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Banana Fruit Stem Fiber Reinforced with Polyester Composites on Mechanical Properties

M. Venkateswarlu*, M. Ashok Kumar, M. Nagakiran

Dr. K. V. Subba Reddy Institute of Technology, Department of Mechanical Engineering, Kurnool, Andhra Pradesh, India

ABSTRACT

This research article presents polymer composites reinforced with Banana stem fruit fiber (BFF) to assess the mechanical properties. The fibers used in the research are treated with NaOH solution gain the advantage over the neat polyester. Fiber was loaded with 2,3,4,5, and 6 wt.% for both the composites. Composites are prepared with the help of hand layup technique and the glass moulds are prepared to provide castings for composites. Banana fiber was treated with NaOH (10%) solution for about 45 minutes. Tensile strength, modulus and flexural strength and modulus were estimated for both treated and untreated composites. It was noticed that treated composites are good candidates for effective improvement of the performance. In SEM analysis reveals the improved/ decreased performance of treated and untreated composites.

Keywords: Banana fruit fiber (BFF), Polyester, Composite, Mechanical Properties, SEM

I. INTRODUCTION

The matrix forms a significant volume fraction of a polymer composite and it has a number of critical functions; it binds the reinforcements together, maintains the shape of a component and transfers the applied load to the reinforcing fibres. it protects the reinforcing fibres from degradation, due to abrasion or environmental attack. It contributes significantly to the mechanical properties of structural polymer composites, acting to resist delamination between plies of reinforcements and to inhibit fibre buckling during compression. Thermoplastics are used in certain applications but constitute a relatively small sector of the structural composites market. Matrices used for structural composites are mainly thermosetting plastics, such as polyester resins, epoxy resins, phenolic resins and vinyl-ester resins. Polyester resins are the most widely used resin systems, particularly in the marine industry. By far the majority of dinghies, yachts and work-boats built in composites make use of this resin system. Thermosetting plastic systems generally consist of liquid mixtures of relatively low molar mass reactants, such as monomers and/or prepolymers, which polymerise upon heating to form highly-crosslinked, network polymers. Thanks to the natural fibers as they are slowly showcasing their lime light when it's come to mechanical properties, and environmental benefits. These have proved to be suitable candidates as a reinforcement material for polymer composite materials, especially thermoset based plastics. A wide variety of such fibers (flax, jute, hemp, sisal, etc.) are already being applied in the automotive industry, offering such advantages as a high rigidity accompanied by a lighter weight and easier reprocessing. The main limitation of the fibers is their hydrophilic nature, low thermal stability, and poor dispersion in polymer melts [1-5]. It is clear that composite technologies allow the producer to add much more value to his product than the processing and trading of raw material. The development of new and more profitable markets will improve the position of the (mainly poor) people working in the coir industry and increase their welfare also. Other natural fibers such as flax and sisal have already shown that they can be used successfully in composite components in order to realize reduction of weight and cost [6-10]. The resulting mechanical properties of composites generally depend on the fiber's

nature, size and distribution, aspect ratio, volume fraction, and the intrinsic adhesion between the surfaces of fiber and polymer. High aspect ratio (fibre type) fibers generally increase the yield strength because the fiber is capable of attaining high local stress transferred from the polymer matrix, which does not happen with lower aspect ratio fibers. It is known fact that polymers are compatible with any type of natural fibers and these have been proved that they can be replaced with synthetic fibers as well. Using glass fibers, aramid fibers strength may be increased significantly but they will damage in environment and also processing of these fibers is cumbersome. Past 15 years continuous research has been going in all over the globe to replace them with synthetic fiber. These problems gave birth to the natural fibers reinforced composites [11-20]. Thus in the present study we are using banana stem fruit fiber are reinforcing agent and the polyester is the matrix we have taken to fabricate composite and also different fiber concentration such as 2,3,4,5, and 6 wt.% ration of natural fibers have been considered for this research to evaluate mechanical and scanning electron microscope.

II. METHODS AND MATERIAL

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 15.3MPa and elongation at break of 3.3%. Tensile strength, three point bending tests were carried out on par with ASTM D 53455. Tensile and flexural tests were performed on Instron universal testing machine (3369). All the tests were accomplished at a room temperature of 20 ºC. At least five samples were tested for each composition and results were averaged. Scanning electron microscopy (SEM) studies of the fractured surface of the tensile specimen were carried out on a Jeol (6380LA, Japan). The specimen was sputter-coated with gold to increase surface conductivity.

