Int. J. Chem. Sci.: 14(4), 2016, 2439-2449
ISSN 0972-768X
www.sadgurupublications.com

EFFECT OF RECLAIM RUBBER LOADING ON THE MECHANICAL PROPERTIES OF SBR COMPOSITES

AHMED M. AJAM, SAMEER HASSAN AL-NESRAWY[*] and MOHAMMED AL-MAAMORI[a]

College of Education for Pure Science, University of Babylon, HILLA, IRAQ
[a]College of Materials Engineering, University of Babylon, HILLA, IRAQ

ABSTRACT

This article explores the possibility of using mix of reclaim rubber as reinforcement in styrene-butadiene rubber (SBR). Mix of reclaim rubber used in this research to enhancement some of the mechanical properties of SBR as additives or fillers. Six different compound was prepared from SBR (100 pphr) and loading level from Reclaim rubber (0, 50, 100, 150, 200, 250) pphr in series while the hardness, tensile strength, tear résistance, elongation, elastic modulus and specific gravity have been studied in this research. We found that some of these properties are increasing with the increment of mix of reclaim rubber loading, such as tensile strength, elongation, tear resistance, specific gravity from other hand hardness, elastic modulus, were decreased with increment reclaim rubber loading %.

Key words: Composite materials, Mechanical properties, Waste of rubber, R. R.

INTRODUCTION

The blending of two or more types of rubber is a useful technique for preparing materials with superior properties, which are absent in the component rubbers[1-4]. The mechanical behavior of a polymer is strongly dependent on its morphology, which in turn is influenced by the thermo-mechanical history during processing. Molecular orientation affects the crystallization behavior in two different aspects: Thermodynamics and hydrodynamic. The thermodynamic effect involves the reduction of entropy in extended chains and this will increase the opportunity of crystal formation by increasing the melting point, while kinetically the extended chain is closer to a crystal state than a random chain. The hydrodynamic effect is a phase transformation, which is responsible for the resultant morphology[5]. The present authors[6] have dealt with the various reclaiming processes of vulcanized rubber in the presence of different chemicals. Mechanochemical reclaiming of

---

[*]Author for correspondence; E-mail: samiralnesrawy@yahoo.com; Mo.: 009647801889584

ground vulcanized rubber was reclaimed by diaryl disulfide and process oil at 110°C for 10 min in an open cracker cum two roll mixing mill[7]. The mechanical reclaiming of ground rubber tire (GRT) by tetramethylthiuram disulfide (TMTD) as reclaiming agent, the extent of reclaiming and the performance evaluation of NR/RR blend were studied by the authors[8,9].

Styrene-Butadiene Rubber (SBR): Is synthetic copolymer, chemically SBR is a copolymer of styrene and butadiene typically containing about 23% styrene and 77% polybutadiene with a glass temperature (T_g) is about -55°C, see Fig. 1[10,11].

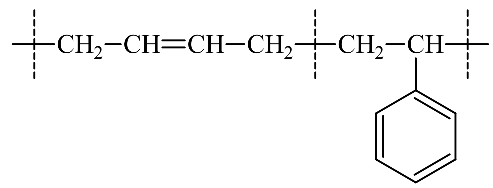


Fig. 1: Compositional formula of SBR Rubber

Reclaim rubber is a rubber-compounding ingredient. Scrap rubber, unlike scrap steel, undergoes a special process before it can be reused and the obtained rubber at the end of this process is known as reclaimed rubber[12]. Reclaim is in fact a mixture of rubber, carbon black, oil, zinc oxide, stearic acid, and other compounding ingredients used in the original compounds. It is lowers the green strength and tensile strength of the compounds in which it is used. Reclaim can be used in many tire applications such as internal casings components and inner liner compounds, sidewalls, chafers, and rubber used in bead components[13].

Vulcanizing Agents: Sulfur is the most well-known vulcanizing agent. It is easily available in powder and prilled form packed in polyethylene bags. Sulfur vastly improves the properties of raw rubber, which is sticky and soluble in solvents. With the addition of sulfur, rubber is converted into a nontacky, tough, and elastic product[14].

