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THE INFLUENCE OF DUAL ACTIVE FILLERS ON CURING CHARACTERISTICS OF ELASTOMERS BASED ON NATURAL RUBBER AND CHLOROSULPHONATED POLYETHYLENE RUBBER

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Abstract

The effects of two type active filler (carbon black and silica) on the characteristics of elastomers based on natural rubber and chlorosulphonated polyethylene rubber blend (NR/CSM) were investigated. For cure studies, torque-time curves were registered at different temperatures (150, 160 and 170°C). It was estimated that higher curing temperature cause decrease of the cure plateau torque and lead to higher crosslinking rate constant.

Introduction

Physical properties of rubber vulcanisates are improved by reinforcing with active fillers such as carbon black and silica [1]. Silica has been used as an important reinforcing agent in a rubber compound together with carbon black [2-4]. Silica has a number of hydroxyl groups on the surface, which results in strong filler-filler interaction and adsorption of polar material by hydrogen bonding and it can aggregate tightly [3-4]. Since intermolecular hydrogen bonds between hydroxyl groups on the surface of silica are very strong and it can form a tight aggregate. Carbon black filled vulcanisates has good polymer- filler interaction, even better than silica [5]. Its property can cause a poor dispersion of silica in a rubber compounds than carbon black and its acidity is responsible for cure retardation, and additional ingredients like ethylene glycol [6]. The aim of this work was to study the influence of carbon black and silica on curing NR/CSM rubber blend at different temperatures and to calculate the crosslinking rate constant.

Experimental

Natural rubber, type SMR CV 60 was supplied by Malaysia. Chlorosulfonated polyethylene rubber type, Hypalon 40S, was supplied by Du Pont, USA. Carbon black with nominal particle size 26-30nm (N-330) and precipitated silica with nominal particle size 15nm (Ultrasil WN3) were used as active fillers. Other ingredients such as zinc oxide, stearic acid, sulfur and poly (ethylene glycol) were of reagent grade. Mixing was carried out on a two-roll mill at 50°C and speed

ratios 1:1.25 (according to ASTM D 3182). For cure studies, torque-time curves were registered at temperatures of 150, 160 and 170 °C by Monsanto rheometer 100S. The expression for the crosslinking rate constant can be written in terms of torque as [5]

$$kt \equiv \ln \left(\frac{M_h - M_t}{M_h - M_l} \right) \dots\dots 1$$

Where M_t is the torque at a given time t . M_l and M_h are the minimal and maximal torque, respectively. k is the crosslinking rate constant, since the rate in the early stages reflects the character of the main forward reaction [6]. The compounds were prepared by using a plasticorder (model PLE-330; Brabender OHG, Duisburg, Germany) at 80C and a rotor speed of 60 rpm. Rubber sheets were prepared by molding the compounds according to the respective optimum cure times.

Result and Discussion

In the Table I are summarized all estimated curing characteristics at different temperatures. It is observed that the addition of carbon black to rubber blend tends to increase torque more rapidly than silica.

Table I Vulcanization characteristics of NR/CSM rubber blend compounds filled with silica and carbon black

	Cure temperature (°C)	Minimum torque M (dNm)	Maximum torque M_h (dNm)	ΔM ($M_h - M_l$) (dNm)	Scorch time t_{s2} (min)	Optimum cure time t_{90} (min)
1	150	9.0	50.2	41.2	7.6	14.7
	160	8.7	49.3	40.6	4.1	8.2
	170	8.6	48.6	40	2.4	5.0
2	150	8.7	48.8	40.1	7.0	14.6
	160	8.3	47.9	39.6	4.8	7.9
	170	8.3	47.2	38.9	2.8	4.9
3	150	7.2	48.1	40.9	2.1	3.4
	160	6.6	45.1	38.5	1.5	2.3
	170	6.3	43.0	36.7	0.9	1.2

The variation of rate constant (k) for carbon black and silica-filled NR/CSM compounds are represented in the figure 1. The optimum and scorch rheometer cure time t_{90} and t_{s2} values, which are a measure of the rate of crosslinking, decrease as the curing temperature increases for all formulation of NR/CSM rubber blends. The initial decrease in torque is due to the softening of the matrix. Torque then increases due to the formation cross-links between the macromolecular chains and cross-links between active filler and macromolecular chains.

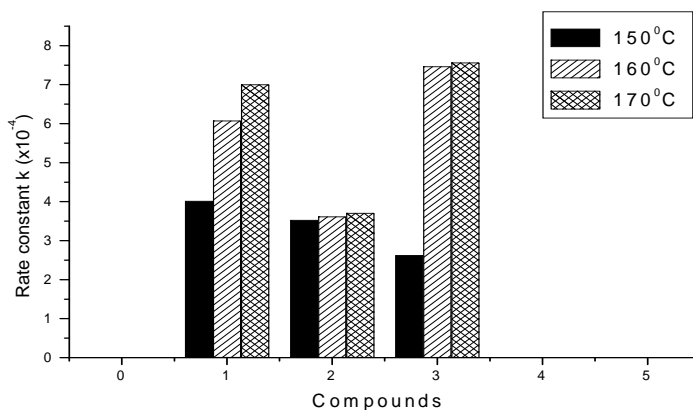


Fig. 1. Variation of rate constant for carbon black and silica filled NR/CSM compounds at different temperatures

Conclusion

The optimum and scorch rheometer cure time t_{c90} and t_{s2} values decrease as the curing temperature increases for all formulation of NR/CSM rubber blends. Higher temperature influenced the decreases of the cure plateau torque and lead to higher crosslinking rate constant.

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