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Effects of a Compatibilizer on the Properties of EPDM/BR Blends

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ABSTRACT: Compatibility and properties of EPDM/BR blends with or without AAHR(a mixture of aliphatic and aromatic hydrocarbon resins) as a compatibilizer were investigated. The melt viscosity, elastic modulus, and tan δ were increased with increasing EPDM contents. The dynamic mechanical analysis and the morphological studies revealed that EPDM and BR were incompatible and the addition of AAHR was very effective to enhance the compatibility between EPDM and BR. The weight percent of bound rubbers was increased with increasing BR contents. It was found that the addition of a AAHR increased the amounts of bound rubbers and hence the vulcanizate properties such as tear strength and fatigue resistance of the EPDM/BR blends were improved. The blends of maleic anhydride-grafted EPDM and BR were also prepared and the properties were compared.

Introduction

Polymer blends have been intensively studied because of their theoretical and practical importances.[1-3] Among the blends widely investigated in rubber industries are natural rubber (NR)/styrene-butadiene rubber (SBR), NR/butadiene rubber (BR), NR/BR/SBR, and etc.[4-10] Recently, the use of ethylene-propylene-diene rubber (EPDM) has been attracted much interest to improve poor performances of other rubbers by blending, since EPDM has excellent outdoor properties such as good resistance to oxygen and ozone.[11-13] Dunn and Wall[14] blended EPDM and BR with NR to develop suitable materials for damping engine mounts having balanced properties of low oxidation degradation and high resilience. However, the poor compatibility of EPDM with other high diene rubbers such as synthetic isoprene rubber (IR) and BR limits the more versatile uses for blends. Thus, several attempts have been made to improve the poor compatibility of EPDM with one of such high diene rubbers by introducing functional groups into the EPDM backbone. For instance, Coran[15] modified EPDM by grafting maleic anhydride (MAH) onto EPDM to obtain blends with high diene rubbers having improved tear strength and impact strength.

Compatibilizers have been also commonly used to enhance the compatibility of incompatible polymer blends.[16-18] It has been known that block or graft copolymers can be used as compatibilizers.

The objective of this work is to investigate the effect of a compatibilizer on the compatibility and the properties of the EPDM/BR blends. For a compatibilizer was used AAHR, a B.A.S.F. product of a mixture of aliphatic and aromatic hydrocarbon resins. For comparison, the compatibility and the vulcanizate properties of the blends of BR with a graft copolymer of maleic anhydride(MAH) onto EPDM (EPDM-g-MAH) were also investigated,[19-20] where the graft copolymer has been prepared for this work.

Table I. Materials in This Work

Material	Description	Source
EPDM	ethylene-propylene diene rubber (E/P: 57/43 by mol.%, ENB 2.3%)	Kumho E.P.
BR	cis 1,4-polybutadiene rubber (cis: 98%)	Kumho Petrochem.
Carbon black	N351	Lucky
ZnO	zinc oxide	Hanil
Process oil	aromatic oil(A # 2)	Michang
Stearic acid	Acid No. 200	Lucky
S	Sulfur	Miyong
NS	N-tert butyl-2-benzothiazole sulfenamide	AKZO
AAHR	miture of aliphatic and aromatic hydrocarbon resins	B.A.S.F.
MBTS	dibenzothiazyl disulfide	Dongyang
MAH	maleic anhydride	Showa Ether

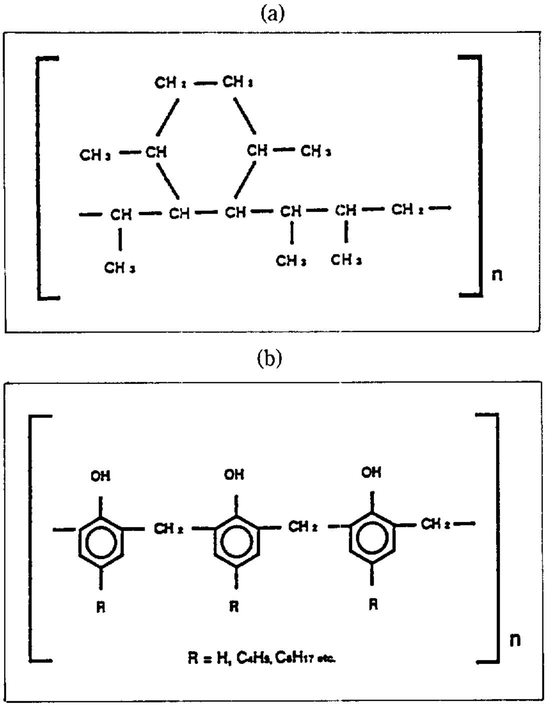
Table II. Recipes of Rubber Compounds

Exp. No.	Rubber ratio	Ingredient (phr)[a]
a	EPDM/BR(100/0)	–
b	EPDM/BR(75/25)	–
c	EPDM/BR(50/50)	–
d	EPDM/BR(25/75)	–
e	EPDM/BR(0/100)	–
f	EPDM/BR(75/25)	AAHR (10 phr)[b]
g	EPDM/BR(50/50)	AAHR (10 phr)
h	EPDM/BR(25/75)	AAHR (10 phr)
i	EPDM-g-MAH/BR(100/0)	–
j	EPDM-g-MAH/BR(75/25)	–
k	EPDM-g-MAH/BR(50/50)	–
l	EPDM-g-MAH/BR(25/75)	–

