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The Effect of Fiber Length on Tensile Properties of Epoxy Resin Composites Reinforced by the Fibers of Banana

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Abstract— *The present paper investigates the effect of fibre content and alkali treatment on tensile, and impact properties of Banana Epoxy composites which are partially biodegradable. The reinforcement Banana fibre was collected from the foliage of locally available Banana tree through the process of water retting and mechanical extraction. The poor adhesion between fibre and matrix is commonly encountered problem in natural-fibre-reinforced composites. To overcome this problem, specific physical and chemical treatments were suggested for surface modification of fibres by investigators. Alkali treatment is one of the simple and effective surface modification techniques which are widely used in natural fibre composites. In the present study both untreated and alkali-treated fibres were used as reinforcement in Banana epoxy composites and the tensile, flexural and impact properties were determined at different fibre contents. The alkali treatment found to be effective in improving the tensile strength.*

***Index Terms*—banana, fiber, epoxy, composites, tensile strength, impact strength.**

I. Introduction

Various natural fibers such as flax [1–3], ramie [2], jute [4], bamboo [5], pineapple [6], kenaf [7], henequen [8] and hemp [9] have been investigated as reinforcements in biopolymers by various researchers. Bast fibers, like banana, are complex in structure and are lignocellulosic, consisting of helically wound cellulose micro fibrils in amorphous matrix of lignin and hemicelluloses.

The cellulose content serves as a deciding factor for mechanical properties along with micro fibril angle. A high cellulose content and low micro fibril angle impart desirable mechanical properties for bast fibers. Natural fiber reinforced polymer composites technology is focused on creating low cost, high performance, and lightweight materials to replace neat polymers or glass fiber composites. Natural fibers are environmentally friendly, fully biodegradable, abundantly available, renewable and cheap and also have low density. Their biodegradability can contribute to a healthy ecosystem while their low cost and high performance fulfils the economic interest of industry [10]. Natural fibers may play an important role in developing biodegradable composites to resolve the current ecological and environmental problems. There are various types of natural fibers today, and the variety continues to increase. Some examples in use include ramie, hemp, kenaf, jute, sisal, bamboo, banana, and oil palm fibers. However, in this study, a banana fiber is used as a material to reinforce a polymer matrix in epoxy composite. Banana fiber is one of the most attractive candidates as a strengthening natural fiber .It has several advantages, such as the environmental load is small, because it is grows rapidly, thus it is easy to regenerate after cutting, and the banana fiber has relatively high strength compared with other natural fibers.

The present study deals with preparation and property evaluation of banana fiber Reinforced epoxy composites. The effects of length of the fibers were studied. The mechanical performance was analyzed to determine the optimum fiber loading.

2. Experimental

2.1 Materials

The matrix system used is an epoxy resin (Lapox-12) and hardener (k-6) supplied by Sun Tech fiber, India. Lapox-12 is a liquid, unmodified epoxy resin of medium viscosity. Hardener k6 is a low-viscosity room-temperature curing liquid. It is generally preferred in hand-lay-up applications. Being reactive, it gives a short pot life and rapid cure at normal ambient temperatures.

2.2 Materials and Methods:

In this work, the main studies were carried out to investigate how fiber length of Banana fiber reinforced composite affects fiber tensile strength. This section presents experimental using the Firstly, Banana fibers were carefully extracted from the bundles with a pen knife. A diameter of fiber was in the range of 240-260 μm. Secondly, the Banana fibers were immersed in NaOH solution for 120 min. Thereafter, fibers were rinsed with deionized water until rinsed solution reached neutral (pH 7). The fibers were then dried at room temperature for 24 hrs. After that, Composites containing 20% by weight of fiber were prepared using fiber of length in the range 2, 4, 6, 8 and 10 mm. A matrix was created by mixing epoxy resin with its hardener in the ratio 100:27 by volume. The mixture was poured into the mould in the dog-bone shape. It was 150 mm in length, 150 mm in width and 3 mm in thickness. Mould release films were put at the upper and the lower of the samples in order to obtain a smooth surface. Finally, the composite samples were left to settle at the room temperature for one day and then removed from the mould. And curried in oven for one hour at 60□c, Tensile test Tensile specimens of dimension 165×13×3 mm, as per ASTM D 638 were used to measure the tensile strength Tensile strength of the sample was measured by the universal testing machine using a cross-head speed of 5 mm/min and 250 mm extensometer. Impact test Specimens of dimension 63.5×12.7×3 mm. were taken for measurement of impact test as per ASTM D 256. The specimens were notched at an angle of 45° and depth of 2.54 mm using a notch cutter prior to test.

The microstructure of composites sample was investigated by scanning electron microscope (SEM). This study investigates the effect of fiber length on tensile properties of Banana.

