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The Effect of Polypropylene Maleic Anhydride (PPMAH) on Properties of Polypropylene (PP)/Recycled Acrylonitrile Butadiene Rubber (NBRr)/ Rice Husk Powder (RHP) Composites

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ABSTRACT

The effect of polypropylene maleic anhydride (PPMAH) on tensile properties and morphology of polypropylene (PP)/recycled acrylonitrile butadiene rubber (NBRr)/ rice husk powder (RHP) composites has been studied. The composites were prepared through melt mixing at 180ºC for 9 minutes using 50 rpm rotor speed. The specimens were analyzed using different techniques, namely tensile test and Scanning Electron Microscopy (SEM). The results obtained showed that the tensile strength and Young's modulus of the modified composites were increased, while the elongation at break showed the opposite trend as compared with the unmodified composites. The morphology results support the tensile properties and these indicated a better interaction between the filler and matrix with the presence of PPMAH as a compatibilizer.

Keywords: Recycled acrylonitrile butadiene rubber, polypropylene, physical properties, PPMAH

INTRODUCTION

Thermoplastic elastomers (TPEs) are advanced polymeric materials with fill the gap between an elastomer and plastomer which is crystalline (Golden *et al*., 1996). Its combined properties in strength and toughness have attracted many researches in this area. Besides, TPE has also been found to be cheap, recyclable, biodegradable, and environmentally friendly (Paul and Newman, 1978). Elastomer, such as recycled acrylonitrile butadiene rubber (NBR), has gained much interest in TPE production due to its availability in market, especially from the surgical glove industries. Meanwhile, cheap fillers from the agricultural wastes such as oil palm empty fruit bunch, rice husk ash, jute fibre, rubber wood powder, and cellulose fibres have been investigated as fillers in elastomers and plastics (Satyanarayana and Arizaga, 2009) due to their vast existence in the agricultural sector.

Lignocellulose materials such as rice husk powder (RHP) from the agricultural waste may serve as a good additive in plastic materials. However, as far as TPEs are concerned, very limited studies have been reported on rice husks as fillers in the PP/NBRr composite. It is because these composites are found to be incompatible or immiscible due to the poor physical and chemical interactions between the phases. This incompatibility may be due to the fact that the polyolefin is non-polar and hydrophobic, whereas lignocelluloses materials such as RHP are polar because of the –OH groups in the cellulose (Satyanarayana and Arizaga, 2009). In this study, surface modification or treatment using compatibilizing agents for the purpose of making the polyolefin chains to become

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more hydrophilic had been performed. Morphology studies of the tensile fracture surfaces of PP NBRr/RHP composites, with and without PPMAH, were also carried out to correlate the change in the morphology with properties.

EXPERIMENTAL

Materials

Polypropylene (PP) used in this work was supplied by Titan PP Polymers (M) Sdn. Bhd., in Johor, Malaysia (code 6331). It has a melt flow index and density of 14 g/10 min at 230° C and 0.9 g/cm^3, respectively. The polypropylene maleic anhydride (PPMAH) was supplied by Bayer (M) Sdn. Bhd. in Selangor, Malaysia. The recycle acrylonitrile butadiene rubber (NBRr), with 33% acrylonitrile content and density of 0.98 g/cm^3, was obtained by grinding nitrile rubber gloves retrieved from Juara One Resources Sdn Bhd., Penang, Malaysia. The range of particle size of NBRr used in this study was 300 µm – 500 µm and the density of NBRr was 1.015 g/cm^3. The rice husks, containing 35% of cellulose, 25% of hemicelluloses, 20% of lignin and 17% of ash by weight, were supplied by a rice factory, Thye Heng Chan Enterprise Malaysia Sdn. Bhd., located in Penang. The rice husks were dried at 110ºC for 24 hours in a vacuum oven prior to grinding for a particle size of 300-500 µm and with a density of 1.4702 g/cm^3. *Fig. 1* (*a-b*) show the scanning electron micrograph of recycled NBR powder and rice husk powder at a magnification of 21x.

