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Effects of Higher Non-Black Filler Loadings on the Mechanical Properties of Ethylene Propylene Diene Monomer-Natural Rubber Blends

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Blends of natural rubber and ethylene propylene diene monomer rubber in three blend ratios were prepared and the variation in mechanical properties was investigated with different non-black fillers at different loadings. The fillers used were clay and silica in the ratio 50, 100, 200 and 20, 10, 10 parts per hundred parts of rubber respectively. Among the three blends the one with 75 weight % of natural rubber gave better tensile properties. The increased filler loadings lowered the tensile strength in all blend ratios. The hardness in general was increased with increased filler loadings in all blends and was recorded maximum for blend with 75 weight % of natural rubber. The thermal ageing studies revealed that the thermal stability increased considerably with increased weight % of ethylene propylene diene monomer rubber. The enhanced thermal stability is evidenced from the tensile strength and elongation at break measurements before and after ageing.

Key words : EPDM, Natural rubber, Clay, Silica, Blends.

INTRODUCTION

Raw rubber has poor physico-mechanical properties. To improve these properties blending of different elastomers, incorporation of fillers, ingredients such as accelerators, activators, antioxidants, softeners etc. are usually employed[1]. Yuan *et al.*[2] recently studied the mechanical properties of ethylene propylene diene monomer rubber (EPDM) loaded with different quantities of semi-reinforcing furnace (SRF) black. Mark *et al.*[3] showed the technological importance of rubber blends that enhance the physical properties of rubber vulcanizates and improve their processing behaviour. Poh and Tang[4] investigated the effects of stearic acid and Poh *et al.*[5] studied the influence of sulfur concentration on the scorch property of epoxidized natural rubber (EPNR).

The aim of this work was to study the mechanical properties of natural rubber—ethylene propylene diene monomer rubber (NR-EPDM) blends with respect to blend ratios. It was also aimed to study the stability of blends after thermal ageing. The investigation on the mechanical properties of the above blends by incorporating various amounts of non-black fillers was of special interest.

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EXPERIMENTAL

Ribbed smoked rubber sheets of (RSS) grade 4 for this work was supplied by India Rubbers, Kottayam. EPDM-502 employed for the blend preparation was supplied by M/s. Herdillia Unimers Ltd., Mumbai. The rubber chemicals such as zinc oxide, stearic acid, sulfur, clay, silica, naphthenic oil, mercaptobenzothiazole (MBTS), tetramethylthiuram disulfide (TMTD), etc. used for the compound preparation were of commercial grade and were supplied by M/s Associate Chemicals Ltd., Ernakulam.

Blend Preparation: The NR-EPDM blends were denoted by NR_{75}, NR_{50}, and NR_{25} where the subscripts denote the weight % of NR in the blends. The blends were prepared by masticating the components and homogenizing them on a two-roller mixing mill (friction ratio 1 : 1.4), according to ASTM D15627 (Table-1). The cure characteristics of the samples were determined in an elastograph (MDR-2000). The compounds were compression moulded using an electrically heated hydraulic press at 150°C for an optimum cure time, t_{90}.

TABLE-1
COMPOUNDING INGREDIENTS AND COMPOSITION

Ingredients	pphr*								
	$NR_{75}S_1$	$NR_{75}S_2$	$NR_{75}S_3$	$NR_{50}S_1$	$NR_{50}S_2$	$NR_{50}S_3$	$NR_{25}S_1$	$NR_{25}S_2$	$NR_{25}S_3$
NR-EPDM blends	100	100	100	100	100	100	100	100	100
Poly butadiene	5	5	5	5	5	5	5	5	5
ZnO	10	10	10	10	10	10	10	10	10
Stearic acid	1	1	1	1	1	1	1	1	1
Sulphur	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Clay	50	100	200	50	100	200	50	100	200
Silica	20	10	10	20	10	10	20	10	10
Naphthenic oil	10	12	15	10	12	15	10	12	15
MBTS	1	1	1	1	1	1	1	1	1
TMTD	1	1	1	1	1	1	1	1	1

*pphr: parts per hundred parts of rubber

Mechanical Testing: Mechanical testing was carried out in a Universal Testing Machine (UTM) at 30°C with a cross head speed of 500 mm/min using dumbbell shaped tensile specimens according to ASTM D412-8080. The hardness measurements were done on specimens of 6 mm thickness using a durometer (Modex-India) as per ASTM D 2240–86. The thermal ageing of the test specimens were conducted in a multicell-ageing oven as per ASTM D 572–53.

