MECHANICAL CHARACTERIZATION OF PLA COATED JUTE FIBER REINFORCED COMPOSITES

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Abstract: The main objective of present study is to lessen the limits of natural fibers. Woven jute fiber used as a normal fiber, to develop the possessions of jute with alkali reaction and (PLA) eco-friendly coating. Mechanical strength of jute was studied in present work and manufactured with hand lay-up method fiber weight constant 30%. Mechanical strength tensile, flexural, and impact properties was studied. Coated by PLA shown the highest value compares with other natural fiber and treated composites. Chemical treated and coated with PLA (JL4) shown the highest value compare with natural jute fiber (JL1).

***Keywords* - Natural jute fiber (JL1), PLA (JL4), tensile; flexural, impact.**

I. INTRODUCTION

Different physical and chemical property of materials they are connected together to build a composite material. Properties of composite materials are depending on the ingredient materials, resin and fiber used. Currently, the advance composite materials with their good mechanical properties are broadly used in the engineering field. Advantages are electric insulation, fatigue resistance, less weight and widely suitable for formation applications. [1] The global dumping of millions tons of plastics, universal ecological concern, increasing global hotness, decrease in polar ice caps, rapid deplete fuel resources, rising sea level etc, contain a weight on atmosphere. Overhead mention are reasons for the condition to expand green and bearable goods they are gradually allowed to justifiable growth. [2] Green composites were divided into two categories for instance partially recyclable and completely recyclable complexes. Moderately green-complexes in which one of element use from natural resources similar to reinforcement as a normal fiber and epoxy as matrix, PLA and strengthening are synthetic fiber. In fully degradable composite together the reinforcement and matrix are the normal like natural fiber as strengthening and normal polymer are PLA, PVA as a matrix. [3] Many researchers were working on the synthetic resin and synthetic fibers for the development of industrialized goods. But with non-biodegradable behavior, there are lot of problems to the nature, reduction of fossil assets, global warming, and growing oil cost result increased research for sustainable improvement. Totally above are the reasons for the researchers to develop the completely bio-degradable in countryside and with good mechanical attributes. [4] In the green fibers jute is frequently used normal fiber as strengthening. Indonesia, Nepal, Thailand and brazial produce good quality of jute fiber. Jute plant grow height of 2-3.5m and very sensitive, with break to extension is low because high lignin content (up to 12-16%) [5-6].

The limitations of natural fiber are overcome with surface modification by using chemical treatments. Woven jute fiber is eco-friendly & chemical treatments (alkaline, sodium hydrogen carbonate and benzoylation) and PLA covering are used to progress the performance. [8] PLA and Banana fiber bio-composites are made-up using compression molding. Both the modulus and tensile strength are increased for surface modified BF bio composites which is found that there is an increase interfacial attachment between fiber and epoxy material. [9] It also absorbed that concentration of NaOH, immersion time and fiber loading are major factors of increasing and decreasing physical, mechanical and thermal stability of alkali treated green composite. [10] Pre-treatment are used to change the structure and fiber surface morphology. With this decreased the moisture absorption and the dimension stability. [11] Thermoplastic polyurethane, PLA and wood flour particles are as a materials. The TPU taken from (0-50) % and WF is (10) % constant. These were prepared using thin screw extruder. The mechanical, dynamic analysis and biodegradation were studied. Here is an enhancement in tensile strength and with impact strength around 147% and 870% were found from PLA50/TPU50/WF10. [12] Nano fiber 2wt%, DMA were seen improved and thermal stability also increased due to incorporation of hemp nano fibers. [13] 30% weight jute fibre shows better results in Tg and load bearing capacity. Frequency increases the storage modulus also increased and with increasing frequency Glass transition temperature/thermal stability reduced. [14] HCT3 shows better results in storage modulus, glass transition temperature and maximum water absorption resistance. [15] Found that JT1 and JT2 decrease in its impact properties with negative effect of chemical treatment and further increased with coating. JT3 shown highest mechanical properties with strong bonding in between jute and matrix. [16] Fiber kept with constant weight of 20% and examined static, dynamic and water absorption properties. Above tests coated with PLA improved its results compare with untreated and treated. [17] SC1 shows best results with less void and fiber matrix bonding control with chemical treat and coating. [18] In this article effect of weight fraction, surface treatment, orientation, geometry and hybridization are presented. Better tensile and flexural properties are obtained with 30-40% with weight fraction and 20-50mm fiber length. [19]

Composites properties are not increase only with chemical treatments. Hence, there is a need of fresh treatment to increase the composite properties consequently they are used in advanced manufacturing and other requests. In present research overawed the main boundaries of JFRPCs with latest treatment as PLA covering on alkali treated woven jute fiber.