[a] A masterbatch containing, 40 phr N351 carbon black, 2 phr sulfur, 5 phr zinc oxide, 1 phr NS, and 10 phr process oil were used in all experiments pertaining to blend polymers.

[b] The amount of AAHR was fixed at 10 phr based on the total amount of EPDM and BR mixtures.

Scheme I. Chemical structure of AAHR, a mixture of aliphatic resin (a) and aromatic phenolic resin (b).



Experimental

Materials. The materials used in this work is listed in Table I. The EPDM having ethylidene norbornene (ENB) as a termonomer and BR are all commercially available grades. The compatibilizer AAHR, a B.A.S.F. product, is a mixture of aliphatic and aromatic resins of the chemical structures in Scheme I. The EPDM-g-MAH was prepared by reacting EPDM with given amounts of MAH in the presence of dibenzothiazyl disulfide (MBTS) in a Banbury mixer under the processing condition of 40 rpm at 230 ℃ for 3 minutes. To prepare the blends of EPDM-g-MAH with BR, 2.0 phr of MAH and 0.2 phr of MBTS were used.

Preparation of Blends. In order to investigate the effect of the addition of the AAHR on the rheological properties of EPDM/BR blends, the unfilled EPDM/BR binary and EPDM/BR/AAHR ternary blends were prepared in a Haake-Buchler System 40 Brabender by mixing rubbers for 30 minutes at 100 ℃. The polymer ratios were 75/25, 50/50, and 25/75 EPDM/BR by weight. The amounts of AAHR for the ternary blends was fixed at 10 phr based on the total amount of EPDM and BR mixture. Mixing of the carbon-black filled compounds was done in a Banbury mixer using conventional mixing procedures by two stages; In the first stage (without curatives), masterbatch blends of EPDM (or EPDM-g-MAH) and BR were prepared by mixing the rubbers with 40 phr of carbon black for 6 minutes at 155 ℃, 40 rpm rotor speed. Two EPDM/BR masterbatch blends, one from the unmodified EPDM and one from the maleic anhydride modified EPDM were prepared. In the second stage, stocks for vulcanization and evaluation were prepared from each of the EPDM/BR and the

EPDM-g-MAH/BR masterbatch blends by the addition of other ingredients such as sulfur and zinc oxide on 6″×12″ two-roll mill at 100 ℃ for 5 minutes. Curing was done in a thermo-fluid press. The test recipes are given in Table II. A masterbatch containing, 40 phr N351 carbon black, 2 phr sulfur, 5 phr zinc oxide, 1 phr NS, and 10 phr process oil was used in all experiments pertaining to blend polymers. For the study of the effects of a compatibilizer, AAHR, on the vulcanizate properties of EPDM/BR blends, ternary blends of EPDM, BR and AAHR were prepared with the same batch weights as the EPDM/BR masterbatch blends given in Table II, except that 10 phr of AAHR was added.

Measurements and Physical Testing. Molecular weight was determined by a gel permeation chromatography (GPC; Waters 150C) at 140 ℃ using 1,2,4-trichlorobenzene (TCB) as an effluent. IR spectra were taken on the Attenuated Total Reflectance FTIR spectroscopy(Bruker IFS 85). 32 scans were signal averaged. Rheological properties were measured at 100 ℃ by a capillary rheometer (Monsanto Processability tester). The dimension of a capillary was 1.5 mm in diameter with the L/D ratio of 20. The glass transition temperature was measured using a differential scanning calorimeter (DSC; Perkin-Elmer DSC7) at a heating rate of 20 ℃/min in nitrogen. Dynamic mechanical properties were measured using a dynamic mechanical analyzer (GABO Eplexor-150N) at the frequency of 11 Hz with the amplitude strain of 0.25%. The stress relaxation properties were measured by a dynamic stress relaxometer (DSR; BF.Goodrich).[21] Morphology observations were done using transmission electron microscopy (JEM-2000FX TEM). Samples were microtomed and stained with osmium tetraoxide. Cure characteristics, which include scorch time, cure rate, and torque values were measured over a 12 minutes period at 180 ℃ using a Monsanto oscillating-disc rheometer (Monsanto Rheometer R-100) according to ASTM Method D1084.

