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A Study on the Mechanical Properties of Natural Rubber Vulcanizates Using Precipitated Silica and Treated Coir Pith as Filler

KEYWORDS: Natural rubber,rubber vulcanizates,silica and coir pith.

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ABSTRACT *Natural rubber is the prototype of all elastomers which allows elasticity and flexibility to be combined with crystallization-induced strength and toughness when stretched. Natural rubber are frequently compounded with fillers so as to improve their properties, as well as to reduce cost. Thus, the mechanical properties of natural rubber vulcanizates using precipitated silica and treated coir pith as filler was assessed. Natural rubber vulcanizates compounded with silica fiber yielded better results than that treated with coir pith filler. Natural rubber vulcanizates prepared with silica showed more hardness than coir pith due to the reinforcing power of silica. Abrasion loss of coir pith is greater than silica due to higher moisture absorption capacity.*

Introduction

Natural rubber (NR) is an exceptional material with commercial applications due to its awesome physical properties, especially high mechanical strength, low heat build-up, excellent flexibility, and resistance to impact and tear, and above all its renewability (Daniel et al., 2009). However, raw dry rubber is rarely used in its original state for any engineering and domestic diligences. Rubber manufacture requires the addition to rubber many auxiliary materials called additives to allow the rubber compounds to be satisfactorily processed and vulcanized in order to ameliorate the application attributes. Additives used in rubber manufacture include vulcanizing agents, accelerators, activators and/or retarders, fillers, anti-degradants etc. (Onyeagoro, 2012).

Rubber technology is currently moving in an era of paradigmatic change, as rubber products require myriad of properties, often in specific directions to meet plethora of industrial demands. This can be achieved by compounding rubber with specific ingredients to produce a useful polymer according to its end use (Hussain et al., 2003). In today's complex world of rubber industry, fillers have accomplished tremendous role as a compounding ingredient. Fillers are solid materials which are embedded in polymers to ameliorate not only performance but also reduce production costs. Filler size, shape, aspect ratio and the filler-matrix interactions are the key parameters in deciding the properties of polymers (Hohenberger, 2001). Fillers like glass, graphite, boron, carbon black or silicon carbide fibers are studied extensively. The present study is an attempt to compare the mechanical properties of natural rubber vulcanizates using precipitated silica and treated coir pith as filler.

Materials and methods

In order to compare the properties of rubber mixed with treated coir pith and silica as filler, a standard mix was prepared using silica alone as filler. Three other combinations were also prepared using treated coir pith and silica in different ratios. One mixture is prepared using treated coir pith alone as filler. Zinc oxide and Stearic acid together form Zinc stearate which is employed as activator. F is the combination of Tetramethylthiuram disulfide (TMTD) & 2-Mercaptobenzothiazole disulfide (MBTS) which gives better reversion and resistance. Retted coir pith treated with phenol formaldehyde resin cured in oven which is powdered to fine particle size (240 mesh). F is activated Thiazole. Silica is prepared by precipitating Sodium silicate solution. 2,2.4-trimethyl-1.2-dihydroquinoline (TDQ) is used to prevent oxidative degradation of natural rubber. Higher polar phenolic oils are used as plasticizers. Sulphur is used as vulcanizing agent. Diethylene glycol is added to control the highly adsorptive reinforcing silica.

Natural rubber was masticated in a two roll lab mixing mill. Other ingredients are incorporated in sequence and Sulphur at the end. Uniform mixing shall be ensured during the compounding process. When the rubber is passed through the nip it is squeezed between the rolls and on repeated passage it becomes soft.

After mixing the compounded natural rubber was sheeted out, optimum cure time (TC 90), scorch time (TC2) (Gottfert Elastograph 67.98) were fixed and moulded in an electrically heated hydraulic press at 500^{0}C and at a pressure of 2000 psi for vulcanization. The samples were tested for tensile properties (tensile strength and % strain break), hardness, percentage of water absorption, abrasion loss and specific gravity.

