ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 3, Issue 2, March 2014

Review on natural fiber reinforcement polymer composites

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Abstract: ***The natural fiber-reinforced polymer composite is rapidly growing both in terms of their industrial applications and fundamental research. They are renewable, cheap, completely or partially recyclable and biodegradable. These composites are having low density and cost as well as satisfactory mechanical properties make them an attractive due to easy availability and renewability of raw materials. Natural fibers have been proven alternative to synthetic fiber in transportation such as automobiles, railway coaches and aerospace. Other applications include military, building, packaging, consumer products and construction industries for ceiling paneling, partition boards. This paper deals with review of different natural fibers reinforced polymer composite with its manufacturing processes and characterization especially coir and jute fiber.***

Index Terms**- Natural fiber, processing, testing of composites.**

I. INTRODUCTION

Natural fiber composites include coir, jute, baggase, cotton, bamboo, hemp. Natural fibers come from plants. These fibers contain lingo cellulose in nature. Natural fibers are eco-friendly; lightweight, strong, renewable, cheap and biodegradable. The natural fibers can be used to reinforce both thermosetting and thermoplastic matrices. Thermosetting resins such as epoxy, polyester, polyurethane, phenolic are commonly used composites requiring higher performance applications. They provide sufficient mechanical properties in particular stiffness and strength at acceptably low price levels. Recent advances in natural fiber development are genetic engineering. The composites science offer significant opportunities for improved materials from renewable resources with enhanced support for global sustainability. Natural fiber composites are attractive to industry because of their low density and ecological advantages over conventional composites. These composites are gaining importance due to their non-carcinogenic and bio-degradable nature. Natural fiber composites are very cost effective material especially in building and construction, packaging, automobile and railway coach interiors and storage devices [7].These composites are potential candidates for replacement of high cost glass fiber for low load bearing applications [18]. Natural fibers have the advantages of low density, low cost and biodegradability. However, the main disadvantages of natural fiber composite are the relative high moisture absorption. Therefore, chemical treatments are done so as to modify the fiber surface properties.

II. CLASSIFICATION OF NATURAL FIBERS

Fibers are a class of hair-like material that are continuous filaments or are in discrete elongated pieces, similar to pieces of thread. They can be spun into filaments, thread, or rope. They can be used as a component of composites materials. They can also be matted into sheets to make products such as paper or felt. Figure 1 shows the classification of natural fibers.

Natural fibers include those made from plant, animal and mineral sources [19].Natural fibers can be classified according to their origin as:

1) Animal Fibers *contains wool, silk, avian fiber. It includes sheep's wool, goat hair, horse hair, feathers and feathers fiber.*

2) Mineral fiber: *Mineral fibers are naturally occurring fiber or slightly modified fiber procured from minerals. These can be further categorized as asbestos, Ceramic, Metal fiber.*

3) Plant fiber*: Plant fibers are generally comprised mainly of cellulose. This fiber can be further categorizes into following.*

a) Seed fiber: Fibers collected from the seed and seed case e.g. cotton and kapok.

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b) Leaf fiber: Fibers collected from the leaves e.g. sisal and agave.
c) Skin fiber: Fibers are collected from the skin or bast surrounding the stem of their respective plant. These fibers have higher tensile strength than other fibers. Therefore, these fibers are used for durable yarn, fabric, packaging, and paper. Some examples are flax, jute, banana, hemp, and soybean.
d) Fruit fiber: Fibers are collected from the fruit of the plant, e.g. coconut (coir) fiber.
e) Stalk fiber: Fibers are actually the stalks of the plants such as straws of wheat, rice, barley, and other crops including bamboo and grass. Tree wood is also such a fiber.