Tear strength was determined according to ASTM D624 using a die C specimen. The fatigue resistance was measured at room temperature using a Fatigue-to-fail tester (Monsanto). Dumbell-shaped samples of 5×76 mm size were subjected to the cyclic tension with 124% of elongation at the rate of 95 cycle/min. The number of cycles to show failure in samples was taken as the fatigue resistance data.

For the determination of bound rubber contents, 0.2 g of samples with the thickness of below 0.5 mm were dissolved in 100 mL of toluene at room temperture for 10 days. After filteration, the bound rubber contents were determined from the change in weight of samples before and after dissolving in toluene with the following relationship.

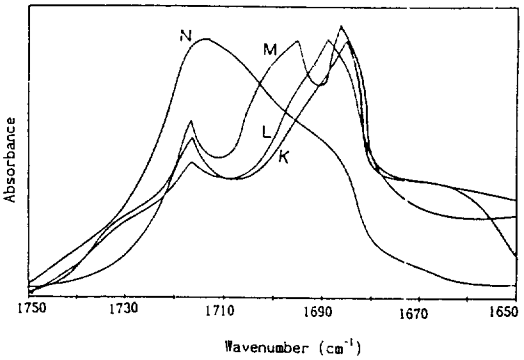


Figure 1. FT-IR spectra of EPDM and maleic anhydride-grafted EPDM. (Sample notations are described in Table III; K: EPDM-1, L: EPDM-2, M: EPDM-3, and N: EPDM-4.

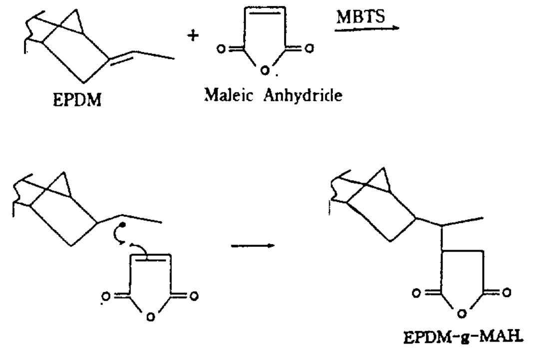
Bound rubber content(%)=weight residue(g) after dissolving in toluene/initial sample weight(g)×[total filler content(phr)-carbon black content(phr)-inorganic filler content(phr)].

Gel contents(%) of EPDM-g-MAH's were determined from the ratio of weight residue, after 0.1 g of samples (caged in a cube of 100 mesh steel-wire screen) had been placed in 100 mL of benzene for 40 hrs and dried under reduced pressure, to the initial sample weight. For the determination of the carbon black dispersion, samples of 5×3×3 mm size were attached to microtome by a rubber cement and freezed in liquid nitrogen. The carbon black dispersion was determined visually using optical microscope(Optiphot Biological Microscope, Nikon) with a graticule in the eyepiece (ASTM D 2663, Method B). The % carbon black dispersed down to a given agglomerate size was derived from the number of total squares covered by black and the black volume loading.[22]

Results and Discussion

Identification of Grafting of MAH onto EPDM. Table III shows the characterization data of the MAH grafted EPDM(EPDM-g-MAH). In order to characterize the graft copolymer, three different copolymers have been prepared from three different MAH contents, ranging from 1.0 to 2.0

Scheme II. The reaction mechanism of EPDM-g-MAH.



phr, with three different MBTS contents, ranging from 0.1 to 0.2 phr. The grafting of MAH onto EPDM was identified on their FTIR spectra. Figure 1 shows the change in their FTIR spectra around 1600~1800 cm^{-1} region. It is seen that a characteristic peak due to C=C bond was observed around 1600 cm^{-1} for unmodified EPDM but the peak shifted to shorter wavelength as more MAH was grafted onto EPDM. For EPDM-4, for instance, a strong peak due to C=O bond was observed at 1714 cm^{-1} whereas the peak due to C=C bond at 1600 cm^{-1} was almost disappeared. The result exhibits the fact that a C=C bond in EPDM was almost disappeared and instead a new carbonyl group was formed by introducing MAH into EPDM backbone. The reaction mechanism is given in Scheme II. The grafting of MAH onto EPDM can be also proved by the increases in the gel contents and in the molecular weights of the graft copolymers with the increase in MAH contents, as shown in Table III. The grafting of MAH, however, did not affect on the glass transition temperature of EPDM. EPDM-4 will be used later to prepare the blends with BR, unless otherwise specified.

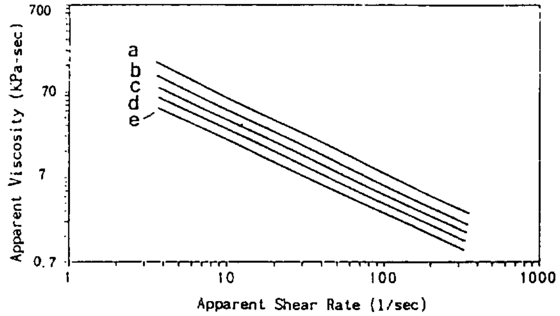


Figure 2. Melt viscosities vs. apparent shear rate of the EPDM/BR blends; a: EPDM/BR (100/0), b: EPDM/BR (75/25), c: EPDM/BR (50/50), d: EPDM/BR (25/75), and e: EPDM/BR (0/100).

