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Effect of Temperature Variation on Surface Treatment of Short Jute Fiber-Reinforced Epoxy Composites.

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Abstract

Surface treatment was performed on jute fibers to produce effective jute reinforced fiber epoxy composites. An improvement has been observed in physical appearance of the jute fiber while analyzing with the bleaching agent. There was no significant enhancement observed in the mechanical properties by adopting this surface treatment. At three different temperature conditions silane treatment was performed on the bleached jute fibers. The mechanical properties showed an enhancement due to silane treatment. Also liquid retaining capacity of the treated fibers increased which indicates better wetting properties of the jute fibers. The gel point also showed better pseudo elastic properties in case of silane treated jute fiber.

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*Keywords:*Jute fiber, epoxy, bleaching agent, surface treatement, silane treatment.

1. Introduction

In the past decades, natural fiber composites are being used extensively so as to replace the commonly used synthetic composites. The use of chemical agent over natural fibers so as to modify the fiber surface can create a marked difference from the original property of the material. Extensive research has been done so as to find the mechanism behind the surface modification of the fibers and the change in properties of the composites thereafter. This chapter deals with literature survey associated with the bleaching and silane agents used for fiber surface treatment, fabrication, mechanical testing of the fiber reinforced composites and also gel point and LRV measurement techniques of the composites related to present work.

Himanshu Bisaria et al. [1] studied the effect of fiber length on mechanical properties of the fibers. This work investigated the tensile, flexural and impact properties of epoxy and randomly oriented short jute fiber reinforced

