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Flexural Properties of Polycarbonate Toughened Epoxy- Bamboo Fiber Composites

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Abstract

In effect of polycarbonate content on flexural properties of Epoxy-PC blend matrix is studied and it is observed that the blend matrix Epoxy-PC containing 10% of weight of PC showed to have maximum flexural strength.

Poly carbonate (10% of weight) toughened epoxy-bamboo fiber composites have been developed with varying fiber content and it is evident that the flexural strength of the composites is increased with the increase in the fiber content. It is also observed that the longitudinally oriented composites showed superior properties than transversely oriented composites. In addition to flexural strength, toughness also increased with increase in fiber content.

1. Introduction

Several studies on the composites made from thermoset materials and natural fibers like jute, wood, bamboo, sisal cotton, coir, wheat straw, palmyra, etc., have been reported in the literature. In order to improve the properties of such composites, several methods have been adopted. Modification of matrix is one of these avenues. Toughening of epoxy resins cab be achieved by mixing the resin with elastomers or even with ductile thermoplastics before curing. Chen et al. (1992) studied the miscibility and fracture behaviour of epoxy resin/ polycarbonate blend. They indicated that the blend is miscible and has better mechanical properties. Though bamboo is extensively used as a valuable construction material from time immemorial (because of its high strength and low weight), studies on reinforced plastics using this fiber are meager. In the present investigation, the epoxy resin was toughened with a thermoplastic, namely bisphenol-A polycarbonate, and this blend was used as the matrix. The present paper explains the effect of polycarbonate content on flexural properties of epoxy-pc blend matrix, and development of polycarbonate toughened epoxy-bamboo fiber composites by varying fiber content.

2. Materials and Methods

2.1 Materials

The epoxy resin araldite LY–556 (M/s Huntsmen advanced materials) and curing agent, hardener HY-951, and polycarbonate (M/s Dow chemical company) system is used as the matrix. Dichloromethane (M/s S.D. fine chemicals) is used as the solvent in the preparation of the blend and sodium hydroxide is used for surface modification of fibers. The Bamboo fiber mat (Dendrocalamus strictus) is used as the reinforcement.

2.2 Materials

2.2.1 Sample preparation

A glass mould with 150 mm x 150 mm x 3 mm dimensions is employed for the preparation of flexural test specimens. The mould is coated with a thin layer of aqueous solution of polyvinyl alcohol (PVA) which acted as a good releasing agent. In order to make the blend, the epoxy resin is added with polycarbonate dissolved in dichloromethane. The solvent is removed by degassing in vacuum for about one hour. The blend and the hardener are mixed in the ratio 100:10 parts by weight respectively.

Composites with bamboo fiber mat as reinforcement are prepared using toughened epoxy resin and cured for 24 hrs at room temperature. To ensure complete curing, the composite sheets are post cured at $100^{O}C$ for three hours. Then they are cut to required size and shape according to the ASTM standards.

In order to obtain optimum content of polycarbonate in Epoxy-PC blend, the specimens of matrix material are also prepared in similar lines.

2.2.2 Testing

Flexural test is performed using Instron 3369 Universal Testing Machine. The test specimens with 100 mm x 12.7 mm x 3 mm dimensions are cut as per ASTM D 618 specifications. The temperature and humidity for this test are maintained at 22^{O}C and 50% respectively. In each case five specimens are tested and average value is recorded.

3. Results and Discussion

3.1 Effect of polycarbonate content on flexural properties of Epoxy–PC blend matrix

The blend matrices Epoxy–PC with varying weight percentage of PC content in epoxy are prepared. They are first subjected to mechanical strength analysis and then the blend matrix that showed the maximum strength among the combinations is chosen to be the matrix for developing composites. From Table 6.1 it can be observed that the blend matrix Epoxy–PC containing 10 wt% of PC showed to have maximum flexural strength. On the basis of the result, this combination is selected as the matrix to prepare composites.

The variation of flexural strength and toughness with varying polycarbonate content in the Epoxy–PC blend matrix are presented in Figure 6.1 and Figure 6.2 respectively. From the Figure 6.1, it is evident that the flexural strength of Epoxy-PC blend increased upto 10 wt% of PC content in Epoxy and on further increase in the PC content, the strength decreased. From the Figure 6.2, the flexural toughness also shows a similar trend. Similar observation was made by S.K Rai et al. [59] in the case of PMMA toughened epoxy-silk and PC toughened epoxy-silk fabric composites. From Table 6.1, it is also observed that, the Epoxy–PC blend matrix showed a minimum increment in flexural strength of about 6.5% over pure epoxy, for 2.5 wt% of PC content, and then the maximum increment is about 55.95% for 10 wt% of PC content.

