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Study of Mechanical and Chemical Properties of Biodegradable Fibers before and after Alkali Treatment

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Abstract
The Tensile, Flexural properties, Chemical resistance and Scanning Electron Microscope analysis of bamboo, jute and grass fibers reinforced polyester composites were studied. The effect of alkali treatment of the bamboo, jute and grass fibers on these properties was also studied. It was observed that flexural properties of the hybrid composite increase with bamboo 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 epoxy composites. The effect of alkali treatment on the bonding between Glass/Bamboo composites was also studied. The chemical resistance of Bamboo, jute and grass reinforced polyester composites to acetic acid, Nitric acid, Hydrochloric acid, Sodium hydroxide, Sodium carbonate, Benzene, Toluene, carbon tetrachloride and water was studied.
Keywords: Bamboo fiber, jute fiber, grass fiber composites, chemical resistance, polyester, flexural strength, tensile strength, SEM test, chemical resistance test.

INTRODUCTION

Several studies on the composites made from polyester matrix and natural fibers like jute, wood, banana, sisal, cotton, bamboo, 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, jute and grass fiber reinforced high performance polyester composites were developed and their tensile, flexural properties with fiber content (with varying ratio of glass/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.

MATERIALS AND METHODS

Materials :

High performance polyester resin and the curing agent accelerator and catalyst in 10:1 ratio 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. The jute fibers have been procured from company (mat) were used in making the composite percentage. The grass fibers have been procured from local area.

Preparation of mould:

For making the composites, a moulding box was prepared with glass with 200mmx200mmx3mm mould (length x width x 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 polyester and accelerator and catalyst taken in the ratio of 10 and 1 parts by weight respectively. Then the moulding box loaded with the matrix mixture and bamboo, jute and grass 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 and flexural test 150mmx20mmx3mm and for chemical test with dimensions of 10mmx5mmx5mm. For comparison sake the specimen for matrix were also prepared in similar lines. For Scanning electron microscope analysis the cryogenically cooled and fractured specimen surfaces were gold coated and the fractures surface was observed using scanning electron microscope.

Tensile and Flexural load measurement

The Tensile, Flexural stress and the Tensile ,Flexural modulus were determined using Instron 3369 model UTM.

The cross head speed for tensile test was maintained at 10mm/min, flexural test was maintained at 5mm/ min. The temperature and humidity for this test were maintained at 18 ^{0}C and 25% respectively. In each case 5 samples were tested and average values were reported.

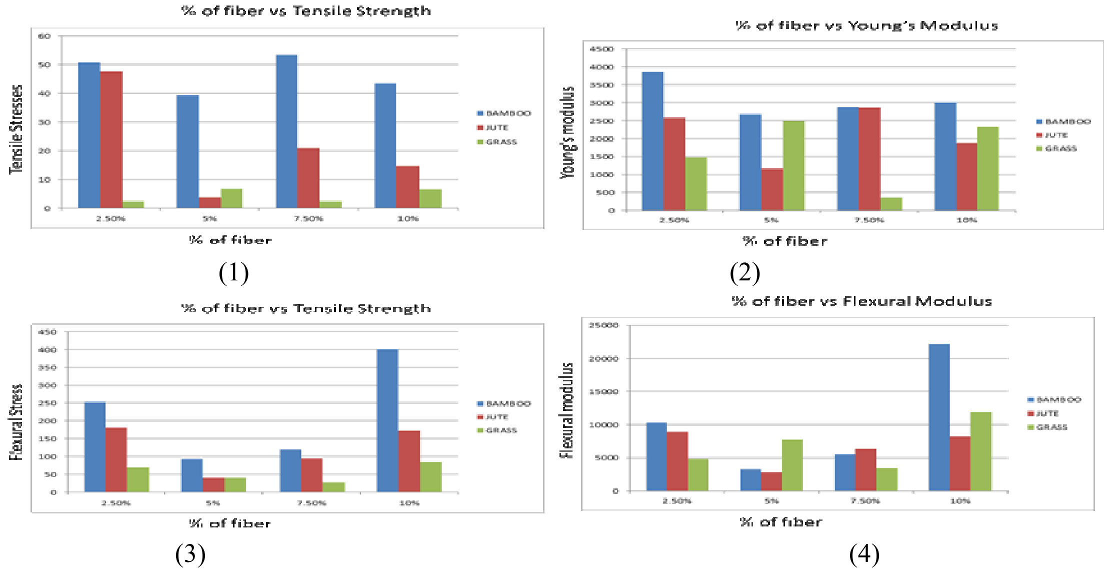


Fig 1: Variation of Stress and modulus with ratio of bamboo, jute, grass fiber reinforced polyester composites

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 reported.

