EFFECT OF TRANS-POLYOCTYLENE RUBBER (TOR) ON MECHANICAL PROPERTIES AND MORPHOLOGY OF POLYPROPYLENE/RECYCLED ACRYLONITRILE-BUTADIENE RUBBER/RICE HUSK POWDER (PP/ NBRr/ RHP) COMPOSITES

Ragunathan[1,*], H. Ismail [1], and K. Hussin[2]

[1]*School of Materials and Mineral Resources Engineering, USM Transkrian, Penang, MALAYSIA.*
[2]*School of Environmental Engineering, University Malaysia Perlis UniMAP, Jejawi, Perlis MALAYSIA.*

Polymer composites based on different ratio of PP (polypropylene) and recycled acrylonitrile butadiene rubber (NBR) and rice husk powder (RHP) with and without trans-polyoctylene rubber (TOR) as a compatibilizer were investigated. Five compositions of PP/NBRr/RHP (i.e. 100/0/15, 80/20/15, 70/30/15, 60/40/15 and 40/60/15) were prepared with constant TOR ratio at 10 phr. Results indicated mechanical properties of the PP/NBRr/RHP composites decreased with increasing NBRr content. However tensile strength and tensile modulus was found to be improved in TOR compatibilized composites. TOR was found to successfully make interaction with NBRr. The morphological studies of the tensile fracture surface supported good interaction between PP/NBRr matrices and RHP in the presence of TOR.

Keywords: Polypropylene, recycle acrylonitrile butadiene rubber, trans-polyoctylene (TOR), Mechanical Properties

INTRODUCTION

Composite fabrication by using waste materials has gained much attention in recent years. Rice husk (RH) is among natural fibers accounts for 20% of paddy weight [1]. RH is waste material after rice milling. It has been disposed by open burning and become a serious environmental problem. The use of RHP as fillers in polymer may serve as an alternative to utilize the waste material [2-4]. However it has to blend with a hard and soft polymeric segment to fabricate well balance properties of the resulting material. Polypropylene (PP) is a conventional polymer which inherits low density at 0.9 g/cm^3 with highly crystalline structure. It is highly preferred as the hard segment of TPE's due to its low cost and resistance to solvent and high temperature [5]. As for the soft segment synthetic rubber such as waste Acrylonitrile butadiene rubber was founds to be popular among the researcher due to large quantity of waste generated in the pharmaceutical and medical sectors [6]. However NBRr primary set back, it requires some modification for adequate adhesion between the non polar PP and polar RHP. Trans-polyoctylene rubber (TOR) is a low-molecular-weight polymer, made from cyclo-octene by metathesis polymerization, and has been known as a compatibilizer for incompatible blends as well as a processing aid. As such, mixing of natural fibers like RHP with PP and NBRr may result in excellent mechanical and processing characteristic inherit from PP [7]. Relatively good properties on chemical and oil resistant due to NBRr characteristic and improved tensile modulus in the presence of RHP. Therefore; in this work, a new class of thermoplastic elastomer (TPE) material by blending PP with recycle NBR gloves and RHP were aimed and the effect of TOR on mechanical properties of PP/ NBRr/ RHP composites were investigated.

EXPERIMENTAL

Materials and ingredients

Polypropylene (PP) Grade 6331, Homo-polymer with MFR at 230 °C=14 g/10 min were obtained Titan Polymers, Malaysia. Rice husk (RH) were obtained from Thye Heng Chan Enterprise Sdn. Bhd. Malaysia was grounded at 300-500 μm to produce rice husk powder (RHP). Waste Acrylonitrile butadiene rubber (NBRr) was obtained in a form of used NBR gloves which were masticated and pulverized at 300-500 μm and Trans-polyoctylene rubber (TOR) grade Vestenamer 8012 was bought from Huls, Germany.

*Corresponding author: Tel. + 6(04)9798994; Fax. + 6(04)9798636
E-mail.ragunathan25@yahoo.com (Ragunathan Santiagoo)

Compounding

The PP/NBRr/RHP composites were formulated based on 100/0/15, 80/20/15, 70/30/15, 60/40/15 and 40/60/15 (phr). The TOR content has been fixed at 10phr. The composites were melt-mixed in an internal mixer (Haake Polydrive R600/610) at a temperature of 180 °C and rotor speed of 50 rpm. For both systems, PP was melted in the mixer for 4 min prior to the addition of NBRr. After 6 min the RHP was added and the mixing was continued for another 3 min for a total mixing time of 9 min. For the system with TOR, TOR is added into the mixture together with NBRr at the 4^{th} minutes. Then, the composites were left to cool down at ambient temperature prior to molding.

Test Sample Preparation

About 36 g of PP/NBR/RHP composites were placed in a mold and pressed between smooth sheets and the moving platens of an electrically heated hydraulic press to produce a 2 mm sheet. The blends were preheated for 6 min and compression-molded for 4 min at 180 °C. The blends were subsequently cooled under running tap water and pressure for 2 min at ambient temperature. Then, dumb-bell-shaped test specimens were punched from the sheets. Tensile dumbbells with 1 mm thickness were cut from the molded sheets with a Wallace die cutter S6/1/6.A.

