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Research Article

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Morphological and mechanical behavior of sugarcane bagasse fibers reinforced polyester eco-friendly biocomposites

A. Balaji[1]*, B. Karthikeyan[2] and C. Sundar Raj[1]

[1]*Department of Mechanical Engineering, A. V. C. College of Engineering, Mayiladuthurai, Tamil Nadu, India*
[2]*Department of Mechanical Engineering, Faculty of Engineering and Technology, Annamalai University, Tamil Nadu, India*

ABSTRACT

Recently, Sugarcane bagasse fiber (SBF) is being used as a reinforcement material in the advancement of reinforced plastics for a variety of engineering applications. Thus, eco-friendly composites reinforced with sugarcane bagasse fiber-polyester (SBP) were prepared using compression molding process. The weight percentage of the fiber reinforcement was varied as 0, 5, 10 and 15%. The samples prepared to underwent morphological examination and to examine mechanical properties. The microstructure result shows that the good adhesion between fibers and matrix up to 15 wt% fibers in the composites and it is evident that the mechanical property improved due to the suitable adhesion of matrix and fiber. The tensile, compression and hardness properties of the composite increased with increasing percentage of the SBF up to maximum of 15 wt% fibers.

Keywords: Polymer Matrix, Bagasse Fibers, Biocomposite, Eco-friendly Composite, Polyester.

INTRODUCTION

Fiber reinforced plastic composites have played a leading role for a long time in a variety of applications for their high specific strength and modulus. Recently, there has been an increasing interest in the completely biodegradable composites reinforced with natural fibers [1 - 2] because they are renewable, environmentally friendly, production of natural fibers - annual renewability and lower energy inputs in production per unit, commonly known processing methods, excellent specific strength and high modulus, reduced density of products, lower cost, corrosion resistance, high creep resistance, high toughness, biodegradable and some biocomposites can have much higher wear resistance than metals [3].

Natural fibers have different origins such as bamboo, wheat, barley, corn, elephant grass, oat, wood, pulp, cotton, straw, and flax, jute, hemp, sisal [4 - 5]. Along with, Bagasse is as the leftovers from the pulling out of juice from the sugarcane and has been used as a flammable material for energy supply in sugar industries, as a pulp raw material in paper industries and as a reinforcing material for fiber board [6]. In addition, had utilized bagasse to compose bagasse –cement composites for construction industries, [7 - 9] reported the function of bagasse in fiber reinforced composites, and developed bagasse-filled bulk moulding composite by an injection moulding. However, a number of studies on the eco-friendly composites reinforced with SBF have been reported [10 - 12].

All of the natural fibers major weaknesses are such as low thermal resistance, hygroscopic in nature, inherent polarization, less dimensional stability, and anisotropic fiber properties. These disadvantages cause in weak fiber-resin interaction [13].

Conversely, there are a number of methods of surface modifications to get better fibers and polymer matrices compatibility, which can be physical or chemical according to modification technique to decrease the hydrophilic character. Regularl treatments are bleaching, etherification, use of compatibilizer, saline treatment, acetylation, alkali treatment, plasma treatment and treatment with additional chemicals [14 - 17].

The objectives of this paper are to prepared eco-friendly composites reinforced with SBP in the compression molding process, and compositions with 0, 5, 10 and 15 wt% of fibers. The material was evaluated in morphological behavior by techniques scanning electron microscope (SEM), density, water absorption and mechanical tests in order to measure impact, compression, hardness and tensile properties.

EXPERIMENTAL SECTION

Materials

The raw materials used to prepare the new composites are polyester, as matrix material, and SBF as reinforcement. The polyester was supplied by Sakthi Glass Fiber, Chennai, Tamil Nadu, India. In the form of jell. It is one of the commercial thermoset polymers which contain a number of carbons, C=C double bonds. The polyester has a density of 1.2 g/cm^3 at room temperature, the melting temperature (T_m) is 254 °C. The SBF obtained from Thalainayuru Sugar Mill, Nagai District, Tamil Nadu, India. SBF consists of approximately 50% cellulose and 25% each of hemicellulose and lignin. Chemically, bagasse contains about 50% α-cellulose, 30% pentosans, and 2.4% ash.

