Improvement The Mechanical Properties of Styrene Butadiene Rubber by using Silica Fume

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Abstract—Styrene butadiene rubber (SBR) is considered to be one of the greatest important polymeric materials used as a bond, so we discussed in this study to improve its properties. This study covers the effect of silica fume on mechanical properties of styrene butadiene rubber reinforced with silica fume. The composites were prepared with (1 to 3 wt. %) of silica fume particles. The results had indicated that the tensile strength and flexural strength are improved by (11.6% and 13.5%) respectively at 2 wt% and the hardness is improved by (9.3%) at 3wt%.

Index Terms—Silica Fume; Composite Materials; Styrene Butadiene Rubber.

I. INTRODUCTION

Recently, interest in using of high performance polymer composite materials is increased for engineering applications. In order to produce safe and economic parts, those materials must have exceptional mechanical and tribological properties joint with highly resistance to degradation and low weight [1],[2]. SBR is considered to be one of the greatest rubbers that is used in the industrial applications. The production of this synthetic SBR was not actively pursued in the United States or elsewhere in the world until the supply of natural rubber had been curtailed by war activities in the Pacific during the late 1930s and early of the 1940s decay [3]. In addition, SBR is widely used in industrial applications as a synthetic rubber. SBR has high filler-loading capability, high resistance to flex, high resistance to initiation of crack, and scratch resistance that make the SBR very valuable in numerous engineering and industrial applications [4]. In composites applications, SBR is used as the main matrix. There are many researches have investigated the effect of fillers and additives on the SBR performance. However, some researches focus on studying the mixture of SBR with other rubbers materials that could be used in composite and nano composites applications. Guo et. al. worked on the SBR nano composites with nanotubes and with presence of methacrylic acid [5]. Gu and coworkers combined styrene butadiene rubber with natural rubber to form main matrix for nano composites preparation [6].

They used organobentonite on the SBR/NR based nano composites and reported that the nanobentonite improved mechanical properties of rubbers. Melt mixing has been recognized for its flexibility and proper to use especially for

industrial applications. For styrene butadiene rubber based nanocomposites, melt mixing could be one of the main routes for preparing the nanocomposites. Lai and coworkers prepared nanocomposites based styrene butadiene rubber by melt mixing [7]. They mixed their materials with batch mixer. For enhancing the properties, they used from clay nanoplatelets with this mixing method. Mohan and coworkers used banbury mixer for preparation styrene butadiene rubber and natural rubber compounds for assaying mechanical properties [8]. In this work, we use from two roll mills for mixing styrene butadiene rubber with nano iron oxide to prepare nanocomposites. Some researchers used nano particles or nano platelets for enhancing properties of SBR based nanocomposites. Some researchers used nano clay for enhancing SBR based nanocomposites properties [9]. In these papers, characterization of nanoclay/SBR nanocomposites especially mechanical properties has been investigated. Additionally, other researchers studied the effect of nano particles such as silica nano fillers and nano CaCO_3 on the physical and mechanical properties of SBR based nanocomposites [10].

However, there are limited studies on the influence of silica fume on physical and mechanical properties of the SBR based composite materials. Hence, in this research paper the influence of silica fume on the mechanical properties of SBR. The obtained test results are discussed in detail in the following parts of the present study.

II. EXPERIMENTAL

A. Materials

The SBR as main matrix of composites is SBR 1502 which purchased from Jilin Rubber Co. Ltd. in China. The Styrene content is 22.5% and Rubber Mooney viscosity ML (1+4) 100°C. Curing system was used Sulfur, Zinc Oxide, stearic acid as accelerator activator and MBT (2-Mercaptobenzothiazole) as accelerator. Silica fume particles which purchased from Jordan / BASF company and typical properties of silica fume was shown in Table I and II respectively.