Mechanical Properties

Tensile tests were carried out according to ASTM D638 using the Instron tensile machine model No 3366. Tensile dumbbell with 1 mm thickness were cut from the molded sheets with a Wallace die cutter S6/1/6.A. Young's modulus, tensile strength at peak and elongation at break were measured at a cross head speed of 5 mm/min and tests were performed at room temperature (25± 3°C).

Morphology

The failure mode of the fractured tensile specimens was examined using Field Emission Scanning Electron Microscope (FESEM.ZEISS SUPRA36VP-24-58). SEM micrographs were taken at various magnifications for fracture and other observations. Prior to the SEM observations the fractured ends of the specimens were mounted on aluminium stubs and were sputter coated with a thin layer of gold to avoid electrical charging during examinations.

RESULTS AND DISCUSSION

Mechanical Properties

Fig. 1 and Fig. 2 Show the variations of tensile strength and tensile modulus of PP/NBRr/RHP composites with and without TOR as compatibilizer. It was observed that tensile strength and modulus decreased with increasing NBRr content. This is expected as RHP was poorly distributed in NBRr-rich composites as compared to that in PP-rich composites. This, in turn promotes high particle–particle interaction with increasing NBRr content, which at the end contributes to the reduction in tensile properties. A similar trend was observed in PP/RHP and recycled NBRr [8]. However, for composites compatibilizer with TOR showed significant increase in both tensile strength and Young modulus. The Young's modulus marks a 30% increase with the 20 phr of NBRr into the composites. The TOR was found to make good interaction with NBRr which will be discussed later in the morphological studies.

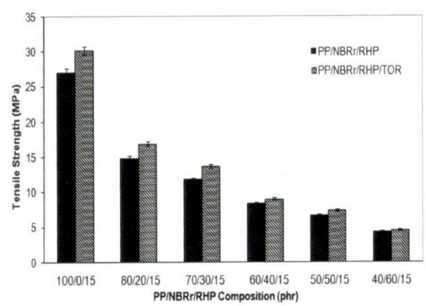

Fig.1. The effect of different composite composition on tensile strength of PP/NBRr/RHP composites.

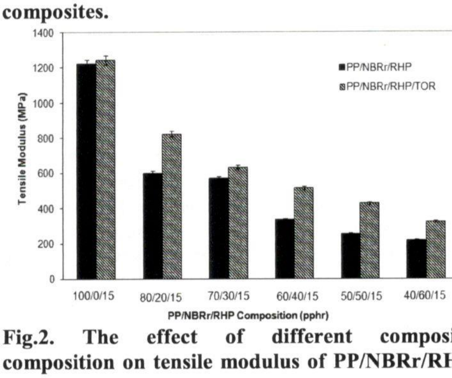

Fig.2. The effect of different composite composition on tensile modulus of PP/NBRr/RHP composites.

The tensile strength improvement is exhibited in all composite composition in the presence of TOR. This observation may be attributed to a better distribution of RHP in the PP/NBRr matrices with the presence of TOR, which acts as a processing aid, as well as the formation of cross-links throughout the PP/NBRr matrices. TOR which inherits low viscosity was likely to locate at the interfacial area of the PP/NBRr matrices phase and RHP filler in the composite [9]. Having some unsaturated chains, TOR is anticipated to participate in the formation of network structure in the composites. RHP filler were also found to be well encapsulated by PP/NBRr matrices with the presence of TOR. Similar finding was reported in our previous work between PP/RHP/NBRr with the addition of Polypropylene Maleic Anhydride (PPMAH) coupling agent addition [2].

The relationship between elongation at break, Eb, and PP/NBRr/RHP compositions is shown in Fig. 3. Generally, E_b increases with increasing NBRr content, which is due to the increasing content of elastomer. However, the E_b of the PP/NBRr/RHP composites are quite low (<30%) due to the presence of the crosslinked NBRr [10] coupled with other contents such as stabilizer, curing dispersion, pigments, accelerators and thickener which hinder the flow and mobility of the composites. RHP filler, for example, can restrict molecular orientation and mobility of polymer blend molecules [11]. With addition of TOR, all composite compositions exhibit lower Eb than the composites without TOR. This observation was attributed to the formation of interfacial adhesion between PP and NBRr as a result of the ability of TOR to locate at the interfacial area of the PP phase and NBRr due to TOR elastomer characteristics during the mixing process. This may promote the formation of interfacial bonding. This is in agreement with the morphology of fracture surfaces which shows better encapsulation of RHP and less removal of RHP from the PP matrix with incorporation of TOR.

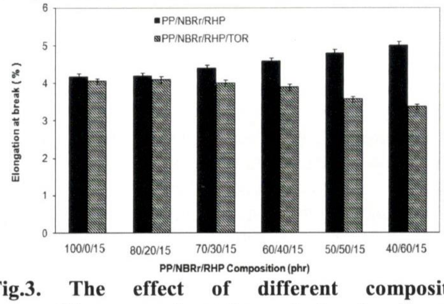

Fig.3. The effect of different composite composition on elongation at break, E_b of PP/NBRr/RHP composites.

