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Chemical resistance and tensile properties of styrenated polyester-coated bamboo fibres

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The chemical resistance and tensile load of bamboo fibres (*Dendrocalamus strictus*) before and after coating with styrenated polyester resin have been studied and compared with those of the bamboo fibres coated with epoxy resin. The improvements in these properties on coating indicate that the styrenated polyester, epoxy resin and bamboo fibres are favourable materials for composites.

Keywords: Bamboo fibre, Chemical resistance, Composites, *Dendrocalamus strictus*, Tensile load

1 Introduction

Various studies on the composites made from epoxy and polyester matrices and natural fibres like jute, wood, banana, sisal, cotton, coir, wheat straw are reported in the literature[1-7] . To make natural fibre-reinforced plastics, suitable matrix materials are to be identified. Jindal[8] studied the mechanical properties of bamboo fibre-reinforced plastic composites using Araldite (Ciba-CY230) as matrix. Recently, Varada Rajulu *et al.*[9] have studied the chemical resistance and tensile properties of high performance epoxy-coated bamboo fibres and suggested that these are favourable materials for making composites. Though bamboo is extensively used as a valuable material from times immemorial (because of its high strength-to-weight ratio), the studies on this fibre are meagre. In the present study, bamboo fibres have been coated with styrenated polyester and their chemical resistance and tensile properties have been studied to ascertain whether the polyester-bamboo fibre system can effectively be used for making composites.

2 Materials and Methods

2.1 Bamboo Fibres

Bamboo fibres (*Dendrocalamus strictus)* were procured from Tripura in the dried form. The greasy material and lignin were removed from the fibres by soaking them in 1 % aqueous NaOH solution for 30 min as described elsewhere[9]. These fibres were then washed thoroughly in distilled water and dried under the Sun for two weeks. The length of the fibres was found to be 22 cm. The fibre cross-section was rectangular with breadth and thickness varying from 0.1 to 0.6 mm. The fibres with a thickness of 0.2 mm were selected for the study. For tensile properties and chemical resistance studies, the fibres were cut to 15 cm and 2 cm lengths respectively.

2.2 Chemicals

Glacial acetic acid, conc. nitric acid, conc. hydrochloric acid and conc. ammonium hydroxide were used as such. Aqueous sodium carbonate and sodium hydroxide solutions of 20 % and 60 % concentrations respectively were used. Polyester resin, accelerator (Cobalt naphthenate) and catalyst (Methyl ethyl ketone peroixde), all supplied by M/s Bakelite Hylam, were used. The styrene monomer was used after removing the inhibitor.

2.3 Sample Preparation

The resin matrix was prepared by mixing 100 parts of unsaturated polyester, 25 parts of styrene monomer, 0.5 parts of accelerator and 0.5 part of catalyst in the order given. Here, styrene was used as the cross-linking (curing) agent, and accelerator and catalyst were used to hasten up the curing reaction. For tensile test, the fibres soaked in the matrix were hanged to a wooden frame in the vertical position. The curing was complete in 2 h. For chemical tests, the short fibres were soaked in the resin mixture. The excess resin was removed by placing the fibres in a vertical position and then on a glazed polyester sheet.

2.4 Tensile Load Measurement

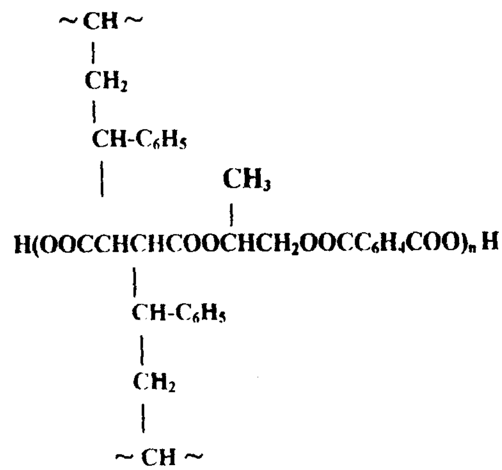
The tensile load at break of the coated and uncoated bamboo fibres was determined using Mikrotech Tensometer employing disc wire chuck. Ten samples were tested in each case and the average tensile load was determined.

2.5 Chemical Resistance Measurement

The resistance of the bamboo fibres with and without styrenated polyester coating was studied using ASTM D 543-87 method[10].In each case, ten pre-weighed samples were dipped in the respective chemical for 24 h, removed, immediately washed with distilled water and dried by pressing them between the filter papers. The samples were then weighed and the percentage weight loss/gain was determined.

3 Results and Discussion

Based on the infrared analysis[11], the structure of styrenated polyester is represented as shown in next column.



The average tensile loads at break of the bamboo fibres before and after coating with styrenated polyester were found to be 1.41 kg and 4.35 kg respectively (the average thickness of the coating was 100 μm),thus showing an improvement of 208%. When a high performance epoxy resin was used, the increment in tensile load was found to be 140%. The higher tensile load with polyester resin may be due to the addition of accelerator and catalyst to the resin mixture.

The weight loss/gain for the fibres treated with different chemicals is shown in Table 1. For comparison, the values for epoxy-coated fibres[9] are also presented. It is observed that on acetic acid treatment, both uncoated and coated fibres show gain in weight. The gain in weight for uncoated fibres is 29% whereas for the fibres coated with styrenated polyester and epoxy, it is 16.6% and 80.6% respectively, showing that epoxy-coated fibres are more resistant. The gain in weight for coated fibres is due to the crosslinked resin coating which does not dissolve in many chemicals but only swells as it is chemically inert.

Table 1—Effect of chemicals on weight of bamboo fibres coated with styrenated polyester and epoxy resin

Chemical	% Change in weight after dipping for 24 h		
	Uncoated fibre	Coated with styrenated polyester	Coated with epoxy resin
Acetic acid	+29.0	+16.6	+80.6
Hydrochloric acid	-14.6	+49.7	+26.8
Nitric acid	completely dissolved	completely dissolved	+54.4
Sodium hydroxide	-14.5	+54.4	+21.1
Sodium carbonate	-36.6	+48.4	+16.6
Ammonium hydroxide	-10.7	+48.3	+21.6
Benzene	-35.8	+25.1	+18.1
Carbon tetrachloride	-36.5	+17.9	+17.6
Toluene	-19.1	+16.6	+29.4

For treatments with other chemicals, a decrease in weight is observed for uncoated fibres whereas reverse is the trend for epoxy-coated fibres. In the case of styrenated polyester-coated bamboo fibres, a gain in weight is observed except in conc. nitric acid in which the fibres were completely dissolved after 1h of immersion. A close observation of Table 1 indicates that epoxy-coated bamboo fibres show more acid resistance whereas styrenated polyester-coated fibres show more alkali resistance but on the whole the coated fibres are chemically resistant than uncoated ones. The solvent resistance of the epoxy-coated fibres is comparable with that of styrenated polyester-coated fibres.

The above observations clearly indicate that the tensile load at break and chemical resistance of bamboo fibres increase on coating them with either styrenated polyester or epoxy resin and hence these are favourable materials for making composites.

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