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Influence of Alkaline Treatment on Improving Mechanical Properties of Jute Fiber-Reinforced Epoxy (LY556) Composites

Composites are currently in a wide range of applications such as aerospace, automotive, house hold items, marine industries etc. There is always a need for improvement in the synthesis of composites without compromising on the mechanical properties and physical properties. In this article, the jute fiber reinforced polyester composite is synthesized by alkaline treatments and the mechanical properties are evaluated. The objective of this article is to discover any significant changes in the mechanical properties before and after alkaline treatments of fiber reinforcement. The specimens are prepared with and without alkaline treatments. SEM images of specimens before and after alkaline treatments are discussed for microscopic analysis. The mechanical properties such as tensile strength, flexural strength and impact strength are determined for the specimens and the results are compared. From the results, it is found that alkaine treated jute fiber-reinforced epoxy composites exhibit better mechanical properties than untreated fiber.

Keywords: *natural fibers, LY 556 composites, Alkaline treatment*

1. INTRODUCTION

Natural fibers have become popular reinforcements for the reinforced composite materials because they are renewable, cheap, and biodegradable [1]. Jute is one the promising natural fibers used as reinforcement in composites. Many research works are carried with jute fibers in the recent time. Girisha [2] prepared the epoxy and polyester matrix composite by reinforcing jute/hemp fiber at different orientations and the results showed 90º orientation showed better mechanical properties than in 45º and 30º orientations. Jawaid, M. et al. [3] stated that, due to higher impact strength and flexural strength of the natural fibres than the synthetic fibres, the natural fibres were played an important role in polymeric composites.

Moreover the natural fibres have the advantages of low density, good strength to weight ratio, environ–mentally friend, availability and its low cost. Hossain[4] prepared jute composites using vacuum assisted resin infiltration method and found that the tensile properties composites strongly depends on the tensile strength of jute fiber. Ramesh [5] made a mixture of sisal, jute and glass fiber-reinforced polyester composite and found that the mechanical properties were improved. Westman [6] identified the major problems with natural fibers are resin compatibility and water absorption. The water absorption is believed to occur start with free hydroxyl groups present in the cellulose chains. Water absorption can be reduced if the hydroxyl groups are capped. There are some promising fiber treatments developed in this area of research. Among these treatments, alkaline treatment, silanes treatment, acetylation have positive results on natural fibers. Kabir [7] improved the fiber matrix adhesion properties, alkalisation, silane and acetylation treatments by alkali-treated and untreated hemp fibers. Karthikeyan [8] studied about the impact behaviour of the coir fiber reinforced epoxy composite upon alkali treatment and fiber. Alkali treatment showed 15% higher impact strength when compared to unt–reated fiber. Durai Raj [9] used chemically treated natural fiber for improving bond strength between fiber and matrix. Sharan Chandran [10] studied the effect of alkali treated jute fibers on mechanical properties of composite and improved significantly. It was observed that fibers of 0 to 4 h alkali treatment were pulled easily, whereas fibers of 6 to 8 h alkali treatment had minimum fiber pull out. In this article, the influence of alkali treatment is analyzed for improving mechanical proper–ties of jute fiber-reinforced epoxy composite Sk. Shar–fuddin Chestee et.al [11] prepared short jute fibre reinforced polypropylene (PP) composites using a single screw extrusion moulding and fibre content in the com–posites is optimized by analysing mechanical properties.

Applications of Jute Fiber-Reinforced Epoxy composite in making automotive parts are widespread because of its significant mechanical properties. This composite is also used in aerospace, main rotor blade for the light multipurpose helicopter propulsion system, decking and window frame because of its strength to weight ratio [12-15]. Beaumont P.W.R et.al [16] discussed inventive modelling methods and smart

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design of various fiber composites including importance of textile composite layup, textile architecture and damage growth. Also challenges for modelling textile composites comprise dealing with large macroscopic gradients, transient loads and mesh generation in composites are discussed.

