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# Brief Notes on The Effect of A Laser Treated on Nano Aluminum Trioxide on The Behavior of Composite Carbon Black Rubber

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**Abstract**

Rubber-based composites are widely used especially in transportation. The goal of this paper is to study the mechanical properties of rubber-based composites of carbon black and Nano Aluminum trioxide additive (50 nm). Various percentage of carbon black was used (20,40, and 60 phr). The increase in Carbon black percentage shows an increase in mechanical properties of the composites (for 60 phr properties tensile test improve by 49%, for hardness resistance the improve was 21%, and for the wear test the composite improve by 22%). Various wetting percentage of nano Aluminum trioxide was used (1,1.5,2, and 2.5 %). Increasing the wetting percentage increase tensile strength (27%, hardness resistance increase by 28%, and wear resistance increase nonlinearly with a percentage reaching 70%). Selecting the optimal composition of the two fillers, then study different irradiances for it with the ultraviolet laser of moderately low energy after the vulcanization process. Post ultraviolet laser of (345 nm). Furthermore, laser vulcanization shows improvement in mechanical properties.

**Keywords:** rubber composites; Nano composite; laser vulcanization

## 1- Introduction

Traffic safety has been significantly threatened by the increase in vehicle speed, making vehicle movement performance a general study topic. The steering stability of automobiles and the friction properties of tires are intimately related, and the importance of the two aspects to vehicle safety has grown. Tire and automobile control circles have been paying more and more attention to tire friction characteristics on snowy roads. It is worth to mention that, the engineering consideration alongside the simulation and optimization is the modern methodologies to address the real-world problem [1–10], however, the experimental-based analysis is equally important, to rectify, enrich or even reform the assumptions and correct considerations. As such, this work is intending to address the problem with both concepts .

Rubber is used widely in many industrial and domestic applications such as road tires, belts, dash ports, etc. Rubber is usually used in form of composite materials. Many researchers work on rubber composite enhancements. S. Varghese et.al [11], they study silica impact on the mechanical properties of natural rubber (NR), and showed enhancement in them generally; Jiwon Choi et al [12] explore the concept of composite construction simultaneously at nano- and macroscopic length scales by combining molecular level hybridization using a silsesquioxane epoxy nanocomposite with macroscopic modification using core−shell rubber particles and examine fracture toughness and thermal stability; Yonglai Lu et al [13] examine zinc dimethacrylate within styrene butadiene rubber in forming process and also the end product morphology of the composite using scanning electron microscopy (SEM). Bobby Russell et al [14] used (SEM) and atomic force microscopy (AFM) to determine the morphology and phase distribution of the rubber particles and measure the mechanical properties of the rubber particles using (AFM) to understand how the changes in morphology and mechanical properties measured at the micro and nano-scales affect both the elastic modulus and fracture toughness of rubber-modified epoxy polymers. Ling Yang et al [15] combine PVC and silicon rubber with Nano $CaCO_3$ to improve its mechanical properties. Huang Ying et al [16] studied the influence of adding nano-$SiO_2$ materials on the electrical and mechanical properties of rubber-based composite for a certain application. Ali Samadi [17] studied

nano clay's effect on the mechanical and physical properties of rubber.
Fillers contain such as for tire applications. The mostly filler used is carbon black, with other aided contains. Carbon black gives generally good mechanical properties, as well as it is considerably cheap. To improve composite materials, the interest in nanomaterials as aided filler is increase in recent years, such as metallic oxides and carbides. Nanomaterials have superior properties to bulk materials.
Vulcanization is very important in the industrial application of Rubber. Without it, considering Rubber as used material jeopardizes the application itself. Vulcanization transforms rubber mechanical properties radically; so, modify the polymer by forming cross-links (bridges) between individual polymer chains. Sulfur is the major and one of the first vulcanized agents discovered. Nanomaterials were used in the present work as additives to the rubber recipe, as well as to enhance the mechanical properties of the composite.

## 2- Experimental Works

### 2-1 Preparing samples

The rubber compounds used in this paper were prepared from natural rubber (SMR-20); The recipes with other compounding materials such as filler; vulcanizing agent (sulfur) and accelerator were prepared with the compound formulations as shown in table (1).

