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The effect on hardness and density of filling materials in NR/SBR rubber compounds

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ABSTRACT

The effects of SBR and NR compounds on characteristics of different filing were examined. Natural rubber (NR RSS3) and styrene-butadiene rubber (SBR 1502) were used as the main matrix material. New compounds were formed by replacing the fillings in the general compound of the existing factory (SiO_2, $CaCO_3$) with 10 % blast furnace flue dust, rice husk, reclaimed rubber (recycled) and wood ash. Comparison of the new compounds with the existing compounds revealed a decrease in hardness and density.

1. Introduction

Natural and artificial rubbers are widely used in various industries, particularly in shoe sole making, due to their superior properties. For the product that will be obtained from these materials to have the required properties, many filling and additive materials having various properties are added during the process. A review of the literature have shown that various materials such as mica powder, wollastonit, glass sphere, glass fiber, nanoclay, calcium carbonate, talk, carbon black are used as filling materials. High cost of filling materials has led the people to seek cheaper filling materials. The reason for adding particle reinforced fillings to rubber material in appliances was generally to produce the desired commercial elastomers [1].

Şahin Y.M. showed that superior rheological and dynamic mechanical properties can be obtained by the use of composites in which grinded waste rubber (reclaimed rubber) is replaced with certain ratios of carbon black, when compared to those that only contain carbon black [2].

Savaşçı et al., reported that bending capability, failure strength, hardness should be enhanced while material cost should be reduced to achieve the desired properties in the use of filling materials in elastomers [3].

Ichazo et al., studied the effects of wood ash on rheological, mechanical and wearing effects in NR compounds. They compared the values with those obtained with carbon black. The researchers used 15-30% wood ash as filling material in NR. They reported that materials with a grain size of 250–300 μm did not deteriorate wearing properties; they increased failure strength and that wood ash can be used as a semi-reinforcing filling material in NR composites [4].

Sumaila et al., analyzed tensile, compressive and impact resistance values by adding 2-10% peanut husk powder (wood cellulose) into polyurethane material. They reported that as the quantity of filling material increased, tensile strength increased as well. They also reported that filling material had a negative impact on impact resistance. As the quantity of filling material increased, a decrease was observed in impact resistance. They found that 4% filling material gave the best result in compressive strength, while 8% filling material gave the worst result. In conclusion, the researchers reported that it can be used as a filling material in polyurethane [5].

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Akçakale et al., analyzed the effects of mica powder on NR/SBR type elastomer based materials. They reported that material type, type of filling material and grain size were important parameters on mechanical properties [6].

In a study on rheological behavior of mineral fillings in shoe sole materials, Jolene et al., used 10% mica powder or 10% glass sphere instead of calcium carbonate ($CaCO_3$) in SBS block copolymer and studied the changes in mechanical properties of the material. They reported that glass sphere yielded the best result (5.8 MPa); calcium carbonate ($CaCO_3$) filled composite gave the value of 5.49 MPa and mica powder filled mixture gave the value of 5.41 MPa. In elongation at break tests, glass sphere filled composite gave the value of 630, calcium carbonate filled composition gave the value of 685; mica powder filled mixture gave the value of 650. As for the hardness values of the obtained SBS copolymer composites, they reported that all three materials were identified as 62 Shore A; wearing ratios of glass sphere filled materials, calcium carbonate ($CaCO_3$) filled materials and mica powder filled composites were found to be 273 mm3, 307 mm3 and 378 mm3 respectively. Tearing strength values of glass sphere, ($CaCO_3$) and mica powder filled composites were found to be 25 N/m, 23 N/m and 24 N/m respectively [7].

Mohan et al., reinforced NR/SBR rubber with nanoclay filling and analyzed the effects on mechanical and thermal properties. The researchers observed that as % weight ratio of nanoclay increased, hardness increased as well, however, cold tearing strength decreased [8].

Prasertsri et al. studied NR/SBR composite ratios and the effect of t transition temperature of silica (SiO_2) materials on these composites. The highest t transition temperature was determined in alloys which contained equal amounts of NR/SBR rubbers. They observed that t transition temperature increases as % weight ratio of Silika (SiO_2) increases [9].

El-Nashar et al., used modified phosphate instead of carbon black. They observed that mechanical properties improved and vulcanization times decreased [10].