Though many research works are carried out with jute there is a need of comparative study. In this research paper the characteristics of alkaline treatment of the jute fibre properties were studied and compared them with natural jute fibre without alkaline. Thus study of mechanical properties of jute fibre before and after the alkaline treatment is carried out to investigate whether the influence of alkaline changes the charac– teristics or not.

2. METHODOLOGY

2.1 Jute Fiber Preparation

A Jute fiber, of fabric form was purchased from Ananafit Textiles, Chennai and is cut into the size of 300mm x 300mm. The fibers were used in two con– ditions: treated and untreated. The untreated fibers were prepared with the raw jute fiber without any further treatment.

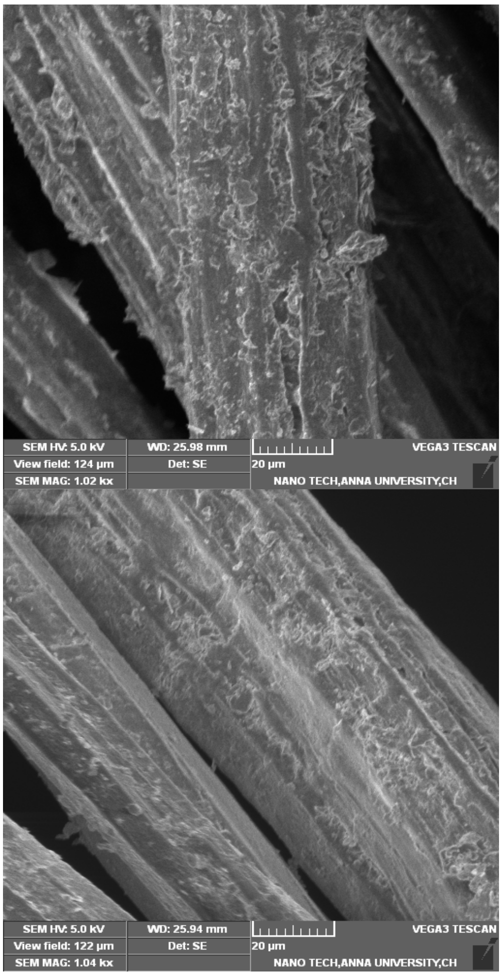


Figure 1: SEM Image of (a) Untreated Jute Fibers, and (b) Treated Jute Fibers.

The alkaline treatment is performed on jute fiber to obtain treated fiber. In this treatment, 5 to10 percentage of NaOH pellets were mixed in distilled water and the jute fibers were immersed in the solution for about 2 hours. The treated fiber was then removed from the solution and dried in sunlight for 2 days. Post-treatment was also performed to remove any moisture content by supplying hot air. The SEM results of untreated and treated fibers are shown in the figure 1.

2.2 Composite Preparation

The epoxy resin (LY556) was used as the matrix to prepare the composite. In addition, suitable hardener (HY951) and accelerator (DY070) were also used for controlling viscosity and speed up the curing process. These chemicals were purchased from Javanthee Enter– prises, Chennai. The matrix of 70% and jute fiber (Treated or Untreated) of 30% were used in this work. The fabrication of composite is described in the Figure 2. Hand layup process was used composite preparation, and compression moulding for curing process.

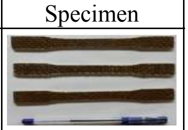
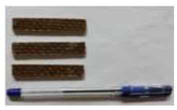
A homogeneous mixture of epoxy resin, hardener (1.5%) and accelerator (1%) is first prepared with the pot life of 30 minutes. A dam of 300mm x 300mm was placed over a polyethylene sheet and sprayed with a releasing agent (Silicone spray). The epoxy resin was applied using a brush to make the first layer of resin. Jute fiber fabric was placed over the resin layer without any slack. A hand roller was used to roll over on the jute fiber to ensure uniform flow of epoxy resin. The second layer was thus formed with jute fiber. The epoxy resin was applied over the jute fiber fabric to form the third layer. The jute fiber was then placed and rolled over to form the fourth layer. The process was repeated for the required thickness. The top layer contained epoxy resin. A polyethylene sheet was put over and a galvanized sheet was placed over the polyethylene sheet. The entire thing was placed in a compression moulding machine for curing at about 350 psi pressure. After 24 hours, the composite was removed and test specimens were cut in a saw cutter and finished using emery sheet.

