Innovations in Production Engineering
Volume 1 Issue 1

Mechanical Properties of Banana Fiber Reinforced Polyester Composites

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ABSTRACT

In present work, a new class of polymer composite is developed with polyester resin as base matrix and short banana fiber as reinforcement. Composites are prepared for varying content of banana fiber up to 15 wt. %. Hand lay-up method is used for fabrication of composites. In addition with fiber, flame retardants were also added to enhance fire worthiness behavior of material. Two categories of composites are prepared, one without flame retardant and other with flame retardant. The effect of filler content and flame retardants on different mechanical properties of the prepared sample is studied. From the results, it is clear that inclusion of banana fiber enhances most of the mechanical properties of the material. Further, when flame retardants are added, mechanical properties of the material further modifies.

Keywords: *Polymer Matrix Composites, Polyester, Banana Fiber, Mechanical Properties.*

INTRODUCTION

Composite materials is an advanced material and used in various sectors due to its outstanding properties [1]. Natural fiber-polymer composites (NFPCs) are becoming increasingly utilized in a wide variety of applications because they represent an ecological and inexpensive alternative to conventional petroleum-derived materials. Huge amount of work is going on around the world with natural fiber as a reinforcing material in polymer matrix.

Azwa and Yousif [2] studied the tensile properties of bamboo fiber reinforced polyester composites and found with increase in fiber content tensile strength and tensile modulus increases. Nabila et al. [3] studied the effect of weight fraction of jute fiber on the tensile strength of the polypropylene based composites. In their study, they found increment of around 20 % and 80 % in tensile strength and tensile modulus when 40 wt. % of jute fiber is reinforced in polypropylene composites. Shahinur and Ullah [4] took jute fiber of varying length form the different part of the same plant and reported to observe varying value of tensile strength of fiber.

Durante et al. [5] showed a perfect example of such behavior. They used hemp fiber and increase its loading in PLA matrix and found that, with increase in fiber loading, flexural strength increases as a pure function of fiber content. They reported to achieve maximum flexural strength at a fiber content of 30 wt. %. Jayaseelan et al. [6] evaluated the flexural strength and modulus of banana fiber reinforced epoxy composites. They used banana fiber in three different forms *i.e.* short fiber, micro particles and macro particles. Das et al. [7]

observed the flexural strength and flexural modulus of two layer sequence of jute fabric/waste paper polyester composites. Atiqah et al. [8] used combination of honeycomb filler with epoxy matrix and evaluated the surface hardness of the material. The result shows that, for a test sample of 9 wt. % fiber, indentation diameter of 1.8 mm is obtained which is the smallest indentation obtained in their study. Corresponding to the indentation diameter, 58.09 is the Brinell hardness number of the specimen with 9 wt % filler.

Banana fibers, a well-known natural fiber is a promising reinforcement for use in composites on account of its low cost, low density, high specific strength and low modulus, no health risk, easy availability and renewability. Joseph et al. [9] compared the mechanical properties of glass fiber reinforced composites with banana fiber reinforced composites. In their study, they used both the fibers in the form of long fibers and fabricated composites with varying filler loading. They performed fiber pull out test to evaluate the adhesion between fiber and matrix body.

Ramesh et al. [10] were also fabricated banana fiber reinforced polymer composites with thermoset polymer epoxy and experimentally determined its mechanical properties. All the composites were fabricated using hand lay-up technique and the fractured surface were studied under scanning electron microscopy. Jorden et al. [11] improves the interfacial bonding between banana fiber and LDPE matrix with the help of chemical treatment.

Muktha, and Gowda [12] focused their work on water absorption and fire resistance behavior of banana fiber reinforced polyester composites. They concluded that water absorption and fire resistance of composite is a function of thickness of specimen. Against this background, the present research work is undertaken which explores the possible utilization of banana fiber in the form of short fiber in polyester polymer with and without incorporation of fire retardant. Effect of flame retardants (Magnesium hydroxide and zinc borate) on various mechanical properties of banana fiber/polyester composites is studied.