	Parts per hundred of rubber (Phr)				
Ingredients	I	II	III	IV	V
Natural rubber	100	100	100	100	100
Zinc oxide	5	5	5	5	5
Stearic acid	2.5	2.5	2.5	2.5	2.5
F	1.5	1.5	1.5	1.5	1.5
Precipitated silica	80	60	40	20	--
Treated coir pith	--	20	40	60	80
TDQ	1	1	1	1	1
Process oil	2	2	2	2	2
Sulphur	2.5	2.5	2.5	2.5	2.5
Diethylene glycol	1	1	1	1	--

Table 1: Proportion of ingredients used for the test

Results and Discussion

An attempt was done to compare the mechanical properties of natural rubber vulcanizates using precipitated silica and treated coir pith as filler, under laboratory conditions.

Volume : 5 | Issue : 7 | July 2015 | ISSN - 2249-555X

The preliminary results of the optimum cure time and scorch time, tensile characteristics, hardness, percentage of water absorption, abrasion loss and specific gravity of the tested samples yielded promising results.

The results of the optimum cure time and scorch time was given in Table 2. The precipitated silica alone gives best results followed by II, III, IV and V (coir pith alone). This is due to the higher surface area, high volume to area aspect ratio and the adsorption of accelerators by the filler compared to treated coir pith.

The effect of filler on tensile strength of the resulting vulcanizates depends upon many factors including composition, physical and chemical properties of the filler (Onuegbu and Igwe, 2011). Here, precipitated silica imparts maximum tensile strength to natural rubber than coir pith (Table 3). The smaller particle size and higher surface area per unit weight of the precipitated silica contributes to this phenomenon. The variations in hardness and tensile strength of natural rubber due to the effect of fillers added was already established (Al-Mosawi, 2013). Natural rubber compounded with silica showed maximum hardness and minimum for the coir pith alone (Table 4). It can be concluded that the filler rubber interaction is the reason for this change in hardness.

The use of silica as filler results in more penetration which causes better filler rubber interaction. Hence, precipitated silica yielded maximum hardness to vulcunizates than other mixes of precipitated silica and coir pith.

The percentage of water absorption increases gradually as moved down from precipitated silica to treated coir pith filler (Table 5). This is due to the high moisture absorption capacity of the coir pith. However, the available results depicts not much variations, as the treatment of treated coir pith with phenol formaldehyde resin which has excellent water resistance and this reduces the water absorption capacity of the coir pith. The effects of fillers on water absorption capacity of natural rubber were already reported (Wang et al., 1999).

The abrasion loss analysis revealed that precipitated silica owes best result because of its highest resistance to abrasion followed by II, III, IV and V (Table 6). Coir pith imparts little resistance to abrasion, so abrasion loss is maximum for it. The specific gravity study showed a gradual decrease from precipitated silica to coir pith (Table 7). This is due to the high density of precipitated silica with treated coir pith.

Conclusion

Natural rubber vulcanizates were prepared with five different compositions of fillers both reinforcing and non-reinforcing. Vulcanizates prepared with precipitated silica showed commendable enhancement in the physical properties like tensile strength, tensile characteristics, hardness and specific gravity. It has less abrasion loss and water absorption capacity than coir pith. Silica reinforced vulcanizate surmounted all other compositions of silica and coir pith mix, and coir pith alone in all aspects of physical analysis which is attributed to higher surface area and high volume to area ratio of reinforcing filler, silica.

Sample	Optimum cure time (TC 90) at 150^{0}C (min)	Scorch time (TC2) at 150^{0}C (min)
I	13.47	3.31
II	9.84	1.48
III	8.38	1.12
IV	8.29	0.23
V	6.76	0.12

Table 2: Optimum cure time (TC 90) and Scorch time (TC2) of the tested samples

Sample	Tensile strength (N/nm^2)	% strain at break
I	11.64	528
II	6.70	443.12
III	3.35	474
IV	3.14	478
V	3.08	352

Table 3: Tensile properties of the tested samples

Sample	Hardness (Shore A)
I	86
II	68
III	62
IV	52
V	51

Table 4: Hardness of the tested samples

Sample	% of water absorption
I	4.8471
II	5.6922
III	7.2031
IV	8.5084
V	9.0154

Table 5: Percentage of water absorption of the tested samples

Sample	Abrasion loss (nm^3)
I	146.8026
II	224.8808
III	229.6940
IV	439.1871
V	701.0323

Table 6: Abrasion loss of the tested samples

Sample	Specific gravity
I	1.208
II	1.143
III	1.091
IV	0.892
V	0.752

Table 7: Specific gravity of the tested samples

Volume : 5 | Issue : 7 | July 2015 | ISSN - 2249-555X

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