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PROCESSING AND CHARACTERIZATION OF NATURAL FIBER-LYCRA COMPOSITE REINFORCED WITH EPOXY RESIN

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ABSTRACT

As the name suggests composite material are formed by combining two or more constituents at macroscopic level. Fiber reinforced polymer composites have acquired a dominant place in variety of applications because of their high specific strength and modulus. The fiber which serves as reinforcement may be synthetic or natural; while matrix material binds the fibers together can be thermoset or thermoplastic resins. The use of synthetic fibers (glass, aramid, boron etc.) in composites tends to affect environment, on the other hand natural fibers (Coir, jute, flax etc.) are environmentally superior to synthetic fibers. The present work includes the processing and characterization of natural fibers with small percentage of cotton-lycra and epoxy resin (thermoset resin). Cotton knitted fabric with 5% lycra was used along with natural fiber to obtain certain elastic property. Compression molding technique was used for composite manufacturing. Natural composites have wide variety of applications from automobile industry to sporting goods industry, production conveyer systems & also in strong infrastructure for roads, airport etc. A comparison was carried out between the properties of jute, jute-lycra and jute-coir-lycra composites.

Keywords: lycra fabric, polymer composite, coir fiber, jute fiber, compression molding.

INTRODUCTION

Lots of research was carried out on natural fiber composites. Since the 1990s, natural fiber composites are emerging as realistic alternatives to glass-reinforced composites in many applications. Natural fiber composites are also claimed to offer environmental advantages such as reduced dependence on non-renewable energy sources, lower pollutant emissions, lower greenhouse gas emissions, enhanced energy recovery, and end of life biodegradability of components. Thus such superior environmental performance is an important driver of increased future use of natural fiber composites [1]. In recent years; there has been growing environmental consciousness and understanding of the need for sustainable development, which has raised interest in using natural fibers as reinforcements in polymer composites to replace synthetic fibers such as glass [2]. Jute fiber reinforced polyester composites were developed and characterized for friction and sliding wear properties. Effect of fiber orientation and applied load on tribological behavior of jute fiber reinforced polyester composites was determined. Maximum wear resistance was observed where fibers were normal to sliding direction [3].

A research has been carried out on preparation and characterization of chemically modified jute-coir hybrid fiber reinforced with epoxy resin. The maximum improvement on the properties was achieved for the hybrid composite containing the jute-coir content of 50: 50 [4]. A research was carried out on a composite reinforced with silicon carbide (SiC) particulates derived from rice husk. Incorporation of these fibers modifies the tensile, hardness, flexural, inter-laminar shear strength of jute epoxy composite [5]. The effect of hybridization on mechanical properties on coir and sisal reinforced polyester composite, coir and jute reinforced polyester composite, jute and sisal reinforced polyester composite were evaluated experimentally. The tensile and flexural properties of hybrid composites are markedly improved as compare to unhybrid composites [6]. Jute fibers were subjected to a small percentage of alkali (NaOH) solution showed improved mechanical properties. [7]. The study was carried on the effect of moisture content on the properties of silanized Jute-Epoxy composites and it was found that application of y-glycidoxypropyltrimethoxy-silane as coupling agent enhances the fiber matrix adhesion because silanol bonds and hydrogen bonds are provided. The enhanced adhesion leads to distinctly improved mechanical properties [8]. Laminates were made of alkalized fibers with unsaturated polyester resin, using hand lay-up and compression molding. Alkalization of fibers at low concentrations of 1 and 5% resulted in improvements in tensile and fatigue properties of composites made from these fibers [9].

A Comparison between Compression Molding and Resin Transfer Molding was done and the properties were evaluated. Tensile and flexural properties are found to be higher in resin transfer molded composites whereas the impact strength of RTM composites are slightly lower than that of CM composites [10]. Mechanical properties of ukam, banana, sisal, coconut, hemp and E-glass fiber reinforced laminates were evaluated to assess the possibility of using it as new material in engineering applications. Samples were fabricated by the hand lay-up process (30:70 fiber and matrix ratio by weight) and the properties evaluated [11]. The authors carried out the mechanical performance of short randomly oriented banana and sisal hybrid fiber reinforced with polyester resin and found out that the maximum tensile strength was obtained in composite for ratio of banana and sisal as 4:1. As the volume fraction of sisal increases the impact strength of composite showed an improvement. [12]. Authors has done research on sisal (*Agave sisalana*),

