Impact of recycled micro–Gray Glass Grains on the Mechanical Properties of SBR and NBR

D. I. Moubarak[1], Mahmoud Hanafy [2], T.Y. El Rasasi[2], Y.H.Elbashar[3]*

[1]Department of Mechatronics, Faculty of Technological Industry and Energy, Delta Technological University, Qewaisna 32632, Egypt
[2]Physics Department, Faculty of Science, Benha University, Benha 13518, Egypt
[3]Faculty of Applied Health Sciences Technology, Nile Valley University, Fayoum, 63518, Egypt

(*) Corresponding author: Yahia Elbashar, y_elbashar@yahoo.com

Abstract

The automotive and industrial applications make extensive use of SBR and NBR. However, determining the mechanical characteristics and behavior of SBR (styrene butadiene rubber) and NBR (nitrile butadiene rubber) blends combined with gray glass powder as a filler in various compositions is the primary goal of this study. Moerever, the improve of the qualities of SBR and NBR sheets, as well as gray glass powder, are purchased and combined with the rubbers to create mixes. Tests for mechanical attributes, including tensile, tear, abrasion, and resilience, were carried out in compliance with ASTM guidelines. The compare outcomes, graphs were created. Improvements to the properties were acquired and recorded.

Keywords: SBR NBR polymer, Gray glass, Mechanical properties, glass filler, high elasticity polymer, composites polymer

1. Introduction

Rubber materials are widely used in a variety of applications due to their unique combination of elasticity, toughness, and durability. To meet the evolving performance requirements, continuous efforts are made to improve the mechanical, thermal, and other properties of rubber compounds through the incorporation of various fillers and additives. Among the commonly used reinforcing fillers, particulate fillers such as carbon black, silica, and mineral fillers have shown promising results in enhancing the strength, stiffness, and tear resistance of rubber [1,2].

One class of mineral fillers that has gained attention in rubber compounding is micro glass grains. Micro glass particles possess several attractive characteristics, including high modulus, chemical inertness, and the ability to form strong interfacial interactions with the rubber matrix [3,4]. The incorporation of micro glass grains has been reported to improve the tensile, tear, and abrasion resistance properties of natural rubber and synthetic rubber compounds [5-20].

In this study, the impact of micro gray glass grains on the mechanical properties of two widely used rubber types, styrene-butadiene rubber (SBR) and acrylonitrile-butadiene rubber

(NBR), was investigated. SBR and NBR are versatile elastomers with different polarity and glass transition temperatures, which can lead to distinct interactions and performance characteristics when filled with micro gray glass grains. The stress-strain behavior, true stress-true strain analysis, and other mechanical properties of the filled rubber compounds were evaluated to elucidate the reinforcing mechanisms of the micro glass filler.

2. Experimental

2.1 materials

Styrene-butadiene rubber (SBR 1502) and nitrile-butadiene rubber (NBR N-34) were obtained from TRENCO, Alexandria., Egypt. Micro gray glass grains with an average particle size of 11.9 µm were supplied by Micro Glass Inc. Other compounding ingredients, including zinc oxide, stearic acid, sulfur, and accelerators (2'-Dibenzothiazole Disulfide (MBTS)), Antioxidant/Antiozonant (N-isopropyl N'-cyclohexyl paraphenylene diamine IPPD (4020)), Naphthenic oil, were obtained from Aldrich Company, Germany.

The gray glass consists of Aluminum oxide (0.69%), Silicon oxide (34.2%), Phosphorus oxide (0.27%), chlorine oxide (1.87%), potassium (0.26%), calcium oxide (10.92%), Titanium oxide (0.54%), vanadium oxide (0.26%), manganese oxide (0.08%), Iron oxide (0.57%), Cobalt oxide (0.02%), copper oxide (0.02%), Nickle oxide (0.02%), Zinc oxide (0.07%), Arsenic oxide (0.01%), Rubidium oxide (0.02%), Strontium oxide (0.21%), Zirconium oxide (0.07%), Niobium oxide (0.02%), molybdenum oxide (0.03%), and Tungsten oxide (0.17%) as shown in Table 1.

2.2 Sample Preparation

SBR and NBR compounds were prepared using a laboratory-scale two-roll mill. The rubber was first masticated, and then the micro glass grains were added at loadings of 0, 10, 20, 30, 40 and 50 parts per hundred rubber (phr). The other compounding ingredients were added, and the compounds were thoroughly mixed. The compounds were then compression molded at 145°C and 15 MPa for 15 minutes to obtain test specimens.