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epoxy composite. The composite was prepared using Hand lay-up method with 30 wt. % of jute fiber in the various lengths of 5, 10, 15 and 20 mm into epoxy matrix. The results show that the tensile and flexural properties were found maximum for the composite with 15 mm length of fiber whereas the impact properties were found maximum for the composite with 20 mm length of fiber. Ajith Gopinath et al. [2] investigated the fiber reinforced composites prepared with jute fibers of fiber length 5-6 mm. The resins used in this study are polyester and epoxy. The composites were synthesized at 18:82 fiber-resin weight percentages. The prepared composites were tested to study the mechanical properties of the composite such as tensile strength, flexural strength, impact strength and hardness. The results show that the jute reinforced epoxy composite exhibited better mechanical properties than Jute-polyester composite. Md Nuruzzaman Khan et al. [3] studied short jute fiber (2 - 3 mm) reinforced polypropylene PP-based composites (20% fiber by weight) fabricated using compression molding and the mechanical properties were evaluated. Tensile strength (TS), tensile modulus (TM), elongation at break (Eb%), flexural strength (FS), flexural modulus (FM), impact strength (IS), and hardness of the composites were found to be 32 MPa, 850 MPa, 12%, 38 MPa, 1685 MPa, 18 kJ/m2 and 96 shore-A, respectively. Then short E-glass fiber (2 - 3 mm) reinforced PP-based composites (20% fiber by weight) were fabricated and mechanical properties were compared with short jute-based composites. Short jute-based composites showed excellent mechanical properties and comparable to short E-glass-based composites. Soil degradation test of both types of composites indicated that jute/PP composites significantly lost much of its mechanical properties but E-glass/PP composites retained major portion of its original integrity. Interfaces of the degraded composites were investigated by scanning electron microscopy and supported the biodegradation properties of jute/PP composites. A.K. Rana et al. [4] investigated the effect of fiber loading and impact modifier on short jute/ PP composites. In general, it was found that increase in toughness was always with decreasing tensile/flexural properties. However, the extent of increase/decrease depends on the type of modifier, its dose and its compatibility with the jute/PP system. Effect of impact modifier on fiber loading, however showed different results. There was increase in impact strength with rise in fiber loading. Tensile and flexural properties were found to optimize at 40% fiber loading. Interface studies were carried out by field emission scanning electron microscope (FESEM) to investigate fiber morphology, fiber pull out and fiber polymer interface.M.A. Islam et al. [4] made a quantative analysis of the hollow lumens of jute fibers so that they could be considered in the composite manufacturing process. Experimental results revealed that proper analysis of the hollow lumens, their consideration and selection of proper processing techniques for natural fiber reinforced composites (NFRC) can effectively improve and reduce the degree of scatter of the resulted mechanical properties of natural fiber reinforced composites. K Deepak et al. [5] studied the effect of addition of nano clay abd water absorption on jute fibers. Although glass and other synthetic fiber reinforced plastics possess high specific strength, their fields of application are very limited because of the inherent higher cost of production. To overcome this limitation, an investigation had been carried out to make use of jute, a natural fiber which is abundantly available at lower cost. Here, a new composite was formed in which jute fibers were reinforced with polyester resin and with addition of nano clay. Thermo-mechanical properties of the new composite were evaluated. The wide variety of bio composite processing techniques as well as the factors such as moisture content, fiber type and content and their influence on composites exhibited significant improvement in the mechanical properties at lower cost and therefore can be used as a substitute to glass and synthetic fibers. G. B. Nam et al. [6] studied the effect pf solvent free, catalyst free, anhydride treatment on different ligno-cellulosic materials in order to produce cost effective totally biodegradable composites. Two different methods: alkali (NaOH) treatment and plasma treatment were investigated in this study. The former technique was investigated in room temperature condition varying the weight percentage of NaOH and the latter was carried out to make uniform deposition of pin hole free thin film over jute fibers. Surface morphology was investigated by ATR-FTIR and SEM methods. X.Y. Liu et al. [7] studied the method of treating jute fibers with NaOH and maleic anhydride grafted poly-propylene (MPP) emulsion to enhance the performance of jute/PP composites prepared by film stacking method. The surface modification of jute fiber mat has been found to be very effective in improving the fiber-matrix adhesion. it was shown that treatments changed not only the surface topography but also the distribution of diameter and strength for the jute fibers, which was analyzed. Consequently, the inter-facial strength, flexural and tensile of the composites all increased, but the impact strength decreased slightly. These results demonstrated a new approach to use natural materials to enhance the mechanical performance of composites. Amit Rawal et al. [8] treated jute with 40%NaOH solution to study its tensile property change. A series of needle-punched non woven geo textiles were then fabricated by formulating blends of untreated jute and PP and corresponding sets of non-woven containing alkali treated jute and PP in defined weight proportions. Subsequently, a comparison has been made between the physical and mechanical properties of these blended non-woven geo textiles. In general, the alkali treated jute blended non-woven geo textiles offer higher puncture resistance i addition to higher tensile and tearing strengths. Marwah Rayung et al. [9] investigated the effect of fiber bleaching treatments. In this work, biodegradable composites from poly (lactic acid) (PLA) and oil palm empty fruit bunch (OPEFB) fiber were prepared by melt blending method. Prior to mixing, the fiber was modified through bleaching treatment using hydrogen peroxide. Bleached fiber composite showed an improvement in mechanical properties as compared to untreated fiber composite due to the enhanced fiber/matrix interfacial adhesion. Interestingly, fiber bleaching treatment also improved the physical appearance of the composite. The study was extended by blending the composites with commercially available master-batch colorant. Nur Inani Abdul Razak et al. [10] studied the bleaching treatment of kenaf fiber performed in alkaline medium containing hydrogen peroxide solution maintained at pH 11 and 80 °C for 60 min. The bleached kenaf fiber was analyzed using Fourier Transform Infrared (FTIR) and X-ray Diffraction (XRD) analysis. The bleached kenaf fiber was then compounded with poly-(lactic acid) (PLA) via a melt blending method. The mechanical (tensile, flexural and impact) performance of the product was tested. The fiber treatment improved the mechanical properties of PLA/bleached kenaf fiber composites. Scanning electron micrograph (SEM) morphological analysis showed improvement of the interfacial adhesion between the fiber surface and polymer matrix. Magnus Bengtsson et al. [11] investigated silane cross-linked wood–polyethylene composite profiles were manufactured by reactive extrusion. These composites were evaluated regarding their durability and mechanical properties in comparison with two non-cross-linked wood–polyethylene composites. An addition of only 2% w/w of silane solution during manufacturing was enough to achieve almost 60% degree of cross-linking after curing. The cross-linked composites showed flexural toughness superior to the non-cross-linked composites. The cross-linked composites also absorbed less moisture during a boiling test in water and this was an indirect evidence of improved interfacial adhesion. After accelerated weathering for 1000–3000 h the general trend was a decrease in flexural modulus and strength of both the cross-linked and non-cross linked composites.. The decrease in modulus seemed to be lower for the cross-linked composites while the decrease in strength seemed to be higher compared to the non-cross-linked composites. Weathering also resulted in a considerable color fading of the composites. There was decrease in the flexural modulus of non-cross-linked composites considerably while there was no statistical decrease in modulus for the cross-linked composites. There was only an insignificant decrease in strength of the composites. From the detailed literature survey, it has been observed that a good number of studies has been done on silane treated jute fiber composites and their effect on mechanical properties. But a very few studies relate to effect of temperature variation on chemical treatment over the surface of fibers. Moreover, few investigations have been done on gel point of natural fiber composites and evaluation of liquid retention value of natural fibers. Accordingly, the objectives of the present work are as follows:

- To treat non-woven short jute fibers using bleaching agent (H_2O_2) and silane coupling agent namely 3-Aminopropyltriethoxy silane (APTES).
- To study the effect of temperature variation on silanization of the fibers.
- To determine the Liquid Retention Value for the untreated and treated jute fibers.
- To fabricate jute reinforced epoxy composites.
- To investigate the tensile properties of the composites.
- To determine the gel point for the composites.

2. Materials and Experimental Procedure

2.1 Methodology

The fabrication of jute reinforced composites is done by hand layup technique which was developed in the composite laboratory of the Mechanical Department of NIT Silchar. The specimen is polished and prepared according to ASTM standards. Molecular structure is analysed using Fourier Transformation Infrared Spectroscopy (FTIR). The tensile strength is analysed using tensile test and SENB test is also done. Both are performed on INSTRON testing machine in the composite laboratory of NIT, Silchar.

2.2Effect of bleaching treatment on jute fibers:

Bleaching treatment with hydrogen peroxide (H_2O_2) has a very pronounced effect on the brightness of the fiber as shown in Figure 2.1. The use of H_2O_2 as an oxidizing bleaching agent causes discoloration of fiber. Theoretically, per hydroxyl ions (HOO−) are generated by the dissociation of hydrogen peroxide in alkaline media and are responsible for the de-colorization of the fiber. These ions attack the light absorbing chromophoric groups of lignin and cellulose (carbonyl and conjugated carbonyl groups and quinones) [1].

Fig. 1(a) H_2O_2 treated jute fiber **(b)** Untreated jute fiber

2.3 SENB Test:

SENB results of the specimen shows that the fracture toughness of the specimen also increases with increase in the temperature range of the silane treated jute fiber. The figure below shows the SENB test on a pristine epoxy specimen. As it can be seen, the strain whitening region increases with the application of the force.

