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Characterization of Aegle Marmelos Fiber Reinforced Composite

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Abstract: Due to environmental contamination, a lot of research is being done to evolve on green engineering in the area of material science. To cope up with the problems, researchers are showing their interest in the industrial applications of composites made from natural fibers, bio or industrial waste. Because of their superior properties, the natural fiber-reinforced polymer composites are being used more frequently in the composite industry and more researchers are studying them. In this paper, the bark of Aegle Marmelos is taken as natural fiber for examining tensile strength and flexural strength. Scanning Electron Microscope (SEM) analysis is also accomplished to know the bonding between the reinforcement and the matrix.

Keywords: Composites, Aegle marmelos, Natural fiber, Tensile strength, Flexural strength, Scanning Electron Microscope.

I. Introduction

Composite is a combination of two or more distinct materials (such as base, binder, filler, reinforcer) that do not merge (do not lose their individual identities) but still impart their properties to the product resulting from their combination. Generally, a composite material is made by combining a binding resin (matrix) with small filaments of solid material (reinforced material). The matrix is usually a viscous material which binds together the reinforcing fibers of a composite. It hardens to give shape to the composite part and also protects the fibers from damage. The reinforced material provides strength, stiffness, and the ability to carry a load. When designed properly, the new combined material offers better strength than would each individual material. Green composite or bio-composite is a composite material which consists of one or more phase(s) of natural or biological origin. As reinforcement, it includes bio wastes like leaves of coconut shell, waste wood powder, waste paper, or even byproducts of food crops, or fibers from plant or vegetables such as cotton, flax, hemp, jute, cane, banana and the like.

Today, scientists and technologists are looking for substitute materials, due to the scarcity of conventional materials. Natural waste materials have potential to supersede the existing conventional materials because of their good characteristics like low cost, easy fabrication, high strength to weight ratio, better thermal and insulating properties, renewable, totally or partially recyclable and biodegradable. Most of the research to date has concentrated on using various natural fibers or particulates to reinforce natural polymer composites, but a very little study has been practiced along the bark of Aegle Marmelos, commonly known as Bel, Bilva or Maredu, which grow throughout India, Bangladesh, Sri Lanka, and other nations.

Aegle Marmelos belongs to the Rutaceae family. It is an important indigenous fruit of Asia and is identified by different names such as bael, bel, bengal quince, golden apple, stone apple, wood apple, shul, shailphal, vilvam etc. Besides the wide medicinal utility, its leaves and fruits are of religious importance since the tree is considered as one of the sacred trees of Indian heritage. It is believed in India that Aegle Marmelos tree is able to grow in places where other trees cannot. The bark of like Aegle Marmelos can be a promising material for use as reinforcement in polymer matrix. The bark of the Aegle Marmelos meets the demands of industry and consumers to find new materials that are compatible with the environment. This paper presents the study of tensile and flexural strengths and scanning electron microscope (SEM).Validation of experimental data has been done through regression analysis.

II. Literature review

Lot of research has been carried out on the natural fibers composites prepared by various methods by taking various natural fibers and considering different parameters like fiber length, orientation of the fibers, distribution of fibers whether continuous or discontinuous fibers etc. **Maya Jacob et al.** [1] studied the effects of concentration and modification of fiber surface in sisal/oil palm hybrid fiber reinforced rubber composites on the mechanical properties. The natural rubber was reinforced with untreated sisal and oil palm fibers chopped to different fiber lengths and were treated with varying concentrations of sodium hydroxide solution and for different time intervals. The mechanical properties of the alkali treated fibers exhibited better tensile properties than untreated composites.

N. Venkateshwaran et al. [2] predicted the tensile properties of banana and sisal fibers epoxy resin composite. The fabrication of the composite material Hybrid composites were prepared using banana/sisal fibers of 40:0, 30:10, 20:20, 10:30, and 0:40 ratios by laying fibers uniformly was carried out through the hand lay-up technique, the test specimens were subjected to various mechanical tests as per ASTM standards. The tensile strength and modulus of short, randomly oriented hybrid-natural fiber composite was found out experimentally and predicted using Rule of Hybrid Mixture (RoHM). It was observed that the RoHM equation predicted tensile properties of hybrid composites are little higher than experimental values.