3. EXPERIMENTATION

Specimen Preparation

The test specimens were cut according to ASTM stan– dards. The tensile, flexural and impact properties of the treated and untreated jute-epoxy composites are tested. The details of the specimen such as ASTM standard, size, dimension and figure are shown in the table 1.

Table 1. Details of Specimens

No.	Test Name	ASTM Standards	Specimen Size in mm	Prepared Specimen
1	Tensile test	D638	165 x 19	
2	Flexural test	D790	100 x 13	
3	Impact test	D256	62.5x13	

Tensile Test

Tensile testing is performed on the universal testing machine (UTM). Standard test method for is ASTM D790, specimen dimension used for tensile test is length=165 mm, width=13mm. Figure 2 shows the tensile strength experimental arrangement and figure 3 shows the tested specimens. The tensile force is recorded as a function of the increase in gauge length. During the application the elongation of the gauge section is recorded against the applied force. There are three different types of specimen prepared using the fiber composite. The specimen consists of untreated jute-epoxy composite and the second specimen treated jute- epoxy composite.

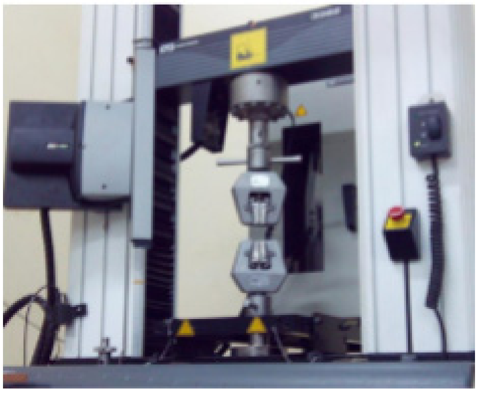


Figure 2: Tensile testing machine

Figure 3: Tensile tested specimens

3.3. Flexural Test

The three point flexural test is the most common flexural test for composite materials. Figure 4 shows the flexural strength experimental arrangement and the tested specimens The flexural test measures the force required to bend fewer than three point loading constraints. Standard test method for flexural testing is ASTM D790, the specimen dimensions used for testing is length = 100mm, width = 13 mm. The testing process involves placing the test specimen in the universal testing machine and applying force to it until it fracture and breaks.

3.4 Impact Test

The impact test is done using an Izod impact tester TINUS OLSEN-104. Figure 5 shows the tensile strength experimental arrangement and figure 6 shows the tested specimens. The standard test method for impact testing is ASTM D256. The specimen dimension used for test–ing are length = 63.5mm, width = 13 mm. During the testing process, the specimen must be loaded in the impact testing machine and the pendulum is allowed to impact the specimen until it fractures or breaks

