

Studies on the Cure Characteristics of Elastomer Blends

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Blends of natural rubber (NR) with styrene-butadiene rubber (SBR), polybutadiene rubber (BR), ethylene-propylene terpolymer (EPDM) and acrylonitrile-butadiene rubber (NBR) were vulcanised using an efficient vulcanisation (EV) system and a semi-EV system. Compatible blends show a definite pattern of curing whereas the incompatible blends show no such pattern.

INTRODUCTION

Polymer blends have attained an important status in the science of polymers in the past decade. Blends of elastomers are also gaining importance these days. Even though they are largely used in tires, their use in other applications is not widespread. Proper use of elastomer blends may give property improvements. EPDM added to elastomer formulations yields improved oil acceptance and ozone resistance, nitrile rubber yields improved oil resistance, chloroprene yields improved flame resistance, polybutadiene is used for low temperature flexibility, butyl rubber imparts low gas permeability.¹ One difficulty in the processing of elastomer blends is that of achieving optimum cure in both the elastomeric phases, particularly in the case of incompatible elastomers.² In this study a semi-EV and EV systems designed for NR are used for the curing of blends of

NR with SBR, BR, EPDM & NBR and the cure characteristics compared.

Experimental

Materials

a) Elastomers

- NR (Mooney viscosity (ML 1 + 4, 100°C)-85.3)
- SBR (Mooney viscosity (ML 1 + 4, 100°C)-49.2)
- BR (Mooney viscosity (ML 1 + 4, 100°C)-48.9)
- EPDM (Mooney viscosity (ML 1 + 4, 100°C)-55.5)
- NBR (medium nitrile, Mooney viscosity (ML 1 + 4, 100°C)-40.9)

b) Curatives

- Sulphur, N-cyclohexyl-2-benzothiazole sulfenamide (CBS), tetramethyl-thiuram disulfide (TMTD), Zinc oxide and stearic acid (all rubber grade)

Compound preparation

Two blends were prepared with each of the synthetic rubbers (SBR, BR, EPDM & NBR) and NR by keeping the amount of the synthetic rubber at 20% and 40% of the total elastomer weight. Blends were made in a Brabender plasticorder model PL3S (rotor speed: 30 rpm, sensitivity 0-5000 mg) at 90°C. The formulations employed for the two types of curing systems are shown in Table I. NR was added initially and allowed to homogenise for two minutes. Then the other elastomer was added and blended for two minutes. ZnO and stearic acid were added next and a blending time of one minute was given. Then the accelerators (CBS and TMTD in the case of the semi-EV system and TMTD alone in the case of the EV system) were added and blended for one minute. Finally sulfur was added and blended for thirty seconds.

Evaluation of cure characteristics

The cure characteristics of the various compounds were determined in a Monsanto Rheometer model R100 at 150°C.

TABLE I
Formulations used for compounds

(a) <i>Semi-EV System</i>	
Elastomer(s)	100
ZnO	2.50
Stearic acid	1.50
CBS	1.25
TMTD	0.20
Sulfur	2.25
(b) <i>EV System</i>	
Elastomer(s)	100
ZnO	2.50
Stearic acid	1.50
TMTD	3.50
Sulfur	0.50

Results and Discussions

Semi-EV system A comparison of the cure characteristics of NR with those of NR-SBR blends shows that the scorch and cure times are increased with the percentage of SBR in the compound. This is expected because SBR vulcanises more slowly than NR and it requires higher acceleration.^{3,4} The addition of BR also shows the same pattern of change in the cure characteristics but with less pronounced effects. This is also expected since the cure characteristics of BR are similar to those of SBR but the sulfur and accelerator requirements are intermediate between those of NR and SBR.^{3,5} The values shown by NR-EPDM blends seem to be abnormal, since EPDM has a cure rate slower than SBR.⁶ Also a definite pattern of change in the cure characteristics with varying amounts of EPDM is not visible. This behaviour may be attributed to the incompatible nature of NR and EPDM.^{2,7} The cure characteristics of NBR are also similar to those of SBR, but NBR requires less sulfur and more acceleration.^{3,8} The behaviour of NR-NBR blend similar to that of NR-EPDM blend is also abnormal and does not exhibit a clear pattern of change in the cure characteristics of NR with the addition of NBR. This also may be explained as due to the incompatibility of the rubber phases.^{2,7} The reversion resistance of NR is improved with the addition of the synthetic rubbers, as expected.⁸ Blends of NR with SBR and BR which are fairly

TABLE II
Cure-characteristics of elastomer blends

	NR-SBR Blend		NR-BR Blend		NR-EPDM Blend		NR-NBR Blend		
	NR	20% SBR	40% SBR	20% BR	40% BR	20% EPDM	40% EPDM	20% NBR	40% NBR
<i>Semi-EV System</i>									
Scorch time (mts)	3.5	5.0	6.0	4.5	5.0	3.5	4.0	2.4	4.5
Cure time (mts)	6.5	7.5	8.5	6.5	7.0	5.5	6.0	4.5	6.5
Reversion characteristics. (Number of units dropped in 5 mts.)	2.0	Nil	Nil	1.0	Nil	1.0	Nil	1.5	0.5
<i>EV System</i>									
Scorch time (mts)	2.2	2.5	2.5	2.5	2.5	2.2	2.5	2.5	2.5
Cure time (mts)	7.0	8.0	8.0	8.0	8.0	6.2	8.5	8.5	7.0
Reversion characteristics. (Number of units dropped in 5 mts.)	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

compatible⁷ show a definite pattern of improvement in this case also. SBR seems to give better reversion resistance to NR even at low concentrations.

EV System

As in the case of the semi-EV system, NR-SBR and NR-BR blends show a clear pattern of increase in scorch and cure times over the values of NR. However, the differences in cure characteristics between SBR and BR with different percentages of addition are not obvious. The values shown by the NR-EPDM and NR-NBR blends again display the incompatible nature of the elastomers. The reversion resistance of all the blends is superior in this system compared to the previous system as expected.⁹

CONCLUSION

The study shows that in the case of compatible elastomers a suitable curing system which is suitable to both elastomers can be designed

easily. In the case of incompatible polymers, detailed studies are required to assess the states of cure in each phase under each system to design a suitable curing system.

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