 100 nm. Nano filler dispersion and distribution in polymer nanocomposites can also be quantitatively investigated by SAS. We also review some recent works on characterization of polymer and polymer blends using both SAXS and SANS.

Keywords: *Polymers; Biopolymers; Small angle scattering*

Introduction

SASS unveils invaluable information about the nanoscale size and structural profile in the bulk of systems. As such SAS has been applied to topics in materials science including ranging from soft materials, phase behaviour of polymer blends, molecular self-assemblies, structure, size and size distribution of nanomaterials, size and structural characterization of micelles, gels, protein and virus, etc. One major advantage is the ability to determine a statistic ally significant bulk average particle size in the nanoscale of the order 1nm to over 100 nm with very small quantity (~60 mL) sample for the SAXS experiment. A vast number of scatters, e.g. over 105 can be probed in a single experiment with SAS whereas imaging such a number using microscopy would be inconceivable, even with the aid of image analysis software. Moreover, SAS can visualise the internal structure, such internal pore structure of porous materials.

Methods and Materials

Differernt polymer and polymer nanocomposites like polyethylene, polymer nanocomposites filled with carbon black, carbon nanotubes, graphene were prepared by solution and melt mixing techiques. Aligned carbon nanotube-polymer nanocomposites were synthezed to study the effect of anisotropic characteristic on polymerization. SAXS was performed in room temperature with a CuKα source (λ =1.54 Å) by using microfocused X-ray generator of GeniX3D (operates at 50kV and 0.60 mA, 30 W, Xeuss 2.0, Xenocs, France). The scattered X-ray were counted with the sample-to-detector distance of 2500 mm over scattering q range of 0.004 to 0.18 Å-1 ($q = 4\pi/\lambda \sin(\theta/2)$, where λ is the x-ray wavelength and θ is the scattering angle) by using a Pilatus 300K (D ectris) two-dimensional area detector. Silver Behanate with the first order scattering vector q = 0.1076 Å-1 was used as reference calibration purpose for circular average 1D SAXS data [1].

Result and Discussion

First we see how SAXS techniques are used to study anisotropic characteristic and structure of aligned carbon nanotubes array. For example, Fig. 1a-b shows SAXS spectrum and SEM images of a vertically aligned carbon nanotube (VACNT).

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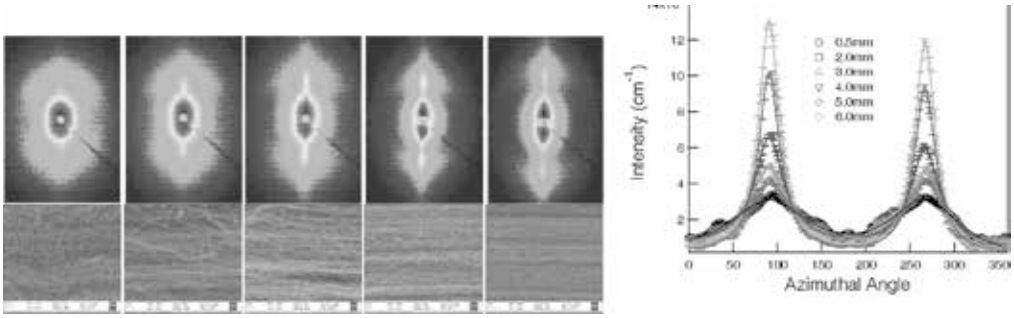

Figure 1a SAXS patter (top) and FESEM composites, Azimuthal scan from 2D spectrum of aligned CNT-polymr. The SAXS patterns show anisotropic, distinct higher cloud along y direction indicates alignment of CNTs. Scanning electron microscopy images also support similar behaviour of nanotube array. Fig. 1b shows the azimuthal scan of 2D SAXS patterns of same CNTs. The presence of peaks at ø = 900 and 2700 corresponds to alignment of the CNTs. The degree of alignment is quantitatively estimated by Hermans equation [2].

Second, how SAS is used to investigate early stage crystallization of polymers. Fig. 2 shows time resolve SANS pectrum of isothermal polymer crystallization in the solution. Quantitative analysis of the SANS spectrum provides differential structural parameters such as crystal size, lamellae stacking and long Third the application of SAS to investigate the size and structure of biomolecules 2 like capsid protein or virus and so on [4].

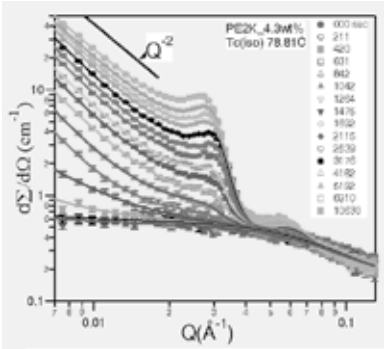

Figure 2: Time resolve SAS spectrum

Analysis of this SAXS spectra (Figure 3) gives a clear indication of size, size distribution of protein and RNA packing and their structure in the BMV and so on.

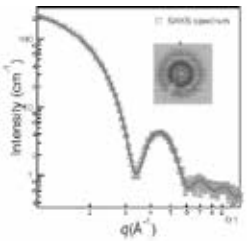

Figure 3: SAS spectrum for capsid protein

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Conclusions

SAS can be an unique and effecient ieal tool to characterize polymer and biopolymers in term of structure,size & size distribution, anisotropic characteristics of nanoand fiber materials, phase behaviour of polymer blends, crystallization of polymer and distribution of nanomaterials in polymer nanocomposites, so on.

Acknowledgements

Author thanks to the Science and Engineering Research Board (SERB), Department of Science and Technology (DST), Ministry of Science and Technology, Govt. of India (ECR/2016/000048) for financially supporting this work sincerely.

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Invited Lecture

IL-15: Depth-Resolved Structure Analysis of Polymer Thin Films by Grazing-Incidence Small Angle X-ray Scattering utilizing of Tender X-rays

Katsuhiro Yamamoto

Frontier Research Institute for Materials Science, Nagoya Institute of Technology, Gokiso-cho, Showa-ku, Nagoya, 466-8555, Japan

Corresponding author, e-mail:yamamoto.katsuhiro@nitech.ac.jp

Abstract: The intricate nanoscopic morphology of soft materials such as block copolymer and polymer blend system successfully analysed by small-angle X-ray scatterings (SAXS). In thin films, those soft materials system has attracted great attention because of a potential for practical use of functional materials. The morphology has been revealed by grazing-incidence (GI) methods. Recently, advanced grazing-incidence technique for analysis for surface-, volume-, material-sensitive method (high time-, spatial- and/or material-resolution) has been reported. Using low X-ray photon-energy, tender X-ray (1-4 eV) and soft X-ray near K-edge carbon, allows probing a complex nano-morphology with those sensitivity. In this work, recent GI-SAXS with tender X-ray will be picked up to open for discussion on depth-resolved structure (phase separated structures) analysis of block copolymer thin films.

Keywords: *grazing-incidence X-ray scattering, thin film, block copolymer, tender X-rays, depth-profiling*

Introduction

Block copolymer (BCP) thin films have attracted great attention as an applicable material for various fields, such as lithography technique, solar cells, photonic crystals and permselective membranes because they can self-assemble into periodic micro-phase separated structures. For practical application of BCPs, control of the structures and orientation of the micro domains is important. Additionally, it must be significant to visualize the structure near air/polymer or substrate/polymer interface and depth profiling of the structure in thin films. Neutron and X-ray reflectivity, X-ray photoelectron spectroscopy and secondary ion mass spectrometry measurements have been the most feasible ways to enable the depth profiling of the structures in thin films. Here, we introduce new method to reveal nanostructure dependent on the depth by means of GISAXS in tender X-ray region (relatively low energy ~ 2.5keV). In the case of low energy X-ray, the penetration depth of X-ray becomes smaller and controllable mechanically near the critical angle of X-ray so a higher depth-resolution can be anticipated.[1,2] Herein, BCP thin film forming cylinder structures oriented parallel to the surface (substrate) was investigated.

Methods and Materials

Polystyrene-*b*-poly (2-vinylpyridine) (S2VP-26k; Mn = 2.6×10^4, Mw / Mn = 1.26, fPS = 0.8) was used here. The S2VP-26k was dissolved in toluene (5wt%) followed by spin-coating at 3000 rpm for 30 s on a silicon substrate. The thin film was thermally annealed at 170˚C for 48h in vacuum. Low energy GISAXS measurement was performed at BL15A2 in Photon Factory, KEK, Tsukuba in Japan. Operating conditions of this research were at a X-ray energy of 2.4 keV (corresponding to the wavelength, 5.16Å) and sample to detector distance of about 830 mm. Pilatus 2M specified for use in vacuum was used as a detector of 2D scattering pattern. An incident angle of X-ray was varied between 0.29˚ and 0.62˚ to control a penetration depth of X-ray.

Result and Discussion

Penetration depth K of X-ray is defined as the depth where X-ray intensity is attenuated by 1/e. The K depends on X-ray energy (in other words, wavelength κ), the critical angle, c, of total reflection, and the incident angle, i, which is defined hereafter as an angle between incident X- ray and the surface for convenience. The K under experimental conditions is given by

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where α is the imaginary part of complex refractive index. The critical angle, χ (deviation from the real part of the refractive index) andαα =are√given2 by(2)

$$\Lambda = \frac{\lambda}{4\pi}\sqrt{\frac{2}{\sqrt{(\alpha_i^2-\alpha_c^2)^2+4\beta^2}-(\alpha_i^2-\alpha_c^2)}} \quad (1)$$

where β is the imaginary part of complex refractive index. The critical angle, δ (deviation from the real part of the refractive index) and β are given by

$$\alpha_c = \sqrt{2\delta} \quad (2)$$

Figure 1 shows calculated penetration depth K of S2VP. it can be seen that the K changes gradually near the critical angle and the depth over the critical angle is shallow as the X-ray energy decreases. Therefore, since the critical angle and the attenuation coefficient are much larger than those for hard-X-rays, better control of the K is expected for depth resolved GISAXS measurements in case of tender X-ray (2.40 keV).

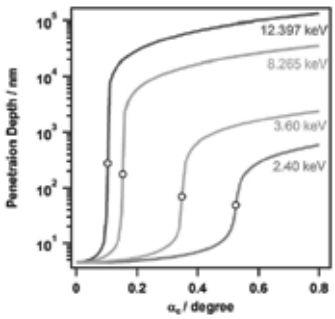

Figure 1 Penetration depth calculated for the present S2VP film depending on X-ray energy, 12.397 (blue), 8.265 (green), 3.60 (orange) and 2.40 (red) keV. Symbols represent the penetration depth at the α_c.

Figure 1 Penetration depth calculated for the present S2VP film depending on X-ray energy, 12.397 (blue), 8.265 (green), 3.60 (orange) and 2.40 (red) keV. Symbols represent the penetration depth at the c.

Lattice parameters of the cylindrical microdomains at each penetration depth were determined. The cylinder lattices normal to the substrate and along lateral direction were found to be narrowed and elongated as compared with the value in the bulk state of S2VP-26k, respectively. Moreover, this deformation was relaxed as the depth was shallow (near the surface) except that the parameters in the lateral direction were almost unchanged as shown in Figure 2

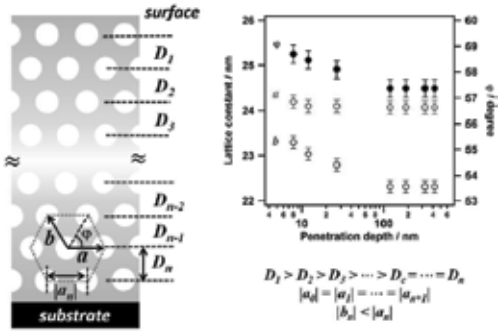

Figure 2 Lattice parameters plotted against the penetration depth. Inset represents the unit cell of the cylindrical microdomain in real space. *n* direction is normal to the surface.

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Conclusions

We demonstrated GISAXS measurement with low energy X-ray to a BCP thin film whose micro-phase separated structure was hexagonally packed cylinder oriented parallel to the substrate. Non-destructive and low energy GISAXS method enabled depth-resolved analysis of the periodicity and deformation of the hexagonal packing along not only depth direction but also lateral direction and deformation of the hexagonal packing. FWHMs of the Bragg spots at each incident angle can be used for confirming a depth-resolved analysis. The theoretical FWHMs dependent on depth were calculated by the Laue function with an attenuation decay of the X- ray intensity. Comparison of the theoretical FWHMs with the experimental ones lead that depth-resolved structure analysis was successfully achieved. It was revealed that the hexagonal lattice of the cylindrical microdomains deformed along depth direction inside of the film and the deformation of the lattice was more relaxed in the vicinity of the air/polymer surface. The relaxation near the surface is associated with a higher mobility of polymer chains near the surface. GISAXS utilizing tender X-rays is useful and effective way to investigate the depth dependent nanostructure of thin films. Depth dependent ordering and orientation behavior related to the dynamics of the microphase separated structure will be analyzed. Namely, a mechanism of those phenomena near the surface will be discussed and revealed.

Acknowledgements

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Invited Lecture

IL-16: Innovative Treatment Technology for Improving the Quality of Plastic Granules Produced From Recycled Waste Plastics

Harsh Jadia and Dr. Deepali Jadia

drharsh@errl.co.in and drdeepali@errl.co.in

Enviro Remediation & Research Laboratory (ERRL), Mumbai

Abstract:

To mitigate the impact of plastic waste urgent disposal and recycling becomes indispensable. In India, out of 908 KTA total plastic waste generated about 570 KTA (63%) post consumer plastic waste leads to recycling. Safe procedures have been devised to turn plastic scraps into productive items. Reprocessed plastic granules produced by trusted manufactures stress on quality and sell their products at competitive prices to the customers. However, waste plastic contains plenty of dirt and other organic impurities and during the process of recycling, these components mix with plastic leading the poor quality of plastic granules. Our technology addresses this challenge and removes impurities as well as bad smell from waste plastic, making it suitable for recycling. It increases the quality of recycle plastic granules leading to a commercially viable solution to waste plastic. Therefore, our innovative treatment technology provides complete cleaning of the plastic scraps prospecting into good quality granules with significant increase in its market value for recycle plastics.

Keywords: Plastic waste, Recycling, Quality, Innovative treatment technology

Invited Lecture

IL-17: Color Tolerances /Pass Fail Methodology and Appearance

Subhash Naik

Datacolor Solutions Pvt. Ltd. Mumbai

We will cover two topics namely Color Tolerances /Pass Fail Methodology and Color and Appearance. Normally the question in front of us is what are the tolerances to be set/specify and which is the color equation to select which will minimize my rejection due to color variation. This will be explained in the first topic.Irrespective of selecting the correct color equation and perfect tolerance set, in some cases the color difference is very low and well fit in the tolerance limits but the color appears different and nonacceptable. This will be explained under the topic color and Appearance.The points which are covered are as below.

1) Color Tolerances /Pass Fail Methodology.

Defining Tolerances.

Different ways to specify the tolerances using colorometric data.

CMC ,CIE1994, CIE 2000 Color difference equations.

Artificial Tolerances. The purpose of Artificial Tolerances.

2) Color and Appearance

Defining Color and Appearances.

Limitations of visual color assessment.

Influence of Gloss, Haze , Opacity on Appearance.

Types of Instrument geometry suitable to measure the Color and Appearance.

Invited Lecture

IL-18: Glycopolymer Grafted Nanoparticles: A Step towards the Development of Vaccine

Tushar Jana
School of Chemistry, University of Hyderabad, Hyderabad
E-mail: tusharjana@uohyd.ac.in

The weak binding between carbohydrates and proteins is a major constraint towards the development of carbohydrate-based therapeutics. To address this, we have developed a method for the synthesis of glycopolymer (GP) grafted nanoparticles by using Reversible Addition Fragmentation Chain Transfer (RAFT) polymerization through in-situ/grafting from approach using a multistep process. GP chains of various lengths with controlled molecular weight and narrow polydispersities were grown on the RAFT agent anchored nanoparticle surface using various type of glycomonomer. Spectroscopic (FT-IR, NMR) and thermogravimetric studies confirmed the grafting of glycopolymer chains on the nanoparticle surface. The mean diameter of the glycopolymer grafted nanoparticles (GP-g-NPs) can be readily tuned by altering the chain length, type of nanoparticles and the type of glycomonomers used in the polymerization feed. Hydrolysis of nanoparticle cores using aqueous HF enabled characterization of cleaved polymer using GPC and the obtained unimodal chromatogram and narrow PDI confirmed that the polymerization proceeded through RAFT mechanism. GP-g-NPs displayed stronger binding to the carbohydrate specific lectin such as Concanavalin A owing to the larger positive binding entropic contribution which resulted in an association constant that is 800 and 400-fold stronger than that of monomeric carbohydrate and GP chains, respectively.

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Invited Lecture

IL-19: Starch and cellulose based films for food packaging and drug delivery applications

R. Anandalakshmi

Advance Energy & Materials Systems Laboratory (AEMSL), Department of Chemical Engineering, Indian Institute of Technology Guwahati, Assam-781039.

Email address: anandalakshmi@iitg.ernet.in

Abstract

In our laboratory, a series of bionanocomposite films were produced from different starch sources with different amylose-amylopectin ratios (potato starch, 20:80; wheat starch, 25:75; corn starch, 28:72 and high amylose corn starch, 70:30). Different starch sources were blended with either carboxyl methylcellulose (CMC) or chitosan (CH) and nanoclay (Na-MMT) to produce bionanocomposite films. It was observed that molecular structure of amylose-amylopectin and their molecular space influenced in strong interaction with CMC or CH and nanoclay. Also, it was inferred that amylose-amylopectin ratios affect the tensile strength, film solubility, water vapour permeability and glass transition temperature. The prepared bionanocomposite films showed antifungal property for at least 15 days when bread samples were packed at 25°C and 59% RH.

We also investigate to gain fundamental knowledge in producing hydrogel films by two ether cellulose derivatives such as sodium carboxymethyl cellulose (NaCMC) and hydroxylpropyl methylcellulose (HPMC) using citric acid (CA) as crosslinking agent for drug delivery applications. It was found that molecular weight of HPMC and CA concentration influenced swelling degree in NaCMC-HPMC based hydrogel films.

Invited Lecture

IL-20: Synthesis and characterization of functional polylactides consisting of L-lactyl and D-lactyl segment

Kazunari MASUTANI *, Masaki YAMAMOTO,
Yoshiharu KIMURA, Hideki Yamane
Kyoto Institute of Technology, Kyoto 606-8585, Japan
* Corresponding author, e-mail:kzn16@hotmail.com

Introduction

Among the biobased polymers developed, Polylactides (PLA) has been the most widely used in many fields. To expand utilization of PLA, high-performance and specialty PLA can be designed and synthesized by controlling structure and properties of PLA. Stereoblock polylactides (sb-PLA) having PLLA and PDLA block sequences show only sc crystallization at different PLLA/PDLA compositions. To synthesis functional PLA having excellent cost-property balance, we selected telechelic oligo(L-lactic acid) (OLLA: L-lactyl segment) and oligo(D-lactic acid) (ODLA: D-lactyl segment) having hydroxyl terminals as new building blocks. Lactyl segment can be prepared by the direct polycondensation from lactic acid and diol or ring-opening polymerization (ROP) of lactide using diol as an initiator. In this presentation, flexible segmented PLAs having the different segment lengths were synthesized by the chain-extension reaction of a mixture of lactyl segment and polyester-polyol with a diisocyanate.

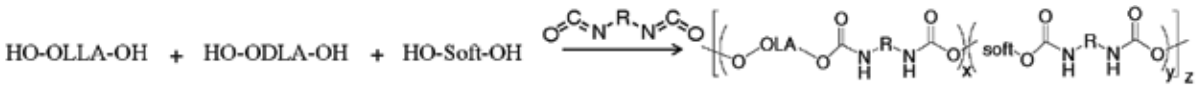
Methods and Materials

L- and D-lactyl segment having Mn = 3500 and 5000 were synthesized by ROP of L- and D-lactide using dodecamethlene glycol (DMG) as an initiator. Then flexible segmented PLAs having the different segment lengths were synthesized by the chain-extension reaction of a mixture of lactyl segment and soft segment polyol with a diisocyanate as shown Scheme 1. We selected poly(1,2-propyleneladipate) (APG) and polyethylene glycol (PEG) as soft segment polyol.

Result and Discussion

D- and L-lactyl segments having Mn of 3500 and 5000 were synthesized by controlling the feed ratio of monomer and initiator. Flexible segmented PLAs were synthesized by the chain-extension reaction of a mixture of lactyl segments and polyester-polyol with HMDI. Table 1 shows typical results of synthesis and thermos-mechanical properties of flexible sb-PLAs consisting of D- and L-lactyl segment and soft segment polyol using APG and PEG. The obtained flexible segmented sb-PLA samples are differentiated by the code names DLXk-Y (Z%) where X represent the Mn values in kDa of lactyl segment, and Y denotes APG or PEG.c The Z in the parenthesis corresponds to the percent composition of PLA in the copolymer. Therefore, DL5k-APG (80%), for example, consists of D- and L-lactyl segment block of 5 kDa in Mn and APG. The molecular weights of the obtained flexible segmented sb-PLA were increased compared to those of each prepolymer. It was indicated that the obtained segmented sb-PLA preferentially formed sc crystals and that their Tm reached about 190 ºC. The tensile test of the segmented sb-PLA films revealed that the elongation of the obtained samples using APG was increased as increasing the feed ratio of APG as a soft segment, while those of the obtained samples using PEG was decreased as increasing the feed ratio of PEG because of the crystallization of PEG.

Invited Lecture



Scheme 1. Synthesis of segmented polylactides by chain extension of lactyl segments and polyols

Table 1. Typical results of synthesis and thermos-mechanical properties of flexible sb-PLAs.

Sample	Mn [a] ×10³	Mw [a] ×10³	PDI[a]	Tm °C	$Xc_{(PLA)}$ %	Elongation at break %	OLA/(APG or PEG) wt%
DL5k-APG (100%)	50.6	143	2.8	197.2	53.5	10.3	100
DL5k-APG (80%)	29.7	59.1	2.3	199.6	42.9	29.1	80
DL5k-APG (50%)	37.3	89.1	2.4	197.7	29.8	118.4	50
DL5k-APG (33%)	56.8	206	3.6	186.8	17.1	710.1	33
DL5k-APG (20%)	60.5	206	3.6	193.7	13.2	960.4	20
DL3.5k-PEG (80%)	27.0	262	3.2	191.1	47.9	101.6	80
DL3.5k-PEG (50%)	-	-	-	194.5	31.4	13.3	50
DL3.5k-PEG (33%)	-	-	-	189.9	19.3	10.3	33

Invited Lecture

IL-21: Fabrication of nanostructures through self-assembly of non-ionic amphiphiles for biomedical applications

Sunil K. Sharma

Department of Chemistry, University of Delhi, Delhi 110 007, India

Abstract: Fabrication of self-assembled nanostructures with defined size and morphology represents a formidable challenge and thus, has gained tremendous momentum in research because of their potential applications in various biological systems. Herein, novel non-ionic amphiphiles using 2,2-di(prop-2-yn-1-yl)propane-1,3-diol as a core further functionalized with poly(ethylene glycol) monomethyl ether and alkyl chains were synthesized using a chemo-enzymatic approach. Surface tension and fluorescence measurements along with dynamic light scattering studies revealed that all of the amphiphilic systems spontaneously self-assemble in aqueous solution, which was further supplemented by cryogenic transmission electron microscopy. Effective encapsulation of hydrophobic entities like Nile red, nimodipine, curcumin and dexamethasone by these systems was observed. Comparative study with a standard excipient, Cremophor® ELP demonstrated that our nanocarriers exhibited superior/equivalent solubilization behavior for curcumin. Confocal laser scanning microscopy revealed efficient uptake of encapsulated dye in the cytosol and lysosomes of lung cancer cells. Study of cytotoxicity showed that the synthesized amphiphilic systems are non-cytotoxic at the concentrations studied. The release profile of encapsulated Nile red incubated with/without a hydrolase enzyme *Candida antarctica* lipase demonstrated that the dye is stable in the amphiphilic nanostructures in the absence of enzyme for up to 12 days, however, more than 90% release of the dye occurred in 12 days when incubated with lipase. The results advocate the potential of these nanostructures as prospective drug delivery vehicles.

Keywords: *non-ionic amphiphile, physico-chemical characterization, encapsulation, cellular uptake, cytotoxicity, enzymatic release*

Introduction

Confronted with the challenges of drug delivery such as low aqueous solubility of drugs, non-selective diffusion all over the body, short half-life in the bloodstream and high drug dosage, concomitant with the adverse effects associated with the current solubilizers used [1-4], research on biocompatible nanoscale drug delivery vehicles which are indispensable to mediate target specific deployment of drugs, holds substantial promise.

Among the many nano-structured drug delivery vehicles being studied, amphiphilic architectures have garnered considerable attention. Non-ionic amphiphiles have emanated as potential biomedical candidates and have witnessed tremendous research due to the limitations experienced by the ionic counterparts, particularly the cationic one [1,5]. Gemini surfactants, characterized by the presence of two hydrophilic head groups and two hydrophobic tails, linked by a rigid or flexible spacer, holds unique properties and rich self-assembly behaviour, as a result of which they have gained considerable attention as nano-carriers [6,7].

Methods and Materials

All the chemicals, dyes/drugs, solvents and immobilized *Candida antarctica* lipase (Novozym 435) used were obtained from Spectrochem Pvt. Ltd. (India), Sigma-Aldrich Chemicals (USA), Julich Chiral Solutions GmbH (Jülich, Germany), Fluka Chemie GmbH (Buchs, Switzerland). Pre-coated TLC plate (Merck silica gel $60F_{254}$) was used to monitor the progress of the reactions with visualization of the spots on TLC using cerric solution. Silica gel (100-200 mesh) was used for column chromatography. Benzoylated dialysis tubing (molecular weight cut-off (MWCO) 2000 Da), procured from Sigma-Aldrich was used for the purification of amphiphiles. Millipore water used for preparing samples for physico-chemical characterization and transport analysis, was obtained from Merck Millipore Milli-Q Integral System. Cremophor® ELP was obtained from BASF, Ludwigshafen, Germany.

Invited Lecture

Results and Discussion

The amphiphilic architectures grafted with mPEG (M_n: 550/1000 g mol^{-1}) as hydrophilic moiety and *n*-alkyl chains (C-10/C-18) conjugated with aromatic moiety as hydrophobic units, were synthesized by following the Novozym 435 catalyzed chemo-enzymatic approach followed by copper catalyzed "1,3-dipolar cycloaddition reaction" (**Figures 1a** and **1b**).

All the amphiphiles exhibited a low critical aggregation concentration in the order of 10^{-5} M. The estimated assembly dimensions of the dominating nanosized species in the aqueous solution ranged from 6-19 nm. Cryogenic transmission electron micrograph (**Figure 1c**) for amphiphile **3** showed a population of micellar assemblies with a diameter of 8 nm, with some of them having discoidal morphology.

Amphiphile **3** exhibited highest transport efficiency for Nile red (5.79 mg g^{-1}), nimodipine (22.86 mg g^{-1}) and curcumin (41.66 mg g^{-1}). However, for dexamethasone encapsulation, amphiphile **1** was found to be the best candidate (transport efficiency: 17.33 mg g^{-1}). Dynamic light scattering study showed that there was no significant change in size after encapsulation of the hydrophobic guest molecules.

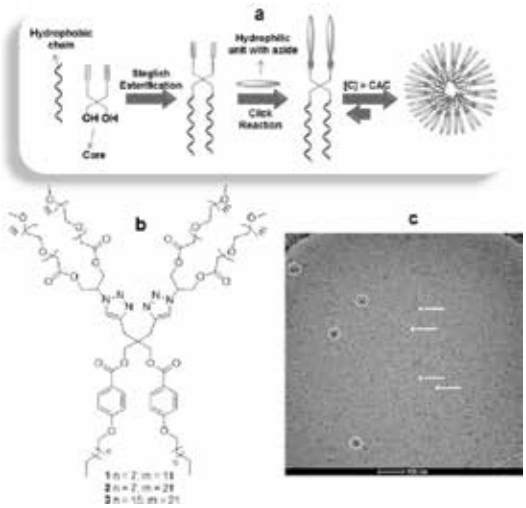


Figure 1. (a) Synthetic approach and self-assembly of the amphiphiles in aqueous media. (b) Synthesized amphiphiles. (c) Cryo-TEM image of amphiphile **3**.

Comparison of curcumin encapsulation by Cremophor® ELP with that of the amphiphiles **1**-**3** revealed that the drug encapsulation was comparable/higher in the latter. The confocal laser scanning microscopy images (**Figure 2**) revealed that the dye encapsulated in amphiphiles **1** and **3** could be internalized into the cells and that the fluorescence intensity was increasing over time indicating a continuous uptake of the encapsulated dye and accumulation.

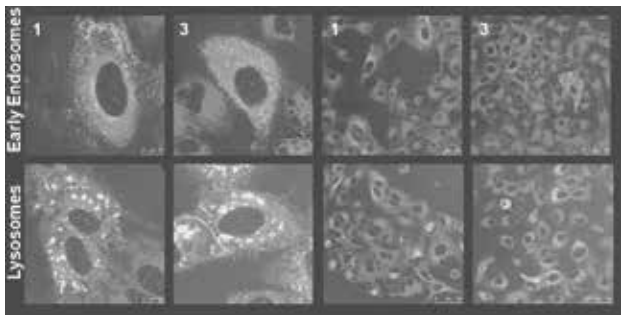


Figure 2. Confocal laser scanning fluorescence microscopy images from A549 cells after 5 h incubation with Nile red encapsulated by amphiphiles **1** and **3**.

Invited Lecture

The cytotoxicity study unveiled that all the developed systems exhibited nearly no cytotoxicity even up to the highest concentration tested. In the presence of enzyme, the intensity of the pink colour of the Nile red encapsulated solution of amphiphile **3** diminished with time. Approximately 50% decay in the intensity occurred after 54 h and it was possible to have more than 80% release only after 120 h. However, in the absence of the enzyme, insignificant amount of dye was released.

Conclusions

Herein, a "greener" chemo-enzymatic method was used to synthesize non-ionic amphiphiles from biocompatible starting materials, *i.e*., mPEG and glycerol. Supramolecular aggregation in aqueous solution was observed, with CAC in the order of 10^{-5} M and DLS size in the range of 6-19 nm. Cryo-TEM study of the amphiphiles showed the formation of micellar assemblies. An enhancement in the encapsulation potential for Nile red, nimodipine and curcumin was observed with increase in the hydrophobic content of the amphiphilic systems. The encapsulation of hydrophobic entities did not result in a significant change in the size. A comparison of the synthesized nanocarriers with standard excipient revealed that the developed systems have higher or equivalent solubilization for curcumin. Efficient uptake of encapsulated dye in the cytosol and lysosomes of lung cancer cells was shown by confocal microscopy indicating, that the amphiphilic systems can transport drugs into cells. The cytotoxicity profile obtained from MTS assay unraveled that the synthesized amphiphiles showed negligible cytotoxicity at the tested concentrations. The enzyme-triggered release profile of the encapsulated dye revealed that approximately 50% decay in the fluorescence intensity occurred after 54 h in the presence of the enzyme with more than 90% release taking place in 12 days. Insignificant Nile red release occurred in the absence of enzyme. This study may facilitate further development of optimized amphiphiles as nanocarriers for biomedical applications.

Acknowledgement

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Invited Lecture

IL-22: Nano-bio interactions dependent optimization of polymeric nanoparticle design for PLK1 siRNA delivery

Neetu Singh

Centre for Biomedical Engineering, Indian Institute of Technology-Delhi, New Delhi, India.

sneetu@iitd.ac.in, +91-11-2659-1422

Abstract

Polo-like-kinases 1 (PLK1) is a serine-threonine protein kinase that is over expressed in a number of cancer types and is known to be involved in inducing resistance to certain chemotherapeutic drugs. Though few PLK1 inhibitors are under clinical trials, their efficiency is limited by the poor bioavailability and off target effects. Therefore, a more specific approach using RNAi technology is now under consideration for downregulation of PLK1. We demonstrate the design optimization of an efficacious poly-N-isopropylacrylamide (pNIPMAm) based polymeric nanoparticle system, for delivery of PLK1 siRNA. Firstly, the polymer composition of the nanoparticles was optimized for overcoming the premature release of siRNA from the thermoresponsive pNIPAm nanoparticles (LCST=~32°C), by incorporation of a more hydrophobic comonomer, N-isopropylmethacrylamide (NIPMAm). pNIPMAm nanoparticles (LCST=~45°C) were biocompatible, able to retain and protect siRNA in biological milieu, exhibited endosomal escape ability and were also able to knockdown the PLK1 gene in a cervical cancer cell line, HeLa. Secondly, considering the series of events that take place after entry of siRNA into the cytosol, we probed the interaction of siRNA loaded nanoparticles with the core of RNAi machinery, argonaute 2. Taking into account, a) the similarity between the siRNA-RNAi machinery and the enzyme-substrate interactions and b) the size of the nanoparticles and the RNAi machinery, nanoparticle deformability and size was optimized. Towards this, pNIPMAm nanoparticles, varying in size (small vs large) and deformability (soft vs hard) were synthesized, an in-house assay for evaluating the nanoparticle-AGO2 interaction was developed and their knockdown efficiencies were compared. Based on these studies, small and soft pNIPMAm nanoparticles were observed to have better interaction with the AGO2 protein as well as were efficient in PLK1 gene knockdown.

Invited Lecture

IL-23: Conversion of Paper Industry Fibrous Waste to Value added Sustainable Polymers

Umesh Bhardwaj*, Sila Ponnappan and Manoj Gupta
R&D Centre, Bank Note Paper Mill India Pvt. Ltd., Mysuru, India.
*Speaker & Corresponding author.
Email: umeshbhardwaj@bnpmindia.com ; b.umesh@alumni.iitg.ernet.in

Abstract

To upgrade the technology for the human benefit has resulted to a blindfolded approach towards the environment. Advancement in technology leads to a better luxury/comfort, compromising with the environment and earth. Paper industry is one of the contributors to above effect producing millions of tonnes of paper every year with disposing of thousands of tonnes of waste in landfilling and disposal in water bodies. Various measures may be taken to avoid the pollution created by the industry like mandatory zero discharge projects, solid waste to be utilized for secondary usage, liquid waste to be either recycled or sent to other small scale industries after treatment. Fibrous waste including fibres from pulp mills and paper mills can be used for the manufacture of value added sustainable polymers mainly cellulose derivatives like cellulose nanocrystals and carboxyl methyl cellulose. Cellulose nanocrystals is the focus of the present era researchers due to better mechanical, optical, rheological properties etc. These nanocrystals are the excellent fillers to produce nanobiocomposites for high strength materials, food packaging etc. Carboxyl methyl cellulose is one of the main materials for detergents & toothpastes, food, pharmaceutical, paper industries. This material produced from the fibrous waste can be used as one of the input chemical as a carrier for wet strength resin in the paper industry. Applications for the above value added sustainable polymers are not limited but are to be explored further.

Keywords: Paper Industry, Fibrous Waste, Cellulose Derivatives, Cellulose Nanocrystals, Carboxyl Methyl Cellulose.

Invited Lecture

IL-24: Dyeing Fabrics by Using Extracts from Mulberry Branch/Trunk

YASUNAGA Hidekazu; NGUYỄN Thị Kim Thu; KURODA Akihiro; URAKAWA Hiroshi
Department of Fibre Science and Engineering, Kyoto Institute of Technology, Kyoto, Japan

1. Introduction

Mulberry (Morus) trees belonging to the family of Moraceae are important plants that have been used for sericulture to produce silk fibres as it is generally well known. The leaves, fruits and root barks of mulberry trees have long been used widely in the field of silk production, food industries and medicines. On the other hand, the great mass of them are treated as industrial wastes. The exploitation and development of novel sustainable dyestuff materials and the effective utilization of industrial wastes are very important to establish a sustainable society and achieve environmental preservation. Under such the situation, the authors tried to dye fabrics with mulberry extracts in the study. The dyeability of the extracts from mulberry branches and trunks for natural and chemical fibres such as wool, silk, cotton, ramie, nylon, acrylic and polyester fabrics was investigated as a first step in the study. The properties of the mulberry extracts were also examined.

2. Results and discussion

Brown powders were obtained by the extraction with water. The dyeability of the mulberry extracts for silk, cotton, ramie, nylon, acrylic and polyester fabric in addition to wool was examined. The results show that acrylic and polyester are not dyed at all, cotton and ramie are dyed a little (actually almost not), whereas silk and nylon are dyed with the mulberry extracts, as well as wool. The photographs of the wool, silk and nylon fabrics before and after the treatment with the mulberry extracts are shown Fig. 1. The wool is dyed light yellowish ocher, silk is dyed yellowish brown and nylon is dyed vivid yellow as shown in the Figure. The dyeable three fibres have charges and amide bonds in their molecular chains in common. The results show that the dyeabilities are due to such the chemical characteristics and higher ordered structures of the fibres. In fact, the fibres are dyed with acid dyes and their dyeability against a sort of dye molecules is very similar. It is known that morin, isorhamnetin, kaempferol, quercetin and myricetin show fluorescence, when they form a complex with Al^{3+}. If such the flavonols that have 3-hydroxyl and 4-carbonyl groups would be contained in the mulberry extracts, they could show fluorescence with the addition of $AlCl_3$ into their solution.

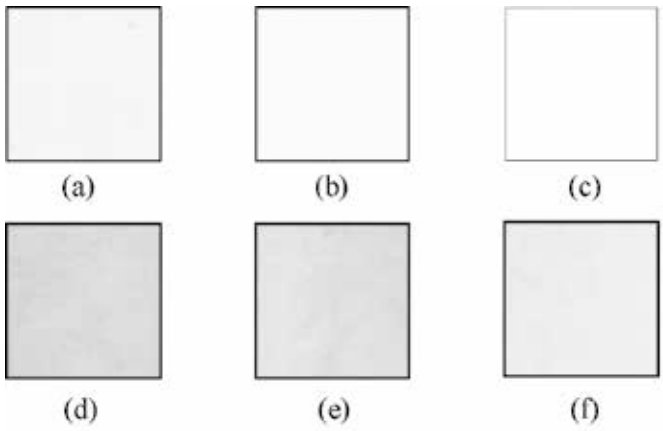

Fig. 1 Photographs of the wool (a and d), silk (b and e) and nylon (c and f) fabrics before (a-c) and after (d-f) the dyeing with mulberry extracts solution. Conc. of mulberry extracts: 2.0 wt%, dyeing temperature: 40 °C, dyeing time: 3 h, pH: 6.5.

Invited Lecture

Fig. 2 shows the pictures of $AlCl_3$, mulberry extracts and mulberry/$AlCl_3$ extracts solutions, which are irradiated with UV lights, of which centre wavelengths (λ) are 312 or 365 nm. While no light emission is observed for $AlCl_3$ solution, mulberry extracts and $AlCl_3$/mulberry extracts solutions emit fluorescent light by the UV irradiation. It was found that more intense emission from the mulberry extracts solution is obtained with 312 nm UV irradiation (Fig. 2 (b)) than with 365 nm one (e), and the emission light colours from the mulberry/$AlCl_3$ extracts solution with 312 nm (c) and 365 nm UV (f) irradiation are different. The results show that the mulberry extracts may contain the flavonoids as mentioned above and they might contain also Al compounds or some other substances, which show fluorescence.