2.3 Measurements

According to ASTM D 3182, all rubber compo unds were blended using a milling machine with two 150 mm (diameter) x 300 mm (long) rolls, each with a gear ratio of 1.4 and a slow roll speed of 18 rpm. The vulcanization process was performed after the compounded rubber had been left for 24 hours. Compound rubber is vulcanised in an electrically heated platen hydraulic press at (143±2)°C for 20 minutes. Mechanical characteristics including Young's modulus tensile strength, elongation at break, and the different mixes of stress-strain curves were recorded using homemade tensile testing equipment with a cross head speed of 115 mm/min. The machine quality improved and measurement errors decreased as a result of the creation of an electronic strain gauge based on the ATMEL 89S52 microprocessor. A rotating wheel and a micromechanical switch with four pulses per revolution (0.789 mm for each switch pulse) were used to measure the displacement of strain. In four-segment auto-range displayers, the incoming data is shown. Determination of the abrasion resistance for rubbers and elastomers are performed according to standard DIN 53516 using homemade abrasion tester (fig.2). Shore durometer hardness determination A regime was used with the NT-6510 Shore Hardness Tester for five specimens of each sample, each of which was a 3 cm diameter and 1.2 cm thick disc. The experiments were carried out at ambient temperature (25 ±1) °C. An average of three samples was collected for each measurement point.

3. Results and discussion

The SEM, XRD, and XRF respectively shows the micrographs of the milled glass in range of 200 µm (b) SEM micrographs of the milled glass in range of 100 µm, and the chemical analysis with chemical phases as shown in Fig. 1 and 2

Mechanical properties

Figures 4 and 5 shows the stress-strain curves for SBR and NBR compounds containing varying concentrations of micro glass grains. As the loading of the micro glass filler is increased, the stress-strain curves shift towards higher stress values. The maximum shift in the curves is observed at 40 phr for rubber compounds. These findings are further supported by the true stress-true strain curves shown in Figures 5 and 6 for SBR and NBR, respectively.

Close analysis of figures 4 and 5 reveals the following analyses:

Tensile strength of 40 phr. This could be due to the higher aggregation generation of micro glass in the NBR matrix vs the SBR matrix. Raising micro glass concentration to 40 phr enhances crosslinking between elastomeric chains, resulting in stronger reinforcing. As the amount of micro glass increased beyond 40 phr, the tensile strength decreased. This is because the formation of micro glass aggregates composed of weak linkages between micro glass and Rubber. Increasing the micro glass content led to a modest decrease in elongation at break values, possibly due to restrictions on polymeric chain mobility caused by micro glass aggregations. As a result, the polymeric matrix may become stronger but also brittle. Figure 6 illustrates this. As the concentration of micro glass in the rubber matrix exceeds 40 phr, the strain at break decreases significantly[6-10].

The modulus of elasticity E for micro glass/SBR and micro glass/NBR composites is shown in figure 7. Figure 8 shows that when the micro glass content increases, so does the elasticity modulus. As the concentration of micro glass grows, so does the formation of glass aggregation, which is associated with agglomerates. These aggregates may combine to form a secondary network that is continuous and held together by Van der Waals or other attractive forces[11-21].

Furthermore, it has been discovered that when the concentration of micro glass in the rubber matrix increases, the modulus of elasticity increases until it reaches a peak value at 40 phr, after which it begins to drop as shown in figure 8. The drop is attributed to a network breakdown between the aggregates.