Rheological Properties and Cure Characteristics. Figure 2 shows the melt viscosity of the EPDM/BR blends with various polymer ratios as a function of apparent shear rate. One can see that the rheological behavior shows a typical power-law behavior. The melt viscosity increased with increasing EPDM contents. Figure 3 shows the comparison of the rheological behaviors of the AAHR added EPDM/BR ternary blend as well as the EPDM-g-MAH/BR blend with that of the EPDM/BR blend having the same polymer ratios of 75/25 EPDM/BR by weight. It is seen that the addition of AAHR decreased the melt viscosity of the EPDM/BR blends, meaning that the AAHR functioned as a lubricant for the blends. Even though little is known about the actual basic mechanism of the compatibilizing effect of AAHR, the lubricant fuction of the

Table III. Characterization Data of Maleic Aanhydride-grafted EPDM

Sample No.	Description	Molecular weight Mn	Molecular weight Mw	Gel content (wt%)	T_g (℃)[a]
EPDM-1	unmodified EPDM	116,000	313,700	0.00	−46
EPDM-2	grafted EPDM with 1.0 phr MAH and 0.1 phr MBTS	119,800	291,700	1.68	−47
EPDM-3	grafted EPDM with 1.5 phr MAH and 0.15 phr MBTS	126,400	321,800	22.75	−47
EPDM-4	grafted EPDM with 2.0 phr MAH and 0.2 phr MBTS	127,700	363,100	39.63	−46

[a] measured by DSC.

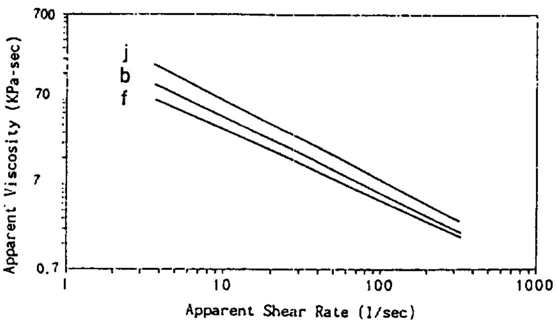


Figure 3. Melt viscosities vs. apparent shear rate of the EPDM/BR blends; b: EPDM/BR, f: EPDM/BR/AAHR, and j: EPDM-g-MAH/BR (The polymer ratios of EPDM to BR are 75/25 by weight).

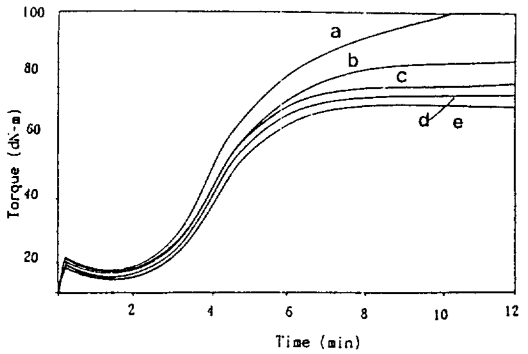


Figure 4. Rheograph of the EPDM/BR blends with different polymer ratios; a: EPDM/BR (100/0), b: EPDM/BR (75/25), c: EPDM/BR (50/50), d: EPDM/BR (25/75), and e: EPDM/BR (0/100).

AAHR can be explained as follows; The AAHR is a blend of aliphatic and aromatic resins of differing polarities: aliphatic resins are non-polar whereas aromatic resins are very polar. In polymer blending, this mixture of polarities gives a true solvating effect in wetting out two component polymers, here EPDM and BR. At the same time their polymeric nature ensures that they have a high viscosity at mixing temperatures which maintains high shear during mixing. This latter effect can be useful in improving the break-down, incorporation and dispersion of carbon blacks, fillers, and crumb in compounds. This effect optimizes dispersion and processability through more efficient mixing. A consistent and faster mixing time can be achieved. Their general effect is, therefore, to give a more efficient mixing action which leads to improved processability.