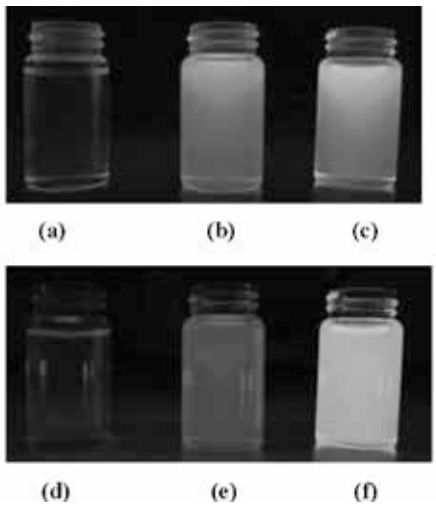

Fig. 2 Photographs of AlCl3 aqueous solution (a and d), mulberry extracts aqueous solution (b and e) and mulberry/$AlCl_3$ extracts aqueous solution (c and f). Samples were irradiated with 312 nm UV lights (a-c) and 365 nm UV lights (d-f).

Fig. 3 shows 3D fluorescence excitation-emission spectra for the mulberry extracts (a) and mulberry/$AlCl_3$ extracts (b) solution. The small signals found the spectra are Rayleigh scattering, half Rayleigh scattering and secondary Rayleigh cattering lights, and Raman scattering light from water. A highest emission for the mulberry extracts solution is observed with 310 nm excitation light as seen in **(a)** and the highest one for the mulberry/$AlCl_3$ extracts solution is detected with 310 nm excitation light as seen in **(b)**. Another second highest signal is detected for the mulberry/$AlCl_3$ extracts solution with 410 nm excitation light. It can be said that most intensive fluorescence emission from the mulberry solutions is made with 310 nm light. The relationships between the dyeing condition and the dyeability, and the fluorescence of the fabrics treated the mulberry extracts combined with Al^{3+} solution will be reported.

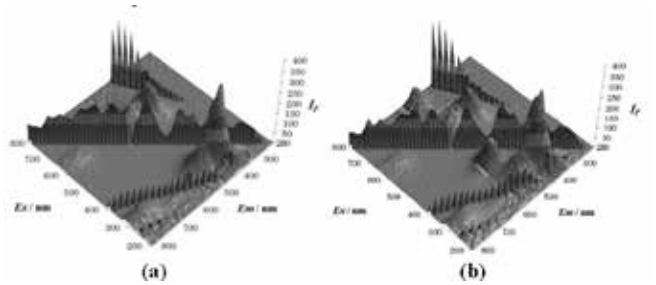

Fig. 3 The 3D fluorescence excitation-emission spectra for the mulberry extracts (a) and mulberry/$AlCl_3$ extracts (b) aqueous solution. E_x: excitation wavelength, E_m: emission wavelength, I_f: fluorescence intensity. Conc. of mulberry extracts for each solution: 1.0×10^{-2} wt%, Conc. of $AlCl_3$ for (b): 0.050 M, solution pH = 6.5 (a), ≈ 6.5 (b).

3. Reference

T. K. T. NGUYỄN; A. KURODA; H. URAKAWA; H. YASUNAGA, *American Journal of Plant Sciences*, 8, 1888-1903 (2017). DOI: 10.4236/ajps.2017.88128

Invited Lecture

IL-25: New Generation Polymer Composites

Kuruvilla Joseph

Department of Chemistry, Indian Institute of Space Science and Technology(IIST), Thiruvananthapuram, 695 547, Kerala, India. (Email: kuruvilla@iist.ac.in)

Microfibrillar in-situ composites are characterized by an isotropic thermoplastic matrix reinforced by fibrils of another thermoplastic material (dispersed phase) which are generated insitu during processing. Thus they are different from the conventional composites which are made by the blending of the constitutive components (matrix and fibre). MFCs are generally prepared by a three step strategy blending (mixing),fibrillization and isotropization.The third step is intended to create an isotropic matrix of the polymer with the lower T_m in which randomly oriented microfibrils of the polymer with the higher T_m is distributed. Since the matrix and the reinforcement are thermoplastic polymers and the reinforcements are generated insitu during the process they are also called insitu reinforced polymer/polymer composites. The morphology of the neat blends, microfibrillar blends (MFBs) and the corresponding microfibrillar composites (MFCs) based on low density polyethylene (LDPE) and poly ethylene terephthalate (PET) was analyzed. As the PET concentration increased, an increase in the diameter of PET fibrils was observed. The fibrils with relatively uniform diameter distribution were obtained in the range of 15 to 25 wt% PET concentration. The tensile properties of the blends and MFCs increased with PET concentration up to an optimum level. The neat blends exhibited inferior tensile properties in comparison with the MFCs. As the PET concentration increased, the solvent uptake reduced. The diffusivity and permeability of the MFCs were lower than the corresponding blends. The solvent uptake was found to be lowest for the composite with 25 wt% PET concentration. The PET microfibrils in the MFCs offered a tortuous path for the diffusion of the solvent.

Commingling is a cost effective way of mixing thermoplastic fibres with reinforcing fibres with good alignment. In commingled yarns the reinforcing fibres and matrix fibres are blended intimately at the filament level. In this study the properties of commingled Cotton/Polypropylene fibres were analyzed. Of the various treatments, modification with maleic anhydride modified polypropylene was most effective in increasing the tensile strength of cotton/PP commingled composite system. Thermal stability of the composite was found be intermediate between that of PP and cotton fibres. The theories of heterogeneous nucleation and crystal growth kinetics were used to explain the growth of transcrystalline layer of PP on cotton fibres. DMA analysis of cotton/PP commingled composites were carried out with reference to the fibre content, chemical treatments, processing conditions and applied frequency. The storage modulus and the glass transition temperature increased while the intensity of the damping peak decreased with the increase in fibre content. The chemical treatments with $KMnO_4$ and MAPP increased the value of storage modulus at all temperatures. Accelerated solar aging deteriorates the tensile strength and modulus. MAPP modified system was found to be more effective in resisting the deterioration of tensile properties.

The incorporation of nanofillers into epoxy matrix is gaining significant interest in the structural composite application, where strength, stiffness, durability, lightweight, design, and process flexibility are required such as in aerospace and automobile industry. The inherent brittle nature of the epoxy matrix can be improved by the incorporation of nanofillers in the matrix. The realization of nanofiller reinforced epoxies with high toughness requires a homogeneous dispersion and strong interfacial interaction between the nanofiller and the polymer matrix. In our work, the surface of multi-walled carbon nanotubes (MWCNTs) were modified by grafting with carboxyl terminated poly(acrylonitrile-co-butadiene) rubber (CTBN) and hydroxyl terminated poly(ethersulfone) (PES). Incorporation of PES and CTBN grafted MWCNTs in epoxy matrix composites imparted tremendous improvement in fracture toughness when compared to pristine and acid modified MWCNT/epoxy composites in addition to the improvement in mechanical characteristics. Similarly, CTBN and polyethylenimine(PEI) were grafted on to graphite oxide (GO) to prepare GCTBN and GOPEI in order to improve the dispersion and interfacial bonding between GO and epoxy resin in an epoxy/DDS system. Fracture toughness and tensile strength, improved remarkably for polymer grafted GO modified epoxy matrix.The surface morphology

Invited Lecture

revealed improved interfacial bonding between the filler/matrix. Therefore, polymer functionalized GO modified composites were able to carry higher level of loading during fracture. The viscoelastic properties also showed drastic improvement in modulus and T_g. In another work, TiO_2(B) nanowires (TiO_2(B)-NWs) were synthesized and characterized by XRD, and SEM and the influence of different morphologies of TiO_2 nanostructures on the mechanical performance of epoxy nanocomposites were thoroughly investigated. The TiO_2(B)-NWs shows the highest mechanical properties and comparable thermal properties when compared to TiO_2 nanoparticle. The optimum properties of this system are attributed to the particle shape or particle dimension that has been described by the aspect ratio wherein the elongated filler shows the highest aspect ratio hence improving the bonding between resin and filler.

Invited Lecture

IL-26: Polymeric Organic Framework as Potential Toxicant Remover from Drinking water

Rajan Kumar, Sayantani Bhattacharya and Raja Shunmugam

Polymer Research Centre, Department of Chemical Sciences,

Indian Institute of Science Education and Research Kolkata (IISER K),

Mohanpur-741 246

*E-mail id: polyraja@gmail.com

Contaminated drinking water is the prime cause that has raised the concern for the health hazard. Though the industrialization has improved the comfort to human life but the chemicals released from industries has been ignored over decades. Such chemicals are prime discomfort for human ecosystem. Therefore, preventive measurements from science society need to be enrolled for their removal. Initially, the non-biodegradable metal-organic hybrid materials such as Zeolite and Metal Organic Framework (MOF) were used vividly, but since past decade biodegradable Polymeric Organic Framework (POF) has geared its influence on its utility towards removal of such toxicants. Presence of toxicants in drinking water can interfere with the body metabolism. Therefore, their removal turned out to be most essential. Our group has been working on biodegradable, photo-clicked, non-toxic and highly efficient detoxifying remedial tool for purification. Rigorous effort is in progress towards enhancement of material strength with low solubility and controlled swellability. Architectural designed networks with and without functionalization is dependent on necessity. We have carefully designed the material functionalization that can trap the toxicants eliminated from industry (organic and inorganic). At initial stage, we have successfully prepared biodegradable functionalized organic to amphiphilic polymer network with high stress bearability via facile synthetic routes. The material marked itself as the prominent tool towards removal via physisorption for dyes, chemisorption for water soluble heavy metal ions (Hg^{2+}, Pb^{2+}, etc). Based on observation, our functionalized material could even remove hard water causing constituents like Ca^{2+} and Mg^{2+} along with Fe^{2+} present in ground water. Material developed for removal of fluoride and chloride via electrostatic interaction using ion exchange resin has worked quite efficiently. Further, efforts are in progress towards improvement of material in terms of synthesis and application.

We have successfully demonstrated that using our newly developed POF's, the organic dyes and non-degradable inorganic toxicants can be trapped significantly such that the water can be made drinkable.

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Invited Lecture

IL-27: Title: Microfluidics based fuel cells for low power applications

Dr. Ravi Kumar Arun, Scientist

CSIR-Central Mechanical Engineering Research Institute, Durgapur, West Bengal

Abstract

The growing demand to find alternative ways to meet the energy requirement of portable electronics and lab-on-a-chip devices has generated interest in the development of miniaturized power sources. In this context, the potential of microfluidics for energy generation is immense. Microfluidics involves structures where one of the dimensions is in the range of 1-1000 μm to control the fluid flow at low Reynolds number, i.e. laminar flow. This means that mixing by turbulence is minimized and the only remaining mechanism for mixing is diffusion. Fuel cells which convert the chemical energy of a fuel into electric power have emerged as an alternative means for energy production. However it requires constant feeding with a liquid fuel and also needs an ion-conducting membrane that prevents mixing of oxidant and reducing species, which has to be carefully placed to ensure optimal performance. The emergence of microfluidic fuel cells can produce electrical energy that can meet the power demands of current portable appliances. Miniaturized fuel cells offer several benifits over conventional methods, such as portability, faster mass transfer, and hence, a fast start up for rapid power generation, and higher power density. We have explored the potential of paper microfluidics in the development of durable, inexpensive and on-board energy generating devices. The solution is a simple, novel and inexpensive method to have on-board energy source for the low power applications. The stress of on- board energy source will be crucial for the microfluidic technology which can satisfy the requirements of high power density, low cost and disposability with minimum environmental impact.

Invited Lecture

IL-28: Water and salt dynamics in multilayer graphene oxide (GO) membrane: role of lateral sheet dimensions

Abhijit Gogoi, Tukhar Jyoti Konch, Kalyan Raidongia and Anki Reddy Katha
Departments of Mechanical Engineering, Chemistry and Chemical Engineering Indian Institute of Technology, Guwahati, Assam, India-781039.

Abstract

Dependence of salt rejection efficiency and water permeability of layered graphene oxide (GO) membranes on the lateral dimension of constituting sheets are studied through equilibrium molecular dynamic (MD) simulation and experiments. This study suggested that with increasing sheets dimension permeability of the GO membranes decreases but its selectivity increases. The velocity and permeation time of the water molecules are found to be dominated by the pore offset distance (W) of the membranes. The increasing W also increases the path length of the water molecules for permeating through the lamellar GO membranes. The ions permeability is also found to be dependent on W which is further confirmed by the experimental study. Based on the simple technique discussed in this work, one can construct GO membranes of required water permeability and salt rejection without the inclusion of any foreign nanomaterials inside the GO membrane.

Keywords: Multilayer GO membrane, water permeability, salt rejection, molecular dynamics simulation, pore offset distance.

Invited Lecture

IL-29: Thermoresponsive Imidazolium Compounds: Synthesis and Applications in catalysis

Nagaraju Pentela[1], Gayathri V[2], Debasis Samanta*[3]

[1-3]Polymer Science & Technology Department, CSIR-Central Leather Research Institute,Chennai, Tamilnadu-600 020, India.

[1-2]PhD student under Academy of Scientific and Innovative Research

*Debasis Samanta, e-mail:debasis.samanta@gmail.com

Abstract: In this article, we report the preparation of poly N-isopropyl acrylamide (NIPAM) tagged imidazolium comounds which can be used to generate N-heterocyclic carbenes for the generation of metal catalysts for Suzuki coupling reactions. The modified catalyst is easily recoverable by tuning the temperature of the reaction medium at above Lower Critical Solution Temperature (LCST) and reusable up to 5 cycles with minimal loss of catalytic activity. In this case, SET-LRP (Single Electron Transfer-Living Radical Polymerization) technique was used and the molecular weight of the polymer is controlled by tuning the monomer/initiator ratio. The synthesized polymer was characterized and confirmed by NMR (Nuclear magnetic resonance) and GPC (Gel permeation chromatography) techniques, X-ray powder diffraction, DSC (Differential Scanning Calorimetry).

Introduction

Thermoresponsive compounds like poly(N-isopropylacrylamide) (PolyNIPAAM) undergo physical change in response to external thermal stimuli. Particularly, poly(NIPAAM) becomes less soluble in water at elevated temperature. Lower Critical Solution Temperature (LCST) is the temperature above which poly(NIPAAM) undergoes from soluble to insoluble state in water. At this temperature, polymer chain shrinks into insoluble globular form exposing the hydrophobic part. This may be attributed to the dehydration of isopropyl side chains. This is particularly useful to prepare protein-polyNIPAAM conjugates and thermoresponsive nanoparticle-polyNIPAAM conjugates.

Imidazolium compounds are useful precursor for the preparation of N-heterocyclic carbenes. Those N-heterocyclic compounds can be conveniently used for immobilization to metal centres to prepare various catalysts for metathesis reactions, coupling reactions, polymerization reactions etc. These NHC (N-Heterocyclic Carbenes) ligands are particularly important because they are highly electron rich, more stable towards moisture, air and tolerate most of the functional groups, forms very strong bonds with the majority of the transition metals.[1] The electronic and steric factors of NHC ligands influence the catalytic activity in Suzuki coupling reactions. During the past two decades, many reports on the development of homogeneous NHC palladium catalyzed systems for Suzuki coupling reactions[2-4] can be found. Even though homogenous palladium catalytic systems are highly active; there are some challenges like catalyst recovery from the medium, purification of the end product without metal contamination and the loss of expensive metal complexes are very challenging. To overcome these drawbacks development of the heterogeneous catalytic systems are necessary due to their easy separation from medium and easy to recycle which in turn prevents the contamination of the ligand and decreases the environmental pollution caused by residual metals in the

reactivity than the homogeneous system. Several kinds of supported NHC-palladium metal complexes have been designed and reported like on silica,[5-8] zeolite, ionic liquid, grapheneoxide and polymer.[9-14] Out of different supported catalytic systems, polymer supported catalytic systems are more important due to easy handling, and recovery of the catalyst.

In this work, we present the synthesis of thermoresponsive imidazolium compounds by using proper initiator and monomer like NIPAM. In this case SET LRP reaction was used. From this, the N-heterocyclic carbene was prepared *in situ* and immobilized to palladium. This can be used as reusable and recyclable catalyst for various coupling reactions.

Invited Lecture

Methods and Materials

Palladium chloride ($PdCl_2$), 2,3-Dibromopropanol, 2,4,6-Trimethylaniline, Trimethylsilyl chloride (Me_3SiCl), 2-Bromo-2-methylpropionylbromide, Ammonium tetrafluoroborate (NH_4F_4), Acetic acid triethyl orthoformate($CH(OEt_3)_3$), Triethylamine (Et_3N), Copper(0), PMDETA, DMF, anhydrous dichloromethane DCM, N-isopropyl acrylamide (NIPAM), Ethanol, Phenylboronic Acid, Potassium carbonate, Idoacetophenone, Chloro acetophenone, Bromo acetophenone, 4-Idonitrobenzene, 4-Bromophenol, 4-IdoAnisole, 4-Bromobenzioicacid, 4-Idotoluene 4-Bromobenzaldehyde deuterated chloroform ($CdCl_3$)Chloroform-*D* were purchased from Aldrich, USA and used as received. All the solvents were purchased from Merck, India. Thin-layer chromatography was performed on Merck 60 F254 precoated silica gel aluminum sheets, visualized by exposure to UV (254 nm) or stained by iodine vapor. Column chromatography was performed by using silica gel (60-120 mesh) under nitrogen or air flash. NMR spectra were recorded at 400 MHz with Bruker Avance-III spectrometer. The following terminology was used for the NMR signals, s: singlet, d: doublet, t: triplet, q: quartet, m: multiplet, br: broad. TGA analysis was performed by using Q50, TA instrument with a heating rate 10 °C/min under N_2 atmosphere. DSC experiments were performed by using Netzsch DSC 214 Polyma with a heating rate 10 °C/min under N_2 atmosphere. GPC experiments were performed to measure the molecular weights using JASCO gel permeation chromatography (GPC), MX-2080-31 fitted with PL gel 5 µm Mixed-C columns, 300 X 7.5 mm and refractive index (RI) detector, in tetrahydrofuran with a flow rate at1 mL min^{-1} at 30 °C.

Result and Discussion

Scheme.1 represents the synthesis of poly(NIPAM) tagged NHC palladium catalyst for Suzuki coupling reactions. First Imidazolium alcohol **1a** was synthesized following the literature procedure. Esterification of alcohol **1a** with 2-bromoisobutyrylbromide in the presence of base trimethylamine afforded the NHC initiator **2a**. The initiator was purified by recrystallization method by using the mixture of solvents DCM/Diethyl ether. NMR spectroscopy confirmed the compound **2a**; the characteristic carbonyl peak at around 170 ppm in ^{13}C NMR and two methyl groups ($2xCH_3$) appeared in the range 1.84 to 1.87 ppm in ^{1}H NMR respectively. The two methene carbons were observed by DEPT-135 NMR, and the peak at -152.07 ppm in ^{19}F NMR represents the presence of counterion.

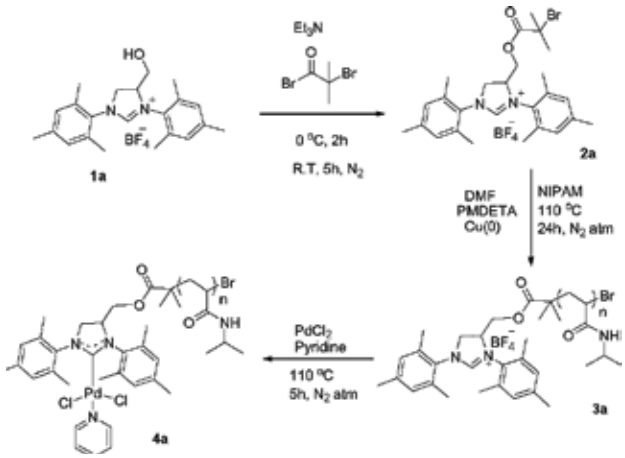
Initially, we tried atom transfer radical polymerization (ATRP) by using different solvents like methanol, water, and methanol-water mixture at different temperatures at 35 and 60 ºC in various molar ratios of initiator **(2a)** and monomer (NIPAM) by using Cu(I) as a catalyst. However, all the attempts were unsuccessful. Next we moved to SET-LRP polymerization method by using DMF as a solvent, Cu(0) as a catalyst, PMDETA as a ligand and NIPAM as monomer at 110 ºC. In all the cases polymerization was confirmed by ^{1}H NMR; appearance of broad peaks from 1.10 to 2.25 ppm clearly indicates the success of the polymerization **3a**. The synthesized polymer **3a** was purified by reprecipitation method by using the solvents like THF, diethyl ether.The number average molecular weight (Mn) of the polymer is 2655, with the polydispersity is 1.63 was observed from GPC analysis.

The final step of the scheme is binding, or immobilization of the palladium catalyst with poly(NIPAM) tagged NHC ligand in the presence of pyridine as a solvent at 100 ºC. The compound **4a** was confirmed by ^{1}H NMR spectroscopy; the characteristic peaks of pyridine protons around 8.89 ppm for ortho protons, 7.78 ppm for para and 7.34 ppm corresponds to meta protons as a multiplet was observed. The compound **4a** was purified by reprecipitation method by using THF/ diethyl ether solvents. The purified polymer palladium complex was in light brown.

The thermal stability, glass transition temperature (*Tg*) was analyzed by TGA and DSC; it was noticed that the stability and T_g of the polymer palladium complex (112 **°C)** were lower than that of the corresponding polymer. The polymer palladium complex was highly soluble in water below 36 ºC and shows the thermoresponsive nature above lower critical solution temperature.

Invited Lecture

Scheme.1: Synthesis of thermoresponsive Poly(NIPAM) tagged NHC Palladium catalyst.



The recyclability and reusabiliy of the catalyst for Suzuki coupling reactions were confirmed by taking aryl boronic acid and various bromides. For this, in a 10 ml two-necked round bottom flask 0.375 mmol of phenylboronic acid, 0.25 m.mol of aryl substrates, 0.8 mol % of the catalyst, 0.5 m.mol of the base and 2 ml of water was charged altogether. The stirring was continued for 24h after that the temperature of the reaction medium was raised at 38 °C; the polymer palladium catalyst was precipitated as a solid (due to breaking of hydrogen bonding) then the crude product was decanted from the solid form of the catalyst. Again the solid catalyst was dissolved in 2 ml of cold water and reused for next cycles of similar scales of the starting materials.

Conclusions

In conclusion, we have successfully synthesized thermoresponsive poly (NIPAM) tagged NHC palladium catalyst for Suzuki cross coupling reactions in a water medium. The modified palladium catalyst is highly soluble in water and exhibits the phase separation at elevated temperature due to the presence of Poly(NIPAM) moiety. it shows better stability and reactivity due to the presence of NHC ligand. The modified polymer palladium complex catalyzes the Suzuki coupling of different aryl halides under homogeneous conditions. The catalyst can be easily recovered by simply elevating the temperature of the reaction medium at above LCST; it could be used up to five cycles with minimal loss of catalytic activity.

Acknowledgements

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Invited Lecture

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Invited Lecture

IL-30: AEROBIC COMPOSTING OF BIOPLASTICS- A LABORATORY SCALE STUDY

Harsh Jadia and Deepali Jadia

drharsh@errl.co.in and drdeepali@errl.co.in

Enviro Remediation & Research Laboratory (ERRL), Mumbai

Abstract:

Wide production of conventional plastics and their different marketable use front a significant threat to fossil fuels sources and the environment. In current Indian scenario, even after majority of total plastic waste being managed through recycling about 16,000 tonnes plastic waste generated daily adds to the pollution. Therefore, in recent years, there has been a striking increase in the interest in bioplastics as an alternative in applications such as packaging, agriculture and medicine. These polymers made from renewable bio-based resources can be disposed of in a safe and eco-friendly manner like composting or soil application. Biodegradability of bioplastics in different environments enabled it to be more easily acceptable than the conventional plastics. The biodegradability of bioplastics is highly affected by their physical and chemical structure as well as the environment it lands up in. The present study conducted at ERRL facility highlights the findings attributed to the biodegradation of bioplastics in aerobic composting conditions. In a laboratory scale set up, bioplastic sample was subjected to ultimate level of aerobic biodegradation in a Microbial Oxidative Degradation Analyzer (MODA) and CO_2 evolved was measured gravimetrically. Sample then underwent disintegration in a composting reactor through ambient stage to Theromphilic phase at temperature $58^oC \pm 2$ via Mesophilic phase to form the final product i.e compost. The finished product was then tested for metals concentrations by ICP-AES MS and toxicological studies on plant growth as per OECD standards were conducted at ERRL to confirm no negative impacts. The product obtained from aerobic composting of bioplastic sample was found to be nontoxic good quality compost.

Keywords: Bioplastics, Aerobic composting, MODA, Toxicology testing, Compost, ERRL.

Invited Lecture

IL-31: Learning from Nature: Producing synthetic biomimetic membrane with water transporter protein from salt tolerant mangrove trees

Prakash P. Kumar

Department of Biological Sciences, and NUS Environmental Research Institute, National University of Singapore, 10 Science Drive 4, Singapore 117543 (email: dbskumar@nus.edu.sg)

Abstract

Salinity is an abiotic stress that affects the growth and productivity of plants worldwide. Mangrove trees such as *Avicennia officinalis* exhibit remarkable ability to grow in saline environment by means of various adaptations. The roots of *A.officinalis* can exclude ~95% salt with the help of enhanced hydrophobic root barriers (Casparian bands and suberin lamellae). Cytochrome P450s play a key role in biosynthesis of suberin precursors. We identified several cytochrome P450 (CYP) genes that were differentially expressed upon salt treatment in the roots of *A.officinalis*. Using appropriate *Arabidopsis* mutants, such as *atcyp86b1,* we characterized the function of *CYP86B1* gene in regulating suberin biosynthesis. The *atcyp86b1* mutant seedlings showed salt sensitivity with reduction in root elongation. When treated with salt, their roots exhibited reduced suberin lamellae and Casparian bands. Heterologous expression of the coding sequence of *A.officinalis CYP86B1* in *atcyp86b1* resulted in rescuing of the salt sensitive phenotypes, indicating the involvement of CYP86B1 enzyme in suberin biosynthesis. Additionally, we have cloned several genes of *A.officinalis* encoding aquaporin water transporter and ion transporter proteins. We expressed a codon optimized aquaporin gene in yeast and used the purified recombinant protein for synthesizing a biomimetic test membrane. The test membrane exhibits salt exclusion and selective water transport. This suggests the possibility of using such biomimetic membranes for future water purification needs. Similarly produced ion transporter-embedded membranes can have biomedical applications. Our current efforts in these projects will be discussed.

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Invited Lecture

IL-32: Experiment and Modeling of Microbial Fuel Cell

Saksham Sharma and Vimal Katiyar
Department of Chemical engineering,
Indian Institute of Technology Guwahati, Guwahati, Assam, India.
Email: vkatiyar@iitg.ernet.in

This talk will present the initial work undergo in our laboratory to correlate the experimental findings with the simulation of Microbial Fuel Cells. We have started with the first-principles governing protocols of conventional fuel cells followed with COMSOL Fuel Cell solver to validate the results of conventional transport processes involve in MFC. This is a departure from the existing trend in literature where significant work have been executed, focusing on developing rigorous mathematical models of processes involved in MFC. However, the drawback of COMSOL module is that it can go beyond the calculation of activation losses. Hence, a coupled COMSOL and analytical modeling is required to successfully prove the experimental results. As initial work, we built an in-house Microbial Fuel Cell system using Bacillus Megatarium. We will be targeting to achieve innovation on the fronts of electrode flexibility and flow parameters and its simulation work to correlate the power efficiency of fuel Cell. As a beginning, mathematical models to understand relation between proton transfer and Reynold's number have been incorporated in this study.

Invited Lecture

IL-33: Rotary Drum Composting of Vegetable Waste Followed By Biodegradation of PLA

Ajay S. Kalamdhad

Department of Civil Engineering, Indian Institute of Technology Guwahati, India

Email: kajay@iitg.ernet.in, kalamdhad@gmail.com

Abstract

Decentralized composting at a neighborhood or community scale provides small groups to pursue it at a relatively low cost. An efficient and promising technique in decentralized composting is the rotary drum composter. Rotary drum provides agitation, aeration and mixing of the compost, to produce a consistent and uniform end product. Therefore, to understand the process (compost dynamics) and operational aspects of a rotary drum composter, a full-scale rotary drum composting plant under continuous flow developed to simulate what happens on an industrial scale. Institutional waste i.e. vegetable wastes and tree leaves were utilized as waste materials for drum composting. Composting was examined by measuring changes in temperature, moisture content and total organic content. Long term monitoring (150 days) suggest that organic wastes were composted successfully within 7 days of composting period. Continuous maintained higher temperature (60 to 70^{o}C) at inlet and (50 to 60^{o}C) at middle portion, resulted higher degradation possible within the drum. Studies suggested that Poly lactic acid (PLA) undergo biodegradation under composting condition within a short time period resulting in complete mineralization of the biopolymer. Therefore, the present study demonstrates the aerobic biodegradation of melt extruded (15-18 cm wide) PLA based biocomposites film under composting condition in accordance with ASTM, by online monitoring of CO_2 using gas chromatography technique. Results showed that PLA/Chitosan 5% biodegraded ~97% in 113 days, which is followed by NPLA> PLA/CNC-(SO_4) (1%) > PLA/Gum Arabic 5% taking 136, 138 and 146 days, respectively. Further, in the case of NPLA, 94.2 % biodegradation is observed in 136 days, whereas, 88.3% biodegradation is observed in 138 days for PLA/CNC and 80.5% biodegradation for PLA/Gum based bionanocomposites films. The results exhibits different biodegradation rate for different PLA based composites under food waste compost.

Keywords: Rotary drum composter, Vegetable waste, Temperature, PLA composites, and biodegradation

Invited Lecture

IL-34: Laser Surface Bio-Coating of Functionally Graded TiO_2-HAp on Textured Ti Alloy for Enhancing Bioactivity and Cell Proliferation

Rasmi Ranjan Behera[1], Abshar Hasan[2], Lalit Pandey[2], Mamilla Ravi Sankar[1]*

[1]Department of Mechanical Engineering, Indian Institute of Technology Guwahati, Assam, India

[2]Department of Bioscience and Bio Engineering,
Indian Institute of Technology Guwahati, Assam, India

**Email: evmrs@iitg.ernet.in*

Abstract

In the present study, the morphology and composition of Titanium alloy (Ti-6Al-4V) surfaces were modified by laser surface coating (LSC) process to enhance the biocompatibility and bioactivity of orthopaedic implants. Ti-6Al-4V substrates were first textured using a pulsed Nd:YAG laser and measured the contact angle for hydrophobic or hydrophilic nature. Once the hydrophilic surface is achieved, these textured Ti-6Al-4V substrates were laser coated with various precursors: 100% HA and TiO_2-HA based functionally graded material (FGM). A set of laser parameters having 21.6 J/mm^2 laser energy density was applied for coating, to execute a comparative study. The morphology, phases and wettability with different biological tests including bioactivity, protein adsorption, cell adhesion and proliferation were performed on coated substrates. The substrate processed with FGM precursor showed higher apatite precipitation than substrates with 100% HA precursor. Both LSC substrates had significantly higher amount of protein adsorption lead to higher cell adhesion and proliferation compared to uncoated Ti-6Al-4V alloy. In between the LSC substrates, coating with FGM precursor had more protein adsorption and cell adhesion than coating with 100% HA precursor. With six days of incubation, the proliferation rate of FGM substrate (215.6±17.2%) was significantly higher than 100% HA substrate (134.6±9.5%) and uncoated Ti alloy control (100%). All these outcomes reveal that the LSC process improves the biocompatibility and bioactivity of Ti-6Al-4V alloy.

Invited Lecture

IL-35: Polymers in stimuli responsive membranes

M K Purkait

Department of Chemical Engineering,
Indian Institute of Technology Guwahati, Assam, India.

Abstract

Separation is an integral section of various downstream operations in chemical, petrochemical, food, biochemical and several other related process industries. It is necessary to achieve the goals of purification, refining, enrichment and concentration of any desired product from a mixture. Efficient separation processes are also required to obtain high-value products in the pharmaceutical and food industries, to provide communities and industry with high quality water as well as to recover and remove valuable or toxic components from industrial effluents. In the present era use of membranes has become increasingly important, especially in the food processing and biotechnology industry for separation, concentration and fermentation of food products with high yield and purity. Other than these industries membranes can be efficiently used in textile, vanadium flow battery, active packaging and electrodialysis applications. In recent years, membranes and membrane separation processes have grown from a simple laboratory tool to an industrial process with considerable technical and commercial impact.

A variety of polymers such as cellulose acetate (CA), polyvinylidene fluoride (PVDF), polysulfone (PSF), polyacrylonitrile (PAN), polyethylene (PE), polypropylene (PP) and polyether sulfone (PES) are available for the preparation of commercial UF/MF membranes. Among these polymers, PSF is most preferable polymer for the preparation of polymeric membranes because of its good heat resistance, physicochemical stability, resistance to chlorine, oxidation and chemical compatibility resistance over wide range of pH. Other than this, solubility of PSF brings it under the category of suitable candidate for polymer blend membranes, as it is very soluble in N-methyl-2-pyrrolidone (NMP) and dimethyl acetamide (DMAc) and these solvents are further soluble in the coagulation medium which is mainly water for the preparation of asymmetric membrane. Although, PSF membrane has several advantages, these membranes are prone to be fouled because of its hydrophobicity, which can be resulted in declination of flux and life of membrane. To overcome the problem of hydrophobicity, research is going on the changing membrane surface properties using various methods such as plasma treatment, coating, UV-induced graft polymerization, redox initiated grafting, etc. However, these methods are very useful for altering the pore size and pore size distribution of the membrane without internal pore modification. At the same time these methods have the drawback of required additional complicated steps. Our current research is focused on the addition of nanoparticles (NPs) and polymers within membrane matrix to increase the membrane hydrophilicity. However, uniform distribution of NP in casting solution is actually difficult because of the agglomeration of NP and increased viscosity of the casting solution. Again, NPs were getting trapped within the pores, then the flux would have decreased with increasing concentration of the NPs. This was due to the blockage of membrane pores by agglomerated NP.

Blending of hydrophilic polymers, co-polymers, organic acids and plasticizer in the casting solution can be an important alternate to obtain different polymeric membranes with required properties and additional features. In this lecture, our

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recent work on the use of various water soluble polymers, co-polymers, organic acids and plasticizers for preparing hydrophilic and responsive UF membranes will be discussed. For more information, few of our recent work may be accessed.

M K Sinha and M. K. Purkait, Preparation of novel thermo responsive PSF membrane, with cross linked PVCL-co-PSF copolymer for protein separation and easy cleaning, *RSC Advances*, 5 (2015) 22609-22619.

N. Sharma and M. K. Purkait, Preparation of hydrophilic polysulfone membrane using polyacrylic acid with polyvinyl pyrrolidone. *J Appl. Poly. Sci*, 132 (2015), 41964.

M K Sinha and M. K. Purkait, Use of CS-PAA nanoparticle as alternative of metal oxide nanoparticle and its effect on fouling mitigation of PSF ultrafiltration membrane, *RSC Advances*, 5 (2015) 66109 -66121.

M K Sinha and M. K. Purkait, Preparation and Characterization of Stimuli-Responsive Hydrophilic Polysulfone Membrane Modified with Poly (N-vinylcaprolactam-co-acrylic acid). *Desalination* 348 (2014) 16-25.

M. K Sinha and M. K. Purkait, Preparation and characterization of novel pegylated hydrophilic pH responsive polysulfone ultrafiltration membrane, *J. Membr. Sci*. 464 (2014) 20-32.

P Mandal, M K Purkait, Effect of polyethylene glycol methyl ether blend humic acid on poly (vinylidene fluoride-co-hexafluropropylene) PVDF-HFP membranes: pH responsiveness and antifouling behavior with optimization approach, *Polymer Testing* 61 (2017) 162.176.

Invited Lecture

IL-36: Biodegradable Copolyester Composites Reinforced by Wheat Stalked Micro crystalline Cellulose

J. Giri* [1], R. Lach [2], H. H. Le [2], W. Grellmann [2], H.-J. Radusch [2], G. H. Michler [3], J. M. Saiter[4], S. Henning [5], R. Adhikari [1]

Central Department of Chemistry, Tribhuvan University, Kirtipur, Kathmandu, Nepal

Center of Engineering, Martin Luther University Halle-Wittenberg, Merseburg/Saale, Germany

Department of Physics, Martin Luther University Halle-Wittenberg, Halle/Saale, Germany

Universite´ de Rouen, Laboratory LECAP, Faculte des Sciences, Avenue de l' Universite, Rouen, France

Fraunhofer Institute for Mechanics of Materials, Halle/Saale, Germany

*Corresponding author: girijys@yahoo.com

Abstract: In this work, agricultural waste wheat stalk was kept in a series of thermo-chemical and mechanical to extract microcrystalline cellulose (MCC). The extracted MCC was compounded with biodegradable polymer,

poly(butylenes adipate-co-terephthalate), PBAT, biodegradable polymer, via melt mixing using Brabender followed by compression moulding. The samples were characterized by Fourier transform infrared spectroscopy tensile test, microindentation technique (HM), thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC). The degradation behaviour of the composites was measured by soil composting and the water holding capacity using environmental chamber at 23 ^{o}C. Cellulosic filler were found homogeneously dispersed in the composites. The composites possessed low ductility with good thermal stability. Tensile reinforcement of the PBAT/ MCC composites were studied with respect to yield stress and young's modulus with the variation of MCC content, shown in Figure 2. reinforcement was observed up to 40 phr MCC content in the composites. These composites were found to be degrading under soil composting and showed good water holding capacity with the increased in MCC content.

Keywords: *biodegradable polymer, microcrystalline cellulose, mechanical properties, microhardness*

Introduction

Application of waste to produce novel materials like MCC or NCC in itselfs is a green practice. Nowadays substitute to fossile fuel is the necessity of the era and the application of synthetic random biodegradable polymer, which resembles its properties with LDPE would be one of the option to address the problem. Therefore it has become very essential to study the properties of PBAT and fabrication of it with some green materials [1]. Here the work focused on extracting MCC from agricultural waste and compounding it with biodegradable polymer PBAT. The homogeneous compounding of MCC in composites showed enhancement in mechanical properties upto 40 phr, where as higher loading did not show significant effect. Similarly the thermal studies also showed stability in the composites and biodegradation increased with the green filler, MCC content.

Methods and Materials

In this work MCC extraction was done from agricultural waste, wheat stalk by a series of thermo-mechanical process followed with chemical treatments [2]. The process involved: preliminary treatments, mercerization, steam explosion, bleaching and 10% H_2SO_4 acid hydrolysis. Chemicals such as H_2SO_4, NaOH, NaClO and deionized water used in this process were bought from the market and used without further purification.

MCC extracted was compounded with PBAT by melt mixing process in plasticorder brabender at 120 ^{o}C, 70 rpm for 15mins in which MCC content were varied (10, 20, 40 and 60 phr).

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Composites were characterized for morphological study by Scanning Electron Microscopy (SEM), thermal stability by Thermogravimetric analysis (TGA) and Differential biodegradation by soil composting and water absorptiontest in Environmental Chamber [2].

Result and Discussion

Morphological studies showed the homogeneous compounding of the filler into the matrix. In Fig. 1, 40 phr of MCC were found to disperse homogeneously into PBAT.

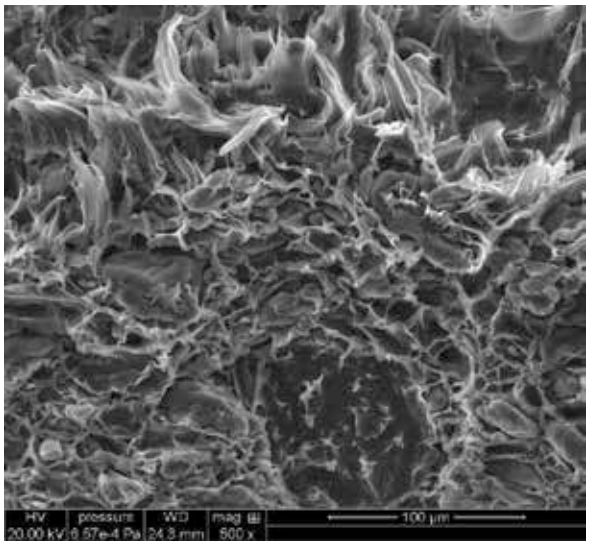

Figure 1 Scanning electron microscopy image of 40 phr MCC/PBAT composite.