Composite Fabrication Process

Initially, the SBF is dried for 3 - 4 days under sunlight. Those SBF is put into ball mill for a micro size reduction. Fine particles of SBF mix with the polyester resin for one hour by using stirrer. The accelerator is Methyl ethyl ketone Peroxide (2% of weight for each composite) and catalyst Cobalt Napthalate (1% of weight for each composite) are added after stirring process. Once accelerator and catalyst is added, the curing reaction starts immediately at room temperature. The mixture was transferred to a silicon rubber mold size and polyethylene sheet in dimension of 300 × 300 × 3 mm is fabricated. After the curing process, the material is taken into the compression molding machine. By compression molding process, under temperature of 80 °C, the laminate is produced. The weight percentage of fiber reinforcement was varied as 0%, 5%, 10% and 15%.

0% 10% 20% 30%

Fig. 1. Photograph of the developed composites

RESULTS AND DISCUSSION

The eco-friendly composites reinforced with various weight percentage SBP were prepared using compression molding process and tested for its morphological and mechanical behavior.

Density

The fundamental method of determining the density of composite samples by determining the mass and volume of the sample was used. A sample is weighed in the digital weighing balance machine and measure the mass of the sample. The density of the sample was calculated from the equation below.

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}, \left(\frac{g}{mm^3}\right)$$

From Fig. 2, it was found that the composite density decreases with increasing of wt% SBF particles E.g. the density of the developed composites was 0.8 g/ mm^3 at 15 wt% SBF particles.

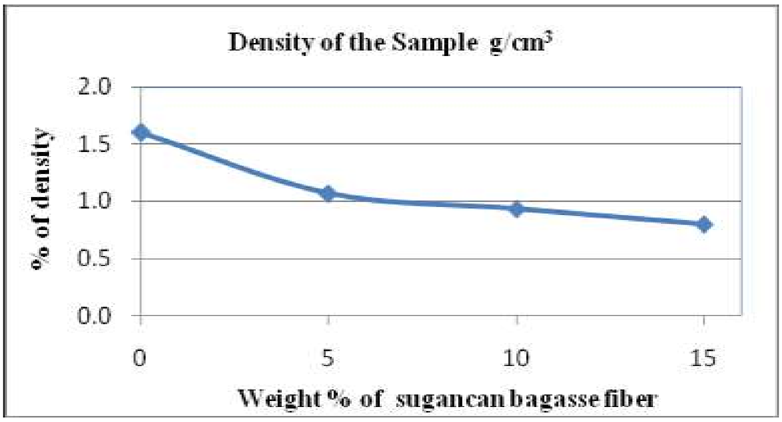

Fig.2. % of density Vs Wt% of Sugarcane bagasse Fiber

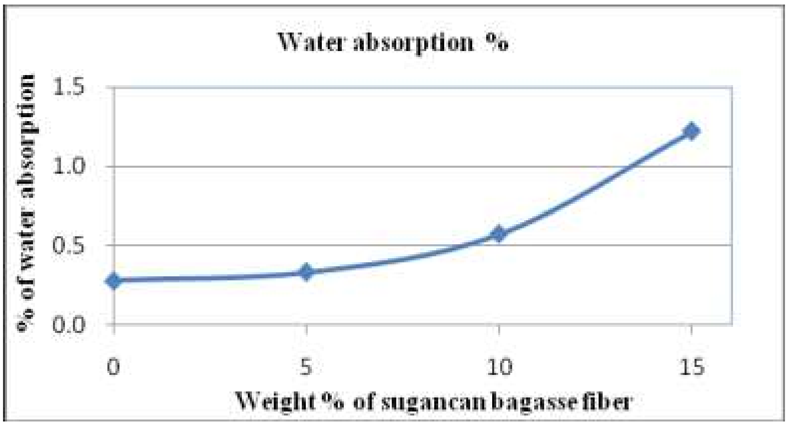

Fig.3. % of water absorption Vs Wt% of sugarcane bagasse fiber

Water absorption test

Water absorption test was carried out to find out the absorptivity of the composites and fibers. The samples were weighted by weighing balancing to get the mass of the sample before immersed in water and recorded. Then they were immersed in the beaker contains water for 24 hours to measure the water absorption by the samples. After 24 hours, they were taken out from the beaker and weighted again to record the mass water absorbption. From Fig. 3, the water absorption of the composites increases with increasing of wt% SBF because reinforcement material SBF absorb more water than the matrix material polyester.

SEM images

The SEM micrograph is an excellent technique for examining the surface morphology of SBP portrayals show in Figs. 4a – 4d. When compared to these four samples, the 15% of the SBF sample has good interfacial adhesion to the polyester resin. There are voids between the SBF and polyester resin. In the case of this composite, the good coverage of the fiber by the resin may prevent its exposure to air, improving its stability to oxidation. Wt% increasing has an effect on the fiber it increases surface roughness resulting in better mechanical properties [18].

