Penerbit Akademia Baru

Journal of Advanced Research in Materials Science
ISSN (online): 2289-7992 | Vol. 3, No.1. Pages 15-20, 2014

Compatibilized Ethylene Vinyl Acetate/ Natural Rubber Thermoplastic Elastomer Blend: The Effect of Potash Feldspar Loading and Isophthalic Acid-Maleic Anhydride (IAMA) on Tensile Properties and Thermal Degradation

S. H. Ho [*,1,a], *A. G. Supri* [2,b] *and P. L. Teh*[3,c]

[1,3]School of Materials Engineering, Universiti Malaysia Perlis (UniMAP), Kompleks Taman Muhibah, Jejawi 2, 02600, Perlis, Malaysia
[2]Faculty of Engineering Technology, Universiti Malaysia Perlis (UniMAP), Main Campus, Pauh Putra, Perlis, Malaysia
[a,*]*HoShuhHuey_1989@yahoo.com*, [b]*supri@unimap.edu.my*, [c]*plteh@unimap.edu.my*

Abstract –*EVA/NR/PF composites with and without IAMA were prepared using Brabender Plasticorder 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 analysis of EVA/NR/PF composites were studied. The results indicated that tensile strength and elongation at break for EVA/NR/PF and EVA/NR/PFIAMA composites decreased as the filler loading increased. EVA/NR/PFIAMA composites showed higher value of tensile strength and elongation at break compared to EVA/NR/PF composites. Besides, EVA/NR/PFIAMA composites showed better thermal stability than EVA/NR/PF composites.*

Keywords: Potash 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 physical properties of conventional elastomers at room and service temperatures, as well as excellent processing characteristics of thermoplastic materials at high temperature. TPE has economic advantages, good processability and 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 will affect the properties of EVA such as crystallinity [2]. EVA is easily blended with LLDPE, a heat sealable polymer, and provides good processability during extrusion. Due to its excellent whiteness, low density, resistance to 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 to extenders); and those that are dispersed through polymer to improve its electric conductivity (less common) [4]. The examples of functional fillers are carbon black, precipitated silica and calcined clay. Fillers are used due to cost reduction, improved processing, density control, optical effects, thermal conductivity and control of thermal expansion [5]. In this paper, the effects of potash feldspar loading and IAMA on tensile properties and thermal stability of ethylene vinyl acetate (EVA)/ natural rubber (NR)/ feldspar (PF) composites were investigated.

2.0 METHODOLOGY

2.1 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 Composition	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	**Value**
Mean particle size (µm)	13.6
Surface area (m^2/g)	0.73
Density (g/m^3)	2.0

2.2 Sample Preparation

The compounding was carried out by melt blending in Brabender Plasticorder. 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 started. NR was added after EVA had 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 being removed from the chamber. The formulations of EVA/NR/PF composites and EVA/NR/PFIAMA composites are shown in Table 2.

Table 2: Formulations of EVA/NR/PF composites and EVA/NR/PF_{IAMA} composites with different filler loadings

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

2.3 Characterization and Measurements

Dumbbell-shaped specimens were prepared. Tensile properties of the composites were measured by using Universal Testing Machine Instron 5582 with crosshead speed of 50 mm/min. Thermogravimetry analysis of the composites was done using a Perkin-Elmer Pyris 6 TGA analyzer. The sample was about 7±2 mg in weight and was placed into a platinum crucible. Then, the sample was heated from 30°C to 850°C at a heating rate of 10°C/min under nitrogen atmosphere condition with the nitrogen flow rate of 50 mL/min.

3.0 RESULTS AND DISCUSSION

3.1 Tensile Properties

Figure 1 shows the effect of filler loading on tensile strength of EVA/NR/PF and EVA/NR/PFIAMA composites. From Figure 1, it can be clearly seen that as the filler loading increases, the tensile strength decreases for both EVA/NR/PF and EVA/NR/PFIAMA composites. This is due to poor interaction and incompatibility of the matrices. Besides, the dispersion of filler was poor. EVA/NR/PFIAMA composites showed higher tensile strength than EVA/NR/PF composites. A good interfacial adhesion and homogeneous dispersion have been observed in the feldspar filled EVA/NR/PF composites, which caused the increase in 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. El-Sabbagh [6] studied the compatibility study 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 are improved.

Figure 2 shows the effects of filler loading on elongation at break of EVA/NR/PF and EVA/NR/PFIAMA composites. From the figure, the elongation at break decreased with the increase of filler loading. With the addition of PF, the stiffness of the composites increased. EVA/NR/PF/IAMA composites show lower elongation at break at the same filler loading. The ductility of the composites decreased with the addition of IAMA.

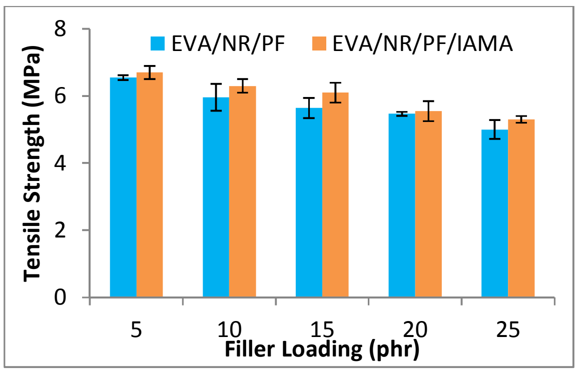

Figure 1: Tensile strength vs filler loading of EVA/NR/PF and EVA/NR/PF_{IAMA} composites

