PRELIMINARY STUDY ON THE MECHANICAL PROPERTIES OF POLYPROPYLENE RICE HUSK COMPOSITES

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ABSTRACT

The interest in the utilization of rice husk as fillers in thermoplastics has increased recently mainly due to the needs in overcoming the environmental problems caused by agricultural by-product. This paper reports on the effects of coupling agent and impact modifier on the mechanical properties of polypropylene rice husk composites. Ethylene 1-octene copolymers (EOC) and maleic anhydride grafted polypropylene (MaPP) were used in this study as the impact modifier and coupling agent, respectively. These compounds were melt blended using twin screw extruder and then injection molded into standard test samples. Improvement of 35% in flexural strength was observed with the addition of 4 wt% of MaPP into the composites with 30 wt% rice husk. Incorporation of 20 wt% of EOC in the composites has also shown significant enhancement in the impact properties of the blends but reduced the flexural modulus.

Keywords: *rice husk, mechanical properties, impact modifier, coupling agent, thermoplastics composites*

INTRODUCTION

Lignocellulosic-filled plastic composites have received a lot of attention particularly on the types of fiber, filler characteristics, types of coupling agent and so forth. Growth of lignocellulosic-plastic composites has been attributed to the density factor of the lignocellulosic filler in addition to other advantages such as greater deformability and less abrasiveness to expensive moulds. The increasing trend in using non-wood materials has been induced by the growing demand for light weight, high performance materials coupled with the abundant supply of lignocellulosic. Using lignocellulosic fiber as reinforcement in a common thermoplastic matrix would provide versatility on the properties of the composite materials.

In recent years, the utilizations of lignocellulosic materials are basically fibers derived from agricultural sources such as jute, oil palm fruit bunch, wood flour and rice husk. Rice husk is one of such major agro-waste products, which contains cellulose 35%, hemicellulose 25%, lignin 20% and ash 17% (silica 94%), by weight [1]. Studies are ongoing to find ways to use lignocellulosic fibers in place of synthetic fibers as reinforcing fillers. The benefits offered by lignocellulosic materials include making the final product light, decreasing the wear of the machinery used, low cost, biodegradability and absence of residues or toxic byproducts [1-3]. Rice husk which has become environmentally problematic waste are now can be converted into useful industrial materials.

Physical blending have the possibility of tailoring properties to suit end user requirements, ability to achieve enhanced properties and/or properties that are unavailable in a single polymer and environment benefits. Economic gains offered by this technology leading to cost reduction of the materials with required properties are the prime motive for wide acceptance of the polymer blends. By joining together between wastes and blending technology, better and improved composites would be achieved.

This factor has prompted us to investigate the performance of ground rice husk as filler in polypropylene composites. In this study, polypropylene was used as matrix and lignocellulosic material (rice husk flour) as a reinforcing filler to prepare polypropylene rice husk (PPRH) composites. Impact modifier and coupling agent were also used in this study to investigate the effects of variation formulation of blends on mechanical properties of PPRH composites.

EXPERIMENTAL

Materials

The reinforcing filler used was rice husk (RH) obtained from Bernas Perdana, Penang. This rice husks were ground and then sieved to obtain rice husk flour with size of $\leq 75\mu m$. Polypropylene copolymer grade (Titanpro Profax SM 240) was supplied by Titan PP

Polymers (M) Sdn. Bhd., with melt flow index of 25g/10min (230^oC/2.16 kg) and a density of 0.9 gcm^{-3}. Elastomer, Engage 8150 acts as impact modifier was supplied by DuPont Dow. With 39 wt% comonomer content, melt index of 0.5 dg/min (190^oC/2.15 kg) and 0.868 g/cm^{-3} in density, these ethylene-octene copolymers have an excellent flow characteristic and provide superb impact properties in blends with PP and PE. Coupling agent used to compatibilized rice husk and polypropylene matrix was maleic anhydride modified polypropylene wax (MaPP) with trade name of Licomont AR 504. This MaPP were yellowish in colour and has acid value between 37-45 mg KOH/g.