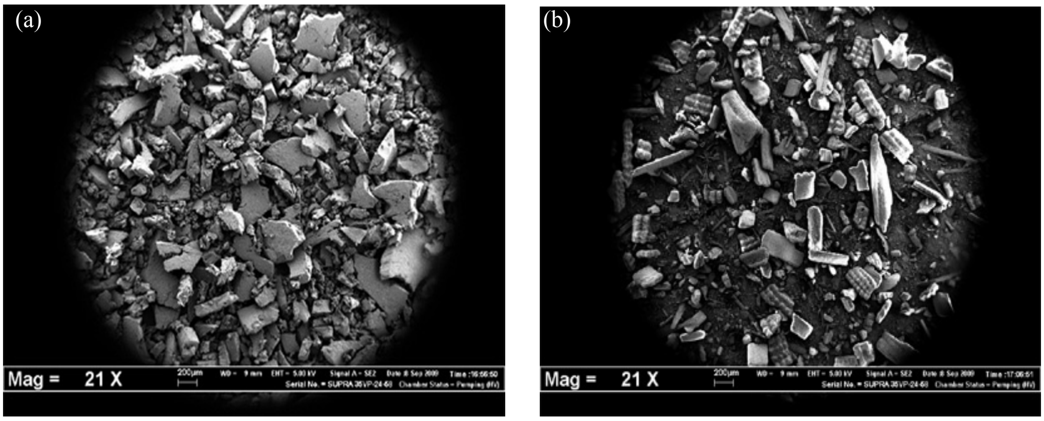


Fig. 1: Scanning electron micrograph at magnification of 21x for (a) Recycled NBR powder, (b) Rice husk powder

Preparation of the Composites

The formulation of the composites is given in Table 1.

TABLE 1
Formulation for PP/NBRr/RHP/PPMAH composites

Materials (pphr)	Composition											
	1	2	3	4	5	6	1a	2a	3a	4a	5a	6a
PP	100	80	70	60	50	40	100	80	70	60	50	40
NBRr	0	20	30	40	50	60	0	20	30	40	50	60
RHP	15	15	15	15	15	15	15	15	15	15	15	15
PPMAH	-	-	-	-	-	-	5	5	5	5	5	5

The composites were prepared by melt mixing using a Haake Rheomix Polydrive R 600/610 mixer at 180ºC at a rotor speed of 60 rpm. The PP was charged into the mixing chamber and melted for 4 min before the NBR was added. Subsequently, RHP was added at 6 min while mixing was continued for 3 more minutes and a total of 9 min mixing time.

Compression Moulding

Samples of the composites were compress moulded in an electrical heated hydraulic press. The moulding procedure involves a preheating of the samples for 7 min at 180ºC, followed by compressing of the mould for 2 min at the same temperature and subsequently cooling under pressure for another 2 min.

Tensile Properties

The tensile tests were carried out according to ASTM D638 using the Instron tensile machine model no 3366. Specimens in the form of one milimeter thick dumbell tensile were cut from the moulded sheets with a Wallace die cutter S6/1/6.A. A cross head speed of the tensile machine was maintained at 50 mm/min and the tests were performed at 25± 3ºC. Stress at peak (MPa), Young's modulus (MPa) and elongation at break (%) were also measured. All the experimental tests were repeated trice (3 times) and found to be consistent and reproducible.

Morphological Study

The morphology of the tensile fractured surfaces of the samples was analysed using the SUPRA36VP-24-58 Field Emmission Scanning Electron Microscope (FESEM). The fractured ends of the specimens were mounted on aluminium stub and sputter-coated with a thin layer of gold to avoid electrostatic charging during examination.