II. MATERIALS AND METHODS

2.1. Materials

Jute fiber

Jute is from Taxaceae blood and its methodical term is corchorus capsularis and extracts from corchorus of the plant, this has less cost fiber. Throughout the world jute produces 2300x103 to 2850x103 tones. Jute has large choice of applications in industry such as construction, textile and automobile. Woven Jute fibers were purchased from Vruksha Composites & services, Guntur, Andhra Pradesh.

Resin and hardener

The polymeric material epoxy resin consists of higher properties they are good chemical, mechanical, easy processing and corrosive resistance properties. Because of its large applications, epoxy was selected as matrix material for present study. The hardener additives serve as catalysts that speed up the curing process. In the fabrication AralditeLY556 epoxy resin and hardenerHY951is used for the preparation of the composite and are brought from Vruksha Composites & services, Guntur, Andhra Pradesh.

Alkaline treatment

Woven jute fiber is treated with the 5% NaOH in the current work. 4h with 30 0C jute fiber were placed in the alkaline solution. After that taken out from solution and cleaned with floating water numerous times and then placed into the HCL solution to eliminate NaOH adhere from the outside of fiber. Again fiber were cleaned with water and dry in oven maintained 60 0C for 24h.Reaction of fiber with alkaline is providing under:

$$\text{Fibre–OH} + \text{NaOH} \rightarrow \text{Fibre –O–Na+} + \text{H2O} \qquad .....(1)$$

PLA coating on treated and untreated

PLA is a completely biodegradable, renewable and fully biological and good processing capacity and mechanical strength. PLA manufacture through lactic acid during fermentation farming foods like corn, rice, potatoes, forming waste and sugar beet etc. PLA properties shown in Table 1. At first, PLA pellets with weight of 2% w/v were placed in chloroform mixture up to 8 h. consequently, stirred the mixture to dissolve the PLA in chloroform solution and maintaining 600C. After PLA solvent woven jute fiber were soaked for 5mins. Lastly, coated fibers were dried 24h at room temperature and dried at 600C for 4h in hot air oven. Schematic diagrams provide below Figure 1. PLA pellets brought from Vruksha Composites & services, Guntur, AP.

Table 1: Physical & Mechanical attributes of PLA.

Properties	Values
Tensile strength (MPa)	37
Density (g/cm^3)	1.29
Tensile modulus	27-16
Melting temperature(^{0}C)	173-178
T_g (^{0}C)	55-80
Impact strength (J/m^2)	13

2.2. Fabrication of Composites

The laminates of required dimensions are fabricated with the help rectangular shape mould made of hardened steel. The dimensions of the mould which is used to prepare the laminates are in the size of 200mm X 200mm and thickness 4mm. In this project hand Layup technique is adopted for the preparation of composite laminates because of its flexibility in material design and good surface finish. Layers of jute fiber are marked and cut according to the mould dimensions. Based on the GSM of the fabric the quantity of resin is calculated. The low temperature curing Epoxy resin LY556 and hardener HY951 is added to epoxy resin with percentage of 10:1 by weight % and mix thoroughly with the support of vertical stirrer and weight of jute fiber is constant with 30%. The composite laminates made of different composition of untreated, treated, coated and treated & coated were named as JL-1, 2, 3 and JL-4 are shown in Table 3. Finally the laminates are cut with the help of hack saw in order to get the test specimens as per ASTM standards for characterization and testing. Nomenclature of composites in Table 2.

Table 2: Nomenclature of composites.

Composites	Jute fiber (wt)%	Alkaline treatment (wt) %	PLA coating (wt) %
JL1	30%	-	-
JL2	30%	5%	-
JL3	30%	-	2%
JL4	30%	5%	2%

III. MECHANICAL PROPERTIES

3.1. Tensile Strength (T.S) of the specimens were conducted as per ASTM D3039 grade. INSTRON make UTM-3369 machine has been employed for evaluating the T.S on the specimens. For evaluating T.S specimens were cut to 165 × 20 × 3 mm3 size. The characterization of T.S was done with a cell load of 30 kN, 10 mm/min speed of the crosshead (CHS), temperature at 270 C and 60% humidity [20]. Each laminate type, 3 undistinguishable laminates were verified and the average value is stated as the stuff of particular composite.

3.2. Flexural Strength (F.S): F.S was performed as the ASTM D 790 with span length 80 mm. F.S specimens was cut to 80 × 13 × 3 mm3 with a constant cell load of 2 kN, CHS travel of 5 mm/min, temperature at 270 C and 60% humidity [20]. Results were used to calculate the flexural properties strength and modulus.

