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BLENDS OF ACRYLONITRILE BUTADIENE RUBBER/SUPERIOR PROCESSING/NATURAL RUBBER AND POLY (VINYL CHLORIDE)

PART 1 - A STUDY OF SOME OF THE TECHNOLOGICAL PROPERTIES OF NBR/SP RUBBER/NR/PVC BLENDS

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ABSTRACT

The advantages of using Superior Processing (SP) rubber in place of Natural Rubber (NR) in blends with NBR and NBR/PVC is discussed here in detail.

Various technological properties such as tensile, resilience, hardness, compression set, specific gravity, cross-link density and resistance to oil were measured and compared. It is advantageous to use SP rubber in place of NR in the above blends probably due to higher cross-link density in the SP rubber component when compared to NR. It may be possible to use the ternary blends of SP/PVC/NBR in manufacture of injection moldable and recyclable products due to their thermoplastic nature.

INTRODUCTION

Academic and commercial interest have been shown for chemical or physical combination of two or more structurally dissimilar polymers since it enables modification of properties of component polymers to suit specific requirements (Omoto, Klempner & Frisch, 1989).

Polyvinyl Chloride (PVC) homopolymer is a stiff and brittle material. For many applications, it is useful to blend PVC with other polymers or copolymers in order to improve certain properties. One of the most suitable modifying additives is Acrylonitrile Butadiene Rubber ((NBR) (George *et al.*, 1986); NBR acts as a permanent plasticizer for PVC in applications such as wire and cable coverings, food containers, bond liners used for oil containments, *etc*. On the other hand, PVC improves ozone, thermal aging, and chemical resistance of NBR in applications such as fuel hose covers, gaskets, conveyor belt covers, printing roll covers *etc*. Because of good NBR/PVC compatibility, their blends can be prepared in any proportion with predicable properties. However, non polar rubbers such as Natural Rubber (NR), Styrene Butadiene Rubber (SBR) and Butadiene Rubber (BR) are not compatible with polar PVC or NBR and maldistribution of cross-links could occur in the vulcanization net-work.

It has been found (Tinker, 1998) that certain polar vulcanizing ingredients prefer polar NBR phase in NR/NBR blends rather than non-polar NR phase. The vulcanization of NR phase could therefore be somewhat retarded or inefficient,. Replacing NR, component with Superior Processing (SP) rubber where the cross-links are already available was thought to be a good solution in this respect for better vulcanization characteristics and cross-link distribution within the polar and non-polar phases in blends (Lewan, 1998).

In this study SP20 rubber, with 20 parts of cross-linked and 80 parts of uncross-linked rubber, was blended with NR and NBR/PVC (70/30) blend to study the improvements in physical properties and heat and oil resistance when compared with the blends containing NR.

EXPERIMENTAL

Prevulcanized latex used to produce SP rubber was prepared from ammoniated field latex by using the formulation in Table 1. The chemicals were added to latex as 50% aqueous dispersions. Prevulcanization was carried out at 70°C for 45 min.

Table 1. *Formulation used for prevulcanization*

	Phr
NR	100
ZnO	0.75
ZDC	0.2
MBT	0.4
S	2.0

SP 20 rubber sample were prepared by blending 20 parts of prevulcanized latex with 80 parts of unvulcanized latex by weight. The latex mixture prepared was coagulated by adding 2% formic acid. The coagula were milled to obtain laces and dried in a drying tower.

A set of blends was made by using the formulations given in Table 2.

Table 2. *Formulations used in compounding*

Components	a	b	c	d
Crepe rubber	50	50	-	-
SP-20	-	-	50	50
NBR	-	50	50	-
NBR/PVC (70/30)	50	-	-	50
Dutrex R	2.5	2.5	2.5	2.5
DOP	2.5	2.5	2.5	2.5
ZnO	5.0	5.0	5.0	5.0
St. acid	2.0	2.0	2.0	2.0
Carbon black N 333	45.0	45.0	45.0	45.0
IPPD	1.0	1.0	1.0	1.0
Sulphur	0.35	0.35	0.35	0.35
MBTS	1.1	1.1	1.1	1.1
TMTD	1.2	1.2	1.2	1.2
DPG	0.5	0.5	0.5	0.5

Above compounds were cured at 140°C for their corresponding cure times which were obtained from rheographs. Technological properties such as tensile strength, modulus at 100% and 300% elongation and elongation at break were measured for both aged and unaged samples [ISO 1798-1983, ISO 2440-11983(E)]. Properties such as specific gravity, hardness, resilience, cross-link density, compression set and oil resistance (ISO 845-1977, 1400-11975,1653-1975 & 1817-1975) were measured using standard procedures.

