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Chemical Resistance, Tensile And Impact Properties of Bamboo / Drumstick Fibers Reinforced Epoxy Hybrid Composites

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Abstract *:* In the present work, the chemical resistance of Bamboo/Drumstick reinforced epoxy hybrid composites to acetic acid, Nitric acid, Hydrochloric acid, Sodium hydroxide, Sodium carbonate, Benzene, Toluene, Carbon tetrachloride and Water was studied. The tensile and impact properties of these composites were studied. The effect of alkali treatment of bamboo fibers on these properties was also studied. It was observed that the tensile and impact properties of the hybrid composites increase with drumstick fiber content. These properties found to be higher, when alkali treated bamboo fibers were used in hybrid composites. The hybrid fiber composites have shown better resistance to the chemicals mentioned above. The elimination of amorphous hemi-cellulose with alkali treatment leading to higher crystallinity of the bamboo fibers with alkali treatment may be responsible for these observations.

Keywords*:* Bamboo Fiber, Composites, Chemical Resistance, Tensile Strength, Epoxy, Impact Strength, Drumstick Fiber.

1. INTRODUCTION

Several studies on the composites made from epoxy matrix and natural fibers like Jute, Wood, Banana, Sisal, Cotton, Coir and Wheat Straw were reported in the literature. Jindal, (1986) reported the development of bamboo fiber reinforced plastic composites using araldite (CIBA CY 230) resin as matrix. Though bamboo is extensively used as a valuable material from times immemorial (because of its high strength and low weight) the studies on this fiber reinforced plastics are meager. In the present work, the bamboo/drumstick fiber reinforced high performance epoxy hybrid composites were developed and their tensile and impact properties with fiber content (with varying ratio of drumstick/bamboo fibers) were studied. The effect of alkali treatment of the bamboo fibers on these properties was also studied. The chemical resistance properties with varying fiber percentage were also studied.

2. MATERIALS AND METHODS

Materials

High performance epoxy resin LY 556 and the curing agent hardener HY 951 system were used as the matrix. Bamboo fibers (*Dendrocalamus Strictus*) were procured from Tripura State of India in the dried form. Some of these fibers were soaked in 1% of NaOH solution for 30 min. to remove any greasy material and hemi cellulose. Washed thoroughly in distilled water and dried under the sun for one week. The fibers with a thickness of 0.3 mm were selected in the mat form.

Preparation of Mould

For making the composites, a moulding box was prepared with drumstick with 200mm×200mm×3mm mould (length × width × thickness).

Preparation of the composite and the test specimens

The mould cavity was coated with a thin layer of aqueous solution of *Poly Vinyl Alcohol* (PVA) which acts as a good releasing agent. Further a thin coating of hard wax laid over it and finally another thin layer of PVA was coated. Each coat was allowed to dry for 20 minutes at room temperature.

A 3mm thick plate was made from the epoxy and hardener taken in the ratio of 100 and 10 parts by weight respectively. Then the moulding box was loaded with the matrix mixture, bamboo and drumstick fiber in random orientation (with varying percentage) and was placed in vacuum oven which was maintained at 100^{o}c for 3 hours to complete the curing. After curing, the plate was removed from the moulding box with simple tapering and it was cut into samples for tensile test 150mm x 15mm x 3mm, Impact test 120mm × 13mm × 3mm and for chemical test with dimensions of 10mm × 5mm × 5mm. For comparison sake the specimen for matrix were also prepared in similar lines.

3. TENSILE LOAD MEASUREMENT

The Tensile stress and tensile moduli were determined using Instron 3369 model UTM. The cross head speed for tensile test was maintained at 10 mm per minute. In each case 5 samples were tested and average values are reported.

