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The Effect of Fiber Length on Tensile Properties of Polyester Resin Composites Reinforced by the Fibers of *Sansevieria trifasciata*

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ABSTRACT

This paper presents the study of the tensile properties of *Sansevieria trifasciata* – fiber (here after called STF) reinforced polyester composites. The composite sample was fabricated with five different fiber lengths of STF (2, 4, 6, 8 and 10 mm). The fabrication was made by hand lay-up technique. Mechanical properties were determined using tensile testing. An interact between fiber and matrix was observed from the SEM (scanning electron microscope) micrographs. The study reveals that the tensile strength increased with fiber length without effecting the elongation at break of the composite.

Keywords**:** *Sansevieria trifasciata*; fibers; tensile strength; polyester composites

1. INTRODUCTION

Fiber reinforced polymer composites have potential application in structural and non-structural areas as they have interesting properties such as specific stiffness and strength, good fatigue performance and damage tolerance, corrosion resistance, low thermal expansion, non magnetic properties and low energy consumption during fabrication. They are two type of fibers, that are used as reinforcements; natural and synthetic fibers. In the recent years, there is growing interest in the use of natural fibers as the reinforcing components for thermoplastics and thermo-sets. The growing interest in the natural fibers is mainly due to their economical production with few requirements for equipment and low specific weight, which results in a higher specific strength and stiffness when compared to synthetic fiber composites. Also they offer a safe handling and working conditions compared to the synthetic fibers. Natural fibers from renewable natural resources offers potential to act as a biodegradable reinforcing materials alternative for the use of synthetic fibers. These fibers offers several advantages including high specific strength and modulus, low cost, low density, renewable nature, biodegradability, absence of associated health hazards, easy fiber surface modification, wide availability and relative non- abrasiveness. The physical and mechanical properties of natural fibers are mainly depends on their physical composition such as structure of fibers, cellulose content, angle of fibrils and cross section. Their biodegradability can contribute to a healthy ecosystem while their low cost and high performance fulfills the economic interest of industry [1-7]. 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. Various natural fibers such as flax, ramie [8-10], jute [11], bamboo [12], pineapple [13,14], kenaf [15], henequen [16] and hemp [17-20] 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 main aim and scope of the author is to build a composite system which has a high performance and is a partially green-composite and cost-effective.

In the present study, the epoxy filled STF composites were prepares with respect to fiber length and mechanical properties such as tensile strength and elongation at break (%) and scanning electron microscope analysis were characterized.

2. MATERIALS AND METHODS

In this work, the main studies were carried out to investigate how STF length of reinforced composite affects fiber tensile strength. This section presents experimental using the preparation of composites from raw materials. Firstly, the STF were collected from the Yenumuladoddi Village, kalyanadurgam-taluk, Anantapur-dist., Andhra Pradesh, India. STF were carefully extracted from the bundles with a sickle knife. The STF age was in this work of 4 year old. A diameter of fiber was in the range of 100-120 μm. Secondly, the STF were immersed in NaOH solution (NaOH 40 % solution for 60 min [5]. Thereafter, fibers were rinsed with deionized water until rinsed solution reached neutral (pH 7). The fibers were then dried at room temperature for 5 days. 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. Polyester (Ecmalon 9911,Ecmas Hyderabad, with 2 % cobalt accelerator, catalyst 50 % methyl ethyl ketone peroxide (MEKP) in 10 % DMA solution, ratio of the resin/accelerator/catalyst: 100/2/2. The resin has a density of 1335 kg/m^3,Young's modulus of 450 MPa, tensile strength of 15.3 MPa and elongation at break of 3.3 %. The mixture was poured into the rubber mould in the dog-bone shape. It was 130 mm in length, 25 mm in width and 1 mm in thickness with a gage length of 33 mm. It is noted that Mylar 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.

Tensile strength of the sample was measured by the Universal testing machine with a cross-head speed of 50 mm/min. The microstructure of composites sample was investigated by scanning electron microscope (SEM). This study investigates the effect of fiber length on tensile properties of STF.

3. RESULTS AND DISCUSSION

Fig. 1 shows the variation in tensile strength of composite with the change in length of the fiber (in the range 2-10 mm). In general the thermoset composites showed an increasing trend in their mechanical properties with the fiber length [6].

