



Mechanical performances of surface modified jute fiber reinforced biopol nanophased green composites

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ABSTRACT

Surface modification of jute fibers was accomplished by performing chemical treatments, including detergent washing, dewaxing, alkali, and acetic acid treatment. Morphology of modified surfaces examined using scanning electron microscopy (SEM) and Fourier transform infrared spectroscopy (FTIR) revealed improved surfaces for better adhesion with matrix. Enhanced tensile properties of treated fibers were obtained from fiber bundle tensile tests. Using solution intercalation technique and magnetic stirring, 2%, 3%, and 4% by weight Montmorillonite K10 nanoclay were dispersed into the biodegradable polymer, biopol. Jute fiber reinforced biopol biocomposites with and without nanoclay manufactured using treated and untreated fibers by compression molding process showed almost the same volume fraction for all the samples. However, the lower void content was observed in the surface modified and nanoclay infused jute biopol composites. Mechanical responses of treated fiber reinforced biopol composites (TJBC) without nanoclay evaluated using dynamic mechanical analysis (DMA) and flexure tests showed 9% and 12% increase in storage modulus and flexure strength, respectively, compared to untreated jute fiber reinforced composites (UTJBC). The respective values were 100% and 35% for 4% nanoclay infused TJBC, compared to UTJBC without nanoclay. Lower moisture absorption and better mechanical properties were found in the nanophased composites even after moisture conditioning.

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1. Introduction

Manufacturing of synthetic fiber composites not only consume huge energy but also their disposal at the end of the life cycle is very difficult since there is virtually no recycling option. Hence, the biocomposite industry is developing at a significant pace to meet growing consumer awareness and follow new environmental regulations [1]. Lignocellulosic bio-fibers derived from leaf, bast, fruit, grass or cane contribute to the strength of bio as well as synthetic polymer composites in various applications [2].

Elements of jute fibers are cellulose, hemicelluloses, lignin, and pectin. Cellulose is the main element of jute fiber, which is resistant to alkali but hydrolyzed in acid. Hemicellulose works as supporting matrix agents of cellulose. Hemicellulose is hydrophilic, soluble in alkali, and easily hydrolyzed in acids. Lignins are amorphous and hydrophobic in nature. They contain aromatic and aliphatic constituents. Pectins are like waxes that provide plant flexibility [3]. Jute, like other lignocellulosic fibers, consists of –OH group, which therefore causes it to be susceptible to moisture and directly impairs the properties of jute composites, especially dimensional stability. These natural fibers do not efficiently adhere

to non-polar matrices due to this polar group. To overcome this difficulty, these fibers should be modified chemically or physically [4]. Chemically modified surfaces decrease moisture absorption, and increase tensile strength [5,6] and wettability of fibers by matrix [7].

Various research groups have worked on biodegradable polymeric materials, such as bionolle, biopol, poly(3-hydroxybutyrate) (PHB) and polylactic acid (PLA) [8], to use in natural fiber reinforced composites. However, PHB and biopol can be considered as true biopolymers because they are synthesized by bacteria as macromolecules. The remaining biodegradable polymers are synthetic or semi-synthetic [9]. The homopolymer poly(3-hydroxybutyrate) (PHB) is brittle in nature and has narrow processability window, compared to the conventional plastics. To overcome these drawbacks, 3-hydroxyvalerates are added with PHB to prepare copolymers. PHB and its copolymers are highly crystalline and have a melting point, strength, and modulus comparable to those of isotactic polypropylene [10].

Moisture barrier, flammability resistance, thermal, and mechanical properties of polymeric composites can be improved by adding a small amount of nanoclay as filler particles [11]. Nanoclay agglomerates into the composites due to improper dispersion. A stabilization process is used to remove larger clay agglomerates in the nanoclay suspension [12].

