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Natural Fiber Reinforced Polypropylene Composites: A review

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Abstract : *Natural fiber reinforced composites, nowadays, are in great demand in industries because of their advantages such as low cost, biodegradability, acceptable mechanical properties and so on. Scientists and researchers prefer thermoplastic polymer matrix (polyethylene, polypropylene etc.) compared to thermosetting polymer matrix (epoxy, polyester, Bakelite etc.), reason being the low processing cost & high repair ability. Various natural fibers such as jute, flax, ramie, hemp, sisal, pineapple, cotton and many more are widely used as reinforcements in the polypropylene (PP) matrix and their mechanical properties were investigated by many researchers. Few of them are highlighted in the present paper.*

Keywords: *Biodegradable material, Fiber reinforced composites, Natural fiber, Polypropylene.*

I. INTRODUCTION

In the past decades, there is a growing trend of using natural fibers with the thermoplastic polymer matrix to prepare various composites. These are being used as an alternative to synthetic/man -made fiber reinforced composites. The advantages of natural fibers are environmental friendly, low cost, easy availability and bio-degradability. In natural fiber reinforced thermoplastic composites (NFRTC's), the reinforcement is of natural fibers which can be jute, sisal, hemp, banana, cotton , bamboo, pineapple etc. embedded in the thermoplastic polymer matrix. These composites have received significant applications in automobile parts, window frames, household articles and toys. A number of investigations have been carried out to reveal the potential of natural fibers as reinforcement in thermoplastics. These studies showed positive results for NFRTC's.

Natural fiber reinforced polypropylene composites are made by combining natural fibers and polypropylene (PP). Polypropylene acts as a binder and is called the matrix which holds the reinforcement which is natural fibers. Natural fibers are the fibers which naturally comes from mineral, plant or animal having the advantages that they are renewable resources and good market appeal. These are mostly achieved from stems, leaves and seed of plants. On the other hand, polypropylene is a thermoplastic polymer which possesses several useful properties such as dimensional stability, transparency & flame resistance etc.

The objective of the present paper is to provide a brief review of natural fiber reinforced polypropylene composites.

II. REVIEW OF LITERATURE

Natural fiber reinforced polymer composites are gaining popularity day by day because of the positive results showed by the researches towards them. Few of the past researches on natural fiber reinforced polypropylene composites are highlighted below.

[1]*kim et al. (2008)* studied the mechanical properties of polypropylene (PP)/natural fiber composites. For the natural fiber component of the composites, cotton fiber was compared with wood fiber. In order to improve the poor interfacial interaction between the matrix and reinforcement, maleic anhydride (MAH) grafted PP (PP-g-MAH) was used as compatibilizer. The samples were fabricated using compression molding technique by taking three types of matrixes- H720P, H380P and H360 F with melting index 2, 25 and 12 g/10min. The results showed that tensile strength of PP/wood fiber composites decreased with increase in wood fiber loading, whereas, in PP/cotton fiber composites, it first decreases with 10 w. % fiber and then increases with 20 and 30 wt. % of cotton fiber. Flexural strength behavior was similar to that of PP/cotton fiber composites. Compatibilizer also had an effect on mechanical properties, for PP/cotton fiber (80/20 wt. %) and PP/wood fiber (80/20 wt. %) composites, tensile and flexural strengths were increased with increase in wt % of PP-g-MAH.

[2]*Ashori and Nourbaksh (2010)* studied the effect of coupling agent (maleated polypropylene) and nanoclay particles on the mechanical properties and water absorption of the composites with PP as matrix and fresh poplar as reinforcement. For this, the composites were prepared using injection molding technique by fixing 30 wt. % of fiber while the concentrations for nanoclay and maleated polypropylene (MAPP) were varied

from 0-3-6% & 0-2.5-5-7.5% respectively. The samples for testing tensile properties were prepared in accordance with ASTM D638 and for water absorption with ASTM D570. The results revealed that tensile and flexural strengths increases up to 3% nanoclay loading, after then the mechanical properties starts decreasing. The maximum values of mechanical properties were achieved for samples with 3% nanoclay in addition to 7.5% MAPP. Finally, it was found that addition of nanoclay or/and MAPP reduced water absorption properties of composites.

[3]*Yang et al. (2010)* investigated the effect of jute fiber content and the hot water immersion (hydrothermal aging), on the tensile properties of jute/polypropylene composites. The samples were fabricated using the injection molding technique and two kind of pallets- jute/PP pallets and neat PP pallets (in various mix ratios) were used to make jute composites along with variation in jute fiber loading 10-50 wt. %. Then the samples were aged in hot distilled water at 80 ^{o}C. After the fixed period of aging (3, 10, 30, 100, 300, 1000 and 3000 hrs.), the changed weight and tensile properties were investigated. It was found that with increase in jute fiber loading, ductile to brittle behavior was seen. Tensile modulus increased linearly however, tensile strength increased firstly up to 30 % fiber loading, followed by a decrease with further increase of jute fiber loading. It was also found that the specimens with jute fiber content of or over 30 wt. % absorbed water easily. After aging, tensile modulus and strength decreased significantly in these composites with jute fiber content of or over 30 wt.% and all the jute/PP composites showed the lower strength than neat PP after aging of 1000 hours.

[4]*Bettini et al. (2011)* studied the effect of compatibilizer and fiber loading on the mechanical behavior of PP/coir fiber composites. The compatibilizer used was the PP grafted with maleic anhydride (PP-g-MAH). Before fabrication, the fibers were conditioned in aluminium bags containing moisture and light barriers. Two kinds of composites were prepared- PPFC30 and PPFC30C with composition of PP+30 wt. % coir fiber and PP+30 wt. %+6 PP-g-MAH using injection molding. Results revealed that presence of coir fiber reduced the tensile strength when compared to polypropylene alone. The composite PPFC30C exhibits more tensile strength and more fatigue life when compared to PPFC30 and pure PP. This showed that compatibilizer enhanced the mechanical properties of composites. The impact strength increased with the addition of 30 wt. % coir fiber without addition of compatibilizer.

