International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 06, June-2015

Evaluation of Mechanical Properties in Banana Fiber Reinforced Thermoplastic Polymer Composites

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***Abstract*—Composite materials with thermoplastic polymer matrices and a reinforcement of natural fibers are increasingly regarded as an alternative to material replacement for various applications. In this work two types of Polypropylene (PP) which is a thermoplastic polymer, Banana fiber which is a natural fiber and a coupling agent named Maleic Anhydride Polypropylene (MAPP) are used in different combination to get the specimen using vertical injection moulding machine and mechanical properties such as tensile, bending and impact strength, water absorption test, SEM test were studied.**

***Keywords*—Banana fiber; polypropelene; MAPP; injection moulding**

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.

Fiber Reinforced Plastics (FRP), in which manmade fibers such as glass, carbon, boron etc. are used as reinforcing materials. 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 ininexpensive 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.

Many scientist and technologists have made many attempts to make use of natural fibers in the fabrication of FRP [1, 2].The following reasons shows their efforts to introduce the natural fibers as composites.

1. Natural fibers are easily available and are renewable resources.
2. Composite with specific strengths because of their low density.
3. They are nontoxic and eco-friendly and biodegradable and are quite cheap.

In this paper, two types of bio-plastics i.e. two types of polypropylene are used as matrices and banana fiber as a reinforcing material are used to prepare a composite material. The mechanical properties of different combination of fiber and matrix are studied and results were reported.

II. MATERIALS AND EXPERIMENTAL

A. *Materials*

Two types of PP were used as the polymer matrix and was obtained from Selan Bioscience, Naroda, Ahmedabad, India. Banana fibers were obtained from SheebaFiber and Handicraft, Poovancode, Tamilnadu, India. The coupling agent was MAPP, type G-3002 was obtained from Eastman Chemical Products (Kingston, Tamilnadu).

Fig. 1 PP type-1 Compostable Polypropylene (PP1)

Fig. 2 PP type-2 Biodegradable Polypropylene (PP2)

B. *Fiber extraction and surface treatment*

During extraction of natural fiber from plant care should be taken to avoid damage. In the present experiment, first the sections of banana plant were cut from the main stem and then excess moisture was removed by lightly rolling action. Impurities in the fibres such as pigments, broken fibres, coating of cellulose etc. were removed manually by means of comb, and then the fibres were cleaned and dried.

1) Alkali treatment

5% solution of NaOH was prepared and the dry banana fiber was soaked in the solution for about 4h to remove the unwanted soluble cellulose, hemi cellulose,pectin, ligin, etc from the fiber. Later treated banana fiber was washed in distilled water to remove excess of NaOH and dried under the sunlight for about 6-8h.

The treated banana fiber was chopped into smaller length and grinded into fine powder. The grain size of powdered banana fiber was tested using sand testing machine and it was obtained around 100 – 140 microns.

C. *Combination of Materials*

Table 1 shows how different combination of materials is done to prepare composite materials.

TABLE 1.Different combination of materials.

Sl.No	PP type	%of PP	% of fiber	% of MAPP
1	1	100	-	-
2	1	70	30	-
3	1	65	30	5
4	2	100	-	-
5	2	70	30	-
6	2	65	30	5

D. Composite fabrication

A 2 part mould box was made each with the dimension of 170 mm (L) x 25 mm (W) x 1.5 mm (T), so as to get the cavity of 3 mm (T). The runner is made for the flow of molten material into the cavity.

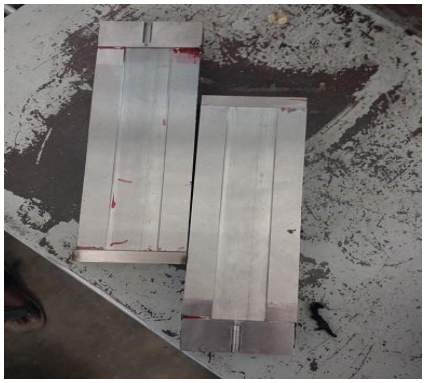

Fig. 3 Two part mould box

The hot press moulding machine consists of a hopper, plunger, clamper, hydraulic system, electrical motor, and a temperature control unit. In this process the different combination of materials as shown in Table 1 are feed into the hopper and it is set to desired temperature to melt the materials inside the hopper. Now the plunger whit high pressure pushes the molten material into the mould cavity.

Fig. 4 Hot press moulding machine

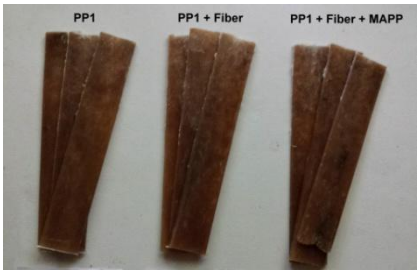

Fig. 5 Samples made with PP1

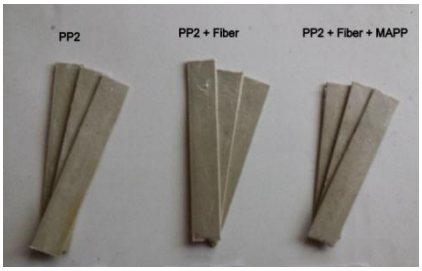

Fig. 6 Samples made with PP2

E. Testing of the composites

The composite specimens were tested as per ASTM standards. Tensile test was done as per ASTM D 638-I with the help of Universal Testing Machine KIC-2-1000-C Capacity 100 KN. The specimen dimensions were (165 x 19 x 3) mm. Flexural testing was done as per ASTM D 5943-96 standards using three point bending method at a crosshead speed of 1 mm/min and the specimen dimensions were (100 x 15 x 3) mm. The impact testing was done as per ASTMD 256 by Izod impact machine, the specimen dimensions were (64 x 12.7 x 3 mm. In each case, 4 samples were tested and average values were reported.