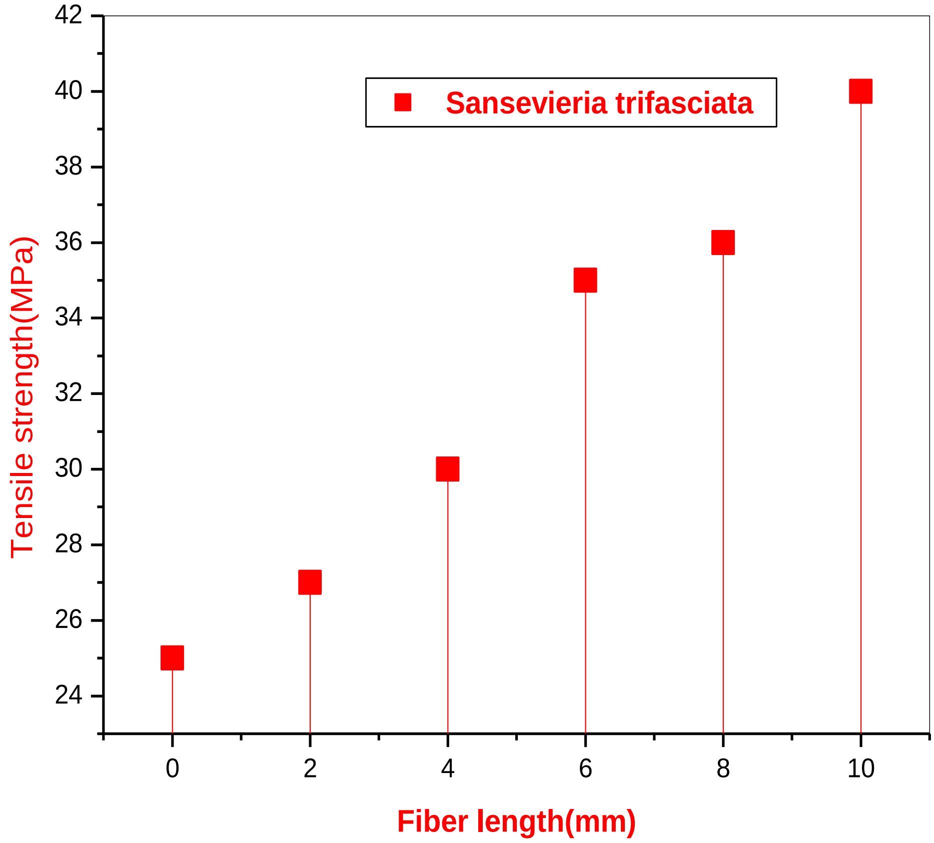

Figure 1. Average tensile strength of short *Sansevieria trifasciata* reinforced polyester composite with fiber length.

However, the optimal condition is at a fiber length of 10 mm. The fiber length from 8 to 2 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 2.

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 [14]. The SEM micrograph of the failure surfaces was used for direct observation of composite structure, and particularly to examine the resin fiber interface.