J. Madhukiran et al. [3] investigated the flexural properties of composites made by reinforcing banana and pineapple as the new natural fibers into epoxy resin matrix prepared by using hand layup technique. The natural fibers were extracted by retting and manual process. By using banana/pineapple fibers, hybrid composites were fabricated in weight fraction ratios 0/40, 15/25, 20/20, 25/15, and 40/0. It has been observed that the increase in fibers weight fraction increased the flexural properties. The flexural strength of hybrid composites exhibit better results than natural fibers reinforced composites. Similar results were observed for flexural modulus, inter laminar shear strength and break load values. **K. Mohan Babu et al.** [4] attempted to produce natural fiber made hybrid polymer composite. The matrix is made from Cashew Nut Shell (CNSL) resin and General Purpose resin with jute as fiber. The CNSL and GP resin were prepared with various weight ratios (5/95,10/90,15/85,20/80, 25/75) for each proportion two samples one was with jute fiber and other was without fiber were fabricated. The composite stress-strain behavior was identified during tensile loading. The results show that, the strength of the composite decreased by the addition of cashew nut shell resin while tensile strength and elongation were improved with increase in CNSL proportion and CNSL/GP ratios respectively.

H. Raghavendra Rao et al. [5] studied the impact properties and chemical resistance of Bamboo/Glass reinforced epoxy hybrid composites. The composites were made by hand layup technique with dimensions of 200mm×200mm×3mm using a glass mould. From the results, it was observed that impact properties and chemical resistance of the hybrid composites found to be higher when alkali treated bamboo fibers were used in the hybrid composites. The hybrid fiber composites showed better resistance to the chemicals mentioned above, may be due to the alkali treatment of the bamboo fibers.

Vemu Vara Prasad et al. [6] studied the tensile properties of Bamboo/Glass reinforced epoxy hybrid composites and chemical resistance of hybrid composites to acetic acid, Nitric acid, hydrochloric acid, sodium hydroxide, ammonium hydroxide, sodium carbonate, benzene, toluene, Carbon tetrachloride and water. The effect of alkali treatment of the bamboo fibers on these properties was studied. It was found that tensile properties of the hybrid composites increase with glass fiber content and the properties found to be higher when alkali treated bamboo fibers were used in the hybrid composites. The hybrid fiber composites showed better resistance to the chemicals mentioned above, may be due to the alkali treatment of the bamboo fibers.

Raghavendra Yadav Eagala et al. [7] have conducted a study on the physical and abrasive wear behavior of the composites. Cylindrical discontinues Hybrid Composite pins of 10mm diameter using high strength E-glass fiber were made and with Epoxy as a matrix by using metal mold by hand layup method, natural bamboo fiber were made. Different set of composites are prepared using E-glass fiber, bamboo fiber and Epoxy. Two-body abrasive wear tests were performed using a single pin-on-disc wear testing. Taguchi's experimental design was used to identify the abrasion wear characteristics and Leitz micro-hardness tester was used to identify the micro-hardness of composite specimens. **C.S.Verma et al.** [8] studied the tensile Strength of Bamboo and layered laminate Bamboo composites in which Bamboo laminae, prepared from bamboo slivers, were used. Fracture behavior of laminas and LLBCs were studied using scanning electron microscopy (SEM). The experimental results revealed that tensile strength of unidirectional LLBC reduced when compared to average of laminae of bamboo Culm. It was mentioned that the properties of LLBCs resembled with the properties of the teak wood.

Pruttipong Pantamanatsopa et al. [9] focused on the mechanical properties of natural rubber (NR) green composite fabricated using two roll mills followed by hot compression molding technique . The weight% of jute fiber taken were 0, 10, 20 and 40. Structure analysis, tensil testing and dynamic mechanical analysis was performed using a Scanning Electron Microscopy, Universal Testing Machine and Perkin Elmer DMA 8000 respectively. The results suggested that the increase of filler content increased the modulus and hardness but tensile strength was decreased. It was also observed that NR/jute untreated improved mechanical properties of composite more than NR/jute treated.

III. Materials and Methods

3.1 Raw materials used in this experimental work are as follows:

I. Epoxy resin
II. Hardener
III. Aegle Marmelos(Bilvam) Fiber:

3.2 Composite preparation

Aegle Marmelos fibers dispersed in epoxy matrix composites have been prepared. For this purpose, a glass mold of 200 X 200 X 03 mm^3 is used. A white waxed Mylar sheet is employed to shield the glass mold for good surface finish and easy withdrawal of prepared specimen. Firstly, a number of Aegle Marmelos leaves were collected from its tree and then fibers were extracted from them. The fibers of 10 grams in weight were taken and cut down as per the specifications of the mold. Those reaped fibers were then placed in the mold. Meanwhile, the epoxy and the hardener were taken into a flask and mixed in a proportion of 10:1. The mixture was continuously being stirred with a mechanical stirrer for homogenous mixing. After placing the fibers in a required orientation, the mixture of epoxy and hardener was poured slowly into the mold. An Overhead projector (OHP) sheet was used to withdraw the excess epoxy and hardener solution out of the mold. After 24 hours, the mold was placed in an oven for a certain period of time and taken out for a safe removal of the prepared composite from it. After removal from the mold, the composite was cut with a diamond cutting tool according to ASTM standard for different tests.