In a study conducted on the compounds formed by adding different phosphates to the NR/SBR matrix material, it was stated that the most appropriate mechanical test results were obtained from the NR and SBR compounds at the rate of 75/25. It was indicated that the different phosphate types added to the compound in addition to the carbon black decreased the vulcanization time while significantly increasing the mechanical properties (tensile strength, percentage elongation, hardness and tearing strength) [11].

Mohan et al., examined water intake property of nanoclay filling support to NR/SBR rubber structure and observed that increases in nanoclay weight amount decreased temporal water permeability properties of the rubber [12].

In this study, apart from conventional filling materials, we used different waste materials (non-recyclable) as filling materials. The aim of this studies the effects of filling materials on hardness and density properties in rubber compound materials.

2. Experimental

2.1 Materials used in rubber preparation

The NR RRS3 natural rubber and SBR 1502 Styrene Butadiene rubber were bought from Defne Kauçuk Import and Export Co. Ltd. Turkey. Silica (SiO_2), Kalsit ($CaCO_3$), blast furnace flue dust, reclaimed rubber and wood ash were purchased from Petkim Inc., Miner Madencilik Co. Ltd., İron-Steel Factory of Karabük, Selçuk Rubber Co.Ltd. and Kafkas Etliekmek Co. Ltd. Turkey, respectively. The other rubber compounding ingredients used in the study were obtained from Defne Kauçuk Import and Export Co. Ltd., Turkey.

2.2 Preparation of raw rubber

NR-SBR rubbers and fillers were compunded in a laboratory type banbury (Farrell brand) at 80 ^{o}C and 60 rpm for 10 minutes. Then, blast furnace flue dust, rice husk, reclaimed rubber and wood ash were added at the rates of 10 % wt. into the NR/SBR rubber compounds. After blending, the blend was left to rest for 24 hours. The dough was then blended in a two-roll open mixer at 80 ^{o}C and at a speed of 40 rpm for 5 minutes, followed by addition of additives such as softeners, activators, vulcanization, accelerators and sülfür, and stirring was continued for 3 minutes. The usage rates of fillings and additive materials added into the compounds are given in Table 1.

2.3 Vulcanization of rubber compounds

The rubber compounds were cut in small pieces, placed in a 180x180x6 mm mold that could be compressed by press (Hidrosan) device for 160 ºC at 5 minutes under 16 MPa pressure and the compounds were vulcanized under the same conditions. All the tests were performed after the compounds were cut into the standard dimensions according to relating test standards and were kept in an environment having 50 % relative humidity at 25±2 ºC for 24 hours. The hardness measurement of the vulcanizates was conducted by using a Shore A durometer (Commerciale, AFFRI 3001 model) according to ISO 868. Densities of the compounds were measured in line with Archimedes Principle (ISO 2781).

Table 1.Composition of rubber compounds.

FILLING MATERIALS	% phr				
	G	WA	RH	RR	BFFD
NR	50	50	50	50	50
SBR 1502	50	50	50	50	50
Calcite	26.6	-	-	-	-
Silica	33.4	-	-	-	-
Wood ash	-	10		-	-
Rice husk	-	-	10	-	-
Reclaimed rubber	-	-	-	10	-
Blast furnace flue dust	-	-	-	-	10
POACHERS					
Zinc oxide	3	3	3	3	3
Sulphur	1.5	1.5	1.5	1.5	1.5
Stearic acid	1.5	1.5	1.5	1.5	1.5
[a] PEG 4000	2	-	-	-	-
ACCELERATORS					
[b] DM	1	1	1	1	1
[c] CZ	1	1	1	1	1
[d] DPG	1	1	1	1	1

[a] Polyethylene Glycol
[b] Dibenzothiazole disulfide
[c] N-Cyclohexyl-2-benzothiazole sulfenamide
[d] Diphenyl guanidine

3. Results and Discussion

Hardness test results were conducted according to ISO 868 norm. It was observed that the hardness of G compound was 65 Shore A. The lowest hardness value was observed in RH (40 Shore A), while the highest hardness value was observed in WA 49 Shore A (Figure 1).

Results of the tests that were performed according to ISO 2781 density methods. Density should not exceed 1,5 g/cm^3 according to international standards. Although the density of the G compounds was 1,2 g/cm^3, density values of new compounds varied between 1,03 g/cm^3 and 0,96 g/cm^3. It was found that RH (rice husk) had the lowest density and the density of RR (Reclaimed rubber) decreased by 18,3 %. Density of BFFD (blast furnace flue dust) formulae deceased by 1,02 g/cm^3-% 15. Even the density of WA (wood ash) formulae which had the highest density, decreased by 1.03 g/cm^3- % 14,1.