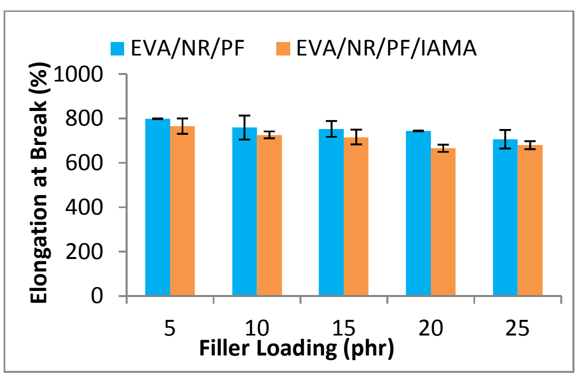

Figure 2: Elongation at break vs filler loading of EVA/NR/PF and EVA/NR/PF_{IAMA} composites

Journal of Advanced Research in Materials Science
ISSN (online): 2289-7992 | Vol. 3, No.1. Pages 15-20, 2014

3.2 Thermogravimetric Analysis

Figure 3 shows the TG thermograms of EVA/NR/PF composites with different PF loadings whereas Figure 4 shows the TG thermograms of EVA/NR/PFIAMA composites with different PF loadings. Table 3 presents the degradation temperature at 50% weight loss (T-50% wt), residual mass and final decomposition temperature (FDT) of EVA/NR/PF composites with and without IAMA. T-50% wt and residual mass for the composites increased with the increase of PF loadings. Better dispersion of the filler throughout the matrix slows down thermal decomposition process. The addition of IAMA in the blends makes the composites become more thermostable. This can be seen in the residual mass and FDT for the EVA/NR/PFIAMA composites that are higher than EVA/NR/PF composites. Besides, the presence of the IAMA had improved the interaction of the EVA and NR phases. Better interaction helps to prevent the permeation of volatilization gasses, which then reduces the thermal degradation of the composites.

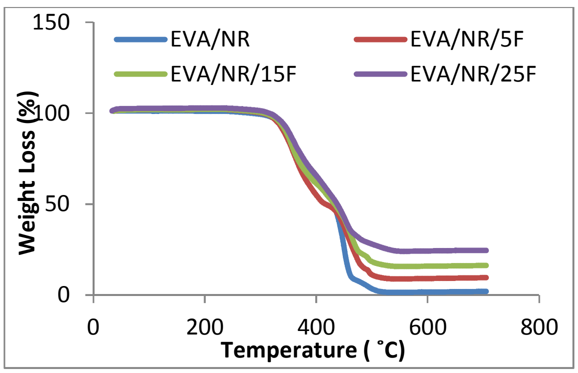

Figure 3: TG thermograms of /EVA/NR/PF composites with different PF loadings

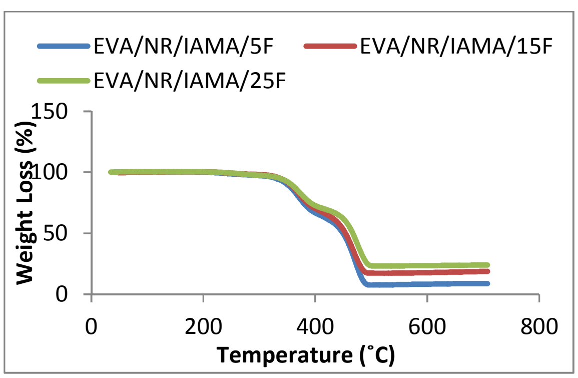

Figure 4: TG thermograms of EVA/NR/PF_{IAMA} composites with different PF loadings

Table 3: Degradation temperature, residual mass and final decomposition temperature (FDT) of EVA/NR/F composites with and without IAMA

Composites Code	$T_{-50\%\ wt}$ (ºC)	FDT	Residual Mass (%)
EVA/NR	430.87	704.03	2.04
EVA/NR/5F	416.89	704.11	9.58
EVA/NR/15F	432.75	704.65	16.30
EVA/NR/25F	437.62	704.72	24.50
EVA/NR/IAMA/5F	449.57	699.80	9.70
EVA/NR/IAMA/15F	453.83	707.62	18.80
EVA/NR/IAMA/25F	466.92	707.82	24.62

4.0 CONCLUSION

As the filler loading increased, tensile strength and elongation at break decreased. EVA/NR/PF with IAMA composites showed slightly higher tensile strength and elongation at break compared to EVA/NR/PF without IAMA composites. In addition, EVA/NR/PFIAMA composites showed better thermal stability than EVA/NR/PF composites.

REFERENCES

[1] W. Pechurai, C. Nakason, K. Sahakaro, Thermoplastic natural rubber based on oil extended NR and HDPE blends: Blend compatibilizer, phase inversion composition and mechanical properties, Polymer Testing 27 (5) (2008) 621-631.

[2] Y.T. Sung, C.K. Kum, H.S. Lee, J.S. Kim, H.G. Yoon, W.N. Kim, Effects of crystallinity and crosslinking on the thermal and rheological properties of ethylene vinyl acetate copolymer, Polymer 46 (25) (2005) 11844-11848.

[3] S. Park, S. Choe, The compatibilizing effect of maleic anhydride in ethylene-vinyl acetate (EVA)/ethylene-α-olefin copolymers blends, Macromolecular Research 13 (4) (2005) 297-305.

[4] T.A. Osswald, Polymer Processing Fundamentals, Hanser, Munich, 1998.

[5] R.N. Rothon, Particulate Fillers for Polymers, Rapra Technology, United Kingdom, 2002.

[6] S.H. El-Sabbagh, Compatibility study of natural rubber and ethylene-propylene diene rubber blends, Polymer Testing 22 (1) (2003) 93-100.