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Effect of Filler Loading and Isophthalic Acid-Maleic Anhydride (IAMA) on the Properties of Ethylene Vinyl Acetate/Natural Rubber/Potash Feldspar (EVA/NR/PF) Composites

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Abstract –*EVA/NR/PF composites with and without IAMA were prepared using Brabender Plasticoder at 160ºC with 50 rpm rotor speed. The effects of potash feldspar loading and isophthalic acid-maleic anhydride (IAMA) on the tensile properties and morphology of EVA/NR/PF composites were studied. The results indicated that the tensile strength for EVA/NR/PF and EVA/NR/PFIAMA composites decreased, but the M100 increased as the filler loading increased. EVA/NR/PFIAMA composites showed higher value of tensile strength and M100.* ***Copyright © 2014 Penerbit Akademia Baru - All rights reserved.***

Keywords: Feldspar, Ethylene vinyl acetate, Natural rubber, Isophthalic acid, Maleic anhydride

1.0 INTRODUCTION

Thermoplastic elastomer (TPE) is based on rubber and plastic blends. TPE has the physical properties of conventional elastomers at room and service temperatures, and excellent processing characteristics of thermoplastic materials at high temperature. TPE also has economic advantages, good processability and is reprocessable [1].

Ethylene vinyl acetate copolymer (EVA) is a random copolymer that consists of ethylene and vinyl acetate (VA). The repeating units of EVA are ethylene and vinyl acetate. VA content affects the properties of EVA, such as crystallinity [2]. EVA is easily blended with LLDPE, has heat sealability, and provides good processability during extrusion. Due to its excellent whiteness, low density, resistance of color change, low cost and easiness of injection molding, EVA is used widely [3].

Fillers can be classified into three groups; those that reinforce polymer and improve its mechanical performance, those that are used to take-up space and reduce the amount of resin to produce a part (sometimes referred as extenders),and those that are dispersed through polymer to improve its electric conductivity (less common) [4]. The examples of functional filler are carbon black, precipitated silica, and calcined clay. Fillers are used for cost reduction, improving processing, density control, optical effects, thermal conductivity and control of thermal expansion [5]. In this paper, the effect of potash feldspar and IAMA loading on the

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tensile properties and morphology of ethylene vinyl acetate (EVA)/ natural rubber (NR)/ feldspar (PF) composites was investigated.

2.0 MATERIALS

Ethylene vinyl acetate (EVA) containing 18.1 % VA content was obtained from The Polyolefin Company (Singapore) Pte. Ltd. Natural rubber (SMR-L) was purchased from Rubber Research Institute of Malaysia (RRIM). Potash feldspar was obtained from Commercial Minerals (M) Sdn. Bhd., Penang, Malaysia. The chemical composition and physical properties of potash feldspar are given in Table 1. Maleic anhydride and isophthalic acid were supplied by Zarm Scientific & Supplier Sdn. Bhd., Penang, Malaysia.

Table 1: Chemical and physical properties of potash feldspar

Chemical Compositions	Value (%)
SiO	67.0
Al_2O_3	19.0
CaO	0.11
Na_2O	2.3
P_2O_5	0.18
SO_3	0.028
K_2O	11.0
Fe_2O_3	0.12
NiO	0.025
Rb_2O	0.28
Ignition loss	0.2
Physical Properties	
Mean particle size (μm)	13.6
Surface area (m^2/g)	0.73
Density (g/m^3)	2.0

The compounding step was carried out by melt blending in Brabender Plasticoder. Brabender Plasticorder was set at the temperature of 160˚C and rotor speed of 50 rpm. EVA was loaded into the mixing chamber and preheated for 3 min before the compounding process was initiated. NR was added after EVA was melted. The mixing was continued until a constant torque was obtained. Then, potash feldspar with IA and MA were added. The total mixing time was 10 min. The soften blend was pressed into thick round pieces after it was removed from the chamber. The formulations of EVA/NR/PF composites and EVA/NR/PFIAMA composites are shown in Table 2.