3.3. Impact Strength: Impact test were performed in room temperature 270 C and 60% humidity as the ASTM D 256 grade dimension of 65 × 13 × 3 mm3[20]. Impact energy of each specimen is directly noted on the pointer. Three specimens of each laminate were investigated and average value reported as its property.

IV. RESULTS AND DISCUSSION

Mechanical Properties describes the characterization of mechanical attributes mainly, Tensile properties, Flexural strength and modulus and impact strength of manufactured composites with 5%wt NaOH treatment and 2%wt PLA coating specimens.

4.1. Tensile properties:
Tensile testing value gained with tensile load v/s displacement untreated, treated with coated composites shown figure 7. The tensile values closed to previous published works. The chemically treat and PLA covered composites enhanced their tensile properties of woven jute composites. Treated and coated composites JL4 have highest value compare with all other composites JL1, JL2 and JL4. Only coated with PLA have less value compare with JL2 and JL4 because average bonding between matrix and fiber composites. Tensile strength and the modulus of coated and treat are presented in Table 3. The alkaline treated coated with PLA have advanced tensile strength and with modulus compare with untreated JL1. This with removing contamination by alkaline treat leads to solid attachment in among fiber and epoxy material and increase tensile characteristics. The overall composite laminates JL4 have highest value of tensile value is (35.6 MPa) and with tensile modulus value (4.5 GPa) compare with other laminates. With alkaline treatment remove the unwanted material (lignin, wax and hemicelluloses) and reduce thickness and increase the attached surface between the fiber and matrix. The highest tensile properties are absorbed JL4 due to both the effect alkaline treatment and PLA coating. Tensile strength and Modulus of untreated and treated jute fiber composites as shown in fig.1.

Table 3: Tensile attributes of chemical treated and modified jute composites.

Composites	Tensile Strength (MPa)	Tensile Modulus (GPa)
JL1	28.7	3.3
JL2	33	4.0
JL3	31.2	3.7
JL4	35.6	4.5

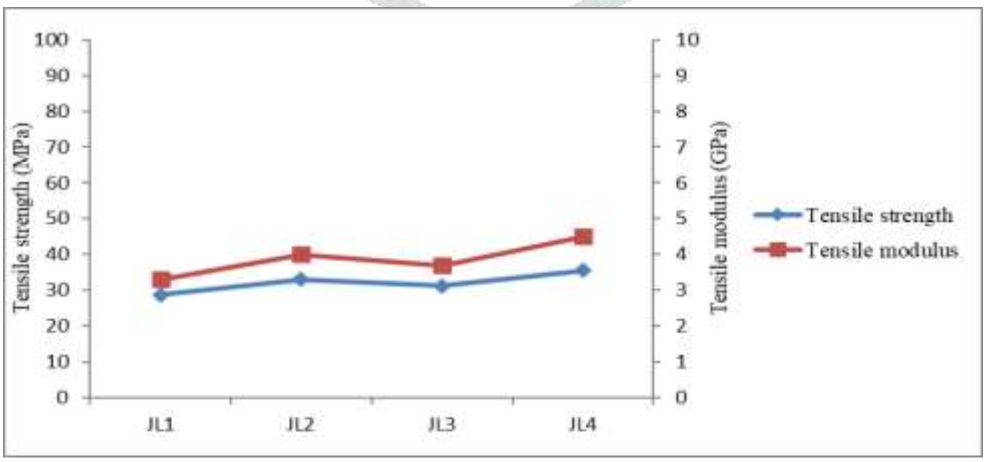

Fig.1: Tensile strength and Modulus of untreated and treated jute fiber composites.

4.2. Flexural properties:
Flexural strength and modulus of entreat and changed jute composites are provided in Table 4. Same as alike tensile properties, flexural properties results are obtained. The laminate JT2 has 9.2% and 6% extra flexural strength and modulus than JC1, correspondingly, where has composite JT3 have maximum results of flexural strength (86.3 MPa) and modulus (7.6 GPa) this are 16.3% and 11% greater later JC1, respectively. Grater values of flexural properties in laminate JT4 with good interfacial attachment among fibres and epoxy matrix this primes to efficient stress handover from matrix to jute fibres. Flexural properties

increased with PLA coating of jute fiber with non-polar behave and well adhesion of matrix. Coated jute fiber has in between properties JL2 and JL4. Maximum flexural properties are absorbed in JL4. The increase in flexural properties is JL4>JL2>JL3>JL1 are shown fig.2.

Table 4: Flexural attributes of chemical treated and untreated jute composites.

