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Investigation on Mechanical Properties of Banana Fiber Glass Reinforced Hybrid Thermoplastic Composites

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Abstract

Natural fibres have played a significant role in human civilization since pre history times with human having depend on them for garments and simple domestic uses as well as complex uses such as load dwelling, military, marine engineering etc. The conventional application of fibers in relation to the technology of synthetic fibre reinforced composites reveal the clue to widen the scope and to adopt the natural fiber composites for industrial applications. In the present work, banana fiber is incorporated in polypropylene resin matrix hybridized with glass fiber for preparing composite specimens at various fiber weight percentages. The developed banana fiber, glass reinforced hybrid polypropylene composites (BGPP) were then tested for their mechanical properties. It was found that the increase in fiber content reduces the mechanical properties of Bananaa glass-PP composite

Key words: Hybrid Composite, banana Fiber, glass Fiber.

1. Introduction

Composites consisting lignocellulosic fibers and synthetic thermoplastics have received substantial attention in scientific literature as well as in industry, primarily due to improvements in process technology and economic factor. Natural fiber-based thermoplastic composites are generally lower in strength performance compared to thermoset composites. However, they have the advantage of design flexibility and recycling possibilities.

Hybridization with small amounts of synthetic fibers makes these natural fiber composites more suitable for technical applications such as automotive interior parts. Performance of injection-molded short hemp fiber and hemp/glass fiber hybrid polypropylene composites were analyzed [1]. Results showed that hybridization with glass fiber enhanced the performance properties. Thermal properties and resistance to water absorption properties of the hemp fiber composites were improved by hybridization with glass fibers. Overall studies indicated that the short hemp/glass fiber hybrid polypropylene composites are promising candidates for structural applications where high stiffness and thermal resistance is required. The effect of hybridization on mechanical properties of coir and sisal reinforced polyester composite (CSRP), coir and jute reinforced polyester composite (CJRP), jute and sisal reinforced polyester composite (JSRP) were evaluated experimentally [2]. The results demonstrate that hybridization play an important role for improving the mechanical properties of composites. The tensile and flexural properties of hybrid composites are markedly improved as compare to unhybrid composites.

Water absorption behaviour indicated that hybrid composites offer better resistance to water absorption. A hybrid composite materials using Wood Powder, Groundnut Husk and Cashew nut Husk have been developed [3]. The behaviour of composites and hybrid composites of short bamboo and glass fibers in a polypropylene (PP) matrix under hygrothermal aging and under tensile–tensile cyclic load were studied and this hybrid showed better fatigue resistance [4]. Mechanical and physical properties of oil palm empty fruit bunch/glass hybrid reinforced polyester composites were studied and showed hybrid composites exhibited good properties [5]. Different composites based on polypropylene and reinforced with flax and glass fibers have been made and their mechanical properties are measured together with the distribution of the fiber size and the fiber diameter [6]. Maleic anhydride-polypropylene copolymer has shown to be a very effective compatibilizer for lignocellulosic/PP composites [7-11]. The effect of fiber treatments and matrix modification on mechanical properties of flax fiber bundle/polypropylene composites was investigated [12] and the results suggested that matrix modification led to better mechanical performance than fiber surface modification [14 - 15].

The effect of the fiber content and the interfacial adhesion on the mechanical properties of BG/PP and BG/MAPP composites prepared by injection moulding process is investigated.

2. Experimental Procedure

2.1. Extraction of fiber

Banana fiber is obtained from the leaf –sheath of the plant, the fiber is extracted from the plant after the bananas had been harvested, as a useful by-product for the banana producers. After the harvesting of the fruits, tree is cut as near to the ground as possible. Two or three of the outermost sheaths are removed and rejected. Inserting a knife at one end, and drawing it length wise strips of about 8 to 10cm of breadth are prepared. The tuxes are the scraped as clearly as possible to yield strands. The scraping is done by the apparatus gripping one end of the tux facing upwards his foot and drawing a blade of sufficient sharpness a way to scrape away the pith from the fibers. The process may be repeated after keeping upside down the tux till the fibers looses the pith. Then the fiber is clean and dried. The dried fibers are bundled.

The banana fibers are suitable for manufacturing strings, ropes cords, cables, packing fabrics as well as mats and rugs.