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Saha et al. showed 65% enhancement in tensile strength of jute fibers by alkali-steam treatment [13]. Zini et al. found that surface acetylation of the flax fiber promotes fiber–matrix interaction and improves the mechanical properties of the flax fiber–biopol composites [8]. Corrales et al. used fatty acid derivate for the chemical modification of jute fibers [4]. Doan et al. used maleic anhydride grafted polypropylene (PP) as a coupling agent in jute-PP composites and showed better tensile properties by matrix modification [1]. Hong et al. used silane for the surface modification of jute fiber to improve the interfacial interaction between jute fibers and polypropylene matrix [14]. Mohanty et al. showed that alkali treatment and low grafting of acrylonitrile (AN) resulted in better mechanical properties in jute–biopol composites [15]. Vilaseca et al. found increased strength and stiffness in the NaOH treated jute-starch composites compared to untreated jute composites [16]. Bledzki et al. evaluated the mechanical performance of man-made natural fiber reinforced PP/PLA/PHBV composites and found improvements in impact and tensile strength [17]. Reddy et al. observed about 25 MPa maximum flexural strength in the completely biodegradable syprotein-jute biocomposites [18]. Sing et al. fabricated wood/bamboo fiber reinforced PHBV composites using extrusion followed by injection molding process and the highest flexural strength was observed to be 31.09 MPa in the wood-PHBV composites [19]. Jawaid et al. evaluated chemical resistances, void content, and tensile properties of the epoxy-based trilayer oil palm-jute composites and found better properties [20]. Hu et al. studied the effect of coating on jute-PLA composites and observed lower moisture absorption and better tensile properties using adhesive tape coating [21]. Xie et al. evaluated the effect of nanosilica in the PHBV and found improved toughness and stiffness with 1% silica loading [22]. Huang and Netravali observed better tensile and flexural properties in flax fibers/soyprotein-nanoclay green composites compared to conventional composites [12].

To the authors' best knowledge, no study was reported in the open literatures performed on the jute-based nanocomposites that are 100% biodegradable. Hence, the objective of this study is to develop a 100% biodegradable jute-based nanocomposite for structural applications. Jute fibers were chemically treated with a modified 4-step process for better interfacial adhesion with matrix and evaluated the treated fibers by FTIR, SEM, and tensile tests. Treated/untreated jute fiber–biopol biocomposites with/without nanoclay were manufactured using compression molding process and their mechanical performance was studied through DMA, moisture absorption, and flexure tests.

2. Experimental

2.1. Materials

Poly(3-hydroxybutyrate-co-3-hydroxyvalerate-12%)-Biopolymer granule (Biopol) obtained from Goodfellow Cambridge Ltd. (UK), hessian jute fabrics (Natural Color Burlap, Material: 100% Jute, Width: 47", 11 Oz.) supplied by OnlineFabricStore.net, and Montmorillonite K10 nanoclay (surface area: 220–270 m²/g) supplied by Sigma–Aldrich (USA) were used as matrix, reinforcement, and nanofillers in this study. Alcojet detergent, 50% ethanol solution, 50% NaOH solution, and 99% acetic acid solution for chemical treatments, and 99% chloroform solution to dissolve Biopol were used. These chemicals were also collected from Sigma–Aldrich (USA).

2.2. Surface modification

Detergent washing, dewaxing, alkali treatment, and soaking with acetic acid were performed on hydrophilic jute fibers to improve interfacial bonding with hydrophobic polymer, biopol. Dirt was removed from fibers by detergent washing keeping fibers into

5% detergent solutions at 30 °C for 1 h and washing them subsequently with water. After drying pectin was removed from these detergent washed fibers by keeping them into 5% ethanol solution at 30 °C for 1 h followed by washing with water and drying. Dewaxed fibers were kept into 5% NaOH solution at 30 °C for 2 h and washed with distilled water to remove lignins and hemicelluloses. Alkali treatment resulted in major number of –OH group accessible on surfaces of fibers [16], and broke down fiber bundles into single fibers and increased effective surface area available for interacting with matrix. Alkali treated fibers were soaked with distilled water–acetic acid (2%) solution for 1 h, followed by washing with distilled water and drying. Acetic acid neutralized sodium ions that came with fibers during alkali treatment, reacted with –OH group on fiber surfaces to convert hydrophilic surfaces of fibers into hydrophobic for better adhesion with biopol.