Experimental

Ground RH was dried at 105^oC in air dryer oven for 24 h to expel any moisture trapped to a content of 1 – 2% and then stored over desiccant in sealed container. This RH was then mixed with PP using tumbler mixer to obtain better dispersion of RH and PP. Later the mixed compounds were melt blended using twin screw extruder at temperature profile of 160^oC to 190^oC from feed zone to die zone, respectively. Twin screw extruder has 33 L/D and is a co-rotating type. Using 100 rpm of screw speed, the compounds were extruded and palletized. These pallets were stored in a sealed container and then dried for about 3-4 hours before being injection molded. Temperature used for injection molded samples was 170^0C to 190^oC from feed zone to die zone. The samples were injected at injection pressure between 45-50 kg/m^2 with cooling time about 30 seconds. Through this procedure, composites with different filler loading (Table 1) were prepared consisting rice husk, POE and coupling agent.

Table 1: Polypropylene rice husk composites formulation.

Sample	**PP (wt %)**	**RH (wt %)**	**POE (wt %)**	**MaPP (wt %)**
A (PPRH30)	70	30	-	-
B (PPRH40)	60	40	-	-
C (PPRH30MPP4)	66	30	-	4
D (PPRH30POE10MPP4)	56	30	10	4
E (PPRH30POE20MPP4)	46	30	20	4

Determination of Mechanical Properties

Determination of mechanical properties of the composites was done for flexural and Izod impact test. Flexural modulus and strength were measured according to ASTM D790 test method with three point bending and was carried out using Instron Universal testing Machine Series XI. While Izod impact strength was measured using Izod impact tester pendulum type according to ASTM D 256.

RESULTS AND DISCUSSION

Figure 1 shows the effects of rice husk, impact modifier and coupling agent on flexural strength of polypropylene rice husk composites. The result showed that the incorporation of rice husk has resulted in the decrease of flexural strength. The incorporation of 4 wt% of MaPP into the composite with 30 wt% of rice husk has resulted in the increase of flexural strength by about 35% compared to the untreated composites. The plausible reason for the increase in flexural strength of the composite was due to better interfacial adhesion between rice husk and PP matrix in the presence of the coupling agent. Further addition of POE sample D (10 wt % POE) decreased flexural strength of the composite. However, sample D flexural strength was still higher than sample A.