Mechanical properties

Mechanical properties of studied composites are review in from Figs. 5, 6, & 7. Composites showed different mechanical properties, indicating that the SBF - matrix interaction compared to the 0% wt of SBF. The mechanical properties such as tensile strength, hardness and compression strength increased with the increasing of Wt% of the SBF. This may be due to the fact that additional increase in the Wt. % of SBF into the polyester matrix reduces the matrix mobility, which increases the stiffness of the composite [19].

From Fig. 8, it is shown that the capability to resist impact strength is SBF has launched some brittleness as an increase in hardness show the way to a decrease in impact strength. The polyester matrix and the composite with 5 wt% SBF particles have the maximum impact strength [20]. Alternatively, as can be recommended from the impact test, the elastic behavior of the matrix proportionately varies with the addition of the SBF. As the loading of SBF increases, the ability of the composites to absorb impact energy decreases since there is less ratio of the polyester matrix to particles. However the results obtained are within the standard level for bio-composites [21].

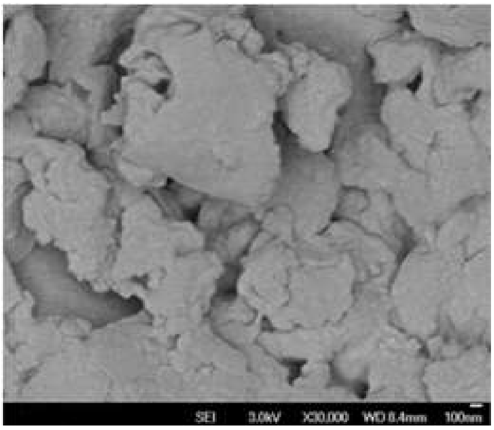

Fig. 4a. 0 %Wt of sugarcane bagasse fiber

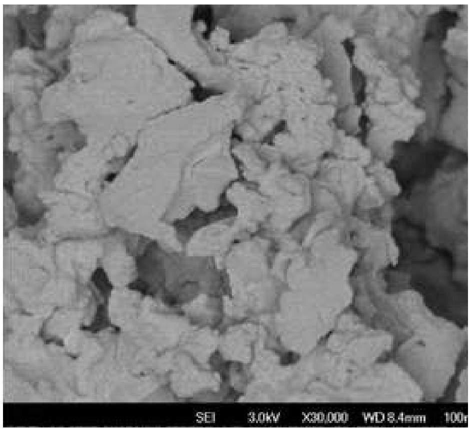