This article study some of the mechanical properties such as tensile set and specific gravity and hardness, specific gravity tests were carried out by Densitron according to Archimedes principle, it was weighed in air and in water. The specific gravity is calculated by the following equation:

$$\text{Specific gravity} = \frac{\text{Weight in air}}{\text{Weight in air} - \text{Weight in water}} \times \text{Specific gravity of water} \quad \ldots(1)$$

So, we can calculate the tensile strength (T.S.) by the equation;

$$T.S. = F/A \quad \ldots(2)$$

where F is the observed force required to break the specimen and

A is the cross sectional area.

Young's modulus was reported as the slope of the initial linear region of the stress–strain. Actual experimental values were reported as stress–strain curves. The stress (σ) and strain (ε) are described by the following expression[15];

$$\sigma = (\text{Force or load F})/(\text{Cross sectional area A}) \quad \ldots(3)$$

$$\text{Strain } (\varepsilon) = (L-L_o)/L_o \quad \ldots(4)$$

Thus, Young's modulus in a tensile test is given by;

$$E = \Delta\sigma/\Delta\varepsilon \quad \ldots(5)$$

Therefore, the ultimate elongation is mathematically calculated by the relation;

$$E = [(L-L_o)/L_o]*100\% \quad \ldots(6)$$

where L_o = Initial thickness and

L = Final thickness.

with respect to the tear strength or the tear resistance in rubber, it may be described as the resistance for growing a neck or cut when the tension is applied on the specimen and it depends upon the width and thickness of the test piece and the test results as the load necessary to tear specimen of standard width and thickness.

$$\text{Tear strength} = F*t_1/t_2 \quad \ldots(7)$$

where F = Maximum force,

t_1 = Thickness of standard piece and

t_2 = The measured thickness of the specimen tested.

Hardness may be defined as resistance to indentation under specific conditions. This test is conducted on rubbers in accordance with ASTM D2240-75, ASTM D1415-68, and ASTM D531-78.

EXPERIMENTAL

Materials

The SBR used is SBR–1502 with 23.5% styrene content (made by the emulsion process), Supplied by the Petkim, Turkey. The Properties of SBR are listed in Table 1. The properties of reclaim rubber are listed in Table 2.

Table 1: Properties SBR 1502

Properties	
Density (g/cm^3)	0.95
Bound styrene	23.5 ± % max
Volatile matter	0.75% max
Ash	1.5% max
Soap	0.5% max
Organic acid	4.7-7.2%

Zinc oxide (97%) and stearic acid (99.4%) were supplied by Durham, U.K. MBS [N-oxydiethylenebenzothiazole 2-sulfonamide] (98.2%) is supplied by ITT, India. Paraphenic oil was supplied by the South Patrol Company. Sulfur was supplied by the Durham, U.K.

Table 2: Properties of reclaimed rubber products

Type of reclaim	Hardness shore A	Resilience (%)	Tensile strength (Mpa)	Elongation at break (%)
Mechanical waste NR/SBR (1:1)	61	22	6.6	270
Mechanical waste NBR	63	5	6.8	220
Mechanical waste CR	64	12	4.6	230
Truck tires 80-100% NR	58	35	4.4	200
Passenger car tires 80–100 SBR	60	22	7.4	200

Equipments

Laboratory mill: Baby mill was used, the two roll mills, having provisions for passing cold water. These rolls are cylindrical in shape and of 150 mm diameter and 300 mm length. The roll speed is 20 r.p.m. The hydraulic press is equipped with thermocouple and maximum temperature is equal to 300°C and vulcanization process done at 20 min. Ingredients of SBR composite are listed in Table 3.

Table 3: Ingredients of SBR composite

Compounding ingredients	Ratio pphr
SBR (Styrene-butadiene rubber)	100
R. R. (Reclaim rubber)	0, 50, 100, 150, 200, 250
Zinc oxide	3.5
Stearic acid	1.25
TMTD	1.75
Sulfur	1.75

Equipment for the measurement of tensile strength, tear resistance, elongation and modulus of elasticity

Tests are carried out on samples, which were prepared mill laboratory according to ASTM D412. Monsanto T10 tensometer was used. The test sample, which is movable at speed of 200 mm/min for all except tear resistance at 50 mm/min.