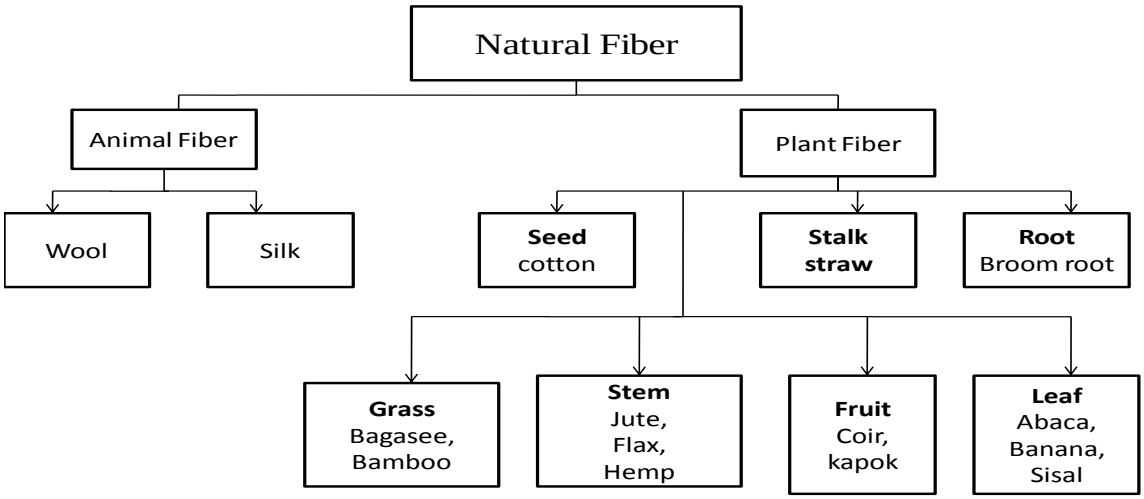

Fig 1: Classification of natural fibers

III. PROPERTIES OF NATURAL FIBER COMPOSITES

Physical and mechanical properties of composites depend on the single fiber chemical composition (Cellulose, hemicelluloses, lignin, pectin, waxes, water content and other minors) according to grooving (soil features, climate, aging conditions) and extraction/ processing methods conditions.
Grooving conditions is recognized as the most influent parameter for the variability of mechanical properties of the fibers. The chemical composition of several natural fibers is summarized in Table 1,

Fiber	Cellulose %	Lignin %	Diameter (μm)	Hemicellulose %	Elongation %
Coir	37	42	100-450	0.15	47
Banana	64	5	50-250	6-19	3.7
Sisal	70	12	50-200	10-14	5.1
Pineapple	85	12	20-80	16-19	2.8
Jute	71	13	15.9-20.7	13-20	3.0

Table 1: Chemical composition of natural fibers [3]

Many factors influence mechanical properties of natural fibers. In many cases, the experimental conditions are different. The mechanical properties of the natural fiber material depend largely on lengths and diameters of individual fibers. The density and tensile properties are tabulated in table 2.

Material	Densiy (g/cm^2)	Tensile strength (MPa)	Young modulus (GPa)	Failure strain (%)
Flax	1.45	500-900	50-70	1.5-4.0
Hemp	1.48	350-800	30-60	1.6-4.0
Jute	1.3	300-700	20-50	1.2-3.0
Bamboo	1.4	500-740	30-50	2

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ISO 9001:2008 Certified
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Sisal	1.5	300-500	10-30	2-5
Coir	1.2	150-180	4-6	20-40

Table 2: Properties of natural fiber materials [18]

IV. NATURAL FIBER REINFORCEMENT COMPOSITE

The recent area of research is concentrated on plant fiber composites, which are blended with resins. The natural fiber composites are seen as potential materials for many engineering applications. The coir, jute and bagasse are discussed in details as follows:

A. Coir fiber reinforced composite

Coir comes from the husk of coconut fruit fiber. Coir has more life compared to other natural fibers due to its high lignin content [3, 15]. Coir fiber reinforced with both thermoset and thermoplastic resins. The mechanical property of the composite depends on interfacial adhesion of fiber to the matrix material. Coir fiber showed very high interfacial adhesion under dry conditions. The interfacial adhesion characteristics of coir fiber with polyester matrix were tested different aging solutions [1]. Coir fiber reinforced polymer composites developed for industrial and socio-economic applications such as automotive interior, paneling and roofing as building materials, storage tank, packing material, helmets and postboxes, mirror casing, paper weights, projector cover, voltage stabilizer cover [2],[1],[3],[18].

Fig 1: Coconut husk and coir fiber

Coir fibers are more efficient and superior in reinforcement performance when compared to other reinforcement composites [17]. However, the main limitations of coir fibers are high moisture content. It can be controlled with chemical treatment. The interface between the reinforcing agent and the matrix are the key issue in terms of overall performance. The performance of coir fiber reinforced epoxy composites are depends on alkali treatment and fiber length. Coir fibers were treated with sodium hydroxide (NaOH) 2,4,6,8 and 10 % for 10 days. Fiber length was 10,20 and 30 mm. Alkali treated composite along with increased fiber had better impact strength (27 KJ/m^2). Coir fiber length 30 mm and 8% alkali concentrations had better results [12]. Pretreated coir based composite performed better in mechanical properties than untreated coir based composite [12], [13].