4. Conclusion and Further Suggestions

Test results showed that new filling materials which replaced SiO_2 and $CaCO_3$ reduced density. The lower density values are, the lighter the shoe sole will be as the volume will remain unchanged. Hardness value slightly decreased when compared to G compound.

Varying ratios of wood ash, rice husk, blast furnace flue dust and reclaimed rubber materials can be added to G compound without removing SiO_2 and $CaCO_3$. Rice husk can be used in NR/SBR type rubber shoe soles by furnacing and adding their dust.

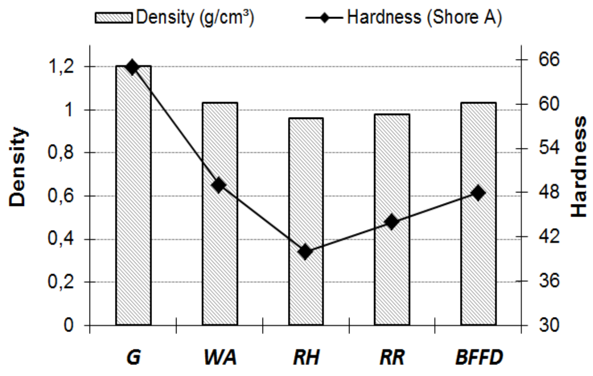

Figure 1. Density and hardness of carburized corncob ash filling compounds.

In this study not only in shoe soles but also rubber materials used in interfaces in machines of new filling materials

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References

1. Park, S.J., and K.S. Cho, *Filler–Elastomer Interactions: Influence of silane coupling agent on crosslink density and thermal stability of silk/rubber composites.* J Colloid Interf Sci. 2003. **267**: p. 86–91.
2. Şahin, Y.M. *Scrop rubber recycling in nitrile rubber composites.* Boğaziçi University, Having Satısfactorıly Completed All Requırements of the Department of, Masters of Science Thesis. (2001).
3. Savasci, O.T., N. Uyanik, and G. Akovali, *Plastics and plastic technology*. Cantay Publishing, İstanbul (1998).
4. Ichazo, M.N., M. Hermandez, C. Albano, and J. Gonzales, *Natural rubber filled with wood-floor: Influence of particle size.* Proc. of the 8th Polym. of Adv. Tech. Int. Sym. Budapest, Hungary p. 13–14 (2005).
5. Sumaila, M., B.I. Ugheoke, L. Timon, and T. Oloyede, *A preliminary mechanical characterization of polyurethane filled with lignocelluloses materials.* Leonardo J. Sci. 2006. p. 159–166.
6. Akçakale, N., A. Demirer, E. Nart, and I. Özsert, *Effects of glass spheres on the mechanical characteristics of NR-SBR type elastomers*. Scientific Research and Essays, Academic Journals. 2010. **5(8):** p. 758–762.
7. Jolene, F.S., R.C.R. Nunes, and V.J.R.R. Pita, *Rheological Behavior of Mineral Fillers in Shoe Soles Composites.* Universidad Federal do Rio de Janeiro P.O Box 68525 Rio de Janeiro, RJ, Brazil (2000).
8. Mohan, T.P., J. Kuriakose, and K. Kanny, *Effect of nanoclay reinforcement on structure, thermal and mechanical properties of natural rubber–styrene butadine rubber (NR–SBR).* Journal of Industrial and Engineering Chemistry. 2011. **17:** p. 264–270.
9. Pasertsri S., F. Lagarde, N. Rattanasom, C. Sirisinha, and P. Daniel, *Raman spectroscopy and thermal analysis of*

gum and silica-filled NR/SBR blends prepared from latex system. Polymer Testing. 2013. **32:** , p. 852–861.

10. El-Nashar D.E., Youssef E.A.M., Abd El-Ghaffar M.A.: Modified phosphate pigments as high performance reinforcing materials for rubber vulcanizates, Materials and Design, Vol. (31), pp. 1350–1359 (2010).
11. El-Nashar, D.E, E.A.M. Youssef, and M.A. Abd El-Ghaffar, *Modified phosphate pigments as high performance reinforcing materials for rubber vulcanizates.* Materials and Design. 2010. **31:** p. 1350–1359.
12. Mohan T.P., J. Kuriakose,and K. Kanny, *Water uptake and mechanical properties of natural rubber–styrene butadine rubber (NR-SR) – Nanoclay composites.* Journal of Industrial and Engineering Chemistry. 2012. 18: p. 979–985.