IV. Mechanical properties

The mechanical properties of a composite material are influenced by so many factors like type of reinforcement, amount of reinforcement, processing parameters, distribution of reinforcing material in the matrix and kind of bonding that takes place between matrix and reinforcement. After fabrication, the test samples were subjected to various mechanical tests as per the ASTM Standards. The tensile test and flexural tests were carried out by using Universal Testing Machine (UTM).

Fig. 4.1: UTM for tensile and flexural tests

Fig. 4.2: Specimens in Straight, Criss Cross and Slant Orientations for tensile test

Fig. 4.3: Specimens in Straight, Criss Cross and Slant Orientations for Flexural test

4.1 Tensile test

The samples prepared for tensile test had a dimension as per ASTM: D638-10. The samples were tested at a crosshead speed of 10mm/min, using UTM, at the room temperature. Three samples in each orientations were examined to receive a good error estimates. The Tensile test determines the overall strength of a given object. In it, the specimen is fitted between two grippers and load is applied slowly which pulls the object apart until it breaks.

The tensile strength of Aegle Marmelos composite fiber of different weights in three different orientations has been obtained experimentally using UTM. The results are compared and given below in Table 1 and are also shown in Fig. 6 with the help of bar graphs.

Table 4.1: Comparison of tensile strength of three different orientations

Weight of fiber	Straight orientation	Criss-cross orientation	Slant orientation
5	29.71	9.44	6.69
10	32.64	13.32	12.52
15	35.87	15.83	8.65
20	39.93	18.31	14.35

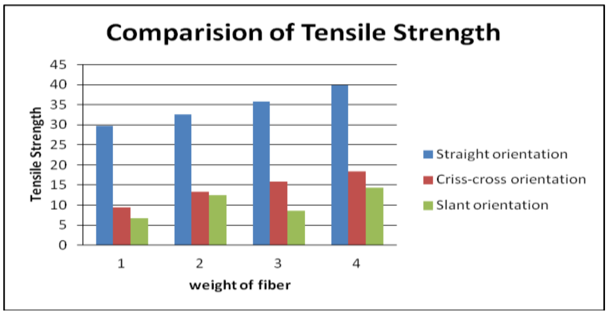

Fig. 4.4: Comparison of tensile strength

4.2 Flexural test

The Flexural method measures the behavior of materials subjected to simple beam loading. It is also called as transverse beam test. It plays a very important role in structural application purposes. To determine the flexural strength of composites a three-point bending test was carried out as per ASTM D790-03 procedure. The samples were tested at a crosshead of 10 mm/min, at a temperature of 18°C and humidity 50%. Three samples in each orientations were examined to receive a good error estimates.

The flexural strength of Aegle Marmelos composite fiber of different weights in three different orientations was obtained experimentally using UTM. The results were compared and are given below in Table 2 and are also shown in Fig. 10 with the help of bar graphs.

Table 4.2: Comparison of flexural strength of three different orientations

Weight of fiber	Straight orientation	Criss-cross orientation	Slant orientation
5	63.35	19.91	63.85
10	83.77	21.22	66.35
15	95.18	29.54	71.66
20	101.86	48.37	80.36

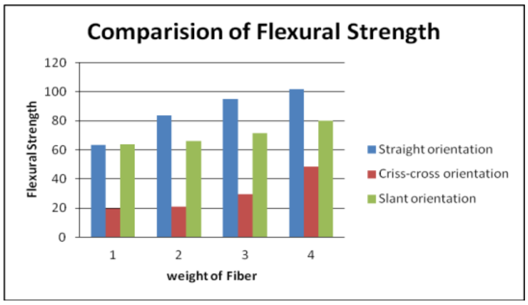

Fig. 4.5: Comparison of Flexural Strength

V. Validation of the experimental results

Validation of the experimental results is carried out using regression analysis. In this work, one factor analysis has been carried out with a single factor, weight of the fiber (W). regression equations are modeled with the experimental results to identify the relation between the input parameter 'w' and the responses, tensile strength and flexural strength, given in the equations 5.1 to 5.6.