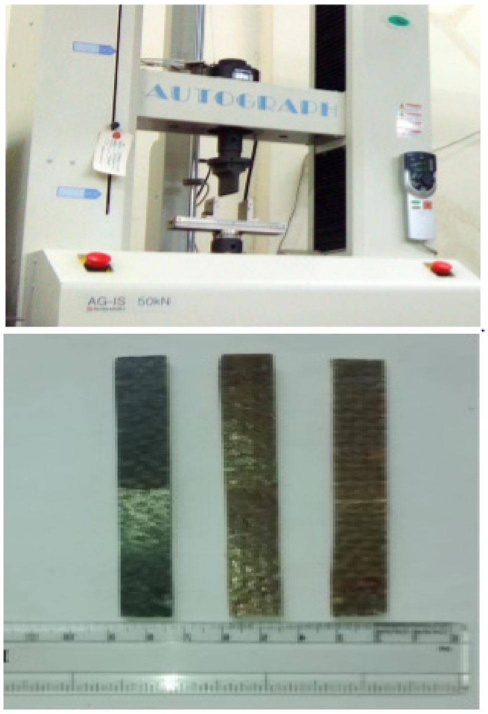


Figure 4: Flexural testing machine and the tested specimen samples

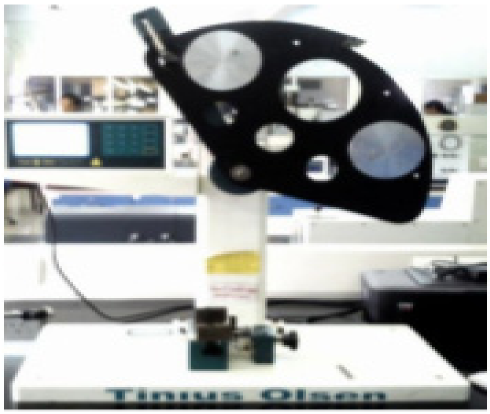


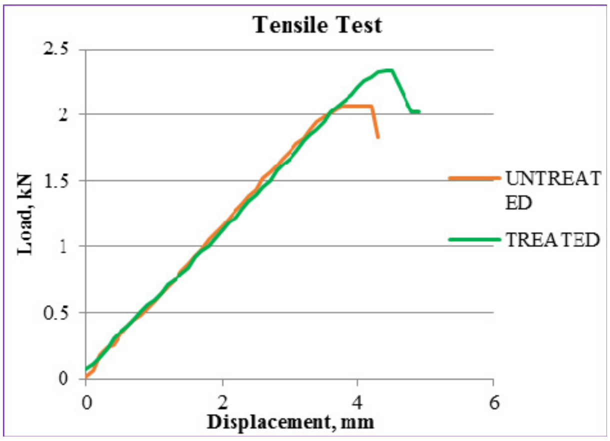
Figure 5: Impact testing machine

Figure 6: Tested specimen samples after Impact test

4. RESULTS AND DISCUSSION

Tensile Strength

Tensile strength of treated jute-epoxy is found increased than that of untreated jute-epoxy composite which has a tensile strength of 50.19 MPa but the untreated jute-epoxy composite consists of flexural strength of 45.628 MPa. Hence the alkali treatment has increased flexural strength by an amount of 4.562 %. This is due to high adhesion offered by treated jute particles against tensile loading. Tensile testing machine and tested samples are shown in Figure 2 and Figure 3.The results of tensile test is shown in Figure 7.



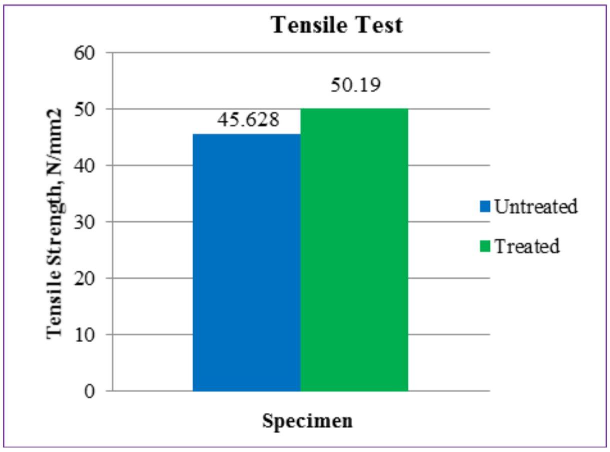


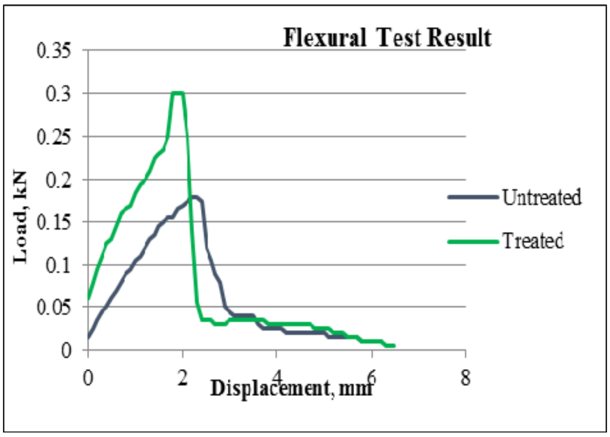
Figure 7: Tensile Strength of untreated and treated fibre reinforced composite