[5]*Ayrilmis et al. (2011)* evaluated the physical, mechanical and flammability properties of coconut fiber reinforced polypropylene composites. The samples were fabricated using a press technology by varying coir fiber loading from 40 to 70 wt. % and there is addition of 3 wt. % maleic anhydride grafted PP (MAPP) which acts as a coupling agent. The tests were carried out as per ASTM standards. The properties which were investigated are- flexural strength, modulus of elasticity, thickness swelling, water absorption and tensile strength. The results showed that physical properties which are thickness swelling and water absorption increased with the increase in coir fiber content. Also, the flexural properties, hardness and tensile strength increased with increase in fiber content up to 60 wt. % and after that both these properties started decreasing because polymer matrix was insufficient to hold the reinforcement fiber. Modulus of elasticity increased with increasing fiber loading. Also, limiting oxygen index and the janaka hardness increased while the internal bond strength decreased with increase in fiber loading.

[6]*Zaman et al. (2012)* studied the physical-mechanical properties of banana fiber reinforced polypropylene composites. The samples were prepared using compression molding technique. Before fabrication, banana fibers and PP were irradiated with ultraviolet radiation at different intensities so as to enhance mechanical properties. These optimized banana fibers were treated with 15 % 2-hyroxyethyl methacrylate (HEMA) solution and then the samples were fabricated. The tensile test and impact test samples mere made in accordance to DIN53455 and DIN EN ISO 179 standards respectively. The results revealed that tensile strength, tensile modulus and impact strength of the treated composites were higher than those of untreated composites with the addition of banana fibers. It was also observed that water uptake (determines the water –swelling behavior) values by the 15 % HEMA treated composites were lower than that of the untreated specimens.

[7]*Samariha et al. (2012)* investigated the mechanical properties of baggase flour reinforced polypropylene composites. For this purpose, the polypropylene was mixed with 25, 35 and 45wt% of baggase flour. An MAPP coupling agent was also used. The samples were prepared using pressing technology. The tensile strength and impact strength were conducted as per ASTM D639 and ASTM D256 standards respectively. After testing, it was found that tensile properties improved with increase in fiber loading from 25 to 45 wt. % while the impact strength decreased. It was also found that the composites with fiber content 45% and coupling agent 4% exhibit higher mechanical properties.

[8]*Haque et al. (2012)* prepared and characterized polypropylene reinforced with chemically treated coir composites. The coir fibers were treated chemically in two steps. First dried and clean coir was oxidized with 20 % aqueous solution of $NaIo_4$ and then after washing this oxidized coir fiber, it was immersed in 5% solution of p-aminophenol which was prepared in ethanol/water mixture for 4 hours at 70 ^oC so that coupling reaction would occur. The amount of fiber varied from 10-25 wt. %. The samples were fabricated using injection molding method and the mechanical properties of these composites were computed. It was found that upon chemical treatment, hydrophilic nature of coir has significant reduced. The value of flexural properties, young's modulus and the impact strength increased for the treated composites and also with increase in fiber loading. It was also seen that for both raw and treated coir/PP composites, an increase in fiber loading increases the micro-space in fiber- matrix interfacial region and as a result the tensile strength values of components decreased but an in initial increase was seen. Hardness values for both treated and untreated coir-PP composites were found much higher than that of raw coir composites. Also the water absorption of the composites increased with increase in coir content, with treated coir composites having larger value as compared to the raw coir composites. So, chemical treatment had a great influence in enhancing various mechanical properties except for tensile strength.

[9]*Siddika et al. (2013)* investigated the effect of reinforcement and chemical treatment of fiber on the properties of jute-coir fiber reinforced hybrid polypropylene composites with fiber loading variation and observes the effect of chemical treatment of fiber on the properties of composites. Composites were manufactured using hot press machine at four levels of fiber loading – (5, 10, 15 and 20 wt. %). Fiber ratios were varied (jute: coir = 1:1, 3:1 and 1:3) for 20 % fiber loaded composites. Both jute and coir fibers were treated using 5 % and 10 % NaOH solutions. Composites were also prepared using treated fiber with jute: coir fiber ratio of 3:1. Tensile, flexural and impact tests samples were prepared as per ASTM D638, ASTM D790 and ASTM D6110 respectively. Results showed that, with increasing fiber loading, tensile strength decreased while young's modulus increased. During flexural, impact and hardness tests, the flexural strength, flexural modulus, impact strength and hardness values were found to be increased with increase in fiber loading. All these properties enhanced with the enhancement of jute content except the impact strength. 5% NaOH treatment provided an improving trend of mechanical properties whereas, 10% NaOH treatment showed the reverse one.

III. CONCLUSION

In this paper, the literature review on Natural fiber reinforced polypropylene composites (NFRPPC's) is provided. The synthetic fibers are being replaced by natural fibers in the past few decades due to their advantages like low cost, recyclability and biodegradability etc. NFRPPC's have been successfully fabricated and are being used in various technical applications such as in automobile sector, toys making, window frames etc. Although the properties so far achieved are less when compared with synthetic fibers reinforced composites but by selecting the proper fiber ratio, mechanical properties can be enhanced. This paper can be utilized by the researchers in their research work and there is a lot of future scope in the research field of these natural fiber based Polypropylene composites.

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