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banana (*Musa sepientum*), and roselle (*Hibiscus sabdariffa*) polymer composites, with an objective to explore the potential of these fibers and to study mechanical and material characterization of different composites. In future, the final composite material coated by calcium phosphate and hydroxyapatite (hybrid) composite can be used for both internal and external fixation on the human body for fractured bone. [13]. The author reported the use of natural fiber such as sisal, bamboo, coir, jute for structural upgradation as these materials are do not pollute the environment and endanger bio reserves.[14]

From the above literature it can be seen that not much research has been done on the natural fiber with small percentage of cotton-lycra fabric. The research carried out in the past on coir composites is very limited; much more information is available on composites with the other natural fibers (flax, sisal, hemp). Coir fiber has low density (1.2 gm. /cm^3), high lignin content, durability etc. Jute fiber is commonly and abundantly available in India. Among different natural fibers, jute fibers are prominent reinforcing material in fabrication of different types of polymer based composites, due cost effectiveness, high strength, etc. Jute fiber has good tensile strength (393-773 MPa) compared with other natural fibers.

On the basis of above researches carried out in this field, the present research work conveys the idea of using natural fiber (coir and jute) to which synthetic fabric (lycra-cotton blend 5/95) was incorporated and an attempt was made to make this composite a little more elastic and to develop a new class of natural fiber. Evaluation of mechanical properties such as tension test and three point bending test was carried out.

MATERIALS AND METHODS

Materials

Jute, coir and cotton knitted fabric with 5% lycra are used in this study. Hardener used is polyamide hardener. The epoxy resin and hardener are mixed in the ratio of 2:1 and stirred thoroughly. Release agent used was mansion polish.

Experimental methods

Most mentioned method to clean fibers found in literature is distilled water cleaning and then alkaline treatment (NaOH). The concentration of NaOH used is 5%. The fibers (jute and coir) are washed with fresh water thoroughly. The fibers are then soaked in NaOH solution for 8 hours. The fibres were then washed several times with fresh water to remove the residual NaOH sticking to the fibre surface and neutralized by Acetic acid finally washed again with water. The fibers were then dried at room temperature for 10 hours. Removal of lignin, hemicellulose, silica and pith from the fiber to have better impregnation between fiber and matrix and improving fiber surface roughness to have a better interaction are the main objectives of fiber chemical treatment [15]. Figure-1 shows the jute fibers before treatment and Figure-2 shows the jute fibers with 5% NaOH treatment for 8 hours.

Figure-1. Untreated jute fibers.

Figure-2. Treated jute fibers.

The compression molding process was used for manufacturing of composites. The fibers were cut in an equal length of 30 cm. The epoxy resin and hardener were mixed in the ratio of 2:1 and stirred thoroughly before applying to fibers. Release agent was applied on both the surface of mold for easy removal of composite. Then fibers were laid down on mold parallel to each other. For manufacturing of jute-lycra composite, jute was placed in between lycra fabrics and then the material was reinforced with resin. For manufacturing jute-coir-lycra composite, first jute was placed over which lycra and then coir was placed and then reinforced with epoxy resin. Finally the composites were cured for 48 hours at room temperature. Table-1 shows the combination of fibers used to manufacture the composite.

Table-1. Combination of fibers.

S. No.	Fibers/fabric	Resin
1	Jute	Epoxy
2	Jute+Lycra	Epoxy
3	Jute+Coir+Lycra	Epoxy

EXPERIMENTS

The tension test was carried on Universal testing machine (UTM) to measure the tensile strength of Composite material, while bending strength was measured on 3-point bending test machine. Figure-3 shows the universal testing machine and 3-point bending machine is shown in Figure-4. During tension test a uniaxial load was applied from both the ends of specimen. The gauge length of 150mm was taken while testing. For bending test the distance between the supports was 100mm. The speed of stroke was 5mm/min.

Figure-3. Universal Testing Machine.

