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Reinforcement Effect of Nano Silica on Tensile set Properties of the Tire side wall Batch

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ABSTRACT

The aim of this research it is to get the best batch of the side wall as tire of the terms of the mechanical properties by using nano silica. This is done by precipitation from water glass by adding hydrochloric acid.

Many tests were conducted on nano silica such as the (XRD, SEM). The results of the tests nano silica prepared that it forms a spherical irregular, which has a high surface area of roughly sizes less than 100 nm exactly in the range of (50-84) nm are confirmed by SEM .With purity of silica is 100% and density of 0.3511 g/cm^3. Sems -amorphous structure at ($2\theta = 21^{\circ}$) is obtained by XRD and after being modified by a coupling agent (APTS) a crystalline peak appears.

Nano silica which is used as filler using the following percentages of (0.02, 0.04, 0.06, 0.08, 0.1, 0.2, 0.4, 0.6, 0.8, 1) pphr to the rubber recipe consisting of styrene butadiene rubber(SBR) / Natural Rubber (RSS) with the optimum constant percent of carbon black (50pphr). Get a perfect blend of nano silica with rubber, it was added modified nano silica worker couplings on the same percentage of nano silica, which protects the surface of the polar silica and reacts with the rubber matrix.

Achieve the effect of nano-silica on the mechanical properties of the side wall tires (Tensile strength, Elongation, elastic modulus, tear resistance) are required. The results showed that the addition of small amounts of nano-silica and modified nano silica, an increase in tensile strength, modulus of elasticity and tear resistance values up to 19.50Mpa, 13.96Mpa and 7.50MPa respectively at 1 pphr of nano silica. The elongation properties decreased by the addition of small amounts nano silica and modified nano silica.

KEY WORDS: composite materials, Mechanical Properties, silica.

1. INTRODUCTION

Composite materials are substances consisting of two or more substances whose physical or chemical properties differ materially when combined, produced with different properties of individual physical components. Individual components remain separate and distinct within the final structure. New materials may be better for several reasons: Common examples include stronger, lighter, and less expensive materials when compared to traditional materials Albert Holder (2013). The increased use of composite materials reinforced advanced dramatically in recent years. High specific strength and stiffness make the candidate composite materials for many available applications. However, fiber backed using thermal resin matrix compounds, such as epoxies, they have a low Accept damage and low service temperatures as compared to conventional materials. Overcome these disadvantages, and there is considerable interest in the use of thermoplastic resins and matrix materials for fiber reinforced compounds. Thermoplastic resin is high in hardness materials in general and can be improved to withstand the damage of composite materials Golam Newaz (1989). An amorphous silica consists of silicon and oxygen atoms arranged in the tetrahedral structure of a three-dimensional lattice with silenol groups (Si-OH) present inside and on the surface. Silica are considered to be a highly polar, reactive filler and the tendency for filler agglomeration rise, because they have a number of surface silenol groups (Si-OH) (Thomas, 2010; Jeffrey, 1990) in composite nano rubber material, due to the interactions of the particles with a solid matrix, and the incorporation of the filler particles in the plastics reduces the move series Thomas, Stephen (2010). Nano silica became more important reinforcing filler for rubber industry. The main reason is the biggest boosts the power of nano silica compared with the carbon black. The use of this method to change the history of stress and breakdown properties of hardness of the material. This is due to the inclusion of filler and behavior overall composite part the impact of the main spasm of particulate filler. An increase in the use of flexible materials in many commercial applications and, as a result of a strong impact is relatively small Menkmyat of filler particles, the mechanical properties of elastomers Jorgen, Mary (1999).

Composite materials Nano major improvements appear in a flame of fire, mechanical properties and thermal stability and other regions Koo (2006). Results boosters increase in modulus and hardness, for plastics. Cut the padding molecules replace part of the matrix, so i the replacement of part of the deformable matrix of solids does not diminish her deformity. The use of reinforcing Fillers lead to the building the same time increasing coefficient and deformation break Mark (2005).