**Table 1 Recipe of Rubber composite**

| Material | phr |
|---|---|
| SMR 20 | 100 |
| Zinc oxide | 5 |
| Stearic acid | 2 |
| Paraffin wax | 1 |
| Process oil | 8 |
| Carbon black | 20 , 40 & 60 |
| Sulphur | 2.2 |

The standard vulcanization process for all samples implied that the vulcanization press was primarily heated by an electric source from (30 to 200±1ºC) according to perili co. ltd. specifications and the mold brought to curing temperature within (±1°C) in the closed press, and held at this temperature for at least 20 min before the unvulcanized pieces are inserted. The temperature of the mold is verified by a thermocouple inserted in one of the overflow grooves and in intimate contact with the mold, then the press is opened, after that the uncured rubber composites are inserted into the mold, and the press is closed in the minimum time possible, and insuring moderate time of temperature loss. The experimental samples categorized to three groups, first one is rubber composite of different carbon black phr (20, 40, and 60). The second group of nano rubber composite of different Nano alumina (50 nm) of wetting percentage (1%, 1.5%, 2%, and 2.5%) respectively for the best results of the first stage. The third group represent the optimal combination of the previous two classes with different energy irradiance of dispersed ultraviolet laser after vulcanization process. The third harmonic generation of Nd-YAG laser, of 1064 nm. To scan large areas by pulsed laser beam, partial overlapping method can be used. Overlapping percentage can be calculated according to the relation [18,19].

$$\%\,Overlap = \left(1 - {d_c}/{2r_f}\right) * 100\% \quad \ldots (3)$$

where (*rf*) is radius of spot, (*dc*) center to center spacing; The overlapping percent has been used in this paper 25%. The energy of the third harmonic pulsed laser (345 nm) was 30 mJ of 30µs plus duration. Spot size was 3.5 mm. the entire area was pulsed (0,1,2,3,4 ) times.

### 2-2 Mechanical Tests

#### 2-2-1 Tensile test:

The tensile properties (modulus at 100% elongation, tensile strength and elongation at break) of Rubber composite were tested according to ASTM D412-98 (1998) for (20) different samples at 20ºC, with the use of dumbbell shaped samples . The applied force was (1KN) with a pulling device velocity (20 mm/ min) [20].

#### 2-2-2 Hardness Test

In this work the hardness is done by using two different measurements shore (A) according to ASTM D 2240 [20,21,22,23,24]. Five measurements of hardness were made at different positions on the specimens, let $H_1$, $H_2$ …, $H_5$ be the values of the measured hardness arranged in increasing order of magnitude. The mean hardness value of the five measurements $H$ is defined as follows:

$$H = \frac{1}{5}\sum_{i=1}^{5} H_i \quad \dots (3)$$

The specimen should be at least 6 mm in thickness, the surface on which the measurement was made had to be flat and the lateral dimension of the specimen had to be sufficient to permit measurements at least 12 mm from the edges.

### 2-2-3 Abrasion Wear Resistance: Wear Test

A compatible ASTM apparatus was used to measure weight method wear. Wear specimen was ASTM G99. Wear rate was calculated using weighting method.

## 3- Results and Discussion

### 3-1 Tensile Tests

Tensile tests results of rubber composite with various phr of carbon black is in Figure (1)

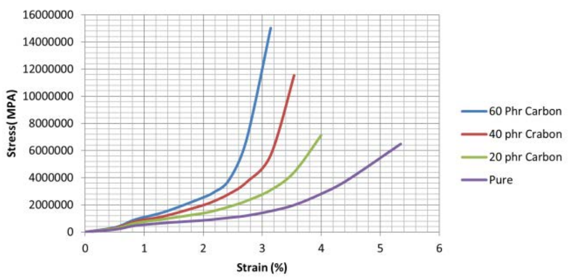


**Figure (1) stress strain for Carbon black rubber composite**

It shows the tendency of tensile strength to increase with increasing carbon black amount in the Micro filler rubber composites. The best properties are to the 60 phr carbon black.

Tensile test of Nano filler Aluminum trioxide volcanized rubber composites is in Figure (2) It shows improve in tensile strength with increasing the wetting percentage of Nano filler.

