EFFECT OF VARIOUS SURFACE TREATMENTS FOR JUTE FIBER REINFORCED COMPOSITES

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1. Introduction

Over the past decade there has been a growing interest in the use of lignocellulosic fibers as reinforcing elements in polymeric matrix [1–5]. The specific properties of this natural product, namely low cost, lightweight, renewable character, CO_2 neutral, high specific strength and modulus, availability in a variety of forms throughout the world, and the possibility to generate energy motivate their association with organic polymers to elaborate composite materials. However, it is well known that different surface properties between the fiber and the matrix, i.e. the former is highly polar and hydrophilic while the latter is, generally, non-polar and relatively hydrophobic, impose the surface modification of the fibers surface, in order to improve the fiber/polymer compatibility and their interfacial adhesion [6]. Without such a treatment, natural fibers embedded in a polymeric matrix generate unstable interfaces and the stress applied to the fiber/polymer composite is not efficiently transferred from the matrix to the fiber and the beneficial reinforcement effect of the fiber remains underexploited. Likewise, the poor ability of the polymer to wet the fiber hinders the homogeneous dispersion of short fibers within the polymeric matrix [7-11].

The main objective of this study is to manufacture chopped jute fiber reinforced composites by injection molding technique as followed by the evaluation of their mechanical properties. Surface treatment and Maleic anhydride grafted polypropylene were employed to improve the bonding between the fibers and matrix.

2. Experimental procedure

Polypropylene (PP) supplied by Honam Petrochemical Corp. (Korea) was used as the matrix. The specific weight, the melting point, and the molecular weight of PP were 0.95g/cm3, 170°C, and 10,000g/mol, respectively. The coupling agent was Maleic anhydride grafted polypropylene (MAPP) (Eastman, USA), which had an average molecular weight of 40,000. MAPP contains 6wt% of maleic anhydride. Jute fibers which imported from Philippine were used as reinforcement. The lengths of the fibers were about 8-10mm. Analytical grade NaOH (98%) from Kudko. Co. (Korea) was used in the treatment of jute fibers. NaOH treatment was used in the delignification of jute fibers. The treatment involved the use of a 2wt% solution of NaOH, where the fiber:solution ratio was 1:6 (by weight). Then jute fibers and the appropriate pre-mixed alkali solutions were mixed in 5L glass beaker and it was kept for 24hours. After treatment, fibers were washed with rinsing tap water and finally thoroughly washed with running distilled water for several times, and after every wash the pH level was measured. The pH level 7 was maintained in the fiber solution. The fibers were vacuum dried at 70°C for 24hours. Treated jute fibers were chopped into short lengths about 2mm to insure an easy blending.

Plasma treated fiber was chopped 2mm then plasma treated during 2min. Plasma treatment is very sensitive so after treatment as soon as possible to have to make pellet for keep surface treatment.

The chopped jute fibers and PP were than compounded with the coupling agent in a manual mixer. As the density of the fibers and matrix were known, the fiber volume fraction was calculated. The volume percentage of jute fiber in the blend was 10%. In the case of MAPP contents, it was varied from 1 to 3wt% on the basis of PP content. The mixed blends were molded in twin-screw extruder to form pellets of diameter 1.0mm by using the melt mixing process. The temperatures of five extruder sections from first heating zone to the die were set as 180, 200, 210, 200, and 180°C, respectively. The hopper rate, the screw and speed, and the speed of roll were adequately adjusted for this process. After extrusion, the pellets were vacuum dried at 70°C for 24hours. The dried pellets were used to make the dog-bone specimens for tensile testing in accordance to the ASTM standard using an injection molding equipment. In addition, the specimens of pure PP were also prepared using the injection molding technique.

The tensile and 3-point bending tests were carried out according to the ASTM D 638 Type I standard (dog-bone specimens) and ASTM D 790, respectively by using machine (RB 301 Unitech M). The gage length was 25mm and the crosshead speed was 2.50mm/min. At the same time, strain was measured by an extensometer over a gage length of 25.0mm. The tensile and flexural modulus, tensile strength, and percentage of elongation at break were computed from the stress-strain curves.

3. Results

3.1 Void Contents

Table 1 shows the densities and void contents of the jute/PP composites manufactured. It was observed that with the increased of MAPP content from 1 to 3%, there was a relative reduction of the void contents.