TABLE I: TYPICAL PROPERTIES OF SILICA FUME

Form	Undensified powder
Thermal stability	-10 °C - +50 °C
PH value	Neutral
SiO ₂ content	≥ 85%
Colour	Gray
Bulk density	150 – 300 Kg/m ³
Physiological effect	Neutral

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TABLE II: PARTICLE SIZE OF SILICA FUME

Finer than 5 micron	99.9%
Finer than 2 micron	99%
Finer than 0.5 micron	96%
Finer than 0.2 micron	60%
Finer than 0.1 micron	20%

B. Molds

The molds used to fabricate tensile specimens are made from wood while molds used to fabricate other specimens are made from carbon steel. To prevent the sticking between the cast specimens and the mold's wall, the internal base and walls of the molds were coated with a thin layer of release agent

For tensile and flexural tests, five samples were fabricated while one sample was prepared for hardness test. Five readings for the hardness were taken from different places of the sample to get high accuracy of the results.

C. Preparation of Samples

For styrene butadiene rubber based composites, the melt mixing processing could be one of the main routes for preparing the composites. In preparation of rubber materials like styrene butadiene rubber, the first stage is mastication. Rubbers like SBR have high viscosity which produced difficult conditions for sample compounding. For decrease the long of chains of polymer in rubber materials, the mastication process should be done for good preparation of samples.

Hence, in rubber compounding, first SBR was masticated by two roll mills. For this purpose, SBR was entered in to the two roll mills mixer over and over. This process caused more shear stress on the SBR chains and resulted to decreasing of molecular weight of SBR compounds. Mastication stage was done for about 5 minutes; Fig. 1 illustrates the position of the tested samples.

Fig. 1. Dividing plate into testing specimens

D. Mechanical Test

1) Tensile Test

The tensile test is carried out by using the computer controlled universal mechanical test (model TINIUS OISEN 100 KN) as presented in Fig. 2.

The tensile test is used to determine tensile properties of PNCs such as tensile strength, percentage of elongation at break and the modulus of elasticity following the ASTM D638M-87b standards. The test is carried out at room temperature and the strain rate is constant (1mm/min) with the using of dumbbell formed samples as presented in Fig. 1.

Fig. 2. Tensile tester

2) Flexural (Bending) Test

Flexural test was done according to ASTM D790 by using microcomputer controlled electronic universal mechanical test machine at room temperature with (5 mm/min) speed rate as shown in Fig. 3.

Fig. 3. Testometric instrument (Flexural test instrument)

3) Hardness Test

Hardness test was done at room temperature by using Shore (D) No. DW53505 following the ASTM D2240 standard.

III. RESULTS AND DISCUSSION

A. Ultimate Tensile Strength (UTS)

The UTS results of silica fume reinforced with a variable weight fraction of (SBR) were shown in Fig. 4. This figure indicated a nonlinear relationship between increasing of the UTS and increasing of silica fume in up to 2wt% of (SBR) composite then UTS is decreased with increasing of the silica fume.

Fig. 4. Effect of silica fume wt. % on tensile strength

B. Flexural Strength

When 1-2 wt. % of silica fume is used, it improves the bending properties with the highest value of flexural strength 27.6 MPa at 2 wt. % and then decreases the bending properties when increasing silica fume more than 2 wt. % as shown in Fig. 5.

Fig. 5. Effect of silica fume wt. % on flexural strength

C. Hardness Test

The relationship between the percentage of silica fume and hardness is a direct relationship, where the greatest value of hardness 93.7 MPa was taken place with 3 wt. % of silica fume/SBR as shown in Fig. 6

Fig. 6. Effect of silica fume wt. % on hardness

IV. CONCLUSION

This study refers to the effect of adding particles of silica fume on some mechanical properties of styrene butadiene rubber. It can be concluded that small amount (1–3 wt. %) of silica fume in the styrene butadiene rubber caused an increasing the mechanical properties of the silica fume /styrene butadiene rubber composite. When the amount of silica fume is 2 wt. %, the tensile strength and flexural (bending) strength are improves by (11.6% and 13.5%) respectively. When the amount of silica fume is 3 wt%, the hardness is improved by (9.3%).

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