Coir fiber reinforced polypropylene composite was tested. Flexural properties of coir fiber pp composite were satisfied in between 40 to 60 wt%. Further increment of coir fiber content the flexural strength decreases. The main reasons for lower flexural strength were insufficient matrix to cover all the surface of the coir fiber. Optimal composite panel formulation for automotive interior applications was mixture of 60 wt% coir fiber, 37 wt% PP powder and 3 wt% MAPP [2].

B. Jute fiber reinforced polymer composite

Jute has wood like characteristics as it is a bast fiber. Jute fiber has a high aspect ratio, high strength to weight ratio, good insulation properties. Jute fiber reinforced polymer composite has tested for door, window, furniture, corrugated sheet, I-shaped beam, trenchless rehabilitation of underground drain pipes and water pipes, false roofing, floor tiles [18],[22].

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Fig 2: Jute plant and jute fiber

The jute fiber reinforced polypropylene composites mechanical properties were analyzed. These are influence of fiber treatment by washing, mercerization and bleaching. Tensile strength and tensile modulus were increased with increasing % weight fraction and NaOH percentage of fibers in the pp matrix. The highest tensile strength and tensile modulus were 31.48 Mpa and 277.77 Mpa respectively [20]. Jute fiber reinforced epoxy composites were analyzed with effect of fiber orientation. The fiber orientations were 0/90°, 15°/-75°, 30°/-60° and 45°/-45°. The higher strength and stiffness were found at 0/90° fiber orientation. Compressive test of jute composite were tested and it found higher strength as compared to bamboo fiber reinforced epoxy composites [21]. The alkali treated jute fiber reinforced epoxy composites showed improved mechanical properties. The improvement was maximum for the composite prepared with 4 hrs alkali treated jute fibers [22]. Jute fibers were reinforced with polypropylene and polyethylene. Jute fiber of 1 mm and 3 mm fiber length were used to fabricate using compression molding process. Degradation rate was designated in terms of weight loss for both composites [23].

Hybrids composites are more than one reinforcing phase and a single matrix phase or single reinforcing phase with multiple matrix phases or multiple reinforcing and multiple matrix phases. They have better flexibility as compared to single fiber containing composites [4]. Hybrid composites are includes multiple reinforcing such as natural as well as synthetic fiber. The natural fibers involved coir, jute, sisal, banana, bamboo, abaca. The effects of hybridization of coir-jute, sisal-jute and coir-sisal fiber with polyester resins were analyzed. The result shows hybridization play important role for improving mechanical properties of composites [5], [8]. Hybrid composites may replace or reduce utilization of synthetic fibers in application of automotive, building industries, aircraft [6]. Jute-coir hybrid composites find into railway coaches for sleeper berth backing, for building interiors, doors and windows besides in transportation sector as backings for seat and backrest in buses [9].

V. CONCLUSION

The present review focuses on the progress of natural fiber reinforced composites. Industries are in constant search of new materials to lower costs and profit margins. Due to the challenges of petroleum based products and the need to find renewable resources. Natural fibers have cost and energy advantages over traditional reinforcing fibers such glass and carbon. Now a day's research is going on development of bio-composites to replace traditional materials. The combination of different natural fibers found to give better mechanical and physical properties.

Several limitations must be overcome in order to exploit the full potential of natural fibers. At first proper fiber surface treatment should be developed and implemented. Secondly properties of composites are greatly depended on the volume percentages of fibers and resin. The quality at fiber matrix interface should be improved. The current challenge is to make them cost effective. The efforts to produce economically attractive composite components have resulted in several innovative manufacturing techniques currently being used in the composites industry.

REFERENCES

[1] Yousif B.F., Ku H.[2012], "Suitability of using coir fiber/polymeric composite for the design of liquid storage tanks", Material & design, vol.36, 847-853.

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 3, Issue 2, March 2014

[2] Ayrilmis Nadir, Jarusombuti Songklod, Fueangvivat Vallayuth, Bauchongkol Piyawade and, White Robert H. [2011], "Coir Fiber Reinforced Polypropylene Composite Panel for Automotive Interior Applications.", Fibers and polymer, vol.12, 919-926.

[3] Verma D.,Gope P.C.,Shandilya A.,Gupta A.,Maheshwari M.K.[2013],"Coir Fiber Reinforcement and Application in Polymer Composites: A Review", Journal of Material Environment science,vol.4, 263-276.

