INVESTIGATION OF MECHANICAL PROPERTIES OF NATURAL FIBER COMPOSITE WITH & WITHOUT FIBER SURFACE TREATMENTS

PANKAJ GIRI, V. JAYAKUMAR, V. CHARAN KUMAR & A. MUNIAPPAN

*Department of Mechanical Engineering, Saveetha School of Engineering, Saveetha University,
Chennai, Tamil Nadu, India*

ABSTRACT

Natural fiber composites are used for various applications in automobile, Industrial and domestic fields due to their high flexibility and tensile strength. Many works have been carried out to enhance the mechanical properties of composites. In this paper, the effect of fiber surface treatments on mechanical properties of different natural fiber composites is investigated. In this work, three composites with jute 20% fiber, with banana 10% fiber and hybrid fiber with jute 15% and banana 15% were fabricated and mechanical tests were carried out. Then the fibers were treated with 3% of potassium permanganate to improve the bonding between fiber and matrix and polyester was used as resin along with 3% cobalt naphthenate for curing and 5% methyl ethyl ketone peroxide. The tensile test, flexural and impact tests were conducted on those surface treated composites. The test results comparing with and without surface treated composites showed that there was good improvement in the flexural strength and tensile test when the fibers were treated.

KEYWORDS: Fiber Surface Treatment, Natural Fiber Composite & Mechanical Tests

Received: Jun 15, 2018; **Accepted:** Jul 06, 2018; **Published:** Jul 28, 2018; **Paper Id.:** IJMPERDAUG201881

1. INTRODUCTION

A Composite material is a material composed of two or more different materials, with the properties of the resultant material being superior to the properties of the individual materials that make up the composite. They are made to obtain unusual combinations of stiffness, strength, weight, high-temperature performance, corrosion resistance, hardness, or conductivity. There are various kinds of composite materials like ceramic, polymer, metal, fibrous etc. It is reported that banana fiber has high specific strength makes a lightweight composite and can be used in automobiles [6]. It is biodegradable as well as possess several other advantages such as lightweight, low cost, high specific strength and safe manufacturing process [7]. The fiber surface treatment is done to enhance the bonding of the resin and the matrix and when they are treated it changes. Jai Inderpreet Singh et al [2] investigated the effect of surface treatment by alkali treatment which improved the tensile properties of the fiber. The banana fiber and jute are quite similar in properties reported by Maries Idicula [3]. The various treatments had been done by various researchers the usage of potassium permanganate is expected to escalate the tensile and flexural strength of composite and the impact strength is directly related to the thickness of the natural fiber composite [4]. Joao Bessa et al [8] in his research highlighted that depending on the interface properties and method of bonding and applied a concentration of surface treatment the properties are altered. Ajithgopinath [12] had shown that the addition of jute fiber (12-24%) increases the mechanical properties. Other interesting works on the effect of surface treatment of fibers on mechanical properties can be found in [13-14]. The following sections, fabrication of three compositions of composites and the effect of fiber surface treatments on mechanical properties

of different natural fiber composites are presented.

2. MATERIAL AND METHODS

In this work, three composites with jute 20% fiber, with banana 10% fiber and hybrid fiber with jute 15% and banana 15% were fabricated using hand lay-up method by applying compression. The jute fiber was made into the length of 4 cm of length for the fabrication. The jute and banana fiber density were to be 1.35g/mm³. Banana fiber is made into 5 cm long fiber. 10% of the volume fraction is used for banana fiber fabrication. The powdered potassium permanganate was mixed 3% in one liter of water and used in this process. Ethyl methyl ketone peroxide is used as a catalyst which starts the cross linking of unsaturated polyester resin. 5% of ethyl methyl ketone peroxide is applied to the resin for the fabrication on fiber. Unsaturated polyesters are long-chain linear polymers containing a number of carbon double bonds. With glycol and an unsaturated dibasic acid (maleic or fumaric), condensation reaction makes polyester. The cross linking agent is the polymerizable monomer such as styrene which contains double carbon bonds by bridging adjacent polyester molecules at saturation.

Figure 1: Raw Jute Fiber

Figure 2: Banana Fiber

3. FABRICATION PROCESS

Initially, the raw fiber is washed in water and dried so that the dirt is removed and is cut into long strands of 5 cm banana and 4 cm jute and mixed with potassium permanganate for treatment 3% for one liter of water as suggested in the study [9]. The fibers are kept in the solution of the specimen plate is cleaned and mansion wax is applied over it so that the fiber doesn't stick to the surface of the specimen plate. The plate is fixed as 300×300×3 mm as ASTM standard. The treated and untreated fiber jute and banana are kept over the compression plate separately for the separate plate and together for hybrid composite and polyester resin is applied along with accelerator 5% cobalt naphthenate and accelerator as 5% ethyl methyl ketone peroxide, the layer of fiber and a resin is made one by one. Similarly for the hybrid fibre same procedure is followed and the weight of over 40 kg applied over to fabricate the composite and based on the study by

Santosh et al [13], potassium permanganate for 24 hours and is allowed to dry in sunlight. For hybrid fiber volume fraction is kept to be 30%. The composite material plate specimens are of three types in this investigation. Jute fiber 20% volume fraction with polyester resin, a banana composite plate with 10% volume fraction and hybrid fiber with 30% volume fraction containing both jute and banana with 15% volume fraction each with jute fiber density 1.35 g/mm^3 and banana fiber density 1.4 g/mm^3 . After fabrication, both plates were cut in 48 samples and samples were subjected to the mechanical test. Wire hacksaw is used to cut the specimen plates for mechanical testing. Figure 3 shows the series of the fabrication process.

