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Tensile and Flexural Properties of Udal Fiber Reinforced Epoxy Composites

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Abstract

Development of epoxy resin based composites reinforced with Udal fiber at different fiber loading (20, 30 & 40 wt%) pattern using hand-layup and compression molding technique has been described. The fibers were chemically treated for better compatibility between fiber and matrix. Mechanical properties of the composites i.e. tensile and flexural properties were investigated. Flexural properties were found enhanced during testing .Water absorption behaviour of the composites were also studied.

Keywords: Udal Fiber, Mechanical Properties, Adhesion, Compression Molding.

Introduction

Over the last thirty years composite materials, plastics and ceramics have been the dominant emerging materials. The volume and number of applications of composite materials have gone steadily, penetrating and conquering new markets relentlessly. Modern composite materials constitute a significant proportion of the engineered materials market ranging from everyday products to sophisticated niche applications[1] while composites have already proven their worth as weight-saving materials, the current challenge is to make them cost effective. The efforts to produce economically attractive composite components have resulted in several innovative manufacturing techniques currently being used in the composites industry.[2] It is obvious, especially for composites, that the improvement in manufacturing technology alone is not enough to overcome the cost hurdle. It is essential that there be an integrated effort in design, quality assurance, manufacturing and even program management for composites to become competitive with metals. The composites industry has begun to recognize that the commercial applications of composites promise to offer much larger business opportunities than the aerospace sector due to sheer size of transportation industry. Thus the shifts of composite applications from aircraft to other commercial uses have become prominent in recent years, increasingly enabled by the introduction of newer polymer resin matrix materials and high performance reinforcement fibers of glass, carbon and aramid, the penetration of these advanced materials has witnessed a steady expansion in use and volume. Composites are now extensively being used for strengthening of pre-existing structures that have to be retrofitted to make them seismic resistant, or to repair damage caused by seismic activity. Unlike conventional materials (e.g. steel), the properties of the composite material can be designed considering the structural aspects[3].The design of a structural component using composites involves both material and structural design. Composite properties (e.g. stiffness, thermal expansion etc.) can be varied continuously over broad range of values under the control of the designer.

Increased environmental awareness and consciousness throughout the world has developed an increasing interest in natural fibers and its application in various fields. Natural fibers are now considered as serious alternative to synthetic fibers for use in various fields. The use of natural fibers as reinforcing materials in both thermoplastic and thermoset matrix composites provides positive environmental benefits with respect to ultimate disposability and best utilization of raw materials[4] Currently, studies on use of lignocellulose bio fibers in place of synthetic fibers as reinforcing materials are being pursued vigorously. These bio fibers are being extensively used for the production of cost effective ecofriendly biocomposites[5,6] The advantages of natural fibers over traditional reinforcing materials such as glass fiber, carbon fiber etc. are their specific strength properties, easy availability, light weight, ease of separation, enhanced energy recovery, high toughness, non-corrosive nature, non-toxic, low density etc.

In the present work, the newly identified *Sterculia villosa* fiber[7] (commonly known as Udal fiber) was used for the preparation of epoxy composite. The fiber was treated with alkali before used. The tensile and flexural strength along with water absorption capacity of the composites were investigated to ascertain the applicability of the composites.

Experimental

Fig. 1: Udal Tree

Fig. 2: Udal Fiber

Method and Materials

The epoxy resin used in this study was a diglycidyl ether of bisphenol-A (DGEBA), with an epoxide equivalent weight of 185g/eq and viscosity11400cps, supplied by Kumud enterprise, Kharagpur, India.The hardener used is a polyamidoamine with amine value 7.1 at 25^0 C.

Collection of Fiber

The Udal fiber is collected from Diphu, KarbiAnglong a renowned hilly district of Assam. It is collected from the bark of the Udal tree.

Processing of the Fiber and Its Treatment with Alkali

1. At first the Udal fiber was thoroughly washed with water and then dried.
2. The Udal fiber is boiled for 30 minutes with 1% of NaOH solution, so as to make the fiber soften and to loosen the fibers from the bark.
3. After boiling it is cooled and washed with distilled water for 13 to 15 times to remove the dirt. Lastly it is washed with water containing a small amount of acetic acid to remove the alkali from the fiber.
4. The fiber is kept in the oven at 60^0 Celsius for 30 minutes for drying.
5. The dried Udal fiber was cut into 2mm pieces with the help of scissors.

Fig: Udal fiber after treatment with NaOH solution

Fabrication of Udal Fiber Epoxy Composite Material

Dried udal fibers were arranged into uniform mats of thickness 3-5mm. These mats and the mold measuring 120X 120 X 3 mm were preheated at 80^{0}C for 5 min and then cooled. Silicon oil, a mold-releasing agent was applied on the surface of the mold to facilitate easy removal of the composite after curing. The resin was degassed before pouring into the mold. Epoxy resin and hardener is mixed in 2:1 ratio. The resin was spread at the bottom of the mold and one udal fiber mat was placed and dipped on it. Again a thin layer of resin was spread on it and another fiber mat was placed over it. The process was repeated to get the proper thickness and in each step the air bubbles that were entrapped inside the mat were released by pressing with a steel roller. Some resin was poured on the top. Mold was closed and kept under pressure (1 ton) for 1 hr in order to compress the fiber mats and kept as such for another 23 h. The composite block was post cured by keeping in open air for 1 day and then machined into specimen of required sized for mechanical test.

The relative amount (wt%) of reinforcing material and epoxy resin in composites is shown below.

Table 1

Composite Designation	Fiber (wt%) Udal Fiber	Epoxy Resin (wt%)
E	0	100
UFC1	20	80
UFC2	30	70
UFC3	40	60

“E” denotes Epoxy resin and “UFC” denotes Udal fiber composite.

