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The Influences of TOR as a Compatibilizer on Cure Characteristic and Morphological Properties of SBR/CRr Blends

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ABSTRACT

Cure characteristics and morphological studies were performed to determine the influences of TOR as a compatibilizer of styrene butadiene rubber/recycled chloroprene rubber (SBR/CRr) Blends. Both uncompatibilised and compatibilised SBR/CRr blends were prepared using a two roll mill at room temperature with blend ratios 95/5, 85/15, 75/25, 65/35 and 50/50. It can be observed that, cure characteristics of compatibilised SBR/CRr blend have shorter scorch time, t_2 and cure time, t_{90} than uncompatibilised SBR/CRr blends. Compatibilised SBR/CRr blends showed lower minimum torque (M_L) compared to uncompatibilised SBR/CRr blends at all blend ratios. However, maximum torque (M_H) of compatibilised SBR/CRr blends exhibit the opposite trend compared with the uncompatibilised SBR/CRr blends. The scanning electron microscopy (SEM) of the tensile fracture surface of compatibilised SBR/CRr blends at 15 and 50 blend ratios illustrated a better adhesion and dispersion in comparison with uncompatibilised SBR/CRr blends.

INTRODUCTION

Among all types of rubber, the chloroprene (CR) is a prominent material. This rubber was the first market synthetic elastomer (1932) due to advantageous properties and has been investigated in the last years. CR are homopolymers of chloroprene. The polymer chains have an almost entirely *trans*-1-4-configuration. Because of this high degree of stereoregularity they are able to crystallize on stretching [1].

It is very versatile and can be cured with sulfur or organic peroxides and has the following characteristics: good elasticity, allows perspiration, resistance to oil, solvents, weather ageing, heat, oxygen, ozone and flame [2]. In Malaysia, the output of CR catheters was found abundantly. Most of this material originates from medical, industrial as well as research activities. After a certain period of time these polymeric materials are not serviceable and mostly discarded. To solve this environmental issue, we have used a recycled CR catheters (waste) obtained from industrial floor in an effort to create a value added instead of being scrapped [3].

Styrene butadiene rubber (SBR), known as a non-polar rubber, has good mechanical properties and does not easily break down. Particularly, it has better ozone resistance, weatherability and abrasion resistance than natural rubber [4]. In this study, we selected commercial styrene-butadiene rubber (SBR), a typical unsaturated polyolefin, which has been widely used in the fabrication of automotive tire sidewalls, cover strips, wires, cables, footwear, roofing barriers and sporting goods [5].

Blending of SBR with CR has been done to obtain better crystallisation resistance, better compression set resistance, lower brittleness temperature and enhanced resistance to sunlight deterioration as compared with CR alone. Other important properties, such as oil, heat, flame and ozone resistance, decrease as the amount of SBR increases [6].

Trans-polyoctylene rubber (TOR) is a low-molecular-weight polymer, made from *cyclo*-octene by metathesis polymerization, and has been known as a compatibilizer for incompatible blends as well as a

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processing aid. It can provide good processability in the temperature range of rubber processing (100–150 °C) as well as good collapse resistance below the melting temperature, 54 °C, due to recrystallization. It has linear and cyclic macromolecules which are un-branched and contain one double bond for every eight carbon atom with prevalently *trans* isomeric double bonds [7].

In this study, TOR has low molecular weight resin which can be crosslinked by sulphur, was added as a third component to the blends and its effect on the rheological and mechanical properties on the modified blends was investigated. TOR is expected to offer interfacial crosslinking between the rubber blends [8].

Experimental:

Materials:

The materials and their characteristics used in this experiment are illustrated in Table 1. The size of recycled chloroprene external catheters was obtained by a mechanical grinding using Crusher model RT34 (Chyun Industrial Co. Ltd.) to achieve a polydispersed rubber powder.