In the rubber industry, tire industry consumes about 70% of the total production of styrene butadiene rubber (SBR), since the SBR has a very good and good corrosion resistance properties suitable for anti-age properties low temperatures (Mark, 2005; Brydson, 1988). Silica which is mainly obtained from rainfall and is used as reinforcing fillers. Precipitated by the reaction of sodium silicate and sulfuric acid are silica prepared under conditions Koo, (2006) alkaline. Precipitated silica is the preferred type of silica used, due to the low price and mix better than textured rubber used to strengthen tires. This is due to the increased use of silica for reinforcement in tires and potential technology in other rubber applications, generally feel that additional study of silica join him with a rubber matrix elements by pairing (Mark, 2005; Brydson, 1988). The Rubber compounding is the art and science of selecting number of different compounding ingredients and their quantities to mix and produce a useful rubber formulation that is process able, meets or exceeds the customer's final product requirements. Some of the ingredients might modify the basic properties of the raw gum elastomer within the compound (Bellanderet, 2006; Stenberg, 2006). Rubber compounding is a highly varied activity in several aspects. Tire compounders generally deal with a relatively small number of compounds that are mixed in extremely large volumes. In the rubber industry, and usually it sets the problem of selection of essential raw materials for the preparation of a specific commercial product for compounder Galimberti (2011). A tire compounder often specializes in one component of a tire, for example sidewall Sommer (2009), The Sidewall compounds consist of natural rubber, SBR along with carbon black and a series of oils and organic chemicals. This part protects the casing from side scuffing, controls vehicle–tire ride characteristics, and assists in tread support (Mark, 2005; Meyer, 2006; Sommer, 2009).

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 Leny (2009). This article study some of the mechanical properties such as tensile set Elongation, elastic modulus, tear resistance, So, we can calculate the tensile strength by the equation; T.S = F/A

Where F is the observed force required to break the specimen.

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 and strain are described by the following expression Al-Nesrawy (2014);

$$\text{Stress } \sigma = \frac{\text{Force or load F}}{\text{Cross sectional area A}}$$

$$\text{Strain } \varepsilon = \frac{(\text{L} - \text{Lo})}{\text{Lo}}$$

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

$$\text{E} = \frac{\Delta\sigma}{\Delta\varepsilon}$$

Therefore the ultimate elongation is mathematically calculated by the relation;

E= [(L-Lo)/Lo]*100%

Where Lo=initial thickness, 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.

Tear .S = $F*t_1/t_2$

Where F=maximum force ,t_1=thickness of standard piece,t_2=the measured thickness of the specimen tested Al-Nesrawy (2014).

2. EXPERIMENTAL TECHNIQUE

Introduction: It describes the experimental work, which is not especially material selection, material properties, silica (SiO_2) to prepare the drafting of a recipe on the tire side wall. And rubber processing technology, roads samples preparation, methods of examination used (mechanical tests).

Materials: The materials used in this research are: Water glass, silica, (3-Amino propyI trimethoxy silane), toluene. The rubber batch materials are Styrene Butadiene Rubber (SBR 1502), Natural Rubber (RSS), zinc oxide, stearic acid, caster oil, sulfur, Rineset Carbon black (N 375), N-phenyl-p- phenylenediamine) (CTP-100), (N-(1,3-dimethylbutyl)-N-phenyl-p-phenylenediamine) (6PPD). Which are supplied by Babylon tire company.

The recipe Formulation of Tire side wall: The rubber nano composite materials to prepare his supporters side wall for tires require numerous mechanical tests that fit the application requirements, such as tensile strength, Elongation, Modulus, tear. This recipe is suitable for applications requiring action to improve those parts of the preparation of some materials to strengthen as silica and blending different proportion of these reinforcements with a recipe for the provision of laboratory models of different recipes for mechanical tests by using standard templates, according to the ASTM. The Standard specification used in this work are those the company Babylon tires for the tire industry, which are described in Table.1.