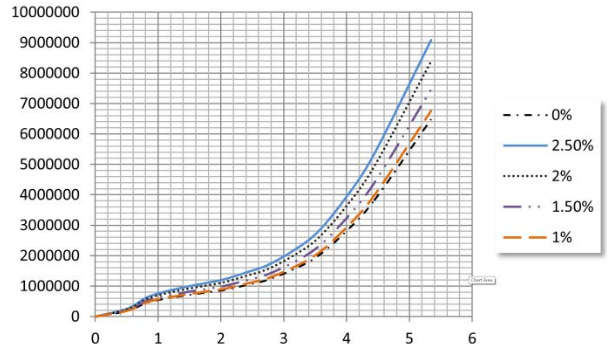


**Figure (2) stress strain for Nano $Al_2O_3$ rubber composite**

Tensile test of Nano filler laser aided volcanized rubber composites of various laser pulse exposure is in Figure (3).

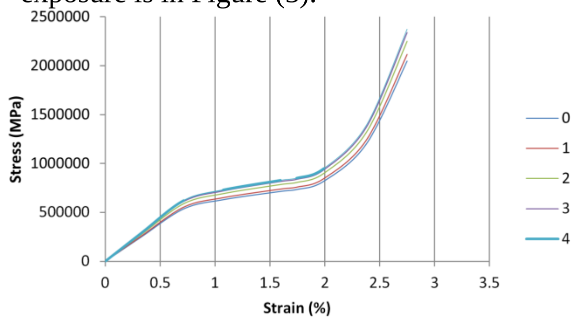


**Figure (3) stress strain for Nano $Al_2O_3$ (2.5%) carbon black (60 phr) rubber composite of various laser pulse exposures**

It show increase in tensile strength with increasing total irradiance of the composite. Nano filler increase laser effect due its nonlinear optical properties, making laser vulcanization more effective.

### 3-2 Hardness Tests

Hardness results of rubber composite with various phr of carbon black is in Figure (4)

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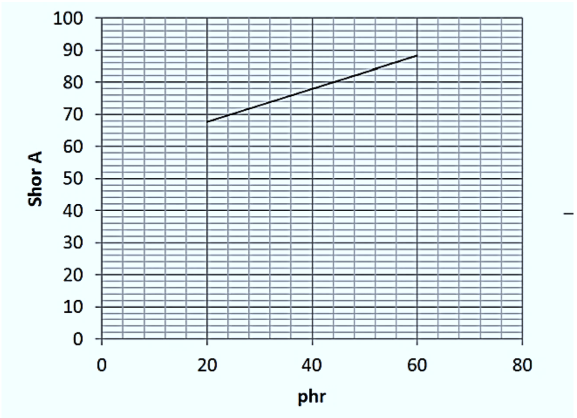


**Figure (4) Shor A hardness for Carbon black rubber composite**

It shows increase in hardness with increasing carbon black contain due to its mechanical properties. Hardness of Nano filler volcanized rubber composites is in Figure (5)

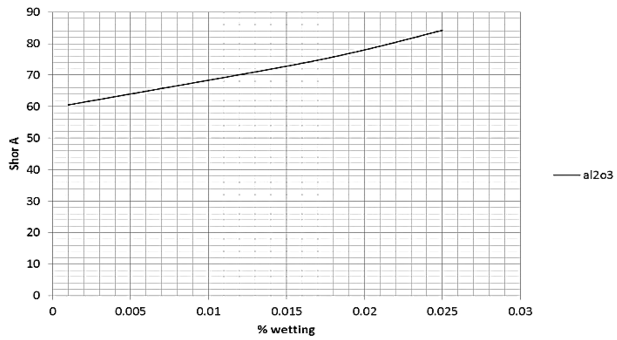


**Figure (5) Shor A hardness for Nano $Al_2O_3$ rubber composite**

It shows increasing in hardness with increasing wetting percentage of the nano filler. Nano filler shows improvement more than for carbon black micro filler as the percentage of the total particle rubber composite, due to the strong mechanical properties of the nano filler and the physical impact of it on the moleculare distribution of rubber with in the whole composite.

Hardness of Nano filler laser aided volcanized rubber composites of various laser pulse exposure is in Figure (6)

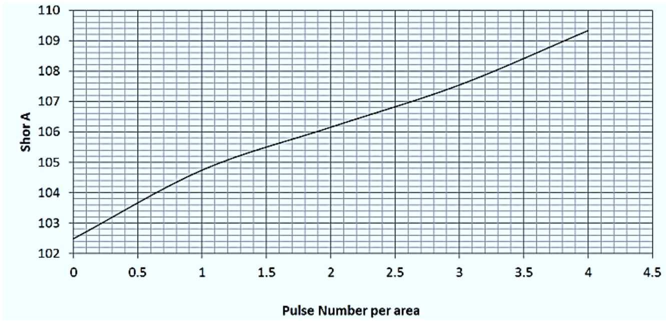


**Figure (6) Shor A hardness for Nano $Al_2O_3$ (2.5%) carbon black (60 phr) rubber composite of various laser pulse exposures**

The composition of micro and nano filler increase the hardness resistance more than for each one effect as shown (Figure (7)).