[4] Siddika Salma, Mansura Fayecka, and Hasan Mahbub [2013], "Physico-Mechanical Properties of Jute-Coir Fiber Reinforced Hybrid Polypropylene Composites", World Academy of Science, Engineering and Technology vol. 73, 1145-1149.

[5] Dixit S. and Verma P. [2012], "The Effect of Hybridization on Mechanical Behaviour of Coir/Sisal/Jute Fibers Reinforced Polyester Composite Material", Research Journal of Chemical Sciences, Vol. 2, 91-93.

[6] Jawaid M., Khalil H.P.S. Abdul [2011], "Cellulosic/synthetic fiber reinforced polymer hybrid composites: A review", Carbohydrate Polymers vol. 86, 1-18.

[7] Drzal Lawrence T., Mohanty A. K., Misra M. [2001], "Bio-composite materials as alternatives to petroleum-based composites for automotive applications."

[8] Chadramohan D., Marimuthu k. [2011], "Tensile and Hardness Tests on Natural Fiber Reinforced Polymer Composite Material", International Journal of advanced engineering science and technologies, vol 6, 97-104. [9] Gon Debiprasad, Das Kousik, Paul Palash, SubhankarMaity [2012], "Jute Composites as Wood Substitute", International Journal of Textile Science, vol.1, 84-93.

[9] Aková Ing. Eva [2013], "Development of natural fiber reinforced polymer composites", Transfer inovácií, vol.25.

[10] Prasad VemuVara and kumarMuttam Lava [2011], "Chemical resistance and tensile properties of bamboo and glass fibers reinforced epoxy hybrid composites", International Journal of materials and biomaterials application, vol. 1(1), 17-20.

[11] Karthikeyan A. and Balamurugan K. [2012], "Effect of alkali treatment and fiber length on impact behavior of coir fiber reinforced epoxy composites", Journal of Scientific & Industrial Research, Vol.71, 627-631.

[12] Asasutjarit chanakan, Charoenvaisarocha, Hirunlabh Jongjit, Khedari Joseph [2009], "Materials and mechanical properties of pretreated coir-based green composites." Composites: part B, Vol. 40,633-637.

[13] Athijayamani, A., Thiruchitrambalam, M., Natarajan, U. and Pazhanivel, B. [2009], "Effect of Moisture Absorption on the Mechanical Properties of Randomly Oriented Natural Fibers/Polyester Hybrid Composite". Materials Science and Engineering: A.Vol517: 344-353.

[14] Bujang, I.Z., Awang, M.K. and Ismail, A.E. [2007], "Study on the Dynamic Characteristic of Coconut Fiber Reinforced Composites".

[15] Khan MdNuruzzaman, Roy k.Juganta, Akter Nousin, Zaman Haydar D.,IslamTuhidul [2012], "Production and properties of short jute and short E-glass fiber reinforced polypropylene based composites", Open journal of composite materials,Vol.2,40-47.

[16] Reem Sabah M., Mohamed Ansari, Mohannad Saleh H. [2012], "A study on mechanical, Thermal and Morphological properties of natural fiber/epoxy composite", Journal of purity, utility reaction and environment,Vol.1(5), 267-296.

[17] Ticoalu A., Aravinthan T. and Cardona F. [2010], "A review of current development in natural fiber composites for structural and infrastructure applications", Southern region engineering conference, 1-5.

[18] Abilash N. and Sivapragash M. [2013], "Environmental benefits of eco-friendly natural fiber reinforced polymeric composite materials", International Journal of application or innovation in Engineering and management (IJAIEM), ISSN 2319-4847, Vol.2 (1), 53-59.

[19] Rajesh Gunti and Ratna Prasad Atluri v. [2013], "Study on effect of chemical treatments and concentration of jute on tensile properties of long and continuous twisted jute/polypropylene composite", Advanced materials manufacturing and characterization.Vol.3 (1), 395-398.

[20] Dash D., Samanta S., Gautum S.S. and murlidhar M. [2013], "Mechanical characterization of natural fiber reinforced composite material", Advanced material manufacturing and characterization, Vol. 3(1), 275-280.

[21] Patel [2012], "Environmental effect of water absorption and flexural strength of red mud filled jute fiber/polymer composite", International journal of Engineering, Science and Technology, Vol.4 (4), 49-59.

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 3, Issue 2, March 2014

[22] Siddiquee [2014], "Investigation of an optimum method of Biodegradation process for jute polymer composites", American Journal of Engineering Research, Vol.3 (1), 200-206.