Figure 3: Fabrication Process

4. MECHANICAL TESTING

The test specimen is made according to ASTM D-3039 standard of length breadth and height $57 \times 12.5 \times 3 \text{ mm}$. A universal testing machine is used for tensile testing of jute and banana fiber composite specimen. The flexural test provides values for the modulus of elasticity in bending, flexural stress, flexural strain and the flexural stress-strain response of the material. The length breadth and height are kept same as like a tensile test. Izod impact testing is a method in which an arm from a specific height impacts on the sample in which the specimen goes through the impact force and it either breaks. The impact energy is determined by the notched sample. The length $\times$ breadth $\times$ height of specimen is taken as $57 \times 12.5 \times 3 \text{ mm}$. Impact = K / A , where K = energy absorbed and A= area under the notch. Figure 4 shows the image of the specimen composite after mechanical testing.

Figure 4: Specimen after Mechanical Testing

5. RESULTS AND DISCUSSIONS

The treated and untreated fibers are compared together with similar volume fraction. Table 1 summarises the tensile test results of three composites and figures 4 depicts the comparison graph of the tensile strength of three composites. The formula of tensile strength is given as $= P/A$, where P is load in kN and A is area where. 3 cm in thickness and 13 cm is the length of the specimen based on the ASTM standard. The tensile strength got increased when the fibers were treated. For 10% volume fraction in banana fiber there was a significant improvement in tensile strength from 0.003820 kN/cm² to 0.0041025 kN/cm², whereas in the Jute fiber for 20% volume fraction there was also a significant improvement in tensile strength from 0.0044487 kN/cm². For 30% hybrid fiber jute 15% and banana 15% composition there was little improvement in the tensile strength for the treated fiber. There was a 6.8% increase in the tensile strength of banana fiber at 10% volume fraction based on the results. The change in the percentage treatment can show varied results whereas in jute there was 1.9% increase in the tensile strength for 20% volume fraction.

Table 1: Results of Tensile Test

Volume Fraction	Untreated Peak Load in kN (P)	Treated Peak Load in kN	Tensile Strength Treated kN/cm ²	Tensile Strength Untreated kN/cm ²
10% banana fiber	0.149	0.160	0.0041025	0.003820
20% jute fiber	0.139	0.1735	0.0044487	0.0035640
30% hybrid fiber	0.323	0.348	0.0089230	0.0082820

Figure 5: Comparison of Tensile Strength for Treated and Untreated Fibers

Table 2 summarises the flexural test results of three composites and figure 5 depicts the comparison graph of flexural strength of three composites. The flexural strength at 10% volume fraction of banana had 1.41% improvement. The jute fiber had an increase in the tensile strength. For hybrid fiber 30% volume fraction, there was a higher increase in the mechanical properties compared to the non-hybrid which concludes that the mixing of two fibers makes the fiber more strong. When the banana fiber was untreated, it showed the highest flexural strength.

Table 2: Flexural Strength for Treated and Untreated Fiber

Volume Fraction	Untreated Peak Load in kN	Untreated Flexural Strength kN/cm ²	Treated Peak in kN	Treated Flexural Strength kN/cm ²
10% Banana Fiber	0.418	0.31768	0.424	0.32224
20% Jute Fiber	0.122	0.09272	0.139	0.10564
30% Hybrid Jute and banana	0.418	0.317678	0.493	0.317678

Figure 6: Comparison of Flexural Strength of Treated and Untreated Fibers

Table 3 summarises the impact test results of three composites. The results of the izod impact test showed that the treatment of the fiber has no increase in the impact strength of the fiber. In fact the impact strength which was expected to improve in the hybrid but the fiber did not show any improvement.

Table 3: Impact Energy for Treated and Untreated Fibers

Volume Fraction	Untreated Fiber (Joule)	Treated Fiber (Joule)
10% Banana Fiber	1. 5	1. 5
20% Jute Fiber	1. 55	1. 5
30% Hybrid banana and jute fiber	1. 5	1. 42

6. CONCLUSIONS

This experiment conducted in this work showed a 6. 8% increase in the tensile strength of banana fiber at 10% volume fraction. This result is in line with the work of Santhosh et al. [13]. The change in the percentage treatment can show varied results whereas in jute there was 1. 9% increase in the tensile strength for 20% volume fraction, whereas there was a decrease in the impact strength. Also, it is observed that the impact strength showed no improvement in the properties by treating the fiber at 10% banana volume fraction at 3% potassium permanganate in 1 liter of water hence the impact strength is the property. The flexural strength at 10% volume fraction of banana had an 1. 41% increase. The jute fiber had an increase in the tensile strength. For hybrid fiber 30% volume fraction, there was a higher increase in the mechanical properties compared to the non -hybrid which can be concluded that the mixing of two fiber makes the fiber more strong. Based on the experiment conducted it can be concluded that the treatment of fiber with potassium permanganate can be done to increase the tensile and flexural strength, but impact strength does not show any improvement in the properties. The results show that the natural fiber composite has the tendency to be used in lightweight objects and the materials which are not subjected to higher force and strength. Since the improvement in the properties was seen in the tensile and flexural strength when it is treated but not in impact strength.