4.2 Flexural Strength

Flexural strength of treated jute-epoxy is found inc–reased than that of untreated jute-epoxy composite which has a flexural strength of 90.89 MPa but the un–treated jute-epoxy composite consists of flexural stren–gth of 81.12 MPa. Hence the alkali treatment has incre–ased flexural strength by an amount of 9.77%. The flexural testing machine and tested samples are shown in Figure 4. The results of flextural test is shown in Figure 8.

4.3 Impact Strength

Impact strength of treated jute-epoxy is found increased than that of untreated jute-epoxy composite which has a impact strength of 88.5 J/cm2 but the untreated jute-epoxy composite consists of flexural strength of 69.5 J/cm2. Hence the alkali treatment has increased flexural strength by an amount of 5.4 %. The impact testing machine and the tested samples are shown in Figure 5 and Figure 6. The result of impact test is shown in Figure 9.



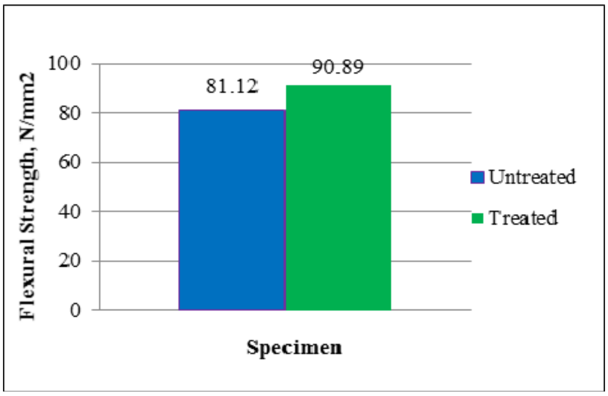


Figure 8: Flexural Strength of untreated and treated fiber reinforced composite

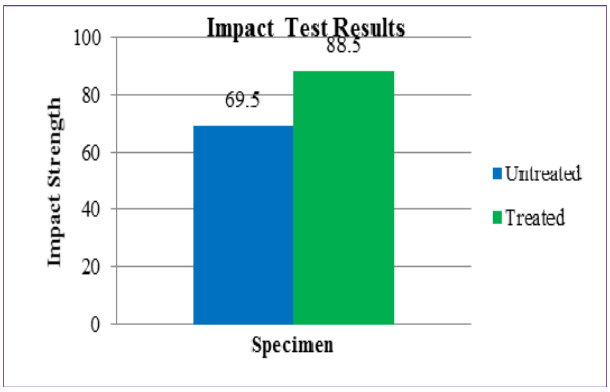


Figure 9: Impact Strength of untreated and treated fiber reinforced composite

Scanning Electron Microscopy (SEM) Analysis

The tensile strength in the epoxy jute depends on its length of the span length. By increasing the span of the jute epoxy decreases the tensile strength. Relatively the lower span of the jute epoxy gives more strength than the higher span. The fracture morphology used to determine the higher values of tensile strength in the direction of longitudinal as shown in figure 10. Because of pull-out and de-bonding of matrix, it shows relatively lower tensile strength than treated jute epoxy. Figure 10 shows the SEM images of treated and untreated specimens. Thus treated jute epoxy having more mec–hanical properties than untreated jute epoxy.