2.3. Composite fabrication

Jute biopol composites were fabricated using treated and untreated fibers and biopol by compression molding process. Biopol was dissolved into chloroform at a ratio of 1:8 at room temperature and stirred by magnetic stirrer for 4 h to prepare a homogeneous solution. In case of nanophased composites, nanoclay were infused into biopol using solution intercalation techniques [23]. Measured amount of nanoclay was dissolved into chloroform and solution was then poured to biopol chloroform solution and again stirred for 2 h to prepare a homogeneous mixture. Final solution with/without nanoclay was poured into a mold to prepare a 1.5 mm thick film and dried in a vacuum oven at 60 °C to evaporate all chloroform. Dried thick films were then placed in the hot press and 13.34 kN force was applied at 166 °C for 10 min to prepare 0.50 mm thin films. Jute–biopol composites were manufactured by stacking prepared films with/without nanoclay and treated/untreated fibers like a sandwich using compression molding process applying 13.34 kN force at 166 °C for 15 min.

2.4. Experimental procedures

The FTIR spectra of parent and surface treated jute fibers were recorded using Nicolet 6700 DX IR spectrophotometer with attenuated total reflectance (ATR) sampling. The crystal material for the ATR was diamond. The background was taken after every 60 min and each spectrum was recorded by co-adding 32 scans at 4 cm^{−1} resolution within the range 4000–600 cm^{−1}. Three samples from each batch were tested for this test. FTIR spectra technique is used to find the functional groups present both above and just below the top molecular layer of flat surface [24].

Tensile properties of untreated and treated jute fiber bundles were characterized using Zwick Roell testing unit according to ASTM D2256-02 standard under displacement control mode at a strain rate of 0.5 min and on a gauge length of 50 mm. The diameter of the round fiber bundle was measured with an optical microscope and ten samples from each category were tested.

Morphological characterization of the treated and untreated fibers was conducted using a JEOL JSM-5800 scanning electron microscope (SEM). The fibers were coated with silver using sputtering machine to prevent charging.

Void content of the jute biopol composites was determined according to ASTM D2734-94 standard [25] using the following equations.

$$V_v = [(\rho_t - \rho) / \rho_t] \times 100 \quad (1)$$

$$\rho_t = 1 / [W_f / \rho_f + W_m / \rho_m + W_n / \rho_n] \quad (2)$$

$$V_f = (W_f / \rho_f) / [W_f / \rho_f + W_m / \rho_m + W_n / \rho_n] \quad (3)$$

$$\rho_e = \text{sample weight (gm)}/\text{sample volume (cm}^3\text{)} \quad (4)$$

where, V_v , V_f , ρ_t and ρ_e are the percentage void fraction, fiber volume fraction (considering no void), theoretical density and experimental density of the composites, respectively. W_f , W_m , and W_n are the weight fraction and ρ_f , ρ_m , and ρ_n are the density of the fiber, matrix, and nanoclay, respectively. Density of biopol, jute fiber, and nanoclay were taken as 1.25 gm/cm³ [19] and 1.4 gm/cm³ [17], and 2.35 gm/cm³, respectively. Experimental density of the composites was calculated using Eq. (4). In this case, three samples from each category were chosen and measured the weight (gm) and volume (cm³) to calculate the density. In case of void fraction calculation, average experimental density (ρ_e) was used.

Storage modulus (E'), loss modulus (E''), and tan delta ($\tan \delta$) (the ratio of E'' and E') of jute–biopol samples were obtained from the DMA tests under three point bending mode at a heating rate of 5 °C/min from 30 to 120 °C with an oscillation frequency of 1 Hz and amplitude of 15 μm according to ASTM D4065–01 standard. Three samples from each category were tested.

Moisture absorption tests of untreated/treated jute–biopol composites were conducted according to ASTM D2495–07. Five rectangular samples from each category (dimension: 100 × 13 × 3 mm) were dried in a vacuum oven at 105 °C for 5 h and dry weight (W_0) was taken after cooling. To make a humid environment, some distilled water was placed into a desiccator and after 12 h the inside humidity was found to be 98%. Dry samples were then kept on a platform above water in the desiccator. The weights (W_t) of the samples were measured after 7, 14, 20, 30, and 60 days conditioning using a precision balance having an accuracy of 0.0001 gm. Moisture content was calculated using the following equation.

$$M_t(\%) = [(W_t - W_0)/W_0] \times 100 \quad (5)$$

Flexural properties of jute–biopol composites with/without nanoclay were evaluated using Zwick Roell testing unit according to ASTM D790–02 standard under displacement control mode at a crosshead speed of 2.0 mm/min [26]. Five samples from each category were tested to determine the average result.