RESULTS AND DISCUSSION

Three blend ratios NR_{75}, NR_{50} and NR_{25} were selected for the mechanical properties study in different filler loadings before and after subjecting to thermal ageing. The following observations were made before thermal ageing.

Fig. 1 shows the variation in tensile strength (TS) with the varying weight % of NR in the three blend ratios at different filler loadings before thermal ageing. It was

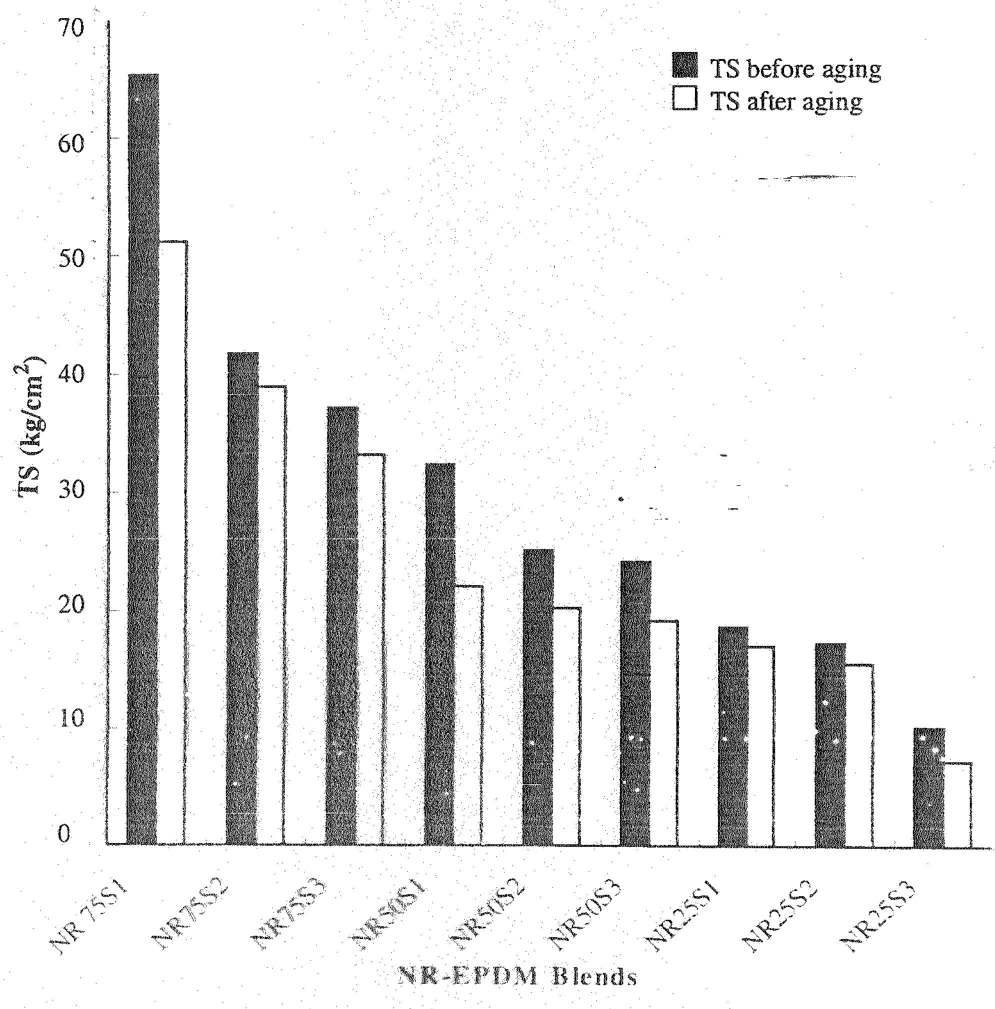

Fig. 1. Tensile strengths of filled NR-EPDM blends before and after thermal ageing

found that before ageing the TS lowered with decreased NR weight %. The tensile strengths of $NR_{75}S_1$, $NR_{50}S_1$ and $NR_{25}S_1$ were found to be 65, 32.3 and 18.6 kg/cm^2 respectively. In addition to this it was found that in each blend ratio the tensile strength dropped considerably with higher filler loadings, which are well evidenced from the figure. The drop in TS might be due to the reduced polymer-polymer interaction by the excessive filler presence.

