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Flexural, Impact Properties and Sem Analysis of Bamboo and Glass Fiber Reinforced Polyester Hybrid Composites

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Abstract
The Flexural, Impact properties and Scanning electron microscope analysis of Bamboo/glass fibers Reinforced polyester Hybrid composites were studied. The effect of alkali treatment of the bamboo fibers on these properties was also studied. It was observed that the Flexural, impact properties of the hybrid composite increase with glass fiber content. These properties found to be higher when alkali treated bamboo fibers were used in the hybrid composites. The elimination of amorphous hemi-cellulose with alkali treated leading to higher crystallinity of the bamboo fibers with alkali treatment may be responsible for these observations. The author investigated the interfacial bonding between Glass/Bamboo reinforced polyester composites. The effect of alkali treatment on the bonding between Glass/Bamboo composites was also studied.
Keywords*:* Dendrocalamus strictus, Bamboo fiber, Glass fiber, polyster Resin, SEM, Flexural Properties, Impact Properties, Hybrid Composites.

I. INTRODUCTION

Several studies on the composites made from polyster matrix and natural fibers like jute, wood, banana, sisal, cotton, coir and wheat straw were reported in the literature. Jindal [1] 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 & glass fiber reinforced high performance polyester hybrid composites were developed and their flexural, impact properties with fiber content (with varying ratio of glass/bamboo fibers) were studied. The author investigated the interfacial bonding between glass/bamboo reinforced polyester composites. The effect of alkali treatment on the bonding between glass/bamboo composites was also studied.

II. MATERIALS AND METHODS

2.1. Materials:

High performance polyester resin 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% NaOH solution for 30 min. to remove any greasy materials and hemi-cellulose, washed thoroughly in distilled water and dried under the sun for one week. The fibers with a thickness of 0.3mm were selected in the mat form. The glass chopped strand mat was used in making the hybrid composite percentage.

2.2. Preparation of mould:

For making the composites, a moulding box was prepared with glass of 200mm × 200mm × 3mm (Length × Width × Thickness).

2.3 *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. Futher a thin coating of hard wax was laid over it and finally another thin layer of PVA was coated. Each coat was allowed to dry for 20 min at room temperature. A 3mm thick plate was made from the polyester 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 & glass fiber in random orientation (with varying percentage) and was placed in a vacuum oven which was maintained at 100^{o}c for 3 hours to complete curing. After curing the plate was removed from the moulding box with simple tapering and it was cut in to samples for impact test with dimensions of 120mm × 13mm × 3mm are cut as per ASTM specifications. For flexural test a sample was prepared with dimensions 200mm × 15mm × 3mm are cut as per ASTM specifications. For comparison sake the specimen for matrix material were also prepared in similar lines. For Scanning electron microscope analysis the cryogenically cooled and fractured specimen surfaces were gold coated and the fractured surface was observed using scanning electron microscope.

III. III. FLEXURAL LOAD MEASUREMENT

The flexural and compressive modulii were determined using M/S Instron 3369 Model UTM. The cross head speed for flexural test was maintained at 10mm/min respectively. In each case 5 samples were tested and the average values are reported.

- The variation of stress at yield with ratio of % Glass/Bamboo fibres reinforced polyster composites is shown in Fig. 1.
- The variation of Flexural modulus with ratio of % Glass/Bamboo fibers reinforced polyster composites is shown in Fig. 2.

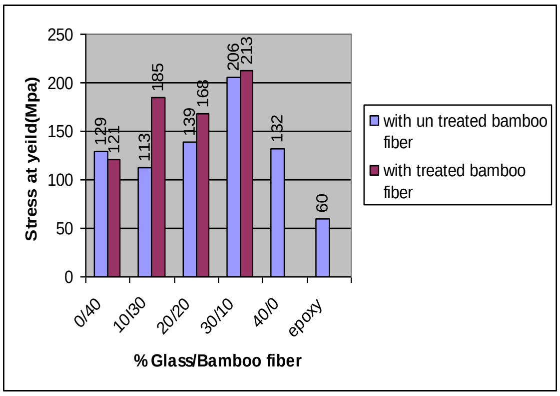

Fig.1. The variation of Stress at Yield with ratio of % Glass/Bamboo fibers Reinforced polyster composites