2.2. Fabrication of composite specimens

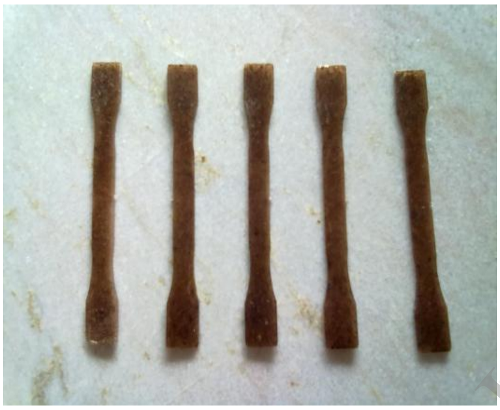
The extracted fiber and polypropylene pellets are dried in an oven at a temperature of 800^0C for 2 hours to expel the moisture before they were used for injection. The composite samples were prepared by mixing of fibers in proper proportions (0, 5, 7.5, 10, 12.5 and 15%) by weight, glass fiber (2.5% of fiber weight) and polypropylene pellets were properly mixed to get a homogeneous mixture. The mixture was then placed in a 2.5 tonne hydraulic Injection Moulding Machine. At a temperature of 210^0C and pressure of 1100 kgf/cm², composites of different weight fractions of fiber were developed. Five specimens were made for each weight fraction of banana fiber glass hybridized polypropylene composites.

2.3. Characterization of composites

2.3.1. Tensile properties

A 2 ton capacity - Electronic Tensometer, METM 2000 ER-I model shown in Fig.1 was used to find the tensile and flexural properties of the composite specimens. Dog bone shaped tensile test specimens were made in accordance with ASTM-D 638M to measure the tensile properties. The samples were tested at a crosshead speed of 1 mm/min and the strain was measured with an extensometer. The sample specimens for tensile testing are shown in Fig.2.

Φιγυρε 1: Shows the Tensometer for testing the Composite Specimens for both Tensile and Bending.



Φιγυρε 2: Tensile Specimens

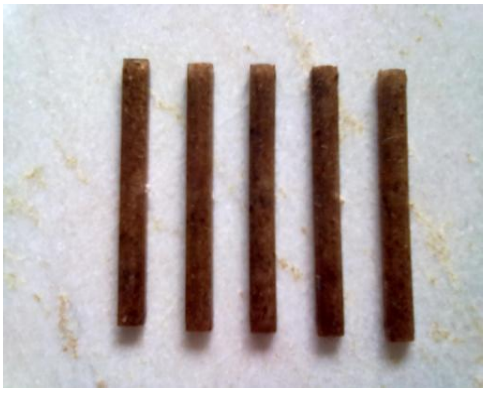
2.3.2. Flexural properties

Three point bend tests were performed in accordance with ASTM D790M test method I, Procedure A to measure the flexural properties. The samples were 98mm long by 10mm wide by 4mm thick. In three point Bending test, the outer rollers are 64mm apart and the samples were tested at a strain rate of 1mm/min. The flexural strength and flexural modulus of the composites are determined.

The flexural modulus, $EB = L^3 m / 4bt^3$

The flexural strength, $S = 3PL/2bt^2$

Where L is the support span (64mm), b is the width and t is the thickness, P is the maximum load and m is the slope of the initial straight line portion of the load-deflection curve. The sample specimen after flexural testing is shown in Fig.3.



Φιγυρε 3: Bending specimens

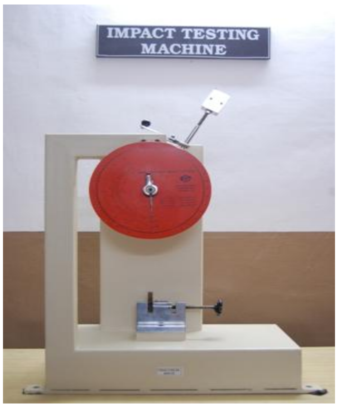
2.3.3. Impact properties

Izod impact test specimens were prepared in accordance with ASTM D256-97, to measure the impact strength. The specimens are prepared to dimensions of 64 x 12 x 9 mm width. A V-notch is provided having an included angle of 45° at the centre of the specimen, and at 90° to the sample axis. The depth of the specimen under the notch is 10.16 ± 0.05 mm. Five identical specimens were tested for each composition. The samples were fractured in a plastic impact testing machine and the impact toughness was calculated from the energy absorbed and the width of the sample. The sample specimen after impact testing is shown in Fig.5. The Impact strength is given by

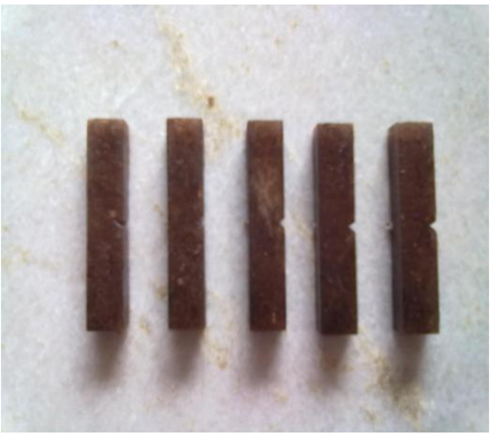
I = EI/T Joules/m, where

EI = Impact Energy in joules

T = Thickness of the sample used.