3. Results and discussion

3.1. Surface modification characterization

Fig. 1 illustrates the FTIR spectra of different modified jute fibers. A broad absorption band in the region of 3200–3600 cm⁻¹ characteristic of hydrogen bonded O–H stretching vibration [27], was common to all of the spectra. The O–H stretching vibration was decreased due to the alkali treatment that resulted in more O–H groups accessible on the fiber surface for the reaction with the acetic acid. The C–H stretching vibration of methyl and methylene groups in cellulose and hemicelluloses was observed near to wave number 2950 cm⁻¹ [28]. It was also decreased due to the surface modification. Hemicelluloses are the main concern of our surface modification, which appeared near to the 1730 cm⁻¹ wave number for the C=O stretching vibration of the carboxylic acid and ester components of hemicelluloses. Hemicelluloses were dissolved into the alkali solution and no peaks was observed in the alkali treated fibers for C=O stretching vibration. The absorbance band near to 1464 cm⁻¹ wave number is responsible for lignin [11]. This peak was weakened due to the chemical treatment, which was the indication of removal of lignin from the treated fibers. As the exposure time of fibers into the sodium hydroxide solution increases, the percentage of cellulose content increases. However, sodium hydroxide has a direct effect on the mechanical properties of the fibers. Fibers exposed into the 5% sodium hydroxide solution for 2 h and washed with the 2% acidic acid solution for 1 h showed optimum results for the surface modification.

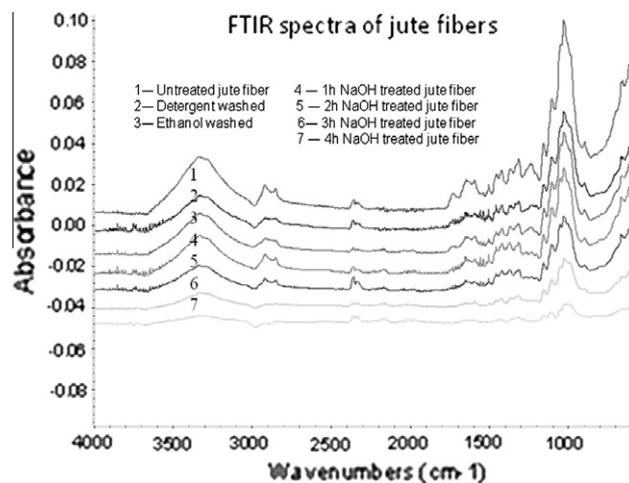


Fig. 1. FTIR spectra of treated and untreated jute fibers.

Uniaxial tensile test results of treated and untreated jute fiber bundles are shown in Fig. 2 and Table 1. Fibers treated with NaOH for 2 h exhibited improvements in tensile strength and modulus by 13% and 17%, respectively, compared to untreated fibers. Alkali treatment caused removal of non-cellulosic materials, including hemicellulose, lignin, and pectin from interfibrillar regions [17] and resulted in a higher percentage of cellulose, which was the main contributor to the higher tensile strength and modulus of fibers [11]. Higher concentrations of NaOH or longer exposed to NaOH weaken fibers and make it more brittle. Two hour-exposure times with 5% NaOH showed optimum results.

Surfaces of treated and untreated fibers investigated using SEM micrographs (Fig. 3) revealed relatively rougher surfaces in treated fibers compared to untreated fibers. Removal of surface impurities, non-cellulosic substances, inorganic materials, and waxes resulted in cleaner and rougher surfaces in finally treated fibers. Chemical treatments converted the mesh-like structure of fibers to clean and rough single fibers which provided higher strength to fibers. This observation was reported elsewhere [29]. Rougher surface and defibrillation were also attributed to better interaction of fibers with matrix for larger surface area.