Equipment for hardness

The International Hardness test is used in measurement of the penetration of rigid ball according to Brinall method into the rubber specimen. The measured penetration is converted to the international rubber hardness degrees. The scale of degrees is so chosen that zero represents a material having elastic modulus equal to zero and 100 represents a material of infinite elastic modulus. The scale covers all the normal range of hardness. Test was carried out according to ASTM D1415 specifications.

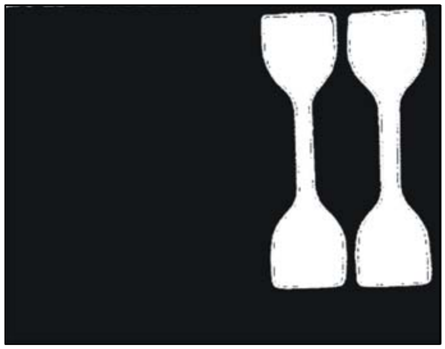
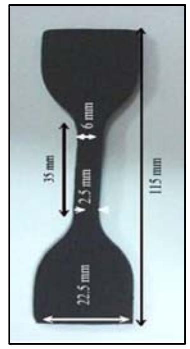
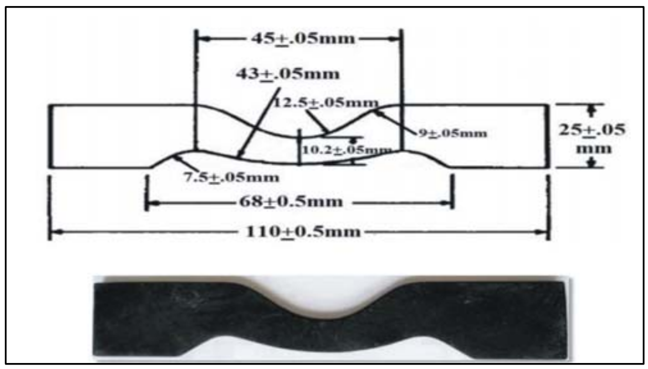
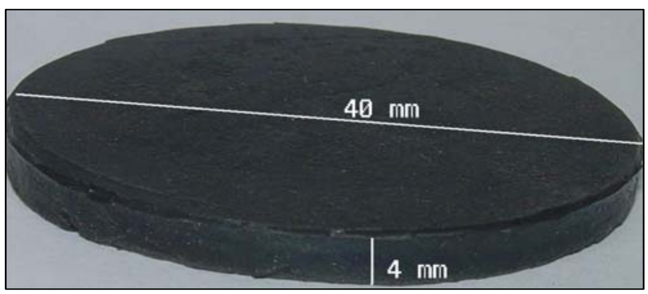
Equipment for specific gravity measurement

Mansanto-Densitron equipment was used to measure the specific gravity. The operating of equipment according to Archimedes principle the sample prepared was weighed in air then in water the resulting data were given to the compile, which was linked to the equipment.

Moulds preparation

The necessary moulds were manufactured for test samples to study their mechanical properties according to British standard (BS).

Table 4: The dimensions of the samples and forms

Standard	Samples and dimensions	Test
ASTM D 3182 & ASTM D 13192	 	Tensile & Modulus & Elongation
ASTM D 624-54		Tear Resistance
ASTM D 1415		Hardness & Specific Gravity

Mould for preparing samples for tensile, tear, elongation, and modulus tests

For preparing samples for the above tests, the sheet sample from each recipe with a dimension of 150*150*2.5 mm was prepared by using mould, which consists of three parts, the middle one in a dimension of 395 mm*158 mm*2.5 mm contains six sections with 150*150*2.5 mm dimension fixed on base of 395*160*10 mm and covered with a cover of the same dimension as that of the base for regulation of thickness.