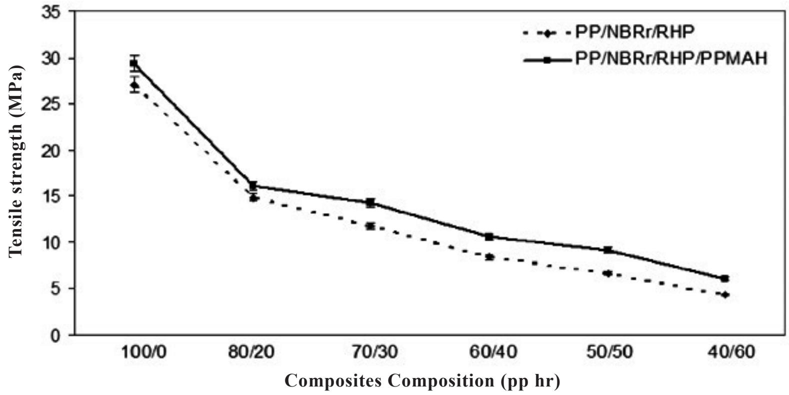


Fig. 2: Tensile strength of PP/NBRr/RHP and PP/NBRr/RHP/PPMAH composites

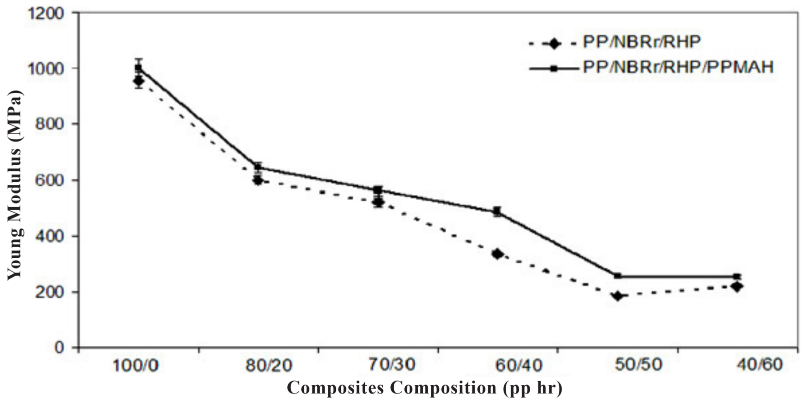


Fig. 3: Young's modulus of PP/NBRr/RHP and PP/NBRr/RHP/PPMAH composites

RESULTS AND DISCUSSION

Mechanical Properties

The effects of composite composition on the tensile properties of PP/NBRr/RHP are shown in *Figs. 2* and *3*. Tensile strength and Young's modulus of composites decrease with increasing amount of NBRr. These are due to the decrease in crystallinity of PP phase in the composite with the addition of NBRr. Similar findings have been reported by many researchers in their studies on thermoplastic elastomer composites (Zhang *et al*., 2002; Ismail *et al*., 2004). The stiffness and brittleness of the composite decreases with increasing amount of NBRr in the composite due to increasing content of elastomer which resulted in higher elongation of the material (Ismail *et al*., 2009). These finding are in agreement with the elongation at break (E_b) for the respective composites as shown in *Fig. 4*. E_b increases with increasing of recycle nitrile rubber content. The compatibilization of PP-MAH in these composites has contributed in higher strength and stiffness as shown in *Figs. 2* and *3*. These are due to good adhesion between the PP and NBRr with RHP in the presence of PPMAH. The relatively low elongation at break for these composites supports the finding that the composite are getting more stiff and stronger after compatibilization.

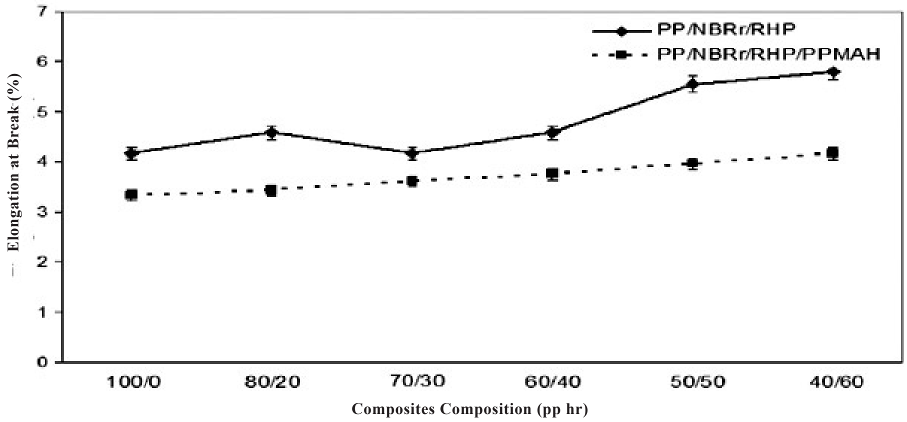
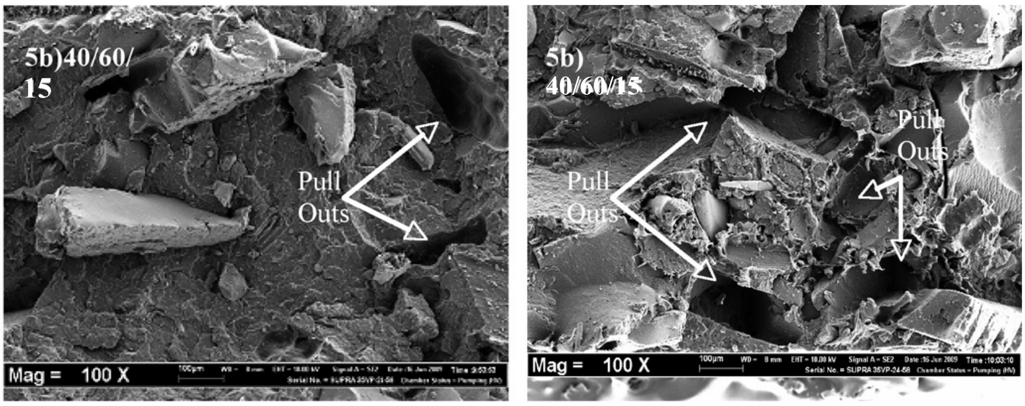