Fig. 2 reveals the variation of elongation at break (EB) in blends with different weight % of NR and filler loadings before and after thermal ageing. The EB of $NR_{75}S_1$, $NR_{50}S_1$ and $NR_{25}S_1$ before ageing was found to be 662, 552 and 403% respectively. Thus it is evident that the EB of blends decreases with decrease in weight % of NR. The same trend was observed in all the three sets of blends with higher filler loadings. Under stress, NR crystallizes fast and hence EB increases in NR-rich blends and vice-versa.

The variations in hardness of the blends before and after thermal ageing are discussed in Fig. 3. It was found that the hardness before ageing decreases with decreasing NR weight %. The hardness of $NR_{75}S_1$, $NR_{50}S_1$ and $NR_{25}S_1$ was found to be 66, 56 and 47 Shore-A respectively. Besides, it was found that in each blend ratio, the hardness increased dramatically with higher filler loadings, which can be

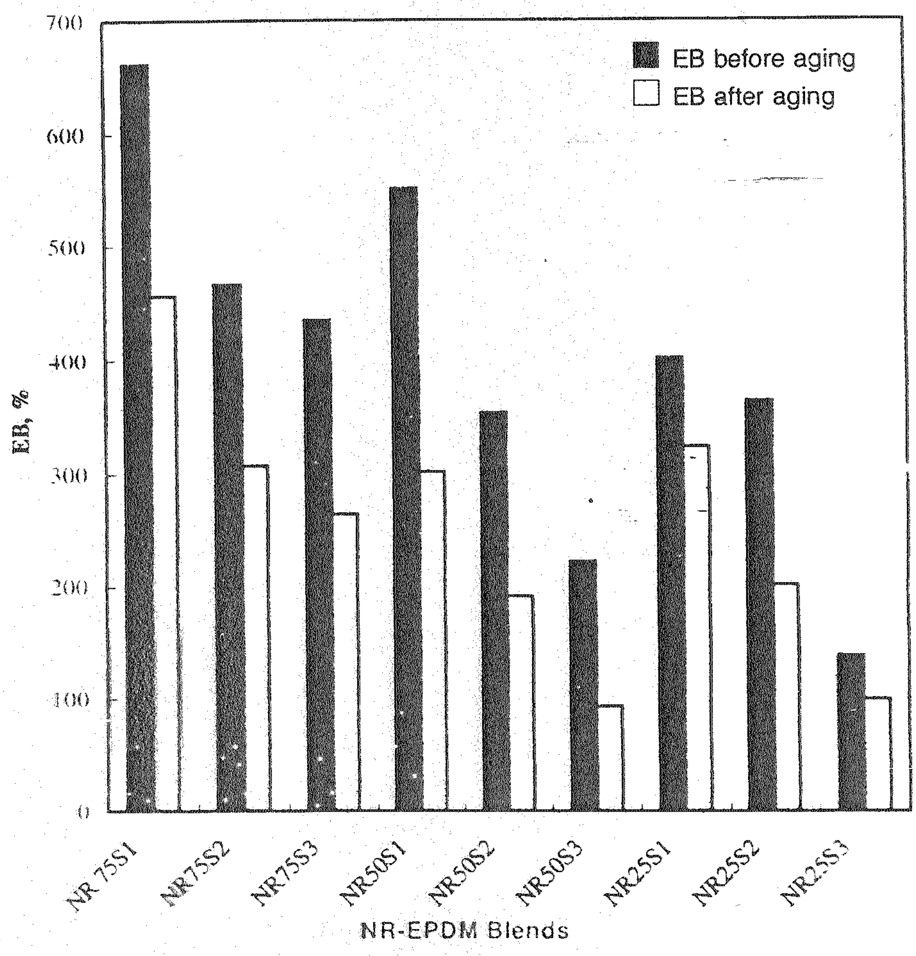

Fig. 2. EB of filled NR-EPDM blends before and after ageing

seen in the figure. The sulphur cross-links as well as the reinforcement by filler particles at the interfaces of the elastomer components may be the reason for the hike in the hardness.