Mould for testing hardness and specific gravity

For preparing samples for hardness, impact and water absorption, the mould in the laboratories of Tyre Company was used the mould consists of three parts, the middle part in a dimension of 200*180*6.5 mm, which contains nine circular equivolume open with 65 mm diameter and 5 mm thickness while one of other two parts is bottom base and the other is a cover for the purpose of samples thickness regulation. They have a dimension of 150*150*10 mm.

Samples preparation

Hand-made wooden molds has been used with measurements and dimensions according to the American Society for testing and Materials (ASTM). Table 4 shows the dimensions of the samples and forms.

RESULTS AND DISCUSSION

Tensile, elongation, modulusm and tear resistance

Figs. 2-5 show that the increasing of loading ratio of reclaim rubber causes increasing in tensile strength, elongation and tear resistance, because of increasing cross-link between rubber and filler, and this result due to sulfur presence in reclaim rubber, which leads to increased cross-link density between the rubber chains as well as the existence of the proportion of carbon black and thus the cross-link density increase gradually and this go along with[15,16], while the elastic modulus inversely proportional to the increase in elongation in the rubber chains lead to reduced elastic modulus of material and give a spongy elastic property.

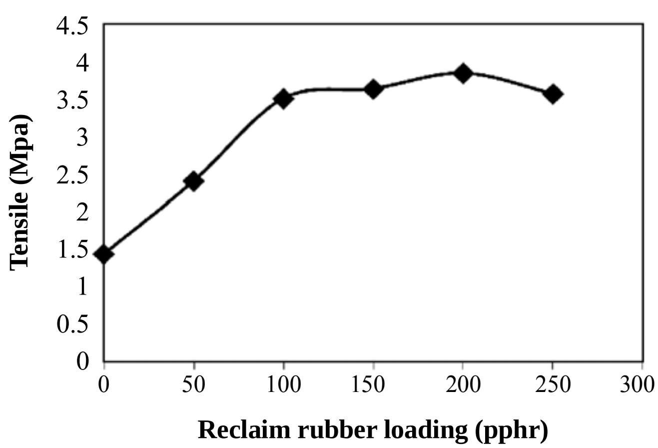