Table.1. the standard specification for the tire industry (IW8035)

Viscosity (moony viscous)	8-16	Tensile Strength (MPa)	16
Cure time (min)	2.2-3.1	Elongation %	450
Scorch time (min)	0.7-1.5	Modulus	Min7.5
Torque (N.m)	Min22		

This is based on the basic components of the formulation of the recipe used in this work about the basic formulation of the passenger side wall of the tire. Master batch is prepared from Styrene Butadiene Rubber (SBR) and Natural Rubber (RSS) with addition of some of materials (Such as zinc oxide, stearic acid, caster oil, sulfur, Rineset, Carbon black (N 375), N-phenyl-p- phenylenediamine) (CTP-100), (N-(1,3-dimethylbutyl)-N-phenyl-p-phenylenediamine) (6PPD).

After this is done to improve the recipe by reinforcement with nano-silica modification of nano silica as ratio shown in Table.2.

Table.2. Shows The composition of the rubber nanocomposites

Compounding ingredients (pphr)	**Pure composite (pphr)**	**SBR/RSS/Silica nanocomposite (pphr)**	**SBR/(Silica with capouling agent)**
Styrene Butadiene Rubber (SBR)	50	50	50
(Natural Rubber (RSS)	50	50	50
Rineset	0.15	0.15	0.15
Stearic acid	1.0	1.0	1.0
Zinc oxide	5.0	5.0	5.0
Wat	2	2	2
CTP-100	0.13	0.13	0.13
Antiozonant (6PPD)	3.25	3.25	3.25
DOP oil	7.0	7.0	7.0
Sulfur	1.8	1.8	1.8
Carbon black (N-370)	50	50	50
Accelerator (CBS)	1.0	1.0	1.0
Silica	0	(0.02, 0.04, 0.06, 0.08, 0.1, 0.2, 0.4, 0.6 ,0.8, 1)	
modification of nano silica	0	0	(0.02, 0.04, 0.06, 0.08, 0.1, 0.2, 0.4, 0.6, 0.8, 1)

After preparation of the samples from the original recipe and make mechanical tests were compared to the results of tests as shown in Table.3, however, the specifications described in Table.1.

Table.3. Mechanical tests for master batch without silica

Properties	**Value**	**Properties**	**Value**
Viscosity (moony viscous)	13.17	Tensile strength (MPa)	16.5
Cure time (min)	2.22	Elongation%	422
Scorch time (min)	1.17	Modulus (MPa)	9.77
Torque (N.m)	24.70	Tear resistance (MPa)	5.80

Models preparation:

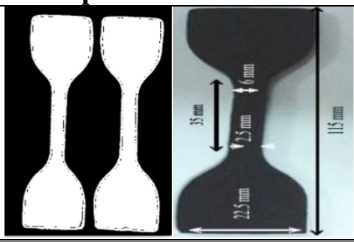
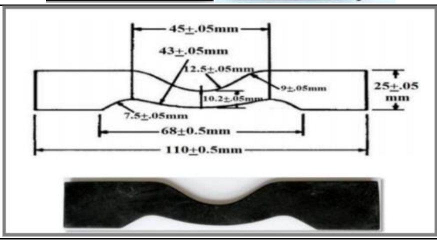
Model for preparing samples for vulcanization of the tire side wall Batch: In this test model is prepared before vulcanization process. The sample is cut with diameter 2mm and thicknesses 6mm and placed in the device (Oscillating disc rehometer) and the vulcanization get inside the device. In this test, the properties of cure time, scorch time, torque and viscosity were studied.

Model for preparing samples for Tensile and Elongation and Modulus test: Template that was used to prepare samples of tensile and elastic modulus and elongation had the following dimensions (150 mm length, 150 mm width, 2.5 mm thickness). This mould is heated to temperature 145ºC and then lubricates it and the appropriate amount of recipe and put in the mould and then it is covered. The mould is put in the hydraulic press at pressure 4MPa and temperature 145ºC for 45min according to the Standard specifications ASTM-D3182, for performing vulcanization process. The samples are taken from the mould and left for 24hr for cooling and then cut the sample (dumbbell specimen) by hand press conduct a tensile test on the samples generated.

Model for preparing samples for Tear resistance: Tear resistance test samples have been prepared in the same way that the tensile test samples are prepared but different in mold and the grooves in the sample are made by the necting cutter. Tested by Monsanto T10 Tonometer 500MM / min speed according to ASTM standard D624-54.