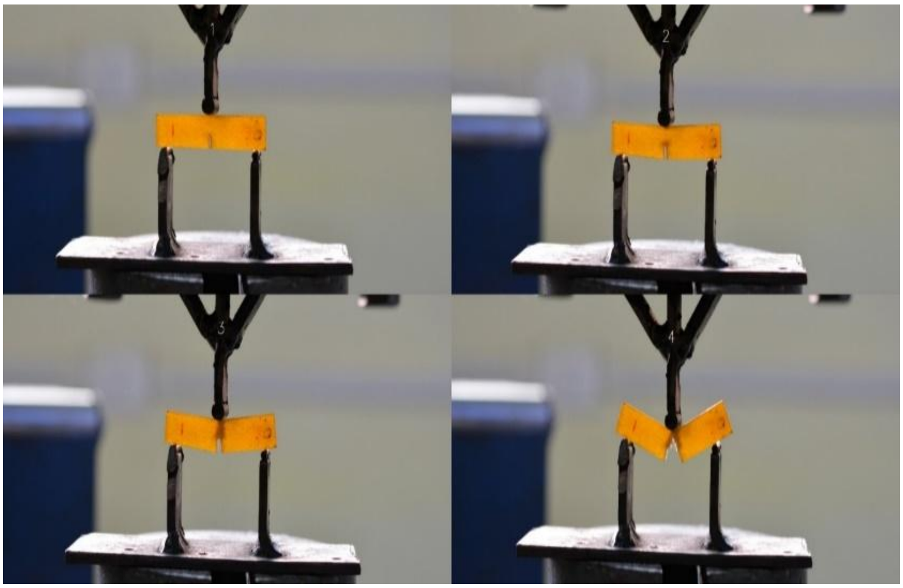

Fig. 2 SENB test on pristine epoxy specimen

3. Results and Discussions

After molding, the specimen was loaded to the UTM machine. It was noted that the failure of the specimen were not catastrophic**. T**he plot clearly shows the fracture toughness of the jute composites enhance with silane treatment at higher temperature but at lower temperature as well as in case of bleached treated jute composites, there is no significant effect of fracture toughness as such [3].

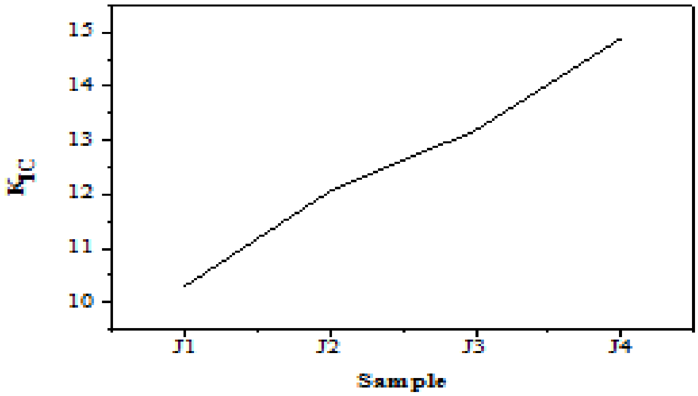

Fig. 3 Stress intensity factor variation for treated and untreated jute fiber reinforced epoxy composites

3.1 Determination of gel point:

From the plot, it is very well visible that the pseudo elastic properties enhanced with the silane treatment of the jute fibers.

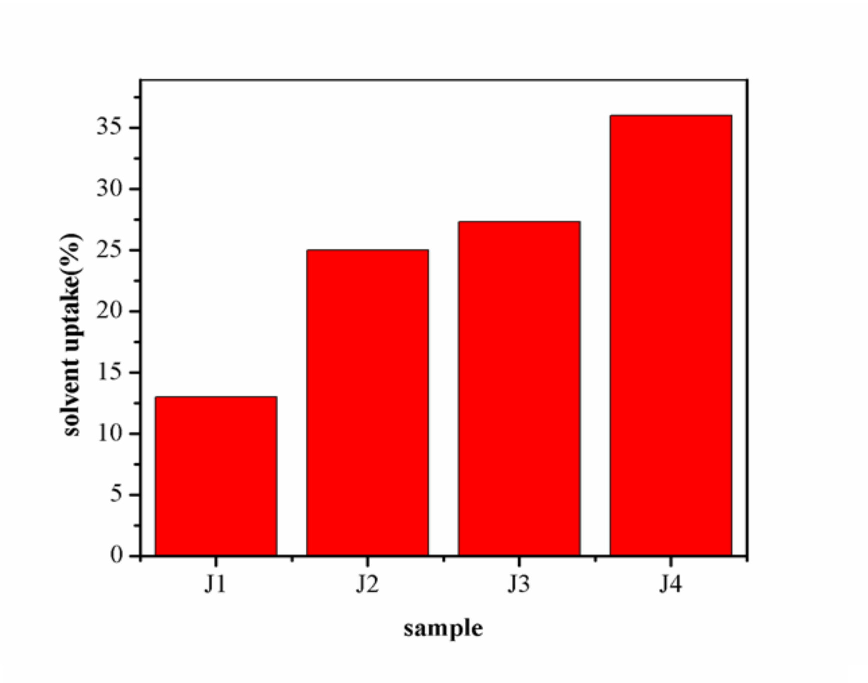

Fig. 4 Variation in solvent uptake for untreated and treated jute fiber epoxy composites.