Fig. 2: Effect of adding reclaim rubber on tensile strength

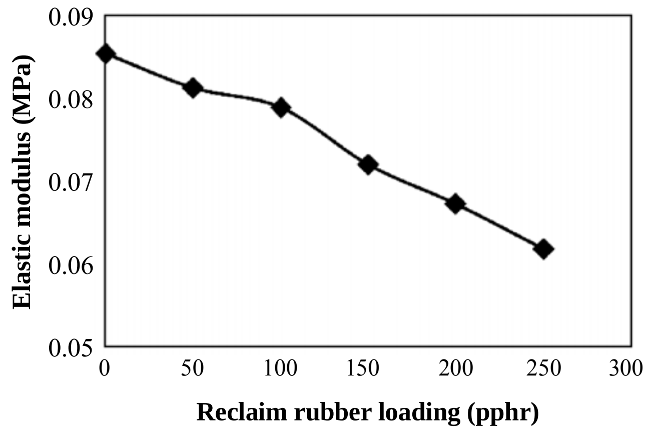


Fig. 3: Effect of adding reclaim rubber on elastic modulus

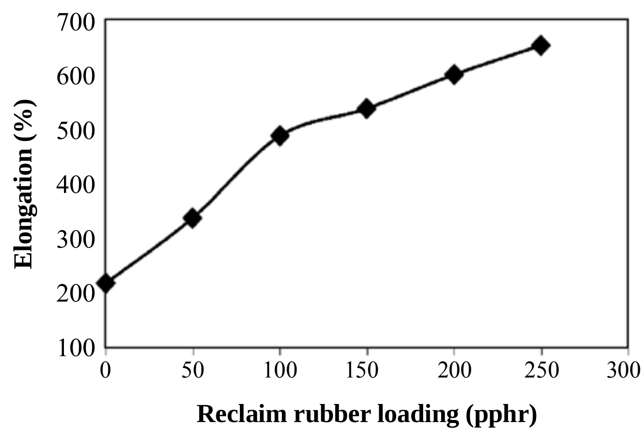


Fig. 4: Effect of adding reclaim rubber on elongation

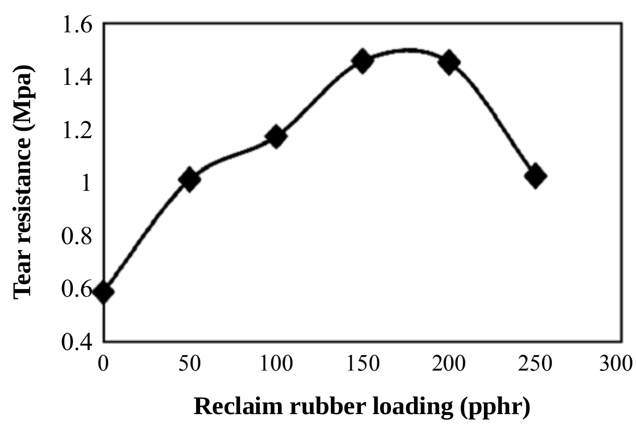


Fig. 5: Effect of addingreclaim rubber on tear resistance

Hardness

Fig. 6 show that the increasing of loading ratio of reclaim rubber causes decreasing in hardness, and this result due to reclaim rubber contain proportion of processing oil, which in turn leads to sliding and divergence of rubber chains that lead to decreasing ability to resist penetration surface and this go along with[17].

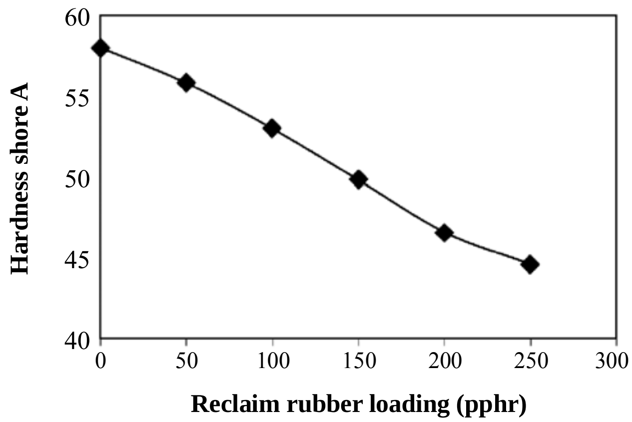


Fig. 6: Effect of adding reclaim rubber on hardness

Specific gravity

Fig. 7 show that the increasing of loading ratio of reclaim rubber causes increasing in specific gravity because of increasing cross-link between rubber and filler and thus material is more stacked, lead to decrease formed pores within the sample and converge the molecules of material from each other.

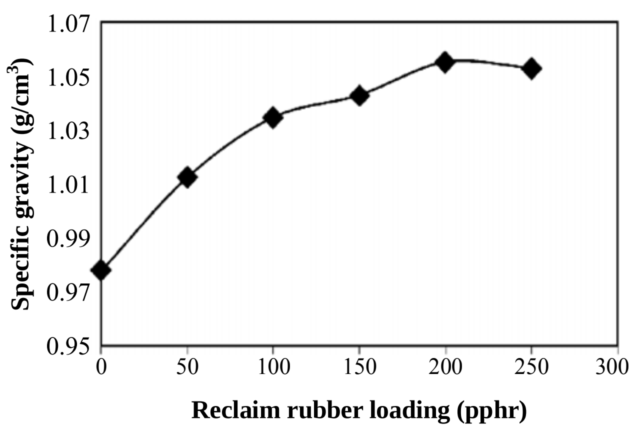


Fig. 7: Effect of adding reclaim rubber on specific gravity

Therefore, it works reducing of weight for unit size due to sulfur presence in reclaim rubber, which leads to increased cross-link density between the rubber chains as well as the existence of the proportion of carbon black and thus the cross-link density increase gradually and this go along with[15].

