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Compatibility Study and Mechanical Properties of Nitrile rubber/Ethylene-Propylene-Diene Rubber Blends

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Abstract

The ethylene-propylene-diene rubber (EPDM) and acrylonitrile butadiene rubber (NBR) are not miscible with each other. In this research, the effect of some materials to create compatibility was investigated and compared. The effect of ultrasil silica (VN3), methyl methacrylate butadiene styrene (MBS), montmorillonite (MMT), and maleic anhydride (MA) on rheometric behavior and mechanical properties such as handness, elongation at break, tensile strength and tear strength of rubber blends of 50/50 NBR/EPDM were evaluated. Rubber compounds with sulfur curing system were mixed by two-roll mill blend and vulcanized at 155°C for about 8 minutes using compression molding operation at 10 MPa. Results showed that the NBR/EPDM blends with MA had the tensile strength 1.3 MPa and elongation at break 316% as the poorest performance. The VN3 silica-based compounds achieved the highest tensile strength and tear resistance about 12.5 MPa and 43.3 kN/m, respectively. For application of NBR/EPDM blend in some rubber industires, the silica could be as potensial compatibilizer to obtain good echanical properties.

Keywords: Rubber blending, NBR, EPDM, Compatibilizer, Mechanical properties.

Introduction

Ethylene propylene diene rubber (EPDM) is non-polar, has high resistance to ozone, moisture, cold and high temperature, but is weak in solvents and hydrocarbon oils. Acrylonitrile butadiene (NBR) with polar properties and high resistance to oils, fuels and good thermal stability, but unfortunately it has poor resistance to ozone and UV radiation[1]. The NBR/EPDM blend might be as a choice with good physical and mechanical properties, resistant to ozone, UV and hydrocarbon solvents, with economic benefits. But these elastomers are incompatible with each other due to the difference in polarity and solubility parameter, so using an effective compatibilizer that connects these two elastomers can be useful. El-Sabbagh et al. [2] were investigated the rheometry and mechanical properties of maleic anhydride (MA) for 50/50 NBR/EPDM blends. They found in 2.5 phr MA, the tensile increased from 4.5 to 7.5 MPa compared to the compounds without compatibilizer. The compatibility effect for montmorillonite (MMT), methyl methacrylate butadiene styrene (MBS) and silica were studied by Mayasari and Wirapraja [3] for NBR/EPDM blends to evalute tensile, tear, hardness, the compression set and aging. Results showed that MMT has shown the best properties. Also, swelling and thermogravimetry in the 50/50 blend of NBR/EPDM with bromobutyl rubber (BIIR), zeolite and compatibilizers have been investigated by Mayasari and Setyadewi [4]. According to their presented data, the MBS was a suitable compatibilizer for swelling and thermal resistance. Jiang et al. [5] used HNBR/EPDM blends for solubility and transprt studies, howewer, there was not reported any compatibilizer in those rubber formulations. As they mentioned the phase separation occurred which could be attributed to the incompatibility between HNBR and EPDM.

According to few studies in NBR/EPDM blending, more studies need in this issue to meet mechanical properties, especially for industrial applications, In this

research, available and widely used materials in rubber industry were applied to evaluate the compability and mechanical behaviour of NBR/EPDM blends at 50/50 conten on the following stuides of our previous resarch in RPL Lab.

Experimental

NBR (35L Komho.), EPDM (KEP 270 Komho.), Carbon black N550, MBS (Ghaed Basir co.), MMT (Sigma-Aldrich), MA from china supplier, other ingredients purchased from rubber production companies. The rubber formulations were presented in table 1. The mixing procedure, vulcanization and rubber testing were done accodring to prevoius instructions [6], just that the compatibilizer materials were added after N550 filler.

Table 1. Presented rubber formualations for NBR/EPDM blends

	ENB4	ENB5	ENB12	ENB6	ENB8	ENB13	ENB15	ENB18
NBR		100	50	50	50	50	50	50
EPDM	100		50	50	50	50	50	50
MBS				5				
MMT					5			
MA								5
Silica						5	5	
Si69							0.4	

Amounts of other components in all rubber compounds: N550, 60, ZnO, 5, stearic acid, 1, S, 0.8, CBS, 1 and TMTD, 0.1 phr.

Results and discussion

The effect of compatibilizers was investigated at 5 phr, for all NBR/EPDM 50/50 belnds. By addition of MA in rubber blend, the mechanical properties had a sharp drop, curing was also done with difficulty and blooming was observed after curing. In Table 2, the MDR rheometric results, the difference of MH-ML torque indicated the ratio of the crosslink density. For samples with VN3 silica and VN3/Si69 (as coupling agent) shwoed the highest compared to other blending samples.

Table 2. Rheometery and mechanical properties of NBR/EPDM blends

	Delta M MH-ML(dN.m)	CIR95 (% /min)	Tensile (MPa)	Elongation at break (%)	Hardness (Shore A)
ENB4	26.6	16.9	19.5	494	68
ENB5	9.8	30	19.9	498	66
ENB12	15.7	27.9	10.1	221	72
ENB6	13.3	26.7	8.8	163	76
ENB8	12.3	29	7.9	199	71
ENB13	17	25.4	10.5	219	73
ENB15	19.12	28.6	12.5	206	72

Also, the maximum torque were the highest values for ENB13 and ENB15, which indicated an easier curing process, homogeneous structure and uniformity of the compound compared to sample without any compatibilizer (ENB12). Therefore, the crosslink density has increased and according to CIR95 the curing speed has increased for samples containing VN3 silica. The results of tensile strength in Figure 1 and tear strength in Figure 2 were confirmed the rheometry data.

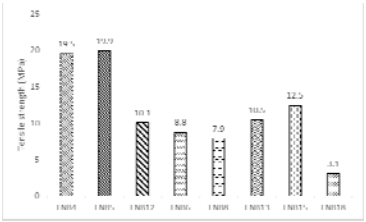

Figure 1. Tensile strength of NBR/EPDM blends without and with compatibilizer

This means that the use of a suitable compatibilizer could increase the uniformity of the blends structure and increase the mechanical properties. Therefore the tensile strength and tear resistance was the highest value for silica VN3/si69 of ENB15 sample. The samples with MA and MBS were shown poor mechanical and rheomtry behaviour.

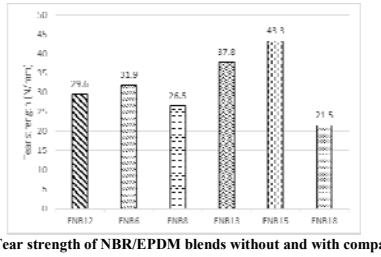

Figure 2. Tear strength of NBR/EPDM blends without and with compatibilizer

Conclusions

In this study, the effect of some potensial materials for compatibility of NBR/EPDM blending were investigated. Obtained results showed that for ENB15 (compound with VN3 silica/Si69) the tensile strength and tear resistance were increased about 20 and 32%, respectively. This sample was the best compatibilizing effect among all NBR/EPDM blends. Since, the silica, due to its 4 free poles and surface reactivity, might interacted between NBR and EPDM to be attracted to the its surfaces and achieve better compounding dispersion. furthermore, by using VN3 silica in rubber formulation, the interaction between silica and sulfur was increased to attain more crosslink density.

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