Composite Preparation

Polyester resin (matrix) was taken in a by weight based on the mould volume and then mixed with matrix/ promoter/accelerator as 100:2:2 stoichiometric ratios. Meanwhile glass moulds are prepared to assist the casting on par with the ASTM standards and then mould ought to coat with polyvinylalcohol (PVA) to remove the casting after post curing without any damage. Then put the 20% of total solution into the mould all over the mould and this will act like wetting agent while fiber is placed upon it. Fiber is stacked in all directions randomly and then the remaining polyester solution has to pour all over the mould as a second layer. Using brush and roller air was removed and then a thin OHP sheet is spread all over the top surface of the mould then weight of 50kg load is placed above the OHP sheet [7, 8]. This weight facilitates the uniform distribution of matrix all over the mould, and mirror surface finish when compared with the bottom surface. After 24 hours post cured samples were cut according to the ASTM standards as mentioned thereof.

Table 1: Illustration of mechanical strength measurements as a function of fiber loading untreated composites.

Fiber Loading (wt.%) (Untreated)	Tensile strength(MPa)	Tensile modulus (MPa)	Flexural strength (MPa)	Flexural modulus (MPa)
PE + 2wt.%BFF (A)	35.04	4256.02	25.04	2589.06
PE + 3wt.%BFF (B)	38.11	4485.45	27.88	2789.52
PE + 4wt.%BFF (C)	42.53	4702.63	29.12	2935.01
PE + 5wt.%BFF (D)	**47.96**	4901.20	30.19	3052.66
PE + 6wt.%BFF (E)	40.23	**5635.05**	**32.07**	**3587.53**

III. RESULT AND DISCUSSION

Table 1 and Table 2 shows that the mechanical properties such ass tensile strength, tensile modulus, flexural strength and flexural modulus measurements as a function fiber loading. Tensile strength performance for untreated and treated composites is shown in the Figure 1. It was noticed from the graph is strength was increased gradually from A to D specimens but decreases after that at 5wt.% BFF loading strength was optimized and also 36.87% strength is increased when compared with the performance of 2wt.% BFF loading.

Table 2: Illustration of mechanical strength measurements as a function of fiber loading of treated composites.

Fiber Loading (wt.%) (Treated)	Tensile strength(MPa)	Tensile modulus (MPa)	Flexural strength (MPa)	Flexural modulus (MPa)
PE + 2wt.%BFF (A)	37.63	4890.25	29.05	2935.42
PE + 3wt.%BFF (B)	39.42	5236.42	33.05	3124.00
PE + 4wt.%BFF (C)	45.36	5428.63	35.47	3302.88
PE + 5wt.%BFF (D)	**50.67**	5698.41	37.63	3634.74
PE + 6wt.%BFF (E)	45.03	**6025.41**	**38.96**	**4865.26**

Tensile strength for treated composites were increased gradually from A to D whereas after that strength was suddenly decreases.

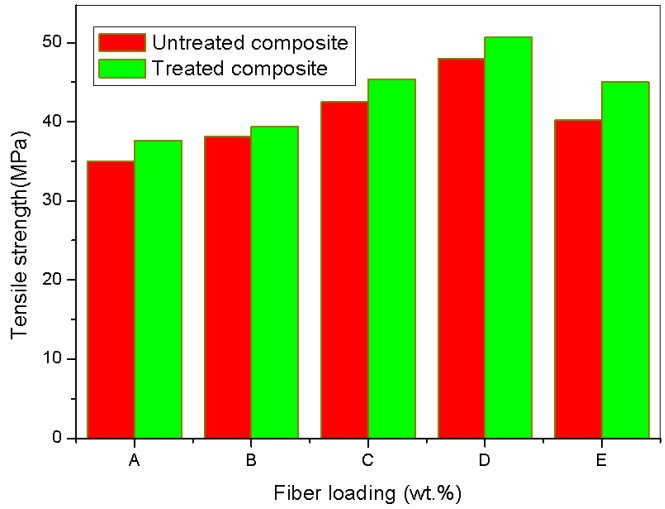

Figure 1: Measurements of tensile strength results PE reinforced with BFF composites.