Table 1: The characteristics of the materials

Materials	Description	Source
Styrene butadiene rubber (SBR)	1502	Bayer (M) Ltd
Recycled chloroprene rubber (CRr)	Size: 181 – 549 µm	Teleflex Medical Sdn. Bhd.
Trans Polyoctylene Rubber (TOR)	Vestenamer 8012 ML_{1+4} at 100°C<10 MW = 100000 Tm = 51°C, Tg = -65°C Crystalinity at 23°C =27%	Huls, Germany
Carbon black	N330	Malayan Carbon (M) Ltd
N-cyclohexyl-2-benzothiazyl sulfenamide (CBS), zinc oxide, stearic acid, sulphur and processing oil		Anchor Chemical Co (M) Ltd

Compounding, Cure Characteristics and Vulcanizing:

The formulation of both uncompatibilised and compatibilised SBR/CRr blend ratios were 95/5, 85/15, 75/25, 65/35 and 50/50, as given in Table 2. The rubber was pre-blended and the mixing procedure was carried out using a two-roll mill at room temperature. Cure characteristics were determined using a Monsanto Moving Die Rheometer (MDR 2000) at 160 ^{o}C with about 6 g samples of the respective compound. Blends were compression molded in an electrically heated hydraulic press to 2 mm thickness at 160 ^{o}C according to respective cure time, t_{90} with force of 10 MPa.

Table 2: The formulation of SBR/CRr blends with and without TOR.

Ingredients(phr)	Blend				
	R05	R15	R25	R35	R50
SBR	95	85	75	65	50
CRr	5	15	25	35	50
TOR	0/3	0/3	0/3	0/3	0/3
Zinc oxide	5	5	5	5	5
Stearic acid	2	2	2	2	2
Sulphur	2	2	2	2	2
CBS	1	1	1	1	1
Processing oil	5	5	5	5	5
Carbon black (N330)	20	20	20	20	20

Scanning electron microscopy (SEM):

The blends were characterized using a JEOL (JSM-6490LV). The fracture surfaces of the tensile test pieces were mounted on aluminum stubs and the surface sputter coated with a thin layer of gold (2 nm thick), prior to scanning to avoid electrostatic charging and poor resolution during examination.

RESULT AND DISCUSSION

Table 3 shows the curing characteristics of uncompatibilised and compatibilised SBR/CRr blends on the cure time, t_{90}, scorch time, t_2, minimum torque, (M_L) and maximum torque, (M_H) respectively. It is clear that cure time, t_{90} and scorch time, t_2 of uncompatibilised and compatibilised blends decreased with increasing CRr content in both blends. This is due to the existance of precursors and unreacted curative in the recycled rubber which the latter would accelerate the vulcanization process. However, at a similiar blends ratio, compatibilised SBR/CRr blends became shorter as CRr content increased. This could be explained due to characteristic nature of TOR such as platicizer effect and can act as an unsaturated rubber particularly when add with polar rubber such as CR.

It is clear that the minimum torque, (M_L) of uncompatibilised and compatibilised SBR/CRr blends increased with increasing CRr contents. This is due to the presence of cross-linked CRr and other additives. Meanwhile, compatibilised SBR/CRr blends show lower value than uncompatibilised SBR/CRr blends at similar ratio particularly. This exhibited the addition of TOR in SBR/CRr blends improving the processability. This could be explained due to the plasticizer effect of TOR which reduced te viscosity of SBR/CRr, and enhanced the interaction between the blend components.

Table 3: The curing characteristics with TOR and without TOR.

Blends (phr/phr)	Cure time, t_{90}		Scorch time, t_2		Minimum torque, M_L		Maximum torque, M_H	
	Without TOR	With TOR	Without TOR	With TOR	Without TOR	With TOR	Without TOR	With TOR
R05	21.39	11.4	5.24	3.43	3.11	2.76	24.66	31.57
R15	18.55	10.49	5.52	3.44	3.63	3.35	21.87	26.55
R25	16.52	9.51	5.81	3.68	3.83	3.59	21.4	23.35
R35	14.72	8.35	6.1	4.36	4.17	4.03	19.38	21.16
R50	13.06	8.23	6.63	4.48	4.75	4.58	18.19	20.47

However, the maximum torque, (M_H) of uncompatibilised and compatibilised SBR/CRr blends decreased with increasing CRr contents due to poor interaction of SBR/CRr. The compatibilised SBR/CRr blend shows a higher value than uncompatibilised SBR/CRr blend. This is due to the improvement in degree of crosslinked density and chain entanglement [9].