MATERIALS AND METHODS

Unsaturated isophthalic polyester supplied by Ciba-Geigy India Ltd. is taken as the matrix materials in the present investigation. Polyester resins are relatively inexpensive, fast processing and due to their ease of fabrication they are used generally for low-cost applications. Banana fiber, a natural fiber is used in present investigation as reinforcement. Banana fiber with its good mechanical strength has an appreciable specific property, even comparable to glass fiber.

In addition to that, it possesses lower density than glass fibers. Apart from good specific properties, smaller elongation, fire resistance quality, great potentialities and biodegradability are the major advantages of this fiber.

Natural magnesium hydroxide (brucite) and Zinc Borate ($2Zn0\cdot3B_20_3\cdot3.5H_20$) is used as a fire retardant. The average density of magnesium hydroxide and Zinc Borate is 2.34 g/cm^3 and 3.64 g/cm^{3}respectively. In this experiment composite fabrication done with varies weight percentage of banana fiber with polyester resin to identify physical behavior of composite material by hand lay-up method. For fabrication of composites, mould is prepared. The mould 320×320×3 mm was used for fabrication of composites. The various sets of composite fabricated during present work are listed in Table 1.

Table 1 Polyester based Composites Reinforced with Banana Fiber

S.No.	Composition			
	Category I		Category II	
1	Set A1	Neat Polyester	Set B1	Neat Polyester + 5 % $Mg(OH)_2$ + 5% $2Zn0 \cdot 3B_20_3 \cdot 3.5H_20$
2	Set A2	Polyester + 3% weight bananafiber	Set B2	Polyester + 3% weight bananafiber + 5 % $Mg(OH)_2$ + 5% $2Zn0 \cdot 3B_20_3 \cdot 3.5H_20$
3	Set A3	Polyester + 6% weight bananafiber	Set B3	Polyester + 6% weight bananafiber + 5 % $Mg(OH)_2$ + 5% $2Zn0 \cdot 3B_20_3 \cdot 3.5H_20$
4	Set A4	Polyester + 9% weight bananafiber	Set B4	Polyester + 9% weight bananafiber + 5 % $Mg(OH)_2$ + 5% $2Zn0 \cdot 3B_20_3 \cdot 3.5H_20$
5	Set A5	Polyester + 12% weight bananafiber	Set B5	Polyester + 12% weight bananafiber + 5 % $Mg(OH)_2$ + 5% $2Zn0 \cdot 3B_20_3 \cdot 3.5H_20$
6	Set A6	Polyester + 15% weight bananafiber	Set B6	Polyester + 15% weight bananafiber + 5 % $Mg(OH)_2$ + 5% $2Zn0 \cdot 3B_20_3 \cdot 3.5H_20$

The tension test is generally performed as per ASTM D3039-76. The tensile test has been performed in universal testing machine (UTM) INSTRON H10KS. The three point bend test was carried out in Universal Testing Machine (UTM) in accordance with ASTM D2344-84 to measure the cross breaking strength of the composites. ASTM D2583-67 barcol Hardness test method is used to determine the hardness of both reinforced and non-reinforced rigid plastics.

RESULTS AND DISCUSSION

The tensile strength of all the fabricated samples of category I and II are measured by universal testing machine and are shown in figure 1 and 2.

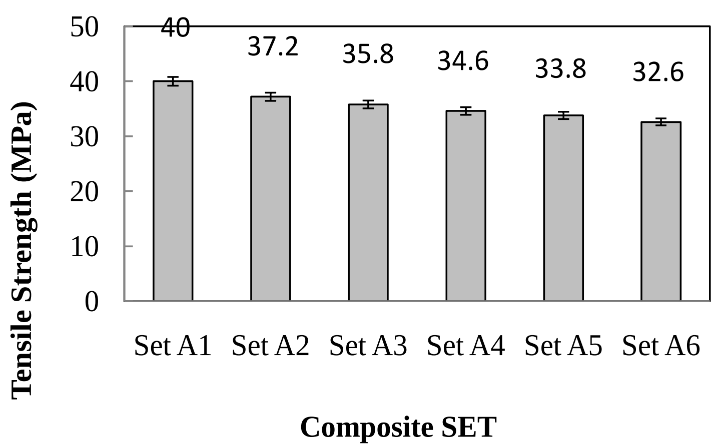

Fig. 1. Tensile Strength Polyester/Banana Fiber Composites without Flame Retardant