Fig. 4b. 5 %Wt of sugarcane bagasse fiber

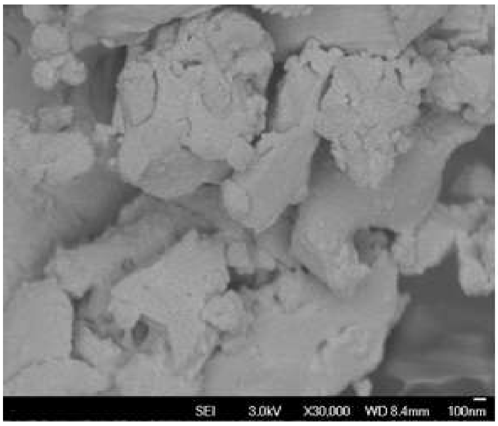

Fig. 4c. 10 %Wt of sugarcane bagasse fiber

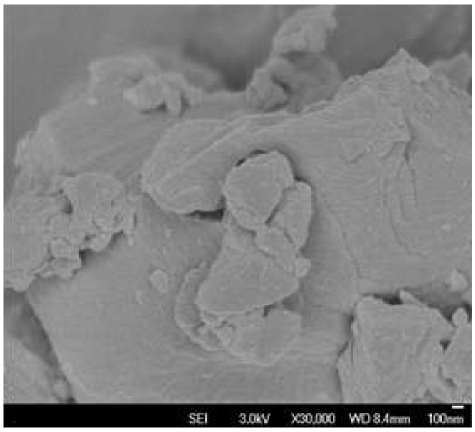

Fig. 4d. 15 %Wt of sugarcane bagasse fiber

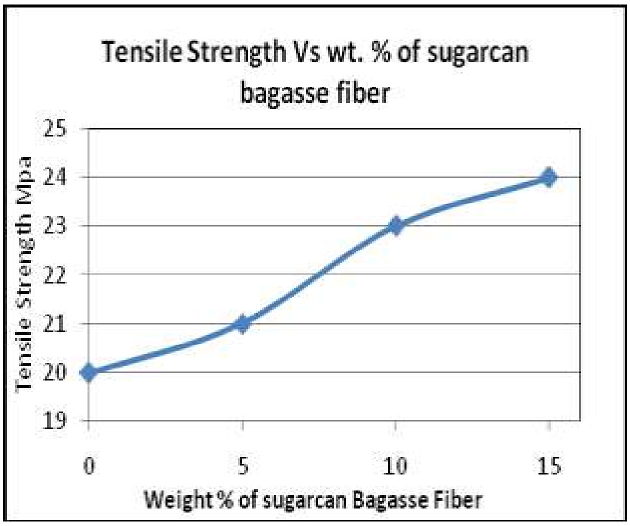

Fig. 5. Tensile strength Vs Wt. % sugarcane bagasse fiber

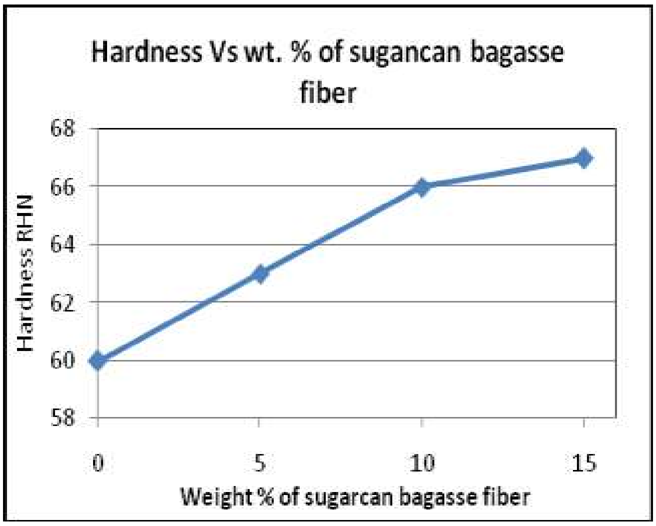

Fig. 6. Hardness Vs Wt. % sugarcane bagasse fiber

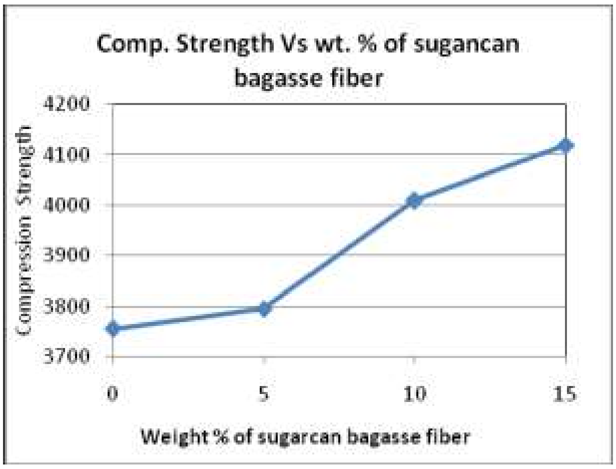

Fig. 7. Compression strength Vs Wt. % sugarcane bagasse fiber

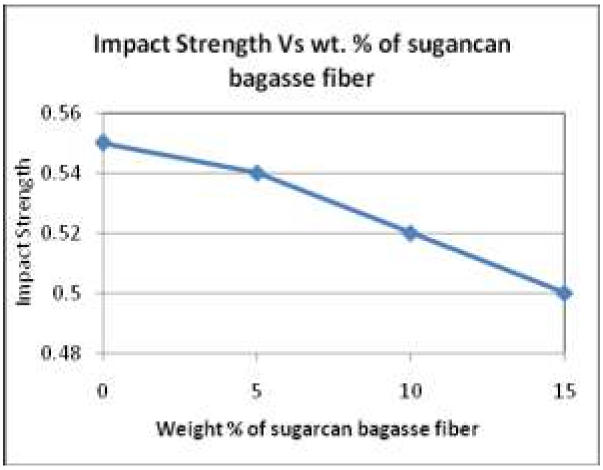

Fig. 8. Impact strength Vs Wt. % sugarcane bagasse fiber

CONCLUSION

In this present work, a few morphology and mechanical properties of polyester eco- friendly composites reinforced with SBF has been examined. From the results and discussion presented above, the following conclusions can be made:

- This work shows the doing well manufacture of polyester and the SBF particles composite by compounding and compression molding technique.
- The uniform allocation of the SBF in the microstructure of the polymer composites is the most important factor responsible for the improvement in the mechanical properties.
- Based on the results, it is suggested that these composites can be used in the manufacture of low strength automotives and other structural applications.

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