CONCLUSION

(i) The increasing of additives ratios of reclaim rubber due to increase the tensile strength, elongation, and tear resistance.

(ii) The increasing of additives ratio of reclaim rubber causes decreasing in elastic modulus.

(iii) The increasing of additives ratios of reclaim rubber causes decreasing in hardness.

(iv) The increasing of additives ratios of reclaim rubber due to increase the specific gravity.

REFERENCES

1. S. H. Al-Nesrawy, M. H. Al-Maamori and H. R. Jappor, Effect of Temperature on Rheological Properties of SBR Compounds Reinforced by some Industrial Scraps as a Filler, Int. J. Chem. Sci., **14**, 1285-1295 (2016).

2. J. B. Gardiner, Curative Diffusion Between Dissimilar Elastomers and its Influence on Adhesion, Rubber Chem. Technol., **41**, 1312-1328 (1968).

3. M. E. Woods and J. A. Davidson, Fundamental Considerations for the Covulcanization of Elastomer Blends, II. Lead Oxide-Activated Cures of NBR–EPDM Blends, Rubber Chem. Technol., **49**, 112-117 (1976).

4. V. A. Shershnev, Vulcanization of Polydiene and other Hydrocarbon Elastomers, Rubber Chem. Technol., **55**, 537-574 (1982).

5. A. H. Al-Noumannee, Effect of Carbon Black and Silica on Physical and Mechanical Properties of NR and SBR Blends and Composites, Ph.D. Thesis, University of Baghdad, Iraq (2010).

6. B. Adhikari, D. De and S. Maiti, Reclaim and Recycle of Waste Rubber, Prog. Polym. Sci., **25**, 909-948 (2000).

7. G. K. Jana and C. K. Das, Devulcanization of Natural Rubber Vulcanizates by Mechanochemical Process, Polym. Plast. Technol. Eng., **44**, 1399-1412 (2005).

8. D. De, A. Das, B. Dey, S. C. Debnath and B. Roy, Reclaiming of Ground Rubber Tire (GRT) by a Novel Reclaiming Agent, Eur. Polym. J., **42**, 917-927 (2006).

9. D. De and G. M. Singharoy, Reclaiming of Ground Rubber Tire (GRT) by a Novel Reclaiming Agent, Part 1: Virgin Natural Rubber (NR)/Reclaimed GRT Vulcanizates, Polym. Eng. Sci., **47**, 1091-1100 (2007).

10. R. H. Gray, Materials and Compounds, Akron University, Ohio, USA (1986).

11. Y. S. Kitagawa, A. Nakafutami, Y. Yamada, H. Karouji and T. Aoyagi, New Technology Polymer for Tyres, Journal Rubber World, **214**, 38 (1996).

12. V. C. Chandrasecaran, Essential Rubber Formulary: Formulas for Practitioners, William Andrew Inc, USA (2007).

13. S. H. Al-Nesrawy, M. H. Al-Maamori and Hamad Rahman Jappor, Effect of Mixed of Industrial Scraps and Lamp Black Percent on the Mechanical Properties of NR70/SBR30 Composite, Int. J. PharmTech Res., **9**, 207-217 (2016).

14. M. Leny, Development of Elastomeric Hybrid Composite Based on Synthesised NanoSilica and Short Nylon Fiber, Ph.D. Thesis, Cochin University of Science and Technology, India (2009).

15. S. H.AL-Nesrawy, Effect of Mixture of Reclaimed Tire and Carbon Black Percent on the Mechanical Properties of SBR/NR Blends, Int. J. Adv. Res., **2**, 234-243 (2014).

16. D. Debapriya, K. P. Prabir, R. Madhusudan and B. Satyaban, Reinforcing Effect of Reclaim Rubber on Natural Rubber/Poly Butadiene Rubber Blends, Materials and Design, **46**, 142-150 (2013).

17. R. Israa, Design of Rubber Humbs from Pollutant Materials and Study their Mechanical Properties, M.Sc. Thesis, University of Babylon, Iraq (2012).

Accepted : 23.09.2016