RESULTS AND DISCUSSION

Sample label	Description
a	NR\NBR\PVC
b	NR\NBR
c	SP\NBR
d	SP\NBR\PVC

Table 3. *Physical properties of the blends*

Sample	Mod at 100% (MPa)	Mod at 300% (MPa)	%Elongation at break	Tensile Strength (MPa)
a	1.12	-	407	12.18
b	1.25	5.12	647	17.88
c	1.51	9.10	420	15.28
d	3.88	10.42	365	12.94

It can be observed that the value for 100% modulus is comparatively low for NR\NBR\PVC sample when compared with the SP\NBR\PVC system whereas elongation at break is higher.

From the results in Table 3 it is clear that when the system is less incompatible *i.e.* when the blends do not contain PVC, they show higher tensile and elongation at break values. However, when NR phase was replaced by SP rubber (samples A & D), there seems to be a significant increase in modulus values and a decrease in % elongation at break probably due to higher cross-link density in the SP rubber phase. The tensile strength values show comparable results. The ageing values at 70°C of the above blends show similar results as indicated in Figures 1-4.

The hardness values in Table 4 give evidence to the above statement indicating high hardness values for SP rubber containing blends. However, sample a which has NR also shows high value for hardness.

Further, Figures 1 & 2, clearly indicate that the highest set of modulus at 100% & 300% values can be observed for SP\NBR\PVC blends. More over, a significant increase in modulus values with ageing can be observed in both samples blended with PVC. During the blending, some vulcanizing chemicals including sulfur might have embedded in PVC phase. These trapped chemicals could have migrated to natural rubber and NBR phases during ageing process at 70°C showing increased cross link density values for blends containing PVC.

However, as expected the blends containing PVC show higher % compression set and lower resilience values. The specific gravity values indicate that the blend containing SP & PVC has lower specific gravity and high hardness. This property could be used where low density materials with reinforcing effect but without fillers is important.