Likewise the dispered MCC found to reinforce the mechanical property upto 40 phr which can be seen in Fig. 2 where tensile modulus and yield stress were found to increase upto 40 phr loading of MCC [3,4].

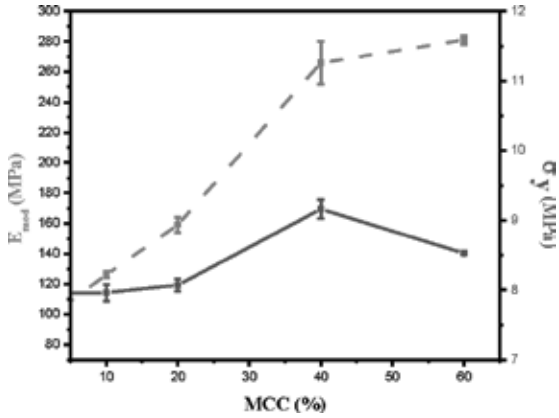

Figure 2 Variation of yield stress (σy) and Young's modulus (E) as a function of MCC content in the composites.

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The moment at which mechanical strengthening with MCC in PBAT was reversed back in composites being more susceptible for biodegradation can be indicated by the Fig. 3 where water holding capacity increased by increase in MCC content.

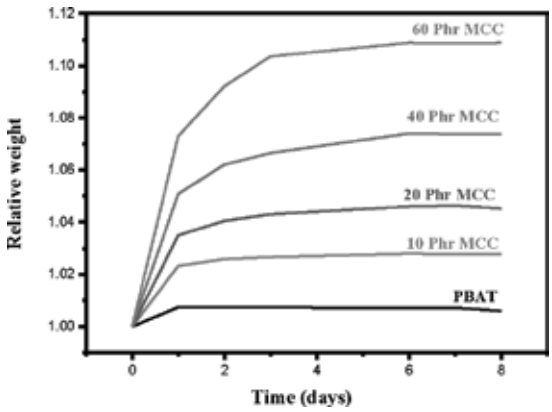

Figure 3 Variation in water uptaken by the composites in comparision with MCC content Similarly, soil composting was also found to be reinforced, as microbes and fungus found to grow higher in the composites with higher MCC content and became more brittle on compositing.

Conclusions

The MCC were successfully extracted from the agricultural waste, wheat stalk and were compounded with biodegradable copolyester PBAT with good enhancement in mechanical and thermal properties andignificant increase in biodegradation in the composites as well.

Acknowledgements

1. Nepal Academy of Science and Technology (NAST), Ph.D fellowship.
2. German Science Foundation (DFG) for providing financial support for this work at Martin Luther University Halle, Germany.

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Invited Lecture

IL-37: Nano-finishing of Bio-Implants using Polymer Rheological Abrasive Complex Suspensions

Mamilla Ravi Sankar
Department of Mechanical Engineering,
Indian Institute of Technology Guwahati, Guwahati-781039, Assam, India
Email: evmrs@iitg.ernet.in

Abstract

Finishing operation is the final step in most of the manufacturing processes. This can cost as much as 15% of the total product manufacturing cost in the production cycle. As the requirement of surface finish increases, the cost of the product escalates exponentially. Abrasive flow finishing (AFF) is one of the advanced nano finishing technologies, which is specifically used to finish simple as well as complex surfaces using polymer rheological abrasive suspensions. The finishing capabilities of the AFF process depends on the complex suspensions (polymer based viscoelastic fluid mixed with abrasive particles) which is used a flexible tool for shearing the surface roughness peaks. The abrasive suspension consists of three basic elements, base polymer/polymers, rheological additives and abrasive particles. Depend on the medium constituents and its quantity, the rheological properties as well as its finishing abilities changes. In abrasive suspension composition, base polymers plays important role. The mechanical properties of polymer depend on the local chain motions and intermolecular interactions between chains. In the current research work, soft styrene and silicone polymers are blended along with rheological additives as well as silicon carbide abrasive particles. Soft silicone polymer is blended with the base soft styrene polymer to modify the intermolecular interactions and also to introduce a new monomer with its own repeating units. Soft styrene polymer possesses dominating elastic properties and partial viscous properties. But soft silicone polymer consist partially dominating viscous and partial elastic properties. Amount of blending of these two polymers gives the flexibility to prepare the base polymer blend of required viscous and elastic properties. However in this research study, the viscous and elastic properties are also varied using softeners, plasticizers and SiC abrasives. Static (Viscosity, Creep compliance, Stress relaxation) and dynamic (Amplitude sweep and frequency sweep) rheological characterization is carriedout on the various medium compositions. In the current paper an attempt is made to develop an indigenous and economic polymer rheological abrasive complex suspension with viscoelastic nature to finish bio implants (Hip, knee and etc). Later, to check the effectiveness of the developed complex suspensions AFF experiments for finishing of knee and hip implants are carried out. These complex suspensions also used to finish micro holes of similar size of drug eluting stents. Hence, this process is a viable and economic solution to nano finishes various bio-implants.

Invited Lecture

IL-38: Compatibilizer Effect on Morphological Thermal, Mechanical and Water Absorption Behaviour of Natural Fiber Based Polymer Composites

NetraLalBhandari[*1,2], Goerg H. Michler [3], Sabu Thomas [4], Jean Marc Saiter[5], Rameshwar Adhikari[1]

[1] Central Department of Chemistry, Tribhuvan University, Kirtipur, Kathmandu, Nepal

[2] Department of Chemistry, Tri-Chandra Multiple Campus, Tribhuvan University, Ghantaghar, Kathmandu, Nepal

[3]Institute of Physics, Martin Luther University Halle-Wittenberg, Halle (Saale), Germany

[4] School of Chemical Sciences, Mahatma Gandhi University, Kottayam, Kerala, India

[5] AMME-LECAP EA4528, International Laboratory, Institute for Material Research, University of Rouen, France

* Corresponding e-mail: nlbhandari@yahoo.com

Abstract

Natural fibers (such as bamboo, sisal, wood fibers etc.) from various sources were subjected to different kinds of chemical modifications (such as mercerization, bleaching, silylation, acetylation etc.) and their textures were investigated using Fourier transform infrared (FTIR) spectroscopy and scanning electron microscopy (SEM). This work deals with the comparative study on compatibility of neat and delignified natural fibers reinforced polymer composites based on isotactic polypropylene (iPP; Moplen PP562N, commercial product of Basell), aliphatic-aromatic copolyester (Ecoflex®, commercial product of BASF, SE) and urea formaldehyde resin. The delignified fibers were prepared by using caustic soda followed by bleaching. It was confirmed by the removal of characteristic peaks at 820 cm^{-1}, 1250 cm^{-1} and increase in peak intensity at 3400 cm^{-1} and 1050 cm^{-1} in FTIR spectra. Alkali treatment followed by bleaching is found to be effective for the removal of phenolic compounds related to lignin and hemicelluloses from natural fibers resulting in well seperated cellulose microfibrils.

The different composition composites were prepared by melt mixing followed by compression molding. Maleic anhydride grafted polypropylene (MA-g-PP with 5% grafting) was used as compatibilizer in polypropylene composites. Results obtained by Fourier transform infrared (FTIR) spectroscopy, scanning electron microscopy (SEM), tensile testing, thermogravimetric analysis (TGA) and water absorption tests were compared. In neat fiber loaded composites, the weak fiber/matrix interface adhesion acts as defects for deformation and also responsible for increased water absorption. Chemically treated fibers were found to be more compatible with matrix compared with neat fibers and effects are reflected on morphological, mechanical, thermal and water absorption behaviors of the composites. In case of polypropylene composites the addition of maleic anhydride grafted polypropylene was found to be positive to enhance the filler matrix interfacial compatibility [3]. Further the moisture absorption and biodegradation of treated fiber composites were relatively higher than the untreated fiber composites.

Keywords: *polymer composites, bamboo fiber, mechanical properties, morphology, compatibilizers*

Introduction

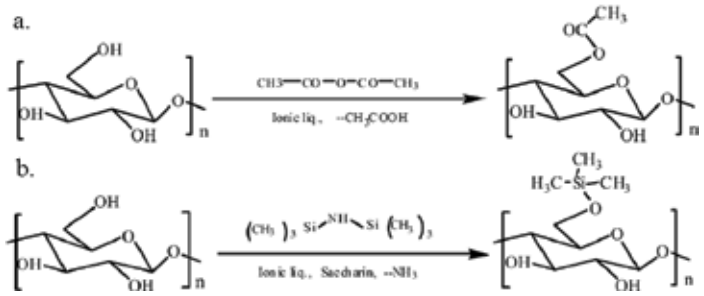
1. The interest in composites based on renewable resources has grown tremendously as a result of environmental awareness 1 Cellulose is a linear polysaccharide and one of the world's most abundant biopolymer with the formula $(C_6H_{10}O_5)_n$

Invited Lecture

2. 2It is a natural polymer, a long chain polymer with repeating unit of D-glucose, a simple sugar. In cellulose D-glucose units are held together by β(1→4) linkage [3-5]. The natural fiber based polymer composites nowadays have very wide field of application such as in electric and electronic devices, house insulation, furnitures, packing materials and in vehicle parts.

During the preparation of natural fiber composites the main challenge is the problem of compatibility in between the highly hydrophilic natural fibers (fillers) and the hydrophobic polymers (matrix) at the interfaces. The problem of compatibility is improved by functionalization of filler or matrix or by the use of suitable compatibilizers [1,5].

The chemical ttreatment on natural fibers are carried out by mercerization, bleaching, acetylation and silylation. The acetylation and silylation on natural fibers in ionic liquids are also confirmed by appearing strong C=O stretching peak at 1740 cm^{-1} and stretching and bending peaks of Si-OCH_3 at 1250 cm^{-1} and 840 cm^{-1} respectively [1-3]. The schemematic representation of acetylation and silylation reaction in cellulose fiber for unit degree of substitution is presented in Scheme 1[2,3].



Scheme 1:a.)acetylation and b.) silylation reactions of cellulose molecule for the unit DS

The objective of this research is to develop eco-friendlylow cost biocomposites based on thermoplastic/thermosetting polymers (polypropylene, copolyester, urea formaldehyde etc.) using locally available natural fibers generated as waste product from furniture industries as fillers. Further this research aims to explore the underlining mechanism of incompatibility between filler matrix interfaces and the effect of compatibilizer on differently chemically modified fillers on morphological, thermal and water absorption properties of the composites materials.

Methods and Materials

Natural fibers obtained from various plat resources (such as *Bambusa nutans,Girardinia diversifolia*, *Agave sisalana,Dalbergia sisaoo*) were used as fillers on different thermosetting (Urea formaldehyde) and thermoplastic (PP, Ecoflex) polymers. The chemical treatment of natural fibers were carried out by mercerization, bleaching, silylation and acetylation in ionic liquids. The differently modified fibers were loaded in the matrix mainly by melt mixing followed by compression molding to prepare different composition composites. Thus prepared composite samples were characterized by spectroscopic, microscopic, thermogravimetric techniques.

Results and discussion

The chemical treatment of fibers and their compositeswere characterized by microscopic (SEM and OM), spectroscopic (FTIR), tensile tests, thermogravimetric analysis (TGA) and water absorption tests. The chemical treatment on natural fibers increases the smoothness on fibers as well as the fibers are clearly visible and distinct. Alkali treatment was found to be better and effective to seperate microcellulose fibers than the other methods.

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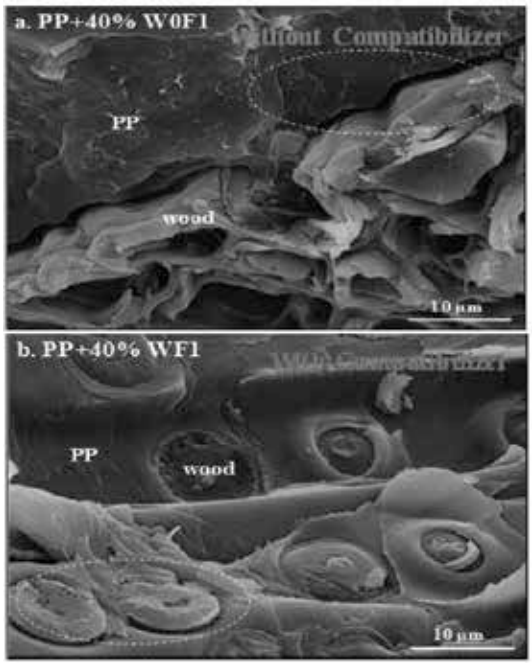

Figure 1:SEM micrograph of polypropylene natural fiber composite (60/40 composition)a.) withoutcompatibilizer and b.) withcompatibilizer

Figure 1 represents the SEM micrographs of 40% natural fiber composites on polypropylene showing the effect of compatibilizer on composites materials. The large voids or the gaps at filler-matrix interphases in composites prepared without compatibilizer are the points for the water absorption and the begining of deformation. These voids are progressively improved in compatibilized composites and the effects are also observed in the thermal, mechanical and waterr absorption behaviours.

Similarly, Figure 2 represents the derivatized thermogravimetric analysis of polypropylene composite with natural fibers. The degradation of natural fibers starts at 220^{o}C and degrades at 320^{o}C. Thethermal degradation of composites decreases with the increase in the filler in the composites. Further, the final degradation of the composites is somehow improved in treated filler loaded composites than in the neat filler loaded composites.

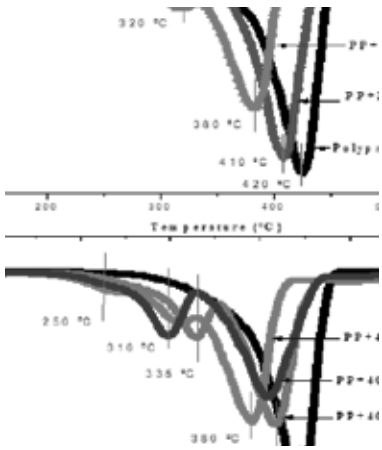

Figure 2:DTG curve of polypropylene natural fiber composite representing a.) effect of filler loading and b.) effect of filler chemical treatment

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Further the water absorption behavior of the composites in Figure 3 represents both the effect of filler chemical treatment (left) and the effect of compatibilizer (right). The treated fiber loaded composites absorbs less water than that of the neat fiber loaded composites. Similarly, the compatibilized composites absorb less water than that of the uncompatibilized composites.

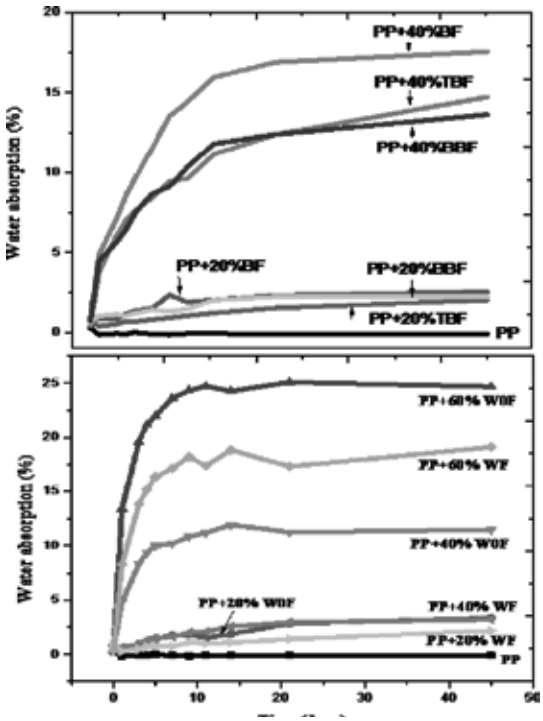

Figure 3:Water absorption behaviour of compatibilized polypropylene natural fiber composite showing a.) effect of fiber chemical treatment and b.) effect of compatibilizer

Conclusions

The different composition composites were successfully prepared by melt mixing followed by compression molding. The compatibilized composites were found to be better in mechanical, thermal and water absorption behaviours than the non compatibilized comosites. The compatibilizer effect is prominent in treated fiber loaded composites than in the neat fibers and results are observed in morphological, thermal, mechanical and water absorption behaviors.

Acknowledgements

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Invited Lecture

IL-39: Correlative Characterisation of Imidazole 2-Carboxaldehyde Thiosemicarbazone Chitosan, Thiophene 2-Carboxaldehyde Thiosemicarbazone Chitosan and their Copper(II) Complexes

Hari Sharan Adhikari*[1], Aditya Garai [2], Rameshwar Adhikari[1,3], Paras Nath Yadav[1]

[1]Central Department of Chemistry, Tribhuvan University, Kirtipur, Kathmandu, Nepal.

[2]Department of Inorganic and Physical Chemistry, Indian Institute of Science, Bangalore, India.

[3]Research Centre for Applied Science and Technology,
Tribhuvan University, Kirtipur, Kathmandu, Nepal.

Corresponding author, e-maii: pnyadav219@gmail.com

Abstract: Chitin is a homopolymer of N-acetyl glucosamine units linked through β (1→4) linkages. This biopolymer, most abundant after cellulose, is extracted from exoskeleton of crustaceans and insects, cell walls of fungi, shells of molluscs etc. Deacetylation of chitin forms a value-added material called chitosan as a copolymer of N-acetyl and N-deacetyl α-(1, 4) glucosamine units. Owing to presence of amino and acetamido groups, chitosan gets functionalized as carboxaldehyde thiosemicarbazone with thiosemicarbazide. Both chitosan and chitosan- thiosemicarbazone act as versatile ligand to transition metal ions. Correlative characterization of the compounds obtained from commercial chitosan oligosaccharide and crab shell chitin shows pathway to effect of molecular weight on anticancer activity and structure activity relation. Chitosan and its numerous derivatives have been found to exert anticancer activity, and facilitate target delivery and bioavailability of anticancer drugs with minimal toxicity in noncancer cells. They attract a great deal of research interest that is associated to more effective anticancer drug development strategy. Novel compounds with anticancer structural behavior can be tailored from chitosan. Biological screening of these compounds against different human carcinoma cell lines as the ultimate objective of this research will be crucial to assess therapeutically effective and safe chitosan based anticancer preparation.

Keywords: *chitosan, chitosan thiosemicarbazones TC), copper(II)-chitosan TC complexes, anticancer activity*

Introduction

Chitin $(C_8H_{13}O_5N)_n$is a natural biopolymer most abundant after cellulose and a component of exoskeletons of crustaceans and insects,cell walls of fungi, shells of molluscs etc. It is a homopolymer that consists of 2-acetamido-2-deoxy- β -D-glucose monomers (N-acetyl glucosamine units) linked through β (1→4) linkages[1]. Chitosan, mostly deacetylated derivative of chitin,on the other hand is a copolymer of N-acetyl and deacetyl α-(1, 4) glucosamine $(C_6H_{11}O_4N)_n$ units. The structures of chitin and chitosan are illustrated in figure 1.

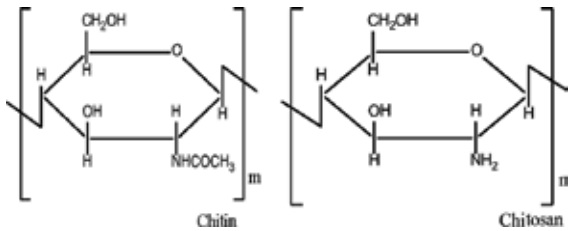

Figure 1 Structures of chitin and chitosan

Isolation of chitin: Chitin can be isolated from crustacean shells by demineralization with HCl, deproteinization in alkaline medium and bleaching.

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Deacetylation of chitin: Chitosan is obtained by deacetylation [2] of chitin by treating the latter with sodium hydroxide (figure 2).

The degree of deacetylation of chitosan ranges from 60-100 % and molecular weight of commercially obtained chitosan is from 3800 to 20,000 Daltons[3].It is a potential pharmaceutical excipient and an industrial agent due to its nontoxicity and biocompatibility[3].

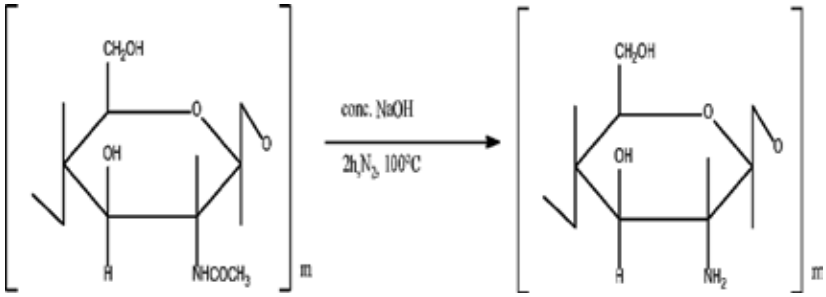


Figure 2 Conversion of chitin to chitosan by deacetylation process

Thiosemicarbazones are synthetic compounds obtained by the condensation of thiosemicarbazides with aldehydes or ketones. They are named by the class name thiosemicarbazone after the name of the aldehyde or ketone condensed [4]

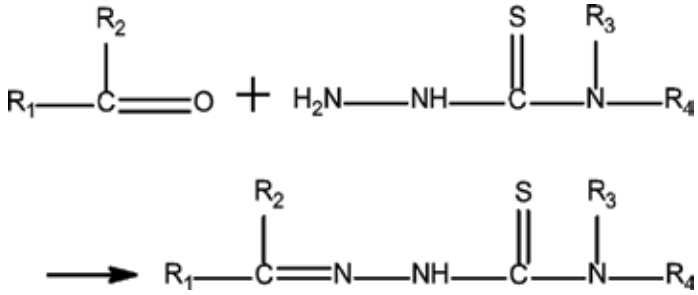
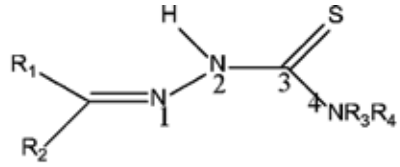


Figure 3 General method for synthesis of TC

The structure of thiosemicarbazones and numbering of its atoms according to IUPAC system [5] is shown in Figure 4.



R1, R2:H, alkyl, aryl or heterocyclic group
R3, R4:H, alkyl, aryl, heterocyclic group or part of a cyclic system

Figure 4: Structure of thiosemicarbazone

2-Formypyridine thisemicarbazones and related aldehydes possess strong antineoplastic activity [6]. The first observation of anticancer activity of heterocyclic thiosemicarbazone (HCT) was made with pyridine-2-carboxaldehyde thiosemicarbazone. It was found effective to prolong the life span of mice bearing the L1210 leukemia [7]. From this observation many HCT derivatives have been synthesized with modification in the heterocyclic ring system, the thiosemicarbazone side chain, as well as with variations in ring substituents [8, 9, 10].

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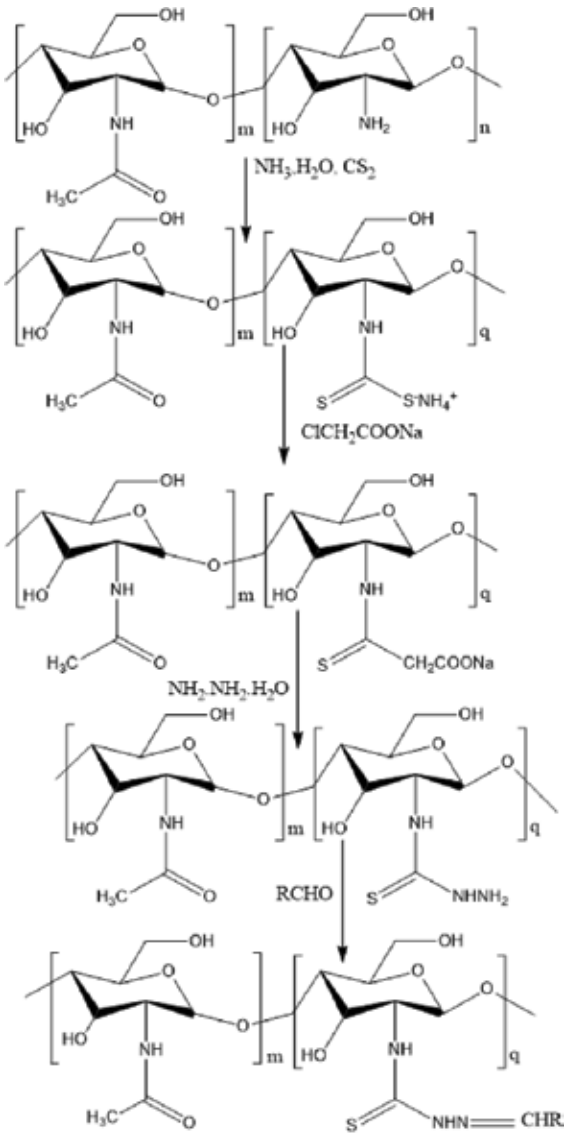

Figure 5: Synthetic scheme of thiosemicarbazone chitosan

Figure 5 Synthetic scheme of TC chitosan

Ribonucleotidereductase (RR) plays a central role in the *de novo* synthesis of deoxyribonucleotides required for DNA replication and repair [11, 12]. As such, RR offers a particularly attractive target for neoplastic agents directed against rapidly growing tumors. The α-(N)-heterocyclic carboxaldehyde- thiosemicarabazones represent a class of compounds that are among the most potent known inhibitors of ribonucleotide reductase (RR) activity [13].

Methods and Materials

Preparation of pure chitosan: Pure chitosan was obtained from crustacean (crab) shells by the chemical processes of (i) demineralization by acid treatment and (ii) deproteinization by extraction with alkali.

Functionalisation of chitosan as chitosan thiosemicarbazide: It involved one pot synthesis of chitosan thiosemicarbazide (Kovala-Demertzi et al., 2009)[53] in which a mixture of chitosan(8 g) and ammonium hydroxide (10ml) was stirred in

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absolute ethanol for half an hour, 4 ml of carbon disulphide was slowly dropped and stirred for 2 hours to get ammonium dithiocarbamate chitosan. 6 g of sodium chloroacetate was allowed to react for 30 min to get carbethoxydithiocarbamate chitosan. Next, 6 ml of hydrazine hydrate was slowly added, allowed to react for 2 hour and filtered through G4 sintered crucible. The residue was washed with ethanol and dried overnight at 40 ^{o}C to get light brown powder of chitosan thiosemicarbazide.

Synthesis of chitosan thiosemicarbazones: 10 mmol of chitosan thiosemicarbazide was mixed with 10 mmol of carboxaldehyde in 100 ml of methanol. 0.2 ml acetic acid as catalyst was slowly added and the mixture was refluxed for 12 hours. The resulting solution was cooled to room temperature and filtered through G4 sintered crucible. The precipitate was washed with methanol and dried overnight at 40 ^{o}C to get chitosan thiosemicarbazone.

Functionalisation of both the crab-shell chitosan and commercial fabrication of chitosan oligosaccharide as thiosemicarbazones of imidazole 2-carboxaldehyde and thiophene 2-carboxaldehyde was carried out.

The scheme of synthesis of these chitosan thiosemicarbazones is illustrated in figure 5.

Preparation of copper(II)-chitosan thiosemicarbazone complexes: 0.4 g of chitosan thiosemicarbazone was dissolved in 50 ml of 1% acetic acid and 40 ml of 0.4 g per L copper(II) nitrate solution was added. The mixture was stirred for 3 hours and the precipitate was obtained by adding 200 ml of acetone followed by G4 sintered filtration. The precipitate of metal complex was then washed with ethanol and dried overnight at 40° C.

Characterisation of compounds: Chitosan thiosemicarbazones and their Cu (II) complexes were characterized by FTIR, solid state ^{13}C NMR spectroscopic techniques, powder XRD, and elemental microanalysis. Thermal stability of chitosan and thiosemicarbazone ligands was confirmed by thermogravimetric analysis.The biological screening of the compounds against human carcinoma cell lines is carried out to assess their anticancer activity.

Result and Discussion

Fourier Transform Infra-Red (FT-IR) spectra

FT-IR spectra of chitosan, chitosan thiosemicarbazone ligands and their copper(II) complexes in powdered state were measured in the 4000-400 cm^{-1} regions with ATR- GeXPm experimentation using BRUKER 1 003 3610 FT-IR spectrophotometer. Gradual shifting of absorption peaks and their intensity levels from chitosan to ligand and to the complex was evident from these spectra. Figure 5 shows FT-IR spectra of chitosan, imidazole 2-carboxaldehyde thiosemicarbazone chitosan ligand and its copper (II) complex. There was variation in broad band absorption peaks ranging from 2950 cm^{-1} to 3450 cm^{-1} attributed to -OH and -NH stretching vibration showing the involvement of these groups in complex formation. In chitosan, the characteristic absorption peak of -CH bending at 2877.3 cm^{-1} and absorption peak of -NH_2 bending vibration at 1557.4 cm^{-1} were shown and the signal from C=O of amide was at 1667.9 cm^{-1} . In the ligand, the peak due to amide at 1557.7 cm^{-1} disappeared , -NH bending at 1557.4 cm^{-1} became weak, the new bands at 1624.0 cm^{-1} due to -C=N- , 987.7 cm^{-1} due to phenyl group showed the formation of ligand.

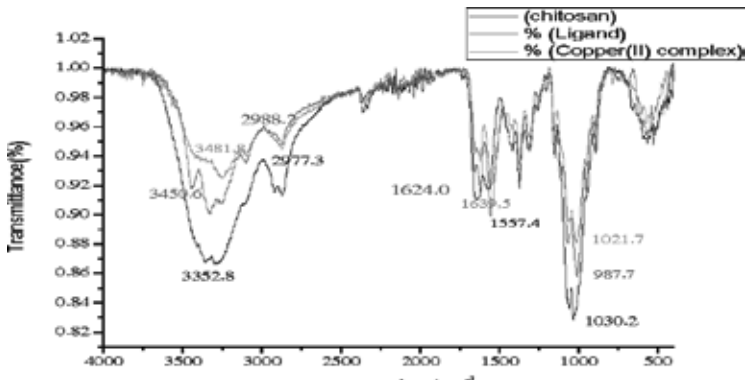

Figure 6 FT-IR spectra of chitosan imidazole 2-carboxaldehyde thiosemicarbazone chitosan thiosemicarbazone (ligand) and copper (II) complex.

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X Ray Diffractograms

X Ray Diffraction (XRD) measurements of the powdered samples of chitosan, chitosan thiosemicarbazone ligands and complexes were performed at scanning scope of 2 Θ at 0 to 60 degrees with an exposure time of 400 S using a D8 advance BRUKER diffractometer with Cu target (λ= 0.154 nm) at 40 KV. The characteristic peaks of chitosan appeared at 2 Θ = 9.52 ^{0} and 19.71 ^{0}. In imidazole 2-carboxaldehyde chitosan thiosemicarbazone ligand, new sharp and high intensity peak was at 2Θ = 11.41^0, 21.51^0 and 26.8 ^{0} showing a distinct change in crystalline phase as a result of chemical modification. A highly ordered structure of the complex has been indicated by the peaks at 2Θ = 15.56 0 and 19.96 0 , but the original crystallinity of the ligand at 2Θ = 15.24 ^{0} was also not completely destroyed (figure 7).

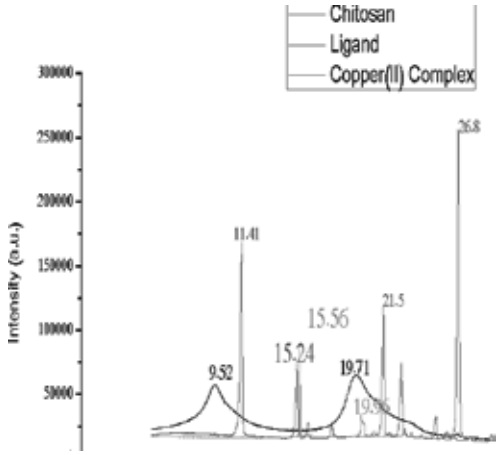

Figure 7 X-Ray diffraction patterns of chitosan, thiophene 2-carboxaldehyde chitosan thiosemicarbazone ligand and copper (II) complex.

Magnetic moment of complexes

The effective magnetic moment μ_{eff} of complexes were measured by magnetic susceptibility balance (Sherwood Scientific, Cambridge, UK) at X_1 range setting using a weighing tube of 0.8233 g with the powdered sample compactly filled in it up to height (L) of 1.5 cm. Paramagnetic behaviour of the complexes were evident from their positive R values while R_0 diamagnetic reading for glass tube was always -34. Hence, from the equation, $kg = \frac{e \times L \times (R - R0)}{10^9 \times m}$ where m =m_2 -m_1, e_{bal} is proportionality constant of unity, gram susceptibility (kg) was calculated.Molar susceptibility (km) was obtained from the equation km=kg.molecular weight.

$$\text{Then, } \mu\text{eff} = \mu B = \frac{2.84\sqrt{\text{km}.T}}{1} \text{BM}$$

For the complex copper (II) chitosan imidazole 2-carboxaldehyde thiosemicarbazone, R= 352, m= 0.2096 g, molecular weight = 80 % of 463 (monomer unit) . Hence μ_{eff} was found to be 1.279 BM (showing the complex has an unpaired electron). The magnetic moments of all complexes were determined.

Solid state ^{13} C Nuclear Magnetic Resonance (NMR) spectra

Solid state ^{13}C CP/MAS NMR spectra were measured using BRUKER AC-800 spectrometer for structural characterization of chitosan and its thiosemicarbazone derivatives. The ^{13} C NMR spectrum of chitosan showed δ=23.07 ppm representing the methyl group carbon, δ= 57.501 ppm due to C2 and δ=60.92 ppm due to C6, δ=75.70 ppm due to C5 and C3, δ= 83.45 ppm due to C4, δ= 104.57 ppm due to C1, δ= 174.23 ppm attributed to C=O carbon, showing that the sample is not fully deacetylated (figure 8).

Compared to chitosan,^{13} C NMR spectrum of imidazole 2-carboxaldehyde chitosan thiosemicarbazone showed the new peaks attributed to carbon of phenyl at δ= 135.22 ppm and δ= 175.23 attributed to N=CH- group showed the formation of imidazole 2-carboxaldehyde chitosan thiosemicarbazone (figure 8).

Invited Lecture

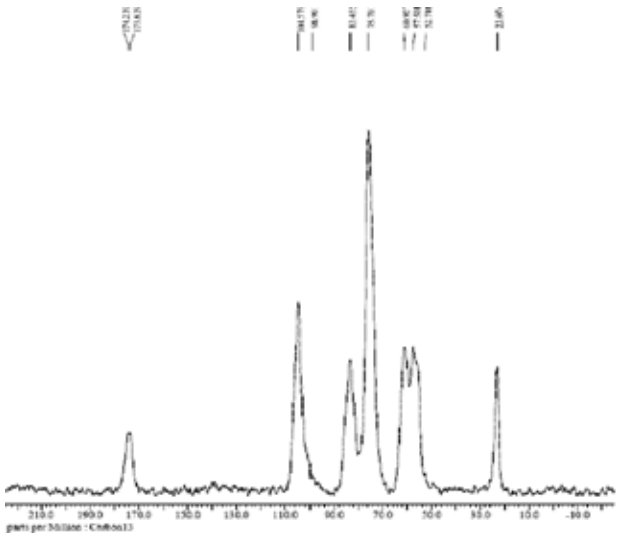

Figure 8 ^{13} C NMR spectra of Chitosan

Elemental analysis of Ligands and Complexes

Elemental analysis of chitosan thiosemicarbazone ligands and their copper (II) complexes was carried out using thermo scientific flash 2000 organic elemental analyzer with carrier gas He (140 ml/min) using CHNS/ NCS column PQS SS 2M 6X5 mm in oven at 75° C (for CHNS).For chitosan, the results showed C(41.1%), H (6%) and N(6.5%). For imidazole 2-carboxaldehyde chitosan thiosemicarbazone, the results C (55.101%), H (5.201%), N (10.041%) and S (3.150%) showed 9.5 % of degree of substitution (DS).This value of DS showed partial incorporation of Schiff's base group into chitosan and formation of chitosan thiosemicarbazone.

Elemental analysis results C (44.04%), H (4.09%), N (7.74%) and S (2.21%) of copper (II) chitosan thiosemicarbazone complex showed the coordination of ligand with copper (II) chloride. Estimated chlorine percentage (8.5%) in the complex also accorded with the results of elemental analysis.

Elemental analyses of all thiosemicarbazone ligands and their copper (II) complexes were performed to evaluate and confirm the structure of corresponding complexes.

Conclusions

Spectroscopic and analytical characterisation of the compounds revealed functionalization of chitosan as thiosemicarbazones of imidazole 2-carboxaldehyde and thiophene 2-carboxaldehyde thiosemicarbazones These compounds were found to show coordination behavior with copper (II) to form the respective complexes. Study of anticancer activity of both these ligands and complexes can reveal the structure activity relation and effectiveness against cancer cells.

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Invited Lecture

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Invited Lecture

IL-40: Removal of lead (II) Ions from Aqueous Solution by Hydroxyapatite Biosorbent Prepared from Ostrich Bone Waste

Komal Prasad Malla*[1], Ram Jeewan Yadav [2], Rameshwar Adhikari [1]

[1] *Research Center for Applied Science and Technology (RECAST), Tribhuvan University, Kirtipur, Kathmandu, Nepal*

[2] *Department of Chemistry Prithvi Narayan Campus, Pokhara, Tribhuvan University, Nepal*

**Corresponding authors,* e mail: komalmalla1971@gmail.com

Abstract: Hydroxyapatite (HAp) is a broadly studied bioceramic for biomedical implant and bone tissue regeneration. Despite this, it is a good adsorbent for heavy metal ions removal. Its chemical formula is $Ca_{10}(PO_4)_6(OH)_2$. HAp was synthesized by calcinations method from Ostrich bone waste.Thus obtained HAp was characterized by X-ray diffraction (XRD) and Fourier transform infrared (FTIR) spectroscopy to acuere crystilline phase and chemical functional groups. Then it was used for removal of lead ion from aqueous solutions by batch adsorpton techniques. A series of experiments were conducted in order to determine the effects of pH, contact time and sorbent dosage in a optimize condition for maximum adsorption. The results showed that removal efficiency of pb(II) ions reached 99.04% with an initial concentration of 50 mgL^{-1}, pH range; 3to7 and a contact time 1 hours. The adsorption rate of lead ions onto the HAp was found incredibly fast and equilibrium was reached within 5 minute. Within this time 72.32% of lead ions were removed. The equilibrium removal process of lead ions at pH range 4.5-5.5 was well described by the Langmuir isotherm model, with a maximum adsorption capacity of 430.7 mg/g in lab temperature.

Keywords: *Hydroxyapatite, FTIR, adsorption , lead ion. pH*

Introduction

Lead ions have been classified as a hazardous heavy metal ions of high priority in the viewpoint of human and environmental risk [1,2]. The toxicity of this metal ions is enhanced through the accumulation in living tissues and the food chain [3]. It is widely used in storage batteries, alloys, solder, manufacture of paints, pigments, ceramics and many more as a result, it is often found in waste water arising from these processes. Thus, removal of lead ions from waste/drinking waters is very important to protect public health [4]. Among the different methods have been proposed for lead ions removal, biosorption is one of the best method [5].The major advantages of this method are low cost, high efficiency, minimization of chemical or biological sludge, possibility of regeneration of the biosorbent, and metal recovery [6-7]. Hydroxyapatite having chemical formula $Ca_{10}(PO_4)_6(OH)_2$ is one of the best biosorbent for removal of lead ions from aqueous solution because of its high sorption capacity, low water solubility, and stability under reducing and oxidizing conditions[8]. It can be prepared from a variety of raw materials. But, frequently cheapest used precursor is animal bone [9] which is easily available in animal slaughter houses.