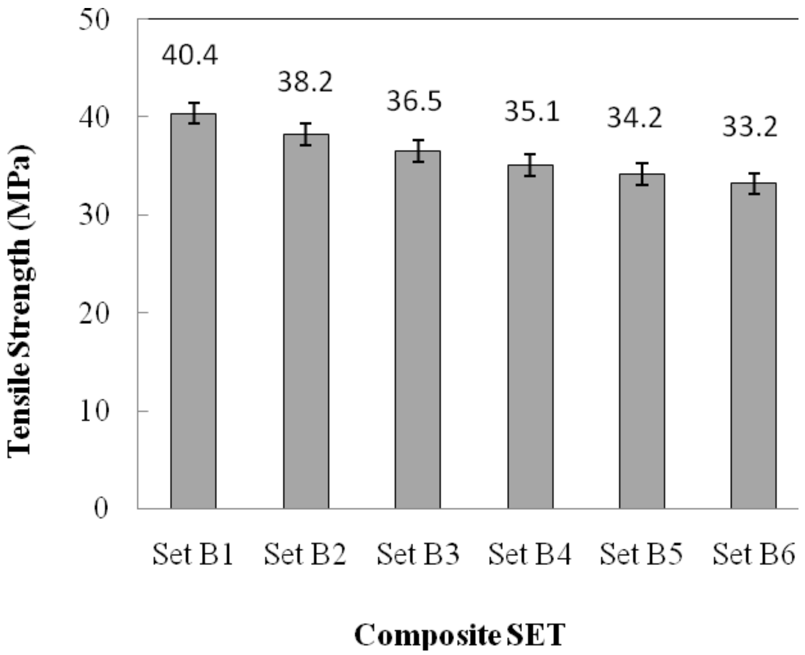

Fig. 2. Tensile Strength Polyester/Banana Fiber Composites with Flame Retardant

It is observed from the figure that the tensile strength of composite decreases with increase in fiber content. The minimum tensile strength reported is 32.6 MPa and 33.2 MPa for category I and II respectively. The reduction in tensile strength with increase in fiber reinforcement may be due to the weak chemical bond between fiber and the matrix body which is unable to transfer the tensile load. The improved tensile strength of $Mg(OH)_2$ and zinc borate filled composites at various fiber loading may be due to better dispersion of filler, better wettability and good adhesion between the matrix and filler. The flexural strength of different composites measured by universal testing machine for category I and II in accordance with ASTM D2344-84 are shown in figure 3 and 4 respectively.