Straight orientation:

$Ts_1=27.4775 + 0.3953*A + 0.0113*A^2$ ---------------- (5.1)

$Fs_1=37.13 + 5.97380*A – 0.1374*A^2$ ---------------- (5.2)

Criss-cross orientation:

$Ts_2=5.195 + 0.9324*A – 0.014*A^2$ ---------------- (5.3)

$Fs_2=28.235- 2.506*A + 0.1752* A^2$ ---------------- (5.4)

Slant orientation:

$Ts_3=3.535 + 0.5124*A + 0.0228* A^2$ --------------- (5.5)

$Fs_3=64.5950 – 0.45320*A + 0.062*A^2$ --------------- (5.6)

Table 5.1 shows that the predicted responses are in close relation with experimental values, which indicates the validity of the models within the range of ±3%deviation.

Table 5.1: experimental and predicted values with percentage deviation

Straight	Tensile strength (MPa)			Flexural Strength (MPa)		
Wt of fiber (g)	Exp	Pred	% dev	Exp	Pred	% dev
5	29.71	29.736	-0.08	63.35	63.56	-0.33
10	32.64	32.56	0.243	83.77	83.13	0.766
15	35.87	35.945	-0.22	95.18	95.82	-0.67
20	39.93	39.903	0.066	101.86	101.6	0.21
Criss-cross						
Wt of fiber (g)						
5	9.44	9.507	-0.71	19.91	20.085	-0.88
10	13.32	13.119	1.51	21.22	20.695	2.474
15	15.83	16.031	-1.27	29.54	30.065	-1.77
20	18.31	18.243	0.365	48.37	48.195	0.361
Slant						
Wt of fiber (g)						
5	6.69	6.667	0.343	63.85	63.879	-0.04
10	10.87	10.939	-0.63	66.35	66.263	0.131
15	16.42	16.351	0.42	71.66	71.747	-0.12
20	22.88	22.903	-0.1	80.36	80.331	0.036

VI. Scanning Electron Microscope (SEM) analysis

A scanning electron microscope (SEM) is a type of electron microscope that produces pictures of a sample by scanning it with a focused beam of electrons. The electrons interact with the atoms in the sample, producing various signals that can be detected and that contain information about the sample's surface topography and composition. The electron beam is generally scanned in a raster scan pattern, and the beam's position combines with the detected signal to produce an image. SEM can achieve resolution better than 1 nm. Specimens can be observed in high vacuum, in low vacuum, in wet conditions (in environmental SEM), and at a wide range of cryogenic or elevated temperatures.

Fig. 5.1: SEM apparatus

In the present work, the interfacial bonding between the matrix and reinforcement composites are carried out. The cryogenically cooled and fractured specimen surfaces are gold coated and the fractured surface is photographed using Scanning Electron

Microscope (SEM), sown in the figure 5.1. Figure 5.2 picturises the microstructures of untreated fiber under SEM.

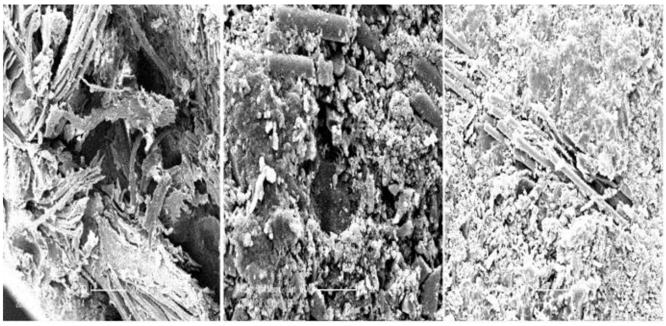

Fig. 5.2: Untreated Aegle Marmelos fiber 200X magnification(Straight, Slant and Criss-cross orientations)

VII. Conclusion

Composites of epoxy dispersed with 5, 10, 15 and 20 wt% Aegle Marmelos fiber, have been successfully prepared. Evaluation of mechanical properties (tensile and flexural strengths) and SEM analysis has been performed for various orientations. It was found that the tensile strength of the composites in straight orientation increases with the weight of the fiber within the experimental range. The flexural strength of straight and criss-cross orientations increases with an increase in weight of the fibers. From the SEM analysis diagrams, it is evident that the fiber pullout within the specimen is due to the lesser bonding between the reinforcement and the matrix material.