Materials and Methods

All the chemicals and reagents used in this research was analytical grade and the materials and method used for synthesis from ostrich bone [10] is shown in Fig. 1.

Characterization of the biosorbenसीt

To study the crystallinity of prepared bio sorbent, powder X-ray diffracton (XRD) patterns were recorded. Fourier transform infrared spectroscopic (FTIR) analysis was performed to identify different functional groups. Determination of acidobasic properties of HAp surface the point of zero charge (pH_{pzc}) method was used [11].

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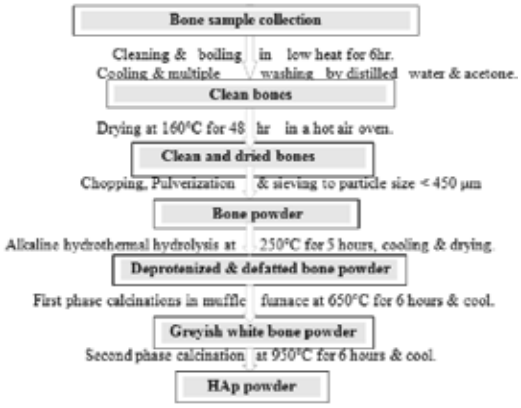

Figure 1 Scheme showing the synthesis of HAp biosorbent.

Biosorption Studies

Biosorption equilibrium assays were carried out by using batch adsorption techniques. Each of the batch adsorption studies was carried out by contacting the adsorbent with lead ions solution. A series of experiments were conducted in a mechanical shaker at 150 rpm in order to determine the effects of pH, contact time and sorbent dosage on adsorption. After required time to reach equilibrium, the solution was filtered, and final conc. Of lead ions in solution was measured by using atomic absorption spectrophotometry. The amount of lead ions adsrorbed onto the biosorbent qt (mg/g) was calculated by a mass balance relationship(1) and percentage of removal calculated by expression (2);

$$qt = \frac{(C0-Ct)V}{m} \quad ....(1)$$

$$Removal\ \% = \frac{C0-Ct}{C0}\ x100 \quad ....(2)$$

where qt (mg/g) is an adsorption capacity of bio sorbent, C_0 & $_{Ct}$ are the initial and equilibrium concentration (mg/L) of lead ions in V volume (L) of solution and m (g) is the mass of the bio sorbent taken.

Results and Discussion

XRD Analysis

The XRD patterns and exhibiting peaks corresponding to prepared HAp were found to be similar with JCPDS card No 01-074-0565, which indicates that there is no secondary phase[12] and synthesized HAp was pure.

FTIR Analysis

The FTIR spectrum clearly shows the presence of phosphate bands at 1051, 1040, 603and 570 cm^{-1} [13,14] and hydroxyl bands at 3572cm^{-1} [15,16] which indicates the presence of HAp as a major mineral component in biosorbent

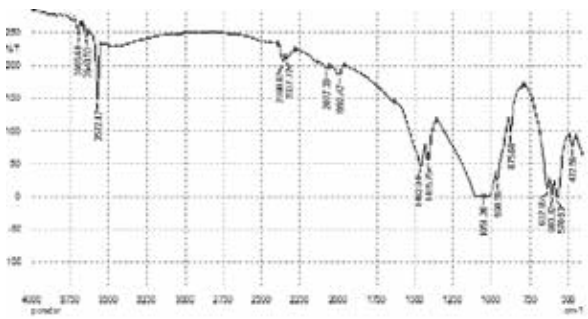

Figure 2 FTIR spectra of HAp biosorbent.

Invited Lecture

Point of zero charge (pH_{pzc}) value

This value of HAp was found in pH 3 This value indicates that at pH< 3.0,+ve charge surface of the HAp is predominated, while at pH > 3.0,the -ve charge surface is predominated.[17]

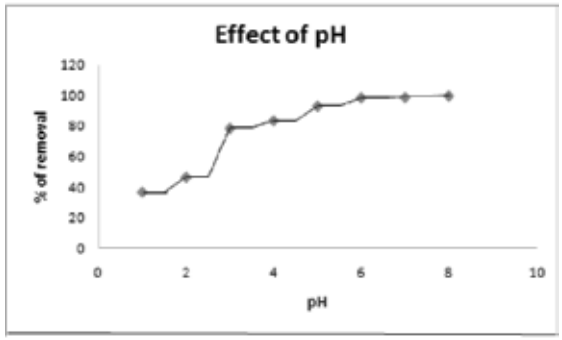

Figure 3. Effect of pH on percentage of removal of Pb(II) ion on HAp surface.

Effect of pH:

The effect of solution pH on adsorption were investigated by varying the solution pH from acidic to alkaline range. Figure-3 shows that the efficiency of Pb(II) ion removal increased significantly as pH increased from 1 to 6 and remains constant beyond 6[18].

Effect of contact time

Figure 4 shows that quick adsorption of Pb(II) ions onto the biosorbent and equilibrium reached within 5 minutes, where removal % reached up to 72.32. Further increase in contact time has no any radical effect on the removal percent.

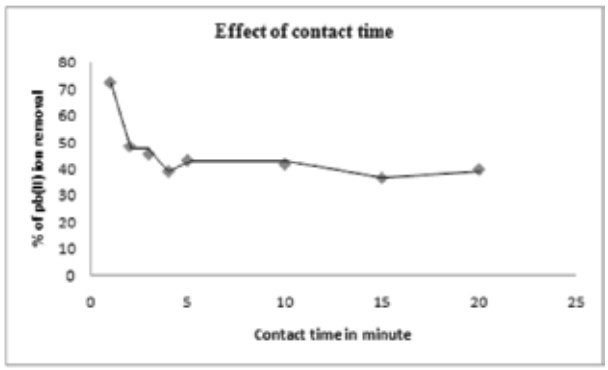

Figure 4. Effect of contact time on percentage of removal of Pb(II) ion on HAp surface.

Effect of adsorbent dose

Adsorption efficiency is greatly affects by surface area and available active sites in biosorbents [19]**.** The amounts of lead ions removal at various amounts of HAp ranging from 10 to 100 mg/L were investigated. At adsorbent dose 10 g/L, there is a significant removal of Pb (II) ions. As the adsorbent dosage increases there is decreasing trends of removal due to aggregation and overlapping of active sites of HAp which lead to the decrease in the effective surface area required for highest adsorption [20, 21]**.**

Conclusions

HAp synthesis form ostrich bone waste could represent a potent source of biosorbent for lead ions adsorption from aqueous solution. The $pH_{(pzc)}$ study indicated that the correlation factor(R^2) is 0.998 at pH 3. Sorption rate of lead ions on HAp surface was incredibly fast and equilibrium was attained within 5 minutes. The removal efficiency reached 99.04%

Invited Lecture

with an initial concentration of 50 mg/L in an acidic pH range. Finding shows that 10mg/L adsorbent dose can remove 430.7mg/g lead ions easily in a pH range 4.5-5.5.

Scope of the study

HAp biosorbent synthesized from ostrich bone waste has shown to have the potential in removing Pb(II) ions from aqueous solution. The results obtained in this research are noteworthy and provide good background for further study which also gives information about great potential on removing other heavy metals excepat lead from aqueous solution.

Future plan

Further research work will be continued in biomedical field due to its chemical and structural similarity with human bone minerals. HAp and its polymer composites will be a hopeful candidate for different biomedical applications.

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Invited Lecture

IL-41: Tuning Morphology and Mechanical Properties in Styrenic Block Copolymer Modified Nanostructured Epoxy Resin

Rajesh Pandit [1,2*], Rameshwar Adhikari [2,3]

[1] Central Department of Chemistry, Tribhuvan University, Kathmandu, Nepal

[2] Tri-Chandra Multiple Campus, Tribhuvan University, Kathmandu, Nepal

[3] Research Centre for Applied Science and Technology (RECAST), Tribhuvan University, Kathmandu, Nepal

Corresponding author e-mail: pandit_rajesh2003@yahoo.co.in

Abstract: The block copolymer (BCP) nanostructures can be utilized to induce nanostructured morphology in other polymeric systems. In this work, chemically modified styrene/butadiene star BCP was used to prepare blends with diglycidyl ether of bisphenol-A (DGEBA) epoxy resin, the former being obtained by the epoxidation reaction using *meta*-chloroperoxy benzoic acid (MCPBA) as an epoxidizing agent. The epoxidation of the BCP was characterized by Fourier transform infrared (FTIR) spectroscopy while the morphology and mechanical behavior of the blends were investigated using electron microscopy and recording microindentation hardness technique, respectively. The BCP with epoxy-philic and epoxy-phobic chains segregated to form quite regular nanostructures and hence it was possible to design the nanostructured blends having optimized mechanical properties.

Keywords: *block copolymer, epoxy resin, nanostructure, epoxidation, mechanical properties*

Introduction

Thermosetting polymers form covalently bonded cross-linked network structures. Epoxy resin is one of the potential materials with the wide range of applications such as in composites, as a crack healer, and in automotive, electric and electronic appliances. In spite of many useful properties, it has several drawbacks, one of the major drawbacks being mechanical brittleness. To overcome this problem, several ways were employed such as by incorporating rubbers, thermoplastics, thermoplastic elastomers and nanofillers.

Toughening by block copolymer is one of the best solutions because the BCPs have different architectures such as di-(AB), tri-(ABA) and star-(AB)x that lead to periodic nanophase-separated structures in the solid state. We are interested in using commercially available, inexpensive block copolymers such as those based on styrene and dienes with the aim of studying the influence of epoxidation degree, copolymer architecture and boehmite nanoparticles on the morphology and properties of the blends with epoxy resins.

Methods and Materials

The chemicals and materials used were diglycidyl ether of bisphenol-A (DGEBA) methylene dianiline (MDA) and styrene/butadiene block copolymer $(SB)_x$ having 70 wt.-% polybutadiene. The BCP was functionalized by *meta*-chloroperoxy benzoic acid (MCPBA) to introduce epoxy groups into the chains containing diene units. The samples characterized by FTIR spectroscopy, transmission electron microscopy (TEM), scanning electron microscopy (SEM), and thermogravimetric analysis (TGA) microindentation technique.

Results and Discussion

The FTIR analyses revealed the presence of peaks centered at the wavenumbers 810 cm^{-1}, 895 cm^{-1}, 1210 cm^{-1} and 1265 cm^{-1} confirming the introduction of the oxirane groups due to epoxidation reaction. The blends of the epoxidized BCP with the DGEBA epoxy resin after curing showed completely nanophase-separated thermally stable structures when the degree of epoxidation was beyond 50%. The mechanical testing showed the softening of the epoxy resin due to

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toughening by the epoxidized BCP. Through the incorporation of small amount of boehmite nanofiller, the hardness of the resin was found to improve significantly while maintaining the toughness of the materials.

Conclusion

Nanostructured transparent blends of (SB)x block copolymer and epoxy resin were successfully prepared

The nature of morphologies of epoxy resin/(SB)x blends was found to strongly depend on the degree of chemical modification of the BCP. The Higher degree of epoxidation led to higher compatibility, higher ease of nanostructuring as well as ease of adjusting toughness and stiffness of the blends.

Acknowledgements

We gratefully acknowledge the support of research groups of Prof. G. H. Michler and Prof W. Grellmann (University of Halle, Germany) and Prof. Albrecht Berkessel (University of Köln, Germany) for providing laboratory facilities and arranging research stay for RP. Dr. Robert Bening, Kraton Polymers, Houston (TX) and Sasol Chemicals (Hamburg) are thanked for providing the materials.

Invited Lecture

IL-42: Flexible Conducting Polymer Nanocomposites using Multiwalled Carbon Nanotubes in Biodegradable Polymer Matrix

Kedar Nath Dhakal[1,2,3], Santosh Khanal [2,3,4], Beate Krause [1], Ralf Lach [4], Wolfmann Grellmann [4], Gert Heinrich [1], Rameshwar Adhikari [1,2,5]

[1] Leibniz Institute für Polymerforschung (IPF), Hohe Str. 6, D-01069, Dresden, Germany

[2] Central Department of Chemistry, Tribhuvan University, Kirtipur, Kathmandu, Nepal

[3] Nepal Polymer Institute (NPI), P. O. Box 24411, Kathmandu, Nepal

[4] Polymer Service GmbH Merseburg, Eberhard- Leibnitz Str. 2, D-06217, Merseburg, Germany

[5] Research Centre for Applied Science and Technology (RECAST), Tribhuvan University, Kathmandu, Nepal

Corresponding author:ram.adhikari.tu@gmail.com

Abstract: Polymers are generally electrical insulators but can be imparted with conducting properties by introducing some conducting fillers such as multiwalled carbon nanotubes (MWCNTs), carbon black (CB), metal particles, conducting fibres etc. In this regard, environment friendly polymerics with optimum electrical and mechanical properties are desirable for several practical applications. In this work, we investigated the nanocomposites of a biodegradable copolyester and MWCNTs with the aim of developing degradable electrically conducting flexible materials. The polymer was melt compounded with MWCNTs using micro-compounder followed by compression molding. The composites were characterized by Fourier Transform Infrared (FTIR) spectroscopy, Scanning Electron Microscopy (SEM) and mechanical testing. Volume resistivity of composites was measured by four probe technique. Electrical and mechanical properties of the composites will be discussed in correlation to the observed morphology of the materials. The optimized materials are thought to be useful for the applications in microelectrodes and sensors.

Keywords: *biodegradable polymer, conductivity, mechanical properties, electrodes and sensor*s

Introduction

The demand of flexible electronics, electrodes and sensors is increasing day by day for monitoring different environmental and physical parameters with respect to analyses of chemicals, gases, pressure, mechanical strains etc. Conductivity of a material is a fundamental requirement to be useful in electrodes and sensors. Conducting composite materials are finding their applications in electronic equipment, conducting cables, photovoltaics and sensors. It inspires to design stretchable conducting materials using commercially available renewable and biodegradable polymers. The conductivity of such composites arises due to the formation of a conductive path of filler particles in polymer matrix [1-4]. Conducting properties with improved mechanical properties of these composite materials make them applicable in flexible electronic devices and strain sensors with minimum waste disposal problem [5].

In this work, MWCNTs are used as conducting nanometric filler in highly flexible and biodegradable PBAT as polymer matrix to prepare conducting nanocomposites using microcompounding followed by compression moulding and their properties are investigated.

Materials and Methods

A commercial biodegradable poly(butylene adipate-co-terephthaate) (PBAT), known as Ecoflex 7011 was used as matrix and MWCNTs NC 7000 LOT 2044 Nanocyl was used as conducting filler.

MWCNTs were melt-mixed with PBAT by the process of microcompounding using Xplore DSM15, Germany at 180 °C and 200 rpm for 5 minutes. Varied MWCNTs content were mixed in polymer matrix i.e. 0.5, 1, 3, 6 and 10 wt.-%.

Invited Lecture

Later, plates having thickness of 1 mm were prepared by compression moulding at 200 °C for further experimentation and characterization.

Results and Discussion

PBAT/MWCNTs composites thus prepared were found electrically conducting in nature. The volume resistivity of each sample was measured with respect to filler content and the value of volume resistivity was found to decrease with increasing MWCNTs content. It suggests that the conductivity of composites increases with increasing MWCNTs content in them.

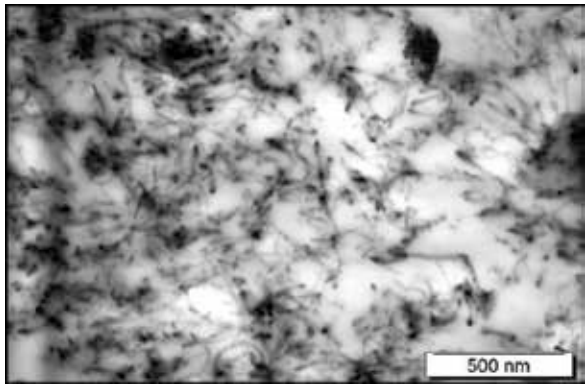

Figure 1 TEM micrograph of PBAT/MWCNT nanocomposites with 3 wt.-% filler

Morphological study of the composites by electron microscopic techniques such as SEM and TEM shows the homogeneous mixing of MWCNTs in PBAT during microcompounding (see TEM image of a composite in Fig. 1). It shows occasional agglomeration of filler particles which might affect the value of conductivity. Tensile stress-strain curves of the composites containing different wt.-% of filler in PBAT matrix (Fig. 2) suggest that all the composite samples broke in the strain range of 100-550% while the pure PBAT broke nearly at 700%. It shows a large plastic deformation and the tensile strength of about 25 MPa.

It can be observed that the mechanical performance of the composites with respect to tensile stress as well as strain at break worsens with increasing filler content. An improving trend in yield stress of the composites can also be observed with increasing filler content in them. The increased slope of stress-strain curves implies that stiffness of the composites increases with increasing filler content. It can be concluded that agglomeration of filler particles might have occurred with increasing filler content.

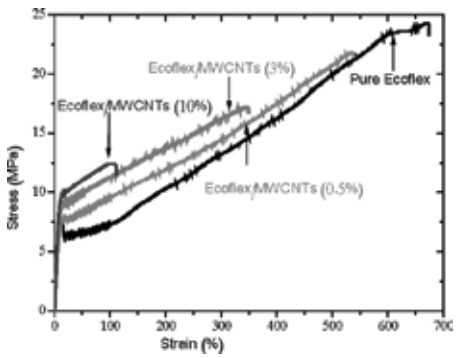

Figure 2 Stress-strain curves of PBAT/MWCNTs composites with variable wt.-% of the filler

Invited Lecture

Fig. 3 shows the volume resistivity of the composite materials as a function of MWCNTs content. It can be observed that the addition of 1 wt.-% of the nanofiller into the polymer matrix dramatically reduces the resistivity of the materials, the trend becoming more significant with an increase in MWCNTs content. Beyond 3 wt.-% filler content, the resistivity almost levels off.

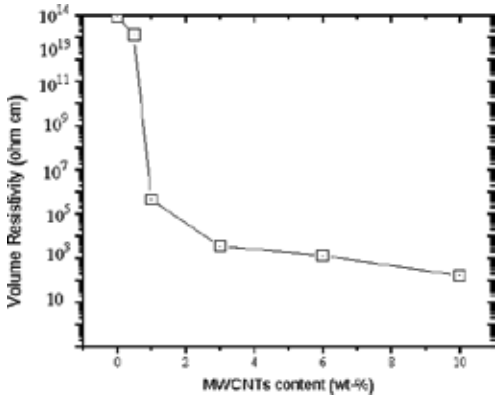

Figure 3 volume resistivity if the composite materials as a function of wt.-% of MWCNTs

The dramatic increase in conductivity of the composite can be correlated with quite well dispersion of the filler into the polymer matrix (see Fig. 1). It can be inferred that the percolation threshold of the conducting filled needed for imparting the volume conductivity to the matrix polymer is reached at about 1 wt.-% of the MWCNTs in the present case.

Conclusions

The results outlined in this paper can be summarized in the following way:

1. Environmentally benign electrically conducting PBAT/MWCNTs composites were successfully prepared using biodegradable polymer matrix.
2. The filler dispersion is the polymer matrix as evidenced by electron microscopic results is quite good ensuring the formation of well-defined percolation network.
3. The high elongation at break of the samples even at high filler content assures the high flexibility of the nanocomposites.
4. Optimum mechanical properties of composites coupled with their high conductivity make them good candidate for developing light and flexible materials for electronic applications

Acknowledgements

We gratefully acknowledge the support of Alexander von Humboldt (AvH) Foundation, Germany for providing financial support for research stay of KND and RA in Germany. We further than Dr. P. Potschke, Dr. J. Pionteck, Dr. R. Boldt (IPF Dresden, Germany) for their cooperation.

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Invited Lecture

IL-43: Comparison of promising pretreatment technologies for lignocellulosic biomass

Vaibhav V Goud, Mood Mohan, Tamal Banerjee

Department of Chemical Engineering, Indian Institute of Technology Guwahati, Guwahati, Assam-781039, India

The present study reveals the dissolution behavior of lignocellulosic biomass components in potential Ionic Liquids (ILs) using both Quantum Chemical (QC) and experimental confirmation. The dissolution order of cellulose and hemicellulose in ILs was primarily determined by the evaluation of hydrogen bonds between the oxygen atom of anion and hydroxyl proton of cellulose/hemicellulose. From this discernible fact, the anion of the IL observed to play a leading role in the dissolution process as compared to the cation in the solvation process. Eventually, acetate $[OAc]^-$ anion and 1-ethyl-3-methylimidazolium $[EMIM]^+$ cation were found to be good candidates for the dissolution of cellulose and hemicellulose. Furthermore, the study was extended to investigate the efficiency of three pretreatment pathways of biomass namely Ionic Liquid, subcritical water (SCW), and dilute acid (H_2SO_4) hydrolysis. Here, IL and SCW treatments are considered as green solvents due to their several attractive properties. From the enzymatic hydrolysis, the highest yield of TRS (63%) was attained in IL-treated biomass at 150 °C, whereas in the case of dilute acid treatment it was 19% (0.2 M and 121 °C). However, TRS yield was also compared with SCW treatment and found that the highest TRS yield obtained was 42.21% at 180 °C. This primarily attributed to the difference in the crystallinity and delignification in IL process. A comparison made between the pretreatment pathways showed that the crystallinity index of biomass found to decrease in [Emim][OAc] treatment (35.96%), while for SCW (71.90%) and acid hydrolysis (75.0%) it was higher. The enzymatic hydrolysis of SCW treated biomass was not performed due to its higher crystallinity. Furthermore, to improve the enzymatic hydrolysis efficiency of biomass, combined pretreatment (dilute acid + ionic liquid) process was also employed and compared with IL pretreated cellulose. The results revealed that IL pretreatment produces higher sugar yield compared to SCW and dilute acid pretreatment process.

Invited Lecture

IL-44: Framework for Designing Sustainable Polymers: An Environmental Perspective

Reddithota J. Krupadam

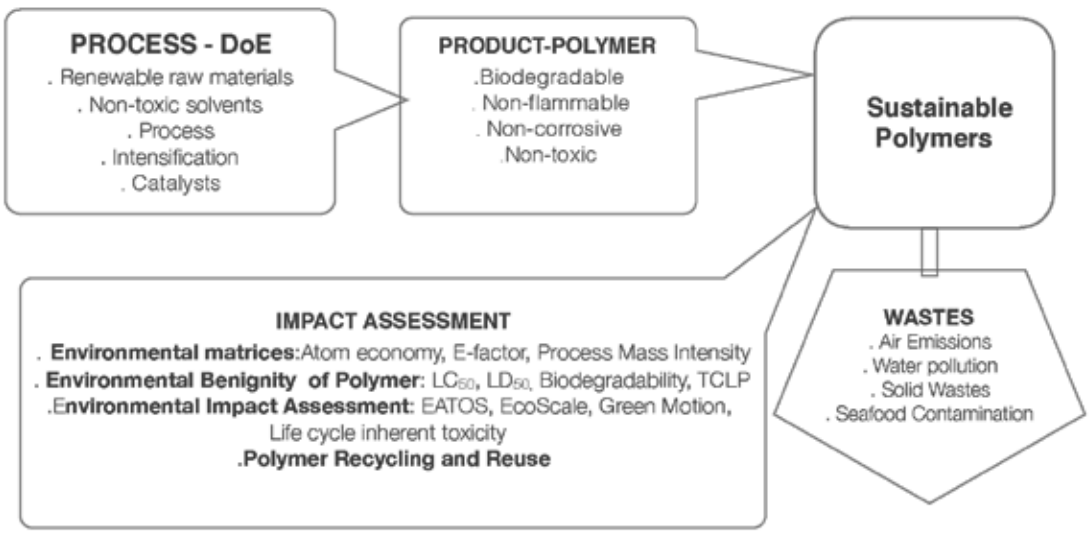
Environmental Impact & Sustainability Division

National Environmental Engineering Research Institute, Nehru Marg, Nagpur 440040, India

Tel:+91-7972397063; Fax: +91-712-2249896; E-mail: rj_krupadam@neeri.res.in

Abstract

Development of sustainable polymers requires synergy between the design of preparation and the polymer's environmental benignity. Important principles for the design of sustainable polymer include (i) selection of suitable reactants (preferably non-petroleum based) (ii) no use of volatile organic solvents (iii) use of cost-effective and reusable catalysts and (iv) processes intensification using emerging technologies such as micro-reactor technologies. Application of different matrices such as atom economy, E-factor, and reaction mass efficiency are useful tools for assessment of sustainability of the polymerization process. Indeed, green chemistry approach called Design of Environment (DoE) is an effective for selecting the reactions and route of synthesis based on low or no waste generation with the use of optimum energy. Another aspect of sustainable polymers is the product polymer should be environmentally benign. The parameters followed for environmental benignity of polymer should be (i) biodegradable (ii) less toxic (iii) non-corrosive and (iv) non-flammable. The polymers during natural decomposition are not intended to produce toxic gases and greenhouse gases such as CO_2 and CH_4. Use of LD_{50} and LC_{50} are two important tests provide information on toxicity of polymers in aquatic/marine ecosystems. Microplastics are partially degraded polymers and these emerging pollutants are reported in seafood. The functional integrity of the polymers should be protected during formulating the new synthesis approaches in the interest of market needs.



Schematic showing the Framework of Design of Sustainable Polymer

Invited Lecture

IL-45: Columnar self-assembly of shape-anisotropic molecules and their applications in organic electronics

A.S. Achalkumar*[1]

[1] Department of Chemistry, Indian Institute of Technology Guwahati, Guwahati, Assam-781039, India.

* Corresponding author, e-mail:achalkumar@iitg.ernet.in, achalkumar78@gmail.com

Abstract: Liquid crystalline semiconductors seem to be a bright option for the application in organic electronics considering their good solubility, processability and excellent reproducibility along with the ease of purification. [1,2] Additionally, the addressability of their molecular alignment and charge trapping by defects in the thin films by thermal annealing provides a major advantage over amorphous polymers and organic single crystals. We report several shape anisotropic molecules containing two centrally placed 1,3,4-thiadiazole units, which vary from each other with respect to the number and length of the flexible chains at the termini.[3] The number, position and length of the peripheral chains connected to the termini showed an impact on the thermal behavior of these compounds. The compounds with two terminal tails exhibited enantiotropic smectic C phase, while the compounds with four terminal tails turned to be crystalline. Surprisingly, among the compounds with six terminal tails, only the compound with longer terminal chain exhibited columnar phase with oblique symmetry. It is also to be noted that only compounds with six terminal chains exhibited gelation in long chain hydrocarbons. The xerogel of the hexacatenar with six n-decyloxy chains showed the entangled network of nanofibers of several micrometer lengths. The aggregation behavior of the hexacatenar in hydrocarbon solvent, is mainly supported by the attractive π-π interactions of the aromatic cores and van der Waals interactions offered by the peripheral flexible tails. The emission behavior is dependent on the number of peripheral tails and not on the length. Further one of the hexacatenar exhibited solvatochromic emissive behavior. This molecular design helps in the development of long molecular nanowires with a central conducting core and insulating peripheral sheath, which will be helpful for the application in organic electronic devices. The application potential of the columnar liquid crystal material was tested by the fabrication of organic light emitting diodes (OLEDs) either as single emissive material or as a guest material in a host polymer. Higher efficiency and brightness was noticed in the host guest OLED, which exhibited a technologically important bright blue emission. In another molecular design we have stabilized room temperature columnar liquid crystals, which were also tested for their application in OLEDs and exhibited higher electroluminescence properties.[4]

Keywords: *Columnar LCs; OLEDs; Organic electronics, Heterocycles*

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Invited Lecture

IL-46: Designing with Bio-composite for Sustainable Development

Amarendra Kumar Das
Professor, Department of Design, IIT Guwahati
E mail: dasak@iitg.ernet.in, dasak.iitg@gmail.com

Abstract:

Industrial/ Product designers play important roles in introduction of various new materials and processes in products and services. These new materials and processes may be the result of scientific research in various domain, but to apply these new materials and processes in various products require these materials to be integrated into useable products. Thus for sustainable development, it is the designers that need to be aware of development in materials and processes and should be keen to apply these materials in practical use.

The author of this research fabricated bio-composites for applications in transportation sector, specifically in Human powered vehicle. Composites fabricated can be considered as Bio-composites because Non-woven jute fabric is used as replacement of the fiber that is in discontinuous or dispersed phase, the matric is polyester resin in continuous phase and interphase region also known as the interface between the fiber and matrix formed by fiber and polyester resin. Once these composites are discarded, due to cellulosic origin of the jute fibers, these get decomposed over time without creating serious pollution in nature. Being natural fibers, these can be cultivated and thus sustainable. Polyester resins too can be produced from natural ingredients like castor oil and these resins gets decomposed without the hazards of solid waste pollution to the environment.

Components fabricated out of bio-composites were used as seat, seat back, floor boards, side boards and roof of Dipbahan Tri-cycle rickshaws.

Key words: Bio-Composites, Jute non-woven fabric, Product design

Oral Presentation

OP-01 Recyclable Polylactic Acid grafted Cellulose Nanocrystal Films through Reactive Extrusion Approach

Dhar Prodyut, Kumar Amit and Katiyar Vimal

[a]Department of Chemical Engineering, Indian Institute of Technology Guwahati, Guwahati, 781039, Assam, India.

E-mail i.d.: vkatiyar@iitg.ac.in

Abstract: This work reports a single step reactive extrusion process for fabrication of thermally stable, polylactic acid grafted cellulose nanocrystal(PLA-g-CNC) nanocomposite films using dicumyl peroxide as crosslinking agent. PLA-g-CNC nanocomposites were recycled without significant breakage in the molecular structure of PLA. The grafted PLA chains shields the sulfate and hydroxyl groups of CNCs, thereby enhancing the compatibilization with PLA matrix and preventing thermal degradation during extrusion. NMR and FTIR spectroscopy studies showed that amorphous PLA chains grafted on CNC surface through C–C bonds formation. Presence of such chemical crosslinks led to efficient transfer of modulus of CNCs to PLA matrix, thereby improving the tensile strength and young's modulus by~40% and~490%,respectively. Recycling of PLA-g-CNC doesn't alter the molecular weight, thermal, crystallization and mechanical properties of the nanocomposites significantly. Therefore, the current study provid es a novel approach for fabricating CNC-reinforced-PLA nanocomposites which can be easily recycled and reused for multiplecycles.

Keywords: *Cellulose nanocrystal, Polylactic acid, Nanocomposites*

OP-02 Shape memory polymer nanocomposites for biomedical application

Arpan Biswas and Pralay Maiti,*

School of Materials Science and Technology, Indian Institute of Technology (Banaras Hindu University), Varanasi 221 005, India.

*Correspondences should be made to pmaiti.mst@itbhu.ac.in (Pralay Maiti)

Abstract: The nanohybrid of polyurethane has been prepared through in-situ polymerization of aliphatic diisocyanate, ester polyol and chain extender in presence of two-dimensional platelets. Polymerization within the platelet galleries helps to intercalate, generate diverse nanostructure and improved nano to macro scale self-assembly leading to the significant enhancement in toughness and thermal stability of the nanohybrid in comparison to pure polyurethane. Nanohybrid exhibits significant improvement in shape memory phenomena (91% recovery) at the physiological temperature suits them for many biomedical applications. Structural alteration, studied through temperature dependent small angle neutron scattering and X-ray diffraction, along with unique crystallization behavior have been extensively revealed the special shape memory behavior of this nanohybrid understanding the molecular flipping in presence nanoplatelets. In-vivo study on albino rats exhibits the potential of nanohybrid as self-tightening suture in keyhole surgery by closing the wound lips appropriately through the recovery of the programmed shape at physiological temperature.

Keywords: *Nanohybrid, shape memory effect,self-tightening suture.*

Oral Presentation

OP-03 Lactic Acid Oligomer (OLLA) Grafted Gum Arabic Conjugates: A Bio-based Adhesive for Structural Applications

Neelima Tripathi[1], Vimal Katiyar[*2]

[1]Department of Chemical Engineering, Indian Institute of Technology Kanpur, Kanpur, Uttar Pradesh - 208016, India.

[2]Department of Chemical Engineering, Indian Institute of Technology Guwahati, Guwahati, Assam - 781039, India.

*Corresponding author, E-mail: vkatiyar@iitg.ernet.in

Abstract: L-Lactic acid (LA)-grafted-gum arabic (GA) graft copolymer [OLLA-*g*-GA] was synthesized by using microwave heating in which the hydrophilic GA was grafted with insitu grown lactic acid oligomer. The grafting at O-H and N-H groups in GA backbone with *oligo*-(L-lactic acid) (OLLA) chains confirmed by FTIR and NMR analyses. The uniform dispersion of GA in OLLA, is due to the formation of amphiphile GA backbone grafted with OLLA chains, which is supported by XRD, SEM and TEM analyses. This synthesized OLLA -*g*-GA graft copolymer showed adhesive characteristics with glass and granite substrates. The single lap shear joint of two glass and two granite substrates were fabricated and the adhesive properties of these laminated substrates were tested using Universal Testing Machine. The synthesized biobased adhesive showed excellent shear strength with respect to the present biobased adhesives and substrate failure was observed at optimized conditions during the sheartest.

Keywords: *bio-based; adhesives; lap-shear; polycondensation*

OP-04 Evaluation of silk fibroin/Xanthan biopolymeric blends using FTIR imaging and DTA analysis

Shailendra Singh Shera*[1], Shraddha Sahu[1], Rathindra Mohan Banik[1]

[1]School of Biochemical Engineering, Indian Institute of Technology (Banaras Hindu University), Varanasi, Uttar Pradesh-221005, India

*Corresponding author, E-mail:rmbanik@gmail.com

Abstract: Blending is a cost-effective method to develop new polymeric biomaterials. The miscibility of blends has great influence on physical and bulk properties of biomaterials. A non-invasive, non-destructive Fourier transform infrared (FTIR) imaging was used to investigate miscibility and phase structure of silk fibroin/xanthan blends. Differential thermal analysis (DTA) was used to evaluate thermal properties and decomposition arising out of different phase structure in the binary system. A 80:20 (SFX82) mixture of 7% silk fibroin and 0.3% xanthan showed uniform distribution of silk fibroin and good miscibility behavior. SFX64 (a 60:40 mixture of 7% silk fibroin and 0.3% xanthan) and SFX55 (a 50:50 mixture mixture of 7% silk fibroin and 0.3% xanthan) showed non-uniform distribution of silk fibroin and partial miscible character. The thermal analysis revealed a decomposition temperature (T_d) of SFX82, SFX64 and SFX55 blend at 284ºC, 281ºC respectively indicating good thermal stability as compared to silk fibroin (T_d= 286ºC) polymeric material.

Keywords: *Miscibility; Phase behavior; Non-Invasive; Quantitative; Qualitative; Thermo gravimetric*

Oral Presentation

OP-05 Aggregation behaviour of non-ionic twinned amphiphiles and their application as biomedical nanocarriers

Abhishek K. Singh[1], Parmanand[1], Boris Schade[3], Katharina Achazi[2], Christoph Böttcher[3], Rainer Haag[2], Sunil K. Sharma*[1]

[1]Department of Chemistry, University of Delhi, Delhi, Delhi- 110007, India
[2]Institut für Chemie und Biochemie, Freie Universität Berlin, Takustraße 3, 14195 Berlin, Germany
[3] Forschungszentrum für Elektronenmikroskopie, Institut für Chemieund Biochemie, Freie UniversitätBerlin, Fabeckstraße 36a, 14195 Berlin, Germany
*Corresponding author, E-mail: sksharma@chemistry.du.ac.in

Abstract: A new class of twinned amphiphiles was developed by conjugating a pair of hydrophilic head groups from mPEG chains (Mn: 350 or 1000) and a pair of hydrophobic segments from linear alkyl chains (C_{11}or C_{18}) through a novel spacer synthesized from glycerol and *p*-hydroxybenzoic acid. The aggregation phenomena of the amphiphiles were proven by DLS and fluorescence experiments, whereas size and morphology of the aggregates were evaluated by *cryo*-TEM, the measurements proved the formation of globular, thread-like or rod-like micelles as well as planar double-layer assemblies, depending on the amphiphile's molecular structure. The applicability of these non-ionic amphiphilic systems as nanocarriers for hydrophobic guest molecules was demonstrated by encapsulating a hydrophobic dye, Nile red, and a hydrophobic drug, Nimodipine. The transport capacity results for both Nimodipine and Nile Red prove them as a promising candidate for drugdelivery.

Keywords: Twinned amphiphiles, self-assembly, nanocarriers, *Cryo*-TEM

OP-06 Rheological, Mechanical and Barrier Studies of Chitosan-graft-Lactic Acid Oligomer Reinforced Poly(Lactic Acid) Bionanocomposite Films

Akhilesh Kumar Pal*[1], Vimal Katiyar[1]

[1]Department of Chemical Engineering, Indian Institute of Technology Guwahati, Guwahati, Assam- 781039, India.
*Corresponding author, E-mail:vkatiyar@iitg.ernet.in

Abstract: Various compositions of nontoxic biodegradable poly(lactic acid) (PLA)/chitosan-graft-lactic acid oligomer (CH-g-OLLA) bionanocomposite films were fabricated with a solution casting technique by the dispersal of CH-g-OLLA copolymer at different amounts (1, 3, and 5 wt %) into the PLA matrix. The filler (CH-g-OLLA) synthesized by an in situ condensation polymerization reaction in a microwave, and the grafting of lactic acid oligomer chains at the C2 position of the chitosan backbone was confirmed by the presence of new

Oral Presentation

peaks at 179.08 and 174.41 ppm in ^{13}C-NMR analysis. The rheological studies showed the viscous behavior of the PLA and PLA/CH-g-OLLA bionanocomposite films as the storage modulus values were found to be lower than the loss modulus values over the entire range of angular frequency at 180°C. Furthermore, a Cole-Cole plot and Han plot described the uniform dispersion of the filler in the PLA matrix, its agglomeration at higher loading, and the structural change between the PLA and PLA/CH-g-OLLA bionanocomposite films [1]. The prepared PLA/CH-g-OLLA bionanocomposite films appeared with uniform dispersion of nanoamphiphilic CH-g-OLLA molecules with self-assembled micelles having size as low as ~20 nm and as high as ~150 nm with core-shell morphology in PLA matrix as shown in Figure 1. This nano-filler was found very effective toward significant reduction in oxygen permeability (OP) by ~10 fold due to the reduction in solubility of oxygen molecules and improvement in crystal nucleation density due to availability of nano -nucleating sites [2]. Ultimate tensile strength (UTS) of PLA/CH-g-OLLA bionanocomposite films were relatively comparable to that of PLA, however, elongation at break was improvedsignificantly.

Keywords: *Biodegradable; Grafting; Micelles; Rheology; Oxygen barrier*

OP-07 Polymer brushes for tuning the spatial arrangement of nanoparticles in polymer nanocompositefilms

Kishore Kumar Sriramoju[1], Venkat Padmanabhan[2]

kishorekumar.s@bvrit.ac.in, vpadmanabhan@tntech.edu

[1]Dept. of Chemical Engg., B.V. Raju Institute of Technology, Narsapur, Medak, Telangana, India.

[2]Dept. of Chemical Engg., Tennessee Technological University, Cookeville, TN, USA.

Surface confined macromolecules known as polymer brushes play an important role in the design and development of novel materials. The tethering of polymer chains to the surface can substantially alter the surface's macroscopic properties. In material science and nano-biotechnology, we see many applications where polymer brushes interact with nanoparticles in composite films. Using Coarse-grained molecular dynamics simulations, we study the effect of polymer brushes on the spatial organization of nanoparticles, which are embedded in polymer nanocomposite films. The polymer brushes and matrix are modeled as bead-spring chains and nanoparticles as spherical beads. In films, nanoparticles often segregate to the substrate due to depletion attraction. When the surface is grafted, the tethered chains shield the depletion attraction between the surface and nanoparticles and prevent them from migrating to the surface. At low grafting density, both polymersand nanoparticles penetrate into the brushes. But as the grafting density increases, the matrix dewets the brush due to strong steric repulsions between the grafted monomers and the matrix chains, causing the nanoparticles to occupy the interfacial region. Our results show that, surface modification using polymer brushes offers additional parameters to tune the spatial arrangement of nanoparticles in films for various applications including,sensors, adhesives, lubricants,etc.

