Fabrication and Performance of Areca Short Fiber Polypropylene Composite at Varying Fiber Loading

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Abstract*: The primary focus of this research is to study the density, impact strength, hardness and dielectric properties polypropylene areca fiber composite reinforced with randomly distributed and varying areca fiber loading. The test samples of plain polypropylene, polypropylene areca fibers composites have been prepared as per ASTM standards using injection moulding technique. Different fiber weight loading fractions (10%, 30%, 50%, & 70%) have been used to prepare test samples. The developed polypropylene areca fiber composites have been characterized for density, izod impact strength, hardness and dielectric strength test. Result showed that improvement in the properties of polypropylene areca fibers composites increase with fiber loading compare to plain polypropylene.

***Index Terms*: Areca Fiber, Density, Izod impact, Polypropylene.**

I. INTRODUCTION

With the increased environmental awareness regarding the disposal difficulty of plastic, the whole research and scientist society of the world is working towards developing an alternate material. Thus recently, focus of natural lignocellulosic material as reinforcement or as a filler material in polymer composites has attracted widespread attention [1] [2] Natural fiber reinforced composite is one such composite which has been attracting the researchers due to its qualities such as lignocelluloses, light weight, renewable, low density and biodegradability [3] [4]. The blend of these natural fibers and thermoplastic polymer has enhanced properties and economic viability, which is the need of industrial segments. Additionally, these natural fibers are economical and amply available and are biodegradable in nature. The introduction of these natural fibers from renewable resources for variety of applications is beneficial to the environment. The outstanding features of these natural fibers can offer some benefits over synthetic fibers. The chemical composition of areca fibers consists of greater percentage of alpha cellulose i.e. 53.20%, hemicellulose 30–64.8%, lignin 7–24.8%, 4.4-4.8% of ash, 11.7 % of moisture and very negligible percentage of pectin and wax [3] [5] [6].

But, these natural fibers are commonly hydrophilic in nature which will affect the interfacial bonding between the fiber and matrix. These are very much incompatible with polymers which are hydrophobic such as polypropylene (PP). The biggest challenge of using natural fibers with thermoplastics is the poor interfacial bonding between the fiber and thermoplastic. Extensive studies on agro-waste materials like cotton, coir, sisal, jute, banana, flex, maize and with recycled thermoplastic material like polyethylene, polypropylene to list few, have been carried out [3] [6] [7] [8]. In recent past several studies have been conducted on mechanical, thermal and electrical behavior of thermoplastics reinforced with other natural fibers, but the literature available on areca fiber as reinforcement with thermoplastic matrix is relatively it scarce [4] [9] [10] [11].

Properties of a natural fiber composite are mainly depending on the types of fiber and matrix, individual properties of both the fiber and matrix, compatibility; fiber surface treatment, percentage of usage, fiber orientation, and manufacturing process used [6]. The main objective of this research is to develop eco-friendly and sustainable areca fiber reinforced polypropylene (PP) composite materials to study properties. Areca fiber were used to prepared composites. Injection moulding process was used to produced polypropylene based randomly oriented and varying fiber loading of short areca fiber composites test samples. The effect of the fiber loading on the density, izod impact strength, hardness and dielectric strength of PP reinforced with areca fiber have been discussed.

II. EXPERIMENTS

A. Materials and Extraction of Areca fiber

Polypropylene (PP) was provided by Reliance Company Private Limited, India as homopolymer pellets. Chosen raw areca fruit from Sagar district which is in Western Ghats of Karnataka. Areca nuts were gathered from the field and nuts were squashed to expel the seed from the shell. Husks of delicate areca were washed in running water and these shells soaked in water for 4 to 5 days. This retting procedure will loosen and areca fibers were detached by hand. The fibers were washed again in running tap water and totally dried under sub for 15 days. With utilizing hammer mill chopper, these fibers chopped to 2 to 4 mm.

B. Preparation of Composite and Test Specimens

In the present study, the composites have been prepared using randomly distributed dried, chopped and varying areca fiber weight loading with PP granules per the Table-I. Twin screw machine Omega 20P Do/Di 1.80 has been used to prepare the composites. The extruded composite is collected and converted into

Revised Manuscript Received on December 22, 2018.

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pellets. Test specimens were prepared as per the Table-II (ASTM Standards) by using a hand operated Injection molding method.

Table-I: PP reinforced with varying areca fiber (%wt.)

Fiber As reinforcement in (%)	Polypropylene Matrix (%)	Composites
0	100	PP
10	90	AF10
30	70	AF30
50	50	AF50
70	70	AF70

Table-II: Test Specimen Standards

Property	ASTM Standard
Density	D792
Impact	D256- 02
Hardness	D695-02
Dielectric	D149

III. RESULTS AND DISCUSSIONS

Polypropylene areca fibers composites with varying fiber loading have been experimentally tested as per the ASTM standard. Results were listed as per Table-III.