2.3 Results and Discussion

Tables 1 properties of Banana Epoxy composites

Fiber type	Tensile strength Mpa	Elongation %	Impact strength j/m
Untreated2mm	125.3	36	17
Treated 2mm	155.8	49	17.6
Treated 4mm	158	51	19.9
Treated 6mm	152.1	52	20.3

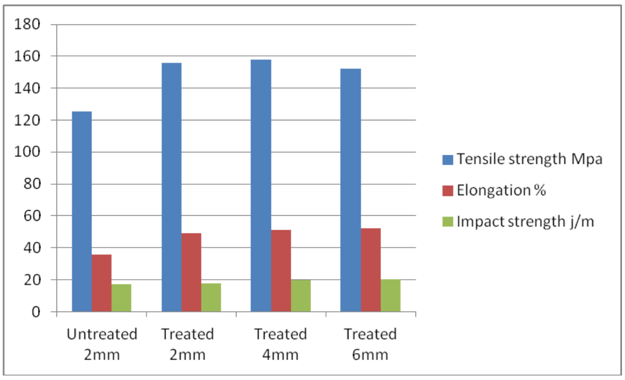

Fig 1. Mechanical properties of banana epoxy composites.

Fig. 1 shows the variation in tensile strength of composite with the change in length of the fiber. In general the thermoset composites showed an increasing trend in their mechanical properties with the fiber length [6]. However, the optimal condition is at a fiber length of 4 mm (158 MPa). The fiber length from 6 mm decreasing tendency in tensile strength has been attributed to two situations: namely, the existence of defects, such as voids, and weak interface bonding between matrix and reinforcement. Moreover, the elongation at break (ε) of composite was not affected significantly by increasing the fiber length shows in Fig 1. The percent elongation at break of the composites is lower than that of the matrix. This could be affected of low fracture strain and the poor adhesion between the matrix and the fibers. The effect of surface treatment on the impact strength of bio composites is displayed in Table 1. It is evident that surface treatments enhance the impact strength of bio composites significantly. As compared with untreated fiber, nearly 8.34 % improvement in the impact was observed when NaOH treated banana fiber used as reinforcement. This confirms an increased fiber matrix adhesion between the matrix and fibers upon surface treatment. The SEM micrograph of the failure surfaces was used for direct observation of composite structure, and particularly to examine the resin fiber interface. The net result of SEM is that the nature of the differing interactions such as the physical mixing of matrix and sizing resins and the nature of chemisorptions at the fiber surface give rise to an interphase region as opposed to a distinct interface between fiber and matrix. The role of the matrix in the fiber-reinforced composite is to transfer the load to the stiff fiber through shear stress at the interface. This process requires a good bond between the polymeric matrix and fiber. The interface between fiber and matrix is shown in Fig. 1. The load acting on the matrix has to be transferred to the reinforcement via the interface. Thus, reinforcement must be strongly bonded to the matrix if their high strength and stiffness are to be imparted to the composite. It is also noticed that the fiber failed by tearing but no interfacial failure is observed. There are traces of matrix is still adhered to the fiber. This in an indication that the adhesion between fiber and matrix was not lost and the failure process was dominated by the matrix material properties.

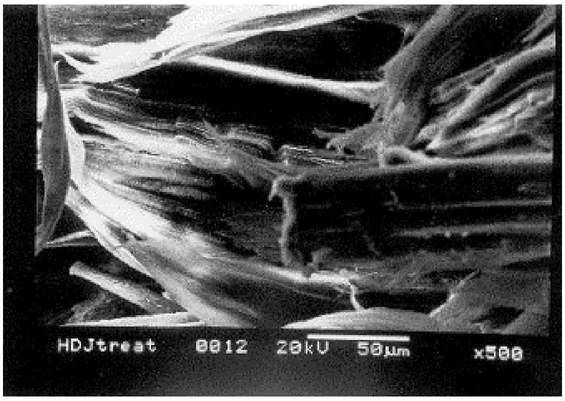

Fig 2 SEM images of Banana Epoxy composites.(NaOH treated 4mm fiber)

Figure 2, it is shown that there was a small gap between fiber and matrix which means a poor adhesion or interfacial bonding for 6 mm in length. The void and small gap formed was probably caused by incomplete wettability or bonding between matrix resin and fiber during the fabrication of composites

Conclusions

In this paper, the mechanical properties of banana fiber reinforced epoxy composite have been measured. Based on the results, it was found that the tensile strength showed an increasing trend as the fiber length was increased but the elongation at break of the composite was not affected significantly by the fiber length. The optimum of fiber length in epoxy resin to obtain the highest tensile strength was found at 4 mm in fiber length. It was also found the void, fiber length and interfacial adhesion between fiber-matrix can affect the mechanical properties of the composite

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