Keywords: Polymer brush, Nanoparticles, Thin films, Grafting density, MD Simulations.

Oral Presentation

OP-08 Synthesis of Non-ionic Bolaamphiphile and Study of its Self-assembly and Transport Behaviour for Drug Delivery Applications

Rashmi[1], Ayushi Mittal[1], Katharina Achazi[2], Boris Schade[3], Christoph Böttcher[3], Rainer Haag[2], Sunil K. Sharma[1]*

[1]Department of Chemistry, University of Delhi, Delhi, Delhi-110007, India
[2]Institut für Chemie und Biochemie, Freie Universität Berlin, Takustraße 3, 14195 Berlin, Germany
[3]Forschungszentrum für Elektronenmikroskopie, Institut für Chemie und Biochemie, Freie Universität Berlin, Fabeckstraße 36a, 14195 Berlin, Germany
*Corresponding author, E-mail: sksharma@chemistry.du.ac.in

Abstract: Bolaamphiphile with polyethylene glycol unit has been synthesised following a Click chemistry approach by chemoenzymatic with immobilized *Candida antartica* lipase (Novozym 435). The aggregation phenomena of the amphiphile was studied by DLS and fluorescence experiments. The applicability of the non-ionic amphiphilic system as nanocarriers for hydrophobic guest molecules was demonstrated by encapsulating a hydrophobic dye, Nile red, and a hydrophobic drug, Nimodipine. The transport capacity results for both Nimodipine and Nile Red proves it to be a promising candidate for drug delivery.

Keywords: Self-assembly, amphiphiles, drug delivery

OP-09 Synthesis of nanocomposite hydrogel using modified carboxymethyl cellulose and AuNPs: A transdermal drug carrier

Barun Mandal and Sagar Pal*

*Polymer Chemistry Laboratory, Department of Applied Chemistry, Indian Institute of Technology (Indian School of Mines), Dhanbad-826004, India.
*E-mail: sagarpal1@hotmail.com

Abstract: A novel transdermal drugs carrier has been developed in authors' laboratory using chemically crosslinked carboxymethyl cellulose and *in-situ* deposited AuNPs. [1]The developed material has been found to be non-toxic and delivers the drugs in sustained manner. It has also been observed that with increase in crosslinking density and subsequent deposition of AuNPs, the sustained release behaviour was enhanced.

Oral Presentation

OP-10 Paper based biofuel cell with photosynthetic microbial anode and air breathing enzymatic cathode

Sharbani Kaushik*[1], Priyanki Das[2], Pranab Goswami[3#]

[1,2]Center for Energy, Indian Institute of Technology Guwahati, Guwahati, Assam- 781039, India.
[3]Department of Biosciences and Bioengineering, Indian Institute of Technology Guwahati, Guwahati, Assam-781039, India.
[#]Corresponding author, E-mail:pgoswami@iitg.ernet.in

Abstract: Miniaturized biofuel cell (BFC) in biodegradable platforms has enormous application potential in the field of biosensors particularly, for diagnostics and environmental monitoring. Here, a miniaturized BFC in paper platform has been developed using cyanobacterial cell and bilirubin oxidase as the anodic and cathodic biocatalysts, respectively. The BFC produced ~ 0.46 V continuously for 300 h when operated under heterotrophic condition using acetate as anodic fuel and air breathed cathode. This novel BFC exp ected to serve as sensing platform for various targets bearing specific influence on the photosynthetic metabolic machinery of the cyanobacterial cells.

Keywords: *Cyanobacteria, paper based photosynthetic microbial fuel cell, bilirubin oxidase*

OP-11 Studies on Silk-based Bionanocomposites

Rahul Patwa*, Amit Kumar and Vimal Katiyar*

Department of Chemical Engineering, Indian Institute of Technology Guwahati-781039, Assam, India.
*Corresponding author, E-mail:vkatiyar@iitg.ernet.in

Abstract: In the current work, crystalline silk nano-discs (CSNs) are extracted from waste Muga silk through novel hydrolysis cum sonication route providing an effective strategy for upconversion of 'waste to wealth'. The average diameter and thickness of CSNs is 49.1±12 nm and 3.1±0.9 nm, respectively. CSNs are hydrophobic in nature, highly crystalline (C.I. = ~93.7%) and have superior thermal stability of 310 °C. Furthermore, surface of CSNs are modified using iron-oxide nanoparticles to fabricate magnetic CSNs (MGCSNs) through one-step reduction reaction. MGCSNs have diameter and thickness of 58.2 ± 4.6 nm and 16.0 ± 2.6 nm, respectively. Subsequently, CSNs are used as reinforcement material in the poly (lactic acid) (PLA) matrix to fabricate PLA/CSN "green" biocomposite through melt-extrusion for potential high temperature engineering and food packaging applications. At optimum loadings of 1 wt. %, the formation of network like structure covering the entire matrix, corroborated through morphological analysis, leads to significant improvement in intrinsic characteristics such as thermal, mechanical, barrier, and processing capabilities. The crystallization behavior is studied using non-isothermal cold crystallization and isothermal melt crystallization using differential calorimetry. Addition of CSNs in PLA matrix results in lower cold crystallization temperatures (T_{cc}) and shorter crystallization half-time ($t_{0.5}$) with enhanced growth rates. It was found that CSNs act as heterogeneous nucleating agents, hence improve non-isothermal crystallization kinetics of PLA. Improvement in crystal nucleation density is observed as CSNs contribute towards new nano-nucleation sites. In addition to this, effect of CSNs on the thermal degradation kinetic studies for PLA and PLA/CSN are carried out using thermogravimetric analysis (TGA) at various non-isothermal heating rates. The apparent activation energies (E_a) of nanobiocomposites, determined from kinetic models increased in comparison to pure PLA which inform that CSNs impede the thermal degradation process. The hydrolytic degradation rate of composites was slower as compared to PLA in

Oral Presentation

acidic, neutral and alkaline media at pH=2, 7 and 12, respectively due to hydrophobic nature of CSN and pH. This work provides valuable insight for the application and reclamation of PLA/CSN bionanocomposites in moist and wet working environments. Further, fabricated CSNs and MGCSNs are utilized for preparation of PLA based nanofibrous scaffolds by electrospinning. Interestingly, alignment of CSN derived magnetic nanoparticles due to effective fiber drawing process during electrospinning could improve cytocompatibility against BHK-21 cells. In vitro cell cytocompatibility studies show improved cell adhesion and proliferation on the surface of the developed biocomposites scaffolds which support its biocompatible nature. Combined effect of curcumin and hyperthermia reduced the growth to ~57%.

Keywords: *Poly (lactic-acid), crystalline silk nano-discs, silk, food packaging, cancer therapy.*

OP-12 Gelatin crosslinked nanoparticles for controlled release of silibinin and lipoic acid

Plabita Gogoi*[1], Tarun K Maji[2]

[1]Chemical Sciences, Tezpur University, Tezpur, Assam- 784028, India.
[2]Chemical Sciences, Tezpur University, Tezpur, Assam- 784028, India.
*Corresponding author, E-mail: plabita41@gmail.com

Abstract: Nanoparticles with suitable bio-compatible coatings using natural biodegradable polymers have been used in pharmaceutical sciences, particularly in drug delivery applications, magnetic resonance imaging (MRI) and tissue engineering. Gelatin nanoparticles were prepared using silibinin and lipoic acid as the active agent. The prepared nanoparticles were characterised by Fourier Transform Infrared spectroscopy (FTIR), X-ray diffractometry (XRD), Scanning Electron Microscopy (SEM) and Transmission Electron Microscope (TEM). The average diameter of the nanoparticles was studied by Dynamic Light Scattering (DLS) analyser. Various effects of surfactant (Tween 80) were evaluated with regard to swelling, encapsulation efficiency and drug release in pH medium (pH- 6.8). The drug release was studied by UV-Vis spectroscopy for 48 h at pH 6.8. Cytotoxicity study was performed by MTT assay analysis using normal human blood, MCF-7 and MDA-MB-435S cancer celllines.

Keywords: *silibinin; lipoic acid; genipin*

OP-13 Synthesis and Characterization of Cardanol based Polybenzoxazine-Epoxy Copolymer for Anti-Corrosive Coating Application

Deepak Patil[1], Ganesh Phalak[2], Shashank Mhaske*

Department of Polymer and Surface Engineering, Institute of Chemical Technology, Mumbai, Maharashtra- 400019, India.
*Corresponding author, st.mhaske@ictmumbai.edu.in

Abstract: The bio-based amine functional benzoxazine (Bnz) resin was synthesized from cardanol, N,N'-Bis(2-aminoethyl)ethane-1,2-diamine and paraformaldehyde by the Mannich condensation reaction. The additional amine functionality in Bnz resin was introduced by using multi-functional amine (N,N'-Bis(2-aminoethyl)ethane-1,2-diamine) to react with monofunctional cardanol. The synthesized amine functional Bnz resin was chemically analyzed for amine value by volumetric titration method. The Fourier Transform Infrared spectroscopy (FTIR) and

Oral Presentation

1H-Nuclear Magnetic Resonance (1H-NMR) spectroscopy used to illustrate the structure of amine functional Bnz resin. The synthesized Bnz resin was copolymerized with conventional epoxy resins to prepare Poly(Benzoxazine-co-Epoxy) coatings for anti-corrosive application. The network formation of Bnz and epoxy resins was monitor by FTIR analysis. The Poly(Benzoxazine-co-Epoxy) coatings have shown good mechanical, chemical, and solvent resistance properties as compared to the Bnz coating. Further, gel content and water absorption of Poly(Benzoxazine -co-Epoxy) and Bnz coatings were also studied. The cured coatings were evaluated for thermal behavior by thermogravimetric analysis (TGA). The corrosion resistance properties of coatings were investigated by salt spray andelectrochemical analysis.

Keywords: Bio-based; Functional; Benzoxazine; Anti corrosive; Poly(Benzoxazine-co-Epoxy)

OP-14 Sustainable Tough Waterborne Hyperbranched Polyester Nanocomposite using Carbon dot and its Nanohybrid through a Greener Approach for Multifaceted Applications

Deepshikha Hazarika# and Niranjan Karak*

Department of Chemical Sciences, Tezpur, Assam- 784028, India.

*Corresponding author, E-mail:karak niranjan@gmail.com

Presenting author, E-mail:hazarikadeepshik ha@gmail.com

Abstract: The sustainable growth is a significant powerful strength behind polymer technology. Thus, in this study sustainable waterborne hyperbranched polyester nanocomposite was fabricated using carbon dot and its nanohybrid (carbon dot@TiO_2) through a greener in situ polymerization technique without using any solvent and compatibilizing agent from bio-based raw materials to address the problem related to high volatile organic compound containing solvent borne one. The nanocomposite showed tremendous enhancement in mechanical and thermal properties as well as exhibited both wavelength dependent down- and up-conversion photoluminescence behaviors. Further, the nanocomposite was used for multifaceted applications including photocatalyst and crude oil purification membrane. Thus, this resultant nanocomposite is a promising sustainable polymeric material in different advanced fields.

Keywords : *Bio-ba sed; ca rbon dot ; nanohybrid ; polyest er nanocompo site ; sustainable*

OP-15 Plastic waste management based on blending of different (Waste Electrical and electronic equipments) WEEE's and their characterization

Jaidev K, Omdeo K Gohatre, Manoranjan Biswal, Smita Mohanty, S. K. Nayak

Laboratory for Advanced Research in Polymeric Materials (LARPM), Central Institute of Plastics Engineering and Technology (CIPET), B-25, CNI Complex, Patia, Bhubaneswar, Odisha 751024, India

Abstract: The aim of this study is to improve the property of a Waste electric and electronic equipments (WEEE) plastic material by blending it with another WEEE material. The material that has been chosen are HIPS, ABS that are

Oral Presentation

recovered from Computer housing scraps, and PVC, which is obtained from building power supply cables and wires. ABS and HIPS are materials which are known for their high impact strength, but due to recycling and degradation, they lose their impact property, so improvement of impact strength of these materials is our prime aim and we have chosen r-PVC, which are recovered from wires and cables to improve its property. Three different ratios of r-PVC with r-ABS and r-HIPS were blended in a batch mixer for homogenous mixing. The bended samples are introduced into micro compounder to make mechanical specimens. Impact strength of the specimen is studied, in which we observed that the impact strength increases in r-ABS/r-PVC as we add r- PVC sample and similarly decreases in r-HIPS/r-PVC with the addition of r-PVC. This difference in impact property of the blend is studied by analysing the morphology of the impact fractured sample. Thermal property of the blend is measured using DSC and TGA, in which the TGA shows the ascending percentage of residue as we add r-PVC. The chemical interaction in the blend is explained through FTIR-ATR which shows shift in specific peaks after belnding. The improvement of impact property is explained with the help of a plausible mechanism, which supports the compatibility in the blend.

Keywords: WEEE, Mechanism, Blending, TGA, FTIR-ATR.

OP-16 Optimization of waste cooking oil lubricant base stock synthesis via epoxidation using homogeneous acidic catalyst

Atanu Kumar Paul[1], Venu Babu Borugadda[2], Vaibhav V. Goud*[1]

[1]Department of Chemical Engineering, Indian Institute of Technology Guwahati, Guwahati 781039 Assam, India.

[2]Department of Chemical and Biological Engineering, University of Saskatchewan, Saskatoon, SK Canada, S7N 5A2.

*Corresponding author, E-mail:vvgoud@iitg.ernet.in

Abstract: Synthesis of waste cooking oil (WCO) based lubricant basestock was prepared via epoxidation, using sulfuric acid (SA) as a homogeneous acid catalyst. Response surface methodology (RSM) was adopted as an optimization tool to study and optimize the effects of reaction variables on maximum oxirane oxygen content(OOC) of the epoxidised WCO. Interaction of the process parameters, such as hydrogen peroxide to ethylenic unsaturation molar ratio, catalyst loading (wt%) and reaction time (h) was examined by ANOVA using Design expert software (DOE, version 7.0.1). The optimum OOC of epoxidised WCO was found to be 4.7 mass% under the experimental conditions of 60°C, 6 h of reaction time, 1.5 g of catalyst loading and 1:2 molar ratio of C=C bonds/ H_2O_2. The product was confirmed by FTIR, $^{1}H/^{13}C$-NMR, and OOC. Thermo-oxidative stability was found by thermo gravimetric analysis (TGA) and cold flow behavior of the end product was estimated by differential scanning calorimetry (DSC). Significant physico-chemical properties of the prepared lubricant basestock was evaluated at optimum condition using standard methods. Further, ANN modeling was carried out by using identical data set. The results of the study revealed that the chemically modified WCO derivatives also can act as potential biolubricantbasestock.

Keywords: *Waste cooking oil; Epoxidation; Oxirane oxygen content; Iodine value; Response surface methodology*

Oral Presentation

OP-17 Sustainable-resource-based tough hyperbranched polyurethane nanocomposites with different carbon based metal nanohybrids: Perspective as multifunctional smart materials

Rituparna Duarah# and Niranjan Karak*

Department of Chemical Sciences, Tezpur University, Tezpur, Assam-784028, India
*Corresponding author, karakniranjan@gmail.com
#Presenting author, rituparnaduarah@gmail.com

Abstract: Developing a smart bio-based hyperbranched polyurethane nanocomposite with collective attributes of high performance, self healing and shape memory behavior is a challenge in the field of scientific and industrial research. In this context, the authors designed biocompatible, biodegradable, tough and smart hyperbranched polyurethane (HPU) nanocomposites using different carbon based metal nanohybrids, devoid of any plasticizer or catalyst. The structural insights of the nanohybrids and their nanocomposites were confirmed from TEM, XRD, FTIR, EDX and thermal studies. The HPU nanocomposites exhibited improved tensile strength, elongation at break, scratch hardness, impact strength and toughness at room temperature. The nanocomposites also demonstrated remarkable non-contact triggered shape-recovery and self-expandable behavior at body temperature. They displayed repeatable self-healing capabilities under sunlight and microwave exposure. The fabricated nanocomposites were also able to degrade various organic pollutants under sunlight by following the pseudo kinetics first order model. Thus, the fabricated nanocomposites have remarkable potential to be used as superior non-contact triggered smart materials for diverse applications, including biomedical.

Keywords: *Smart polymer; hyperbranched polyurethane nanocomposite; shape memory, self-expandable; self-healing; photocatalyst*

OP-18 Developement of Wood Polymer Nanocomposites Based on Modified Soybean Oil and Rosin Derivative

Zakaria Halim*[1], Moon Mandal[2], Tarun K. Maji[3]

[1]Chemical Sciences, Tezpur University, Tezpur, Assam- 784028, India. [2] Chemical Sciences, Tezpur University, Tezpur, Assam- 784028, India. [3]Chemical Sciences, Tezpur University, Tezpur, Assam- 784028, India.
*Zakaria Halim, E-mail:zakaria.halim75@gmail.com

Abstract: Nanocomposites due to its advantageous properties for different construction purposes and outdoor application have gained significant popularity in the recent years as it can be a replacement for solid wood. Wood polymer nanocomposites (WPNC) based on functionalized epoxidized soybean oil (ESO), rosin derivative and nanoclay were prepared via compression molding technique. Methacrylic anhydride epoxidized soybean oil (MAESO) as matrices, wood flour as reinforcing agent, rosin derivative as cross-linker and nanoclay as nano reinforcing filler was used to develop the final nanocomposite. The fiber/resin ratio was maintained at 40:60 and the amount of nanoclay was varied from 0 wt % to 1, 3 and 5 wt %. The nanocomposites were characterized by Fourier transform infrared (FTIR) spectroscopy and X-ray Diffraction (XRD) analysis. Transmission Electron Microscopy (TEM) showed uniform distribution of nanoclay in the composites. Mechanical testing, limiting oxygen index (LOI) and swelling behavior were checked for the prepared nanocomposites. WPNC based on 3 wt % nanoclay exhibited maximum improvement in properties.

Keywords: *Wood Polymer Nanocomposite, Rosin, Vegetable Oil, Wood, Nanoclay.*

Oral Presentation

OP-19 Biopolymer from Oily Bilge Water using Mixed Bacterial Culture

V. Uma[1] and R. Gandhimathi[2]

[1]Ph.D. Research Scholar, [2]Assistant Professor Department of Civil Engineering,
National Institute of Technology, Tiruchirappalli, Tamilnadu, India.
E-mail: umavemburaj88@gmail.com,rgmathii@nitt.edu; Tel: +91431 2503171;

Abstract: The prime environmental concerns of marine industry is the overboard release of the liquid wastes produced from ship operation in the bilge area. Oily bilge water (OBW) is a corrosive mixture of seawater containing a variety of constituents like cleaning agents, solvents, fuel, lubricating oils and hydraulic oils. In other hand petroleum derived non-biodegradable plastics pose a grave disposal problem in municipal landfills and groundwater pollution. Therefore biopolymers such as Polyhy droxyalkanoates (PHA) are gaining importance due to its thermal and elastomeric properties similar to polypropylene and polyethylene. PHA is a renewable raw materials derived from OBW for the production of biopolymer, which can be generated by a wide range of prokaryotic microbes, cultured under feast-famine conditions (excess carbon source and limited nutrients). Currently, the main limitation for PHAs production is cost of production. The aim of this study was to develop a biological treatment process to produce biopolymer from OBW. A fed-batch reactor was utilized to optimize the PHA production. The effect of operational parameters, i.e. Organic loading Rate (OLR) and Cycle Time (CT) was studied. The COD removal efficiency and PHA content was quantified. The produced PHA was characterized for the functional groups primary and higher order structures by FTIR, SEM and XRD.

Keywords: Oily bilge water, Biological treatment, COD removal, Polyhydroxyalkanoates production

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OP-20 A Novel Approach in Development of Bio Based Foam from Biomass Waste

Anil Kumar[1]*, Giridhar B. N[1], Deepak Kumar[2], Shakti Singh Chauhan[1]

Institute of Wood Science and Technology[1],
Indian Institute of Science[2],
Bengaluru, Karnataka, India
*Corresponding author: 091-9632239454 E-mail- anil19wst@gmail.com

Abstract: Liquefaction of woody biomass is solvolysis technology for developing new materials, adhesives and energy systems. The process also provides an opportunity to utilize forest wastes. A large amount of these wood wastes are produced by wood based industries, which is generally incinerated. This paper presents the liquefaction of woody waste in polyhydric alcohols as liquefying media to produce chemically active liquid which has potential to be used as a raw material for development of foam. The formulation used in the production of PUFs was first optimized and the resulting foams were characterized by Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), density and thermal conductivity measurements, compressive tests, dynamic mechanical analysis (DMA) and thermo gravimetric analysis (TGA). The utilization of liquefied lignocellulosic materials can at least partially reduce the chemical consumption, thus increasing the use of the renewable resources in large extent.

Keywords: liquefaction, liquefying media, incinerated, renewable resources

Oral Presentation

OP-21 Rheological behaviour of composite propellant suspension containing aluminium nanoparticles

Rohit Lade*[1], Kailas Wasewar[2]

[1, 2]Advanced Separation and Analytical Laboratory, Department of Chemical Engineering, Visvesvaraya National Institute of Technology (VNIT), Nagpur 440010, Maharashtra, India
*Corresponding author, E-mail:ralade.che15@gmail.com

Abstract: Composite Propellants are highly filled solid materials suspended in a polymeric binder matrix. The solid materials consist mainly of oxidizer and metallic fuel. The solid loading mostly ranges from 85 -90 % w/w which causes difficulties related to the processability and quality of the propellant, hence rheology plays a vital role while preparation of the propellant. Studies related to the rheology of composite propellant slurry containing aluminium nanoparticles (ANP) have not yet been reported. The present work focuses on the rheological behaviour of Hydroxyl Terminated Polybutadiene based composite propellant slurry containing aluminium nanoparticles (ANP) with 86% solid loading. Specifically, the effect of plain mixing and mixing under vacuum was analyzed in the presentstudy.

Keywords: Hydroxyl Terminated Polybutadiene, Chemorheology, Aluminium nanoparticles, Rheological behaviour, Apparent viscosity, Shear stress, Shearrate

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OP-22 Poly Lactic acid/ nano Hydroxyapatite based resorbable composites: Device to fix Podietry fixations

Arbind Prasad[1], Mamilla Ravi Sankar[1], Vimal Katiyar*[2]

[1]Mechanical Engineering, Indian Institute of Technology,Guwahati, Assam-781039, India.
[2]Chemical Engineering, Indian Institute of Technology, Guwahati, Assam-781039, India.
*Corresponding author, E-mail:vkatiyar@iitg.ernet.in

Abstract: Bioabsorbable polymers composite are a highly promising new approach to replace metallic internal fixation devices. The advantages of using bioabsorbable polymers as an internal fixation devices aremainly due to avoid resurgery after healing process and elimination of stress shielding. Poly lactic acid (PLA)is a bioabsorbable polymers used as a matrix phase and nano Hydroxyapatite (nHAp) used as nano bio fillers. In the present work, nHAp was varied in concentration and extruded with PLA in order to investigate the mechanical properties, bioactivity properties and degradation properties. The result shows that loading of nHAp up to certain extent leads to enhancement of mechanical strength, while slower the rate ofdegradation.

Keywords: *Polylactic acid, Hydroxyapatite, Simulated body fluid, Phosphate buffer saline solution, Mechanical properties.*

Oral Presentation

OP-23 Kinetics of thermal degradation of plastic waste and their conversion into liquid fuel by slow pyrolysis

Pallab Das[1*] and Pankaj Tiwari [1]

[1]Department of Chemical Engineering, Indian Institute of Technology Guwahati, Guwahati, Assam 781039, India

[*]Corresponding author: d.pallab@iitg.ernet.in

Abstract: The aim of the current study is to compare the quantitative aspects of the thermal decomposition process for low and high density polyethylene (LDPE and HDPE) and polypropylene (PP), majorly used as packaging materials. The values of activation energy of individual samples were found in the range 170 – 232 kJ·mol^{-1} for LDPE, 143 – 231 kJ·mol^{-1} for HDPE, 133 – 173 kJ·mol^{-1} for PP. The reaction models (f(α)) were calculated as R2 (contracting cylinder) for LDPE/HDPE and R3 (contracting sphere) for PP. A semi-batch lab scale reactor was used to perform pyrolysis experiments at low temperature. Slow pyrolysis scheme was utilized to convert the plastic waste into useful products (light hydrocarbon oil). Lab scale experiments ensured the effectiveness of the slow pyrolysis to produce high quality liquid fuel (gasoline/diesel). A maximum liquid yield of 82% was achieved at 400°C temperature for 8 hrs duration.

Keywords: *Waste plastic; slow pyrolysis; Isoconversional kinetics*

OP-24 Multifunctional Nano-Hydroxyapatite promoted Toughened High Molecular Weight Stereocomplex Poly (lactic acid) based Bionanocomposite

Arvind Gupta[1], Arbind Prasad[2], Neha Mulchandani[1], Mamilla Ravi Sankar[2], Vimal Katiyar[1]*

[1]Department of Chemical Engineering,
Indian Institute of Technology Guwahati-781039, Assam, India.

[2]Department of Mechanical Engineering,
Indian Institute of Technology Guwahati-781039, Assam, India.

*Corresponding author, E-mail: vkatiyar@iitg.ernet.in

Abstract: The current work focuses on the fabrication of high molecular weight stereocomplex poly(lactic acid)/nano-hydroxyapatite (sPLA/n-HAP) based bionanocomposite for high temperature engineering applications. To achieve the same, n HAP is grafted with poly (D lactic acid) (PDLA) via in situ ring opening polymerization of D-lactide followed by its blending with poly(L-lactic acid) (PLLA) which yields sPLA/n-HAP biocomposite with improved storage modulus even at a temperature higher than 140°C. The X -ray diffraction and calorimetric ensure the presence of 100% stereocomplex crystallites of b iocomposite along with significant improvement in the melting temperature (~227°C). Noteworthy improvements in mechanical and gas barrier properties of the biocomposites are achieved due to the uniform dispersion of n-HAP (~60 nm) confirmed by morphological An unusual improvement in elongation at break (~130% at 1 wt% HAP loading) makes this composite a toughened material. However, the tensile strength is improved by ~16% whereas oxygen permeability and water vapor transmission rate are found to reduce by ~48% and ~34%, respectively. Interestingly, the developed material is processed as monofilament followed to 3D printing yielding a middle bone as a representative example of orthopedic implants. This signifies the possible future aspects of the material in the commercial biomedical and temperature engineeringapplications.

Keywords: stereocomplex PLA, hydroxyapatite, n-HAP, biocomposite, grafting

Poster Presentation

PNC-27A Bacterial cellulose/nanohydroxyapatite biocomposites: A novel approach of fabrication method

Julia Rogowska-Tylman[2], Nabanita Saha[1]*, Oyunchumeg Zaandra[1], Witold Łojkowski[2], Petr Saha[1]

[1]Centre of Polymeric Systems, University Institute, Tomas Bata University in Zlin, Czech Republic
[2]Laboratory of Nanostructures, Institute of High Pressure Physics,
Polish Academy of Sciences, Warsaw, Poland
*Corresponding author, E-mail:nabanita@utb.cz

Abstract: Hydroxyapatite (HAp) is a mineral compound that gives the hardness and strength to the bone structure. Due to high affinity to human bone mineral and the osteoconductive properties of HAp, lots of studies have been performed to produce HAp scaffolds or HAp composite scaffolds for maximize bone regeneration. Nevertheless, HAp is brittle compound for composite production and it must be strengthen with another material to mimic natural structures. Bacterial cellulose (BC) show high Young's modulus, tensile strength, water absorption ability and retention capacity. In this study BC/nHAp biocomposites were fabricated by direct introduction of nHAp nanoparticles into the *Gluconacetobacter xylinus* cell culture medium.

Keywords: *Hydroxyapatite, Nanocomposites, Bacterial cellulose, Fabrication method, H.S. medium*

BPS-12A Influence of β-chitin on PVP-CMC and PVP-CMC-$CaCO_3$ hydrogel scaffolds: the bioinspired biomaterials for biomedical applications

Vida Čadež[2], Nabanita Saha[1*], Maja Dutour Sikirić[2] and Petr Sáh[a1]

[1]Centre of Polymer Systems, Tomas Bata University in Zlin, tř. Tomáše Bati 5678,
760 01 Zlín, Czechia
[2]Division of Physical Chemistry, Ruđer Bošković Institute,
Bijenička cesta 54, 10000 Zagreb, Croatia
*Corresponding author, nabanita@utb.cz

Abstract: PVP-CMC hydrogels have the potential for use as biomedical polymers and can be principally considered as biomaterials. To enhance their bioactivity and preserve biodegradability, the PVP-CMC hydrogel reinforced with β-chitin, natural polymer isolated from the cuttlebone of common cuttlefish (*Sepia officinalis*, L.). For further mechanical and functional improvement of such biomaterials (PVP-CMC and PVP-CMC-β-chitin), they were mineralized with calcium carbonate ($CaCO_3$). Rheological data show that incorporation of β-chitin (0.5%) increase the elasticity of all the PVP-CMC hydrogel scaffolds, both non-mineralized and mineralized, while resistance to compression is preserved. Swelling study, conducted in Ringer's solution at 37°C, indicated that non-mineralized (PVP-CMC and PVP-CMC-β-chitin) hydrogel scaffolds have good water absorption and retention properties in comparison with mineralized (PVP-CMC-$CaCO_3$ and PVP-CMC-β-chitin-$CaCO_3$) hydrogel scaffolds. Rheological study confirmed that β-chitin increase the elasticity of PVP-CMC hydrogel scaffold resulting with bioinspired biomaterial that has good biomedical potential.

Keywords: *PVP-CMC; hydrogel; mineralization;* β-*chitin; biomaterials*

Poster Presentation

BPS-07 Synthesis of Ethylene Glycol Initiated Poly(ε-caprolactone) [PCL]

Purabi Bhagabati*, Vimal Katiyar

Department of Chemical Engineering, Indian Institute of Technology Guwahati, North Guwahati, Assam- 781039, India.

*Corresponding author, purabi.bhagabati08@gmail.com

Abstract: The work presents synthesis of moderate molecular weight poly(ε-caprolactone) [PCL] through bulk polymerization technique using ethylene glycol as initiator. The synthesis method adopts the commonly reported co-ordination–insertion technique via. ring-opening polymerization process, where the reaction conditions were optimized with the variation in temperature and time. The obtained PCL was characterized with FTIR, NMR and GPC as preliminary investigation and also referring high yield ~95.5% of PCL. A ratio 500:1 of initiator: monomer and 3:1 of initiator: catalyst was found to be the best suitable condition for the synthesis of PCL with moderate molecular weight. Synthesis of such moderately high molecular weight PCL may have tremendous scope in biomedical applications and hence needs further investigation in the same line.

Keywords: *Bulk Polymerization, Poly(ε-caprolactone) [PCL], Ring-opening polymerization.*

BPS-08 Biodegradable cellulose based superabsorbent hydrogels for water conservation in agricultural lands

Dipankar Das[*1] , Sachin Bhaladhare

[1]Tripura University, Chemical and Polymer Engineering, Suryamaninagar, Tripura, India - 799022.

Abstract: Superabsorbent hydrogels are cross-linked polymer molecules able to absorb and release water in a reversible manner in the presence of external environment stimuli. Hydrogels have been widely used for agricultural applications but majority of hydrogels are non-biodegradable. This study deals with development of cellulose based biodegradable superabsorbent hydrogels to conserve and release water in a sustainable manner in the agriculture soil. Various investigations have shown that the hydrogels reduce irrigation water consumption, lower the death rate of the plants, improve fertilizer retention in soil and increase plant growth rate. The cellulose based hydrogels are synthesized and analyzed for its water swelling capability. The potency of superabsorbent hydrogels in agricultural applications is then assessed by examining the performance of hydrogels in different types of soil after various absorption/desorption cycles. The results affirmed that hydrogel mixed can store a considerable amount of water and can release it gradually to the plant roots whenever it's needed. The expectations of the proposed cellulose based superabsorbent hydrogels in cultivations could thus represent a promising solution for the rationalization of water resources, especially in desert areas.

Keywords: Biodegradable, superabsorbent, hydrogel, cellulose, agriculture

Poster Presentation

PS-09 Waste chicken feather as reinforcement fiber in chemically modified epoxidised soybean oil based composites

Gitashree Gogoi*[1], Tarun K. Maji[2]

[1]Department of Chemical Sciences, Tezpur University, Assam 784028, India.
[2]Department of Chemical Sciences, Tezpur University, Assam 784028, India.
*E-mail:gitashreegogoi25@gmail.com

Abstract: Composites made from biodegradable polymeric materials reinforced with natural fiber are yet to be seen in high magnitude. Chicken feathers are waste byproduct of poultry industry which are produced in large amount annually.Disposal of chicken feathers are difficult and are environmentally restricted. The use of chicken feather fiber is not onlydue to environmental concern but also due to their interesting properties and sustainability. Composites were preparedusing chemically modified soybean oil with waste chicken feather fibers as the reinforcing agent. Epoxidised soybeanoil was functionalised initially by methacrylic acid and finally by methacrylic anhydride in presence of suitable catalyst to form methacrylic anhydride based epoxidised soybean oil (MAESO) and the resultant MAESO was characterised. Rosin acid derivative i.e.divinylacrylicpimaric acid (R2) is used to serve as rigid monomer and it was copolymerized with MAESO to form fully bio based composite.The composites were characterized by Fourier transform infrared spectroscopy (FT-IR) and the morphological structure was studied by scanning electron microscopy (SEM). Various properties of the prepared composites were found to be improved.

Keywords*:* soybean oil; chicken feather; composites; crosslinking; mechanical properties; thermal properties

BPS-10 Chitosan Starch Hybrid Biopolymer Reinforced with Banana Fibre

Nithin T James*[1], Rijin Raju[2], Adarsh Sreekumar[3], Ambili S Nair[4]

[1]Chemical Engineering, TKM College of Engineering, Kollam, Kerala-691005, India.
[2]Chemical Engineering, TKM College of Engineering, Kollam, Kerala-691005, India.
[3]Chemical Engineering, TKM College of Engineering, Kollam, Kerala-691005, India.
[4]Chemical Engineering, TKM College of Engineering, Kollam, Kerala-691005, India.
*Nithin T James, E-mail:nithinicc.ntj@gmail.com

Abstract: Biodegradable and compostable plastics, especially those based on renewable resources from the agricultural industry, are an essential innovation. This innovation offers substantial impulses for the future technologies. Chitosan film has potential applications in agriculture, food, and pharmacy. However, films made only from chitosan lack water resistance and have poor mechanical properties. Forming miscible, biodegradable composite film from chitosan with other hydrophilic biopolymers is an alternative. The objective of this study was to prepare Chitosan-Tapioca starch composite reinforced with banana fiber by combining chitosan solution and thermally gelatinized Tapioca starches. The possible interactions between the two major components were evaluated by X-ray diffraction and Fourier-transform infrared spectroscopy (FTIR). Regardless of starch type, both the Tensile Strength and Elasticity of the composite films first increased and then decreased with starch addition. The natural banana fiber is added to improve the film's tensile strength and elongation-at-break. The obtained product showed improved properties.

Keywords: Chitosan-starch films; Banana fibre; Mechanical properties; Water resistance; Miscibility.

Poster Presentation

BPS-11 Trends in Green Composites - A perspective

Pritam Dey#, Srimanta Ray*

Chemical Engineering Department, National Institute of Technology,
Agartala, Tripura- 799046, India.
*Corresponding author, e-mail: rays.nita@gmail.com
#Presenting author, e-mail: preet.dey@gmail.com

Abstract: The emergence of new variety of biomaterials and new technologies for composites manufacturing have revolutionized the modern composite scenario, with a promise towards sustainable development through induction of green composites. The concept of green composites is well known. The reinforcement material and the matrix/resin are key constituents that define the properties of composites. Accordingly the reinforcements of green composites are usually natural polymer or biomass derived products. The green composite materials being environmentally benign have seen increased production and have found wide applications in various sectors in recent years.

Keywords: Green composites; Polymers; Biomass; Sustainable polymers

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BPS-12 Renewable resource based smart hyperbranched polyurethane elastomer

Tuhin Ghosh[1] and Niranjan Karak*

[1]Department of Chemical Sciences, Tezpur University, Assam, 784028, India.
*Corresponding author, E-mail: karakniranjan@gmail.com

Abstract: Development of a smart polyurethane elastomer from renewable resources is a rapidly expanding fieldin the area of polymer science and technology due to its wide range of advanced applications. In this context, hyperbranched polyurethane (HBPU) elastomer was prepared by a pre-polymerization technique using modified easily available bio-based raw materials. It was found that prepared HBPU showed high mechanical property including elongation at break, UV-resistance, bio-degradation and intrinsic self-healing ability. Therefore, prepared HBPU elastomer hold significant promise as a smart sustainable material for different advanced applications.

Keywords*:* Bio-based polyurethane, elastomer, self-healing, bio-degradable

Poster Presentation

ECA-59 Synthesis & characterization of low cost non-fluorinated aqua-repellent coating

Smruti R. Mohanty, Smita Mohanty, S. K. Nayak

Laboratory for Advanced Research in Polymeric Materials (LARPM),
CIPET (Ministry of Chemicals and Fertilisers, Govt. of India) B - 25,
CNI Complex, Bhubaneswar - 751024
E-mail:108smruti@gmail.com

Abstract: An advanced coating with a splendid hydrophobic property was synthesized in order to enhance the cleanability and to save water. A lot of attention is devoted to the use of non-fluorinated and cheap precursors and low temperature synthesis process to make the workcost efficient. In this research work, deposition of silica sol on ceramic substrates was doneby flow coating method. Silica sol was formulated using certain chemicals in an optimized ratio. TEOS is the primary precursor dissolved in suitable solvents like IPA, ethanol and distilled water to prepare the sol followed by treatment with silylating agent HMDS in one case and direct addition in other. Water contact angle for both the coating materials were obtained and studied to compare the degree of hydrophobicity in both the cases and FTIR was used to confirm the presence of -Si-$(CH_3)_3$ group. Surface morphology was extensively analysed by mean of SEM and optical properties were also investigated with the help of UV- Vis-NIR Spectrophotometer.

Keywords: *Superhydrophobic coating, sol-gel, silylating agent, optical transmittance*

ECA-60 Zwitterionic–polyurethane coatings for non-specific marine bacterial inhibition: A nontoxic approach for marine application

Anthony Yesudass S*, Smita Mohanty, Sanjay K Nayak and Chandi C. Rath[1]

Laboratory for Advanced Research in Polymeric Materials (LARPM), Central Institute of Plastics Engineering &Technology (CIPET), B-25, CNI Complex,
Patia, Bhubaneswar, Odisha, India-751024.
[1]Department of Botany, College of Basic Science & Humanities, Orissa University of Agriculture & Technology (OUAT), Bhubaneswar-3, India.
*Corresponding author, E-mail: *anthonyyds@gmail.com*

Abstract: The present work reports synthesis and development of zwitterionic tri-block copolymer-polyurethane (ZTC-PU) coatings which are thermally stable and have amphiphilic properties, which can be used for marine applications. The zwitterionic tri-block copolymer (ZTC) (poly (sulfobetaine methacrylate) - polydimethyl siloxane - poly (sulfobetaine methacrylate), polySBMA-block-PDMS-block-polySBMA) was synthesized by ATRP (atom transfer radical polymerization) method. Apart from this, the facile synthesis of silane functionalized acrylic polyol was formulated with 4, 4'- Methylene dicyclohexyldiisocyanate (H12 MDI) for the development of polyurethane (PU) coatings. Different weight ratios of ZTC was incorporated in PU to obtain a zwitterionic tri-block copolymer-polyurethane (ZTC-PU) coatings. The ZTC-PU coating exhibit good thermal stability and amphiphilic character. The coating showed excellent non-specific marine bacterial inhibition propertyalong with good stability against gram positiveStaphylococcus aureus (S. aureus)and gram negative Escherichia coli (E.

