International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in

Vol.3., Issue.5., 2015
(Sept.-Oct.)

RESEARCH ARTICLE

ISSN: 2321-7758

FABRICATION AND MECHANICAL TESTING OF NATURAL FIBRE REINFORCED POLYPROPYLENE HYBRID COMPOSITES

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ABSTRACT

Short conventional fibers (glass, aramid, carbon etc) have been extensively used over the last decades as reinforcements of thermoplastic polymeric matrices. Now a days the growing interest in using natural vegetable fibers as a reinforcement of polymeric based composites is mainly due to their renewable origin, relative high specific strength and modulus, light weight and low price. The main aim of this research was to study the feasibility of using a Coconut & Banana natural fibers as reinforcements in the development of partially biodegradable green and environmentally friendly composites. Composites consisting of polypropylene reinforced with Coconut & Banana fibers were prepared by injection moulding technique according to the ASTM standards with varying weight fractions of fiber(0%, 5%, 7.5%, 10%, 12.5% and 15%). The developed Coconut & Banana fiber reinforced polypropylene (PP) Hybrid composites were then tested for their mechanical properties.

Key Words: Coconut & Banana fibre, Hybrid composite, Polypropylene, Mechanical properties

I. INTRODUCTION

In today's world, plastic become vitally important part of life. It is said mostly as disposable carry bags, bottles, containers, food-wraps and product of packing, but there is no particularly disposable about most plastics. If plastics are used in small amount it will be very helpful to us to keep the environment safe, but it is used in staggering quantities. The usage of plastics is becoming huge and it is unavoidable; Plastics are mainly carbon – based polymers made from petroleum oil which is a non-renewable resources and it is becoming increasingly expensive. Thinking of Environment, now it's time to think for alternative. As a result the hottest developments are the increasing interest in plastics prepared from organic matter rather than petroleum which are BIOPLASTICS. The main reason for getting interest in FRP is due to their high stiffness, high strength to weight ratio, specific modulus compared to other conventional materials.

Now a day's natural fibers like banana, sisal, jute, cotton and other natural fibers have attracted the attention of technologists and scientists for application in packing, low cost housing and other structures. Natural fibers composites can exhibit required mechanical strength and properties such as better electrical resistance, acoustics insulating properties and good thermal properties. Since the low cost, less weight, and density of natural fibers make them an attractive alternative.

The increasing interest in inexpensive reinforcement, renewable, degradable materials which have been environment- friendly has stimulated the use of hard cellulose fibers. Banana fibersare hard cellulosic fiberstherefore it has got reasonably high tensile and elongation at break. Coir is the seed-hair fibrous material found between the hard, internal shell and the outer coat (endocarp) or husk of a coconut. Many scientist and technologists have made many attempts to make use of natural fibers in the fabrication of FRP [1,2].

The mechanical characteristics of sisal and jute fibre reinforced polypropylene composites using tensile and compression testing processes were analyzed and compared. Specimens were fabricated by compression molding technique using a film stacking method. The sisal and jute fibres were modified by alkali solutions of NaOH. They also evaluate the effect of alkali treatment on the mechanical properties of sisal and jute fibre reinforced polypropylene composites. The effect on the processing conditions was also analyzed. They took the woven jute performs to prepare the composites using vacuum infusion technique and the fibres were treated with NaOH (5wt. %) for 24 h at room temperature. The results gives that the jute fibre based composites have higher compressive strength than sisal based composite and sisal based composite have higher tensile strength than jute based composite[3].

Discussed the effects of the amount of co-polypropylene K7926 and the type of compatibilizer on the mechanical properties of matrix. And also investigated the effect of type of compatibilizer and fibre loading on the mechanical properties of bamboo fibre mat reinforced polypropylene composites (BMRP). They used the bamboo drop fibre as reinforcement which is waste and easy fibrillation. Bamboo fibre mat was made by wet suspension method (WSM) by dispersing fibre in water. They used the three types of compatibilizers namely maleic anhydrid grafting pp(MPP),vinyl ether grafting PP(VPP), and glycidyl acrylate grafting PP(GPP). Bamboo fibre mat reinforced polypropylene composites were made by double steel belt compression technique. The interface adhesion was observed by scanning electron microscopy (SEM) technique[4].