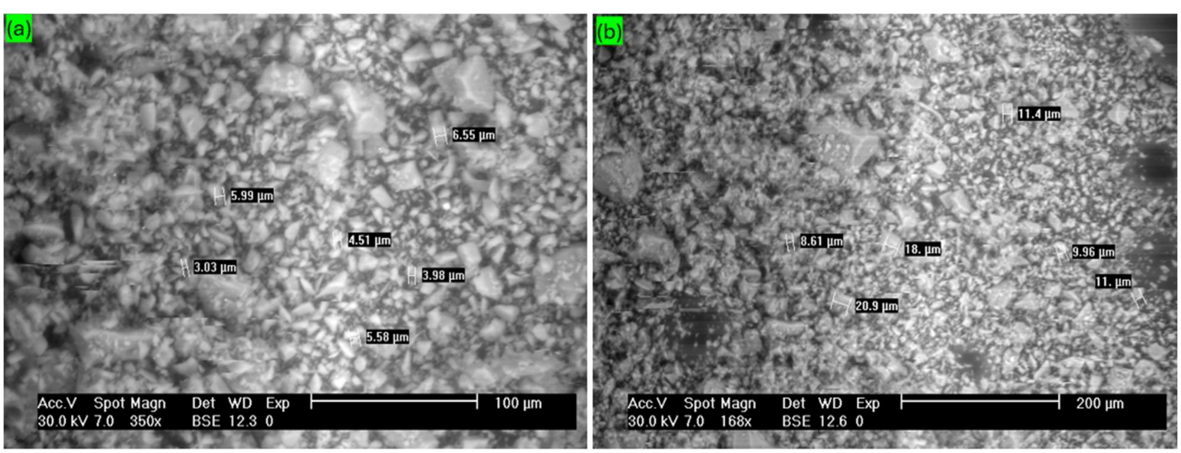

Fig. 1 (a) SEM micrographs of the milled glass in range of 100 µm (b) SEM micrographs of the milled glass in range of 200 µm

Element	Al %	Si %	P %	Cl %	K %	Ca %	Ti %	V %	Mn %	Fe %
	0.69	34.20	0.27	1.87	0.26	10.92	0.54	0.26	0.08	0.57
±	0.108	0.140	0.026	0.018	0.009	0.022	0.007	0.064	0.015	0.015
Element	Co %	Ni %	Cu %	Zn %	As %	Rb %	Sr %	Zr %	Nb %	Mo %
	0.02	0.02	0.02	0.07	0.01	0.02	0.21	0.07	0.02	0.03
±	0.005	0.002	0.002	0.003	0.003	0.002	0.003	0.002	0.002	0.003
Element	W %									
	0.17									
±	0.015									
Reference:										

