ISSN : 0974 - 7486 Volume 9 Issue 3

Materials Science

Trade Science Inc.

An Indian Journal

Full Paper

MSAIJ, 9(3), 2013 [119-122]

Waste thermoplastics lignocellulosic composites for packaging

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ABSTRACT

This research concerned with the use of rice husk (*RH*) as a filler for waste thermoplastics as polypropylene,polystyrene and plastic bags. Composites were prepared by melt extrusion. Mechanical properties,water absorption and density of manufactured panels were investigated. Panels made from waste polypropylene and RH have more density than that made from waste polyethylene and rice husk. Thermogravimetric analysis indicates that rice husk improve thermal stability of filled panels. The effect of blending peanut hulls with rice husk was also studied. Mixing peanut hulls with rice husk (1:1) in presence of waste plastic bags (polyethylene) was effective to obtain panels having low water uptake.

KEYWORDS

Rice husks;
Waste;
Thermoplastics;
Mechanical properties.

INTRODUCTION

Plastics make up a large amount of waste, since they are available in numerous forms. There are two main types of plastic: thermoplastics, which are the most common; and thermosetts. Thermoplastics melt when heated and can therefore be remoulded. This enables thermoplastics to be recycled relatively easily. Recent investigations of polymer based composite materials have developed many methods for polymer formulations and have allowed the manufacture of new products with optimal properties for special applications[1-3].

Lignocellulosic plastic composites constitute an important set within this kind of materials showing several advantages over traditional mineral-filled plastic composites: low density, low production costs, biodegradability, renewability, etc. Stiffness, hardness and dimensional stability of plastics have also been improved by incorporation of lignocellulosic fillers[4,5].

Rice husk (RH) is one of the major agricultural residues produced as a by-product during rice processing. Usually it has been a problem for rice farmers due to its resistance to decomposition in the ground, difficult digestion and low nutritional value for animals. According to Marti-Ferrer the lignin and hemicellulose contents of rice husk are lower than wood whereas the cellulose content is similar. For this reason RHF can be processed at higher temperatures than wood. Therefore, the use of rice husk in the manufacture of polymer composites is attracting much attention[6]. Also,many investigators use peanut hulls in the production of particleboards[7,8].

The mechanical, morphological behavior and water absorption characteristics of polypropylene (PP) and silica, or PP and rice-husk, composites have been studied in the presence of compatibilizer. The silica used in this study as filler was a commercial type produced from soluble glass or rice husks.. In general, a high loading of the studied fillers in the polymer matrix increases the stiffness and the water absorption capacity[9].

Composites were obtained from post-consumer high-density polyethylene (PE) reinforced with different concentrations of rice husk. PE and rice husk were chemically modified to improve their compatibility in composite preparation. Rice husk was mercerized with a NaOH solution and acetylated. The chemical modification of the fiber surface was found to improve its adhesion with matrix. Flexural and impact tests demonstrated that PE/rice husk composites present improved mechanical performance comparatively to the pure polymer matrix[10]. The main purpose of this study is utilizing waste lignocelluosic fibers as RH and peanut hulls (one of the most abundant food industry waste products contains 37% cellulose) and waste thermoplastics in producing polymer composite having characteristic properties to be used in non food packaging applications.

EXPERIMENTAL PROCEDURES

Materials

Waste house hold polyethylene plastic bags, waste polypropylene sheets and waste polystyrene foam were used as matrix. Waste rice husk and ground peanut hulls were selected as lignocellulosic fillers. The RH was used without any subsequent treatment.

Preparation of the composites and samples

A laboratory-size conical co-rotatory twin-screw extruder Haake, Model Rheomex CTW 100p, was employed for compounding RH and waste plastics. The screw speed was 70 rpm and the temperature was 170. 2 levels of filler loading (30 and 50 wt. %) were used. After pelletizing the composites were compression moulded. The hot press procedure involved preheating at 170 ºC for 10 minutes followed by compressing at 300Kgf/ cm^2 for 5 minutes at the same temperature. After this the set was allowed to cool down to room temperature and the samples were manually removed from the moulds.