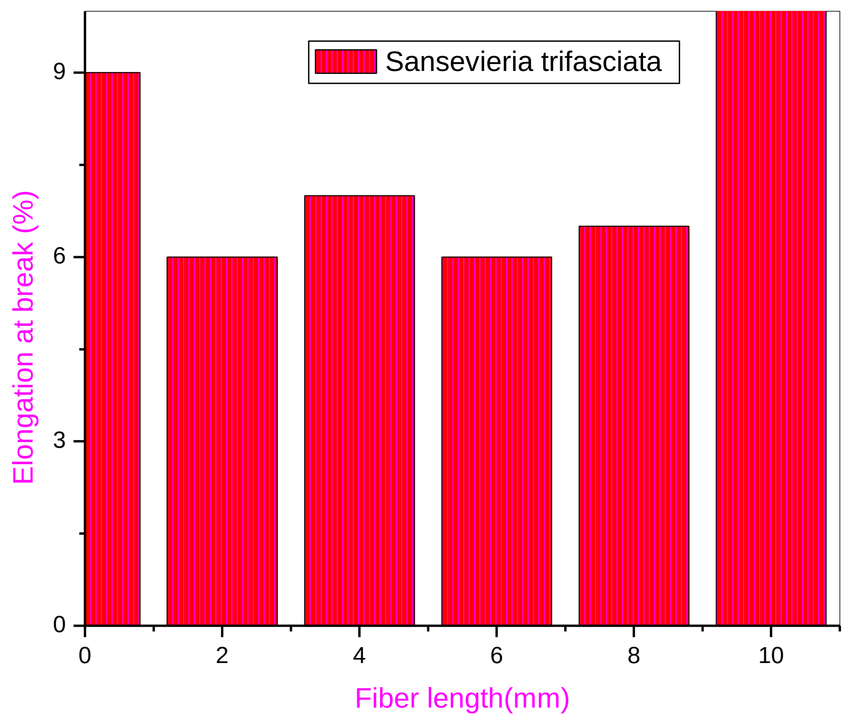

Figure 2. Average elongation percentage at break of short *Sansevieria trifasciata* reinforced polyester composite with fiber length.

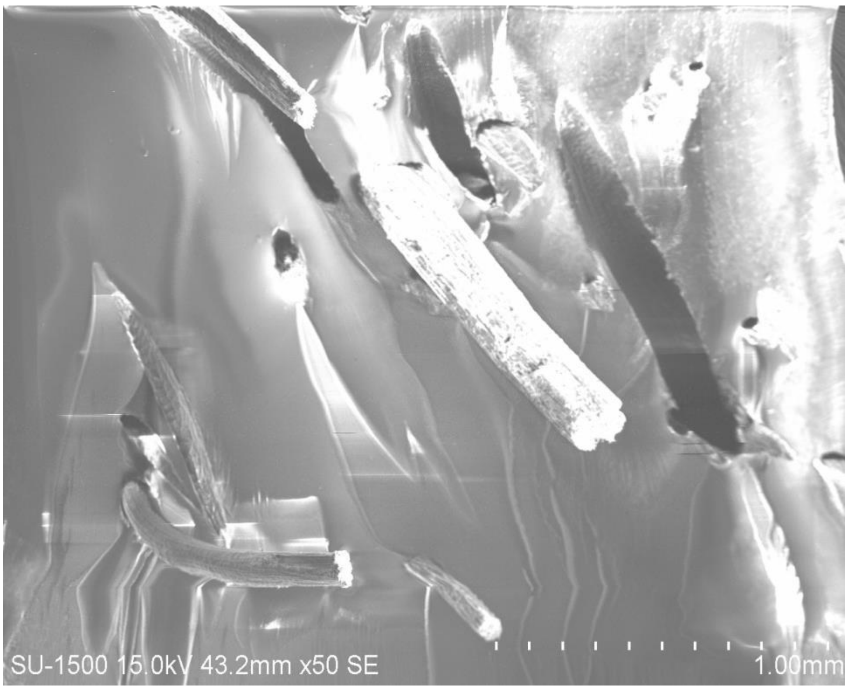

Figure 3. SEM micrographs of interfacial adhesion between fiber and matrix after tensile test.