Composites	flexural Strength (MPa)	flexural Modulus (GPa)
JL1	70	6.5
JL2	79.2	7.1
JL3	72.3	6.9
JL4	86.3	7.6

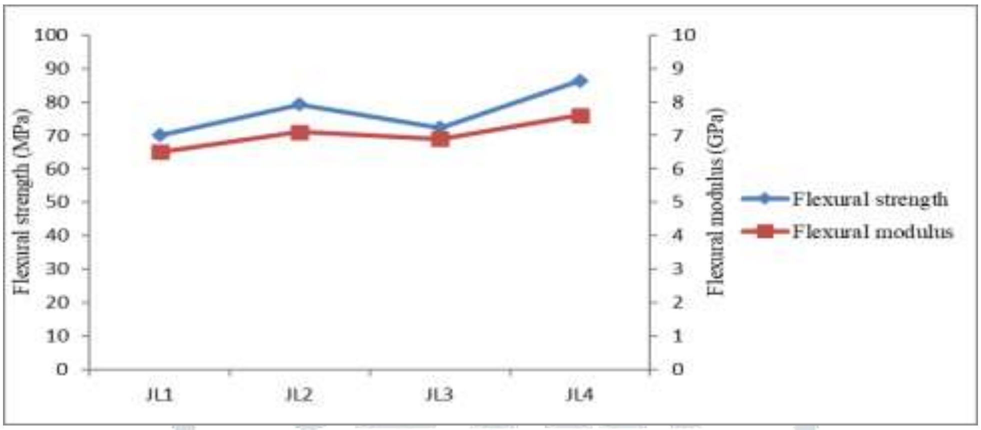

Fig.2: Flexural strength and Flexural Modulus of untreated and improved Woven jute fiber composites.

4.3. Impact properties:

Impact strength of untreated and modified woven jute fiber is shown in Table 6. Impact strength JL2 is reduced compare with treated JL1. During the impact test process mainly concentrate on the fiber pull-out process. With alkaline treatment the fiber pull-out reduces with the strong bonding in between the matrix and fiber. Jute composite laminate JL3 is higher value then the JL2 and lower value then the JL1. The jute composites JL4 have maximum impact strength compare with other composites JL1, JL2, JL3 and JL4 are shown in the fig.3.

Table 5: Impact attributes of chemical treated and untreated jute composites.

Composites	Impact energy (kJ/m^2)
JL1	6.1
JL2	4.4
JL3	4.8
JL4	6.3

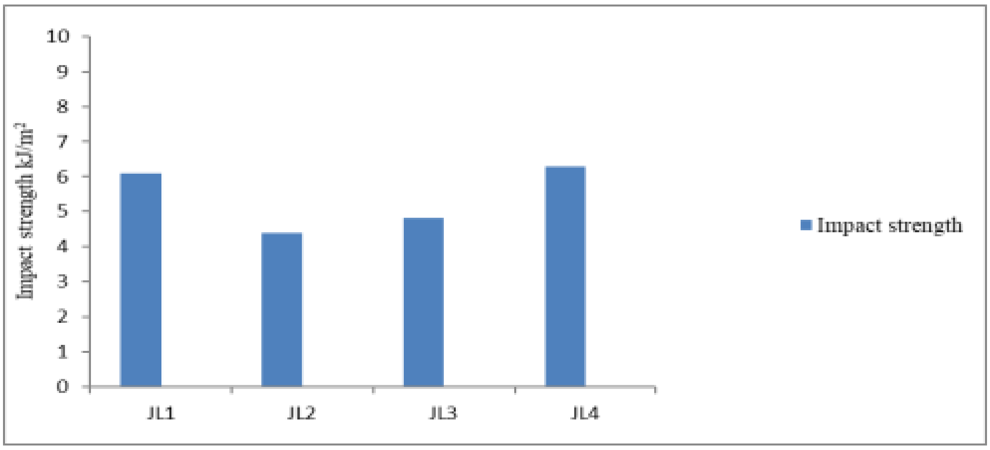

Fig.3: Impact Strength of untreated and improved Woven jute fiber composites.

V. CONCLUTIONS

In this current research, a chemical treat and PLA coating is applied on woven jute fiber and mechanical properties are presented. Limitations of woven jute fiber are reduced with treatment and coating shown good mechanical properties. Alkali treated and PLA coated woven jute fiber Composite (JL4) highest mechanical properties. Chemical treatment and PLA improve the properties but in some cases impact properties reduced with the treatment shown in JL2. Though, composite JL4 shown the enhanced impact strength also. The strong attachment between the fiber and epoxy material are shown highest mechanical attributes in JL4 composite compare with JL1. Natural fibers are completely bio-degradable with PLA coating because PLA itself is a bio-degradable polymer. PLA covering as a fresh treat can encourage researchers for latest and progressive requests of NFRPCs.

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