Mechanical testing and abrasion resistance

Rapture tests were carried out according to ASTM D638 using samples obtained as described above. MOR properties were measured at room temperature using an EMIC tensile tester with 102Kgf load cell, at 5 mm/min crosshead speed. Abrasion resistance has been carried out using Taber abraser 5150 using wheels no.CS-10

Water absorption study

% water absorption was conducted according to ASTM D-570. The samples were weighed, immersed in water for prolonged period and reweighed after 2h,24h and 7 days. The amount of water absorbed by the composites at room temperature was calculated according to the following equation:

$$M_t(\%) = \frac{W_t - W_0}{W_0} \times 100 \qquad (1)$$

where M_t is the amount of water absorbed at time t, w_t is the weight of the sample at time t and w_0 is the initial weight of the sample.

Density calculation

The densities of composite panels were calculated using equation

D= weight/ volume

Thermogravimetric analysis

Thermal analysis (TGA) of selected composite panels were carried out at heating rate 10 ^{0}Cmin-1 from 50–650 ^{0}C on Perkin Elmer Thermo Gravimetric analyzer.

RESULTS AND DISCUSSION

Mechanical and physical properties

Mechanical and physical properties of the panels manufactured from combination of various types of waste plastics and RH are shown in TABLE 1. When rice husk is incorporated into waste polypropylene or waste polyethylene, it can be seen that, bending strength are improved at all. This my be attributed to the presence of some additives in waste plastics which reduce

TABLE 1 : Mechanical and physical properties of the composite panels

Composites Samples	Bending strength, Kgf/cm2	Abrasion mg	Water absorption		
			2h	24h	7day
100 % rice husk	50.34	-	98.43	---	---
30% rice husk+70% waste plastic bags	206.646	10	3.166	7.885	9.272
30% rice husk+70% waste polypropylene	214.015	10	0.86	3.8	6.49
30%husk(50% rice+50% peanut hulls)+70% waste plastic bags	187.6	10	2.1	5.017	6.5
50% rice husk+25% waste PS	143.78	10	3.66	9.21	12.71

immiscibility between rice husk and plastic phases. Replacement of 25% RH by the lignocellulosic fiber peanut hulls cause dropping of MOR. Particle size play a role in this case. The heterogeneous size of RH and ground peanut hulls causes voids or weak points inside the specimens. The presence of voids obstructs stress propagation when tensile stress is loaded and induce increased brittleness[3,11]. Increasing filler load of RH from 30% to 50% cause another dropping of MOR. Since the filler particles are very small a high interfacial surface exists between the polar filler and the a polar matrix. As this area increases the worsening bonding between them decreases the bending strength. It has also been shown that for irregularly-shaped fillers the strength of the composites can decrease due to the inability of the filler to support stresses transferred from the polymer matrix. We can say that filler load and type play the major role in determining the stiffness of composite panels. Also, polymer type has no effect on abrasion resistance and weight loss was small as shown in TABLE 1.

Water absorption

It is widely known that there is some controversy surrounding water absorption by wood plastic composites. From one side there is a perception in industry that wood particles are effectively encapsulated in water impervious plastic. While wood may absorb as much as about 25% water to fiber saturation point, polyolefin, including polyethylene and polypropylene which creates a continuous phase of the composite, may absorb only 0.01% moisture after immersion[12].

Generally, polypropylene and polyethylene hardly absorbs water due to their hydrophobic structure; however, rice husk can absorb water significantly because of its hydrophilic characteristics. Rice husk filled polypropylene or polyethylene specimens can absorb water by three different boundaries, i.e. lumen and cell wall of rice husk, and finally the interfacial area between rice husk and polyolefin. Values of water absorption of composite panels in TABLE 1 indicates that incorporation of rice husk to waste polyethylene or waste poly propylene reduce the hydrophilic nature of rice husk. Comparing between waste polyethylene and waste polypropylene, polypropylene hardly absorb water more than the other. Mixing peanut hulls with rice husk (1:1) in presence of waste plastic bags (polyethylene) was effective to obtain panels having low water uptake. Introducing RH in 50% to mixture of waste polypropylene and waste poly styrene increases water absorption due to the height filler content and my due to voids which exist as a result of different polymers size.