3.2. Composite characterization

The presence of trapped air or volatile materials and incomplete wetting out of the fibers by the matrix causes the void content into

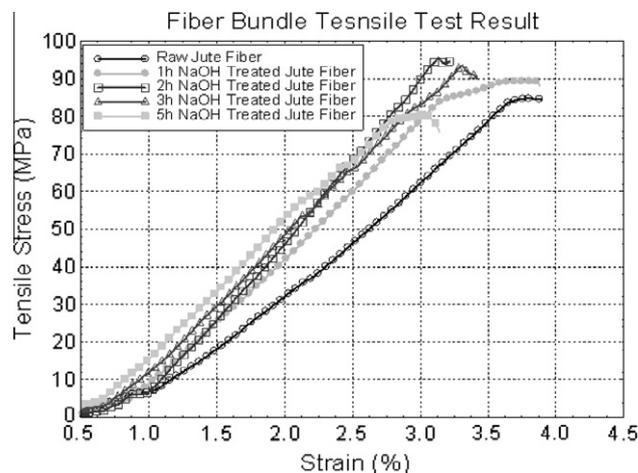


Fig. 2. Tensile stress–strain curves of treated and untreated jute fibers.

Table 1
Tensile test results of treated and untreated jute fibers.

Jute fiber bundle	Strength (MPa)	Strength change (%)	Strain at failure (%)	Strain change (%)	Modulus (GPa)	Modulus change (%)
Untreated	81.42 ± 10	0	3.83 ± 0.62	0	1.92 ± 0.45	0
1 h NaOH treated	85.04 ± 13	4.9	3.62 ± 0.67	−5	2.06 ± 0.64	7.3
2 h NaOH treated	92.54 ± 11	13	3.21 ± 0.68	−16	2.25 ± 0.26	17
3 h NaOH treated	91.68 ± 10	12	3.34 ± 0.64	−13	2.26 ± 0.34	17.7
5 h NaOH treated	80 ± 13	−1.2	2.98 ± 0.69	−22	2.28 ± 0.74	18.7

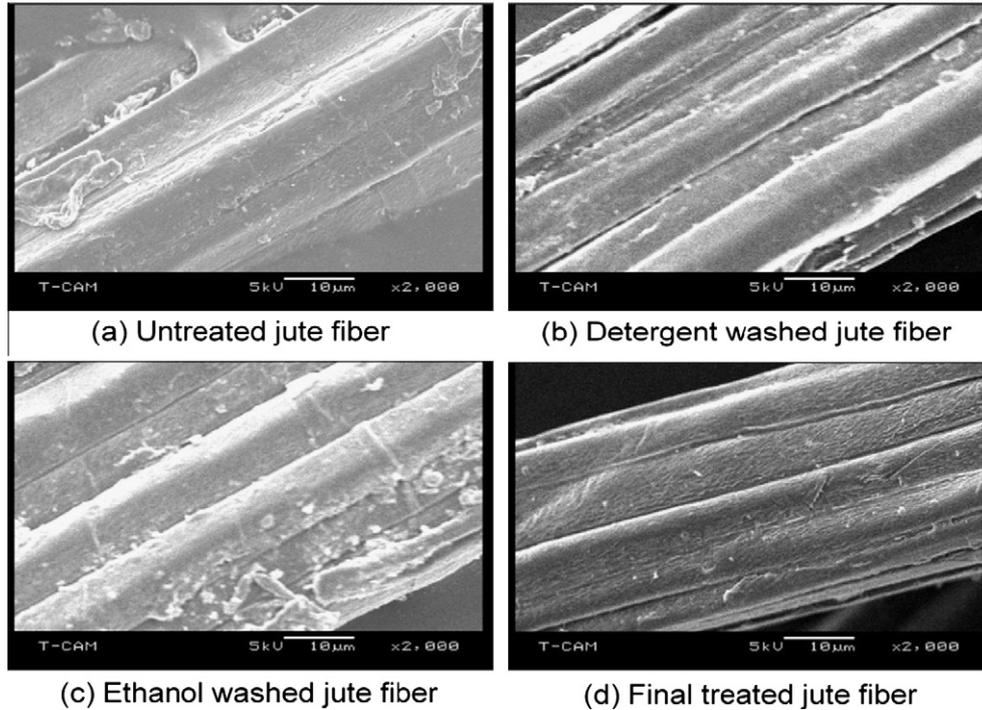


Fig. 3. SEM micrographs of different phase surface treated jute fibers.

the fiber reinforced composites [30,31]. Higher percentage of void was observed in the UTJBC compared to the TJBC (Table 2). This was expected due to the lack of proper interaction between the hydrophilic untreated fibers and hydrophobic matrix. Nanoclay acts as a nucleating agent and takes the space into the voids. Hence, the lower void content was found in the nanoclay infused samples, compared to the conventional composites. As the percentage of nanoclay increases, the percentage of void content decreases into the samples. There are still some voids present in the samples. When the fill and warp direction fiber cross each other, it may cause the presence of voids into the composite system. The fiber volume fraction (considering no void present) calculated using Eq. (3) was found to be about 0.27 for all kinds of composites.