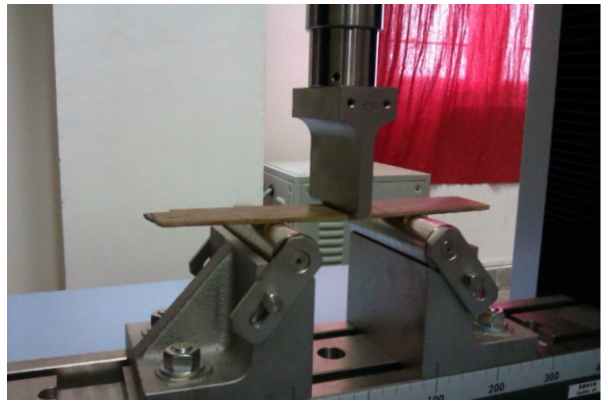

Figure-4. Three point bending machine.

RESULTS AND DISCUSSIONS

Tension test

The results of tension test were plotted in graph of stress vs. strain as shown in following Figures. Figure-5 shows the graph of only jute composite; Figure-6 shows graph of jute-lycra composite and Figure-7 shows the graph of jute-coir-lycra composite.

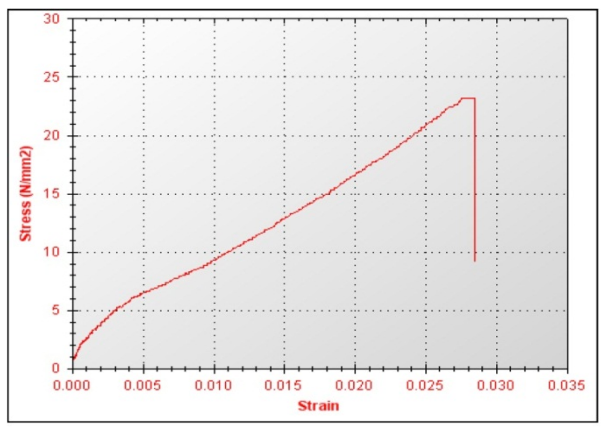

Figure-5. Test analysis of Jute composite.

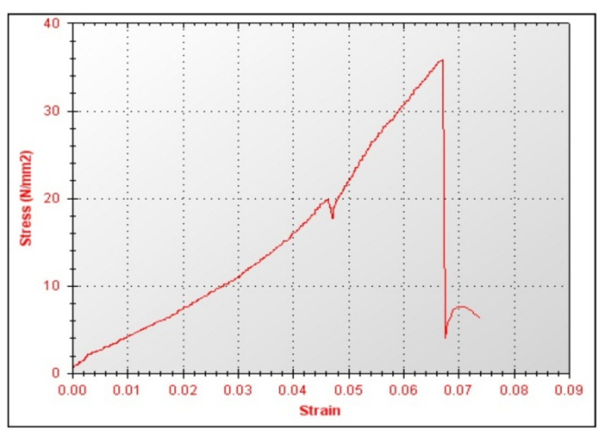

Figure-6. Test analysis of Jute-Lycra composite.

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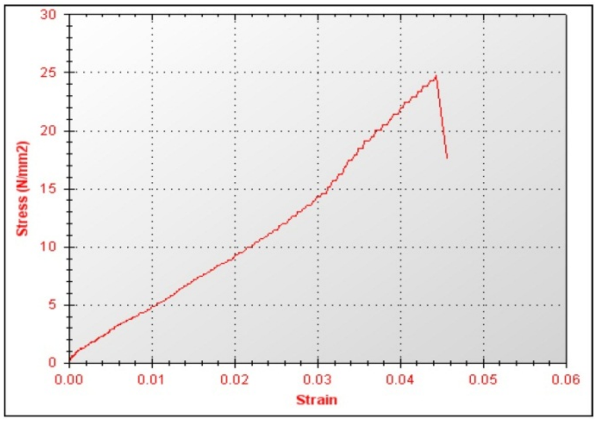

Figure-7. Treated Jute-Lycra-Coir composite.

Bending test

The bending test was carried on 3-point bending machine. The results are as shown in following figures.