REFERENCES

1. P. Senthilkumar and S. Ravi., "The Effect of Alkali Treatment on The Mechanical Properties Of Sisal Fiber Reinforced Epoxy Composites", *International Journal of Advanced Scientific Research & Development.*, Vol. 04, Issue 03, pp. 31–39, 2017.
2. Jai Inder Preet Singh., Vikas Dhawan., Sehijpal Singh., Amrinder Singh Pannu and Sarath. S., "Effect Of Alkali Treatment On Mechanical Properties Of Jute, Sisal, Banana, Hemp And Abaca Fibers For Polymer Composite Reinforcement", *International Journal of Mechanical Engineering and Technology*, Volume 8, Issue 7, pp. 1775–1784, 2017.
3. Maries Idicula, "Banana and Sisal Fibre Reinforced Polyester Composites", A Thesis submitted to the Mahatma Gandhi University, 2006.

4. Easwara Prasad G L., KeerthiGowda B S., and Velmurugan R., "Comparative Study of Impact Strength Characteristics of Treated and Untreated Sisal Polyester Composites", *11th International Symposium on Plasticity and Impact Mechanics, Implast 2016, Procedia Engineering*, Vol. 173, pp. 778 – 785, 2017.
5. M. Sakthivel and S. Ramesh, "Mechanical Properties of Natural Fibre (Banana, Coir, Sisal) Polymer Composites", *Science Park*, Vol. 1, Issue 1, pp. 2321–8045, 2013.
6. Rajesh Ghosh, A Rama Krishna, G Reena and Bh Lakshmi pathi Raju, "Effect of fiber volume fraction on the tensile strength of Banana fiberreinforced Vinyl Ester resin composite" *International Journal of Advanced Engineering Science and Technology*, Vol. 4, Issue 1, pp. 89-91, 2011.
7. S Somashekar and G C Shanthakumar, "Effect of Alkali Treatemnet on Mechanical Properties of Sisal- Reinforced Polymer matrix Composite", *International Journal of Mechanical Engineering*, Vol. 3, No. 4, 2014.
8. Joao Bessa., Joana Matos., Carlos Mota., Fernando Cunha., Isabel Araújo., Luís Silva., Elizabete Pinho and Raúl Figueiro, "Influence of Surface Treatments on the Mechanical Properties of Fibre Reinforced Thermoplastic Composites", *3rd International Conference on Natural Fibers: Advanced Materials for a Greener World, ICNF 2017, Portugal*, 2017.
9. KM, Ahsana Fathima, and Shibi Varghese. "Behavioural Study of Steel Fiber And Polypropylene Fiber Reinforced Concrete. " (2014).
10. T. Rajasekaran and K. Gokul, "Evaluation of mechanical characteristics of treated and untreated sugarcane fiber composites", *Journal of Chemical and Pharmaceutical Sciences*, Vol. 9, Issue 1, 2016.
11. M. J. M. Ridzuan., M. S. Abdul Majid., M. Afendi, K. Azduwin., S. N. Aqmariah, Kanafiah And Y. Dan-Mallam, "The Effects of the Alkaline Treatment's Soaking Exposure on the Tensile Strength of Napier Fibre", *2nd International Materials, Industrial, and Manufacturing Engineering Conference, Procedia Manufacturing*, Vol 2, pp. 353 – 358, 2015.
12. M. Ramesh., T. SriAnanda Atreya., U. S. Aswin., H. Eashwar And C. Deepa, "Processing And Mechanical Property Evaluation Of Banana Fiber Reinforced Polymer Composites", *12th Global Congress On Manufacturing And Management, Procedia Engineering*, Vol. 97, pp. 563 – 572, 2014.
13. Ajith Gopinath., Senthil Kumar. M., Elayaperumal A, "Experimental Investigations on Mechanical Properties Of Jute Fiber Reinforced Composites with Polyester and Epoxy Resin Matrices", *12th Global Congress On Manufacturing And Management, Procedia Engineering*, Vol. 97, pp. 2052–2063, 2014.
14. J. Santhosh., N. Balanarasimman., R. Chandrasekar and S. Raja, "Study Of Properties Of Banana Fiber Reinforced Composites", *International Journal of Research in Engineering and Technology*, Vol. 03, Issue 11, 28-34, 2014.
15. William Jordan and Patrick Chester, "Improving the Properties of Banana Fiber Reinforced Polymeric Composites by Treating the Fibers", *3rd International Conference on Natural Fibers: Advanced Materials for a Greener World, Procedia Engineering*, Vol, 200, pp. 283–289, 2017.