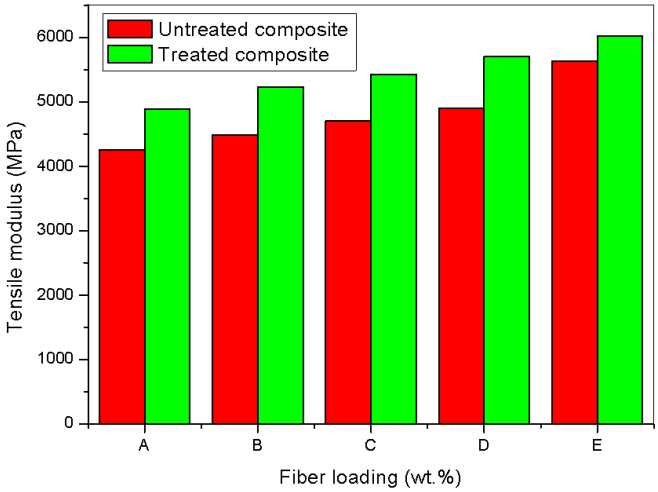

Figure 2: Measurements of tensile modulus results PE reinforced with DFF composites.

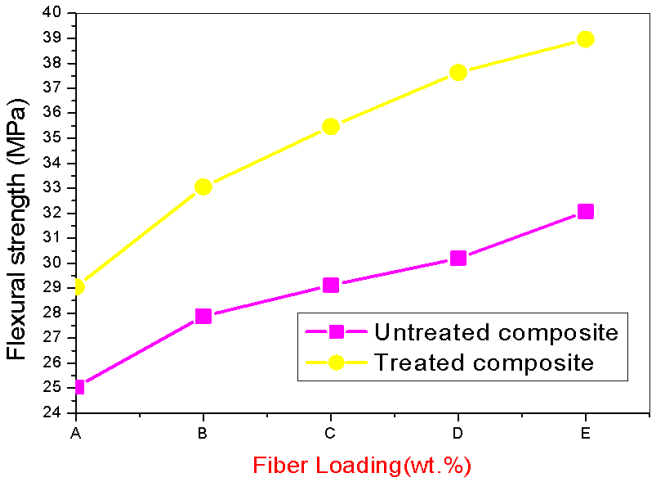

Figure 3: Measurements of flexural strength results PE reinforced with BFF composites.

Tensile strength was increased up to 34.65% when compared with the specimen A magnitude. Over all 5wt.% treated composites are having5.65% greater strength when compared with the same composite from the untreated composites [10]. Tensile modulus performance for untreated and treated composites is shown in the Figure 2. It was noticed from the graph is stiffness was increased gradually from A to E specimens and also 32.40% strength is increased when compared with the performance of 2wt.% BFF loading.

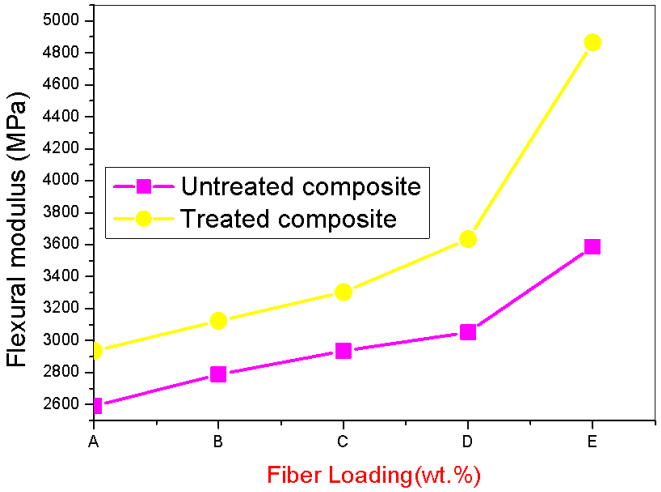

Figure 4: Measurements of flexural modulus results PE reinforced with DFF composites.