Morphological

Fig. 4(a-d) shows SEM micrographs of the PP/NBRr/RHP composites without and with TOR at magnification of 50×, respectively. It can be seen that at every composite composition, ductile behaviors was exhibited by TOR incorporation composites. Lesser NBRr particles were removed from the matrix in composites with TOR than in composites without TOR. Fig.4(c),In higher NBRr content composites closer arrangement of NBRr particle also observed may due to encapsulation of TOR with polymer of higher viscosity such as NBRr and PP during the mixing process. The introduction of TOR into various polymer composites is reported to ductility of the composites, leading to an improvement in mechanical properties [12]. Hence, the above observation strongly supports the earlier finding that the addition of TOR and in PP/NBRr/RHP composites helps to create the interfacial area between the PP phase and NBRr, and also RHP fillers with the elastomer component during the mixing process

Fig.4 (a) 80/20/15(without TOR)

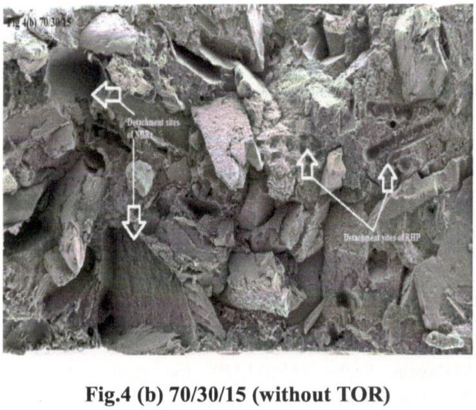

Fig.4 (b) 70/30/15 (without TOR)

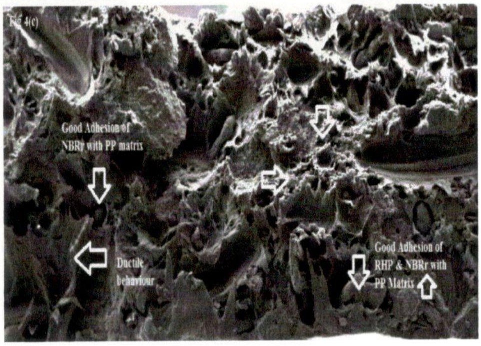

Fig.4 (c) 80/20/15/10 (with TOR)

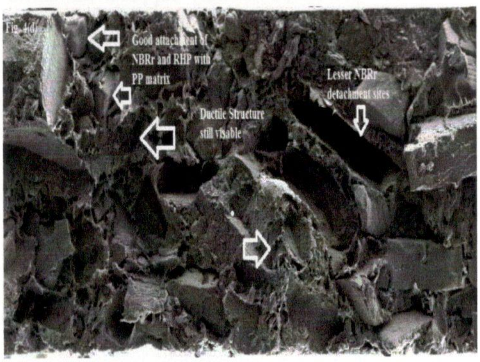

Fig.4 (d) 70/30/15 (with TOR)

This indicates that the addition of TOR did significantly improve the adhesion of NBRr and RHP with PP matrix. RHP was well encapsulated in the presence of TOR thus improved the tensile properties of composite.

CONCLUSION

Incorporation of TOR improved the tensile properties of PP/NBRr/RHP composites as a result of an increase interaction of TOR. The formation of a better interfacial adhesion between PP and NBRr also accounts due to good encapsulation of RHP filler in the presence of TOR.

ACKNOWLEDGEMENT

A gratefully acknowledgment to University Science Malaysia for the financial support (Grant number 1001/PBAHAN/8021028) and University Malaysia Perlis (UniMAP) for study leave in enabling this work.

REFERENCES

[1] Premalal, H.G.B., Ismail, H.,. Baharin, A. (2002). *Polym. Testing.* **21**, 833-839.

[2] Ismail, H., Ragunathan, S., Hussin, K. (2010). *Polym. Plast. Technol. Eng.* **49**, 1323–1328.

[3] Ismail, H., Ragunathan, S., Hussin, K. (2011) *Vinyl Additive Technol.* **17**, 190-197.

[4] S. Ragunathan, S., Ismail, H., Hussin, K. (2011) *BioResources*, **6**, 3714-3726.

[5] G. Holden, N.R., Legge, R. Quirk & H.E Schroeder (1996). *Thermoplastic Elastomers,* 2nd edition (Hanser publisher), pp. 15-64.

[6] C.H. Lufter, (1964). *The vulcanization of nitrile rubber, In Vulcanization of Elastomers,* (Reinhold Publishing Corp.), pp. 10-68.

[7] George, S., Joseph, R., Thomas, S. (1995) *Polymer,* **36**, 4405-4416.

[8] Santiagoo, R., Ismail, H., Hussin, K. (2010) *Pertanika Journal of Science and Technology*, **18**, 427-432.