Table-III: Properties of Polypropylene Areca Fiber Composites

Composites	Density g/cm^3	Hardness Shore -D	Impact Strength Kj/mm^2	Dielectric Strength KV/mm
PP	0.897	63	2.98	2.88
AF10	0.878	66	3.31	2.98
AF30	0.939	67	3.97	3.99
AF50	1.024	70	3.70	3.66
AF70	1.083	72	2.41	3.57

A. Density

The densities of the test samples were tested as per ASTM D792 and estimated by the method of displacement per Archimedes rule. In this test, each of the samples was weighed using an electronic balance of Analytical Balance. Initially weigh the specimen in air, nearest 0.1 mg for specimens. A measuring jar with millimeter marks has been considered and distilled water poured into the jar. Attached a sample holder (sinker) in water with immersion. The weighed sample were then dropped into the sinker and respective weight were recorded. The difference between the initial and final readings provides volume sample dropped in it. The weight of sample to its volume ratio has been obtained by the above method resulting the density of the composites. From the above Fig. 1, PP specimen has a density of 0.897g/cm³. By adding Areca fiber to plain PP, density is increased.

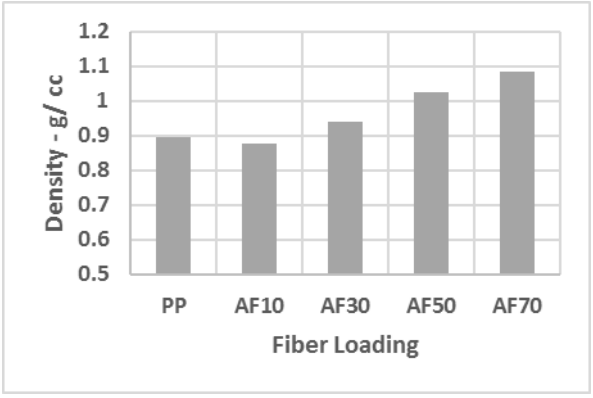

Fig. 1: Density for Plain Polypropylene, Varying Fiber Loading PP Areca Fiber Composites

B. Hardness

Hardness test has been carried out using TH210 Shore-D durometer testing machine. The measurement of hardness has been carried out perpendicular to the fiber orientation of the composite. The effect of areca fiber weight percentage on hardness of areca fiber composites are shown in Fig. 2. It is clear from the results that hardness of polypropylene areca fiber composite increases with fiber loading when compared with plain polypropylene. There is maximum hardness of polypropylene areca fiber composite at AF70 fiber loading when compared to the plain PP matrix.

C. Izod Impact Strength

For Izod impact test, using digital caliper and micrometer screw gauge dimensions (width and depth) of each specimen with notch was measured. Average of these measured dimensions were used for strength calculation. Izod impact strength were determined per ASTM D256-02 utilizing Instron Pendulum Tester (9050 Manual Model). Fig. 2 shows the impact strength of polypropylene areca fibers composites with varying fiber loading and the plain polypropylene. Izod impact tests were performed on plain polypropylene, polypropylene areca fibers composites and results were noted.

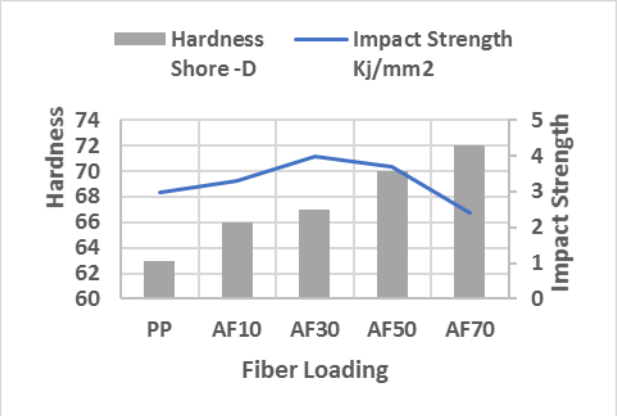

Fig. 2: Hardness and Izod Impact Strength for Plain PP, Varying Fiber Loading PP Areca Fiber Composites

From the results, it can be observed that the impact strength of composites increases with the fiber loading initially and then reduces. There is a maximum increase in the impact strength at AF30 when compared to plain polypropylene.

D. Dielectric Strength

The dielectric strength test was carried per ASTM-D 149. Tests were performed in a displacement controlled mode on a closed-loop condition, at a standard laboratory atmosphere. Fig. 3 shows the influence of areca fiber loading on the dielectric strength. From the present study, it is noticed that dielectric strength of polypropylene areca fiber composite, is initially increases and then decreases. From the results, it has been noticed that dielectric strength of plain PP is 2.88 KV/mm, whereas polypropylene areca fiber composite which are about 3.99 KV/mm at AF30 fiber loading. The reduction in dielectric strength with increasing fiber loading is the predictable behavior in most of the dielectric materials.