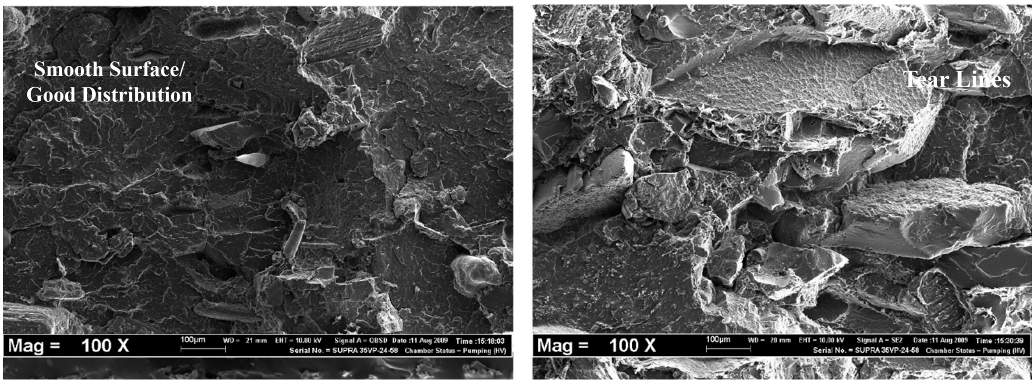
Fig. 4: Elongation at break of PP/NBRr/RHP and PP/NBRr/RHP/PPMAH composites



Figs. 5 (a-b): Scanning electron micrograph of tensile fractured surface of PP/NBRr/RHP at magnification of 100x

Morphological Study

Figs. 5 (*a-b*) show the scanning electron micrographs of the tensile fractured surface of PP/NBRr/RHP at the composition of 80/20/15 and 40/60/15, respectively. It can be clearly seen from the SEM micrographs that the dispersion of NBRr phase in the PP matrix in the presence of RHP has become poor as the NBRr content increases. The increasing number of pull outs indicates that there is low adhesion between the phases. Lower adhesion between the phases gives rise to poor stress transfer across the interface (Ismail *et al*., 2004; Ismail *et al*., 2009).



Figs. 6 (a-b): Scanning electron micrograph of tensile fractured surface of PP/NBRr/RHP/PPMAH composites at magnification of 100x

Figs. 6 (*a-b*) clearly show even distribution of dispersion of NBRr phase in the PP matrix occurred in the composites which were compatibilized with PPMAH. Less pull outs and more tear lines observed in both composites indicate a high adhesion between the phases. This finding may be due to the attachment of NBRr with –OH radicals from the RHP resulted from compatibilization (Ismail *et al*., 2004; Ismail *et al*., 2009).

CONCLUSIONS

The results obtained showed that the tensile strength and Young's modulus of modified composites increased, while the elongation at break indicated an opposite trend as compared with the unmodified composites. The morphology results support the tensile properties revealing a better interaction between the filler and the matrix in the presence of PPMAH as a compatibilizer. Meanwhile, the scanning electron microscopy (SEM) study reveals a better dispersion of NBRr in the continuous PP matrix.

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