The flax fibre reinforced polymeric composites with recent developments were discussed. Discussed the characterization and characteristic properties of flax composites on various polymers such as polylactic acid, epoxy, bio-epoxy, bio-phenolic resin and polypropylene. Presented the properties of flax fibres, fibre treatments such as silane treatment, mercerization, peroxide treatment, acrylation and coatings for the enhancement of flax/matrix incompatibility[5]. Studied the implications on mechanical, chemical, thermal, water absorption , and morphological properties of polypropylene with the addition of small amounts of wood sawdust and wheat flour .They used the hot pressing fabrication method to fabricate the polypropylene and natural fiber composites into sheets. Examined the surface morphology using scanning electron microscopy (SEM) and carried out the thermo gravimetric analysis (TGA) to evaluate the thermal stability of composites performed the water absorption tests to determine the ability of water absorption of composites. Performed the Fourier Transform Infrared Spectroscopy (FTIR) to study the chemical bonding nature in the composites[6].

The mechanical, chemical, morphological and thermal properties of polypropylene and denim fibre composites were characterized. They used the waste denim fibres as reinforcements. Used the hot compression molding technique at 190deg c with 30 KN load to fabricate the composites. They produced the composite at different weight ratios (5%&10%) with two conditions of with and without moisture. Performed the tensile and flexural tests using universal testing machine to determine the mechanical properties. Investigated the morphological characteristics of composite by field emission scanning electron microscopy (FESEM) and carried out the FTIR spectroscopy method to investigate the chemical bonding nature. Investigated the thermal stability of composite by thermo gravimetric analysis (TGA) [7].

The cotton stalks fibre was used for the reinforcement of polypropylene matrix. Evaluated the mechanical properties of cotton stalks fibre reinforced polypropylene composites and compared the theoretical data to the experimental data. Used the melt-mixing method to prepare the composites of polypropylene and cotton stalks fibres. Tested the samples of composites for their tensile and elastic modulus and a comparison was made between theoretical and experimental results[8]. Used the coconut fibre as reinforcement material in polypropylene matrix. Evaluated the physical, mechanical, and flammability properties of coconut fibre reinforced polypropylene composite panels. Prepared the composite panels by adding the four different weight fractions(40, 50,60&70%) of coir fibres with polypropylene powder and a coupling agent of 3wt% maleic anhydride grafted polypropylene powder, firstly, the composite mats were prepared and then these mats were hot pressed to prepare the panels. Carried the different tests such as thickness swelling(TS),water absorption(WA),and limiting oxygen index(LOI) test on samples of composite panels[9].

The mechanical properties of banana-coir fibre reinforced thermoset polymer for untreated and treated fibres were investigated. used the epoxy as resin. With using coir, banana, and epoxy the composites were prepared. Used the NaOH for alkali treatement of fibres. showed that the treated fibres exhibit higher mechanical properties than untreated fibres[10]. Evaluated the mechanical properties of banana fibre reinforced thermo-plastic polymer. Used the two types of polypropylene, maleic anhydride polypropylene(MAPP), and treated fibres with NaOH to get different combinations of specimens using vertical injection moulding machine. studied the SEM tests for tinterfacial adhesion[11].

Evaluated the mechanical properties of treated and untreated short kenaf fibre reinforced poly-ethylene and polylropylene composites. produced the two sets of composites of kenaf, MAPP, polypropylene(PP) and kenaf, MAPE, poly ethylene(PE). kenaf fibres were treated with different concentrations of NaOH. Finally showed that the treated kenaf fibres have improved the mechanical properties especially at 6% of NaOH [12]. In this paper, one bio-plastic material i.e. polypropylene is used as matrix and coconut & banana fibers as the reinforcing materials are used to prepare a hybrid polypropylene composite material. The mechanical properties of different combination of fiber and matrix are studied and results were reported.

II. EXPERIMENTAL

A. *Materials*

1) *Polymeric matrix:* Polypropylene (M 110) was provided as granules by Haldia Petrochemicals Limited, Kolkata, India. It has melting temperature of 180 0C and melt flow index of 11 gm/10 min at 230 0C. Its density at the room temperature is 0.9 gm/cm3.

2) *Extraction of coconut & banana fibre:* The banana fibre is extracted from the leaves, stem of the banana plant. The banana fibres are extracted by cutting and peeling the shealth layer-wise. The peeled layers are dried under sun for 2 weeks in shade and then they were soaked in water by keeping the stones over it for another two weeks. In the first 15 days the top layers on the side on the stem loosen , then these layers are removed, washed and immersed in water retting tank for 3 more days . later they are removed, hand extracted , rinsed in sufficient water and dried under sun. The water retting process take 18-20 days to extract fibres completely.