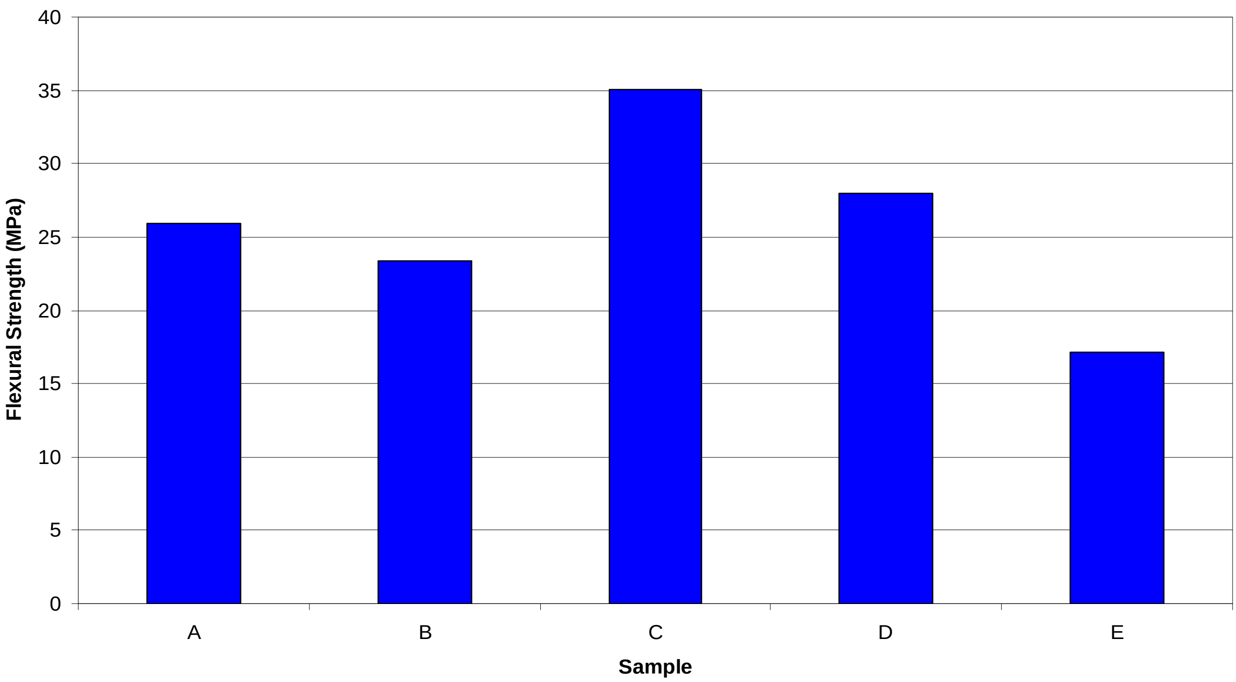

Figure 1: Influence of filler loading and POE on flexural strength of PPRH composites

Figure 2 shows the effects of rice husk, impact modifier and coupling agent on flexural modulus of polypropylene rice husk composites. The result showed that the incorporation of rice husk has resulted in the increase of flexural modulus. The rice husk flour has restricted the mobility of the PP matrix when load was forced onto the composite. The incorporation of 4 wt% of MaPP into the composite with 30 wt % of rice husk has resulted in the increase of flexural modulus by about 4 % compared to the untreated composites. Similar reason for the increase in flexural strength can be given for the increase in flexural modulus that is due to better interfacial adhesion between rice husk and PP matrix in the presence of the coupling agent. Further addition of POE, sample D (10 wt %) decreased flexural modulus of the composite. Even at 10 wt % POE (sample D), the flexural modulus was already lower than sample A.

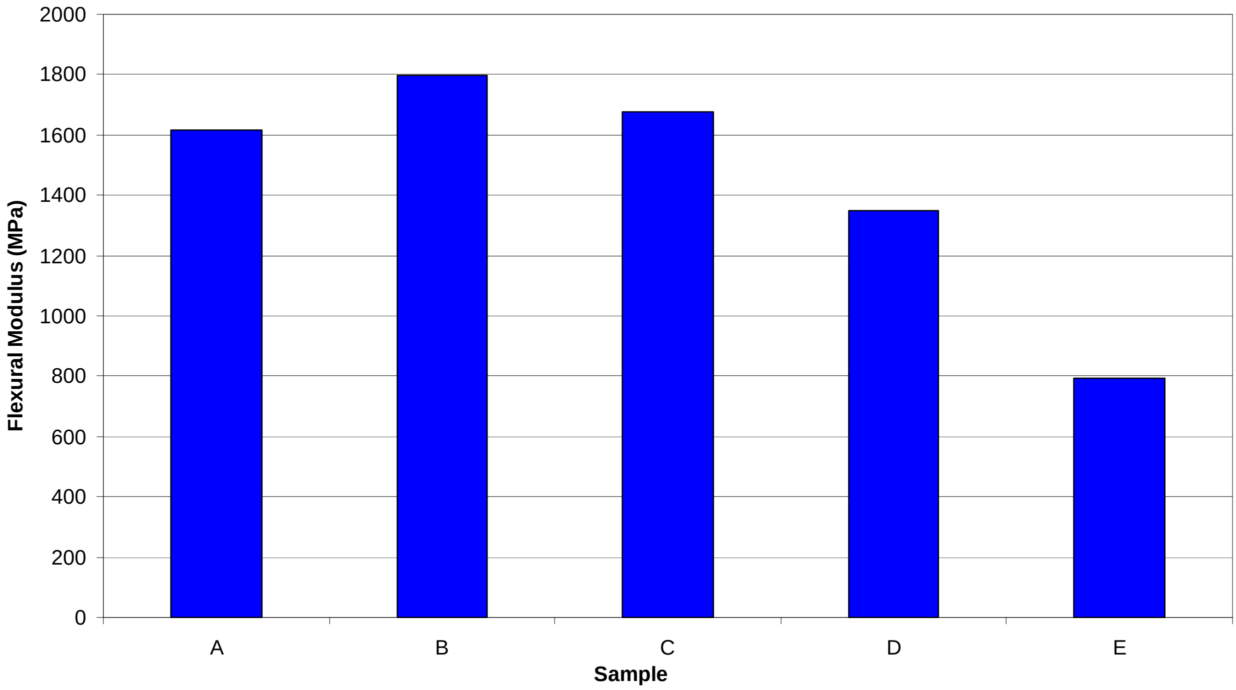

Figure 2: Influence of filler loading and POE on flexural modulus of PPRH composites

