Reinforcing Effect of Organically Modified Montmorillonite Clay in Skim Rubber Nanocomposites

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Introduction

Natural rubber latex obtained from of rubber (Hevea braziliensis) tree is rich in several non-rubber substances such as protein, metal ions, and carotenoids. Skim natural rubber latex is a by-product obtained during the centrifugation process of natural rubber latex and it contains about 3 – 7 % dry rubber content. Although, skim rubber shows poor mechanical properties, strong odor, less quality consistency and poor thermo oxidative stability, it can be used to produce lower grade rubber products such as dip products, rubberized coir mattress and latex foam mattress. Organically modified montmorillonite clay (nanoclay) has received a great attention as a reinforcing and functional material in polymer composite materials since it offers a property enhancement at modest clay addition levels. However, limited literature is reported, how nanoclay affects on physio-mechanical properties of the skim rubber vulcanizates. In this study, skim rubber-organoclay nanocomposites were prepared by conventional processing method to evaluate the effect of organoclay on reinforcing of skim rubber compounds.

Methodology

Skim rubber supplied by Glenrose (Pvt) Ltd Company, Horana, Sri Lanka was used in this study and it was characterized for raw rubber properties according to the methods of International Organization for Standardization (ISO). Skim rubber was melt and mixed with organically modified montmorillonite (OMMT) clay and with other compounding ingredients using a laboratory scale internal mixer (Brabender Plasticorder, T300A). Table 1 shows compound formulations for each skim rubber-clay nanocomposite (SRCN)

Table1. Compound formula of the SRCN.

	Composite Code					
Ingredient	SRCN0	SRCN3	SRCN6	SRCN9	SRCN12	SRCN15
Skim Rubber	100	100	100	100	100	100
OMMT	0	3	6	9	12	15
ZnO	5	5	5	5	5	5
Stearic Acid	2	2	2	2	2	2
Sulfur	2	2	2	2	2	2
TBBS	1.5	1.5	1.5	1.5	1.5	1.5
IPPD	1.2	1.2	1.2	1.2	1.2	1.2
TMQ	0.8	0.8	0.8	0.8	0.8	0.8
PVI	0.4	0.4	0.4	0.4	0.4	0.4

IPPD (N-Isopropyl-N'-phenyl-P-phenylenediamine), TMQ (2, 2, 4-trimethyl-1, 2 dihydroquinoline), PVI (Pre-vulcanization Inhibitor), TBBS (N-tert-butyl-2-benzothiazyl sulfonamide), ZnO (Zinc oxide)

Cure characteristics of all compounds were determined using MDR 2000 (Moving Die Remoter, M/S Alpha Technologies, USA) at 150 °C for 30 min. Reinforcing effect of OMMT clay were evaluated by analyzing tensile properties, tear strength, hardness and rebound resilience as per the ISO standards.

Results and Discussion

Table 2 presents the mechanical properties of different SRCN vulcanizates. Accordingly, skim rubber latex had higher amount of the dirt, volatile matter, ash, non-rubber substance, and metal ion. Mooney viscosity and Nitrogen percentage were higher than that of the crepe rubber. Beside, poly isoprene content and PRI value were lower than the crepe rubber.

SRCN vulcanizates prepared based on the cure characteristics data derived from rheographs were analyzed for static mechanical properties to study the reinforcing effect of OMMT clay.

Table 2. Average raw rubber properties of skim rubber and raw rubber specification of crepe rubber.

Property	Crepe rubber	Skim rubber
Dirt content % (w/w)	0.02 (max.)	0.03
Volatile matter content % (w/w)	0.5 (max.)	2.82
Ash content % (w/w)	0.20 (max.)	0.77
Initial plasticity number (Wallace units)	30 (min)	43
Plasticity Retention index (PRI)	60 (min)	7.5
Nitrogen content % (w/w)	0.35 (max.)	2.61
Poly Isoprene content (%)	80-90	62
Mooney viscosity ML 1+4 @ 100 $^{\circ}C$	75 - 85	90

Both modulus at 100 and 300 % elongation increased with the OMMT loading as shown in Table 3. However, modulus, especially 300 % elongation, increased gradually up to 6 phr and beyond that level there was no significant effect ($P<0.05$) with increase of OMMT loading. These results could be explained by the fact that better intercalation and exfoliation/dispersion of OMMT clay was occurred up to 6 phr and as a result good reinforcement was achieved. However, at higher OMMT loading, OMMT clay particles tended to agglomerate without exfoliating/dispersing within the nanocomposite matrix, resulting no significant reinforcing effect. Elongation at break was dropped, as expected, with the OMMT loading. With the OMMT loading, hardness of the skim rubber-clay nanocomposites increased gradually. Similar to the modulus data, there was no marked increase of hardness beyond 6 phr loading. Winding of rubber molecules with OMMT and good dispersability of the clay are reasons for the improvement of hardness (Yuan and Tian, 2010).

Table 3. Mechanical properties skim rubber-clay nanocomposites (SRCN).

	SRCNO	SRCN3	SRCN6	SRCN9	SRCN12	SRCN15
Tensile strength (MPa)	24.8	22.8	19.6	19.5	18.1	20.8
M@ 100% (MPa)	1.23	1.57	1.80	1.83	1.34	2.32
M@ 300% (MPa)	2.77	3.89	4.17	4.44	4.22	4.07
Elongation @ break %	588	526	504	477	529	560
Tear Strength(Nmm^{-1})	40.7	34.8	33.4	32.0	37.5	35.7
Hardness (IRHD)	48.1	55.7	59.2	60.0	62.4	65.9
Rebound resilience %	60.	58	53	47	45	43

With further addition of OMMT, this winding density increases, although clay dispersion is marginal at high loading, and gives further resistance against deformation. It could be the reason for the increase of hardness with increasing OMMT level. The highest tear strength is in the gum compound containing no clay while no enhancement in the nanocomposites. OMMT tends to form aggregate and therefore, the crack growth could be occurred through the clay aggregates. Rebound resilience was reduced with the addition of OMMT clay loading, indicating the reinforcing effect of clay in the nanocomposites. When OMMT was added to skim rubber reinforcement of the rubber improves and as a result, elasticity was reduced as shown by the rebound resilience data in Table 3.

Conclusions

A series of SRCN vulcanizates with good mechanical properties could be obtained with application of clay based nanotechnology. According to the results, it is clear that SRCNs have showed improved reinforcement because of good intercalation and exfoliation of clay within the rubber matrix. However, the optimum mechanical properties, especially with improved reinforcement while maintaining good elasticity, compared that of SRCN0, could be achieved with 6 phr clay loading. At higher clay loading, OMMT clay acts as non-reinforcing filler and therefore significant reinforcement cannot be achieved. A low loading level of OMMT indicates good reinforcing properties on skim rubber- clay nanocomposite.

References

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