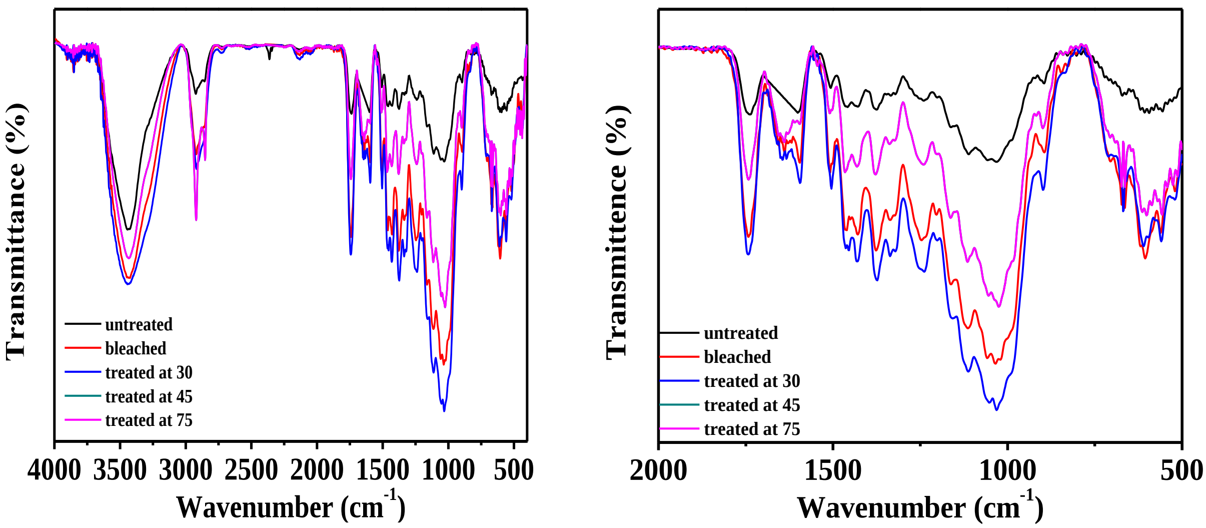

Fig .5 (a) and (b): FTIR analysis of untreated and treated jute fibers

3.2 FTIR Analysis

The wave number 3600-3200 cm-1 indicated the presence of hydroxyl groups (O-H) in both untreated and treated fibers. Absorbance peaks around 2900-2800 cm-1 indicates stretching of C-H group. Peak at 1739 cm-1for untreated fiber is not present in case of peroxide treated jute fiber. It corresponds to C=O, stretching of acetyl group in hemi cellulose. Lack of this peak confirms removal of lignin and hemi cellulose during bleaching process [4].

For the wave number at 3382 cm-1 and 3270 cm-1 assigned as NH2 stretching vibration, 2929 cm-1 assigned as CH2 stretching vibration, 1200 cm-1 assigned as Si-O-C bond, and 1118 cm-1 assigned as NH bending vibration with the APTES coupling reaction .At 1730 cm-1range, the untreated jute fiber shows intensity due to presence of higher amount of hemi cellulose, but the curve diminishes for the silane treatment at lower temperature but again appears at the high temperature condition of silanization.

4. Conclusions

In the present research work bleaching treatment with hydrogen peroxide improves physical appearance of natural fibers. Bleaching action does not significantly enhance the mechanical properties of jute fibers. Silane treatment of jute fibers has better effects on mechanical properties when the process is carried out at high temperature conditions. The wetting characteristics of the fibers enhance due to silanization and more when it is carried out at high temperature. Similarly, the visco-elastic effects which relate to gel point enhance during silanization.

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