### 3-3 Wear test

Wear tests results of rubber composite with various phr of carbon black is in Figure (8)

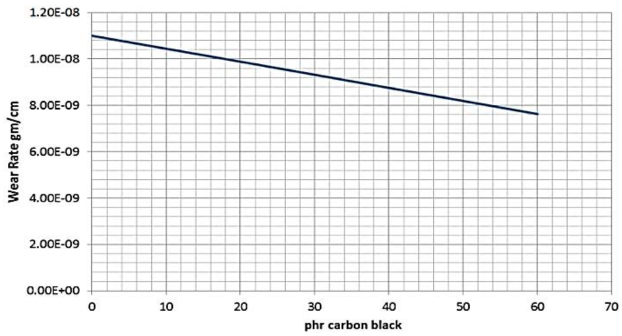


**Figure (8) Wear tests of Carbon black rubber composite**

Carbon black increased wear resistance, and that is what it was expected from hardness test. Hardness of Nano filler volcanized rubber composites is in Figure (9)

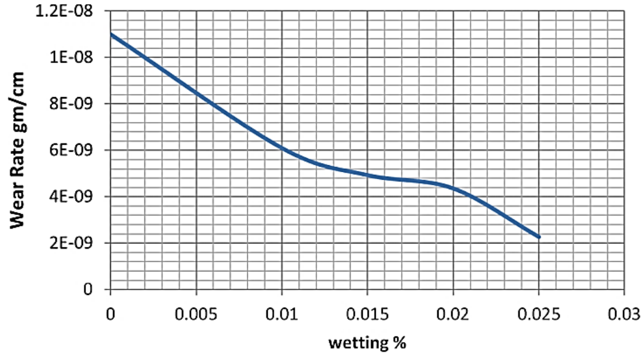


**Figure (9) Wear tests of Nano $Al_2O_3$ rubber composite**

wear resistance also increased as well as hardness; the nonlinearity in wear resistance

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increasing is presented with increasing wetting percentage of Nano alumina; this is due to the complication in surface construction. Considering the Nanomaterials are uniformly distributed within the whole composite; after worn the first layer of the samples, Nano alumina was exposed partially, making it a bit head with a flexible base attachment as shown in Figure (10)

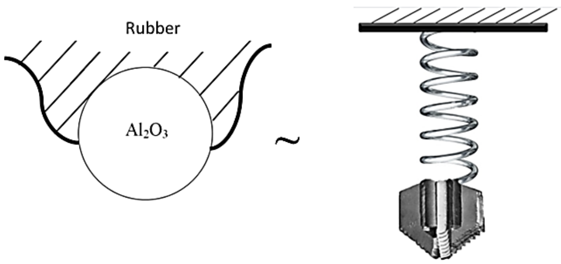


**Figure (10) Nano tip asperity analogy**

The harness of Nano alumina is very high, so it abrade the other contact surface until it peel out of the rubber tray.

Hardness of Nano filler laser aided volcanized rubber composites of various laser pulse exposure is in Figure (11)

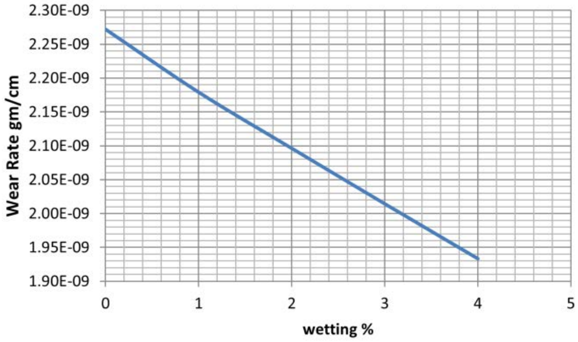


**Figure (11) Wear tests of Nano $Al_2O_3$ (2.5%) carbon black (60 phr) rubber composite of various laser pulse exposures**

Figure (11) shows increasing in wear resistance of the composites. The main effect was for the nano filler in the favors of the micro carbon blac.

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