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Experimental Investigation of Areca fiber Reinforced Polypropylene polymer composite for Automotive Components

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Abstract

Recently the development of natural fiber composites instead of synthetic fiber has led to eco-friendly product manufacturing to meet various applications in the field of automotive, aerospace, construction and manufacturing. The use of natural fibers offers an alternative to the synthetic reinforcing fibers because of their good mechanical properties, low density, renewability, and biodegradability. Different natural fibers are generally utilized as reinforcement in thermoplastic polypropylene (PP) matrix to prepare composites. In this paper, experimental investigation of natural fiber i.e., Areca fiber reinforced with polypropylene polymer matrix is done to analyze the Mechanical and Thermal properties of polymer composite. The modification of composite is done by using Maleic Anhydride (MA) during preparation of composite material. Different fractions of composites with 5wt%, 10wt% and 15wt% fiber content were prepared in twin extruder and 3wt% of Maleic anhydride was added during the mixing process. Mechanical and Thermal properties such as Tensile strength, Bending strength, Elongation at break, Water absorption capacity, Heat Distortion Temperature (HDT) of areca fiber and PP composites were investigated. The above composite polymers are used in manufacturing the components of automobiles such as passenger car interiors, indicator cover, door panels, door pockets, rear view mirror covers etc.

1 Introduction

In created nations natural arrangements are expanding weight on fabricates to think about the ecological effect of their items. Polymeric composites strengthened with normal filaments have turned into a point of enthusiasm amid the most recent decades. Along these lines, a push towards minimal effort lightweight materials has come about extreme enthusiasm for the field of polymers. In that time, for some conventional materials polymers have developed as reasonable choices, for example, metals, because of their inborn properties, for example, simplicity of creation, basic control, profitability, simple accessibility, less physical work, minimal effort, low thickness with similar mechanical properties. To be sure, because of their remarkable properties polymers have substituted most conventional materials for various applications and are at present assuming a critical part in the economies of generally countries. Natural fibers are basically characterized as fibers which are not artificial or manufactured. They can be sourced from plants or animals [1]. The natural fibers delivered from both inexhaustible and non-sustainable sources, for example, oil palm, sisal, flax, and jute are utilized to create composite materials, up until this point. The plants, which deliver cellulose strands can be characterized into bast fibers (jute, flax, ramie, hemp, areca and kenaf) seed filaments (cotton, coir, and kapok) leaf filaments (sisal, pineapple, and abaca), grass filaments (rice, corn, and wheat), and central elements (hemp, kenaf, and jute) and additionally all different sorts (wood and roots)[2]. Areca is a monocotyledonous plant and has a place with palm categories. This is a local of South or Southeast Asia and to a great extent developed in India for its nuts, which are generally wrapped in betel leaves for berating and being spat out or swallowed[3,4]. Gigantic amounts of AFH filaments are disposed of from the tobacco businesses with no fitting utilization causing awful smell and natural issues. These unusable things are utilized to deliver composite materials. The utilization of added substances in plastics is probably going to develop with the presentation of enhanced exacerbating innovation and new coupling specialists that allow the utilization of filler/fortification substance. It would be especially useful in the two terms of biodegradability highlights and financial terms. Polypropylene is a conservative material that offers a mix of extraordinary physical, substance, mechanical, warm and electrical properties not found in some other thermoplastic [5]. Contrasted with low or high thickness polyethylene, it has a lower affect quality, yet prevalent working temperature and elasticity [6].

Areca fiber made out of essentially -cellulose, lignin, and hemicelluloses. Moreover, it contains minor constituents, for example, pectic matters, Fatty and waxy matters. The main point that oversee the properties of short fiber composites are fiber scattering, fiber length dispersion, fiber dispersion, and fiber-grid bond. Blending the polar and hydrophilic strands with non-polar and hydrophobic matrix can bring about challenges related with dispersion of fibers in the matrix. The bonding between the fibers and matrix additionally can be improved by improving the matrix with compatibilizers that adheres well to both fibers and matrix. A standout amongst the most appropriate compatibilizers accessible for use in normal fiber strengthened polypropylene composites is Maleic anhydride polypropylene (MAPP). The presence of MAPP in natural fiber reinforced PP composites acts as bridge between the non-polar polypropylene matrix and the polar fibers by chemically bonding with MA groups. The wide utilizations of NFPCs are developing quickly in various designing fields. The various types of regular strands strengthened polymer composite have gotten an incredible significance in various car applications by numerous car organizations, for example, German auto organizations (BMW, Audi Group, Ford, Opel, Volkswagen, Daimler Chrysler, and Mercedes), Proton organization (Malaysian national auto maker),and Cambridge industry(an automobile industry in USA).