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3.0 RESULTS AND DISCUSSION

Figure 1 shows the effect of filler loading on the tensile strength of EVA/NR/PF and EVA/NR/PFIAMA composites. From Figure 1, it can be clearly seen that as the filler loading increased, the tensile strength decreased for both EVA/NR/PF and EVA/NR/PFIAMA composites. It was due to the poor interaction and incompatibility of the matrixes, as well as poor dispersion of the filler. This can be proven by the SEM morphology that is shown in Figure 3. The agglomeration of the filler and voids between the matrix and filler which leads to lower tensile strength can be seen in Figures 3(c) and 3(f). EVA/NR/PFIAMA composites showed higher tensile strength than EVA/NR/PF composites. A good interfacial adhesion and homogeneous dispersion were observed in the feldspar filled EVA/NR/PF composites, which increased the tensile strength with the addition of IAMA. The–COOH groups from IAMA grafted onto the vinyl group of EVA and NR phases improved the compatibility and interfacial adhesion between the EVA and NR phases.

Table 2: Formulations of EVA/NR/PF composites and EVA/NR/PFIAMA composites with different filler loading

Composite Code	EVA/NR (phr)	Potash Feldspar (phr)	IA-MA (phr)
EVA/NR	70/30	-	-
EVA/NR/FP-5	70/30	5	-
EVA/NR/FP -10	70/30	10	-
EVA/NR/FP -15	70/30	15	-
EVA/NR/FP -20	70/30	20	-
EVA/NR/FP -25	70/30	25	-
EVA/NR/FP-5_{IAMA}	70/30	5	6*
EVA/NR/FP-10_{IAMA}	70/30	10	6*
EVA/NR/FP-15_{IAMA}	70/30	15	6*
EVA/NR/FP-20_{IAMA}	70/30	20	6*
EVA/NR/FP-25_{IAMA}	70/30	25	6*

*IA-MA was added 6 phr in the composites

This is proven by the SEM morphology that is shown in Figures 3 (d), (e) and (f). The composites are compatible in the presence of IAMA. El-Sabbagh [6] studied the compatibility of natural rubber and ethylene-propylene diene rubber blends. The compatibility has been improved with the addition of compatibilizers. Besides, the rheological properties of the blends have also improved.

Figure 2 shows the effects of filler loading on modulus at 100% elongation (M100) of EVA/NR/PF composites and EVA/NR/PFIAMA composites. The M100 for both EVA/NR/FP and EVA/NR/PFIAMA composites showed an increasing trend as the filler loading increased.

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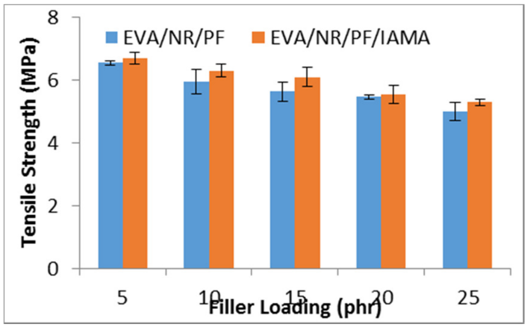


Figure 1: Tensile strength vs filler loading of EVA/NR/PF and EVA/NR/PF$_{IAMA}$ composites