Samples Preparation: The hand-made wooden molds use measurements and dimensions according to the American Society for testing and Materials (ASTM). Table (4) shows the dimensions of the samples and forms.

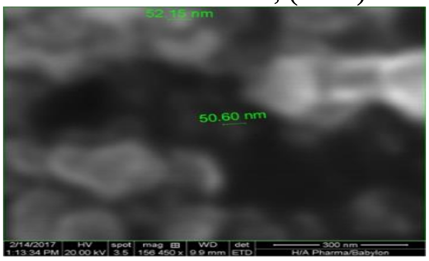
Table.4. shows the dimensions of the samples and forms

	Standard	Samples and dimensions	Test
1	ASTM D 3182 & ASTM D 13192		Tensile & Elongation & Modulus
4	ASTM D 1415		Tear Resistance

3. RESULTS AND DISCUSSION

Analysis results of nano-silica:

Scanning Electron Microscopy (SEM): Figure.1, explained the different magnification of silica that are measured microparticles and nanoparticles surface. The results of these analyzes showed that observed in spherical nanoparticles diameters in the range (50-84) nm and significantly agglomaration by this examination. This agree with the results of research Music, (2011).



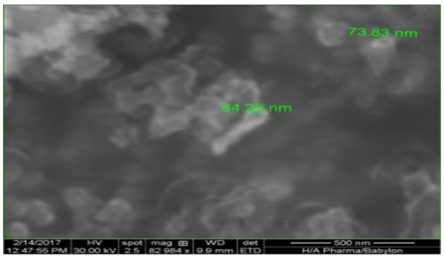


Figure.1. SEM micrographs images of precipitated SiO_2

X-Ray Diffraction Analysis (XRD): Of the test X-ray powder nano silica at the corner of diffracted (10° to 50°), a crystalline peak appeared weak and which refers to the installation of the semi-amorphous ($2\theta = 21°$), figure (1-2a). Also, a peak for sodium chloride peak (by-product), apparently with a very low concentration ($2\theta = 25.69$, $2\theta = 31.574$) Results of neutralizing water glass with hydrochloric acid and disappear this big laundry where the figure (2-2b). This refers to the preparation of amorphous material which agrees with the results of research Sang-Wook Ui, (2009).

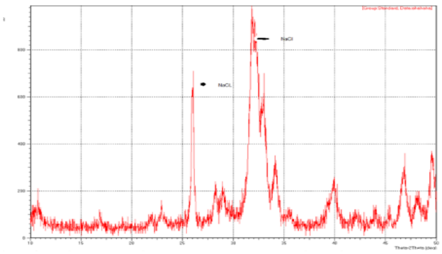


Figure.2a. X-Ray diffraction analysis of precipitated SiO_2 with amorphous peak (before washing)

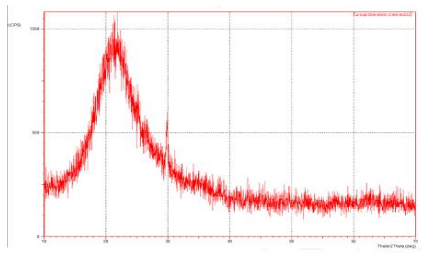


Figure.2b. X-Ray diffraction analysis of precipitated SiO_2 (after extra washing)

Effect of Nano Silica and Modified Nano Silica with Coupling Agent on the mechanical Properties of Recipe: The effect of nano silica and modified nano silica particles on the mechanical properties of tire wall side recipe of constant carbon black (50pphr) shows.

Tensile Strength : When you add a small amount of nano-silica and modified nano silica, we note that the tensile strength increases as shown in figure.3, Such behavior can be interpreted as in the case of small amounts, the particles fill the spaces between the rubber chains, and therefore I will give a solid structure with the best power Walsh (19MPa). But note of fig.(1) when adding small amounts of modified nano silica tensile strength give the best to the lack of conglomerate granules between rubber chains. This result is consistent with the reference (Thomas, 2010; Jorgen, 1999; Al-Nesrawy, 2016; Fadil Abbas, 2014).