2 EXPERIMENTAL PROCEDURE

The schematic representation of the test setup is appeared in this warmth exchange test set up demonstrated is worked as a shut circle framework comprising of a store tank (14 liters), a pump, a detour line, a warmth exchange test area, a water cooler and a stream meter. The warmth exchange segment has a rectangular cross-segment zone (200 cm2) with length and broadness of 20mm and 10mm separately and was produced utilizing copper paper (1 mm thickness); and the aggregate length were 700mm.

2.1 Materials

Areca fibers are extracted from arecaleaf sheath by drenching areca leaf sheath upto 10-15 days. These drenched leaf sheaths are cleaned with the help of running water for 5-10 times daily. Drenching process loosens the fibers and removes the dust particles [7-9]. These leaf sheaths are dried in sun for 3days to remove the moisture content and brushed to extricate the fiber strands for advance processing[10,11].The areca fibers were cleaved into little pieces (3-5 mm) with the assistance of hand scissors.

Figure 1 areca leaf sheath

Figure 2 Areca fiber

Figure 3 Polypropylene Granules

2.2 Chemical composition of areca fiber

Areca fiber contains cellulose, hemicellulose, lignin, fluid concentrate, greasy and waxy and pectic matters. The composition creation of areca fiber is appeared in Table 1. The fiber essentially contains 65.08% of cellulose, 19.59% of lignin, and 8.40% of hemicellulose. Areca fiber has a honeycomb structure with thin lignified dividers and genuinely wide lumen. The density of fiber is low to give light weight structures high particular quality.

2.3 Composite fabrication

For intensive mixing of materials twin screw extruder is used which leads better fiber dispersion by maintaining different temperatures at different zones. The blend of dried areca fiber and polypropylene was set up as per the Table 2 that indicated diverse weight division

(5%, 10% and 15% fiber).The maleic anhydride (3%) was added during mixing as a compatibilizer. The processing temperature was maintained 175$\hat{0}$ C at zone1, 185$\hat{0}$ C at zone2, 195$\hat{0}$C at zone3,195$\hat{0}$ C at zone4 and 195$\hat{0}$ C at zone5 under 8 bar consolidation pressure and at a speed of 72rpm. (Specifiq twin screw extruder). The compound were then crushed by granulator machine to make a form of pellet shape and then heated in hot air oven about 4 hours to remove moisture content. The test specimens were prepared by using Automatic injection moulding machine.

3 CHARACTERIZATION OF COMPOSITES

3.1 Mechanical Testing

Tensile tests and Elongation at break were directed according to ASTM D638 utilizing Universal testing machine and measurements of the test samples kept up as 155mmx12.7mmx3.2mm. The tests were performed at a stacking rate 0.2kN/min. Static three point bending tests were directed by ASTM D790 in 10kN limit Instron general testing machine; and measurements of the test samples were kept up as 127mmx 12.7mmx 6.4mm.

3.2 Water uptake

Five composite examples (155mmx12.7mmx3.2mm) were inundated in the measuring glass containing 100 ml of deionized water at room temperature (25C) for various eras (up to 60 h). Weight of the examples was resolved at first then after specific timeframes, tests specimens were taken out from the recepticle and wiped (5 times) utilizing tissue papers, and afterward weighed once more. The weight picked up, i.e., water take-up of the examples was dictated by subtracting the underlying weight from the final weight.

Table 1: CHEMICAL COMPOSITION OF ARECA FIBER

Sr No.	Name	Percentage
1	cellulose	65.08
2	Hemi-Cellulose	8.40
3	Lignin	19.59
4	Fatty & Waxy matters	5.06
5	Aqueous Exract	0.72
6	Pectic matters	1.15
	Total	100

Table 2: DIFFERENT WEIGHT PERCENTAGES OF ARECA FIBER POLYPROPYLENE GRANULES AND COUPLING AGENT

Formulations	Fiber (wt%)	Polypropylene (wt %)	MAPP (wt%)
F1	5	93	3
F2	10	89.5	3
F3	15	87	3

Figure 4 Image of finished product (composite)

3.3 Heat distortion temperature (HDT) analysis

4 RESULTS AND DISCUSSION

The heat deflection temperature or heat distortion temperature (HDT) analysis is the temperature at which polymer or plastic sample deforms under a specified load. In this test the specimens immersed in oil, and loaded with bending stress of 255kPa, which applies heating rate of 20C/min.