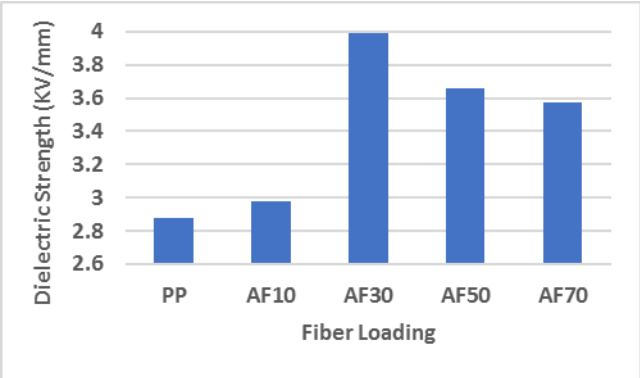

Fig. 3: Dielectric Strength for Plain PP, Varying Fiber Loading PP Areca Fiber Composites

IV. CONCLUSION

From the experimental results, there is possible improvement in the properties of polypropylene areca fiber composites. During this work, the polypropylene reinforced with areca fibers with various fiber loading fractions have been successfully developed using extrusion process and test samples have been prepared with injection molding method. Experiments have been conducted to determine Density, Izod impact strength, Hardness and Dielectric strength properties. Polypropylene areca fiber composites, in general have demonstrated superior density, hardness and dielectric strength properties when compared with plain polypropylene. Izod impact strength polypropylene areca fiber composites have shown improvement with increase in fiber loading initially and decreases at AF70. Hence, it can be concluded that the composites using areca fibers as reinforcement are promising alternative materials which have better strength for the automobile, household, electrical appliances and industrial applications.

ACKNOWLEDGMENT

Author would like to thank The National Institute of Engineering, Mysuru, Karnataka, India for the kind encouragement and constant support provided.

REFERENCES

1. Srinivasa Chikkol Venkateshappa, Suresh Yalaburgi Jayadevappa, Prema Kumar Wooday Puttiah, “Mechanical Behavior of Areca Fiber Reinforced Epoxy Composites,” Advances in Polymer Technology, 2012, 31: No. 4, pp. 319–330.
2. C.V. Srinivasa and K.N. Bharath, “Impact and Hardness Properties of Areca Fiber-Epoxy Reinforced Composites,” Journal of Materials and Environmental Science, 2011, 2 (4), pp. 351-356.
3. Salma Siddika and Ahmed Sharif, “Processing and Characterization of Areca and Waste Nylon Fiber Reinforced Hybrid Polypropylene Composites,” International Journal of Innovation and Scientific Research, 2015, 19, pp. 319-330.
4. Dr. G. Ramachandra Reddy, Dr. M. Ashok Kumar, K.V.P. Chakradhar, “Fabrication and performance of hybrid Betel nut (Areca catechu) short fiber/ Sansevieriacylindrica (Agavaceae) epoxy composites,” International Journal of Materials and Biomaterials Applications, 2011, 1 (1), pp. 6-13.
5. G. C. Mohan Kumar, “A Study of Short Areca Fiber Reinforced PF Composites,” Proceedings of the World Congress on Engineering, 2008.
6. M. Masudul Hassan, Manfred H. Wagner, Hayder U. Zaman and Mubarak A. Khan, “Study on the Performance of Hybrid Jute/Betel Nut Fiber Reinforced Polypropylene Composites,” Journal of Adhesion Science and Technology, 2011, (25), pp. 615–626.
7. W. L. Lai, M. Mariatti, and Mohamad Jani S, “The Properties of Woven Kenaf and Betel Palm (Areca catechu) Reinforced Unsaturated Polyester Composites,” Polymer-Plastics Technology and Engineering, 2008, (47), pp. 1193–1199.
8. Elammaran Jayamani, SininHamdan, Md Rezaur Rahman and Muhammad Khusairy Bin Bakri, “Investigation of Fiber Surface Treatment on Mechanical, Acoustical and Thermal Properties of Betelnut Fiber Polyester Composites,” ProcediaEngineering, 2014, 97, pp. 545 – 554.
9. Kestur G. Satyanarayana, Gregorio G.C. Arizaga, Fernando Wypych, “Biodegradable Composites Based On Lignocellulosic Fibers—An Overview,” Progress in Polymer Science, 2009, 34 (9), pp. 982–1021.
10. Umar Nirmal, Jamil Hashim, Saijod TW Lau, Yuhazri MY and BF Yousif, “Betelnut fibres as an alternative to glass fibres to reinforce thermoset composites: A comparative study,” Textile Research Journal, 2012. 82(11), pp. 1107–1120.
11. B Fyousif and U Nirmal, “On the mechanical properties of a treated betelnut fibre-reinforced polyester composite,” Journal of Adhesion Science and Technology, 2011, (25), pp. 615–626.

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