DMA was performed to study the response of stiffness of the jute/biopol composites as a function of temperature. From DMA tests (Fig. 4a), it was observed that storage modulus was the highest at room temperature and decreased linearly with increasing temperature. Storage modulus (1605 MPa) was higher in TJBC compared to UTJBC (1467 MPa). This may be attributed to the better interfacial bonding between fiber and matrix for the chemical treatment. Jute/Biopol samples with 2%, 3% and 4% nanoclay showed about 2550, 2900, and 3050 MPa storage modulus at 30 °C, respectively. Higher storage modulus with increasing nanoclay content is the indication of the higher crystallinity and brittleness of the composites. A small bump in the region 50 °C was observed in the samples without nanoclay. It indicates the cold crystallization temperature region. During the heating cycle, the specimen enters into

Table 2
Fiber volume fraction and void content of jute biopol composites.

Type of composites	Weight fraction			Fiber volume fraction (V_f)	Theoretical density (ρ_e) (gm/cm ³)	Experimental density (ρ_e) (gm/cm ³)	Void content (%)
	Fiber (W_f)	Matrix (W_m)	Nanoclay (W_n)				
UTJBC	0.30 ± 0.05	0.69 ± 0.04	0	0.27 ± 0.02	1.29	1.150 ± 0.01	10.8
TJBC	0.29 ± 0.02	0.70 ± 0.03	0	0.275 ± 0.01	1.291	1.182 ± 0.02	8.3
2% Nanoclay TJBC	0.29 ± 0.03	0.69 ± 0.03	0.014	0.273 ± 0.01	1.299	1.222 ± 0.07	5.9
3% Nanoclay TJBC	0.29 ± 0.03	0.68 ± 0.02	0.021	0.269 ± 0.01	1.30	1.230 ± 0.02	5.3
4% Nanoclay TJBC	0.28 ± 0.03	0.68 ± 0.02	0.028	0.268 ± 0.01	1.299	1.250 ± 0.02	3.8

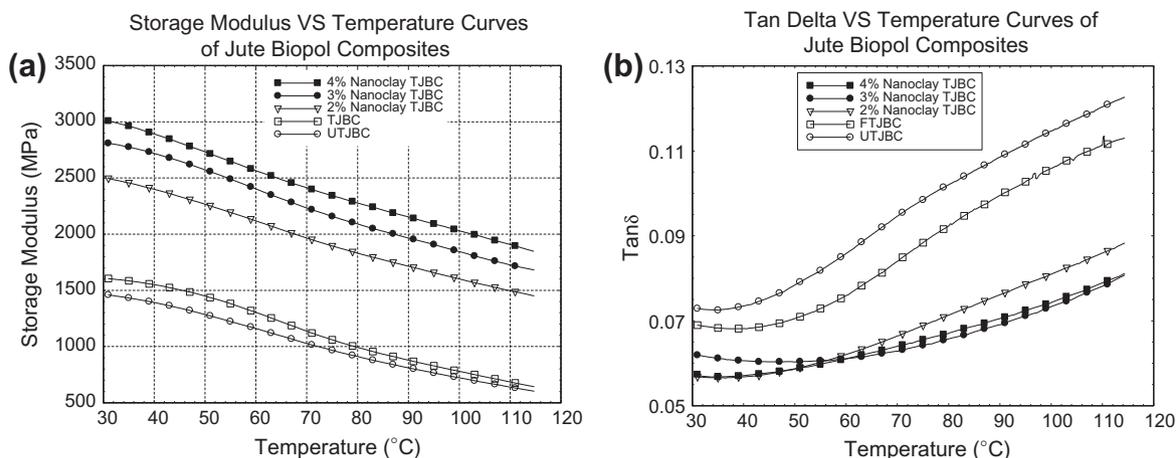


Fig. 4. DMA curves (a) storage modulus, and (b) Tan δ .

Table 3

Moisture absorbed by jute biopol composites.