4.1 Mechanical Properties

Mechanical properties such as Tensile strength, bending strength and Elongation at break were estimated. As indicated by Figure 3, it is observed that the highest tensile strength was obtained for F1 composite i.e., 22.3 Mpa when compared with F2 and F3 composites i.e., 21.3 Mpa and 20.6 Mpa respectively. The highest Bending strength was also observed in F1 formulation i.e., 42.5Mpa compared with other two formulations F2 and F3 formulations i.e., 41.3Mpa and 37.8 Mpa as shown in Figure 4. The increment in fiber content had shown a negative effect on % elongation at break from F1 to F2 i.e., 39.8 to 22.04, and positive effect on increasing the fiber content from F2 to F3 formulation i.e., from 22.04 to 33.45. From the above Figures, better mechanical properties such as tensile strength, bending strength and elongation at break was observed in F1 formulation i.e., Areca Fiber with 92% PP and 3% Maleic Anhydride when compared with other two formulations i.e., F2 and F3 which showed a decreasing trend in mechanical properties which may be attributed to the fact that increasing fiber content in the composite decreased the fiber-matrix adhesion.

4.2 Water uptake of the composites

Water take-up estimations of the F1, F2 and F3 tests were computed by inundating the examples in de-ionized water contained in a static glass measuring utencil at room temperature. The test samples were removed from water after steady time interim and their mass pick up were computed. The after effects of water take-up estimations of the test samples are demonstrated Figure 6. F1, F2 and F3 tests picked up water up to 30 h. The base measure of water was taken up by the F1 test (0.15%) and the most elevated measure of water was tallied by F3 test (0.27%) at the greatest time of perception (60 h). Water was taken up by the F1 test was 0.16% that was close about least esteem (0.15%).

4.3 Heat Distortion Temperature

Heat distortion temperature curve of the prepared composite samples is shown in fig:7. Minor weight loss is observed up to 1200ÔC due to moisture evaporation in the fibers. It shows increase in melt temperature compare to base material.

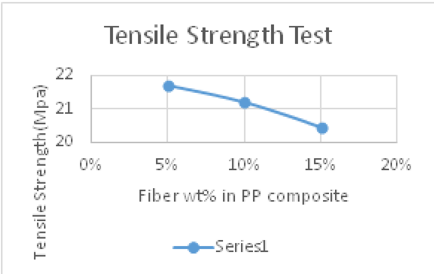

Figure 5 Tensile strength of composites with varying % of Areca fiber.

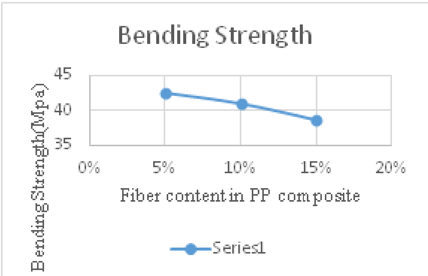

Figure 6 . Bending strength of composites with varying % of Areca fiber.

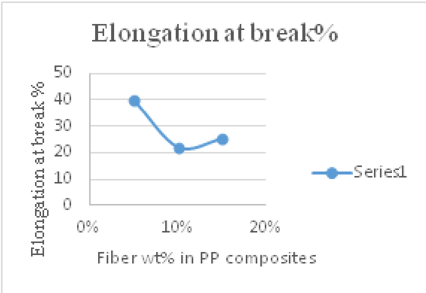

Figure 7 Elongation at break of composites with varying% of Areca fiber.

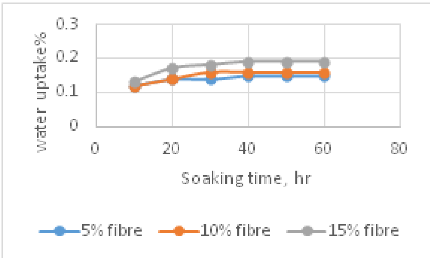

Figure 8 Water uptake (%) of composites with varying % of Areca fiber in aqueous media at 25C.

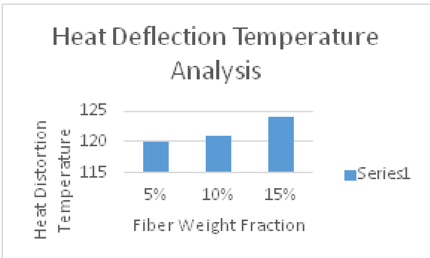

Figure 9 Heat distortion temperature of composites with varying % of Areca fiber.

5 CONCLUSION

In present study, the effect of different fiber fraction of Areca fibers reinforced polypropylene composites were prepared by Injection molding process were investigated. Based on the results, it is concluded that 5% fiber content in the composite showed higher mechanical properties. Mechanical properties were decreased with increasing fiber content due to poor fiber-matrix adhesion. Elongation at break decreased with the increased of fiber (wt %). Water uptake behavior of optimized composite was almost same of the lowest fiber content in the composite. Based on the results, it is concluded that the presence of maleic anhydride as comptibilizer showed good fiber dispertion for PP/Areca fiber between the matrices. These new composites would make possible to explore new applications and new markets in the packaging, furniture, housing and automotive-aviation-shipping sectors.

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