Tensile modulus for treated composites were increased gradually from A to E. Tensile modulus was increased up to 23.21% when compared with the specimen A magnitude [14]. Over all 5wt.% treated composites are having 6.92% greater stiffness when compared with the same composite from the untreated composites. Flexural

strength performance for untreated and treated composites is shown in the Figure 3.

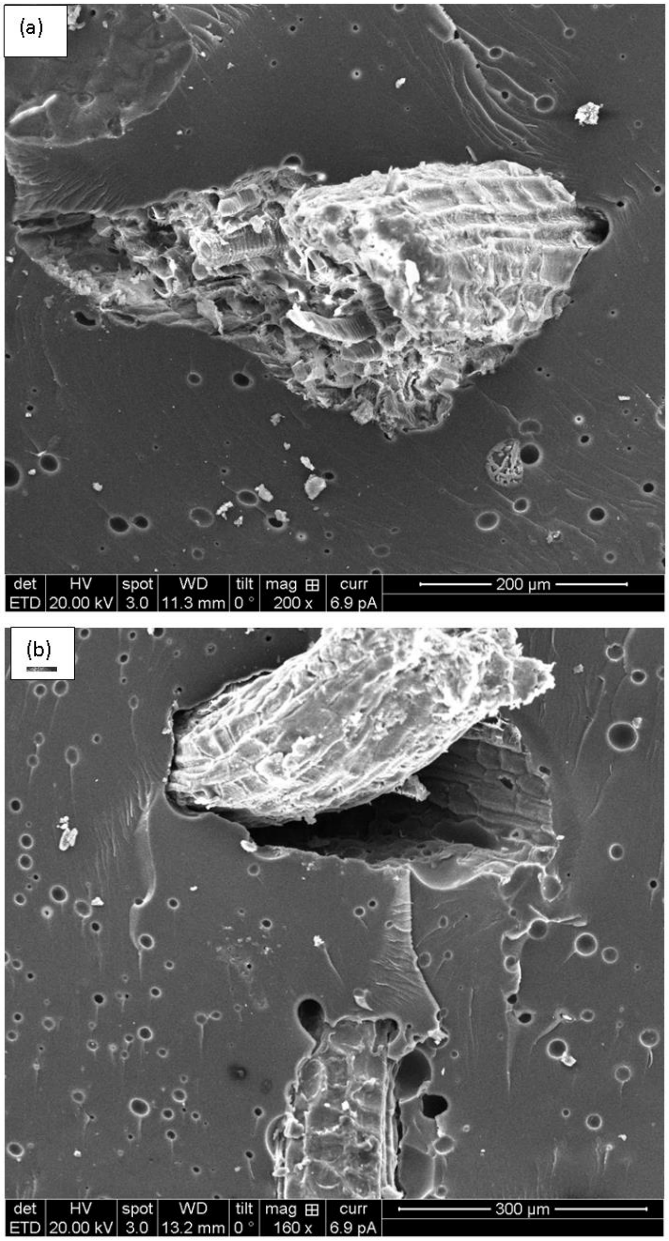

Figure 5: Tensile strength fracture surfaces of Specimen E SEM images (a) 200X and (b) 160X magnifications