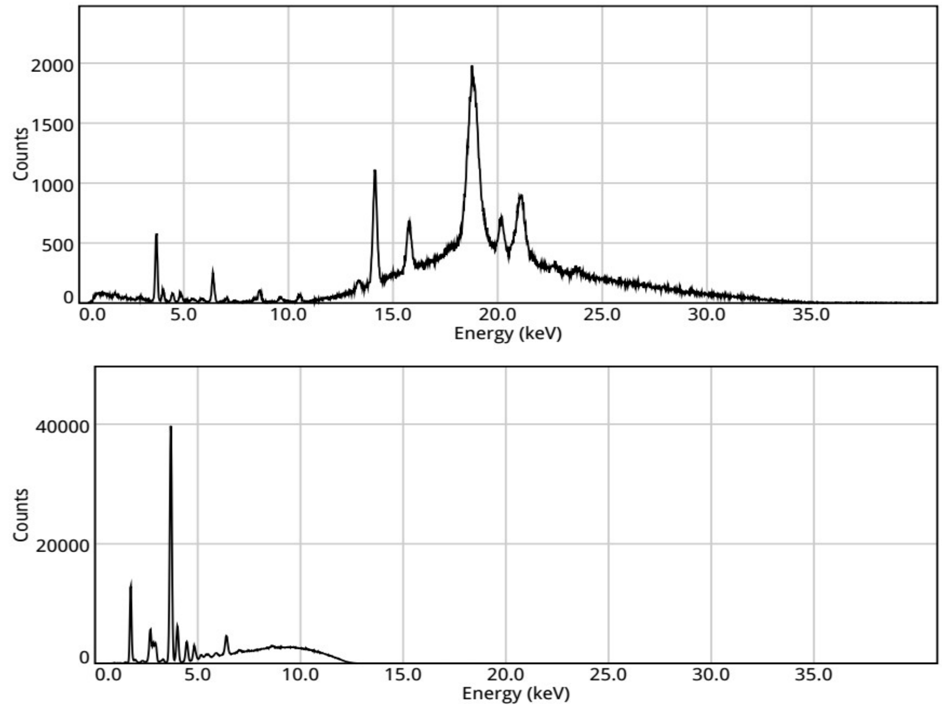

Fig. 2 XRF for milled Gray glass

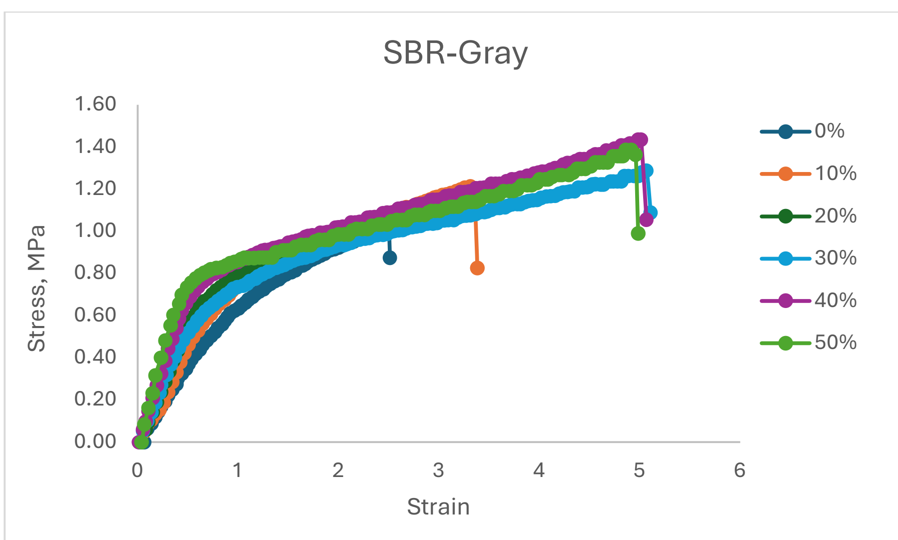

Fig. 3 stress-strain curve of SBR composites with different glass content

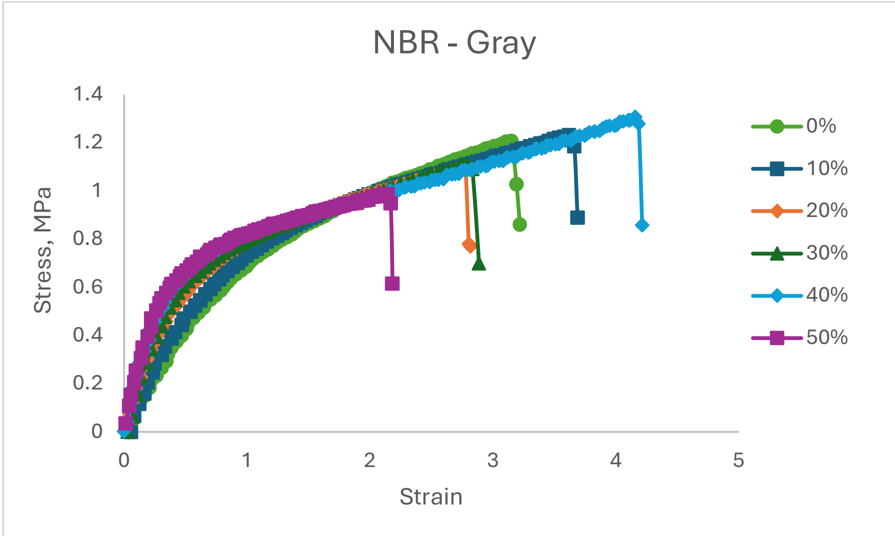

Fig. 4 stress-strain curve of NBR composites with different glass content

Fig. 5 True stress – True stain for micro glass-SBR composites

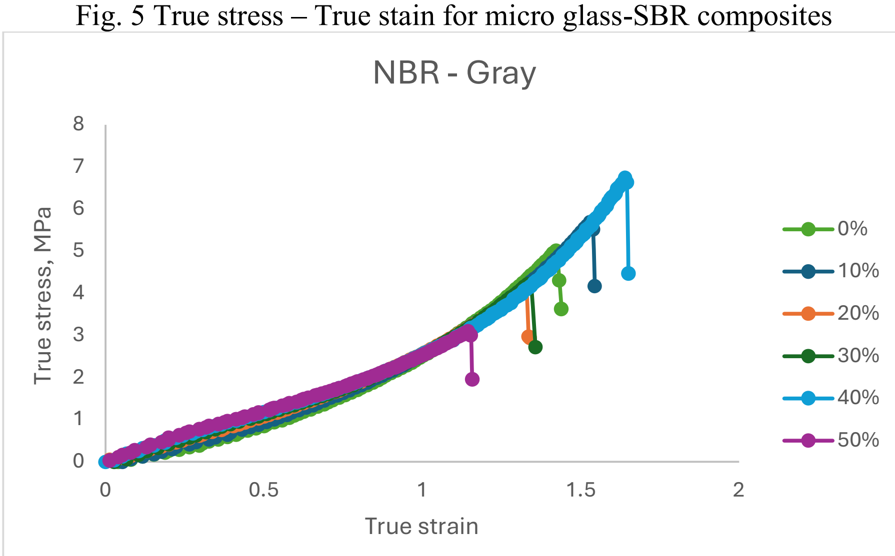

Fig. 6 True stress – True stain for micro glass-NBR composites

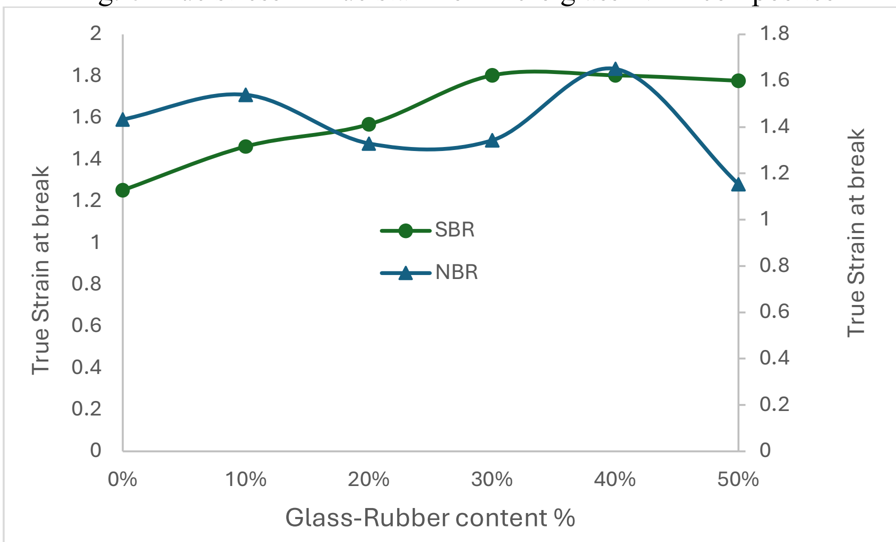

Fig. 7 True strain at break versus micro glass content% for SBR and NBR composites

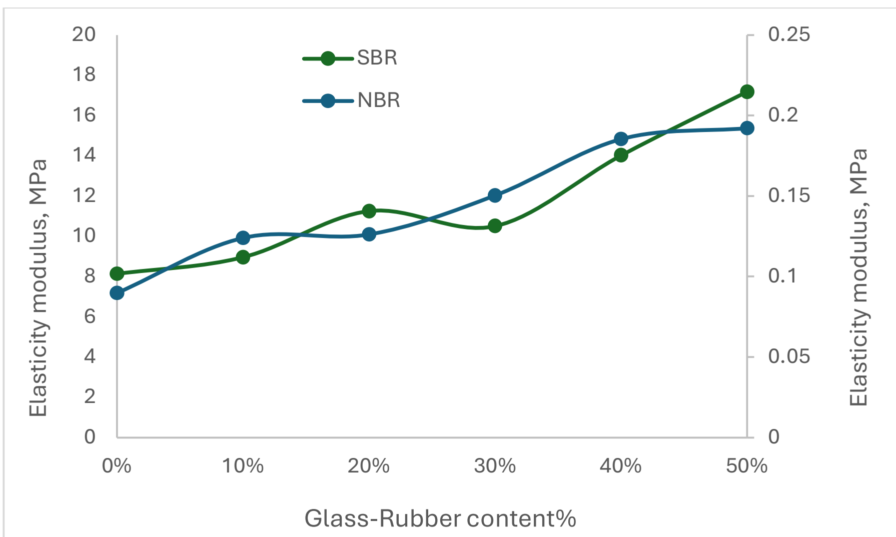

Fig. 8 Modulus of elasticity versus micro glass concentration for NBR and SBR composites

Table 1 SBR formulations with various micro Gray glass concentrations

Ingradients	Phr[1]
SBR	100
ZnO	5
Stearic acid	2
Processing oil	10
MBTS[2]	2

IPPD(4020)[3]	1
Sulphur	2
Micro gray glass	0, 10, 20, 30, 40, 50

[1]Part per hundred parts of rubber by weight

[2]MBTS: methylebenzthiazyle disulfide (accelerator)

[3]IPPD 4020: N-isopropyl-N'-phenyl-p-phenylene diamine (antioxidant, antiozonant, and antiflex)

Conclusion

In this research, the filler, Gray Glass powder was added to SBR/NBR blends in different proportions. Various physical properties of the compounds were experimentally investigated. The maximum values obtained for each of the mechanical properties Different results were obtained at different proportions of Orange Glass powder. Mainly, it is seen that most of the mechanical properties are showing maximum values at 40 phr. Therefore, in conclusion, SBR with 50% by weight of Gray Glass powder shows better combination of properties than other samples.

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