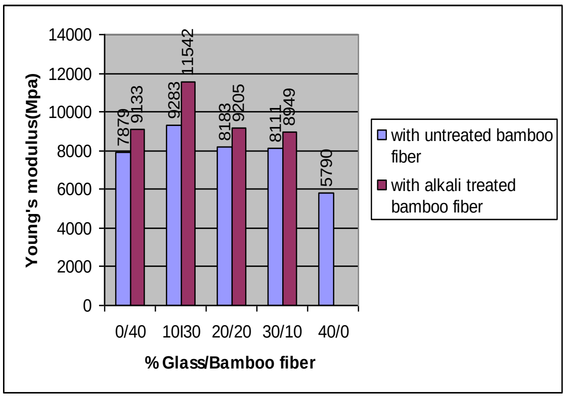

Fig.2. The variation of Flexural modulus with ratio of % Glass/Bamboo fibers reinforced polyster composites

IV. IV. IMPACT LOAD MEASUREMENT

The impact strength was determined using Izod impact testing machine. In each case 5 samples were tested and the average values are reported. The variation of impact strength with the ratio of % Glass/Bamboo fibers reinforced polyster composites is shown in Fig. 3

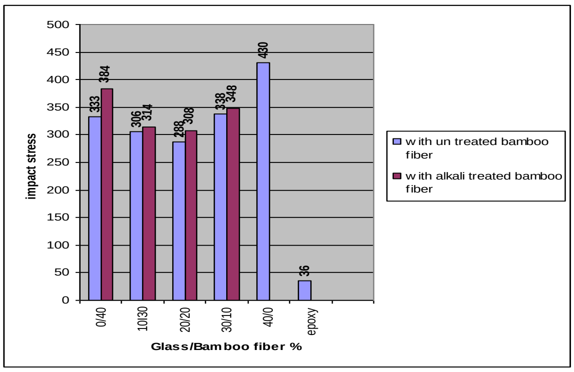

Fig. 3. The variation of impact strength with the ratio of % Glass/Bamboo fibers reinforced polyster composites

V. SEM ANALYSIS

To probe the bonding between the reinforcement and matrix, the Scanning electron micrograms of fractured surfaces of glass/bamboo reinforced polyster composites were recorded. These micrograms were recorded at different magnifications and regions. The analysis of the micrograms of the composites prepared under different conditions is presented in the following paragraphs.

5.1. Untreated Bamboo Fiber:

The micrograms of fractured surfaces of untreated bamboo fiber are presented in Fig. 4 (a), (b), (c & d). Fig. 4 (a) & (b) represents the fractograms at two regions with a magnification of 100X. Fig. 4(c) & (d) are the fractograms at these regions at magnification of 200X. From all these micrograms it is evident that fiber pullout is observed, indicating a poor bonding between the fibers. When the interfacial bonding is poor, the mechanical properties of the composites will be inferior. All the mechanical properties of the glass/bamboo fiber composites studied indicate that these properties are the least for these composites with untreated bamboo fibers. The poor adhesion is indicated in Fig. 4 supports this observation.

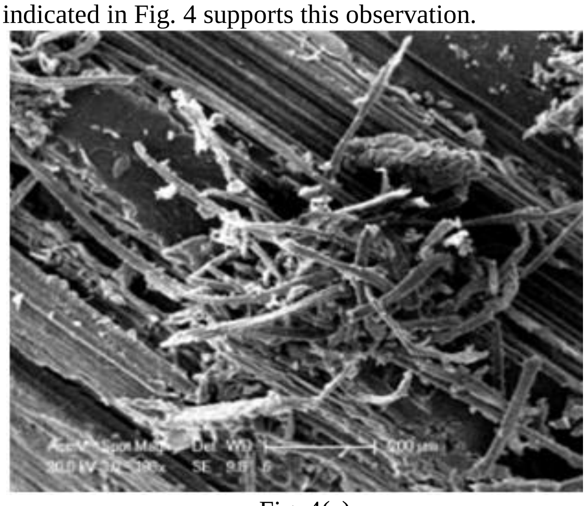

Fig. 4(a)

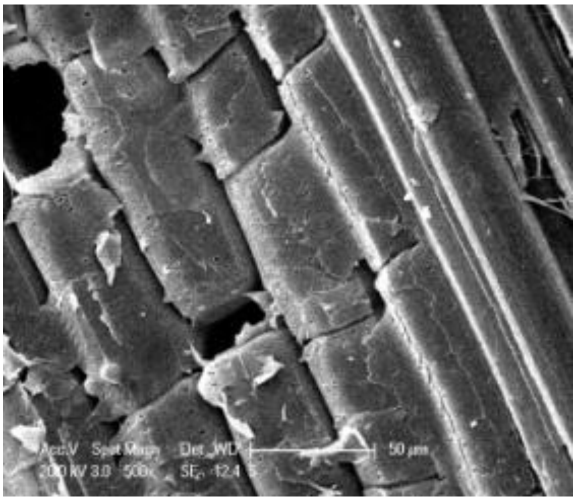

Fig. 4(b)

Fig. 4 (a) & (b) represents the fractograms of untreated bamboo fiber at two regions with a magnification of 100X.