Φιγυρε 4: Shows the analog Izod/ charpy impact tester for Testing the Composite Specimens (Impact)

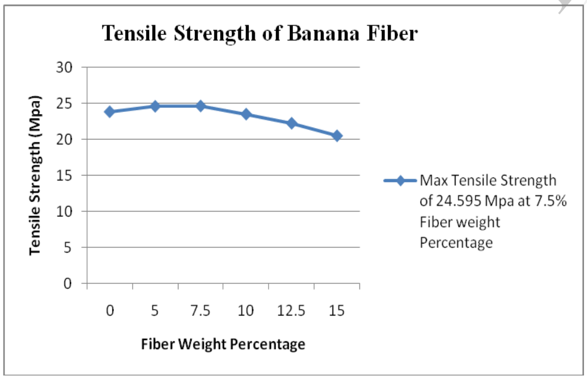


Φιγυρε 5: Impact specimens

3. Results

In this work, we conducted the testing of mechanical properties by using the equipment of Electronic tensometer and impact (izod) machine that has been proved to be an effective method to study the behaviour of materials under various conditions and phase composition of fibre composites and its role in determining the mechanical properties. The following results are.

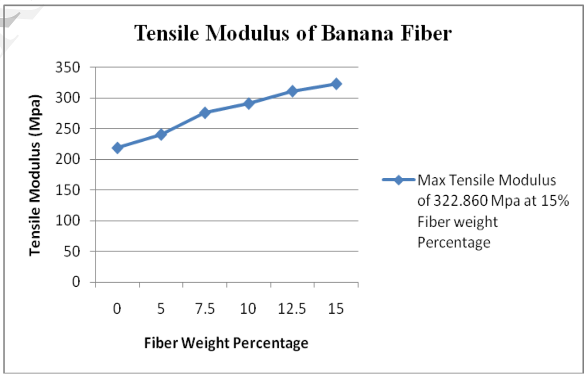
3.1. Tensile strength & Tensile Modulus



Φιγυρε 6: Tensile strength Vs fiber weight percentage

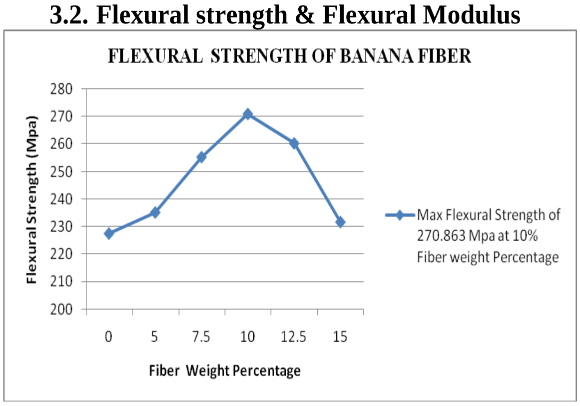
The tensile strength of the BGPP composites at different fiber loading is shown in Fig.6. The tensile strength is found to be increasing up to 7.5% fiber (by weight) and then decreases. The tensile strength of the pure polypropylene is calculated as 23.80 MPa. A tensile strength of 24.59 MPa is noted at 7.5 weight % of BGPP composite. The incorporation of fibers into thermoplastics leads to poor dispersion of fibers due to strong inter fiber hydrogen bonding which holds the fibers together. Improper adhesion hinders the considerable increment of tensile strength [13]. Thus, as fiber percentage increases, gathering of fibers takes place instead of dispersion and melted polypropylene cannot wet them properly due to non entrance of melt through the adjacent two fibers. Since no adhesion is present between the fibers and fibers are also not bonded with matrix, failure occurs before attaining the theoretical strength of composite.

Fig.7 shows the variation in tensile modulus with respect to fiber weight fraction. It is observed that the tensile modulus which is an indication of load bearing capacity increases with fiber weight fraction. As fiber is the stiffer component in the composite, resistance towards deformation increases with increase in fiber content, this consequently increases the stiffness of the composite. The tensile modulus of the pure polypropylene is calculated as 218.85 MPa. The tensile modulus for BGPP composites is 322.86 MPa. Higher tensile modulus value is observed at 15% fiber weight fraction.