Moisture gain (%)	After 7 days	After 14 days	After 20 days	After 30 days	After 60 days
UTJBC	3.987 ± 0.23	5.816 ± 0.16	6.148 ± 0.34	6.189 ± 0.18	6.279 ± 0.13
TJBC	3.836 ± 0.62	5.026 ± 0.53	5.835 ± 0.27	5.949 ± 0.44	5.938 ± 0.40
2% Nanoclay TJBC	3.651 ± 0.44	4.572 ± 0.30	5.669 ± 0.29	5.824 ± 0.29	5.882 ± 0.25
3% Nanoclay TJBC	3.639 ± 0.35	4.554 ± 0.36	5.475 ± 0.47	5.744 ± 0.37	5.8023 ± 0.10
4% Nanoclay TJBC	3.602 ± 0.24	4.5792 ± 0.17	5.337 ± 0.35	5.643 ± 0.26	5.775 ± 0.21

the cold crystallization region where crystallinity increases and the rate of decrease of storage modulus (E') decreases [17]. Thus, a small bump was noticed in this region. Lower cold crystallization temperature (about 40–45 °C) was found in the samples with nanoclay, due to the clay's action as a nucleating agent in the polymeric composites.

Tangent delta ($\tan \delta$) as a function of temperature is illustrated in Fig. 4b. It provides the account of energy dissipated as heat during the dynamic testing [32]. As the stiffness increases, the $\tan \delta$ value decreases reflecting reduced energy losses. With increase of temperature, energy losses increase; thus the value of $\tan \delta$ increases. Nanoclay infusion into the biocomposites decreased the $\tan \delta$ value indicating a higher degree of crystallinity. Crystalline structure reduces the loss modulus giving rise to the storage modulus. Loss modulus is related to the molecular chain movement of the polymer. Lower loss modulus was observed in nanoclay infused samples, due to nanoclay's imposed restriction to the expansion of the molecular chain in the amorphous region.

Table 3 shows the percentage of moisture absorbed by the jute biopol composites at different time period. Most of the natural fibers have a tendency to absorb moisture when they are placed in a humid area which weakens the composites. The percentage moisture absorption for conventional and nanophased composites was almost the same during initial 7 day conditioning period. As the conditioning time was increased, the amount of absorbed moisture was increased. After 20 days, it became almost saturated and there was no significant change in the moisture absorption data even after conditioning for 30 and 60 days. The amount of moisture absorbed by the UTJBC was higher compared to the TJBC and nanoclay infused TJBC, due to the presence of micro voids in the UTJBC for improper interaction between fiber and matrix. Nanoclay infused samples showed lower percentage of moisture absorption, because nanoparticles acted as a moisture barrier to the composites system.

The flexural results of untreated and treated jute–biopol composites are shown in Fig. 5a. Surface modified fibers resulted in

better adhesion with the matrix. As a result, better flexural properties were found in TJBC compared to UTJBC without nanoclay. Nanophased TJBC had resulted in higher strength and modulus. However, addition of nanoclay was attributed to brittleness in composites, which was obvious from reduced percentage of strain at maximum stress. No fiber failure was observed in the both nanophased and conventional green composites. Only the matrix failure occurred. It was also noticed that the jute based composites showed the higher flexural strain, which is the indication of the ductile nature of the jute based biocomposites.

Flexural properties of these composites were also determined after moisture absorption for 60 days (Fig. 5b). Higher flexural strength and flexural modulus were observed in TJBC compared to UTJBC. Better flexural properties were also observed in nanoclay infused samples compared to conventional composites. However, the flexural strength and modulus were decreased after moisture absorption, as expected. The results are shown in Table 4. The percentage decrease in the flexural strength was highest (32%) in the UTJBC and lowest (15%) in the 4 wt.% nanoclay infused samples. The respective values for flexural modulus were 21% and only 6–7% respectively. It is also the indication of the moisture barrier properties of the nanoclay into the composites system.

4. Conclusion

Surface treatments resulted in the removal of pectin, hemicelluloses, and other non-cellulosic substances from the fibers and the higher percentage of celluloses in the final treated fibers. Rougher surface and increased effective surface area of the chemically treated fibers facilitated better interaction between the fiber and matrix. Surface modified fibers showed better tensile properties compared to untreated fibers for the presence of higher percentage of crystalline celluloses.