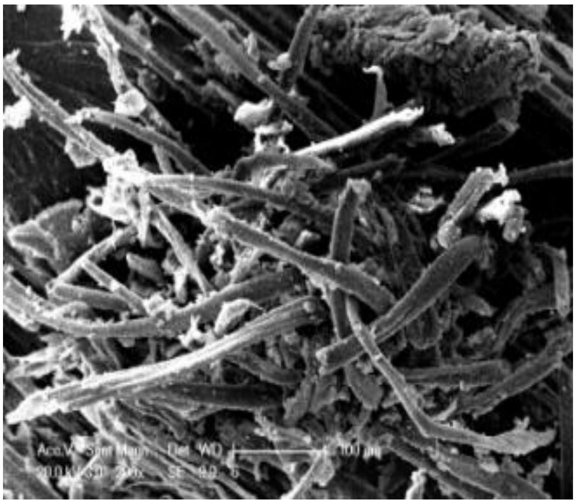

Fig. 4(c)

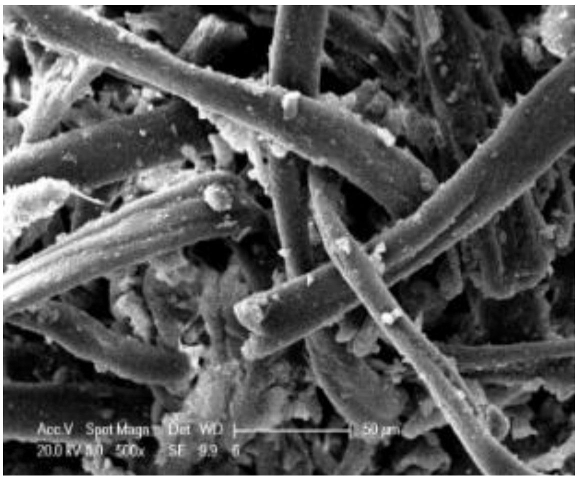

Fig. 4(d)

Fig. 4 (c) & (d) represents the fractograms of untreated bamboo fiber at two regions with a magnification of 200X.

5.2 Treated Bamboo Fiber:

The fibers were soaked in 1% NaOH solution for 30 min. to remove any greasy materials and hemi-cellulose, washed thoroughly in distilled water and dried under the sun for one week. The glass chopped strand mat was used in making the hybrid composite percentage. The fractograms of alkali treated bamboo fiber are presented in Fig. 5(a), (b), (c) & (d). These fractograms were recorded at two different regions at 100X and 200X magnifications. Fig. 5 (a) & (b) represents the fractograms at two regions with a magnification of 100X. Fig. 5(c) & (d) are the fractograms at these regions at magnification of 200X. From these micrograms it is clearly evident that the surface of the fiber becomes rough on alkali treatment. The elimination of hemi-cellulose from the surface of the bamboo fiber may be responsible for the roughening of the surface. Here, though the bonding is improved, fiber pullout is reduced. Thus the alkali treatment improved the bonding. This is in accordance with the mechanical properties of these composites.

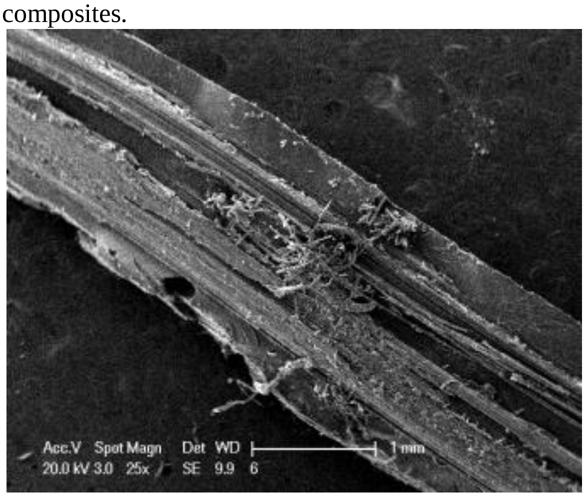

Fig. 5(a)

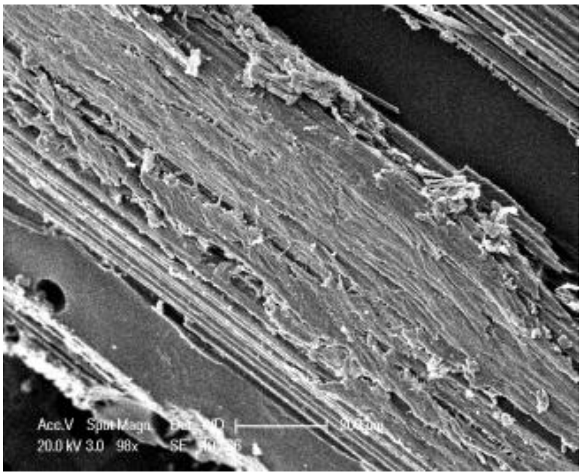

Fig. 5(b)

Fig. 5 (a) & (b) represents the fractograms of treated bamboo fiber at two regions with a magnification of 100X.