Table-1 Resistance of reinforced polyester composite to chemical reagents % change in weight after immersion for 24 hours.

Chemicals	Matrix	Composites
40 % nitric acid	+0.2269	+0.26491
10% Hydrochloric acid	+0.9765	+0.29491
8% Acetic acid	+0.3867	+2.4699
10% sodium hydroxide	-0.4361	-2.7191
20% sodium carbonate	+0.787	-3.9856
10% Ammonium Hydroxide	-0.3793	-2.9158
Benzene	-1.375	-1.347
Tolerance	-0.697	-2.350
Carbon tetrachloride	-1.136	+4.4588
Water	-1.219	-1.696

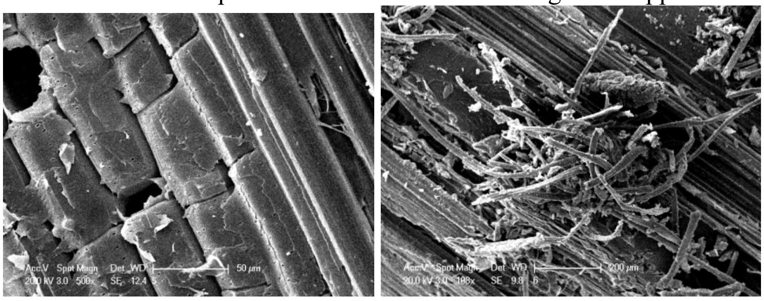
Polyester composites

SEM ANALYSIS

To probe the bonding between the reinforcement and matrix, the Scanning Electron micrograms of fractured surfaces of bamboo, jute and grass reinforced polyester 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.

UNTREATED BAMBOO FIBER

The micrograms of fractured surfaces of untreated bamboo fiber are presented in figure 2 (a),(b). Figure 2 (a)&(b) represents the fractograms at two regions with a magnification of 100X. 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 bamboo, jute and grass fiber composites studied indicate that these properties are the least for these composites with untreated bamboo fibers. The poor adhesion is indicated in figure 2 supports this observation.

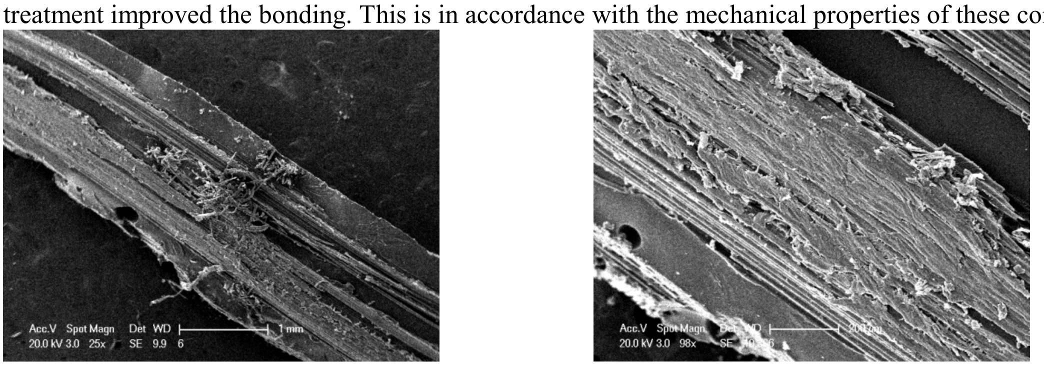


(a) (b)

Fig 2:SEM of untreated Bamboo fiber (a) and (b) at two regions 100x magnification

TREATED BAMBOO FIBER

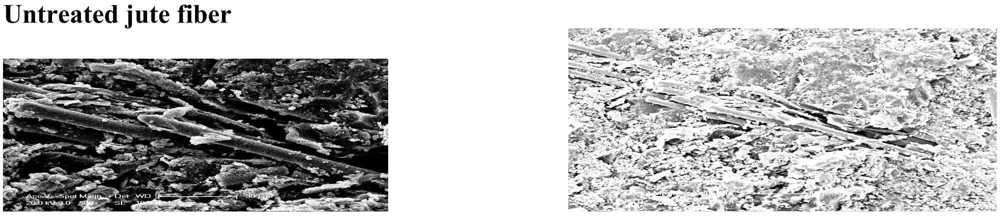
The fractograms of alkali treated bamboo fiber are presented in fig 3(a),(b). These fractograms were recorded at 100X magnifications. From these micrograms it is clearly evident that the surface of the fiber becomes rough on alkali treatment. The elimination of hemi-cellulose from the surface of the 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.