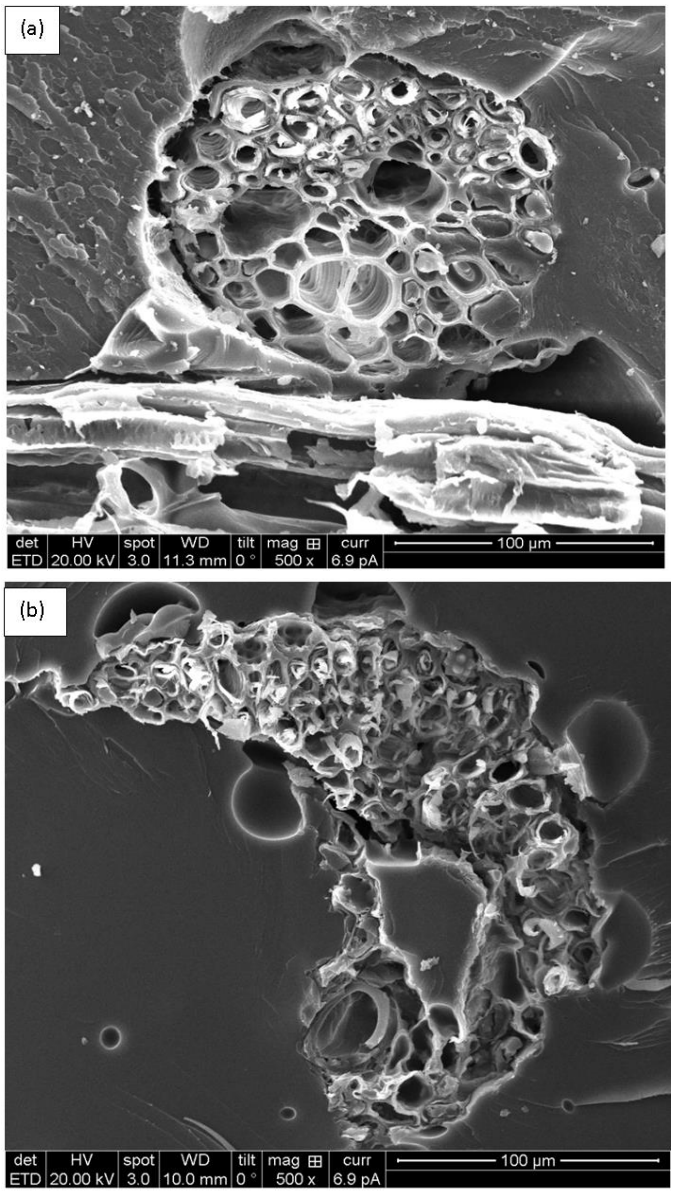

Figure 6: Tensile strength fracture surfaces of Specimen D SEM images (a) 500X and (b) 500X magnifications.

It was noticed from the graph is strength was increased gradually from A to E and also 28.07% strength is increased when compared with the performance of 2wt.% BFF loading. Flexural strength for treated composites were increased gradually from A to E. Flexural strength was increased up to 34.11% when compared with the specimen A magnitude. Over all 5wt.% treated composites are having 21.48% greater strength when compared with the same composite from the untreated composites. Flexural modulus performance for untreated and treated composites is shown in the Figure 4. It was noticed from the graph is that the modulus was increased gradually from A to E and also 38.56% strength is

increased when compared with the performance of 2wt.% BFF loading. Flexural modulus for treated composites were increased gradually from A to E. Flexural modulus was increased up to 65.74% when compared with the specimen A magnitude. Over all 5wt.% treated composites are having 35.61% greater strength when compared with the same composite from the untreated composites. Tensile strength fracture surfaces were analysed with the help of scanning electron microscope in order to assess the reasons of the composites. Figure 5 (a) & (b) shows the SEM images of the untreated composites specimen E. It was observed from the microgram that image is full of voids all over the images 5(a) and also fiber pull outs were also identified in the image 5(b). Voids may be due to poor flowability of the polyester consequently made polyester air entrapment in the some vulnerable points. Fiber and matrix interface is also not up to the mark [12]. These are all the significant reasons for decreased performance. Figure 6 (a) & (b) shows the SEM images of the treated composites of specimen D. It was observed from the microgram that image is out of voids some extent 6(a) and also fiber pull outs were also not identified in the image 6(b). Deprived of voids may be due to flowability of the polyester consequently made polyester no air entrapment in the some vulnerable points [5]. Fiber and matrix interface is also significantly good. These are all the significant reasons for increased performance for the treated composites.

IV. CONCLUSION

This research article presents polyester matrix composites reinforced with treated/ untreated banana fibers. Characterization includes tensile strength, tensile modulus, flexural strength, flexural modulus, and scanning electron microscope analysis measurements were evaluated. For tensile strength treated composites participated comparatively well when compared with untreated composites. Over all 5.65% tensile strength was increased for treated specimen D when compared with untreated specimen D. For tensile modulus treated composites participated comparatively well when compared with untreated composites. Over all 6.92% tensile modulus was increased for treated specimen E when compared with untreated specimen E. For flexural strength treated composites participated comparatively well when compared with untreated composites. Over all 21.48% flexural strength was increased for treated specimen E when compared with untreated specimen E. For flexural modulus treated composites participated comparatively well when compared with untreated composites. Over all 35.61% flexural modulus was increased for treated specimen E when compared with untreated specimen E.

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