The EPDM-g-MAH/BR blend, however, exhibited higher viscosity than both the AAHR added EPDM/BR ternary blend as well as the EPDM/BR binary blend. The result may be ascribed to the higher gel contents and molecular weight of the graft copolymer. The rheographs of the EPDM/BR masterbatch blends with different polymer ratios are shown in Figure 4. It is seen that the EPDM-rich blends exhibit higher torques and lower cure rates than the BR-rich blends, as can be expected from the viscosity behavior in Figure 2. Figure 5 illustrates the effect of the addition of AAHR on the curing characteristics of the EPDM/BR masterbatch blend of 75/25 composition by weight. The cure rate was not changed significantly but the scorch time became longer when AAHR was added. The result may be related to the reduced melt viscosity and hence the improved processability when AAHR was added. It should be noted, however, that in case of the EPDM-g-MAH/BR blends the scorch time became shorter and the cure rate became faster when compared to both the EPDM/BR blend and the EPDM/BR/AAHR ternary blends. The result implies that there might exist co-cure characteristics in the EPDM-g-MAH/BR blends plausibly because of the presence of the functional group, MAH, in the graft copolymer to induce the *in-situ*

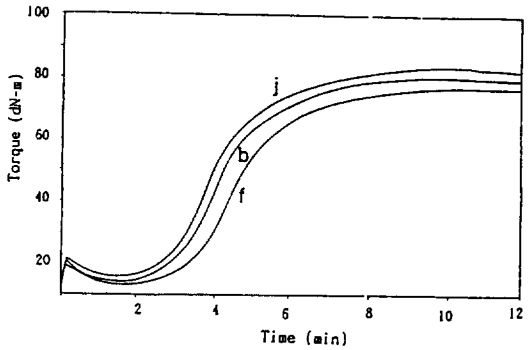
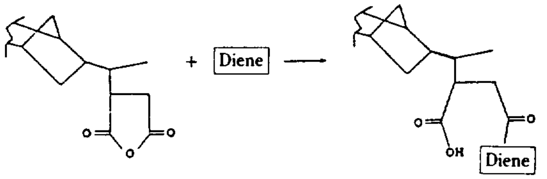


Figure 5. Rheographs of various EPDM/BR blends; b: EPDM/BR, f: EPDM/BR/AAHR, and j: EPDM-g-MAH/BR (The polymer ratios of EPDM to BR are 75/25 by weight).



Scheme III. Possible *in-situ* formation of interchain copolymers of EPDM-g-MAH and diene rubber(BR).

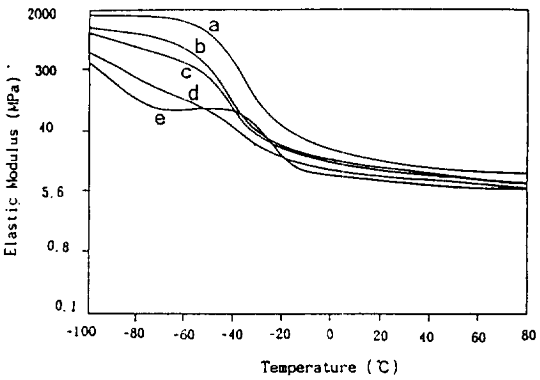


Figure 6. Elastic modulus of EPDM/BR blends with different polymer ratios as a function of temperature; a: EPDM/BR (100/0), b: EPDM/BR (75/25), c: EPDM/BR (50/50), d: EPDM/BR (25/75), and e: EPDM/BR (0/100).

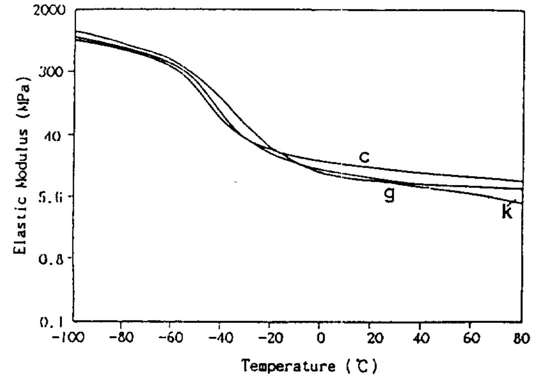


Figure 7. Elastic modulus of EPDM/BR blends as a function of temperature; c: EPDM/BR, g: EPDM/BR/AAHR, and k: EPDM-g-MAH/BR (The polymer ratios of EPDM to BR are 50/50 by weight).

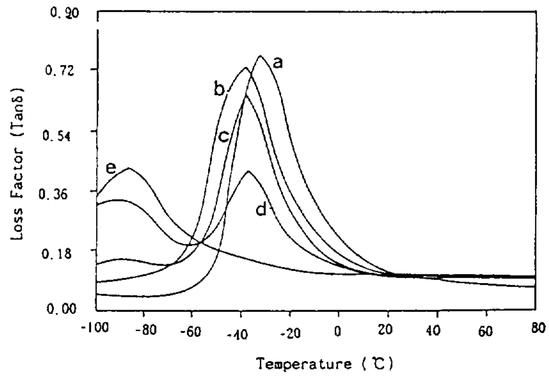


Figure 8. Tan δ of EPDM/BR blends with different polymer ratios as a function of temperature; a: EPDM/BR (100/0), b: EPDM/BR (75/25), c: EPDM/BR (50/50), d: EPDM/BR (25/75), and e: EPDM/BR (0/100).