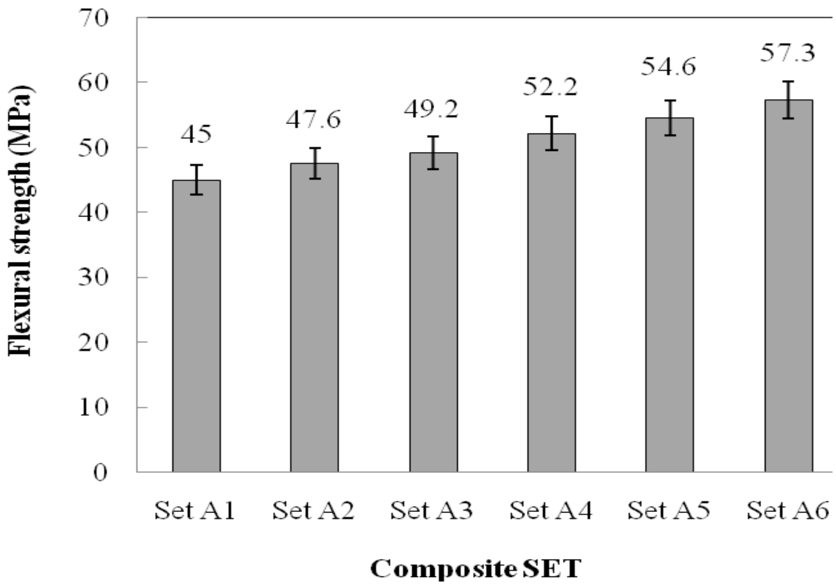

Fig. 3. Flexural Strength Polyester/Banana Fiber Composites without Flame Retardant

From the figure it is clear that there is an increasing trend in flexural strength as the fiber contents in the composite increases. The maximum value for composite under category I is 57.3MPa for set A6 and under category II is 59.8MPa for B6. This is an increment of around 27.3 % and 32.9 % for category I and II respectively. As per the overall observation in the flexural strength of the composite, incorporation of fiber in the polymer composite influences the properties of the composites.

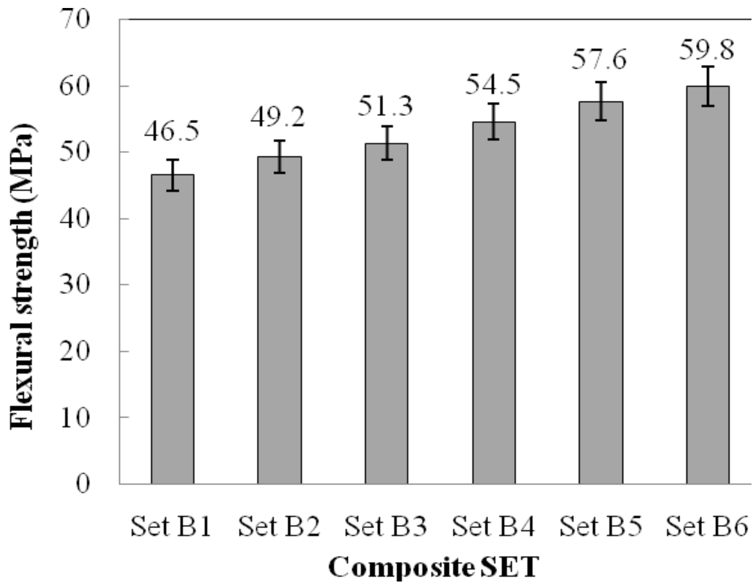

Fig. 4. Flexural Strength Polyester/Banana Fiber Composites with Flame Retardant

In the present investigation, the hardness values of the fabricated composites are measured using Barcol harness tester. The results obtained during the experimentation of category I and category II types composites are shown in figure 5 and figure 6 respectively. From the figures it is clear that, with the increase of fiber loading, hardness of the banana fiber-polyester composites increases and reaches its maximum value of 33.8 at 15% fiber loading for category I composites for set A6 and 34.8 at similar loading for category II composites for set B6. This increment is attributed to 64.8 % and 69.7 % for category I and II respectively.