Figs. 1, 2 and 3 also explain the thermal ageing characteristics of the blends. The studies revealed that TS and EB decrease with thermal ageing while hardness showed appreciable increase. It was interesting to note that the percentage decrease in TS recorded a drop with reduced weight % of NR in the blend. Similar trend was observed in EB also. The fall in the above physical properties may be due to the deterioration in the cross links during thermal ageing. But the fall in the properties could be reduced with higher weight % of EPDM, which has good thermal resistivity. A marginal percentage increase in hardness was observed in blends with higher EPDM content, which may be due to the continued cross-linking of EPDM on thermal ageing.

Conclusion

The present investigation reveals that the mechanical properties such as TS and EB were excellent for NR/EPDM blends with blend ratio 75 : 25. The thermal ageing has reduced these properties considerably with NR-rich blends and this trend shows a reverse effect with increase in EPDM content. The study shows that the hardness in general increases with increased filler loadings in all the blend ratios

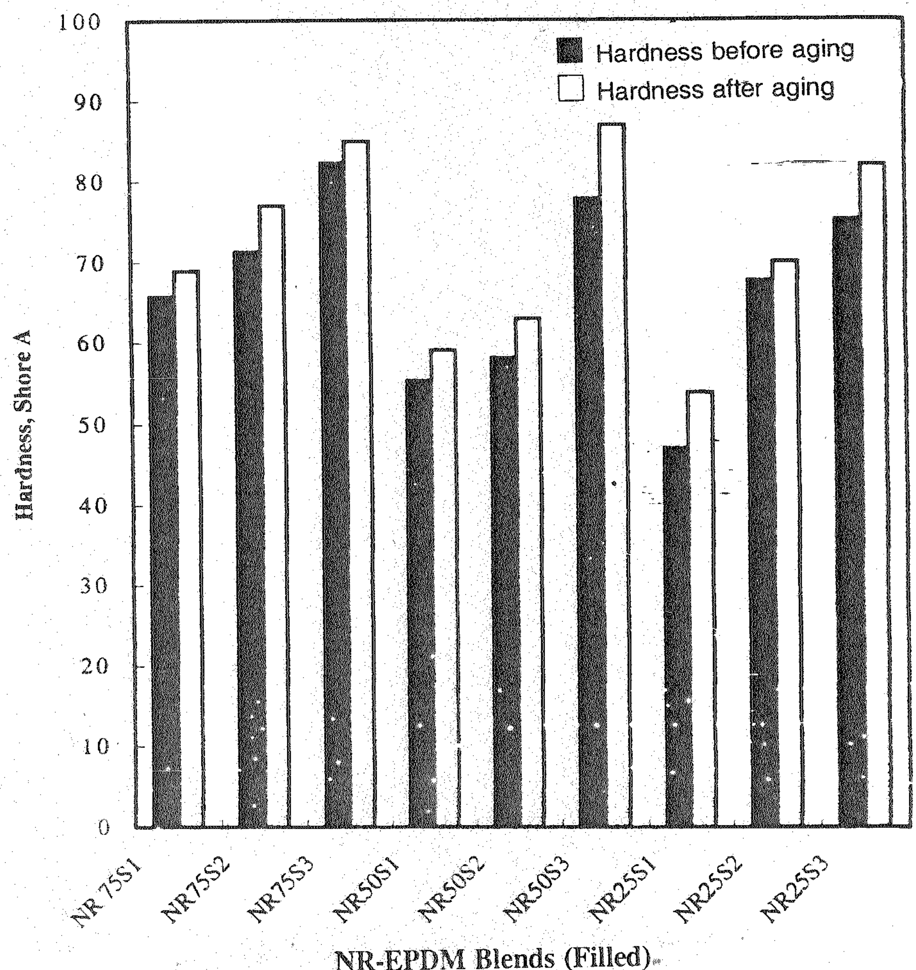

Fig. 3. Hardness (Shore-A) before and after ageing

before and after thermal ageing. The better physical compatibility coupled with good crosslinking ability of EPDM at higher temperatures may be the reason for the increased hardness. Rubber products such as floor mats, floor tiles, automobile components, roofing membranes, etc. which demand high weather resistivity and hardness can be properly designed by incorporating EPDM and fillers in Natural Rubber with NR/EPDM ratio 25 : 75.

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