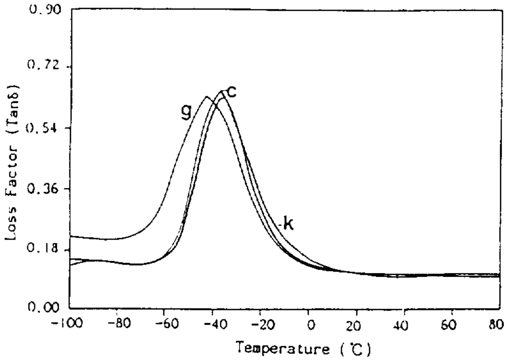


Figure 9. Tan δ of EPDM/BR blends as a function of temperature; c: EPDM/BR, g: EPDM/BR/AAHR, and k: EPDM-g-MAH/BR (The polymer ratios of EPDM to BR are 50/50 by weight).

formation of compatibilizing interchain copolymers of EPDM and BR. The *in-situ* formation of interchain copolymers of EPDM and BR could be expected as shown in scheme III, although more concrete data are needed to draw conclusions.

Dynamic Properties. The elastic moduli of EPDM/BR masterbatch blends with different polymer ratios are illustrated in Figure 6 as a function of temperature. The modulus increased with EPDM contents. Figure 7 compares the moduli of the EPDM-g-MAH/BR blend and the AAHR added EPDM/BR blend as well as the EPDM/BR blend having the same polymer ratios of 50/50 by weight. A significant difference was not observed in the elastic modulus behavior among them, except the slight decrease in modulus over the lower temperature ranges, say, between −20 ℃ and −60 ℃, for the AAHR added EPDM/BR blend. The slight decrease in modulus for the EPDM/BR/AAHR blend may be related to the improved compatibility of EPDM and BR in the presence of AAHR, taking it into consideration that the ternary blend having the polymer ratio of 50/50 EPDM/BR exhibits similar modulus behavior as that of the BR-rich blends (compare Figures 6 and 7).

Figure 8 shows the tan δ vs. temperature curves of EPDM/BR blends with different polymer ratios. The location of the peak in the tan δ temperature curve corresponds to the glass transition temperature(T_g) of the polymer. As expected, EPDM and

Table IV. Stress Relaxation Data of Various EPDM /BR Blends

Polymer ratio	TM (joule)	Sig-2 (joule sec)	λ (sec)[a]
EPDM/BR(100/0)	25.88	13.90	950
EPDM/BR(75/25)	23.28	13.33	899
EPDM/BR(50/50)	19.66	12.43	891
EPDM/BR(25/75)	19.32	11.64	799
EPDM/BR(0/100)	17.97	10.06	681
EPDM/BR(75/25)/AAHR[b]	22.04	12.43	662
EPDM/BR(50/50)/AAHR[b]	18.65	10.06	594
EPDM-g-MAH/BR(75/25)	23.96	16.27	1069
EPDM-g-MAH/BR(50/50)	21.81	14.24	933

[a] TM; maximum torque for 0.035 radian of rotor deflection when samples were subjected to the load of 2.21 kN for 0.005 sec, Sig-2: Summation of torques recorded up to 2 sec, λ: stress relaxation time.

[b] The amount of AAHR was fixed at 10 phr based on the total amount of EPDM and BR mixtures.

BR were incompatible and they showed two separate T_g's. The compatibilizing function of AAHR to improve the compatibility of EPDM and BR can be seen from the tan δ behavior in Figure 9. In Figure 9, one can see that when AAHR was added to the EPDM/BR blend of 50/50 composition by weight, the maximum point of tan δ, i.e. T_g, of EPDM shifted downward to that of BR. No clear shift of T_g was observed, however, in the case of the EPDM-g-MAH/BR blend having the same polymer ratio.