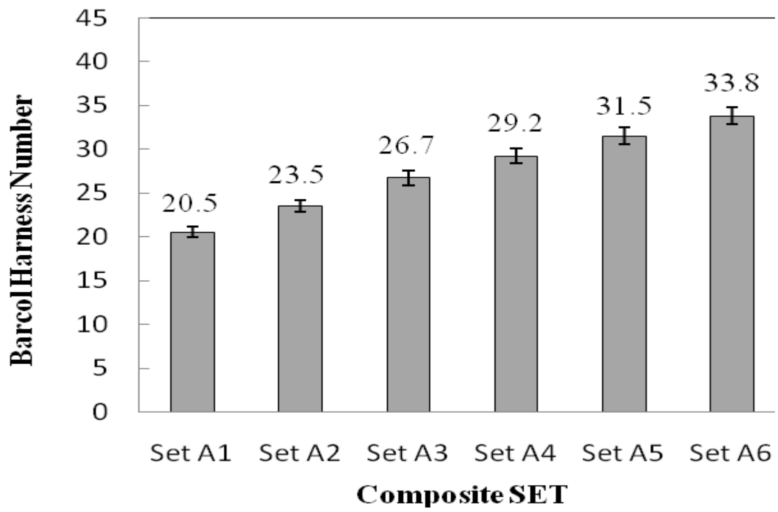

Fig. 5. Hardness of Polyester/Banana Fiber Composites without Flame Retardant

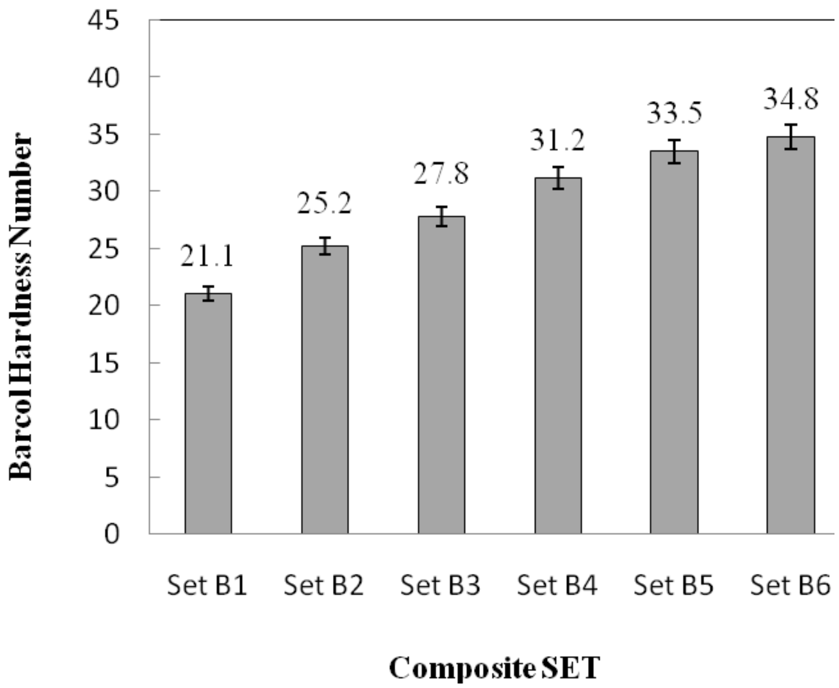

Fig. 6. Hardness of Polyester/Banana Fiber Composites with Flame Retardant

This is attributed to the fact that hardness is a function of the relativefib er content and this may be due to the reason that increase in the weight percentage of the fiber within matrix body increases the ductility of the material which offers resistance for indentation. By addition of fire retardant additives, hardness of the composites marginally increases, because these fire retardant additives are metallic and hard in nature.

CONCLUSION

This experimental investigation on short banana fiber reinforced polyester composites has led to the following specific conclusions:

1) Successful fabrication of polyester matrix composites reinforced with short banana fiber is possible by simple hand-lay-up technique.
2) The ultimate tensile strength of the fabricated composite decreases with increase in banana fiber content. The minimum tensile strength among the various fabricated samples is registered for polyester composites reinforced with 15 wt. % banana fiber without flame retardant.
3) The flexural strength of the fabricated composite increase with increase in fiber content. The maximum value of flexural strength for polyester composite with banana fiber is reported to be 57.3MPa for 15 wt % of banana fiber for category I composites. The increment in flexural strength increased further when flame retardants are used. In this case, flexural strength obtained is 59.8 MPa for 15 wt. % banana fiber.
4) The hardness of the composites increases with the increase in the content of banana fiber in polyester matrix. The maximum value obtained is 33.8 Barcol number for 15 wt. % of fiber loading for category I composites. The increment increased when flame retardants are added in the combination. In that case the maximum value of hardens is measured to be 34.8 Barcol number.

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