Poster Presentation

coli), Pseudomonas aeruginosa (P. aeruginosa)microbial strains. This design method reveals the development of zwitterionic-polyurethane coatings with higher amount of zwitterionic moiety in the coating system that will be efficient and eco-friendly technology formarine bio-fouling application.

Keywords: zwitterionic triblock copolymer, functionalized acrylic polyol, polyurethane, non-specific marine bacteria.

ECA-61 Swelling behaviour and surface switchable wettability of perfluorinated imidazolium amphiphilic ionic copolymer

Santosh N. Chavan*[1], Debaprasad Mandal[2]

[1]Chemistry Department, Indian Institute of Technology Ropar,Rupnagar, Punjab- 140001, India.
[2]Chemistry Department, Indian Institute of Technology Ropar, Rupnagar, Punjab- 140001, India.
*Corresponding author, E-mail: santosh.chavan@iitrpr.ac.in

Abstract: The highly non-polar fluorous monomer was incorporated in ionic imidazolium copolymer. This ionic copolymer was prepared under microwave irradiation and radical polymerization. The microstructure of the polymer was determined by FT-IR, NMR spectroscopy, further purity was checked by DOSY NMR. The swelling ratio/swelling degree of this fluorous copolymer was up to 966%/(90.8%) in methanol due to its self-assembled behavior and the gel nature was studied. The self-assembly nature is studied by NMR, DLS, SEM and water contact angle measurement. The switchable wetting property is controlled by fine tuning of ionic groups and hydrophobic fluorous segments in the amphiphilic copolymer. Fluorous ionic copolymer shown to have variable WCA of 112°, 107° and 97° depending on the hydrophobicity of the surfaces such as glass, compressed carbon sheet and teflon surfaces respectively. Ag-nano particles were electrodeposited on carbon sheet (polymer coated) where the morphology and distribution was studied by SEM, EDAX and AFM.

Keywords*:* Fluorous copolymer; Imidazolium ionic polymer; Ionic ge

ECA-61A Synthesis and characterization of Itaconic acid based Polyurethane acrylate resin for UV curable coating Application.

Ganesh A. Phalak[1], Deepak M. Patil[2], S. T. Mhaske*

Department of polymer and surface engineering,
Institute of chemical technology, Nathalal parekh marg,
Matunga (E), Mumbai-400019, India

* Corresponding author, e-mail: st. mhaske@ictmumbai. edu. in

Abstract: UV curable PUA resin was successfully synthesized from polyol based on sustainable resource originated from itaconic acid (IA), isophorone diisocyanate (IPDI) and 2-hydroxyethyl methacrylate (HEMA). A polyol was synthesized by condensation reaction of IA with 16-hexanediol in the presence of p-Toluenesulfonic acid (pTSA). The synthesized PUA resin was characterized for its structural elucidation by using Fourier Transform Infrared Spectrophotometer (FTIR), ^{1}H and ^{13}C NMR spectroscopy. The synthesized UV curable PUA resin was incorporated in varying concentrations in conventional PUA coating system. The effects of varying concentration of synthesized UV curable PUA resin on rheology, crystallinity, thermal and coating properties were evaluated. The rheological behavior of the resins were evaluated at variable stress and result showed decrease

Poster Presentation

in viscosity of resin as concentration of synthesized UV curable PUA resin increases in conventional PUA resin. The cured coatings have been evaluated for glass transition temperature *(T*g) and thermal behaviour by differential scanning calorimeter and thermo gravimetric analysis respectively. The degree of crystallinity of the coatings was determined from X-ray diffraction patterns using the PFM program. It was found that increase in the mass proportion of IA based PUA in coatings, the coating becomes more rigid and crystalline. The synthesized UV curable PUA coatings showed interesting mechanical, chemical, solvent and thermal properties as compared to the conventional PUA. Further, cured coatings were also evaluated for gel content and water absorption.

Keywords: Sustainable resource; itaconic acid; bio-based; PU acrylate; UV curable.

OT-68 Depressurization induced morphology control in microcellular batch foaming process

Indrajeet Singh, Abhishek Gandhi, Smita Mohanty, S. K. Nayak

Laboratory for Advanced Research in Polymeric Materials,Central Institute of Plastics Engineering & Technology Bhubaneswar,751024, Odisha, INDIA

*Corresponding author, E-mail:indrajeetmaithil@gmail.com

Abstract: In this article, polycarbonate microcellular foams have been prepared using solid-state batch foaming process. Polycarbonate round discs having a thickness of 1.5 µm were saturated in the high-pressure autoclave at 3 MPa and 6 MPa saturation pressure at normal room temperature. Effect of saturation pressure, foaming temperature and foaming time along with depressurization rates have been investigated. Cell size distribution and cell uniformity at different pressure drop rates have been investigated. It was observed that pressure drop rates or pressure drop times are beneficiaries for controlling microcellular foam morphology such as cell size, cell density, cell size distribution and expansion ratio. Depressurisation rates generally affect the amount of physical blowing agent content inside the saturated solid polymer, as a result cell size found to decrease with increasing depressurization rates. We observed that cell size in microcellular polycarbonate found as 9.5, 9, 7.5 and 5 µm along with depressurization rates 0.005, 0.01, 0.01 and 0.5 MPa/sec respectively.

Keywords: *Foaming, Microcellular, Porous Polymer, Polycarbonate, Depressurisation rate*

OT-69 Imidazolium based ionic polymers for alkaline stable anion exchange membrane

Gaje Singh*, Debaprasad Mandal

Chemistry Department, Indian Institute of Technology Ropar,Rupnagar, Punjab- 410001, India.

*Corresponding author, E-mail:gaje.singh@iitrpr.ac.in, dmandal@iitrpr.ac.in

Abstract: This study deals withalkaline stability of presubstituted hindered imidazolium based polymers. Imidazolium cations always suffer from stability due to presence oflabile C2 protons andbackbone protons of tethered at N1 in alkaline. The model imidazolium substituted ionic polymer was synthesized and characterized by FT-IR, ^{1}H, ^{13}C and DOSY-NMR. Further, the polymers were exposedto 1.0 M and 5.0 M NaOH solution at 80 ^{0}C for 10 days to investigate the alkaline stability by ^{1}H-NMR.Moreover, the important membrane properties thermal stability, ion exchange capacities (IEC) and water uptake properties investigated.

Keywords: *Alkaline stability; Imidazolium ionic polymer; Anion exchange membrane*

Poster Presentation

OT-70 Synthesis and Characterization of Chitosan/ Multiwalled carbon nanotube mixed matrix membrane for CO_2 Separation from flue gas

Rajashree Borgohain, Bishnupada Mandal*

Department of Chemical Engineering, Indian Institute of Technology Guwahati-781039, India

**Corresponding author, E-mail: bpmandal@iitg.ernet.in*

Abstract: In this present study synthesis and characterization of chitosan (Cs) membrane for CO_2 separation from CO_2/N_2 gas mixture has been carried out. Fourier transform infra-red spectroscopy, X-ray diffraction, field emission scanning electron microscopy and thermogravimetric analysis has been used for characterization of the synthesized membrane. Also swelling study confirms that the mixed matrix membrane has more swelling properties than the pure chitosan membrane. Alsogas permeation studywere carried out by the membrane at different water flow rate, pressure, and temperature which ensures that the proposed modified chitosan membrane can be a potential candidate for flue gas separation.

Keywords: *Chitosan, Multiwalled carbon nanotube, Gas separation*

OT-71 Photostability of acetylated wood coated with ZnO nanodispersion

B. N Giridhar*, Sreeja Nair, Krishna K.Pandey

Institute of Wood Science and Technology, Bengaluru, Karnataka- 577004, India.

*Corresponding author, E-mail:bngiridhar8@gmail.com

Abstract: UV resistance of acetylated rubberwood coated with zinc oxide (ZnO) nanoparticles was investigated. Rubberwood samples were chemically modified with acetic anhydride (AA). Modified and unmodified wood were coated with 2.5% of aqueous ZnO nanoparticle dispersion. UV resistance of modified wood coated with nanoparticles was evaluated by exposing unmodified and modified wood with or without nanoparticle coatings to UV irradiation in an accelerated weathering tester. Unmodified wood showed rapid colour changes and degradation of lignin upon exposure to UV light. Acetylation of wood with AA inhibiting light induced colour changes (photo-yellowing) at wood surfaces. In contrast to unmodified wood, modified wood exhibited bleaching. Treatment of unmodified wood surfaces with Zno nanoparticles was effective in reducing photodiscoloration. However, effectiveness of nanoparticle was limited in modified wood.

Keywords: *acetylation, photodegradation, UV resistance, ZnO nanoparticles*

Poster Presentation

OT-72 Preparation and Physicochemical Characterization of Pyrolyzed Human Hair

Tika Ram Bhandari[1,2], Bidit Lamsal[1,2*], Nilam Shrestha[2], Tika Bahadur Katuwal[2], Marco Liebscher[3], Rameshwar Adhikari[1]

[1]Research Centre for Applied Science and Technology (RECAST), Tribhuvan University, Kathmandu, Nepal

[2]Tri-Chandra Multiple Campus, Tribhuvan University, Ghantaghar, Kathmandu, Nepal.

[3]Faculty of Civil Engineering, Technical University of Dresden, Germany.

*Corresponding author, E-mail:ram.adhikari.tu@gmail.com

Abstract: Human hair was pyrolyzed at elevated temperature to prepare carbonized material under controlled condition, which was characterized using Raman Spectroscopy, Scanning Electron Microscopy (SEM) and X-Ray Diffraction (XRD). 1D and 2D bands were observed in Raman spectra. The Raman active sp 3 crystalline Diamond band was clearly seen at around 1320 cm -1 while the sp 2 crystalline Graphite band was absent. Furthermore, morphological structures of the hair as well as that of pyrolyzed samples were investigated by SEM in order to ascertain the nature of the substance formed (i.e., to confirm amorphous or crystalline nature). Diamond-like crystalline property of the pyrolyzed samples was assured by spectroscopic and microscopic techniques

Keywords: *Human hair, Pyrolysis, FTIR, Raman Spectroscopy, SEM, XRD*

OT-73 Processing and Characterization of Fly Ash Based Building Materials by Geopolymerization Technique

Dipankar Das*, Prasant Kumar Rout

Department of Material Science and Engineering Tripura University (A Central University), Suryamaninagar, Tripura-799022, India.

*Corresponding author, E-mail: dipankar748@gmail.com

Abstract: Large amount of Fly ash are being released from thermal power plant and possess various difficulties in their disposal. To overcome these waste management issues, the best solution is to utilize these waste products for some other value added applications. Several utilization options of fly ash are currently being practised in India in an effort to minimize waste and protect our green environment. So authors has shown interest towards the potential use of fly ash collected from NTPC, Bongaigaon, Assam for production of geopolymeric building materials which may be suitable for various value added applications. Geopolymer are a class of inorganic polymers synthesized by thermal activation of solid aluminosilicate base materials such as fly ash, metakaolin etc., with an alkali sodium hydroxide solution. This polymer shows three dimensional framework structures that exhibit superior mechanical and physical properties including high early strength, low shrinkage, good thermal resistance and good chemical resistance. In this present work, the geopolymeric specimens were synthesized by various combination of Fly Ash as high alumino silicate resources and sodium hydroxide as activator. The effects of particle size of fly ash powder, sodium hydroxide concentration, curing condition as well on compressive strength of fly ash based geopolymer has been examined. The observed strength value of the geopolymeric specimen has been explained with the help of the micro-structural feature, phase analysis, thermal analysis and spectroscopy study. Further attempt has been made to develop structure- property relationships and to find out the proper geopolymer mechanism.

Keywords*:* *Fly ash, Geopolymer; microstructure; spectroscopy; compressive strength*

Poster Presentation

OT-74 Protein aggregation dependence on different stoichiometric ratio of Transition metal ions

Lalit Pandey*[1], Abhishek Roy[1]

[1]Department of Biosciences and Bioengineering, Indian Institute of Technology, Guwahati-781039, India.

*Corresponding author. Tel: 03612583201, E-mail: lalitpandey@iitg.ernet.in

Abstract: Protein is a natural polymer formed from molecules called amino acid. Polar or charged amino acids coordinate with various transition metals resulting the 3-dimensional structure modulation of protein. Various metal ions are recently implicated in protein aggregation and are associated with numerous neurodegenerative diseases. In the present work, we have scrutinized the effect of stoichiometric variation of Zn(II) on BSA (Bovine Serum Albumin) fibrillation at physiological pH 7.4 through Thioflavin-T dye binding study, residual protein concentration analysis and Isothermal Titration Calorimetry (ITC). Fibrillation was studied through ThT fluorescence, which illustrated dependency on stoichiometric ratio of Zn(II). The ThT intensity data revealed lower rate of aggregation in 1:3 ratio of BSA-Zn(II) reaction as compared to BSA. The lower ThT intensity and higher residual concentration in ratio 1:3 of BSA-Zn(II) agreed to the lower aggregation rate. Further, ITC analysis has shown the presence of two binding sites with many fold difference in binding affinity at prescribed in vitro conditions.

Keywords: Bovine serum albumin, Thioflavin-T, isothermal titration calorimetry

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OT-75 Modified Biopolymer as an Environmental Friendly Dispersant for Treatment of Oil Spills

Pankaj Boruah[1], Chethana Mudenur[1], Akhilesh Kumar Pal [1]and Vimal Katiyar*[1]

[1]Department of Chemical Engineering, Indian Institute of Technology Guwahati, Guwahati, Assam-781039, India.

*Corresponding author, E-mail:vkatiyar@iitg.ernet.in

Abstract: Petroleum is an important and essential natural resource for the development of modern industries. It is a major source for the production of materials and also energy, to serve manufacturing, industrial and consumer needs. Oil/petroleum spill is a major problem that pose serious threat to environment. This requiresa sustainable strategy for oilspill cleanup. So the problem could be overcome by using naturally available biopolymers such as modified chitosan (MCH)as a biodispersant for the stabilization of oil spill droplets. It was predicted that the hydrophobic part of the nanoamphiphilic chitosan preferentially attached to the oil droplets, thereby forming a polymer layer around the droplets, forming a micelle like structuresize ranging from 1500-2000 nm. This acts as a large barrier to droplet coalescence. Xanthan gummakes the water more viscous and restrict the movement of oil droplets. It was found that the smaller stabilized droplets have higher degradation within a time period of 7 days. Application of this natural polysaccharide is environment friendly and can reduce the toxic effects of chemical agents.

Keywords: *Oil spill; biopolymer; nanoamphiphilic; dispersant; bioremediation; nontoxic.*

Poster Presentation

OT-76 Tuning 'de Vries-Like' Properties in Aroylhydrazone based Liquid Crystals

Dr. Hemant Kumar Singh and Dr. Ammathnadu S. Achalkumar

Department of Chemistry, Indian Institute of Technology Guwahati, Guwahati, Assam-781039, India.

Corresponding author, E-mail:hemantsingh@iitg.ernet.in

Abstract: Smectic liquid crystals with 'de Vries-like' properties are characterized by a maximum layer contraction of ≤1% upon transition from the non-tilted SmA phase to the tilted SmC phase. A straight alkoxy chain-terminated conventional aroylhydrazone based liquid crystal N-(4-(tetradecyloxy)-2-hydroxybenzylidene)-4'((4''(hexadecyloxy) benzyl)oxy) benzohydrazide(**BS_{ac}-1416**) undergoes SmA-SmC phase transition with maximum layer contraction of 0.65%. The merits of deVries reduction factor i.e. *R* and *f* values for this mesogen are comparable to, or even lower than, those reported for established perfluorinated and polysiloxane-terminated bonafide de Vries-like materials.

Keywords: *Liquid Crystals; de Vries-like properties; Aroylhydrazone; Mesophase*

OT-77 Room temperature columnar liquid crystalline self-assembly of acidochromic, luminescent, star-shaped molecules with cyanovinylene chromophores

Ravindra Kumar Gupta, Suraj Kumar Pathak, Ammathnadu S. Achalkumar*

Department of Chemistry, Indian Institute of Technology Guwahati,Guwahati, Assam-781039, India.

*Corresponding author, E-mail:achalkumar@iitg.ernet.in

Abstract: Two new star-shaped tris(N-salicylideneanilines) (TSANs) incorporated with cyanovinylene chromophores were prepared through a multistep synthesis. The position of the cyano group was altered in the target molecules, to understand its impact on the photophysical and thermotropic properties, in comparison to the stilbene derivative without a cyano group. The presence of the cyano group enhanced the mesophase range in comparison to the non-cyano stilbene derivative. Further, this enhanced intermolecular interactions led to the stabilization of columnar rectangular phase in comparison to the columnar hexagonal phase of simple stilbene derivative. These compounds exhibited the freezing of columnar phase in a glassy state, which is beneficial from the device fabrication point of view. Thus the introduction of cyano group within the molecular structure of a star-shaped TSAN enhanced the intermolecular interactions and also altered the luminescence behavior. Such ordered luminescent molecular assemblies, which stabilize the columnar order over a long range are promising from the viewpoint of emissive displays. These compounds can be utilized for the sensing of volatile acids in solution at very low concentration (in parts per billion level) or in thin film state, either by fluorescence switching or quenching.

Keywords: *Liquid Crystals, TSAN, Acidochromic, Mesophase*

Poster Presentation

OT-78 Chitosan/Graphene Oxide based Nanocomposite Hydrogel with High Mechanical and Shape Memory Effect

Jayashree Nath, Swapan Kumar Dolui*
Department of Chemical Sciences, Tezpur University, Napaam, Assam-784028, India
*Corresponding author, E-mail: dolui@tezu.ernet.in

Abstract: pH-sensitive nanocomposite hydrogels are synthesized based on Chitosan (CS) and Graphene Oxide (GO) via physical cross linking. Optimization of characteristic properties of the polymeric hydrogels is performed. FTIR spectra proved that GO has been successfully incorporated into the CS matrix. The surface morphology of GO and the composite hydrogels were characterized by SEM. The uniform dispersion of GO in the nanocomposite hydrogels were confirmed by XRD. Thermal properties of the prepared hydrogels were studied. pH-sensitivity of the prepared hydrogels were investigated. Mechanical properties of the hydrogels were increased with the increasing amount of GO. The shape memory behavior of the prepared hydrogel was studied both in alcoholic solution.

Keywords: *Hydrogel, Nanocomposite, Shape memory*

OT-79 Chitosan based free standing electrode for supercapacitors

Aswathy N R[1], Akshaya Palai[2], Smita Mohanty[3], Sanjay Kumar Nayak[4]
Laboratory for Advanced Research in Polymeric Materials, Central Institute of Plastics Engineering &Technology, Bhubaneswar, Odisha, -751 024, India.
*Corresponding author, E-mail:aswathynr1994@gmail.com

Abstract: Ever increasing demands for low cost, light weight materials in every sector make role of plastic inevitable. But the misdealing of plastic products bequeathing misery on earth as well as human kind.So demand to exclude plastic from some of the sector is crucial now. Chitosan is a biopolymer easily extractable from shells of crustaceans such as lobster, crabs, shrimps and also from many other micro-organisms including insects and fungi. We presenting a promising candidate for electrode based on chitosan combined with a conducting polymer. This work insight into the strategies for developing conductive flexible and freestanding electrode from chitosan and PANI. Chitosan is highly stable and can help to improve the low mechanical strength of the PANI. The composite of chitosan/PANI electrode showing high conductivity, and the porous structure of hybrid composite will help to improve absorption of electrolyte. More over it is a highly stable cheap and environment friendly bio-composite. On these aspects chitosan is a strong candidate for fabricating flexible freestanding electrode

Keywords*:* Biopolymer Chitosan, Freestanding, Supercapacitor electrode

Poster Presentation

OT-80 Effect of Surface Modified Graphene on Dynamic Mechanical and Thermal Stability of Epoxy Nanocomposite

Nabajyoti Talukdar*[1], Sudipta Halder[2]

[1]Department of Mechanical Engineering, Indian Institute of Technology Guwahati, Assam, 781039, India.

[2]Department of Mechanical Engineering, National Institute of Technology Silchar, Silchar, Assam, 788010, India.

*Corresponding author, E-mail:talukdarnaba@iitg.ernet.in

Abstract: Graphene nano particle (GNP) is considered as unique reinforcing material in composites for their capability to enhance multi-functional properties. In this work, pristine GNP (P-GNP) has been modified in steps through chemical functionalized route which consist of oxidation by nitric acid and then silanization using 3-aminopropyltriethoxysilane (APTES) to generate oxygenated (O-GNP) and siloxane (S-GNP) functional group onto the P-GNP surfaces. FTIR spectroscopy and TGA analysis confirms the attachment of oxygenated and siloxane functional groups on the surface of P-GNP. The increase in structural defect, creating sites for APTES grafting is evident from Raman spectroscopy. Epoxy nanocomposites were prepared by incorporating 0.5 wt% of pristine and stepwise modified GNP.

Keywords: *graphene; nanocomposite; functionalization*

OT-81 Synthesis of chitosan/GO mixed-matrix membrane for CO_2 separation

Pradip Das, Babul Prasad, Hemanta Kalita, Sasidhar Gumma and Bishnupada Mandal*

Department of Chemical Engineering, Indian Institute of Technology Guwahati, India

pradip.das@iitg.ernet.in

p.babul@iitg.ernet.in

hemantakalitaaec@gmail.com

s.gumma@iitg.ernet.in/ s.gumma@csuohio.edu

bpmandal@iitg.ernet.in

Abstract: The reduction in CO_2 emissions is very important to mitigate the problem of global warming and climate change. Membrane technology for CO_2 separation has shown positive results. The goal of this study is to develop a highly oxidized graphene oxide (GO) and chitosan(CS) based mixed matrix membrane and explore the approaches to enhance the stability of synthesized membrane. In this work, GO nanosheets has been synthesized from graphite powder using a modified Hummer's method. The GO has been mixed with CS solution and membrane was prepared by solution casting method. The structural aspects of synthesized nanosheets and membrane are characterized using thermogravimetric analysis (TGA), Fourier transform infrared spectroscopy (FTIR) and Universal testing machine (UTM). The CS/GO (0.05 wt% & 0.1 wt%) membranes showed better thermal stability and tensile strength compared to pure chitosan membrane.

Keywords***: grapheme oxide, chitosan, mixed matrix***

Poster Presentation

PDD-50 Effect of Variation of Crosslinker on the Drug Release Behaviour of Polymeric Nanoparticles

Bably Khatun[1] & T. K. Maji[1*]

[1]Department of Chemical Sciences, Tezpur University, Napaam, Tezpur, 784028, India.
*Corresponding author, E-mail: tkm@tezu.ernet.in.

Abstract: Curcumin, one of the active components of turmeric plant (Curcuma longa) is a natural polyphenolic compound well known for its anticancer activity. But the major problem of it is the lack of solubility and bioavailability and hence effectivity. So to increase its effectivity, it is complexed with Hydroxypropyl beta cyclodextrin, a natural complexing agent which is well known for its solubility enhancement property. The complex was prepared using reported method with little modification. Anticancer activity of these products were analysed by MTT assay. It is reported that the polymeric carriers for drug delivery transport drugs to the site of action protecting it from other molecules on the way and helps drug release in a controllable manner. Natural polymers are more promising in drug delivery due to its non toxic and biodegradable nature. So I have used Chitosan and Gum acacia for encapsulation of the chosen modified drug by complex coacervation technique. The ratio and pH of the polymers were optimized for maximum complex formation. The drug encapsulated polymer samples were were prepared using the optimized ratio and pH. In the method, Gluteraldehyde was used as crosslinker and different formulations were prepared by varying the amount of crosslinker. It is then characterized through FTIR, TGA, DSC and XRD. Particle size analysis is done and its zeta potential is measured using DLS. Loading and drug encapsulation efficiency of drug into the polymer matrix is calculated. Swelling and invitro drug release behaviour was studied taking both acidic and basic buffer solutions.

Keywords: *Biodegradable Polymers, nanoparticles, Crosslinker*

PDD-51 Development of a chitosan conjugated 5-Fluorouracil prodrug as a nano-carrier for controlled delivery

Himali Horo*[1], Dr. Lal Mohan Kundu[1,2] Dr. Bishnupada Mandal[1,3]

[1]Centre For The Environment, Indian Institure of Technology, Guwahati,Assam- 781039, India.
[2]Department of Chemistry, Indian Institure of Technology, Guwahati,Assam- 781039, India.
[3]Department of Chemical Engineering, Indian Institure of Technology, Guwahati,Assam- 781039, India.
*Corresponding author, himali@iitg.ernet.in

Abstract: Cancer has become one of the leading causes of death in the world. Various antitumor drug has been developed but most of them shows adverse side effect to the human health by attacking the normal cell as well. Biopolymers and nanoparticles have emerged as effective drug- carriers for delivery of such drugs. We have developed a prodrug of 5-Fluorouracil (5-FU) covalently conjugated to chitosan. It is designed to be cleaved upon external stimulation and release 5-FU in a controlled manner. The conjugate was also formulated into nanoparticles by ionic gelation technique. As compared to chitosan, the conjugate showed better water solubility. It also shows gelation properties in water and DMSO to a particular concentration. The conjugate was characterized by UV-Vis, FTIR spectroscopy, Energy Dispersive X-Ray (EDX) and FETEM. The in vitro release of 5-FU from the biopolymer-prodrug nanoparticles shows systematic release of the drug in different time interval.

Keywords: *Chitosan; Controlled drug release; 5-Fluorouracil.*

Poster Presentation

PDD-53 Synthesis, characterization and drug delivery applications of copolymer blend membranes: Kinetics and mechanism of drug release profile

E. Jaisankar[1]*, Raja S. Azarudeen[1], M. Thirumarimurugan[1]

[1]Department of chemical engineering, Coimbatore institute of technology, Coimbatore - 641014, Tamil Nadu, India.

*Corresponding author, E-mail:jaisankar033@gmail.com

Abstract: A novel chitosan blended thiourea/ phenylhydrazine/formaldehyde (CS-TPF) membrane containing metformin (MFN) drug was prepared through condensation polymerization in different compositions. The prepared membranes were subjected to elemental and FTIR analyses to investigate the empirical formula and weight the presence of functional groups present the matrix. The drug loading and releasing capacity of the membrane and were determined using UV- visible spectroscopy. The studies were performed for all the membranes to optimize the parameters for drug loading and releasing profiles. The swelling behaviour, drug loading capacity and drug release profiles of all the prepared membranes were extensively studied and the result were determined using UV-visible spectrophotometer. The surface morphology of the membrane was characterized using scanning electron microscopy (SEM) to depict the porous nature of the membrane. The CS-TPF1 & CS-TPF2 membranes had a minimum swelling index of 71% and 81% respectively. The CS, CS-TPF3 & CS-TPF4 membranes exhibited good swelling profiles and reached the equilibrium state at 7h. The drug loading efficiency of chitosan membrane (without the copolymer) is found to be 71.13%, whereas the chitosan (60%) was incorporated copolymer (40%) membrane was dropped to 65.18%.s However the drug loading efficiency was improved on lowering the concentration of copolymer. The maximum drug loading efficiency was observed, when chitosan (90%) was incorporated with the prepared copolymer. The chitosan membrane released 62.24% of drug. The CS-TPF1 & CS-TPF2 membranes have started to increase and the drug release was maintained at 60%. The CS-TPF3 & CS-TPF4 membranes initially released the drug at a slow rate and steadily at 72.12% and 76.49%, respectively. The presence of chitosan content at different ratio also affects the swelling behaviour i.e. a higher percentage of chitosan content showed a remarkable improvement in swelling behaviour and leads to a more effective drug delivery. The results also reveal that the chitosan blend membranes have successfully released the anti-diabetic drug in a short period of time and turned out with a reliable solution for the drug delivery. The kinetics study shows that the drug release is in good agreement with the Ritger-Peppas and Higuchi model which follows swelling and Fickian diffusion controlled mechanism.

Keywords: *Chitosan, copolymer, kinetics, mechanism, antidiabetic drug delivery*

Poster Presentation

PDD-54 Injectable and pH-Responsive PEG Hydrogels for Sustained Intra-Tumoral Drug Delivery

Peeyush K Sharma[1] and Yashveer Singh[2*]

[1]Department of Chemistry, Indian Institute of Technology Ropar, Rupnagar-140 001, Punjab, India
*Corresponding author, E-mail: yash @iitrpr.ac.in

Abstract: Injectable hydrogels can be utilized in a variety of drug delivery applications, to provide a stimuli-responsive controlled drug release for extended durations. These properties can be exploited in providing an intra-tumoral sustained release of chemotherapeutic agents thereby minimizing systemic toxic effects. The present study involves the development of a pH-sensitive *in situ* forming hydrogel, utilizing hydrazone linkages between 8-arm PEG precursors (PEG glyoxylic aldehyde and PEG hydrazide). The hydrogel was characterized for gelation kinetics at various pH and found to exhibit fastest gelation at pH 4.3. Gravimetric swelling studies at pH 4.3 and physiological pH demonstrated a higher swelling of 280% at pH 4.3 and up to 260% swelling at physiological pH. As confirmed by oscillatory rheology, the hydrogels exhibited a high mechanical resilience. Finally, hydrogels were explored for Dox (Doxorubicin.HCl) release studies *in vitro*. The drug release was found to be faster at tumoral pH (pH 6.4) as compared to physiological pH sink conditions, with release sustained for up to a week period at tumoral conditions. The hydrogels will be further subjected to *in vitro* and *in vivo* anticancer studies to evaluate their efficacy as a chemotherapeutic drug carrier for intra-tumoral drug release.

Keywords*:* Hydrazone, injectable, pH-responsive hydrogel, drug delivery

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PDD-56 A Review on Thymol Encapsulation in Biodegradable Polymer Shells and its ControlledRelease Mechanism

Y. P. Bhalerao[1]*, S. J. Wagh[2]

[12]Department of Chemical Engineering, Shroff S. R. Rotary Institute of Chemical Technology (SRICT), nkleshwar, Gujarat-393135, India.
*Corresponding author, E-mail:yashbhalerao@yahoo.co.in

Abstract: Encapsulation of thymol is important for its volatile nature, taste, and antispasmodic, antioxidant, antimicrobial, anticancer and anti-inflammatory properties. This review provides a brief summary of thymol encapsulation in different biodegradable polymers along with methods of encapsulation and control release mechanism in various parts of the body. Different biodegradable polymers used for the encapsulation of thymol are Xanthum Gum, PVA, Gelatine, Starch, Sodium Alginate and Ethyl Cellulose. Encapsulation of thymol and its controlled and targeted release in vitro and in vivo is discussed.

Keywords*:* thymol, microencapsulation, biodegradable polymers, control release, drug delivery

Poster Presentation

PDD-57 PLA/CNC Electrospun Nanocomposite Fiber as a Controlled Release Vehicle for Urea Fertilizer

Narendren S, Prodyut Dhar and Vimal katiyar*

Department of Chemical Engineering, Indian Institute of Technology Guwahati, Guwahati-781039, Assam, India

*Corresponding author, E-mail: vkatiyar@iitg.ernet.in

Introduction: Electrospun nanofibers because of their tunable features such as high aspect ratio, high surface area, flexibility, special functionalities with large range of material source. Nanofibers have found broad spectrum of applications especially in biomedical (1), self-cleaning (2), reinforcement composites, sensing, and energy devices (3). In case of biomedical application such as controlled drug release from drug-loaded nanofibrous mat at specified rate needed could be achieved by controlled fiber morphology and its composition. The Current research focuses on production of biodegradable polymer based bio-composite nanofibers that can be applied for controlled delivery of fertilizer to the desired target field and the polymer gets degraded on site causing less harm to the site. This study focus on the production of Poly-lactic acid (PLA) electrospun fibers with Cellulose Nano-crystal (CNC) as nanofiller and to evaluate the suitability of the produced fibers for controlled fertilizer delivery. Urea, a broadly used and water soluble fertilizer was used as a model fertilizer. PLA with different concentration of CNC (0.5% to 2%) loaded with 20% concentration of Urea were electrospun into coaxial fibrous anocomposite mats with being PLA as outer shell and PLA/CNC and Urea in the core. The rate of urea release from the fibers with varying CNC composition was analyzed in water. The change in the crystallinity of the fibers after adding the CNC was determined. The change in the morphology and size of the fibers with increasing concentration of CNC and their effect on urea delivery were analyzed using microscopic techniques. We propose that PLA/CNC coaxial electrospun fibers can have the potential for use in a variety of agricultural applications for delivering of various useful chemical in the field, without compromising material properties.

PDD 58 Synergistic Effect of Curcumin Microcapsule Loaded Anticancer Hydrogel

Prasamsha Panta*[12], Moon Suk Kim [2], Elina Maharjan *[1], Kamala Panthi[3], Rameshwar Adhikari[1]

[1]Research Centre for Applied Science and Technology (RECAST), Tribhuvan University, Kathmandu, Nepal

[2]Department of Molecular Science and Technology, Ajou University, South Korea

[3]Tri-Chandra Multiple Campus, Tribhuvan University, Ghantaghar, Kathmandu, Nepal

*Corresponding author, E-mail: prasamsha07@gmail.com

Abstract: This work reports the improvement in anti-cancer activity of curcumin by incorporating the microcapsules of the latter into carboxymethyl cellulose (CMC) and chitosan (CHI) hydrogel (CCH). Curcumin microcapsules were prepared with poly (D,L-lactic-co-glycolic acid) (PLGA) coating. Anticancer activity, drug release pattern, histology and rheology of free curcumin, curcumin microcapsules, and capsule incorporated CMC, CHI and CCH were studied. The microcapsule loaded hydrogel was found to have long term tumor reduction and sustained release of curcumin.

Keywords: drug delivery, curcumin, microcapsule, hydrogel

Poster Presentation

PDW-62 A Study on catalytic co-cracking of waste plastics polypropylene disposal cup and residual fuel oil

Pamreishang kasar[1], and M. Ahmaruzzaman[1]

[1]National Institute of Technology Silchar, Silchar, Assam, India.

*Corresponding author, E-mail:xyx@iitg.ernet.in

Abstract: Industrial waste Polypropylene (PP Homopolymer) and refinery residual fuel oil (RFO) were pyrolyzed together in presence of catalyst under atmospheric pressure at two different temperatures with different mixing ratios. The effects of blending ratios of two feedstocks with respect to the yield of product oil, gas, and residue were determined. The experiments were carried out in a batch reactor at two different temperatures of 500^0C and 600^0C with the blending mixture (PP: RFO=1:1) to catalyst (ZSM-5) ratio of 4:1. The optimum blending ratio of PP and RFO was found to be 1:1 at 500^0C. The percentage of liquid fuel, gas and coke was observed to be 74.8 %, 10.2 % and 15 % at 500^0C.

Keywords: *Pyrolyzed, Catalyst, blending, blending ratio, batch reactor, ZSM-5, liquid fuel, gas and coke*

PDW-63 Effect of moisture absorption on degradation of FRP composites laminate and durability of FRP laminates exposed with sea water environment, simulate the moisture absorption using FEA analysis.

Pitambar Tripathy*[1], Bishnu Panda [1], Smita Mohanty [1], Sanjay Kumar Nayak [1]

[1]LARPM, CIPET, Bhubaneswar.

*Corresponding author, E-mail: pitamtripathy@gmail.com

Abstract: The main purpose of the study is to investigate the effect of moisture absorption and durability of FRP composite laminates exposed to sea water. Square type specimens are submerged in the sea water environment and the Fick's law on moisture diffusion behaviour is studied. To analyse the effect of moisture uptake, durability on mechanical and physical properties- 3 types of tests were carried out such as three points bending test, buckling test, SEM. Results prove that increasing the exposed time up to 3 months increases the moisture absorption rate and simultaneously durability effect was slightly decreases. After three months moisture absorption rate decreases 40% and durability decreases rigoursly .Lastly compare with the experimental and FEA results outcome shows good.

Poster Presentation

PDW-64 Comparative study of recycled PVC [r-PVC] recovered from waste electrical and electronic equipments (WEEE)

Omdeo K. Gohatre[1], Manoranjan Biswal, Smita Mohanty, Sanjay K Nayak

Laboratory for Advanced Research in Polymeric Materials (LARPM), Central Institute of Plastics Engineering and Technology (CIPET), B-25,
CNI Complex, Patia, Bhubaneswar, Odisha 751024, India

Abstract: This paper discusses about the importance of plastic cables and wires recycling and comparative study of plastic scrap recovered from computer cables and building power supply cables. Recycling of E-waste is an important issue in many developing and developed countries, where they recognize the rapidly increasing and serious issues generated by E-waste. PVC is most widely used among other polymers, which is commonly used for insulation and sheathing distribution cables. In this study, we provide information about the recycling and recovery of PVC (r-PVC) from two different sources; they are waste computer power supply cables and building power supply wires. The identification of these samples is done using FTIR-ATR, density and burn test. The work majorly investigates the recycling possibilities of PVC recovered from these two samples. The reprocessing possibilities of the r-PVC is analysed through torque measurement analysis. The physical, mechanical and thermal properties of r-PVC material is analysed, that shows further recycling possibilities of recovered r-PVC with improve some feasible properties. This paper also describes about the rheological studies done for both the samples. The thermal properties of the materials are comparable with each other.

Keywords: *WEEE, PVC Cable/wire scrap, mechanical recycling, mechanical properties, thermal properties, morphology, rheology.*

PDW-65 Aerobic biodegradation kinetic study of PLA based biocomposites under composting conditions

Naba Kumar Kalita[1], Anubhav Sarmah[2], Ajay Kalamdhad[3], Vimal Katiyar[1*]

[1]Department of Chemical Engineering, Indian Institute of Technology, Guwahati, Assam, India.
[2]Department of Chemical Engineering, MNNIT, Allahabad, Uttar Pradesh, India
[3]Department of Civil Engineering, Indian Institute of Technology, Guwahati, Assam, India.
*Corresponding author E-mail: vkatiyar@iitg.ernet.in

Abstract: This study demonstrates the kinetics of aerobic biodegradation of melt extruded (15-18 cm wide) poly(lactic acid) (PLA) based biocomposites film under composting condition in accordance with ASTM. The kinetic model is proposed based on first order degradation reaction in series with a linear lag phase for each test sample. Non-linear regression technique is used to analyze the experimental data for biodegradability of PLA composites. It is observed that PLA/Chitosan composite film produced higher amounts of C–CO_2 evolution than neat PLA (NPLA) film. The kinetic model gave readily hydrolysable carbon values of 46 % and 46 %, respectively with readily hydrolysis rates of 0.045 day^{-1} and 0.025 day^{-1}, respectively for PLA/Chitosan and NPLA. The mineralization rate of NPLA sample is 0.999 day^{-1} as lag phase is observed till 8th day of the biodegradability test, which is significantly higher than that of PLA/Chitosan test sample. Whereas, lower lag phase is observed for PLA/Chitosan. The C-CO_2 rate is higher for PLA/Chitosan sample at 1.131 day^{-1}. The experimental data of both the test samples was having a good fit with the kinetic model equation showing good R^2 values for all the samples.