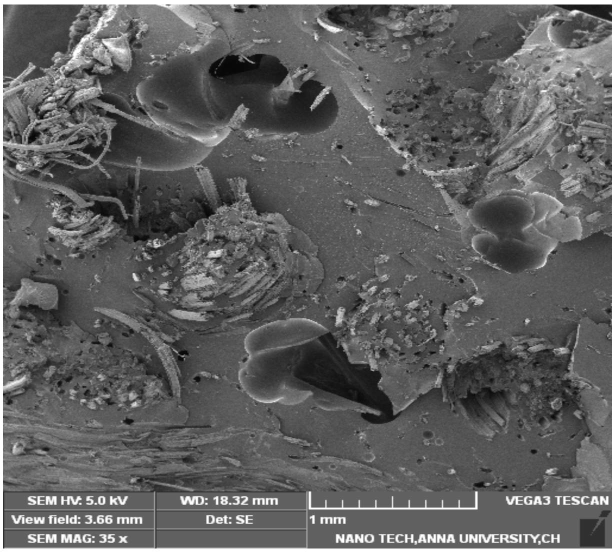


Figure 10(a) SEM Images of Treated Jute fiber-reinforced epoxy composites.

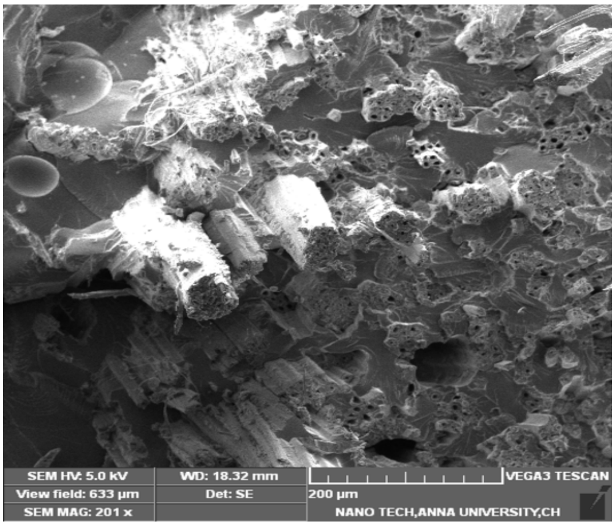


Figure 10(b) SEM Images of Untreated Jute fiber-reinforced epoxy composites.

The sequence of these events are as follows: a) loading b) jute epoxy crazing and cracking c) debonding of interface d) failure initiation of jute epoxy e) propa–gation of the failure f) breakage of the jute epoxy. Since the treated epoxy fiber has high tensile strength, the composite of treated jute epoxy also has high tensile strength in the longitudinal direction

1. CONCLUSIONS

In this research work Jute fiber reinforced polyester composites are fabricated by simple hand lay-up techni–que. From the experimental results it is observed that alkaline treated jute fiber-reinforced epoxy composites exhibit better mechanical properties than untreated fiber.

The main drawbacks in utilizing natural fiber rein–forced composites are resin incompatibility and mois–ture absorption. Fiber matrix interfacial adhesion is improved by the chemical modifications applied to the fiber. Mechanical characterization layered woven trea–ted jute-polyester laminate was carried out through experimental investigation and the results are discussed. Morphological assessment is made using SEM which will focus on the humidity aging of the natural fiber composite.

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УТИЦАЈ БАЗНОГ ПОСТУПКА НА ПОБОЉШАЊЕ МЕХАНИЧКИХ СВОЈСТАВА ЕПОКСИ КОМПОЗИТА (LY556) ОЈАЧАНИХ ВЛАКНИМА ЈУТЕ

Г.Б. Јозеф, Ј. Рајан, Ј. Јевахан, Г. Магешваран

Композити данас имају широку примену у ваздухопловству, аутоматизацији, домаћинству, бродоградњи, итд. Постоји стална потреба да се побољша синтеза композита а да се при томе не наруше њихова механичка и физичка својства. У овом раду је извршена синтеза композита ојачаног влакнима јуте помоћу базног поступка и обављена је евалуација механичких својстава.

Циљ рада је био да се утврди да ли постоје значајне промене у механичким својствима пре и после примене базног поступка. Узорци су припремљени са и без примене базног поступка и извршена је микроскопска анализа. Мерени су следећи параметри: затезна чврстоћа, јачина на савијање и ударна јачина, који су затим упоређени. Утврђено је да епокси композити ојачани влакнима јуте имају боља механичка својства када се изложе базном поступку.