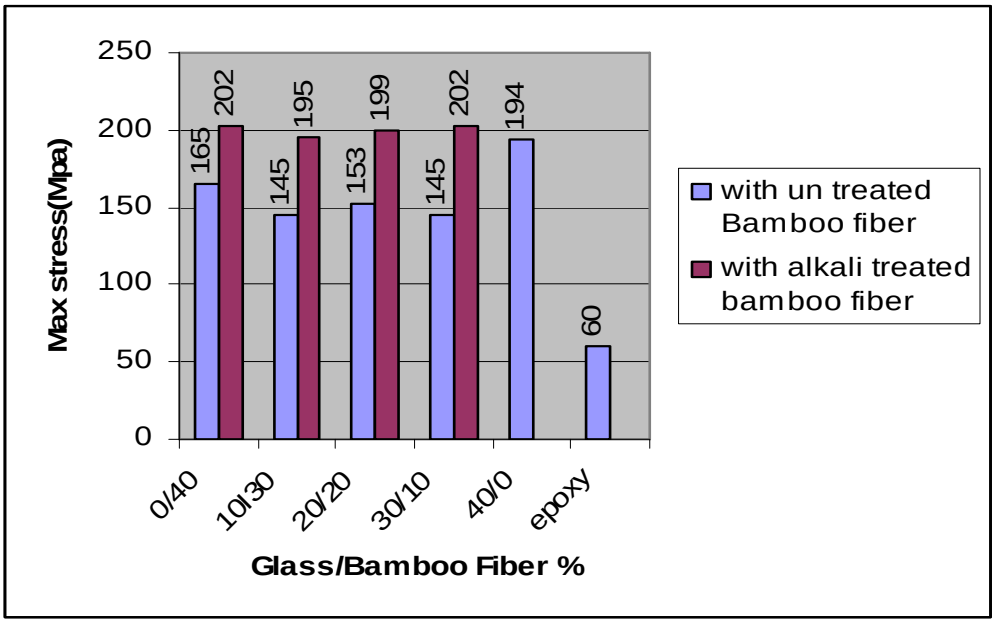

Fig.1: The variation of Tensile Maximum Stress at Yield with ratio of % Drumstick/Bamboo fibers reinforced Epoxy composites

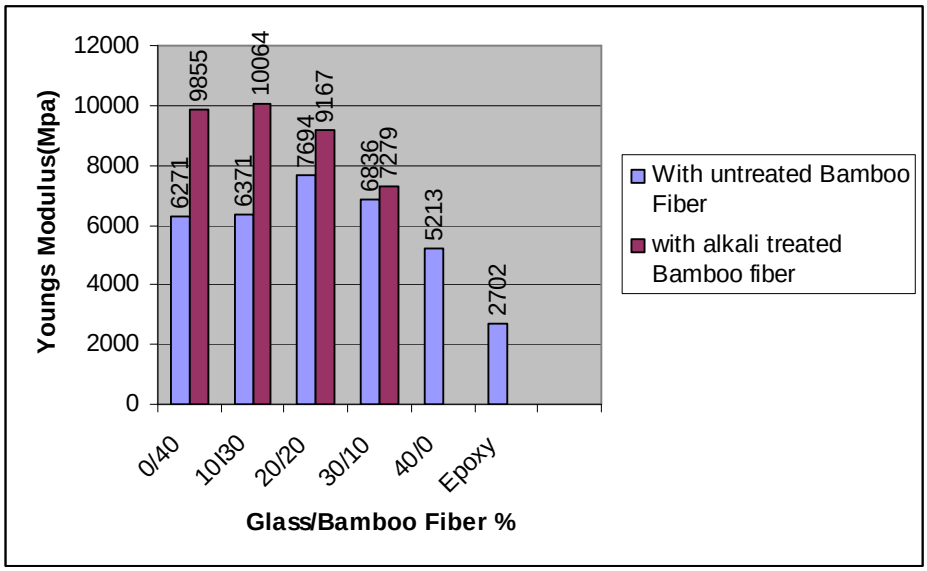

Fig. 2: The variation of tensile modulus with ratio of % Drumstick/Bamboo fibers reinforced Epoxy composites

4. IMPACT LOAD MEASURMENT

The impact strength is determined using IZOD impact tester. The test specimens with dimensions 120mm × 13mm × 3 mm are cut as per ASTM D 256-88 specifications. In each case five specimens are tested and average value is recorded.