Keywords: Biodegradation, poly(lactic acid) (PLA), composting, kinetics and mineralization

Poster Presentation

PDW-66 Aerobic biodegradation study of PLA based biocomposites under composting conditions at thermophilic temperature

Naba Kumar Kalita[1], Ajay Kalamdhad[2],Vimal Katiyar[1*]

[1]Department of Chemical Engineering, Indian Institute of Technology, Guwahati, Assam, India.
[2]Department of Civil Engineering, Indian Institute of Technology, Guwahati, Assam, India.
*Corresponding author E-mail: vkatiyar@iitg.ernet.in

Abstract: This study evaluates the biodegradation of PLA based biocomposites under composting condition. Four test samples namely NPLA, PLA/Chitosan, PLA/CNC and PLA/Gum is used for evaluation of biodegradation. The aerobic biodegradation at composting temperature has been monitored for 80 days. The Molecular weight, microbial count, contact angle analysis, is performed for biodegradation analysis. The decrease in molecular weight for all the test samples till the 80th day of the composting process suggests biodegradation due to chain scission of high molecular weight chains to low molecular chains. PLA/Chitosan decreased from 109 kda to 49 kda over the time of biodegradation. Colony formation is highest in PLA/Chitosan samples and is found to be 5.12×10-6 cfu/ml. Water contact angles of NPLA, PLA/Chitosan, PLA/CNC and PLA/Gum reduced to 39.01 $(\pm 13.41)^0$, 42.12 $(\pm 18.45)^0$, 45.47 $(\pm 17.77)^0$ and 31.87 $(\pm 19.54)^0$ respectively, over a period of 70 days of biodegradation.

Keywords: *Composting, Biocomposites, Biodegradation, molecular weight and colony formation*

PHA-38 Facilitated transport of CO_2 in novel biopolymer blend membrane

Babul Prasad[1] and Bishnupada Mandal[2]*

[1,2]Department of Chemical Engineering, Indian Institute of Technology Guwahati, Assam, India, Guwahati 781039.
Corresponding author, E-mail:bpmandal@iitg.ernet.in

Abstract: The contribution of CO_2 to the global warming is maximum and primary sources of CO_2 emissions are chemical industries, power stations etc. To reduce it, various technologies such as absorption, cryogenic distillation, and adsorption were used, but these technologies have some limitations such as high energy requirement, design complexity, and high cost. Membrane technology overcomes these problems and gives the simple process to separate CO_2 from different gas mixtures like flue gas. The research quest in carbon dioxide (CO_2) separation technology through the polymeric membrane is intensive at this time of energy and environmental crisis. Membrane following facilitated transport is preferred due to its high CO_2 permeance and selectivity. To achieve this, we report a novel membrane prepared by rational blending of two biopolymers that acts as a matrix and another biopolymer that aids as a carrier for facilitated transport. The prepared membranes were characterized by scanning electron microscopy, atomic force microscopy, and swelling tests. The separation of the binary gas mixture (CO_2/N_2) have been studied at temperature, feed absolute pressure and sweep water flow rate ranging from 60-120 °C, 2- 5.93 bar and 0.01-0.07 ml/min, respectively.

Keywords: *membrane, chitosan, gas separation.*

Poster Presentation

PHA-39 Development of Polymer Composites for Enhanced Thermal Conductivity Characteristics

Subhranshu S Pradhan, Lakshmi Unnikrishnan, Smita Mohanty, Sanjay K Nayak
LARPM, CIPET, B-25 CNI Complex, Patia, Bhubaneswar, 751024

Abstract: In this study, PC/ABS based blend nanocomposites have been developed for improved thermally conductive applications. Various loading of fillers like Graphite Flake, CNT, SF and their hybrids were dispersed in PC/ABS blend for improving the thermal conductivity of the system. All blends were analysed for their flow parameters and properties like mechanical strength and thermal conductivity. It was found that higher filler loading of approx. 50% is necessary for imparting high level of thermal conductivity in the composites. PC/ABS showed better dispersion of graphite and less interfacial defects, resulting in better heat conduction ability when compared with other immiscible blends. At filler loading of 50wt%, thermal conductivity of PC/ABS composite reached ~1.574 W/mK, which is nearly 80% higher than that of virgin PC/ABS blend. Morphology and melt rheology measurements confirmed that graphite flake and CNT formed thermally conductive network, which is crucial to the improvement of thermal conductivity

Keywords: *Thermal Conductivity, Carbon Fillers, PC/ABS*

PHA-40 Effect of incorporation of Lignin on Green Polyurethane synthesized via Non-isocyanate route

Munmi Das, Bishnupada Mandal & Vimal Katiyar*
Department of Chemical Engineering, Indian Institute of Technology Guwahati, Assam-781039, India
*Corresponding author, E-mail: vkatiyar@iitg.ernet.in

Abstract: This article demonstrates the synthesis of Green Polyurethanes(GPU) using Carbonated Soybean Oil(CSBO) with the objective to improve its water uptake property. Carbonated soybean oil was reacted with other components, and then lignin was introduced to produce sustainable polyurethane. Fourier transform infrared spectroscopy (FTIR) analysis confirmed the typical linkages of polyurethane and the low contact angle justified the hydrophilicity of the prepared polyurethane. Conventional polyurethanes (PUs) exhibit better mechanical properties, but are highly moisture sensitive having poor hydrolytic stability and insufficient permeability. Also, the presence of isocyanates in its structure make them extremely toxic and dangerous. The absence of toxic components eliminates the need for special safety precaution and handling parameters in GPU. The incorporation of carbonategroups into polymer backbones and side chains enable effortless tailoring of a great variety of urethane-functional polymers.

Keywords: *green polyurethane, water uptake property, sustainable, hydrophilicity*

Poster Presentation

PHA-41 Development of Polymer Nanocomposite for Modulation of Amyloids and Cross Blood Brain Barrier

Subrata Mondal[1]. Sayan Roy Chowdhury[1], Parameswar Krishnan Iye[r*]1

[1]Department of Chemistry, Indian Institute of Technology Guwahati 781039, Assam, India.

**Corres*pon*ding author, E-mail: pki@iitg.ernet.in*

Abstract: Alzheimer's disease (AD) is pathologically highlighted by the aggregation of intracellular neurofibrillary tangles shaped by tau proteins and extracellular feeble torment by amyloid P-proteins (Ap) in the patient brain. Numerous studies have demonstrated that the aggregation of Ap into amyloid fibrils containing trademark cross-P-sheet structure in the mind of AD patients is firmly connected to the pathogenesis of AD and dissolvable Ap oligomers and/or protofibrils are the most poisonous species, in charge of neuron brokenness and death. Here, in this work, nontoxic, biocompatible water soluble polymeric conjugate have been used to modulate toxic amyloid aggregates in human CSF and as well as in preformed amyloid aggregates from commercial Api-40. This modulation strategy leads to the formation of polymer-protein co-aggregates instead of toxic amyloid aggregates which is responsible for plaque formation and is related to disease progression. The intriguing prospect of amyloid fibrils using luminescent conjugate materials technique as a scaffold for polymer-protein hybrid materials is well delineated as this technique provides a direct link between spectral signal and protein conformation and can further be used to gain more information concerning the morphology of the protein deposits and facilitate a greater understanding of the conformational phenotype encoded in the native protein aggregates.

PHA-42Preparation and characterization of biocompatible hydrophilic Polyethersulfone porous membrane for blood purification

Athira V B*[1], Lakshmi Unnikrishnan[1], Smita Mohanty[1], S. K Nayak[1]

[1]Laboratory for Advanced Research in Polymeric Materials (LARPM),
CIPET Bhubaneswar, Odisha.

*Corresponding author, E-mail: athiravb@outlook.com

Abstract: Membrane based blood separation techniques like plasma separation; apheresis and hemodialysis need highly efficient, biocompatible and suitable pore sized membranes for the effective separation of blood components. hemocompatibility and antifouling property are equally important and directly related to the hydrophilicity of polymer membrane. PES is used as the core membrane material which is incorporated with other hydrophilic polymers like PVP and PEG which plays a vital role in pore formation and hydrophilicity. A different set of polymer solutions have made by changing the composition of PES, PVP and PEG in Polyvinylpyrrolidone (PVP) solvent. The concentration of PES was then finalized to 16wt%, 18% wt% and 20wt%. With each set of PES concentration PVP and PEG content varied within a range of 1 wt % to 8 wt% and subjected to the characterization of each set. Thermal studies show the capacity of the membrane to undergo sterilization and capability to withstand high temperature while the surface morphology studies of the membrane to determine pore size and pore size distribution was studied using SEM micrographs. Contact angle measurements paved the way to determine the surface hydrophilicity of membranes. The cytotoxicity tests were carried out in order to prove the hemocompatibility and non-toxicity of PES porous blood purification membranes.

Poster Presentation

PHA-43 Advances in pharmaceutical and therapeutic applications of functional cellulose-based membranes for diabetic wound healing

Veena Vijayakumar*[1], Sushanta K Samal[1], Smita Mohanty[1] , Sanjay K. Nayak[1]

[1]Laboratory for Advanced Research in Polymeric Materials (LARPM), Central Institute of Plastics Engineering and Technology (CIPET), B-25, CNI complex,
Patia, Bhubaneswar, Odisha 751024, India.
*Corresponding author, E-mail: veenateresian@gmail.com

Abstract: Diabetes mellitus is a metabolic disorder of multiple aetiology characterized by chronic hyperglycemia with disturbances in carbohydrate, fat and protein metabolism resulting from defects in insulin secretion, insulin action, or both. India is the diabetes capital of the world and diabetic extremity ulcers develop in approximately 15 percent of people with diabetes and are a leading cause of hospitalization and amputation among such patients.The extreme complication of diabetes mellitus is the occurrence of diabetic foot ulcers and there is no conventional guideline for the selection of wound healing materials in diabetic wounds. But over the past few years, there are some advancements in wound care and management especially in the field of polymer science that several synthetic, as well as natural polymers, have been used for wound healing of diabetic foot ulcers. Nowadays researchers have put forth their effort on the development of a wound healing material from renewable resources in the form of a composite membrane that can heal the chronic wound such as the diabetic foot ulcers in order to tackle the problem of diabetic foot ulcers. For this, there is need to develop a wound healing material which should be cost-effective, non-toxic, biocompatible. Cellulose and its derivative based membranes have a wide variety of application in the field of medicine which includes devices for controlled drug delivery, scaffolds for regenerative medicine, wound dressing etc. Cellulose is a biopolymer which is the most abundant naturally occurring organic substance also a well known renewable, sustainable raw material and can also tackle the problem of chronic wound healing because it is a low-cost material, easily available and also satisfies each and every requirement or characteristics that a wound healing material should possess. Diabetic patients are at increased risk of developing bacterial infections. Hence there is a need to develop an alternative new therapy in order to improve diabetic wound healing.Combination of silver nanoparticles (AgNPs) and an antibiotic incorporated into a polymeric matrix can inhibit bacterial growth and hence inhibit bacterial infections.The silver nanoparticles not only own antibacterial properties but they do have several potential biological properties such as anti-inflammatory effects, exhibits antioxidant capacity and improved wound healing efficacy which can be used in making advanced dressings for chronic wounds and ulcers.

Keywords: *Diabetes mellitus,diabetes foot ulcer,cellulose acetate,wound healing,membrane.*

PHA-44 Self-Healing Crosslinked Polyionic Network

Anil Kumar Padhan*[1] and Debaprasad Mandal[1]

[1]Department of Chemistry, Indian Institute of Technology Ropar, Punjab-140001,India.
*E-mail: anil.padhan@iitrpr.ac.in, dmandal@iitrpr.ac.in

Abstract: Polymeric materials that intrinsically heal at damage sites under wet or moist conditions are highly demanding in biomedical and environmental applications. Herein, we demonstrate an ironically crosslinked polymeric

Poster Presentation

network associated with hydrogen bonding containing polymeric cation and polymeric anion segment. The prepolymer was prepared by radical polymerization and the crosslinked ionic hydrogel was generated by simple mixing in water of individual monomer. The crosslinked ionic network was characterized by FT-IR, TGA, DSC and SEM analysis. The self-healing ability was checked with cut and recovered sample by visualizations methods by attributing dual contribution of hydrogen bonding and ionic interaction.

Keywords: *crosslinked polymer network, Ionogel, Self-healing, Dual network.*

PHA-45 Development of Fe-Cellulose Nanocrystal (Fe-CNC) based thin polymeric film for ethanol sensing

Gourhari Chakraborty[1], Prodyut Dhar, G.Pugazenthi, Vimal Katiyar*

[1]Department of Chemical Engineering, Indian Institute of Technology Guwahati, Guwahati-781039.
*Corresponding author, E-mail:vkatiyar@iitg.ernet.in

Abstract: Conductive polymer composites are presently utilized for several advance applications. Thin film based electrochemical sensor is one of the major area among them because of light weight, casting ease and low cost nature of the films. Poly lactic acid (PLA) based conductive composites also now days are used by several groups for different sensor applications like organic solvent, vapors, gases etc. In this present work Iron loaded cellulose nanocrystal (Fe-CNC) was used to fabricate novel active composite along with exfoliated graphene(GR) and Poly lactic acid. Firstly, loading of Fe-CNC was optimized by morphological, thermal degradation, crystallization and impedance measurement. Then optimized well dispersed composite was used for ethanol detection. It was found that incorporation of Fe-CNC is stabilizing the sensor response towards ethanol.

Keywords: Electrochemical sensor, ethanol, PLA

PHA-46 Waste human hair derived porous carbon filled polymer composites for high performance structural applications

Ravindra Kumar[1], Suyash Varshney[1], Kamal K Kar1,[2]*, Kamal K. Kar[1,2]*

[1]Advanced Nanoengineering Materials Laboratory, Materials Science Programme, Indian Institute of Technology Kanpur, Kanpur-208016, UP, India
[2]Advanced Nanoengineering Materials Laboratory, Department of Mechanical Engineering, Indian Institute of Technology Kanpur, Kanpur-208016, UP, India
[3]Materials Group, Bhabha Atomic Research Centre, Mumbai- 400085, India.
*Corresponding author, E-mail: kamalkk@iitk.ac.in

Abstract: In the present study, waste human hair derived carbon obtained from carbonization of waste human hair at various temperatures in inert atmosphere is characterized through SEM, AFM, XRD, and TGA. This porous carbon is used as reinforcing filler at various proportion with polymer resin to fabricate carbon fabric reinforced

Poster Presentation

polymer composites via simple hand layup for filler-resin slurry impregnation followed by hot pressing under the specific temperature profile to get polymer composite laminates. The composites are characterized through DMTA, hardness, electrical conductivity and density measurements. Test results reveal significant improvement in hardness, storage and loss modulus, while peak height of damping factor decrease greatly with increase in filler content up to 40%. Electrical conductivity shows many fold improvement. Moreover, the composites also exhibit improvement in glass transition temperature, which make it one of the most suitable material for high performance structural applications.

Keywords: *Carbon fabric, Dynamic mechanical properties, Electrical conductivity, Human hair derived carbon, Polymer composites*

PHA-46A Synthesis and characterization of cross-linked poly(vinyl alcohol)/piperazine glycinate/polyethersulfone composite membrane for CO_2/N_2 gas separation

Mridusmita Barooah*[1], Senkhula Lokesh[2], Bishnupada Mandal[3]

[1]Department of Chemical Engineering, Indian Institute of Technology, Guwahati, Assam-781024, India.

[2]Department of Chemical Engineering, Indian Institute of Technology, Guwahati, Assam-781024, India.

[3]Department of Chemical Engineering, Indian Institute of Technology, Guwahati, Assam-781024, India.

*Mridusmita Barooah, e-mail:mridusmita@iitg.ernet.in

Abstract: Global warming, a subject of increased emphasis in the recent years, is caused by the emission of greenhouse gases like CO_2 in the atmosphere. This work studies the synthesis, characterization and gas separation performance of CO2 selective cross-linked poly (vinyl alcohol) (PVA)/piperazine glycinate(PG)/ polyethersulfone(PES) facilitated transport composite membranes synthesised via solution casting methodology. The synthesized membrane is characterized via Thermo gravimetric analysis (TGA), Differential scanning calorimetry (DSC), Fourier transform infrared spectroscopy (FTIR), X-ray diffraction (XRD) and FESEM. The effect of membrane performance on gas transport properties such as CO_2 and N_2 flux ($10^{-6}cm^3$(STP) /cm^2.sec), CO_2 and N_2 permeability (Barrer) (10^{-10} cm^3 (STP)cm/cm^2.sec.cmHg), and CO_2/N_2 selectivity with variation in amine content, temperature, and gas relative humidity was thoroughly studied. The feed gas stream consisted of 20% CO_2 and 80% N_2 by volume. At 100^{O}C and 4.5 atm feed absolute pressure optimum performance was observed with CO_2 permeance of 38 GPU and CO_2/N_2 selectivity of 200 respectively.

Keywords: Polymeric membrane, Poly (vinyl alcohol), Piperazine glycinate, Permeability, CO_2/N_2 selectivity.

Poster Presentation

PMS-47 Modelling of emulsion polymerization of styrene in a semi-batch reactor

Reena Sharma*and Ashwini Sood**

School of Chemical Technology, Department of Chemical Engineering,
Harcourt Butler Technical University, Kanpur-208002, India
*Corresponding author, Ashwini Sood

Abstract: The development of representative computer models is an essential task in understanding complex processes like emulsion polymerization. Detailed models have become essential for getting quantitative insight into behaviour of a process which can be used for efficient operation and control of industrial processes and design of new and improved reactors. The aim of this work was to develop a dynamic computer model for the seeded, semi-batch emulsion polymerization of styrene under monomer-starved conditions. The phenomenon of particle growth was modelled in adequate detail. The mechanistic details include: coupling of the radical concentration in the aqueous phase and the particle phase; determination of average number of radicals inside the particles by radical entry into, exit from and termination inside the particles; partitioning of the monomer in the aqueous phase and the particle phase governed by thermodynamic considerations and the variation of the propagation rate constant and the termination rate constant due to glass and gel effects. The model was validated against experimental data taken from literature.

PMS-48 Study of self-cleaning and blend compatibility of PDMS-PVAc blend using molecular dynamics simulations

Sushanta K. Sethi , Lokesh Soni , Rupam Gogoi[1], Gaurav Manik[1*]

[1]Dept. of Polymer & Process Engineering, IITRoorkee, Saharanpur campus, UP-247001, INDIA
First author mail id: 13susant@gmail.com; susnt.dps2016@iitr.ac.in
Corresponding author mail id: manikfpt@iitr.ac.in; gauravmanik3m@gmail.com

Abstract: Molecular simulations are very promising methods to understand miscibility, the interaction between two polymers, surface energy, and polymer chain dynamics. In this work, the various weight proportion of poly (vinyl acetate) in poly (dimethyl siloxane) base polymer has been taken to form a polymer blend. The properties like water contact angle, blend compatibility and glass transition temperatures are determined by using molecular dynamics simulation.

Keywords: poly dimethyl siloxane; glass transition temperature; Flory -Huggins interaction parameter

Poster Presentation

PMS-49 Failure Analysis of Bubble Canopy: MiG-29 Aircraft

Praveer Verma*[1], Krati Verma[2], Neelam Shukla[3]

[1]Scientist-'F', Defence Research and Development Organization, Kanpur, Uttar Pradesh-208013, India

[2]Dept. of Polymer Science and Engineering, IITRoorkee, Roorkee, Uttarakhand-247667, India

[3]Scientist- 'D', Defence Research and Development Organization, Kanpur, Uttar Pradesh-208013, India

*Corresponding author, E-mail:pvpoly@yahoo.co.in

Abstract: An aircraft canopy is the transparent enclosure on the cockpit of aircrafts which provides a weatherproof and safe environment to its occupants. During World War II ,bubble canopies were brought into use in many aircrafts. It was made without bracing and provided a wider field of view to the pilot. Over the years, there has been paradigm shift in the materials used for the construction of aircraft canopies. Earlier it were made of numerous pieces of flat glass held in position by a frame and muntins. The muntins reduced visibility, which was especially problematic for military aircraft. Then came the glass canopies which were soon replaced by acrylic canopies. These not only protected the occupants from being hit by sharp shattered pieces during accidents but also were very light in weight. They are continued to be used in most of the modern fighter planes. This study involves the evaluation of the causes of failure of a MiG-29 Aircraft whose canopy bubble was found to be cracked on the rear portion of the periscope during last flight service check. The canopy made of stretched acrylic was subjected to various examinations like SEM, DSC, TGA, FTIR and it was concluded that the crack generated from a completely chipped area of material from the canopy glass base. This was likely due to foreign object hit while at higher altitude, where the temperatures are low, thereby having a reduced fracture toughness making the organic glass more brittle.

Keywords: *Canopy bubble, Stretched Acrylic, DSC, TGA, SEM, FTIR*

PMS-49A Molecular Dynamic Simulations of the Ternary system: Quinoline, Heptane and Phosphonium Based Deep Eutectic Solvent (DES)

Papu Kumar Naik*[1], Sandip Paul[2], and Tamal Banerjee[3]

[1]Centre for the Environment, IIT Guwahati, Assam-781039, India

[2]Department of Chemistry, IIT Guwahati, Assam-781039, India

[3]Department of Chemical Engineering, IIT Guwahati, Assam-781039, India

* Corresponding author, papu.naik@iitg.ernet.in

Abstract: Poly aromatic hydrocarbon (PAH) from fuel oil ware most efficiently extracted by using phosphonium based deep eutectic solvent (DES). Here, the DES used is formed by mixing the Hydrogen Bond Acceptor (HBA) (methyltriphenylphosphonium bromide [MTPB]) and Hydrogen Bond Donor (HBD) (ethylene glycol (EG)) at a molar ratio of 1:4 respectively. The classical Molecular Dynamic (MD) simulation technique

Poster Presentation

is then employed to investigate and compare the experimental phase behavior of DES-quinoline-heptane ternary heterogeneous system. Two experimental feed points are considered which gave high selectivity and distribution coefficient values. The interaction energies of different species and the structural properties such as radial distribution functions (RDFs), average number of hydrogen bonds and spatial distribution functions (SDFs) are then computed. It is found that the cation within the HBA namely methyltriphenylphosphonium (MTP) possess a favorable interaction with quinoline when compared to HBD or anion (Br). MTP here acts as a hydrogen bond acceptor (HBA) and contributes to the hydrogen bonding with quinoline which results in higher experimental selectivity values. The calculations of SDFs further reveal the fact that the DES molecules are evenly distributed around the quinoline molecule, whereas heptane molecules are found to occupy the positions above and below of the aromatic ring.

Keywords: *Molecular Dynamics, Deep eutectic solvents, Interaction energy, Quinoline, Heptane, Liquid-Liquid Equilibria*

PNC-13 Development of Chitosan Film Reinforced with Anti-Oxidant Loaded Mesoporous Silica for Active Packaging

P.L. Alagammai[1], C.K. Bijosh[2], G. Pugazhenthi[3], V. Ravi Babu[1]*

[1]Electrochemical Power Source Division, CSIR - CECRI, Karaikudi– 630003.
[2]Centre for Biopolymer Science and Technology (A Unit of CIPET), Kochi – 683501.
[3]Indian Institute of Technology Guwahati, Guwahati – 781039.
*Corresponding author, E-mail:xyx@iitg.ernet.in

Abstract: Plastic packaging is the technology of enclosing or protecting products for distribution, storage, sale, and use. The reason behind this is owing to its ease in handling, storage efficiency, light weight, and inexpensive. Chitosan is a sustainable polymer , biodegradable, biocompatible, have excellent film forming property and possess antimicrobial characteristics. Therefore, in present study chitosan have been used as a sustainable active packaging material for the quality preservation of a variety of food. Although chitosan possess the prospective to compete with the conventional plastics, it is important to spell out the drawbacks which limit their usage in packaging application such as poor mechanical and gas barrier properties. To overcome these limitations and also for the controlled release of antioxidants from incorporated chitosan film. Fillers like MCM 41 is used as it not only improves the properties of film but also used for controlled and targeted antioxidant delivery. These MCM 41 is synthesized from bio resources. Burning rice husk, which are by product from rice mill generates rice husk ash (RHA). RHA MCM 41 particles were synthesized using sodium silicate solution prepared from RHA and cetyltrimethyl bromide (CTAB) as a structure directing agent, around which the framework is built up. The synthesized RHA MCM 41 is functionalized via post synthesis grafting using APTES (**3**amino propyl triethoxysilane) to improve their physical and chemical properties. Antioxidants such as ascorbic acid is loaded into functionalized RHA MCM 41 so that direct contact of antioxidant from food can be avoided and predetermined concentration of active compound is maintained in the food to achieve a desired shelf life. In this study,ascorbic acid loaded RHA MCM 41 is incorporated into chitosan film. The properties of RHA MCM 41 is compared with conventionally synthesized Sds MCM 41 and properties of chitosan and its composite film is characterized.

Poster Presentation

PNC-14 Study on the properties of nanocomposite based on rice husk and polyvinylchloride

Nipu Dutta*[1], T. K. Maji[2]

[1]Chemical Sciences, Tezpur University, Tezpur, Assam-784028, Assam.
[2]Chemical Sciences, Tezpur University, Tezpur, Assam-784028, Assam.
*Corresponding author,E-mail:nipu@tezu.ernet.in

Abstract: Polyvinylchloride (PVC), rice husk, montmorillonite(MMT) were blended by using barbender plasticoder loaded with different percentage of MMT (2,5,10wt%).The blended products were compression molded to prepare the nanocomposite and various properties were studied through thermogravimetric(TGA) analysis, limiting oxygen index (LOI) test, mechanical and dimensional stability analysis. Scanning electron microscopy (SEM) studied the surface morphology for the prepared nano composites. The thermal and mechanical analysis revealed that the nanocomposites with 10wt% of MMT showed better properties among the composites. The nanocomposites also showed high chemical resistance and dimensional stability with lower water uptake properties.

Keywords: *rice husk, nanocomposite, thermal properties, mechanical properties*

PNC-15 All-Solid-State Flexible Supercapacitor Based on Self Assembled Polyaniline Nanotube/Reduced Graphene Oxide Aerogel

Anindita Bora, Swapan Kumar Dolui*

Department of Chemical Sciences, TezpurUniversity, Napaam, Assam-784028,India.
*Corresponding author,E-mail: dolui@tezu.ernet.in

Abstract: Flexible energy storage devices are the need of the hour with the advent of flexible electronics. Reported flexible supercapacitors based on grapheme analogues usually show low specific capacitance. Hybridization of double layer capacitors with pseudo-capacitors presenting way of improving supercapacitor performance. Herein, we prepared ultra-light three dimensional polyaniline nanotube/reduced grapheme oxide (PNT/rGO) composite aerogel by sol-gel technique where PNT acted as aspacerto prevent restacking of rGOsheets. The aerogel was successfully applied as an active electrode material in all-solid-state flexible supercapacitor which exhibited a specific capacitance of 870Fg-1at 1 Ag-1with excellent cycling and temperature stability.

Keywords: *Flexible supercapacitor, Polyaniline nanotube, reduced grapheneoxide, energy storage*

Poster Presentation

PNC-16 A Study of Acid red 52 dye removal from an aqueous medium using PANI/PVP/Nd-ZnO polymeric nanocomposite

A. Gouthaman*, Raja S. Azarudeen, M. Thirumarimurugan

Department of Chemical Engineering, Coimbatore Institute of Technology, Coimbatore –641014, Tamil Nadu, India

**Corresponding author, E-mail:gouthamanasok92@gmail.com*

Abstract: PANI/PVP/Nd-ZnO (PAPV-NZO) polymeric nanocomposite was synthesized by following oxidative polymerization technique for the treatment of aqueous solution containing Acid red 52 dye. Neodymium (Nd) doped Zinc oxide (NZO) nanoparticles were prepared by co-precipitation and calcination methodologies in various concentrations of Nd and were incorporated into the copolymer PANI/PVP (PAPV) during the oxidative polymerization process. SEM, XRD and FTIR analyses were studied for the polymeric nanocomposite to investigate the morphological characteristic features, nature and functional groups, respectively. The dye removal studies were carried out under visible light at room temperature, for different concentrations of dye, adsorbent dosages of polymeric nanocomposite and pH of the dye solution. All the dye removal analyses were conducted for 3 h. The results confirmed that PAPV-NZO has a very high dye removing capacity and it exhibited a greater dye removing tendency than PAPV, due to the addition of NZO which enhanced the stability and the conductive nature of the nanocomposite. The effect of pH was evaluated on the determined optimum dye concentration and adsorbent dosage. The nanocomposite showed a very high effectiveness in dye removal under acidic conditions, especially at pH 2. The nature of the adsorption process has been investigated on the optimum parameters to suit the process to the appropriate kinetic and isotherm models. The maximum dye adsorption capacity of the PAPV-NZO was estimated to be 159.36 mg g^{-1} and the maximum amount of dye removal was 99.6% of the initial dye concentration. From the results, it has been assured that the PAPV-NZO can be effectively used for dye removal studies.

Keywords: *Nanocomposite, Removal, Acid red, Optimization, Kinetics, Isotherms*

PNC-17 Physicochemical properties of wood nanocomposites based on modifed soybean oil

Moon Mandal*, Tarun K Maji

[1]Chemical Sciences, Tezpur University, Tezpur, Assam- 784028, India.

[2]Chemical Sciences, Tezpur University, Tezpur, Assam- 784028, India.

*Corresponding author, E-mail: mnmandal8@gmail.com

Abstract: Wood polymer nanocomposites (WPNC) were prepared from modified soybean oil, nanoclay and softwood by compression molding technique. Three different percentage of nanoclay were employed to prepare the nanocomposites and various properties were studied through limiting oxygen index (LOI) test, mechanical and thermogravimetric (TGA) analysis. The delamination of silicate layers and morphology of the clay-incorporated nanocomposites were explained by X-ray diffractometry (XRD), scanning electron microscope (SEM) and transmission electron microscope (TEM). WPNC with the incorporation of 3 wt% of nanoclay showed better properties compared to composites with 1wt% nanoclay. The nanocomposites with 3 wt% nanoclay enhanced the flexural and tensile strength with significant improvement in thermal properties. The nanocomposites also exhibited higher dimensional stability, lower water uptake (%) and enhanced chemical resistance.

Keywords: wood nanocomposites, mechanical properties, thermal properties, modified soybean oil, nanoclay

Poster Presentation

PNC-18 Functionalized chitosan/AuNPs based composite: An efficient photocatalyst

LipiMidya and Sagar Pal*

Polymer Chemistry Laboratory, Department of Applied Chemistry, Indian Institute of Technology Dhanbad (Indian School of Mines), Dhanbad-826004, India.

**Correspon*ding *author, E-mail: sagarpal1@hotmail.com*

Abstract: Recently, a unique nanocomposite [cl-Ch-p(DEAEM)/Au] has been developed using cationically functionalized chitosan and *in-situ* incorporated AuNPs, which found to be an efficient photocatalyst towards the degradation of toxic organic contaminants.[1] The physical and structural properties of composite material has been characterized using various techniques. Further the degraded products were found to be non-toxic and hence the developed composite material may be considered as sustainable material.

PNC-19 Synthesis and Characterization of PA6/GO and PA6/GO/PANI Nanocomposites

Banalata Kaibarta*[1], Shatrudhan Palsaniya*[2] and Ashok Kumar Dasmahapatra[1,2]

[1]Department of Chemical Engineering, Indian Institute of Technology Guwahati, Guwahati, Assam- 781039, India.

[2]Centre for Nanotechnology, Indian Institute of Technology Guwahati, Guwahati, Assam- 781039, India.

*Corresponding author, E-mail: akdm@jits. ernet. in

Abstract: Polymer nanocomposites are the promising candidates with importance in producing high strength materials by virtue of low cost and easy to process. Graphene Oxide (GO) with large surface area containing a number of oxygen atom with functional groups, produced by the modified Hummer's method using pristine graphite powder. In this work, we have studied the characteristic behaviour and improved properties of Nylon-6 (PA6) by incorporating GO dispersion (PA6/GO binary composite) and with polyaniline (PANI) (PA6/GO/PANI ternary composite). The binary nanocomposite (viz., PA6/GO) was prepared by solution mixing, whereas, the ternary composite was prepared by *in-situ* chemical oxidative polymerization methods. The structural characterizations and physical properties were studied by FTIR, UV-Vis spectroscopy, Raman spectroscopy, Thermogravimetricanaysis and FESEM. The results show that the GO is well-dispersed in PA6 matrix with an enhanced thermal stability.

Keywords: Synthesis of polymer nanocomposite, Characterizations, Materials properties

Poster Presentation

PNC-20 Fabrication of bio based hyperbranched epoxy and its nanocomposite

Aditi Saikia and Niranjan Karak*

Advanced Polymer and Nanomaterial Laboratory, Center for Polymer Science and Technology, Department of Chemical Sciences, Tezpur University, Napaam 784028, Assam, India.
*Corresponding author, E-mail:karakniranjan@gmail.com

Abstract: Renewable resource based polymers has been of extensive research interest in the present decade due to the depleting reserves of fossil fuels as well as environmental and health issues. The renewable resources include vegetable oils, naturally occurring polysaccharides, aliphatic polyesters, etc. which are environmentally benign, compostable, biodegradable, cheap and easily available. Therefore, in the present investigation hyperbranched epoxy resin and its nanocomposites were fabricated from renewable resources like castor oil, sorbitol and carbon based nanomaterials. Both the polymer and the nanocomposites were well characterized by FTIR, ^{1}H NMR, XRD and HRTEM studies. The nanocomposites showed significant improvement of mechanical properties, particularly addresses the shortcomings of conventional epoxy thermosets. Thus, the bio-based hyperbranched epoxy and its carbon based nanocomposite might be successfully utilized as a sustainable material.

Keywords: Hyperbranched, Bio based, Nanocomposites, Sustainable, Sorbitol

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PNC-21 An efficient dye sensitized solar cell based on Polymethyl methacrylate/carbon black polymer gelelectrolyte

Kiran jyoti Mohan, Swapan Kumar Dolui*

Department of Chemical Sciences, TezpurUniversity, Napaam, Assam-784028, India.
*Corresponding author, E-mail: dolui@tezu.ernet.in

Abstract: Dye sensitized solar cells (DSSCs) have received significant attention due to their easy fabrication process and low production cost. However, leakage and volatilization of the organic solvent present in the liquid electrolyte affect its durability. In this work, polymethylmethacrylate (PMMA) based polymer gel electrolyte (PGE) with different weight percent of carbon black (CB) was studied to improve the durability of DSSCs. DSSC with 0.57wt% of CB in PMMA exhibits the highest photo conversion efficiency of 5.52% with short circuit current density (J_{sc}), open circuit Voltage (V_{oc}) and fill factor values of 12.43 $mAcm^{-2}$,766.02mV and 58.01%respectively. The impacts of the PGE in the enhancement of Voc was studied by analyzing the chemical capacitance eat the interface of photo anode and PGEs.

Keywords: *Dye sensitized solarcell, Polymer gel electrolyte, voltage enhancement*

Poster Presentation

PNC-22 Bio-derived aliphatic hyperbranched polyurethane nanocomposites with high performance and smartfeatures

Rajarshi Bayan*[1], Niranjan Karak[†1]

[1]Department of Chemical Sciences,Tezpur University,Tezpur, Assam-784028, India.

[1]Department of Chemical Sciences,Tezpur University, Tezpur, Assam-784028, India.

[†]Corresponding authore -mail:karakniranjan@gmail.com

Abstract: Smart polymers are the new generation materials with multi-dimensional utility. However, the key challenge is to prepare such polymers with high performance, keeping their smart features intact. In this study, bio-resource derived aliphatic hyperbranched polyurethane nanocomposites were fabricated *insitu* with modified grapheme oxide (GO). The nanocomposites were characterized by sophisticated spectroscopic and analytical tools. The nanocomposites displayed superior mechanical properties like tensile strength (>10MPa) and elongation-at-break (>1000%), along with high thermal stability (above300°C).The nanocomposites also demonstrated hydrophobic character and self-healing ability under suitable external stimuli.

Keywords: *bio-derived, hyperbranched, polyurethane nanocomposites, smart polymer*

PNC-23 Characteristic study of adding ZnO nanoparticles in PVDF and PVDF-TrFE films and their voltage responses

Rajesh Sahoo*[1,2], Anantha Kumar Ramadoss[1], Lakshmi Unnikrishnan[1], Smita Mohanty[1], Swapna Mahapatra[2], Sanjay Ku. Nayak[1,3]

[1]LARPM, CIPET, Bhubaneswar, Odisha, 751024, India.

[2]Physics Department, Utkal University,VaniVihar, Bhubaneswar, Odisha,751004, India.

[3]Central Institute of Plastics Engineering and Technology, Chennai, Tamil Nadu, 600032, India.

*Corresponding author, E-mail:rajeshjitu17@gmail.com

Abstract: Piezoelectricity is the property for generating electric potential by applying external stress on piezoelectric material (like PZT, ZnO, BaTiO3, PVDF and so on). Here we have prepared PVDF films by solvent casting method and hot compressed in hydraulic compression to get thin nonporous film. Films prepared from PVDF-TrFE copolymer shows 84% beta-fraction because of having an extra fluorine atom which makes it more polarized as compared to PVDF film which shows 71% of that. To improve the voltage response ZnO nanoparticles were introduced in PVDF and PVDF-TrFE solutions. To check the beta-phase fraction and percentage of crystallinity FTIR and DSC were done and from XRD the presence of ZnO nanoparticles in the films were confirmed. Coating of the films were done by using conductive adhesive tapes. Then the coated films were fabricated inside PET sheets and used for voltage response. With normal hand tapping on the fabricated films the voltage responses were read by using a DSO (digital storage oscilloscope).

Keywords: *Piezoelectricity, PVDF, PVDF-TrFE, ZnOnano-composites.*

Poster Presentation

PNC-24 Ag@SiO_2 modified PVDF Nanohybrid Membrane for Water Purification

Jnyana Ranjan Mishra, Malluru Abhilash, Sushanta Kumar Samal, Smita Mohanty, Sanjay Kumar Nayak

Laboratory for Advanced Research in Polymeric Materials (LARPM), CIPET, Bhubaneswar.
*Corresponding author, E-mail:gyanamishra93@gmail.com

Abstract: As the population is growing in a folded manner, the requirement for safe drinking water is increasing in a multifolded manner. So the primary challenge for the scientific community is to provide the people of all ages, all class and from every corner of the world safe drinking water. So, the main aim is to make the technology that we are going to employ for water purification cost effective. Membrane technology is expected to dominate among the water purification technologies due to its easy handling, cost effectiveness and reliable mechanism. But the major problem with these types of membranes is its easy fouling tendency which leads to the deterioration of the membrane. Keeping these views in mind, the present work focuses on the development of a PVDF (Polyvinylidenedifluoride) - based water purification membrane, with antifouling characteristic. High mechanical strength and long term durability under applicative environment are also other objectives of this work. The resultant PVDF based membrane imparts excellent mechanical strength and durability. Modification of the membrane with Ag@ SiO2 nanocomposites incorporates hydrophilicity of the membrane due to polar and lewis acid type behavior of the silane and antibacterial properties of the membrane also developed due to the presence of the Ag nanoparticles.APTES is used as the crosslinker to bind the nanocomposites with the hydroxylated membrane in order to make sure that the nanocomposites are not was hed out from the membrane surface. After the addition of the Nanoparticles the membrane will show high waterflux, low fouling andexcellent antibacterial properties.

PNC-25 Synthesis of PI/AFG nanocomposite films end capped with diphenylethynyl phenoxy endcap for aerospace applications

Chandra Sekhar Patra, Dr.SKurmvanshi, Dr. Sushanta Kumar Samal, Dr. Smita Mohanty, Dr. S. K. Nayak

[1]Laboratory for Advanced Research In Polymeric Materials (LARPM), CIPET, Bhubaneswar, 751024, India
*Corresponding author, E-mail:chandrasekharpatra94@gmail.com

Abstract: Polyimides are well known for their unique thermal as well as mechanical properties for that they are widely used in a diverse range of applications including the fields of aerospace, defense and optoelectronics. In this study the AFG (Amine-Functionalized Graphene) with different diamines {APB(1,3-Bis(3-aminophenoxy) benzene and BAPPS (bis [4-(4- aminophenoxy) phenyl] sulphone)} were used to prepare poly(amic acid)/AFG nanocompostite film via spin coating. To convert poly(amicacid) into polyimide (PI), the films were thermally imidized after spin coating. The effects of AFG content on the thermomechanical properties, tensile properties, thermooxidative properties, chemical resistance of PI/AFG nanocomposite film were investigated. In order to enhance the chemicals resistance, thermooxidative properties of the film, the poly(amicacid)/AFGisendcappedwith DPEPPA(diphenylethynyl phenoxyphthalic anhydride) and then thermally imidized. A comparative study is carried out between the uncapped and the end capped PI/ AFG nanocomposite films. The uncapped PI/AFG nanocomposite film shows greater mechanical properties while the end capped PI/AFG nanocomposite film shows greater resistance towards chemicals and thermal oxidation.