Morphology studies:

Figure 1 shows the comparison of SEM tensile fracture surfaces of uncompatibilised and compatibilised blends of SBR/CRr at 85/15 and 50/50 blend ratios at 2000x magnification respectively. It can be seen that, tensile fractured surface of SBR/CRr blends without TOR,Fig. 1(a & c) shows a coarser fractured surface due to poor distribution of CRr in the SBR matrix, particularly when more CRr content was added in the SBR matrix. This shows low adhesion between phases and contributed to poor stress transfer across the interface. However, tensile fractured surface of SBR/CRr blends with TOR, Fig. 1(b & d) shows a better ahhesion between CRr and the SBR matrix. This is due to CRr and SBR matrix is still well bonded, which means strong interfacial adhesion occured as compared to SBR/CRr blends withour TOR.

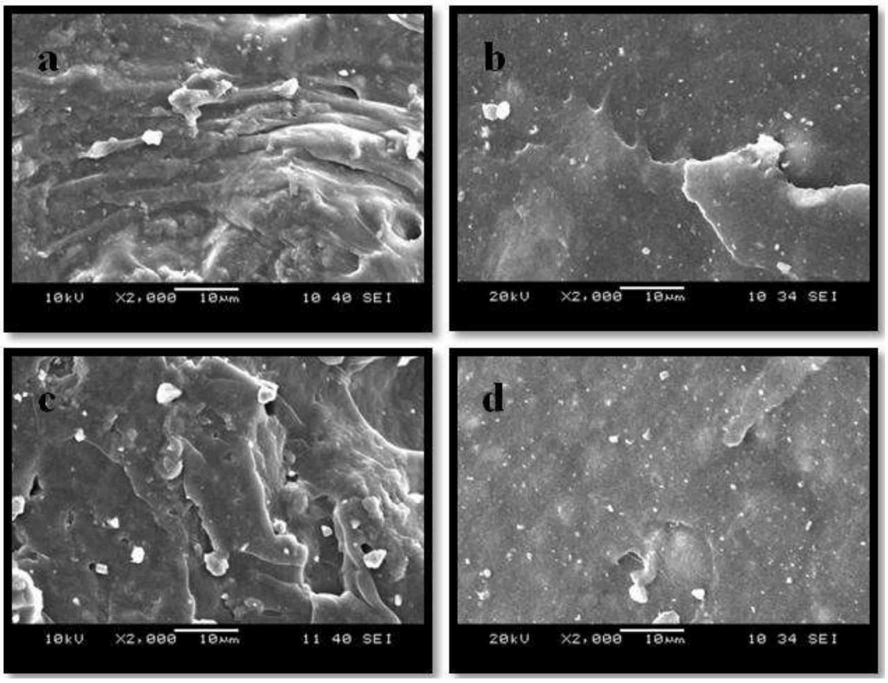

Fig. 1: Scanning electron micrograph of tensile fracture surface of SBR/CRr blends at (a) 85/15 and (c) 50/50 without TOR; and SBR/CRr blends at (b) 85/15 and (d) 50/50 with TOR at 2000x magnification.

Conclusion:

From the above data it is concluded that:

i. The cure time, t_{90} and scorch time, t_2 of uncompatibilised and compatibilised SBR/CRr blends decreased with increasing CRr content in both blends. However, at a similiar blends ratio, compatibilised SBR/CRr blends became shorter as CRr content increased.

ii. The minimum torque, (M_L) of uncompatibilised and compatibilised SBR/CRr blends increased with increasing CRr contents. Compatibilised SBR/CRr blends showed lower minimum torque (M_L) compared to uncompatibilised SBR/CRr blends at all blend ratios. The maximum torque, (M_H) of uncompatibilised and compatibilised SBR/CRr blends decreased with increasing CRr contents due to poor interaction of SBR/CRr.

iii. The tensile fracture surface of compatibilised SBR/CRr blends at 15 and 50 blend ratios illustrated a better adhesion and dispersion in comparison with uncompatibilised blends.

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