Table 1 Void contents of jute fiber

Composites	Void Contents (vol. %)
Jute/PP(1% MAPP)	4.08
Jute/PP(2% MAPP)	3.32
Jute/PP(3% MAPP)	1.53

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3.2 Water Absorptions

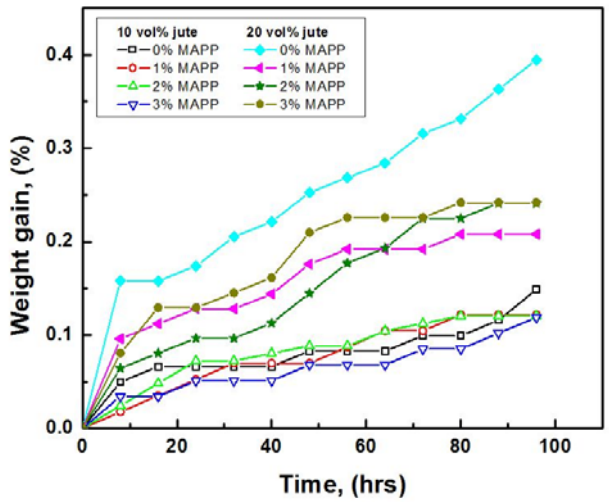

Fig. 1.water absorptions of jute/pp composites

Fig 1. is The results of the water absorption tests

3.3 Mechanical Properties

In case of 10vol.% composites, the addition of 1wt% MAPP increased the tensile strength of the composites from 20.28MPa to 24.19MPa while in case of 20vol.% composites; the addition of 1 wt% MAPP increased the tensile strength from 20.28MPa to 26.81MPa. The improvement of mechanical properties by adding MAPP was occurred through a better bonding between cellulosic fiber surfaces and PP was caused by the esterification of the anhydride groups of MAPP with the hydroxyl groups of cellulosic fibers. Because of the fact that jute fiber is lignocellulosic and contains more than 60% cellulose, we assume that a similar chemical bonding occurred between the hydroxyl groups of jute fibers and anhydride groups of MAPP. Moreover, further improvements of the tensile strengths of the composites were observed by adding MAPP contents from 1% up to 3% for both composites.

They were almost independent of whether coupling agent was added or not even though there are certain increases in the properties by adding MAPP contents. The moduli were determined from the initial slope of the stress-strain curve. At the initial slope, only a very small strain region can be considered, which is practically not influenced by the interface between fiber and matrix. So it was clear that even though MAPP contents can't affect the modulus of the composites, but due to the improvement of the interfacial adhesion between the fibers and matrix, the moduli were increased remarkably.

The decreases can be explained by constrained matrix flow in the presence of less-extensible fibers and the effects of internal stress concentrations initiated by fiber-induced microcracks. However, the percentage elongations of break of the jute fibers composites were increased with the increasing of MAPP content from 1% to 3% for 10 vol. % jute fiber composites. Unlike the 10 vol. % composites, the composites containing 20 vol. % shows the reverse trends for the elongation at break. It means the jute fiber inclusion on the composites have better effects on the elongation at break.

The flexural properties of jute/PP composites were also studied. The additions of MAPP content provide a significant effect on the flexural strengths of the composites. The improvement of flexural properties by adding MAPP was occurred through a better bonding between cellulosic fiber surfaces and PP was caused by the esterification of the anhydride groups of MAPP with the hydroxyl groups of cellulosic fibers. We assume that a similar chemical bonding occurred between the hydroxyl groups of jute fibers and anhydride groups of MAPP.

It was observed that the flexural moduli were remarkably increased. They were almost independent of whether coupling agent was added or not even though there are certain increases in the properties by adding MAPP contents. The average flexural modulus of 10 vol.% and 20vol.% composites were 40.34GPa and 48.85GPa, respectively.

4. Conclusions

Jute fiber reinforced polypropylene matrix composites were successfully developed by the injection molding technique. The improvement of tensile strengths, modulus and elongation at break of the composites can be observed. The addition of MAPP contents as coupling agent improved the composite performance by enhancing the adhesion between jute fibers and PP matrix. As the elongations at breaks were reduced in jute fiber polypropylene composites, it can be suitable candidates for strain improvement in hybrid composite systems. Similar to tensile properties, improvement in flexural properties were also significant. The predictions of mechanical properties coincide well with the experimental results.

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