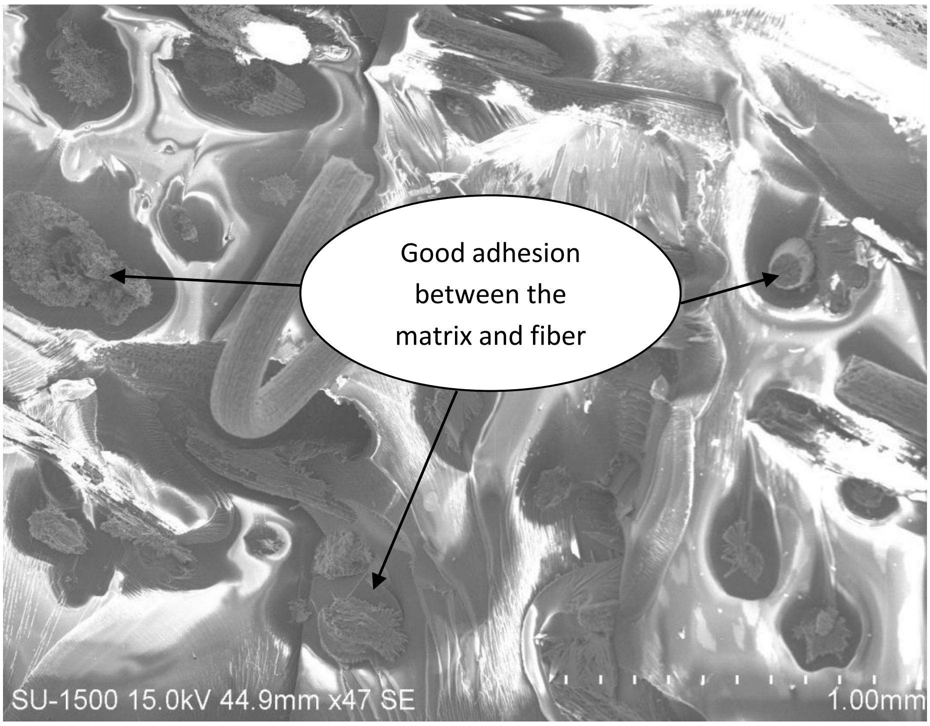

Figure 4. SEM of good adhesion between fiber and matrix (10 mm in fiber length).

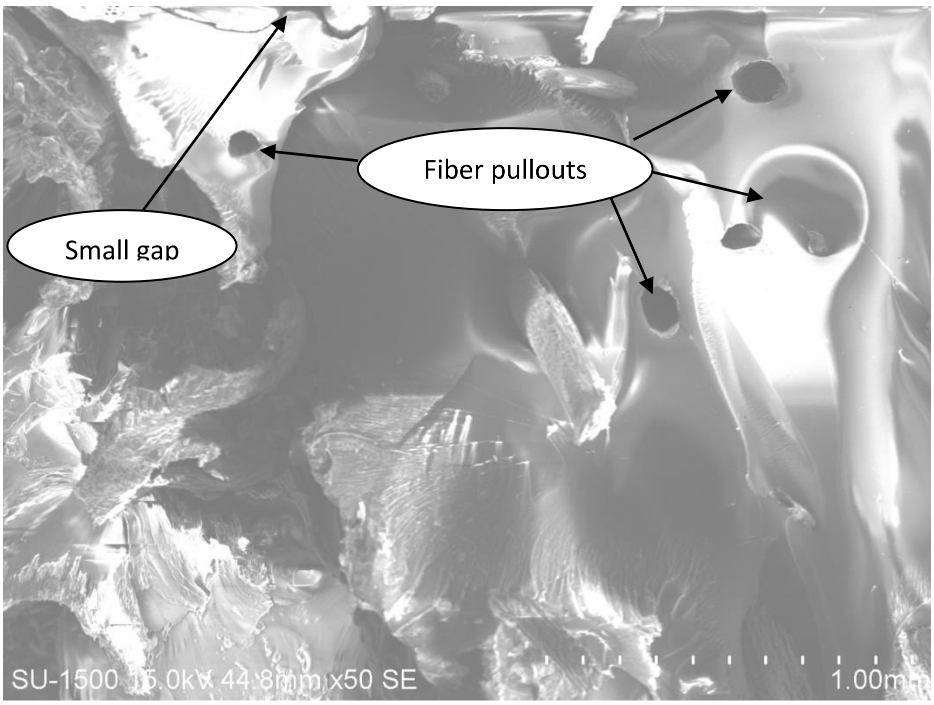

Figure 5. SEM showing the fiber pull-out from matrix (2 mm in fiber length).

The 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 inter-phase region as opposed to a distinct 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 [16]. The interface between fiber and matrix is shown in Fig. 3. In Fig. 4, it is showed that 10 mm in fibers length of composite have a good adhesion between matrix and fiber. The load acting on the matrix has to be transferred to the reinforcement via the interface [17]. 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 [17]. Figure 5, it is shown that there was a small gap between fiber and matrix which means a poor adhesion or interfacial bonding for 2 mm in length. The void and small gap formed was probably caused by incomplete wettability or bonding between matrix resin and fiber during the fiber pulled out was increased with decreasing fiber length.

4. CONCLUSION

In this paper, the tensile properties of *Sansevieria trifasciata* fiber reinforced polyester 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 polyester resin to obtain the highest tensile strength was found at 10 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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