Coir fibres are extracted from the husk of the coconut and is found between the internal shell and outer coat of a coconut. coir fibre is a reddish brown, stiff fibre and is made up of smaller threads. With the help of knife the nuts are picked from the tree the coconuts are de-husked , water retted and the fibres are extracted from the husk with beating , washing and combing respectively.

B. *Processing*

1) *Composite Fabrication:* The extracted fibre was chopped into 3mm length and then the composite samples were prepared in proper proportions of fibers (0, 5, 7,5, 10, 12.5 and 15%) by 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 (Model JIM–1 HDB), supplied by Texair Plastics Limited Coimbatore. At a temperature of 210 0 C and pressure o 1100 kgf/cm2, composites of different weight fractions o fiber were developed. Five specimens were made for each weight fraction of coconut & banana fiber composites.

C. *Characterization of composites*

1) *Tensile properties:*

A 2 ton capacity – Electronic Tensometer, METM 2000 ER-I model supplied by M/S Mikrotech, Pune was used to find the tensile and flexural properties of the composite specimens. Dogbone 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 after tensile test are shown in Fig : 1

Fig: 1 A sample specimens after tensile test

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. A three point bend is chosen because it requires less material for each test and eliminates the need to accurately determine center point deflections with test equipment. The flexural strength and flexural modulus of the composites are determined.

The flexural modulus, EB = L3 m /4bt3

The flexural strength, S = 3PL/2bt2

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 specimens after bending test are shown in Fig : 2

Fig: 2 A sample specimens after flexural test

3) *Impact properties:*

Izod impact test specimens wer 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 450 at the centre of the specimen, and at 900 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 supplied by M/S International Equipments, Mumbai, and the impact toughness was calculated from the energy absorbed and the width of the sample. The sample specimens after impact testing is shown in Fig.3.

Fig: 3 A sample specimens after impact test

The Impact strength is given by

I = EI/T Joules/m

EI = Impact Energy in joules

T = Thickness of the sample used

III. RESULTS AND DISCUSSION

A. *Tensile properties*

The tensile strength of the coconut & banana fiber reinforced polypropylene composites at different fiber loading is shown in Fig.4. The tensile strength is found to be increasing up to 10% fiber (by weight) and then decreases. The tensile strength of the coconut & banana fibre hybrid composite is calculated as 27.584Mpa.

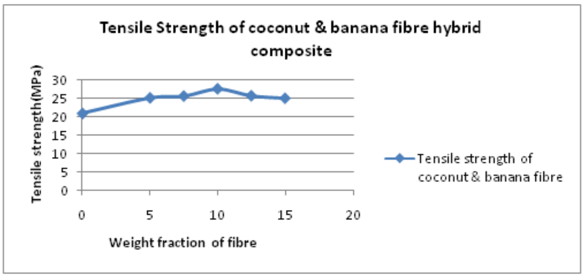

Fig. 4 Tensile Strength of coconut & banana Fiber / PP Composites at different weight fraction of fiber

Fig.5 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 consequently increases the stiffness of the composite. The tensile modulus of the polypropylene is calculated as 263.48MPa. The tensile modulus for coconut & banana fiber reinforced PP hybrid composites is 351.45Mpa.

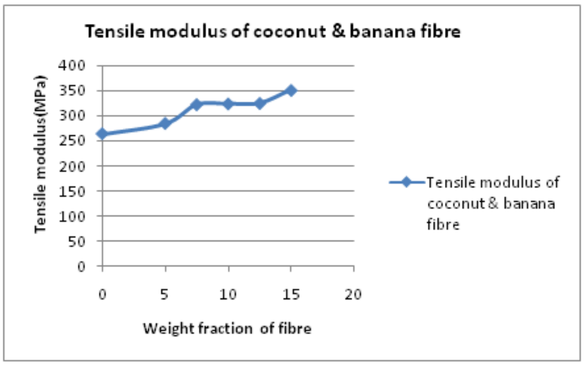

Fig. 5 Tensile Modulus of coconut& banana Fiber / PP Composites at different weight fraction of fiber

Flexural strength of the coconut & banana fiber reinforced polypropylene composites at different percentages of fiber loading is shown in Fig.6. The flexural strength increased with fiber loading upto 12.5% weight fraction of the fiber, and there was a decrement after 12.5% 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 polypropylene is 40MPa and the flexural strength of coconut & banana fibre hybrid composite is 41.4MPa.