Φιγυρε 7: Tensile Modulus Vs Fiber weight percentage

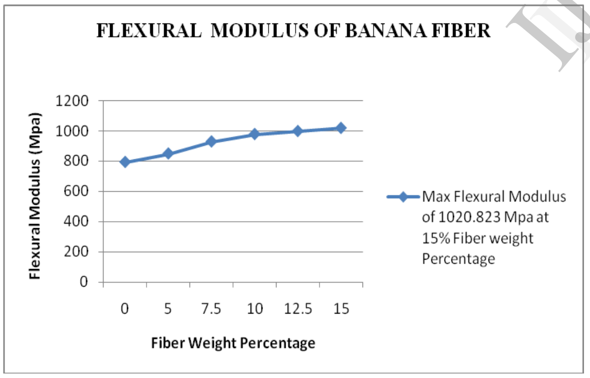
3.2. Flexural strength & Flexural Modulus



Φιγυρε 8: Flexural Strength of Banana Fiber

Flexural strength of BGPP composites at different percentages of fiber loading is shown in Fig 8.The flexural strength increased with fiber loading up to 10% weight fraction of the fiber, and there was a decrement after 10% fiber loaded composites. The reasons for the lower flexural properties at higher fiber fractions are possibly due to the lower fiber to fiber interaction, void and poor dispersion of fiber in the matrix. The flexural strength of the pure polypropylene is 227.57MPa. The maximum flexural strength of the BGPP composite is 270.86 MPa occurring at 10% fiber fraction.

Fig.8 shows the Flexural Modulus as a function of % weight fraction of the fiber for BGPP composites. The flexural modulus increases with the fiber loading. Since, higher fiber concentration demands higher stress for the same deformation due to increase in the degree of obstruction, the modulus values has increased with the fiber content. Increased fiber–matrix adhesion provides increased stress transfer between them. The flexural modulus of the pure polypropylene is calculated as 793.54 MPa. Higher tensile modulus value is observed at 15% fiber weight fraction.

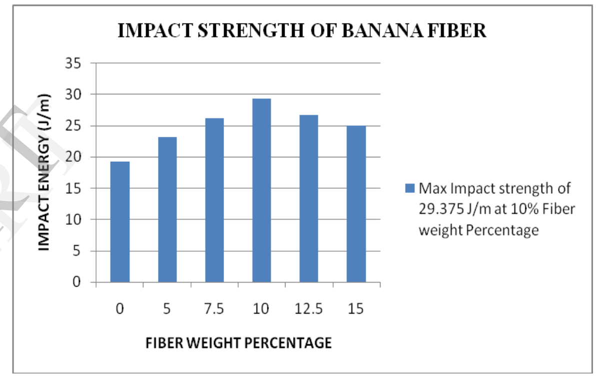


Φιγυρε 9: Flexural Modulus of Banana Fiber

3.3. Impact Strength

Impact strength is the ability of a material to resist the fracture under applied load. The fibers play a very important role in the impact resistance of the composite as they interact with the crack formation in the matrix and act as stress transferring medium. The variation of impact strength with fiber loading for BGPP composites is shown in Fig. 10. The impact strength of the pure polypropylene is 19.25 J/m.

It is observed that the impact strength increases with the increase in the fiber content upto 10% weight fraction of fibers and then decreases. Impact strength of 29.37 J/m is noted at 10 weight % of BGPP composites. The energy dissipation mechanisms operating during impact fracture are matrix and fiber fracture, fiber–matrix de-bonding and fiber pull out. Fiber fracture dissipates lesser energy compared to fiber pull out and is the common mechanism of fracture in fiber reinforced composites. As the main failure mechanism in these composites are fiber pull out, impact strength increases
with fiber loading. High fiber content increases the probability of fiber agglomeration which results in regions of stress concentration requiring less energy for crack propagation [15]. This results in lower energy dissipation and hence impact strength decreases.



Φιγυρε 10: Impact energy vs Fiber weight percentage

4. Conclusions

The incorporation of banana fiber hybridized with glass fiber into the polypropylene matrix has shown a moderate improvement in the tensile, bending and impact properties of the composite. 7.5% fiber weight fraction composites exhibited maximum tensile strength and maximum flexural strength is observed for 10% fiber weight fraction composites. Maximum Impact strength is observed in 10% fiber weight fraction composites. Tensile and Flexural Modulus values increased with increase in fiber weight fraction and higher values are observed in 15% fiber weight fraction composites. The composite can be regarded as a useful light weight engineering material and also the manufacturing cost of the composite can be reduced considerably by adding banana fiber hybridized with glass fiber to the matrix.

5. References

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