References

i. *Maya Jacob, Sabu Thomas, K.T. Varughese, "Mechanical properties of sisal/oil palm hybrid fiber reinforced natural rubber composites", Composites Science and Technology 64 (2004) pp.955–965.*

ii. *N. Venkateshwaran, A. Elayaperumal, G.K. Sathiya, "Prediction of tensile properties of hybrid-natural fiber composites", Composites: Part B 43 (2012) pp.793–796.*

iii. *Madhukiran.J, Dr. S. Srinivasa Rao, Madhusudan.S, "Fabrication and Testing of Natural Fiber Reinforced Hybrid Composites Banana/Pineapple" International Journal of Modern Engineering Research (IJMER) Vol. 3, Issue. 4, July-august. 2013 pp-223-243.*

iv. *Mohan Babu K, Ramanathan K, Viswanath S, Venkatachalam G and Narayanan S., "Fabrication and Analysis of Hybrid Polymer Green Composite", International Journal of Applied Engineering Research, ISSN 0973-4562, Vol. 8, No. 19 (2013) pp.2479-2482.*

v. *H. Raghavendra Rao, P. Hari Sankar and M. Murali Mohan, "Chemical Resistance and Impact Properties Of Bamboo / Glass Fibers Reinforced Polyster Hybrid Composites", International Journal of Engineering Research ISSN:2319-6890)(online),2347-5013(print) Volume No.3 Issue No: Special 1, pp: 79-8.1*

vi. *Vemu Vara Prasad, Mattam Lava Kumar, "Chemical Resistance And Tensile Properties Of Bamboo And Glass Fibers Reinforced Epoxy Hybrid Composites", International Journal of Materials and Biomaterials Applications 2011; 1 (1):pp. 17-20.*

vii. *Raghavendra Yadav Eagala, Allaka Gopichand, Gujjala Raghavendra, Sardar Ali S, "Abrasive Wear Behaviour Of Bamboo-Glass Fiber Reinforced Epoxy Composites Using Taguchi Approach" International Journal of Advances in Engineering & Technology, Nov. 2012 Vol. 5, Issue 1, pp. 399-405.*

viii. *C.S. Verma, V.M. Chariar, R. Purohit, Tensile Strength Analysis of bamboo and Layered Laminate Bamboo composites , IJERA,Vol. 2, Issue 2,Mar-Apr 2012, pp.12531264.*

ix. *Pruttipong Pantamanatsopa, Warunee Ariyawiriyanan, Tawatchai Meekeaw, Rattiyakorn Suthamyong, Ketsara Arrub and Hiroyuki Hamada, "Effect of Modified Jute Fiber on Mechanical Properties of Green Rubber Composite" Energy Procedia 56 (2014) pp.641 – 647.*

x. *Vivek Mishra, Sandhyarani Biswas, "Physical and Mechanical Properties of Bi-directional Jute Fiber epoxy Composites" Procedia Engineering 51 (2013) pp.561 – 566.*

xi. *S.Sabinesh, C.J.Thomas Renald and S.Sathish, "Investigation on Tensile and Flexural Properties of Cotton Fiber Reinforced Isophthallic Polyester Composites" International Journal of Current Engineering and Technology E-ISSN 2277 – 4106, P-ISSN 2347 – 5161.*

xii. *M.K. Gupta, R.K. Srinivasa, "Tensile and flexural properties of sisal fiber reinforced epoxy composite. A comparison between unidirectional and mat form of fibers", Procedia Materials Science 5 (2014) pp.2435 – 2439.*

xiii. *Sukhdeep Singh, Dharmpal Deepak, Lakshya Aggarwal, V.K. Guptab, "Tensile and flexural*

xiv. *behavior of hemp fiber reinforced virginrecycled HDPE matrix composites", Procedia Materials Science 6 (2014) pp.1696 – 1702.*

xv. *N.V. Rachchh, P.S. Ujeniya and R. K. Misra, "Mechanical characterisation of rattan fiber polyester composite", Procedia Materials Science 6 (2014) pp.1396-1404.*

xvi. *Rahul Kumar, Kausik Kumar, Prasanta Sahoo and Sumit Bhowmika, "Study of Mechanical Properties of Wood Dust Reinforced Epoxy Composite", Procedia Materials Science 6 (2014) pp.551 – 556.*

xvii. *Gao Guangfa, Li Yongchi, Jing Zheng, Yuan Shujie, "Experimental Investigation on Thermal Physical Properties of an Advanced Glass Fiber Composite Material", Physics Procedia 25 (2012) pp.339 – 344.*