Characterization of The Epoxy Composite by Following Tests

1. Tensile test
2. Flexural test
3. Water absorption test

Tensile Test

Tensile test was conducted according to ASTM D-638 using a universal testing machine Hounsfield, England, Model: H100K-S at a crosshead speed 50mm/min.

Flexural Test

Flexural test was carried out according to ASTM D-790 using the same testing machine at same crosshead speed.

Water Absorption Test

Water absorption test specimens (50mm X 40 mm) were cut from the composite sheet and all specimens were kept immersed in distilled water after taking initial weight. The specimens were periodically taken out of the water, surface dried with absorbent paper, reweighed put back into the water. Water absorption values were calculated in percentage and plotted in a graph.

The percentage of water absorption was calculated from eq 1.

Water absorption (%) = Wn- Wd/Wd……..1

Where Wn is the weight of composite after immersion and Wd is the weight of the composite before immersion.

Results and Discussion

The mechanical properties like tensile strength and flexural strength of Udal fiber reinforced epoxy composites are shown in table 2

Table 2: Mechanical Properties of Udal Fiber Composite

Sample	Tensile strength (MPa)	Flexural strength (MPa)
E	37.82	59.70
UFC1	22.1	40.5
UFC2	29.81	62.37
UFC 3	29.21	55.6

Tensile Strength and Flexural Strength

It is observed from table 2 that Tensile strength of udal fiber composite increases with fiber loading from 20-30%, but decreases with fiber loading 40%. The highest value of mechanical properties is exhibited by the composite containing 30% fiber loading. But this value is lower than the tensile strength of pure epoxy resin. So it is not expected.

Likewise the tensile strength Flexural strength of the udal fiber composite increases from 20-30% and the highest value of flexural strength is exhibited by the composite containing 30% fiber loading.

Water Absorption test

Udal fibers are hydrophilic in nature due to the presence of polar group(-OH) in its structure, the polar group forms hydrogen bonds by absorbing water molecules and this induces swelling in fibers.

The percent water uptake of pure epoxy and composites were measured with different time interval (days) and presented in fig1.

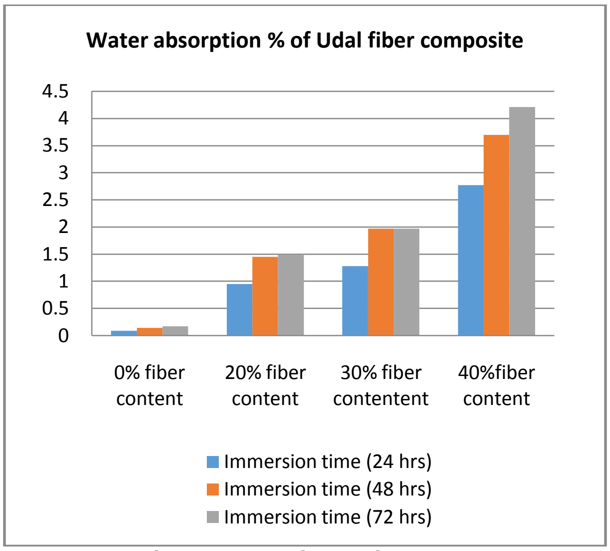

Fig.3: Water Absorption %

It is observed that the epoxy resin observed less amount of water compared to fiber reinforced composites. From the figure it is observed that water absorption of different udal fiber composites first increases and then gradually decreases and finally becomes stable. For different composites with varying fiber content (20-40) water absorption found is 2-4%. As the fiber volume fraction increases percentage of cellulose content increases and hence amount of water absorption also increases.

Conclusion

Based on experimental results this study has led to the following conclusions.

1. The udal fiber can be used as reinforcing material to fabricate composite by suitably bonding with epoxy resin
2. The tensile strength and flexural strength of the composite increases with fiber loading from 20-30% but decreases with 40%. In case of flexural strength a significant result is obtained with 30% fiber content. The best combination is found with 30volm % of Udal fiber with 2mm length.
3. The fiber surface modification by alkali treatment improves the fiber matrix adhesion and also reduces hydrophilicity of natural fiber by leaching out non-cellulosic materials, which in turn improves mechanical properties of composite.
4. The moisture uptake values increases with increase in fiber loading.
5. Therefore fabrication of composite made of epoxy udal fiber system may find effective and potential industrial uses.

References

1. Gassan, Jochen. A study of fiber and interface parameters expecting the fatigue behavior of natural fiber composites. Part A: 2002; 33(3): 369-74
2. Rays D, Crosky A. Evans WJ. Natural bastfiber structure .Int J Mater Product Technol 2002; 17 (1-2): 2-10

3. Kandachar P, Bronwer R. App;ications of bio-composites in industrial products. Mater Res Soc Symp Proc 2002;702:101-12
4. Anon. The competitiveness of natural fibers based composites in the automotive sector the Sisal Agribusiness in Brazil Mater Res Soc Symp Proc 2002;702:113-39
5. Santuli C. Post-impact damage characterization on natural fiber reinforced composites using acoustic emission NDT & E International 2001;34(8): 531-6
6. Mishra, S, Tripathy, S. S., Mishra, M., Mohanty M.K.,Nayak, S.K.,Novel ecofreindly biocomposites: biofiber reinforced biodegradable polyester amide composites- fabrication and properties evaluation. J Reinf Plast Comp 2002:21(1): 55-70
7. M. Reddy, K Varaprasad, E.R. Sadiku, S. Singha Ray, A. Varada Rajulu (2013) Preparation and properties of biodegradqble films from Sterculiaurens short fiber/cellulose green composites: Carbohydrate polymers 93 622-627.