Density

Nowadays lignocellulosic fibers are effectively used as fillers in polymer composites instead of mineral fillers as kaoline, calcium carbonate and aluminium, Waste fibers as RH and peanut hulls are of lower cost,more stiffness, have lower density and renewable. Figure1 illustrates the height density of RH in solid- like composites[13,14] Mixing RH with Peanut hulls (1:1) and waste poly ethylene reduce the density of panels from

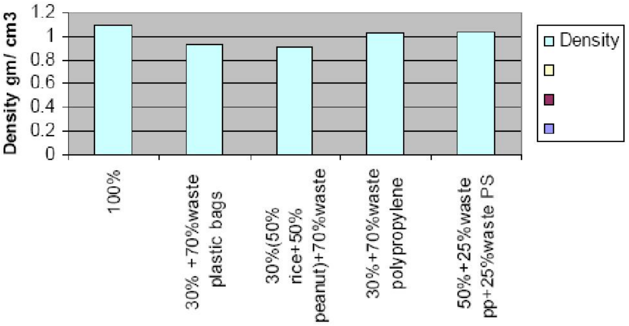

Figure 1 : Effect of husks on density panels

0.93 to 0.907g/cm$^{3.}$ Panels made from waste polypropylene and RH have more density than that made from waste polyethylene and rice husk. Also, increasing the percent of RH filler to 50% lead to panel of height density. The slight change in density reflects that the polymer matrix was not able to penetrate into the lingo cellulosic filler lumen and cell walls thus producing composites with interesting low densities.

TGA

Thermal stability of thermoplastic composites for packaging application is necessary in determining their end use. The curves of Figure 2 confirm that the thermal degradation began to occur only after the materials have absorbed certain amounts of heat energy. A sudden drop in the mass of the samples indicates the thermal degradation of the materials. The initial degradation of RH (a) was occurred at 161^{0}C, plastic bags was at 193^{0}C and 239 ^{0}C for the composites made from RH and plastic bags. However, adding the RH to the thermoplastic matrix, in general, increased the degradation temperature of the composites and also increased the decomposition temperature. This finding seems to be in agreement with Averous & Boquillon[15].

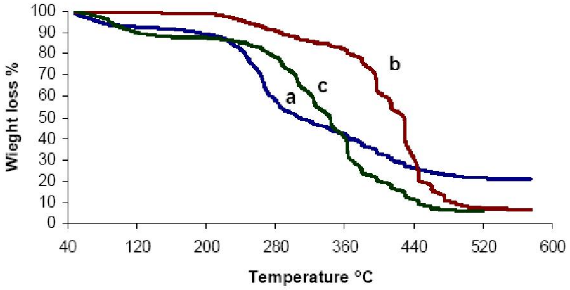

Figure 2 : TGA thermograms of RH(a), plastic bags(b)

CONCLUSION

When rice husk is incorporated into waste polypropylene or waste polyethylene, bending strength were improved at all. Replacement of 25% RH by the lignocellulosic fiber peanut hulls cause dropping of bending srength. Values of water absorption of composite panels in TABLE 1 indicates that incorporation of rice husk to waste polyethylene or waste poly propylene reduce the hydrophilic nature of rice husk. Comparing between waste polyethylene and waste polypropylene, polypropylene hardly absorb water more than the other. Mixing peanut hulls with rice husk (1:1) in presence of waste plastic bags (polyethylene) was effective to obtain panels having low water uptake. Rice husk was thought to be a substitute for wood flour in manufacturing agriculture lignocellulosic fiber- thermermoplastic polymer composites in the aspect of thermal decomposition. According to the origin of polymer matrix the obtained composites can be used in food and non food packaging applications.

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