Figure 3 shows the effects of rice husk, impact modifier and coupling agent on impact strength of polypropylene rice husk composites. The result showed that the incorporation of 40 wt% rice husk has resulted in the decrease of impact strength compared to 30 wt% rice husk. The incorporation of 4 wt% of MaPP into the composite with 30 wt% of rice husk has also resulted in a marginal decrease of impact strength by about 11 % compared to the untreated composites (sample A). The addition of POE increased impact strength of the composite. The addition of 20 wt % POE enhanced the impact strength by more than 4 times.

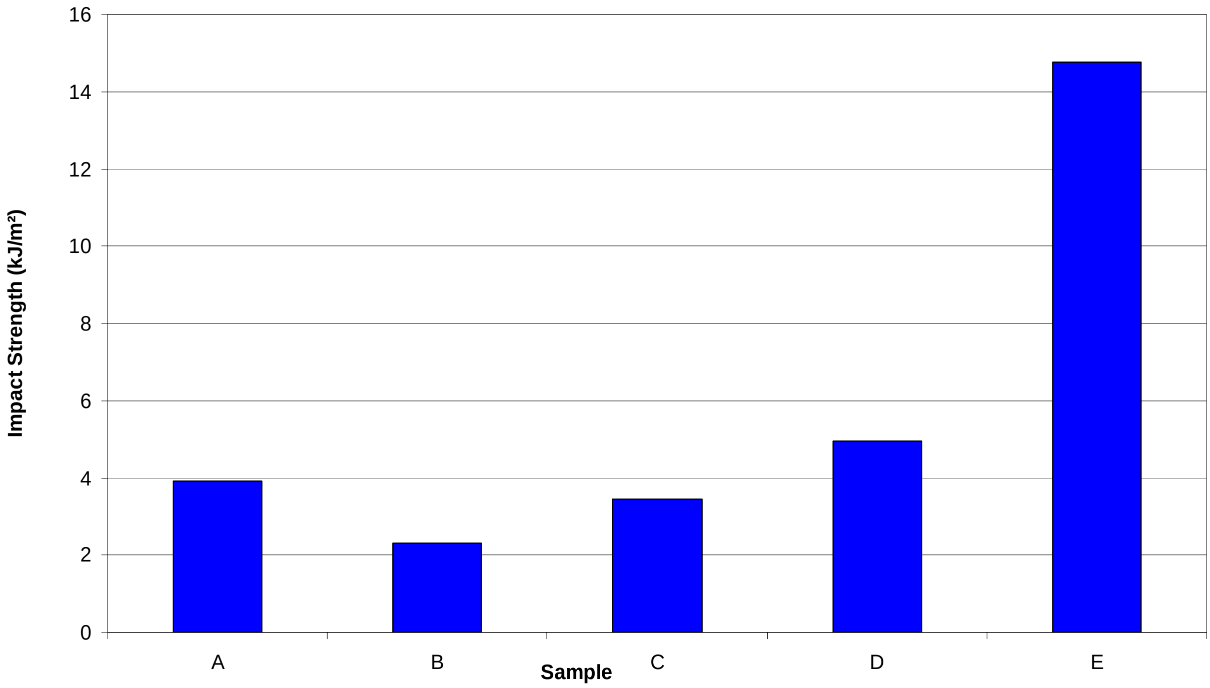

Figure 3: Influence of filler loading and POE on Izod impact strength of PPRH composites

CONCLUSION

The objective of the study is to determine the effects of rice husk, impact modifier and coupling agent on flexural and impact properties of the polypropylene rice husk composites. Based on the study, the following conclusions were derived:

- Rice husk increased the flexural modulus but decreased the flexural and impact strength of PP composites
- The incorporation of 4 wt% of MaPP into the composite with 30 wt% of rice increased the flexural strength but decreased the flexural modulus and impact strength.
- POE is an effective impact modifier for PP rice husk composite with significant improvement shown when 20 % was incorporated into the composites.

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