Table 3.1: Flexural properties of Epoxy–PC blend matrix

Wt % of PC in Epoxy-PC blend	Flexural strength (MPa)	Flexural toughness (MPa)
0	49.85	0.025
2.5	53.09	0.029
5	60.96	0.035
7.5	74.97	0.043
10	77.74	0.056
12.5	67.31	0.051
15	31.01	0.044

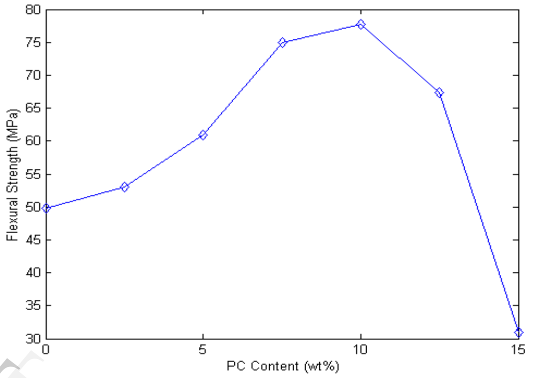

Figure 3.1: Variation of flexural strength with PC content in Epoxy-PC blend matrix.

3.2 Effect of fiber mat content on flexural properties of the composite

The flexural strength and flexural toughness of longitudinally oriented and transversely oriented PC toughened epoxy-bamboo fiber composites with different mat content are presented in Table 6.2. For comparison, these values for the matrix are also presented in the same table. The variation of flexural strength and toughness of the composites are presented in Figure 6.3 and Figure 6.4 respectively. From the Figure 6.3 and Table 6.2, it is evident that the flexural strength of the composites is increased with increase in mat content. This is due to fact that the composites are able to withstand more loads when the population of the fibers in composites increased. The flexural strength of longitudinally oriented composites is found to be greater than that of the of blend matrix. Similar observation was made in unidirectional composites formed of sisal/epoxy [6] or jute/polyester [7] showed that there is a linear relationship between the flexural strength and fiber loading and flexural strength of the composites exceeds that of the resin. However, the longitudinally oriented composites showed superior properties than transversely oriented composites.

In addition to flexural strength, toughness also increased with an increase in the weight fraction of fiber loading in the composites.

The toughness of the PC toughened resin composites is found to be greater than that of the blend matrix. This indicates that, the bamboo fiber introduces plasticizing effect on Epoxy–PC blend matrix. From Table 6.2, it is also observed that the percentage increment of the flexural strength for longitudinally oriented composites is found to be 39.59% over that of blend matrix, for 10 wt% of fiber loading and then the maximum increment is about 96.68% for 40 wt% of fiber loading. This indicates good reinforcement in the composites under study.

Table 3.2: Variation of flexural properties polycarbonate toughened epoxy-bamboo fiber composites with fiber mat content

Fiber mat content (Wt%)	Flexural strength (MPa)		Flexural Toughness (MPa)	
	Longitudinal	Transverse	Longitudinal	Transverse
10	108.52	18.57	0.177	0.007
20	114.43	23.96	0.207	0.021
30	134.34	35.00	0.275	0.035
40	152.90	44.17	0.352	0.040
Matrix	77.74		0.056	

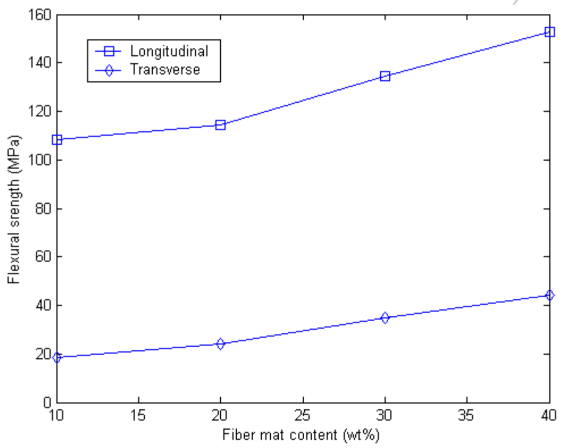

Figure6.3: Variation of flexural strength of longitudinal and Transverse oriented PC toughened epoxy-bamboo fiber composites with fiber mat content

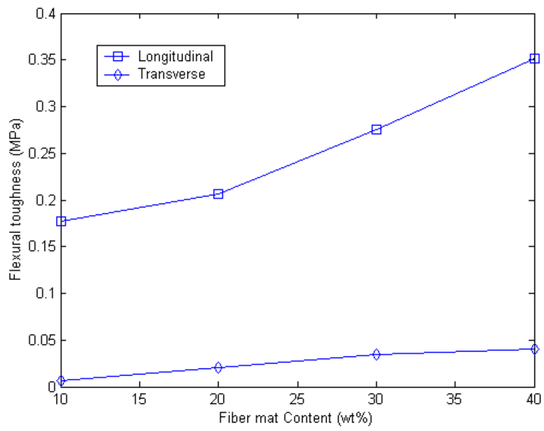

Figure6.4: Variation of flexural toughness of longitudinal and Transverse oriented PC toughened epoxy-bamboo fiber composites with fiber mat content

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