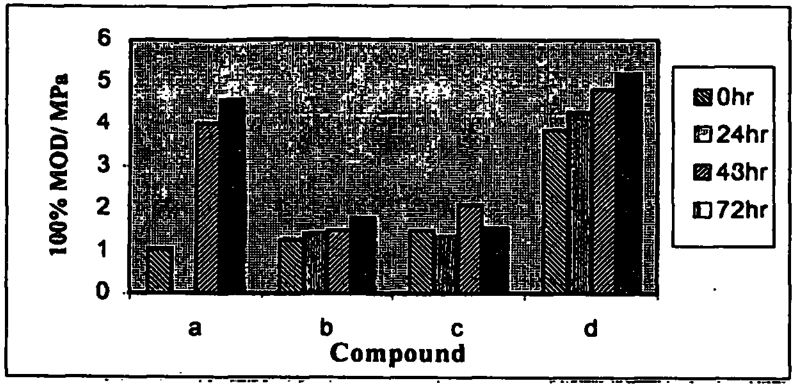

Fig. 1. 100% MOD

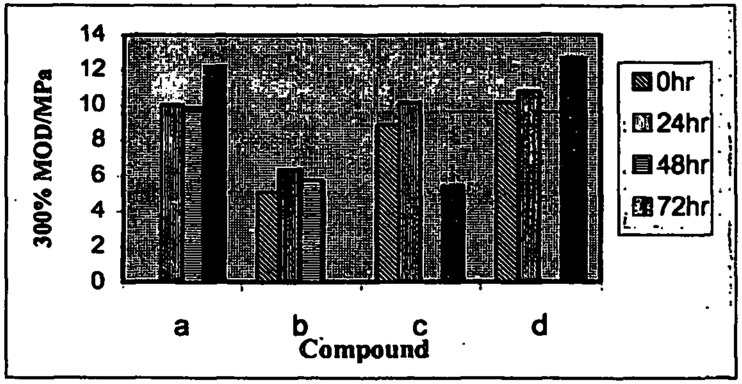

Fig.2. 300% MOD

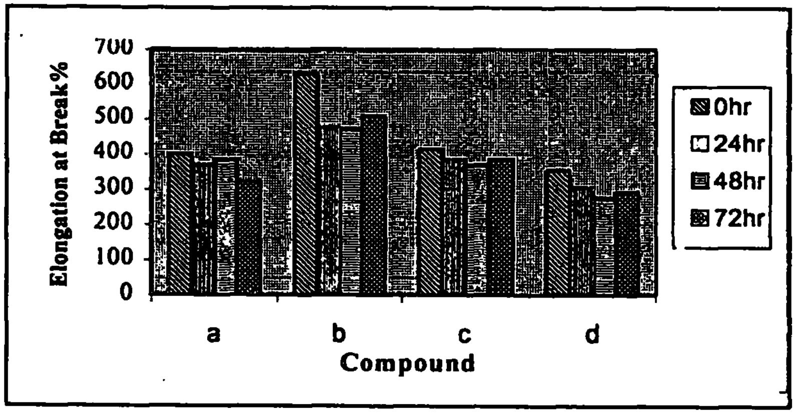

Fig. 3. Elongation at break

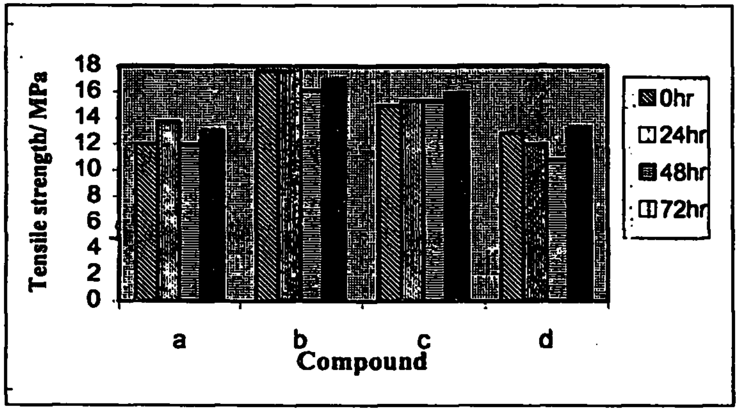

Fig. 4. Tensile strength

Fig. 1-4. Modulus, elongation at break and tensile strength of samples a,b,c,d aged at 70°C

Table 4. *Resilience, hardness and compression set values of blends*

Sample	Resilience %	Hardness IRHD	Compression set %
a	26	83	25.9
b	55	62	16.3
c	35	71	16.7
d	28	84	25.0

Table 5. *Specific gravity, cross link density and resistance to oil of blends*

Sample	S.G.	Cross link density	Degree of swelling %
a	1.0470	9.1 x 10-1	9.3
b	2.7610	6.9 x 10-1	10.2
c	1.4290	6.7 x 10-1	9.9
d	0.9460	10.4 x 10-1	8.1

The high hardness, high compression set and low resilience values obtained with NR\NBR\PVC blend and SP\NBR\PVC blend could be due to thermoplastic nature of PVC present in the blends. Also highest cross-link density and the lowest degree of swelling were observed with SP\NBR\PVC blend. This may be due to the efficient cross link distribution within the phases and possible closely packed mono–sulphidic cross links of prevulcanized rubber in superior processing rubber in the blend.

CONCLUSION

The results show that it is advantageous to use SP rubber rather than NR in blends with NBR or NBR\PVC. Use of SP rubber in place of NR in NR\NBR\PVC blends has also shown a significant improvement in modulus values. This could be due to presence of efficiently distributed cross links in the blends. Observed increase in modulus values of blends containing PVC during ageing could be due to migration of vulcanizing chemicals trapped in PVC phase to NR and NBR phases during the ageing process creating more cross links within the network.

Low specific gravity values obtained for SP\NBR\PVC blends and high hardness values could be useful to obtain low density reinforced materials without reinforcing fillers.

Blends containing PVC have shown low resilience, high hardness and high compression set values indicating thermoplastic nature due to PVC. This advantage could be used in producing NR based materials with injection moldable and recyclable properties thereby introducing a value addition to NR, increasing the productivity. Further study is needed in this respect.

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