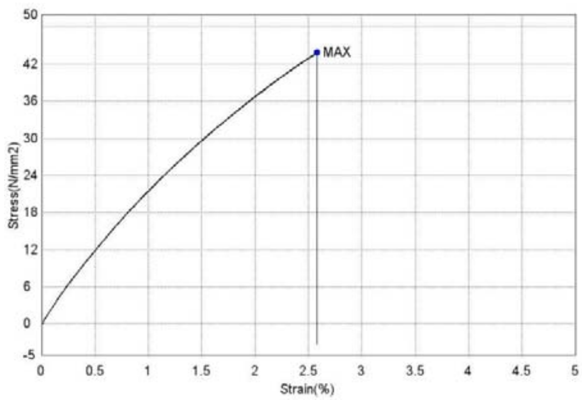

Figure-8. Test analysis of Jute composite.

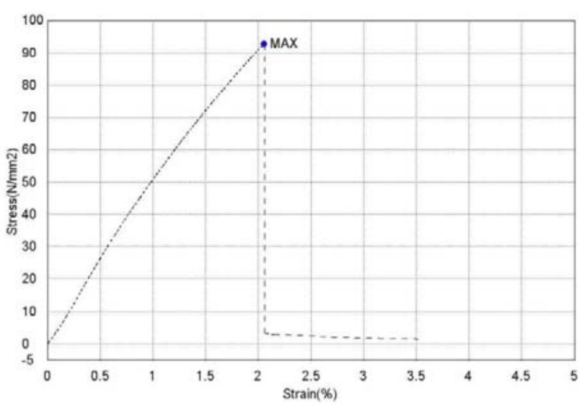

Figure-9. Test analysis of Jute-Lycra composite.

Figure-8 shows the bending test of analysis of jute composite, Figure-9 shows the bending test analysis of jute+lycra composite and Figure-10 shows the bending test analysis of jute+coir+lycra composite.

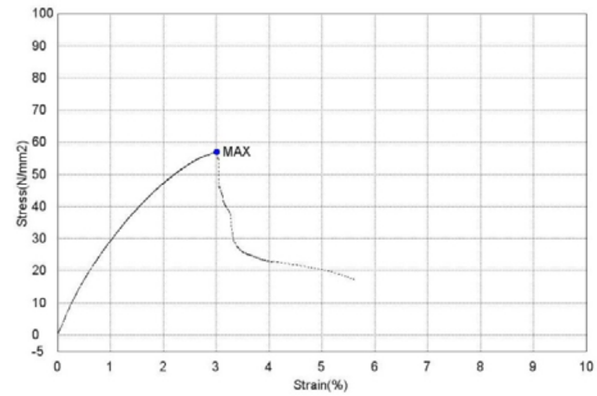

Figure-10. Test analysis of Jute-Coir-Lycra composite.

The tension test shows that the peak load carrying capacity of jute composite was 4.860 kN, which increased to 7.520 kN for jute-lycra composite and for jute-coir-lycra composite it was found to be 5.200 kN. The tensile strengths of jute, jute-lycra and jute-coir-lycra composites were found to be 23.143N/mm^2, 35.810N/mm^{2}and 24.762N/mm^2 respectively. The results of 3-point bending tests are as shown in Table-2.

Table-2. Results of three point bending tests.

Composite material	Max force (N)	Max stress (N/mm^2)
Jute	306.948	43.8497
Jute+lycra	649.881	92.8402
Jute+coir+lycra	399.319	57.0456

CONCLUSIONS

The experimental study of jute, jute-jycra, and jute-coir-lycra composites leads to following conclusions.

This work shows successful fabrication of jute, jute-lycra, and jute-coir-lycra composites. It is seen that jute-lycra composite has the maximum load carrying capacity as compared to other counterparts. Also the tensile strength of jute-lycra composite is greater than other composites. It is also clear from bending test that jute-lycra composite has maximum stress of 92.8402 N/mm^2 with maximum force of 649.881 N/mm^2 as compared to other composites. Hence, considering the entire properties jute-lycra composite is better than rest of composites.

Thus, by adding cotton-lycra fabric to natural fibers the tensile strength and load carrying capacity of composite increased while adding cotton-lycra to coir and jute decreased the properties to a little extent. These fibers can be used in automobile industry for manufacturing various components like door panels, dashboards, mobile cases, laptop cases etc.

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