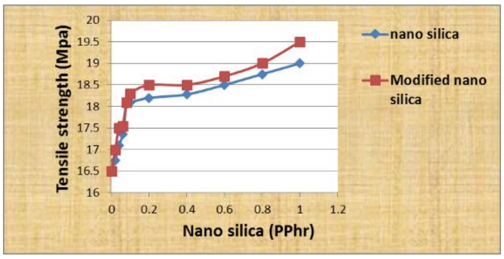


Figure.3. Effect of nano silica and modified nano silica on tensile strength of recipe

Elongation: It was noted that for both silica nano and modified nano silica has the same behavior when added in small quantities reduces the the elongation property after the addition of small amounts of nano silica as the number, because the rubber which extends to a large extent so that when filled with very fine particles in the blanks, it will restrict movement chains and reduce the elongation property as shown in figure.4. This result is consistent with the reference (Al-Nesrawy, 2016; Fadil Abbas, 2014).

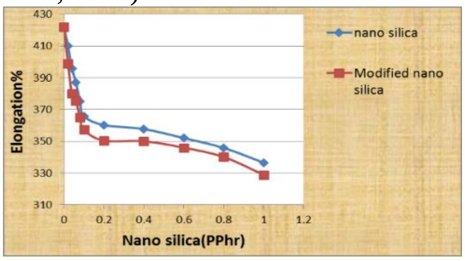


Figure.4. Effect of nano silica and modified nano silica on elongation of recipe

Modulus of elasticity: As mentioned previously, proportional to the modulus of elasticity is inversely proportional to the elongation property figure increase in the modulus of elasticity in small quantities from both nano silica and modified nano silica. This is due Alydrjh softer molecules makes it easy to distribute between rubber chains, and thus increase the modulus of elasticity as shown in figure.3. But note through the form figure.5, that the value of the modulus of elasticity when added in small quantities to modify the silica nano-best result of the lack of conglomerate granules between rubber chain. This result is consistent with the signal (Thomas, 2010; Al-Nesrawy and Al-Maamori, 2016; Fadil Abbas and Al-Husnawi, 2014).

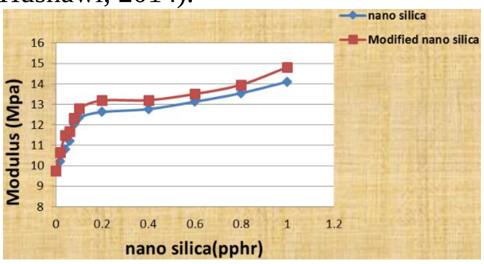


Figure.5. Effect of nano silica and modified nano silica on modulus of recipe

Tear resistance property: Tear resistance appears resistant materials for the growth of any cut when it is under tension. This property is linked to the tensile property. So that the increase in resistance to rupture with the addition of small amounts of both silica and modified silica nano. Up to a maximum value of 9.05MPa when 1pphr of silica. The reason for this is that these particles will fill the spaces between the rubber chains and increase the mechanical bond between them. That leads to the rupture of the best resistance. But when adding slim quantities < 0.8pphr of modified nano silica give us resist tearing better than nano silica as a result of the absence of grained between the strings rubber as show in fig.6. This result is consistent with the signal (Thomas, 2010; Al-Nesrawy, 2016).

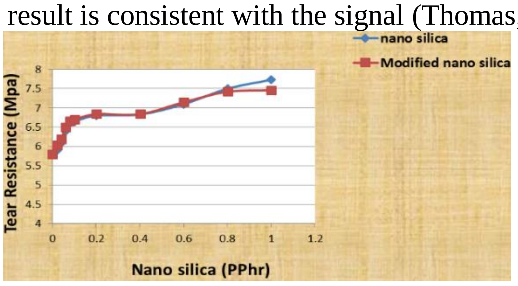


Figure.6. Effect of nano silica and modified nano silica on tear resistance of recipe

4. CONCLUSIONS

In this study, the following conclusions are made:

- High purity silica with the size of the granules (50-84) nm prepared by a chemical process low-expensive.
- Such a silica granules (50-84) nm improved mechanical properties recipe side wall of the tire.

- This method is useful for the company for the manufacture of tires in the character of the side wall of the tire.
- When adding small amounts of modified nano silica give good mechanical properties.

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