Water absorption test is very important to determine the water absorptivity of the composite. A dimension of (10 x 10 x 3) mm is cut from each samples and made dipped in water for few days. For a regular interval of time its weight is checked and results are discussed.

III. RESULTS AND DISCUSSION

Tensile strength, flexural strength and impact strength of composites were presented in table 2 at different combinations of PP, Fiber and MAPP. For proper understanding of the effect of different strength separate chart have been plotted.

TABLE 2.Mechanical properties of composites.

Samples	UTS (MPa)	3Pt Flexural Strength (MPa)	Impact Strength (J)
PP1	1.77	37.68	12.1
PP1 + fiber	2.06	37.68	16.4
PP1 + fiber + MAPP	3.90	10.05	19.4
PP2	2.51	29.49	17.5
PP2 + fiber	1.49	37.95	17.3
PP2 + fiber + MAPP	0.67	22.10	19.7

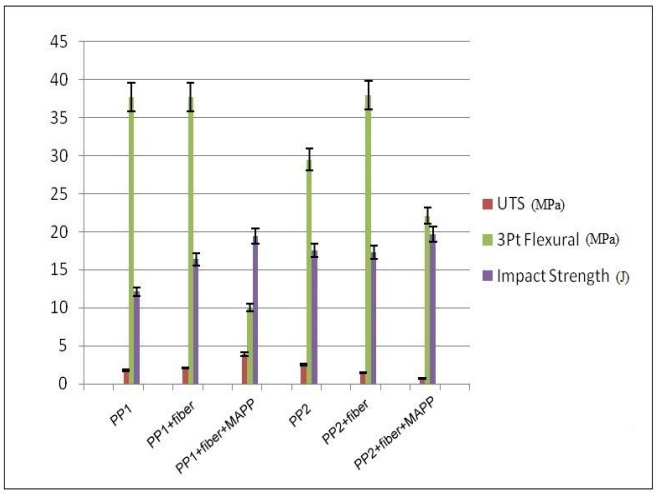

Fig. 7 Chart showing strength for different type of composites

Water absorption test is very important to determine the composite reaction, fiber reaction and molecular instability leading to decrement in strength and shape and tend to failure of the component. Table.3 shows the results of water absorption test.

TABLE 3. Water absorption capacity

Samples	Initial weight in gm	Water absorption %				
		24 (hours)	48 (hours)	72 (hours)	96 (hours)	120 (hours)
PP1	2.90	1.00	1.07	1.13	1.20	1.24
PP1 + fibre	2.95	1.01	1.08	1.12	1.18	1.25
PP1+fiber+MAPP	3.00	1.02	1.08	1.15	1.2	1.23
PP2	2.90	1.02	1.06	1.13	1.18	1.24
PP2+fibre	3.00	1.03	1.1	1.17	1.21	1.23
PP2+fib+MAPP	3.10	1.04	1.12	1.19	1.25	1.32

SEM: The SEM images of fractured surfaces of composite made with different combination of PP1, fiber and MAPP are shown in below figures.

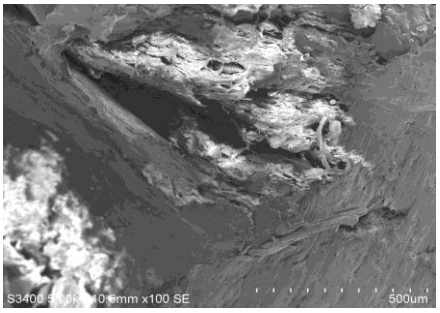

Fig. 8a SEM image of PP1+fiber

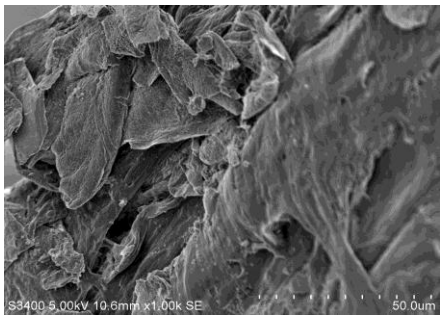

Fig. 8b SEM image of PP1+fiber+MAPP

Fig. 8c SEM image of PP2+fiber

Fig. 8d SEM image of PP2+fiber+MAPP

The above images reveals that the adhesion between the fiber and matrix has increased upon the addition of MAPP in both the cases, but the quality of adhesion was better in the first case PP1+fiber+MAPP it can be observed in the Fig. 8b Therefore PP1+fiber+MAPP have got higher UTS. Fig. 8c and Fig. 8d shows that the PP2 matrix has poor boding property with fiber and MAPP, due to this reason UTS of PP2 with the addition of fiber and MAPP has decreased.

IV. CONCLUSIONS

- This work shows that successful fabrication of banana fiber reinforced polypropylene composites by injection moulding technique.
- In this work it shows, after fabricating polymer composite and subjected to various mechanical tests like Tensile, Flexural, Impact, Water absorption, etc., the Banana fiber has potential to use as a good replacement to use as reinforcement in Polymer Matrix Composite (PMC).
- The sample made with PP1+fiber+MAPP shows a UTS of 3.90 MPa, which indicates that promisable candidate material in FRP composites.
- The impact strength initially obtained was 12.1 J, but after adding both fiber and MAPP it shows a considerable increment resulting 19.7 J.
- In general the Mechanical properties of composite made with PP1 showed good results when compared to PP2.

ACKNOWLEDGMENT

Author's would like to thank the Management of Acharya Institute of Technology, Principal, Head of Department and our professors for supporting us and would also like to thank the Manager of "Associate Tool's" for providing the facilities to carry out this work

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