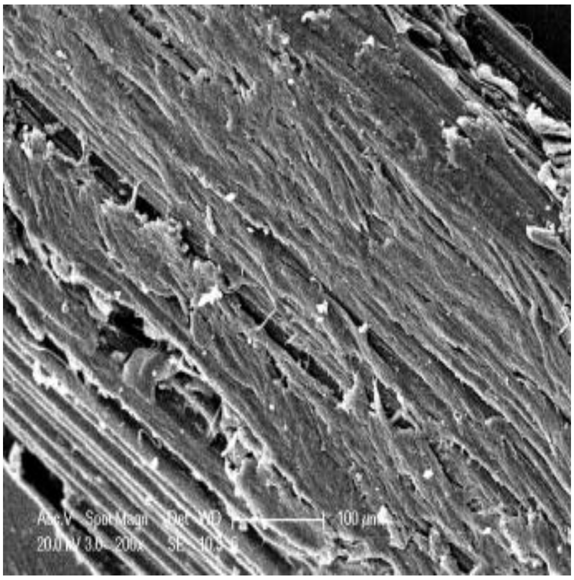

Fig. 5(c)

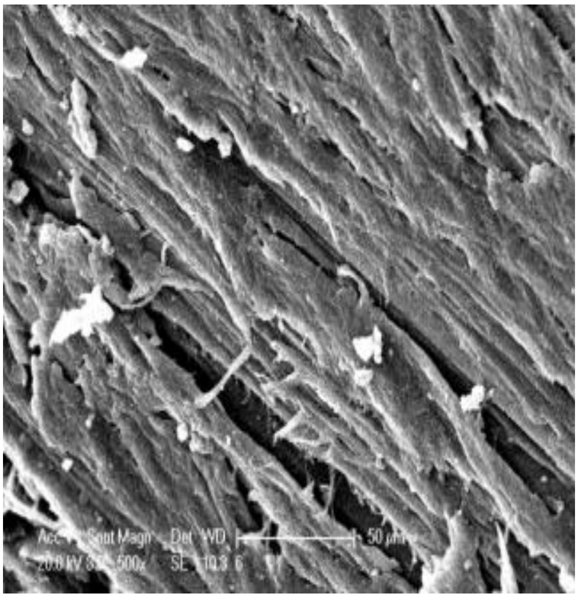

Fig. 5(d)

Fig. 5 (c) & (d) represents the fractograms of treated bamboo fiber at two regions with a magnification of 200X.

VI. RESULTS AND DISCUSSION

The variation of flexural stress and modulus with percentage glass/bamboo fiber ratio is presented in Fig. 1&2 respectively. For comparison, these values for the matrix are also presented in the same figures. From both these figures it is evident that the flexural 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 flexural modulus for these composites are found to be 8949 and 11542 MPa respectively. Similarly, the stress values vary in the range of 60 to 213 MPa. Similar observation was made by Varada Rajulu *et al* [2-9] and srinivasulu *et al* [10] in the case of some fiber composites and polymer coated bamboo fibers.

The variation of Impact strength with the ratio of percentage glass/bamboo fiber in these composites is presented in Fig. 3. In this case also the hybrid composites are found to have good Impact properties. In the case of maximum strength, the values vary between 36 to 430 MPa. The Impact strength of these composites is found to be enhanced when alkali treated bamboo fibers were used in the hybrid composites. Similarities observation was made by Varada Rajulu *et al* [2-9] and Srinivasulu *et al* [10] in the case of some bamboo composites and polymer coated bamboo fibers.

VII. CONCLUSION

The hybrid composites of Bamboo/Glass fiber reinforced polyester were made and their flexural, impact properties were studied. The effect of alkali treatment of the bamboo fiber on these properties was studied. These hybrid composites were found to exhibit good flexural and impact resistance properties. The hybrid composites with alkali treated bamboo fibers were found to poses higher flexural properties. The composites were found to be resistance to high impact loads. The bonding between fiber and matrix were studied by using SEM. It was concluded that alkali treated fibers show good bonding between fiber and matrix. 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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