THE EFFECT OF EPOXIDIZED NATURAL RUBBER (ENR) ON THE MORPHOLOGY AND CURING CHARACTERISTICS OF NATURAL RUBBER / ORGANOCLAY NANOCOMPOSITE SYSTEMS

M.Mokhtari[1], M. Kokabi[*1], A. Bahramian[1]
mehrir@modares.ac.ir[*]
1. Polymer Engineering Group, Chemical Engineering Department, Faculty of Engineering, Tarbiat Modares University, P.O. Box: 14115-143, Tehran, Islamic Republic of Iran.

Introduction

Polymer / layered silicate nanocomposites exhibit enhanced modulus and strength, heat resistance, gas barrier properties and decreased flammability relative to the polymer matrices [1]. Although clay nanocomposites have been prepared based on many thermoplastic and thermosetting polymers, rubber nanocomposites constitute only a minor proportion [2].
Compatibility of natural rubber (NR) with organoclay is poor due to the polarity of organoclay and lack of polar groups in NR backbone. ENR, obtained by epoxidation of 1, 4-polyisoprene, has polar groups in its backbone, so can increase the polarity of the system and overcomes the disadvantages. It causes better dispersion of organoclay in NR matrix, also provides superior curing characteristics in nanocomposite systems. In this work 25 phr of two types of epoxidized natural rubber were used as compatibilizer in the system and the effect of ENR on morphology and curing characteristics of NR/ENR/organoclay ternary nanocomposite systems was investigated.

Experimental

The elastomers used were NR (SMRL), ENR25 and ENR50 (The ENR contained 25 and 50 mol % epoxidized denoted as ENR25 and ENR50, respectively) with money viscosities of ML (1+4)100 ^{o}C = 60, ML(1+4)100 ^{o}C =71 and ML(1+4)100 ^{o}C = 80, respectively. All purchased from Kumpulan Guthrie Sdn.Bhd., Seremban, Malaysia.
Organoclay cloisite 15A (C15A) with 3.15 nm intergallery spacing, ion exchanged by dimethyl dehydrogenated tallow ammoniums bromide, was provided by Southern clay products. The other compounding ingredients listed in Table 1, are obtained from local manufactures.

Table1: Formulation of various nanocomposite systems.

Ingredients(phr)	Nanocomposite Systems		
	NR/C15A	NR/ENR25/C15A	NR/ENR50/C15A
Natural Rubber	100	75	75
ENR25	0	25	0
ENR50	0	0	25
Organoclay	3	3	3
Carbon black	40	40	40
Zinc oxide	5	5	5
Stearic acid	2	2	2
Vulcacit D	0.5	0.5	0.5
Vulcacit M	0.5	0.5	0.5
Sulfur	2	2	2

The natural rubber /ENR/organoclay were made by melt mixing in an internal mixer at 130^{o}C and 60 rpm rotor speed for 15 minutes. Other ingredients were then added on a laboratory model two roll mixer. The mixtures were cured at 140 ^{o}C under an electrically heated hydraulic press for the required curing time (t_{90}).

Results and Discussion

Morphology

Table 2 shows the results of x-ray analysis preformed on nanocomposite systems.

Table 2 Morphology of various nanocomposite systems

Sample	) ^{0} Peak Angle (	spacing(nm)	Morphology
C15A	2.75	3.15	---
NR/C15A	2.015	4.38	Intercalated
NR/ENR25/C15A	2.00	4.7	Intercalated
NR/ENR50/C15A	-----	-----	Exfoliated

The diffraction peak of C15A in the NR/C15A shifted to a lower angle, corresponding to an interlayer distance of 4.38 nm, providing thus the existence of layered/polymer intercalates. With addition of ENR25 the diffraction peak slightly shifted to lower angle which shows no more pronounced intercalation. By addition of ENR50, the diffraction peak disappeared. This suggests that enough polymer chains have been introduced into the galleries so that increase interlayers distance more than 8nm and the layered silicates show an exfoliated morphology.
The polarity of ENR favours the intercalation of this elastomer into the galleries and the dispersion of layered silicates in the matrix.

Curing Characteristics

The Scorch Time (t_{S2}), Maximum Torque (MH) and Minimum Torque (ML) of the nanocomposite systems at 140 ^oC are compiled in Table3.

Table 3 Curing characteristics of various nanocomposite systems.

Sample	T_{S2} (min)	MH(Ib.in)	ML(Ib.in)
NR\C15A	1.43	52.06	2.16
NR/ENR25/C15A	1.15	62.92	2.73
NR/ENR50/C15A	1.05	67.13	4.09

The scorch time of NR/organoclay changes effectively by addition of ENR. It is attributed to the activity effects of epoxy and amine groups on the ring opening pathway of sulphur.
In the presence of ENR as a compatibilizer, the maximum and minimum torques of NR/ENR/organoclay nanocomposite systems increases effectively. This is due to the better interfacial adhesion between NR and organoclay which could be confirmed by XRD data.

Conclusions

According to this study, exfoliated nanocomposites based on NR/ENR50 blend have been successfully developed. Due to ENR polar character, the higher interaction with organoclay improves the dispersion of the filler in the matrix and curing characteristics of the compounds.

References

[1] Y.P. Wu, Y. Ma, Y.Q. Wang, L.Q. Zhang, *J. Macromolecular Materials and Engineering.* 2004, 289, 890-894.

[2] M. Arroyo, M.A. Lopez-Manchado, J.L. Valentin, J. Carretero, *J.Composites Science and Technology*, 2007, 67,1330-1338.