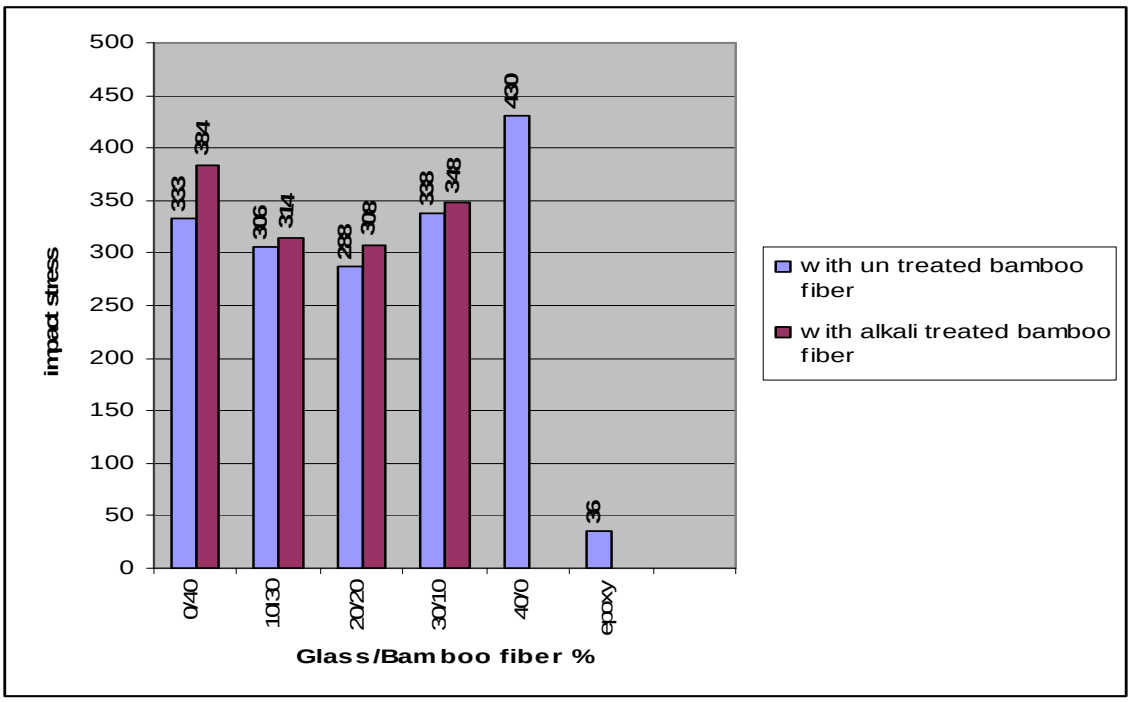

Fig.3: The variation of impact strength with the ratio of % Drumstick/Bamboo fibers reinforced epoxy composites.

5. CHEMICAL RESISTANCE OF COMPOSITES:

The chemical resistance of the composites was studied as per ASTM D 543-87 method. For chemical resistance test, the acids namely concentrated hydrochloric acid (10%), concentrated nitric acid (40%) and glacial acetic acid (8%), the alkalis namely aqueous solutions of sodium hydroxide (10%), ammonium hydroxide (10%) and sodium carbonate (20%) and the solvents- Benzene, Carbon tetra chloride, Toluene and Water were selected. In each case, ten pre-weighted samples were dipped in the respective chemicals under study for 24 hours, removed and immediately washed thoroughly with distilled water and dried by pressing them on both sides by filter papers. The final weight of the samples and % weight loss/gain was determined. The resistance test was repeated for ten samples in each case and the average values are reported.

Table.1 Resistance of Hybrid (drumstick/bamboo) composite reinforced epoxy to chemical regent's % of change in weight after immersion for 24 Hours.

Chemicals	Matrix	Composite
40% nitric acid	+0.2169	+0.25491
10% Hydrochloric acid	+0.9665	+0.25491
8% Acetic acid	+0.3965	+2.4299
10% sodium hydroxide	-0.4361	-2.7191
20% sodium carbonate	+0.777	-3.9756
10% Ammonium Hydroxide	-0.3973	-2.9185
Benzene	-1.371	-1.346
Toluene	-0.691	-2.360
Carbon tetrachloride	-1.134	+4.4458
Water	-1.212	-1.626

6. RESULTS AND DISCUSSION

The variation of tensile stress, tensile modulus and impact stress with percentage drumstick/bamboo fiber ratio is presented in Fig 1, Fig 2 and Fig 3 respectively. For comparison, these values for the matrix are also presented in the same figures. From these figures it is evident that the tensile and impact properties are enhanced when the alkali treated bamboo fibers were used in the hybrid composites. This is understandable as the hemi cellulose and the lignin contents decrease leading to higher percentage of crystalline α-cellulose in bamboo fibers on alkali treatment.The minimum and maximum values of tensile modulus for these composites are found to be 2702 and 10067 MPa respectively. Similarly the tensile stress values vary in the range of 60 to 202 MPa. The minimum and maximum values of impact strength for these composites are found to be 288 and 430 MPa respectively. Similar observation was made by Varadarajulu *et al.* (1998 – 2004) and Srinivasulu *et al.* (2006) in the case of some fiber composites and polymer coated bamboo fibers.

The effect of some acids, alkalis and solvents on the matrix and composite under study is presented in Table-1. From this table it is clearly evident that for matrix and composite, the weight gained is observed after immersion. This is understandable as the matrix is cross linked and as a result formation of gel takes place instead of dissolution. Similar observation was made by Varadarajulu *et al.* (1998 – 2004) in the case of short bamboo fiber reinforced high performance epoxy composites. It is also observed that the effect of sodium carbonate, benzene, toluene and carbon tetra chloride is negligible on both the matrix and composites. The chemical resistance of the hybrid composites with treated bamboo fibers is found to be better for the chemicals mentioned.

7. CONCLUSIONS

The hybrid composites of bamboo/drumstick fiber reinforced epoxy were made and their tensile, impact and chemical resistance properties were studied. The effect of alkali treatment of the bamboo fibers on these properties was studied. These hybrid composites were found to exhibit good impact and chemical resistance properties. The hybrid composites with alkali treated bamboo fibers were found to possess higher tensile and impact properties. The composites were found to be resistant to some acids, alkalis and solvents. The elimination of amorphous weak hemi cellulose components from the bamboo fibers on alkali treatment may be responsible for this behavior.

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