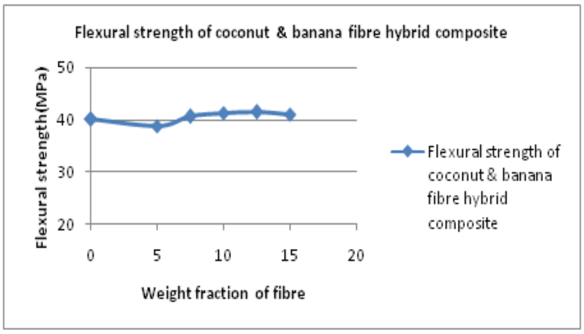

Fig. 6 Flexural Strength of coconut & banana Fiber / PP Composites at different weight fraction of fiber

fiber hybrid 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.

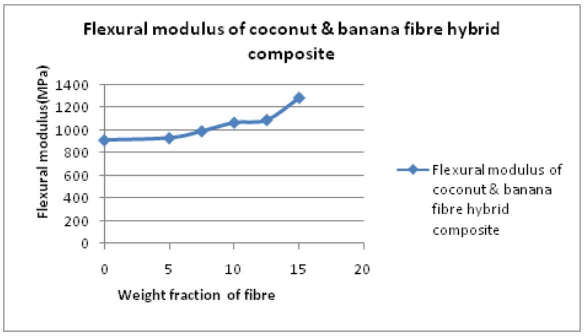

Fig. 7 Flexural Modulus of coconut & banana Fiber / PP Composites at different weight fraction of fiber

C. *Impact properties*

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 composites is shown in Fig .8. It is observed that the impact strength increases with the increase in the fiber content up to 10% weight fraction of fibers and then decreases. Impact strength of 52.8J/m is noted at 10 weight % of coconut & banana fiber hybrid PP composite. The energy dissipation mechanisms operating during impact fracture are matrix and fiber fracture, fiber– matrix debonding 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 .This results in lower energy dissipation and hence impact strength decreases.

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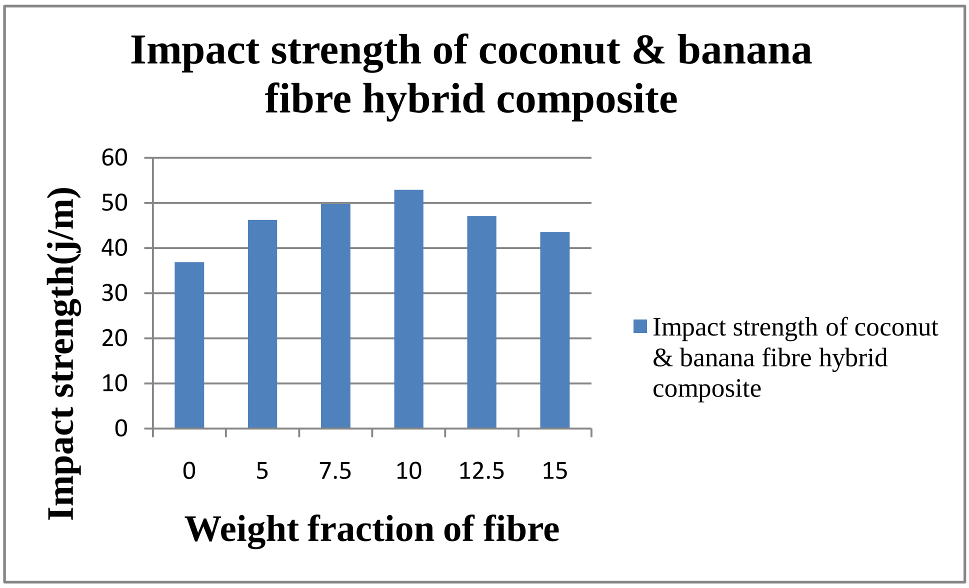

Fig. 8 Impact Strength of coconut & banana fiber / PP Composites at different weight fraction of fiber

IV. CONC LUSIONS

The effect of reinforcement of coconut & banan fiber into polypropylene matrix was investigated on the basis of the fiber loading, and the mechanical properties was also investigated. The following conclusions could be drawn from the experimental results of this study:

- The tensile strength of the composites increased with increase in the coconut & banana fiber loading upto 10% weight fraction and decreased beyond 10% weight fraction
- The Flexural strength of the composites increased with increase in the coconut & banana fiber loading upto 12.5% weight fraction and decreased beyond 12.5% weight fraction.
- The tensile and the flexural modulus of the composites have increased with an increase in the fiber loading. The higher tensile and flexural modulus values are observed in 15% fiber loaded composites.
- The izod impact strength of the composites increased with an increase in the fiber loading. However, the 15% fiber loaded composite had lower impact strength compared to 10% fiber fraction composites.

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