Keywords: *Polyimides, End Cap, Nanocomposites, Amine-functionalized Graphene (AFG)*

Poster Presentation

PNC-26 Development of polystyrene-TiO_2 nanocomposite photocatalyst for treatment of dye wastewaters

Suman Das and Hari Mahalingam*

Department of chemical Enginnering, National Institute of Technology, Surathkal, Karnataka 575025, India.

*Corresponding author, E-mail: mhari@nitk.edu.in.

Abstract: Abstract: In advanced oxidation processes, photocatalytic degradation of wastewater received much attention in the last few decades. There are numerous studies on decolourization/ degradation of textile dyes in a slurry form, which has the biggest disadvantage of a difficult and expensive post-separation method of the photocatalyst because of its small particle size. In order to overcome the separation of photocatalyst after using it for wastewater treatment, TiO2 photocatalyst has been immobilized in polystyrene. Polymer film loaded with TiO2 photocatalyst has been prepared by using solvent casting method and characterized by using SEM, FTIR, TGA and Profilometer. The photocatalytic study of polymer film under UV-C irradiation has been studied by using Remazol Turquoise Blue (RTB) dye solution. Parameters (pH, catalyst loading, dye loading, UV light intensity, polymer film thickness) affecting degradation study of RTB has been optimised and final product after degradation has been predicted from LC-MS data. TOC data also shows the degradation of RTB over a period of time. In a batch study of 200 ml, 10 ppm RTB dye solution has been completely degraded in 1 hr 30 mins at optimized conditions.

PNC-27 Hydrophilic and Antibacterial Polysulfone Ultrafiltration Membranes

Randeep Singh[1*] and Mihir Kumar Purkait[1]

[1]Department of Chemical Engineering, Institute of Technology Guwahati, Guwahati, Assam-781039, India.

*Corresponding author, E-mail:randeep@iitg.ernet.in

Abstract: Polysulfone (PSF) membranes modified with a TiO_2-AMPS based polymer nanocomposite are presented in this study. Non-solvent induced phase inversion technique was used for membrane preparation byusing Poly(ethylene glycol) and N-methylpyrrolidoneas pore former and solvent, respectively,. The synthesized polymer nanocomposites were blended in the PSF membranes in different wt%. The membranes were characterized by using techniques like Field emission scanning electron microscopy and Fourier transform infrared spectroscopy. The permeation tests were carried out to analyze the pure water flux and hydraulic permeability of the prepared membranes. The presence and stability of the hydrophilic and antibacterial nanocomposite in the membranes was confirmed by the Fourier transform infrared spectroscopy. Antibacterial studies of the membranes were carried out by using *E. coli*. The hydrophilicity, depicted from the water contact angles of the prepared membranes, increases with the amount of the polymer nanocomposite. Similarly, the antibacterial nature of the membranes increases with the amount of the polymer nanocomposite in the membranes.

Keywords: *Polysulfone, Ultrafiltration, Hydrophilicity, Antibacterial, Polymer nanocomposite*

Poster Presentation

PPC-01 Role of Dicumyl Peroxide as Compatibilizer in Increasing the Thermal Stability and Thermal Degradation Kinetics of Poly (Lactic Acid)/ Coconut Oil Blends

Siddharth Mohan Bhasney, Rahul Patwa, Amit Kumar and Vimal Katiyar*

Department of Chemical Engineering, Indian Institute of Technology Guwahati-781039, Assam, India.

*Corresponding author, E-mail:vkatiyar@iitg.ernet.in

Abstract: The present work investigates the effect of di-cumyl peroxide (DCP) (a radical initiator) on thermal stability of the poly (lactic acid) /coconut oil blend. Our previous study shows that coconut oil acts as plasticizer and enhances the thermal degradation process (Figure 1).[1] Addition of DCP prevents thermal degradation of PLA [2], hence 1% DCP is incorporated in PLA/coconut blends for its suitability towards high engineering and commodity application. PLA/ Coconut oil with di-cumyl peroxide as compatibilizer blend were melt blended with different amount of coconut oil and 1% DCP using a twin-screw extruder (temperature 180°C, recycle time 1 min and screw speed 100 rpm). The differential TG revealed that even small addition of DCP (1%) when incorporated in the blend, it enhances the thermal stability of PLA/coconut blends. impedes the thermal degradation process, and 1 wt. % DCP incorporated in the blend could enhance the thermal stability of PLA from 375.**1**°C to 375.5, 375.2 and 375.8 °C for 1, 2 and 5 wt % coconut oil, respectively. Upon increasing plasticizer content to 7%, mobility of PLA chains increase which result in enhanced rate of thermal degradation (374.9 °C). Our study shows that apparent activation energies (E_a) of blend increased in comparison to pure PLA which was confirmed by model fitting the experimental data using Kissinger, Flynn-Wall-Ozawa (F-W-O), Kissinger-Akahira-Sunose (K-A-S), and Augis and Bennett degradation kinetic models. This approach shows the thermal stability of PLA/coconut oil blends can be improved by small addition of DCP (1%) which can be applied to other polymer/plasticizer systems.

Keywords: *Poly (lactic-acid), Coconut oil, plasticizer, degradation kinetics, activation energy.*

PPC-02 Ionic Liquid as solvent for development of Sulfonated Polyimide-based Polymer Electrolyte Membranes (PEMs)

Tushita Rohilla[1*], Narinder Singh[2] and Dhiraj K. Mahajan[1]

'Centre for Materials & Energy Engineering, Indian Institute Technology Ropar, Rupnagar-140001, Punjab, India

^Department of Chemistry, Indian Institute Technology Ropar, Rupnagar-140001, Punjab, India

*Corresponding author, E-mail:tushita.rohilla@iitrpr.ac.in

Abstract: Fuel cells are efficient energy generation devices that produce useable energy from continuous redox reactions between a fuel and an oxidant. Polymer Electrolyte Membrane Fuel Cell (PEMFC) is one such device powering stationary and portable devices. But large-scale commercialization of these devices is limited by the expensive per- fluorinated Polymer Electrolyte Membrane (PEM) used in these. Moreover, the commercial membranes have limited performance at higher temperatures and lower humidity conditions. Therefore, the focus for development of cost-effective and efficient PEMs has shifted to hydrocarbon-based polymers. Among available HC-based polymer options only certain classes of polymers are able to meet the stringent

Poster Presentation

property requirements of fuel cells. Polyimide is also a class of polymers that are suitable candidates for PEM owing to their superior thermal stability and mechanical strength. But limited solubility of these polymers in common solvents poses a challenge in processing of these polymers. Polar aprotic solvents such as Dimethyl Sulfoxide (DMSO) are suitable for their processing but these solvents are not sustainable solutions for commercial viability of these PEM candidates. Recently, Ionic Liquids have become popular as an environment-friendly medium for conducting condensation polymerization of dianhydrides and diamines to synthesize Polyimides. We have synthesized sulfonated Polyimide polymer elecrolyte membranes using 1-Butyl-3-methylimidazolium chloride as solvent and evaluated its effect on various parameters. Sulfonated diamine Benzidine Disulfonic acid, a semi-rigid aromatic dianhydride Pyromelletic dianhydride and a non-sulfonated diamine, 4,4'-Methylenedianiline were used as monomers and polycondensation reaction were conducted in [BMIm]+ Cl- medium. The chemical structure of the synthesized polymers was confirmed using Nuclear Magnetic Resonance (H1 and C13) and Fourier Transform Infrared Spectroscopies. Their Ion Exchange Capacities (IEC) were calculated from molar feed and confirmed through back titration method. Effect of solvent on morphology of the membranes was evaluated using Scanning Electron Microscopy (SEM). Effect on fuel cell application-specific properties was measured by conducting Water Uptake, Swelling ratio and Dimensional stability studies. Permeabilities of membrane to different fuels. Oxidative stability and hydrolytic stability was measured. Effect of variation in contents of sulfonated and non-sulfonated diamines on the mentioned parameters was evaluated. Methanol permeability was also measured to assess suitability for use in Direct Methanol Fuel Cells (DMFC). Water uptake, swelling ratio and dimensional stability were measured. Comparisons were made with the membranes of same composition synthesized using Dimethyl Sulfoxide (DMSO), a conventional solvent.

Keywords: *Ionic Liquids; Polyimide; Polycondensation; Polymer Electrolyte Membrane*

PPC-03 Synthesis, Characterization and Immobilization of DPP-based Click Polymers on ITO and Glass Surfaces

P.Ramar[1], Debasis Samanta*[2]

[1]Polymer Science and Technology Department, CSIR-CLRI, Chennai, Tamilnadu-600020, India.
[2]Polymer Science and Technology Department, CSIR-CLRI, Chennai, Tamilnadu-600020, India.
*Corresponding author, E-mail: ppramar93@gmail.com, debasis.samanta@gmail.com

Abstract: Surface functionalized polymer brush playes an important role in a diverse range of applications in medical science, controlled drug-delivery and release systems, anti-fouling surfaces, super hydrophobic surfaces, photovoltaic device and sensor devices. Here, we report the synthesis of dialkynated DPP and diazide monomers and characterization by FT-IR, NMR, UV-vis and UV fluorescence spectroscopy techniques. The polymers were synthesized through click polymerization using different catalyst. Those were characterized by FT-IR, NMR, UV-vis, UV fluorescence and TGA and DSC. Those polymer were coated on the glass and ITO surfaces with drop-casting method.

Keywords: *Click polymerization; Polymer coating; Dialkynated DPP; Surface polymer*

Poster Presentation

PPC-04 Sustained Release of Triclosan from Nano Fibrilliated Cellulose and its Prolonged Antibacterial Activity

Srijita Purkayastha, Saikat Biswas, Sampa Saha*

Centre for Polymer Science and Engineering, Indian Institute of Technology Delhi, Hauz Khas, New Delhi-110016

*Corresponding author, E-mail:ssaha@polymers.iitd.ac.in

Abstract: Nanofibrilliated Cellulose (NFC) have attracted interest in the field of drug delivery since last decade. NFC became popular because of its abundant availability, bio compatibility as well as high surface area. Our aim of this work was to synthesize NFC from soft wood pulp and adsorption of antibacterial (ex. Triclosan) onto them to exploit the use of NFC as drug delivery vehicles. NFC was prepared by acid hydrolysis followed by centrifugation. The length and diameter of fabricated NFC were found to be in the range of 500-600 nm and 22-60 nm respectively as observed by TEM and FESEM. Successful loading of Triclosan onto NFC was confirmed by FTIR, Fluorescence and UV absorption study. In-vitro release study of the nanofibers was carried out in order to understand its release kinetics. Currently, evaluation of its efficacy as slow release antibacterial nanofibers is underway.

PPC-05 Surface initiated self-healing polymers via Atom Transfer Radical Polymerization from the surface of Graphene oxide

Junali Handique and Swapan Kumar Dolui*

Department of Chemical Sciences, Tezpur University, Napaam, Assam-784028, India.

*Corresponding author, E-mail:dolui@tezu.ernet.in

Abstract: Polymers are grown directly on the surface of grapheneoxide.Themethodinvolvesthecovalentattachment of an atom transfer radical polymerization (ATRP) initiator followed by the polymerization of methyl methacrylate, styrene or t-butyl acrylate. The surface initiated polymethylmethacrylate (PMMA-IGO) is embedded with microcapsules containing glycidyl methacrylate (GMA) to introduce self-healing property. The polymeric chains grown on the surface of the graphene showed self-healing behaviour on rupture of the microcapsules. The matrix PMMA-IGO was synthesized by Atom transfer radical polymerization (ATRP) polymerization, it preserves living characteristics and was able to resume the polymerization as long as monomer is available. The GMA is released from the broken capsules upon damage of the composite and gets infiltrated into the cracks followed by copolymerization with the matrix PMMA-IGO. As a result, the cracked planes were covalently re-bonded, offering recovery of fracture toughness.

Keywords: ATRP, surface initiated polymers, graphene oxide, melamine-formaldehyde microcapsule; self-healing polymer

Poster Presentation

PPC-06 Biodegradable Poly (lactic acid)/Modified Gum Arabic (MG) Based Microcellular Composite Foam: Effect of MG on Foam Properties and Thermal Behaviour

Shasanka Sekhar Borkotoky, Tabli Ghosh, Vimal Katiyar*

Department of Chemical Engineering, Indian Institute of Technology Guwahati, Guwahati, Assam- 781039, India.

*Corresponding author, E-mail: vkatiyar@iitg.ernet.in

Abstract: This article mainly demonstrates the fabrication of biodegradable poly (lactic acid) (PLA)/ modified gum arabic (MG) composite microcellular foam. The effect of MG on various properties of foam is investigated in this study. The focus of this investigation is to understand the phenomena of foaming and the effect of MG on the thermal behavior. The detailed study of thermal degradation kinetics has been carried out by using different methods like Flynn-Wall-Ozawa (FWO), Kissinger-Akahira-Sinouse (KAS) etc.

Keywords: *Modified gum Arabic (MG); Poly(lactic acid) (PLA); Biodegradable foam*

PPC-06A: Morphology and crystallinity study of novel polypropylene hybrid composites

Rupam Gogoi[1], Gaurav Manik*[1], ByravanArun[2]

[1] Department of Polymer and Process Engineering, Indian Institute of Technology Roorkee, Saharanpur, UP-247001, India.

[2] Technical Department, Innovation Center, 3M India Limited, Electronic City, Bangalore, Karnataka - 560100, India.

* Corresponding author, e-mail:manikfpt@iitr.ac.in

Abstract: In the present work, morphological and crystallinity studies were carried to understand the effect of hollow glass microsphere (HGM) in short bamboo fibre reinforced polypropylene (SBFPP) hybrid composites. The base matrix was prepared by incorporating maleic anhydride-grafted polypropylene (MA-g-PP) to virgin polypropylene (PP) in the ratio of 1:9. Fibre content in the prepared composite samples was fixed at 10% and the HGM content was varied as; 5, 10, 15 and 20% by weight of the base matrix.

Keywords: *Hybrid composite; Hollow glass microsphere; Bamboo fibre*

Poster Presentation

SPT-29 Effect of Functionalized Chitosan on PLA/PBS Based Bio-nanocomposite for Morphological, Thermal and Mechanical Properties Analysis

Monika[1], Dr. Vimal Katiyar*

[1]Department of Chemical Engineering, Indian Institute of Technology Guwahati, Guwahati, Assam-781039, India.

*Corresponding author, vkatiyar@iitg.ernet.in

Abstract: Bionanocomposites with balance of mechanical characteristics are fabricated from poly lactic acid (PLA)/ poly butylenes succinate (PBS) blend at various loading of functionalized chitosan (*F*CH) through reactive extrusion. The incorporation of *F*CH into PLA/PBS blend shows its plasticizing effect on mechanical properties. FESEM result of PLA/PBS/D*F*CH composite indicates that the addition of 1 wt% *F*CH along with dicumyl peroxide (DCP) improved the interfacial adhesion among the various components, which could significantly alter the mechanical and crystallization characteristics of biocomposite.

Keywords: Bionanocomposite, Reactive extrusion, Functionalized chitosan, Polylactic acid, Polybutylene succinate, Dicumyl peroxide

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SPT-30 Biodegradable Packaging Film From Renewable Resources

Bishwabhusana Palai *, Manoranjan Biswal,Smita Mohanty, Sanjay kumar Nayak

Laboratory for Advanced Research in Polymeric Material (LARPM), Central Institute of Plastics Engineering and Technology, Bhubaneswar, Orissa-751024, India.

*Corresponding author, E-mail:bishwabhusana123@gmail.com

Abstract: Recently bio based, bio degradable polymers has received an enormous attention as the disposal of petroleum based plastics wastes seems to be quite challenging. A recent study reveals that one fifth of total plastics products immediately disposed to the environment after single use which again added to municipal solid waste causes blocking of drainage, affecting the terrestrial environments, in the open ocean, on shorelines of even the most remote islands and in the deep sea. The most common plastics waste of this type is plastic packaging films and the films generally below 50 micron is not possible to recycle. So we strive to develop bio degradable film for packaging application using poly lactic acid (PLA). PLA has inherent problem of brittleness posed a challenge to make a blown film out of it. So suitable plasticisers, chain extenders, impact modifiers are chosen to compensate its brittleness and to improve melt strength during blown process. Various compositions of PLA with poly ethylene glycol (PEG), poly ethylene oxide (PEO), ethylene co ethyle acrylate and epoxy functionalize styrene acrylate were melt compounded with a twin screw extruder and blown with a blown film extrusion. The properties like tensile strength, gas and water vapour barrier property, optical property, DSC, TGA were examined. The tensile strength of film was found to be 35 Mpa (on average), OTR was 165 cc/ m^2 day, WVTR was 97 g/mm^2 day. Haze was found to be less than 4%and gloss 34%.. The thermal study indicates that the glass transition temperature to be 63^0c and film is stable up to 300^0c in nitrogen atmosphere.

Poster Presentation

SPT-31 In situ development of bio-based polyurethane/epoxy hybrid materials via non-isocyanate route and its coating properties

Simanta Doley, Swapan Kumar Dolui*

[1]Department of Chemical Sciences, Tezpur University, Napaam, Tezpur, Assam, India, 784028
*Correspondence author, E-mail: dolui@tezu.ernet.in

Abstract: Bio-based csarbonated sunflower oil (CSFO) containing five-membered cyclic carbonate groups has been obtained by the reaction of epoxidized sunflower oil (ESFO) with carbon dioxide at pressure 40 bar and temperature 120°C and characterized by FTIR, ^{1}H NMR, and ^{13}C NMR. Then, a series of non-isocyanate polyurethane /epoxy hybrid materials (HNIPUs) are synthesized via an in situ solvent and catalyst free methods which avoided the use of toxic isocyanate by using commercial epoxy resin (BADGE) and different curing agents like ethylene diamine (EDA), hexamethylene diamine (HMDA) and isophrone diamine (IPDA). Finally, the effect of the amine structure as well as epoxy resins was reflected on the mechanical, chemical and thermal properties of HNIPU's. These results emphasize the potentiality of this environmental friendly approach to prepare HNIPU materials for surface coatings.

Keywords: *Carbonated sunflower oil, diamine, non-isocyanate polyurethane/epoxy hybrid material, physico-chemical properties*

SPT-32 Sustainable Polymers: Emerging Material for Future

Pranabesh Sahu*and Anil K. Bhowmick

Rubber Technology Centre, Indian Institute of Technology Kharagpur, West Bengal-721302, India.
*Corresponding author, E-mail: pranabesh.cema@gmail.com

Abstract: The article presents the synthesis and characterization of a biobased sustainable polymer from alloocimene, a monoterpene from renewable resources, by redox emulsion polymerization under ambient conditions. Poly-alloocimene has a molecular weight of 14200 Da and subzero glass transition temperature of -17 °C. The microstructure and properties were determined by FT-IR and NMR (1-D, 2-D) spectroscopies, differential thermal analysis, dynamic mechanical analysis, and thermogravimetry.

Keywords: *Biobased Polymer, Terpene, Alloocimene, Emulsion polymerization, Density functional theory*

Poster Presentation

SPT-34 Utilization of an already used adsorbent based on Poly(AAc-AM-SH) superabsorbent hydrogels

Reena Singhal*, Tripti Singh

Department of Plastic Technology, Harcourt Butler Technological Institute, Kanpur, 208002, Uttar Pradesh, India

*Correspondence author, E-mail: reena_singhal123@rediffmail.com,reenasinghal123@gmail.com

Abstract: Over the recent years, the rapid development of modern industries has increased the threat of water pollution to the environment. The chief water pollutant consist non biodegradable matter, dyes, metal ions, hydrocarbons, anions etc. that has been rapidly increased in water. Wastewaters from industries like dying, textile, printing, cosmetics, food coloring, papermaking, etc. are the chief contributors of colored effluents. From environmental point of view, discharge of dyes into the water resources even in a small quantity may affect the aquatic life and food web. Usually, there are two general processes to treat these waste adsorbents(1).

Firstly, these waste adsorbents may be recycled for further adsorption process via regenerating them in elution medium for again next cycle, secondly, they can be disposed or cremated. When the adsorption process proceeded and reached to equilibrium condition, the original polymeric network backbone structure of adsorbent SAHs changed, and these network can function as a new kind of adsorbent. The alteration in original polymeric structure after adsorption can provide a new potential and effective way to utilize these already used SAHs adsorbents, which were after the adsorption process either discarded or may be regenerated in the acidic/alkaline medium. This work dealt with a new potential and economic method to waste adsorbent by reusing an already used adsorbent. Poly(AAc-AM-SH) superabsorbent hydrogels have proved to be a good adsorbent for MB dye and after adsorption the SAHs were recovered in acid medium(2). In this report the MB dye adsorbed SAHs have not undergone any regeneration process and applied directly to adsorb MO dye adsorption respectively. The SAHs poly(AAc-AM-SH) was anionic in nature thus show higher affinity towards MB dye molecules but it hardly adsorb anions/anionic dye molecules due to its characteristics of negative charge existing on the polymeric surface. The adsorption of MB dye molecules makes it positively charged moiety and so it is being capable of anions/anionic dye adsorption. Therefore these MB dye loaded SAHs without any prior treatment functions as a new kind of adsorbent.

In this work, the waste MB dye loaded poly(AAc/AM/SH) SAHs were not recovered but directly applied to adsorb an anionic MO dye from another waste solution. The poly(AAc/AM/SH) SAHs after the MB dye adsorption were stable and suitable for MO dye adsorption for altered surface structures within a wide pH range. The various factors affecting the MO dye adsorption, including pH, contact time, ionic strength, initial concentration of the MO dye, and temperature were systematically investigated. The equilibrium adsorption data fitted very well to the Langmuir adsorption isotherm and the maximum MO dye adsorption capacity reached to a high of 134 mg/g at 30°C. The desorption studies showed that the regeneration of the poly(AAc/AM/SH)-MB SAHs adsorbent can be easily achieved.

Poster Presentation

SPT-35 Studies on the Properties of Polylactic acid/ Polyester Resin based Wood Composites

Prasanta Baishya, Vimal Katiyar*

[1]Department of Chemical Engineering, Indian Institute of Technology Guwahati, Guwahati, Assam-781039, India.

*Corresponding author, E-mail: vkatiyar@iitg.ac

Abstract: An attempt has been made to develop the natural fiber and natural polymer based wood composites using the solution technique method. For this process, natural fiber like bamboo pulp and polylactic acid (PLA) have been employed with the polyester resin to prepare the green composites. Later, different percentage of degradable polymer like polybutylene succinate (PBS) has been added with the PLA (30/70 and 50/50) and the effects of the PBS on the properties of natural fiber based composites were studied. Chloroform has been used as the solvent in the entire process where methyl ethyl ketone peroxide (MEKP) were employed as the catalyst to crosslink the composites. The properties of the bio based composites were investigated.

Keywords: Bamboo pulp, Polylactic acid, Polyester,bamboo composites

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SPT-36 Reactive distillation for D-Lactic Acid Purification: A Process intensifying tool for Biorefineries

Kiran Kumar Gali[1,2], Senthilkumar Sivaprakasam[1,2*]and Vimal Katiyar[2*]

[1]BioPAT laboratory, Department of Biosciences and Bioengineering, Indian Institute of Technology Guwahati.

[2]Centre of excellence for Sustainable Polymers, Department of Chemical Engineering, Indian Institute of Technology Guwahati, Guwahati,Assam-781039 India

*Corresponding author, E-mail:vkatiyar@iitg.ernet.in,senthilkumar@ iitg.ernet.in

Abstract: The stereospecific nature and economic viability of Lactic acid monomer is crucial for the sustainability of Poly (lactic acid). Fermentative production and its subsequent purification is the preferred method in industries for D- Lactic acid when compared with the chemical synthesis, which yields racemic mixtures. Lactic acid is the thermally unstable molecule and has a strong affinity to water and low volatility, which makes its separation by solvent extraction or distillation difficult. The lactic acid separated at high temperatures can undergo thermal decomposition and forms dimers and oligomer. Esterification of Lactic acid and Hydrolysis of the ester is the alternative approach where reactive distillation plays a crucial role in separating other organic acids also from fermentative broth. This advantage makes to intensify the processes in Biorefineries. In this study, different concentrations of the synthetic broths viz, 10%, 20%, 30%, 40%, 50%, 60% are prepared. The concentrations of Amberlyst catalyst are varied from 1-3% and then esterification and hydrolysis experiments are performed to understand the conversion rates and catalyst loading effects. The free acidity analysis and Fourier transform infrared spectroscopy (FTIR) studies are performed to understand the functional groups. The preliminary results are promising and to be validated further.

Keywords: *Reactive distillation; Esterification; D-Lactic acid;Hydrolyis*

Poster Presentation

SPT-37 Fabrication of UV Protective Sustainable Polymer Composites

P.L. Algammai, L. Sravanthi, V. Ravi Babu, *

Central Electrochemcial Research Institute (CSIR-CECRI), Karaikudi,
Tamil Nadu - 630003, India.
*Corresponding author, E-mail:xyx@iitg.ernet.in

Abstract: Plastics play an imperative role in the modern society due to its potential usage in several applications. In particular, packaging remains as the prime application in which huge volume of plastics are being consumed world-wide. It is important to accept that our ecosystem is being continuously disturbed due to the disposal issues associated with these non-degradable polymers. Therefore, eco-friendly plastic materials are adequately required for mankind at this stage. The sustainable plastics possess the advantage of superior biodegradation property in comparison with conventional polymers and hence, they could be readily compostable to natural degradation products. Owing to these reasons, research and development units in academia as well as industries are more attracted towards the development of environmentally benign plastics. Poly lactic acid (PLA) is one among the biopolymer which exhibits biodegradation property because it can be easily consumed by microbes. Although PLA possesses the prospective to compete with the conventional plastics, it is important to spell out the drawbacks such as (i) PLA exhibits poor mechanical properties like elongation-at-break, (ii) PLA suffers from poor gas barrier properties and (iii) high UV light transmittance in comparison with conventional polymers. Many efforts have been undertaken so far to overcome the drawbacks of PLA via incorporation of bio fillers in the PLA matrix. The presence of reinforcement in the PLA matrix is noticed to improve the thermal, mechanical and barrier properties of PLA. Therefore, the current work is focused on fabrication of eco-friendly poly(lactic acid)/Bio filler based composite films with improved UV shielding along with ductility and oxygen barrier properties. The PLA-Bio filler composite films containing different loading of bio filler with an average thickness of 50 m are fabricated. The PLA-bio filler films demonstrated noteworthy light barrier feature by shielding the passage of 0% and 85% in UV and visible light regime, respectively.

SPT-37A Development of blown films of Poly lactic acid and its biocomposites: Its influence on color and migration properties

Tabli Ghosh*[1], Akhilesh Kumar Pal[2], Siddharth Mohan Bhasney[3],Vimal Katiyar[4]

[1234]Department of Chemical Engineering,Indian Institute of Technology Guwahati, Guwahati,
Assam-781039, India
* Corresponding author, e-mail:tabli@iitg.ernet.in

Abstract: The study accounts the formulation of blown films using biocomposites of Poly lactic acid (PLA), including biofillers chitosan (CS), gum Arabic (GA), functionalized CS (MCS), functionalized GA (MGA), and usage of cross linking agent dicumyl peroxide (DCP) with functionalized fillers MCS (DMCS), and MGA (DMGA). In consideration with the optical parameters hue, chroma and %reflectance were greatly affected due to the incorporation of filler material in PLA films, which is a very considerable factor for customer acceptance. Further, the developed biopolymers provide an acceptable limit for migration of filler materials. So, the biocomposites materials could provide a safe and acceptable packaging materials for food packaging apllications.

Keywords: blown films, biocomposites, PLA, color parameters, migration

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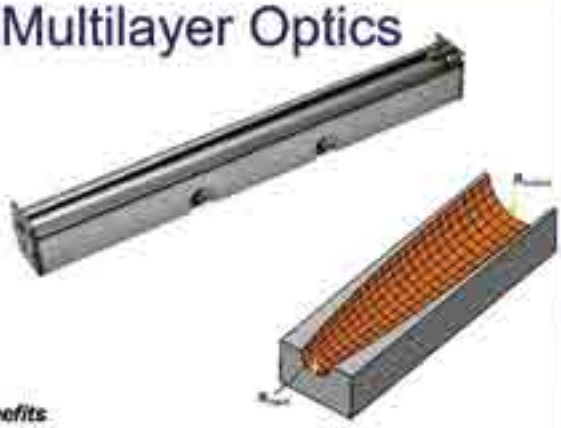

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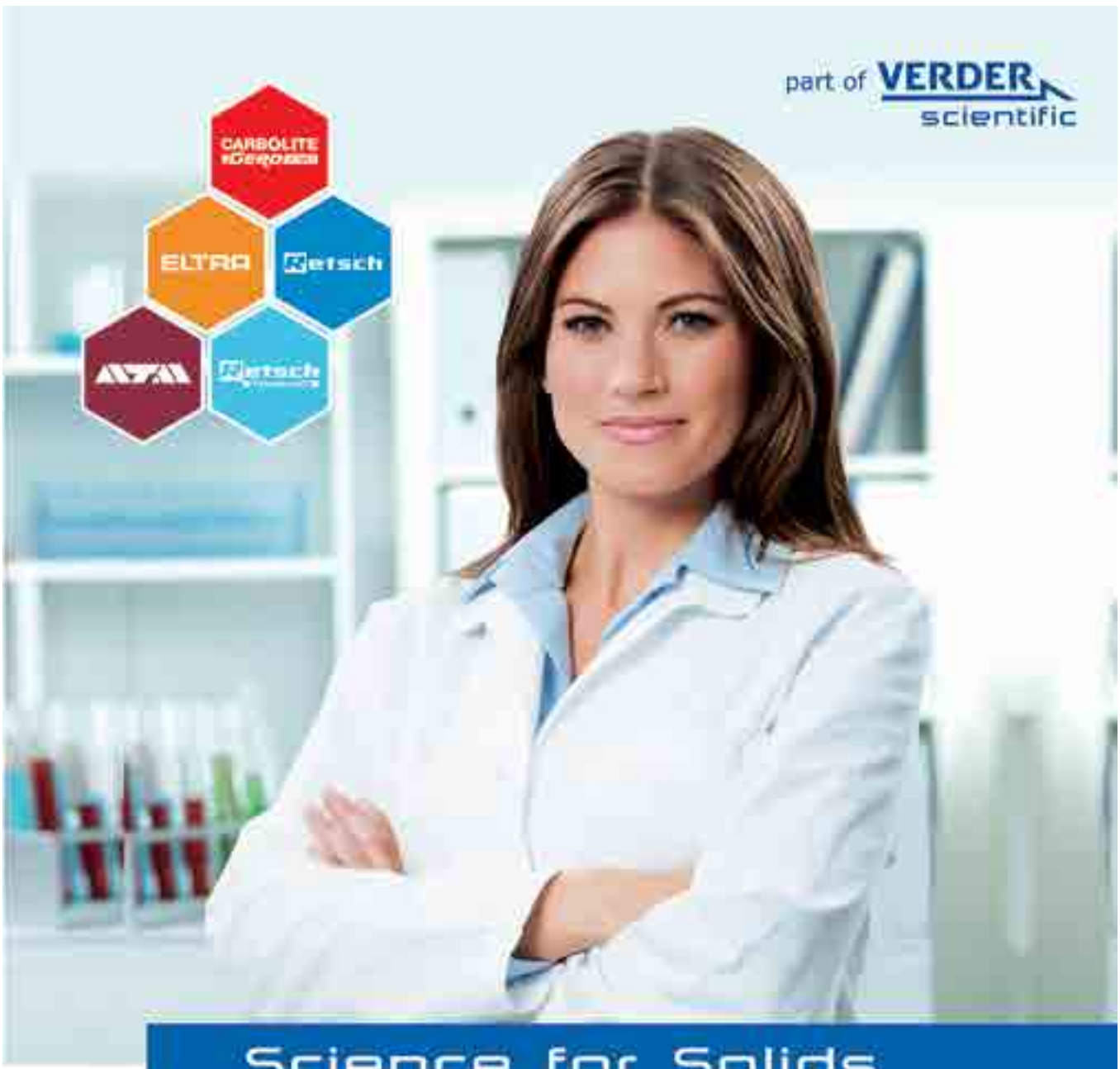

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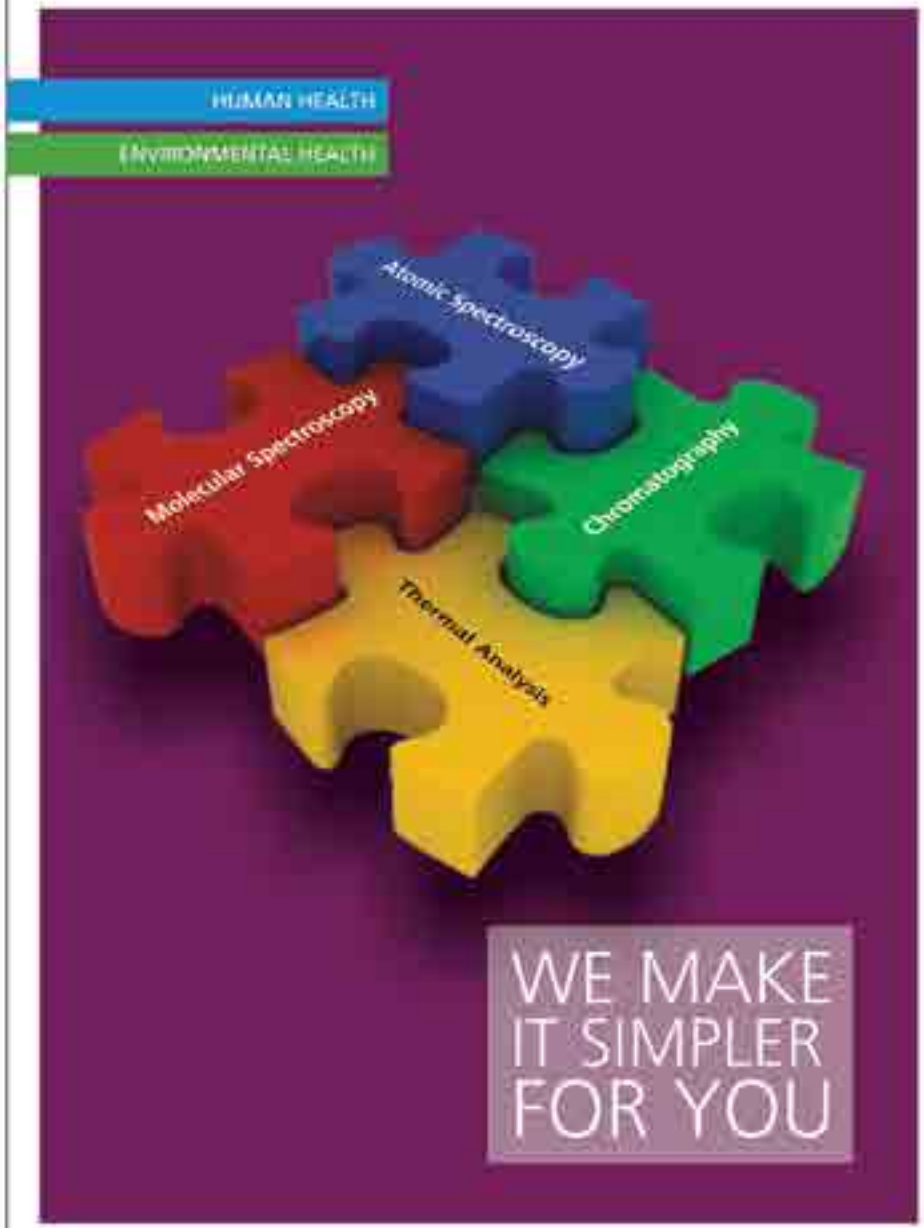

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- Modification of the sample environment
- Evolved Gas Analysis (EGA)
- Simultaneous Analysis

- TG-FTIR
- STA-FTIR
- DSC-RAMAN SPECTROMETER
- PHOTO DSC (DSC-UV)
- TGA-MS
- TG-GCMS
- Photo DMA & controlled humidity DMA

PerkinElmer (India) Pvt. Ltd.
G-Corp Tech Park, 8th Floor,
Near Hypercity Mall, Ghodbunder Road,
Kasarvadavali, Thane (West) – 400 607. India.
Tel: +91-22-3326 1700
Fax: +91-22-3326 1790, +91-22-3326 1791
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www.perkinelmer.in

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KTL GROUP

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Dear Client

We take great pleasure to introduce ourselves as a KTL GROUP having two Principle Companies under our banner **M/s. KVC Process System** & **M/s. Trident Labortek** who are mainly in design, fabrication & supply of import substitute **Pilot Plants and Laboratory & Scientific Equipments.**

KVC PROCESS SYSTEMS

- Semi & Fully Automatic Skid Mounted Pilot Plants & Kilo Lab Equipment
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- Packed Bed Reactors
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- Own R&D facility for API, Process Development
- Process know how, development & optimization studies
- Fully functional Pilot Plant with all equipment for scale up studies
- Product development, process know how and alternate route development

ROAD Safety

When riding in cars:

Fasten your seat belt.

Sit quietly and don't bother the driver. Always sit in the back seat.

Always get out on the curb side of the car.

When walking to and from school:

Unless other plans are made with your family, go right home from school.

Cross only at intersections. Walk, never run.

Obey the school safety patrols, police and crossing guards.

Look in all directions before crossing the street.

Obey traffic signals.

Walk facing the traffic if there are no sidewalks.

Watch for turning vehicles.

Avoid crossing between parked cars.

Beware of strangers and avoid them.

When cycling to school:

Wear a helmet.

Stop and look all ways before entering a roadway from a driveway.

Use a backpack to carry books. Keep your hands on the handlebars.

Go with the traffic and obey the rules of the road.

Walk your bike across busy intersections.

NRL NUMALIGARH REFINERY LIMITED

Issued in Public Interest

Madhuchanda Adhikari Choudhury
Chief Manager (Corporate Communications)
122A, G.S.Road
Christianbasti
Guwahati-781005
Phone: 0361-2303243(O)
Mobile: 94350-54521

NUMALIGARH REFINERY LIMITED

NRL

सत्यमेव जयते

NORTH EASTERN COUNCIL
Ministry of DoNER

NORTH EASTERN COUNCIL

The North Eastern Council was constituted in 1971 by an Act of Parliament. The North Eastern Council is the nodal agency for the economic and social development of the North Eastern Region which consists of the eight States of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura. The headquarters of the council is situated in Shillong and functions under the Ministry of Development of North Eastern Region, GOI.

Over the last thirty five years, NEC has been instrumental in setting in motion a new economic endeavour aimed at removing the basic handicaps that stood in the way of normal development of the region and has ushered in an era of new hope in this backward area full of great potentialities. The Council has, to its credit, demonstrated considerable achievements, mostly in the provision of electricity and education to Indian citizens in the North-Eastern States. The Council has also taken up major highway and bridge building projects and funds many engineering and medical colleges.

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For collaboration: Dr Vimal katiyar, Coordinator- CoE-SUSPOL, Department of Chemical Engineering, IIT Guwahati
Email: vkatiyar@iitg.ernet.in, Ph: 03612582278