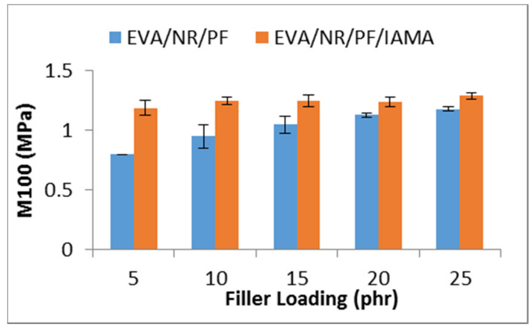
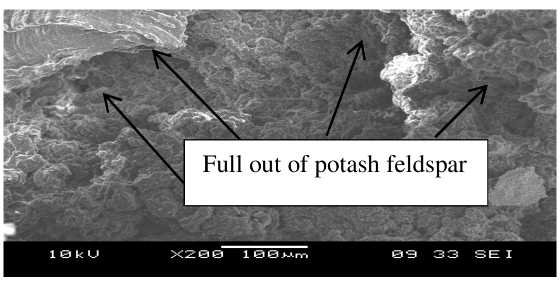
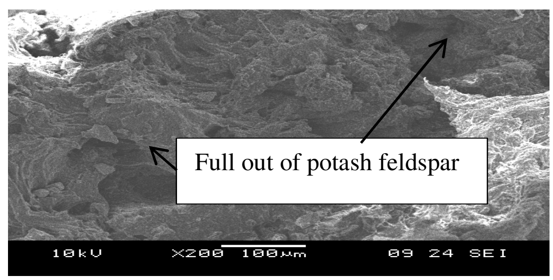
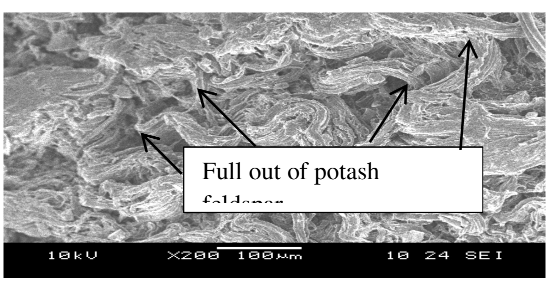
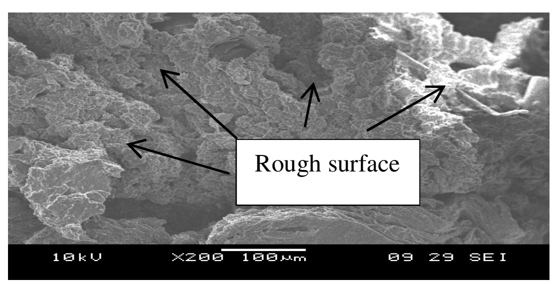


Figure 2: Modulus at 100% elongation vs filler loading of EVA/NR/PF and EVA/NR/PF$_{IAMA}$ composites

This is due to the addition of feldspar that increases the stiffness of the composites. The increase in the crosslink density and hydrogen bonding of the composites caused the M100 for EVA/NR/PFIAMA composites to have a higher value compared to EVA/NR/PF composites.

	
(a) EVA/NR/5PF	(b) EVA/NR/10PF
	
(c) EVA/NR/25PF	(d) EVA/NR/5PF$_{IAMA}$

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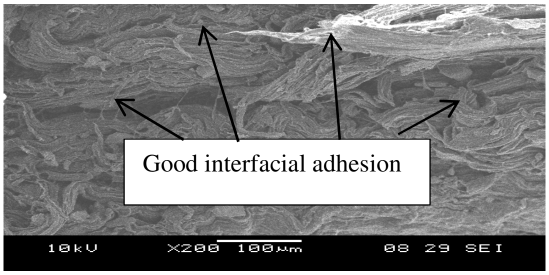	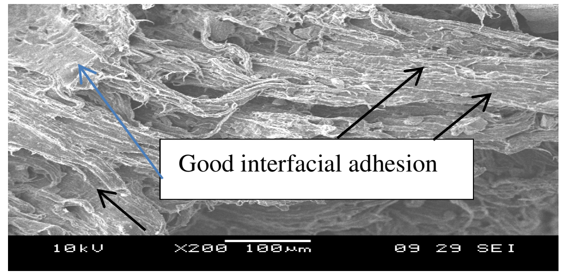
(e) EVA/NR/15PF$_{IAMA}$	(f) EVA/NR/25PF$_{IAMA}$

Figure 3: SEM morphology of tensile fracture surface of EVA/NR/FP and EVA/NR/FPIAMA composites at different filler loading. (a) EVA/NR/PF-5, (b) EVA/NR/PF-10, (c) EVA/NR/PF-25, (d) EVA/NR/PF-5IAMA, (e) EVA/NR/PF-10IAMA, and (f) EVA/NR/PF-25IAMA

4.0 CONCLUSION

As the filler loading increased, the tensile strength decreased whereas the M100 increased. EVA/NR/PF with IAMA composites showed slightly higher tensile strength and modulus at 100% elongation compared to EVA/NR/PF without IAMA composites. The SEM micrograph showed homogenous dispersion of the filler with the addition of IAMA as a compatibilizer.

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