(a) (b)

Fig 3 SEM of treated Bamboo fiber (a) and (b) at two regions 100x magnification

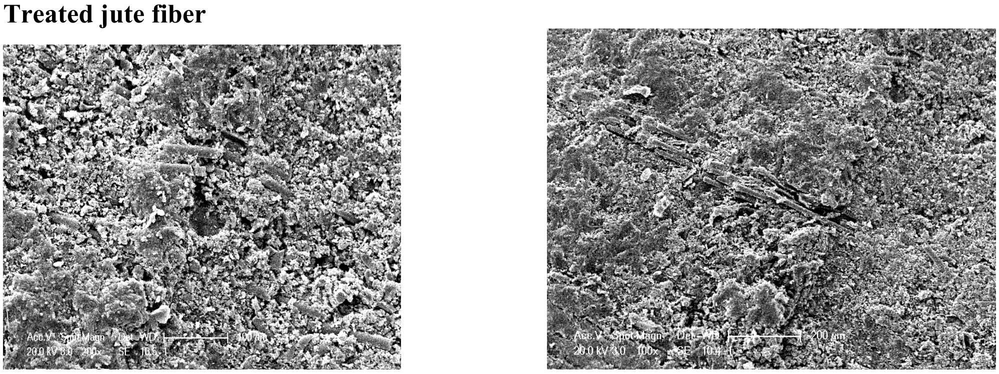
Untreated jute fiber



(a) (b)

Fig 4 SEM of untreated jute fiber (a) and (b) at two regions 100x magnification

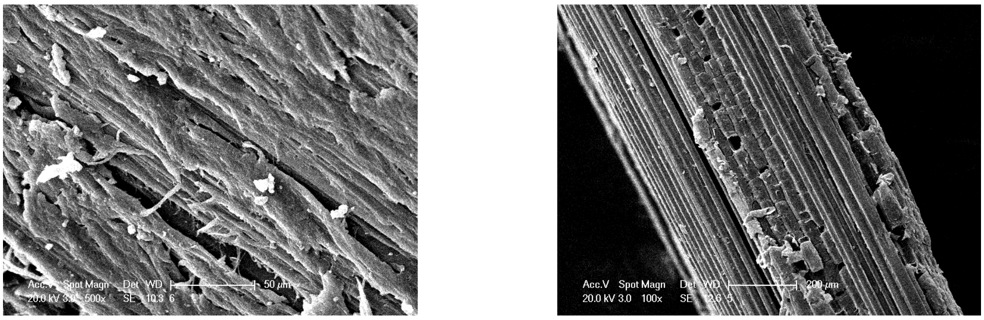
Treated jute fiber



(a) (b)

Fig 5 SEM of treated jute fiber (a) and (b) at two regions 100x magnification

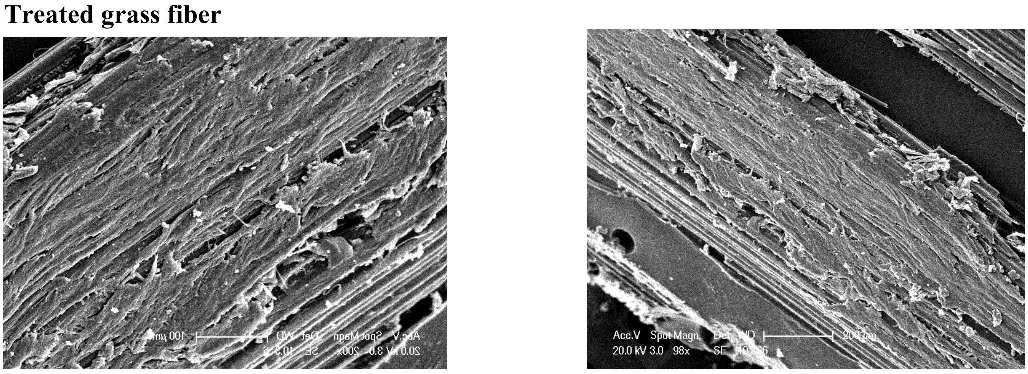
Untreated grass fiber



(a) (b)

Fig 6 SEM of untreated grass fiber (a) and (b) at two regions 100x magnification

Treated grass fiber



(a) (b)

Fig 7 SEM of treated grass fiber (a) and (b) at two regions 100x magnification

RESULTS AND DISCUSSION

The variation of tensile, flexural stress and modulus with percentage bamboo, jute and grass fiber ratio is presented in fig 1, 2, 3 & 4 respectively. For comparision, these values for the matrix are also presented in the same figures. From these figures it is evident that the tensile and flexural properties are enhanced when the alkali treated bamboo fibers were used in the reinforced 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 361.18 and 3849.34 MPa and minimum and maximum values of flexural modulus of these composites are found to be 2872 and 4849 Mpa respectively.

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. The chemical resistance of the reinforced composites with treated bamboo fibers is found to be better for the chemicals mentioned.

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