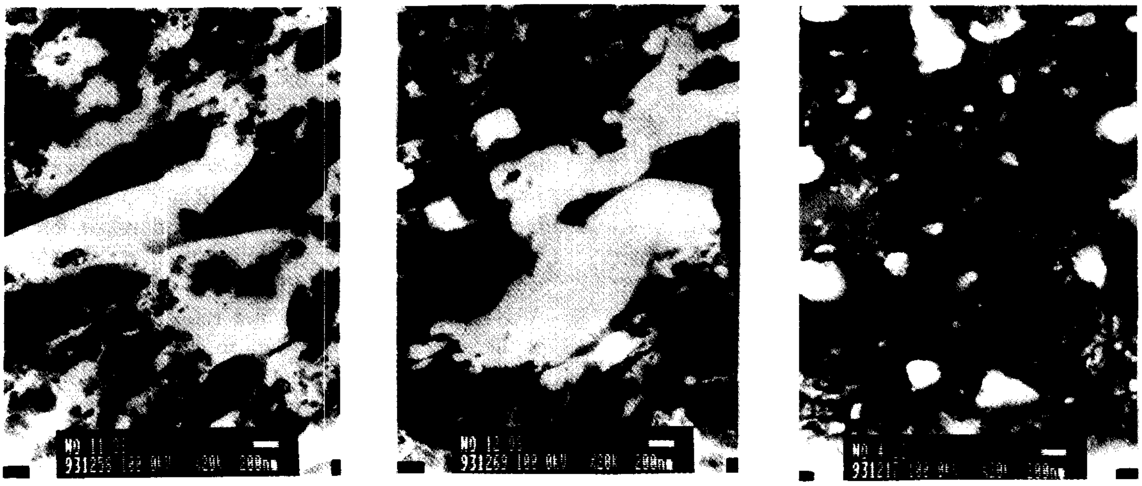
Table IV shows the stress relaxation properties of blends. In this table, the maximum torque (TM, in joule) was taken as the torque when for 0.035 radian of rotor deflection the samples, preheated at 100 ℃ for 1 minute, were subjected to the load of 2.21 kN for 0.005 sec. The sig-2(in joule sec) and the stress relaxation time(λ, in sec) denote that the summation of torques recorded up to 2 sec and the time elapsed from the origin till the torque reduces up to 13.5% of the TM, respectively. In case of the EPDM/BR blends, all of the stress relaxation data increased with increasing EPDM contents due to the increases in the melt viscosity and elasticity. In Table IV, however, the AAHR added EPDM/BR blends showed decreased TM's and relaxation times due to the compatibilizing effect of AAHR when compared to EPDM/BR blends without AAHR, regardless of polymer ratios. The increases of the stress relaxation data in case of the EPDM-g-MAH/BR blends for both polymer ratios of 75/25 and 50/50 may be due in part to the reduced molecular mobilities resulting from the co-cure characteristics for the blends, as already discussed in Figure 5.

Morphology. Figure 10 shows the morphology of the carbon black filled EPDM/BR masterbatch blends having various polymer ratios. In these TEM micrographs, the domain consisting of carbon black agglomerates is BR phase, because the high diene rubber like BR has much larger affinity with carbon black than the saturated elastomer like EPDM. EPDM and BR showed gross phase separation. The morphology in Figure 11, however, shows clearly the enhanced compatibility of EPDM and BR in the presence of AAHR. In the TEM micrographs of EPDM/BR blends of 75/25 composition by weight, BR phase of large domain size is dispersed in EPDM matrix for the EPDM/BR blend but the size of BR domain reduces significantly when AAHR has been added to the EPDM and BR binary blend. The EPDM-g-MAH/BR blend shows finer domain morphology than the EPDM/BR blend but less finer morphology than the EPDM/BR/AAHR ternary blend. Thus, one can conclude that the addition of AAHR to the EPDM/BR blend is more

Table V. Bound Rubber Contents, Tear Strength, and Fatigue-to-failure Data of Various EPDM/BR Blends

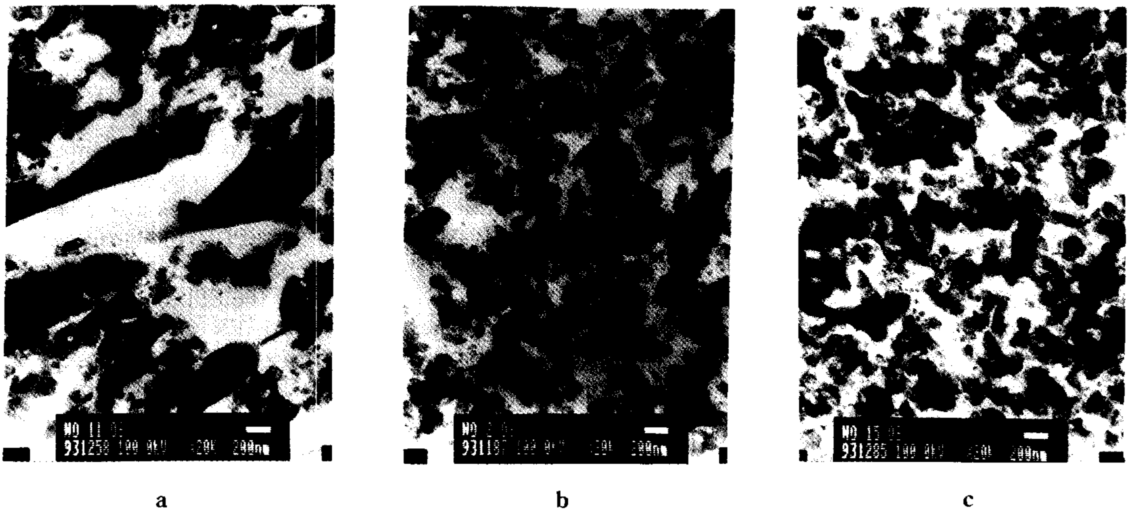
Polymer ratio	Bound rubber contents (%)	Tear strength (Nm)	Fatigue to failure (cycle)
EPDM/BR(100/0)	13.3	2.72	124,500
EPDM/BR(75/25)	14.2	2.65	168,100
EPDM/BR(50/50)	14.5	2.55	340,500
EPDM/BR(25/75)	15.2	2.50	466,600
EPDM/BR(0/100)	15.9	2.46	787,600
EPDM/BR(75/25)/AAHR[a]	15.0	3.14	195,000
EPDM/BR(50/50)/AAHR[a]	16.2	2.94	389,400
EPDM-g-MAH/BR(75/25)	14.8	3.33	200,300
EPDM-g-MAH/BR(50/50)	15.1	3.04	398,500