Natural fibers possess very good specific properties, which are comparable to synthetic fibers. By increasing the fiber volume

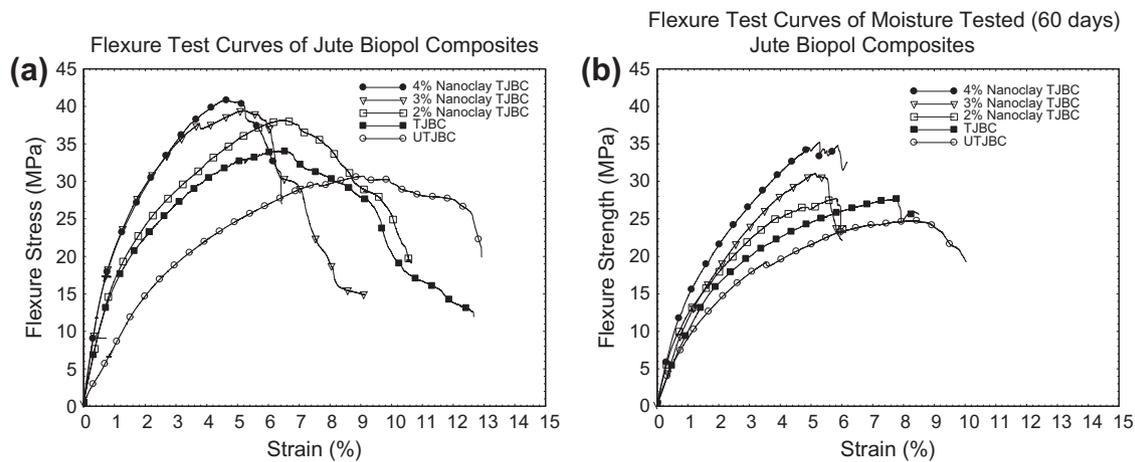


Fig. 5. Flexure test curves (a) before moisture absorption, and (b) after moisture absorption for 60 days.

Table 4

Comparison of flexural properties before and after moisture absorption.

	Strength (MPa)	Strength after moisture gain (MPa)	Change in Strength (%)	Modulus (GPa)	Modulus after moisture gain (GPa)	Change in modulus (%)
UTJBC	30.25 ± 1.38	24.5 ± 1.29	32.36	1.91 ± 0.53	1.50 ± 0.37	21.4
TJBC	33.88 ± 1.62	26.0 ± 1.27	23.2	2.16 ± 0.48	1.7 ± 0.21	21.2
2% Nanoclay TJBC	38.17 ± 1.46	28.0 ± 1.52	26.6	2.17 ± 0.49	2.01 ± 0.28	7.4
3% Nanoclay TJBC	39.43 ± 0.95	30.8 ± 1.31	21.8	3.20 ± 0.51	3.0 ± 0.65	6.25
4% Nanoclay TJBC	40.87 ± 1.43	34.4 ± 1.24	15.83	3.20 ± 0.36	3.0 ± 0.19	6.25

fraction, modifying fiber and matrix, and incorporating nanoparticles, better natural fiber reinforced composites are being developed such that the properties of these composites are expected to be comparable to the properties of the synthetic fiber reinforced composites as the technology advances. Thus, these composites might be the alternative to synthetic fiber reinforced composites in the long run. Instead of compression molding technique, vacuum assisted resin transfer molding (VARTM), extrusion, and hand lay-up techniques can also be employed to fabricate natural fiber reinforced composites depending on the cure requirements. However, in this study, conventional and nanophased composites were fabricated by stacking the biopol film and fibers like a sandwich using the compression molding process. The fiber volume fraction was about 0.27 in all kinds of composites and the void content was lower in the nanoclay infused composites. Treated jute–biopol composites with/without nanoclay showed better storage modulus, loss modulus, flexural strength and modulus compared to untreated jute–biopol composites for the better interaction between fiber and matrix. Properties of the jute based biocomposites were increased with the increase percentage of nanoclay. Nanoclay acted as a nucleating agent in the biopol as well as void reducing agent in the composites. The 4% nanoclay infused composites showed lower moisture absorption, better dynamic mechanical properties, and flexural properties compared to the 2%, 3% nanoclay infused composites as well as the conventional composites.

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