[a] The amount of AAHR was fixed at 10 phr based on the total amount of EPDM and BR mixtures.



a b c

Figure 10. TEM micrographs of the EPDM/BR blends with different polymer ratios; a: EPDM/BR (75/25), b: EPDM/BR (50/50), and c: EPDM/BR (25/75).



a b c

Figure 11. TEM micrographs of the EPDM/BR blends with different polymer ratios; a: EPDM/BR, b: EPDM/BR/AAHR, and c: EPDM-g-MAH/BR (The polymer ratios of EPDM to BR are 75/25 by weight).

effective to enhance the compatibility between EPDM and BR than the modification of EPDM by grafting MAH onto EPDM backbone.

Vulcanizate Properties. Table V shows the bound rubber contents for the EPDM/BR blends. It is seen that the bound rubber contents increases with increasing BR contents, because BR has better carbon black dispersion than EPDM does. The carbon black dispersion is summarized in Table VI. The % carbon black dispersion becomes higher as BR contents increases for the EPDM/BR blends. The high carbon black dispersion of BR is ascribed to its flexible molecular chain structure.[23] Note that the dispersions are higher in the order EPDM/BR/AAHR ternary blend>EPDM-g-MAH/BR blend >EPDM/BR blend, regardless of the polymer ratios.

Table V also shows the bound rubber contents and the tear strength of the AAHR added EPDM /BR blends and the EPDM-g-MAH/BR blends. The tear strength of the blends increased with increasing bound rubber contents, resulting from better carbon black dispersion and hence better reinforcing effect of carbon black. The higher tear strength of EPDM/BR blends in the presence of AAHR should be noted, since the addition of AAHR not only improved the processability but also enhanced the vulcanizate properties of the EPDM/BR blends. Of interesting is the fact that the EPDM-g-MAH/BR blends showed higher tear strength when compared to that of the AAHR added EPDM/BR blends, although they did not have higher bound rubber contents. The result may be ascribed to the combined effects of the high molecular weight and gel contents of the MAH grafted EPDM and the co-cure characteristics of the EPDM-g-MAH/BR blends.

Table VI. Carbon Black Dispersion of Various EPDM/BR Blends

Polymer Ratio	Carbon Black Dispersion (%)
EPDM/BR(100/0)	90.0
EPDM/BR(75/25)	92.2
EPDM/BR(50/50)	94.9
EPDM/BR(25/75)	98.2
EPDM/BR(0/100)	98.8
EPDM/BR(75/25)/AAHR[a]	97.4
EPDM/BR(50/50)/AAHR[a]	98.0
EPDM-g-MAH/BR(75/25)	95.2
EPDM-g-MAH/BR(50/50)	95.6

[a] The amount of AAHR was fixed at 10 phr based on the total amount of EPDM and BR mixtures.

The fatigue properties of blends are summarized also in Table V. The trends in the fatigue properties of the blends was the same as in the tear strength; that is, the BR-rich blends showed higher fatigue resistance than the EPDM-rich blends and the addition of AAHR increased the fatigue properties of EPDM/BR blends due to the increased bound rubber contents. The higher fatigue resistance of the EPDM-g-MAH/BR blends were also noted, as in the case of tear strength.

Conclusions

In this work, studies have been made on the effect of the addition of a compatibilizer for EPDM /BR blends on the compatibility and the vulcanizate properties of EPDM/BR blends. AAHR, a B.A.S.F. product of a mixture of aliphatic and aromatic hydrocarbon resins, was used for a compatibilizer. For comparison, the compatibility and the properties of the blends of BR with EPDM-g-MAH were also investigated, which have been prepared for this work. It was found that the melt viscosity, elastic modulus and tan δ were increased with increasing EPDM contents. The rheological and the dynamic mechanical measurements along with the morphology revealed that the addition of AAHR is more effective to enhance the compatibility between EPDM and BR than the grafting of MAH onto EPDM. The weight percent of bound rubber was increased with increasing BR contents. The addition of AAHR increased the amounts of bound rubbers and thus the vulcanizate properties of the EPDM/BR blends. It was also found that there exists co-cure characteristics in the EPDM-g-MAH/BR blends.

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