# Study of Some Physical and Mechanical Properties of New Polymeric Composition from Rubber

**Haider Abdalwahd Mahdy** **Amer. M . Juda Al-Shamri**
*University of Kufa, Faculty of Science, Department of Chemistry*
**Haider99@yahoo.com**

## Abstract

In this paper,studies of the physical and mechanical properties such as (tensile e strength, elongation, modulus and hardness) to **(IT 1060)** tires in Babylon tire industry are prepared in this study three groups of models

The first group: included 7 samples that contain synthetic rubber with silica in different proportions by weight (1%, 2.5%, 5%, 7.5%, 10% ,12.5%, 15%)phr.

The second group: included 7 samples that contain synthetic rubber with Iraqi kaolin in different proportions by weight (1%, 2.5%, 5%, 7.5%, 10% ,12.5%, 15%)phr.

The third group: contains 4 samples included mix filler (silica & kaolin) of different proportions by weight.

(Two roll mill) are used in preparation after conducting tests and the use of many devices test results showed that the best ratio by weight (7.5 phr) to improve the physical and mechanical properties.

**Keywords** : SBR1502,Silica oxide ,Iraqi kaolin, tensile properties

## الخلاصة

في هذا البحث تم دراسة الخواص الفيزيائية والميكانيكية (الشد,الاستطالة,المرونة والصلابة) للجزء الخارجي لإطار السيارة المصنع في معمل إطارات بابل من خلال المطاط الصناعي (SBR) حيث حضر في هذه الدراسة ثلاث مجاميع من النماذج (العجنات المطاطية)

اولأ: المجموعة الأولى تضمنت 7 عجنات تحتوي على المطاط الصناعي والسيليكا بنسب وزنيه مختلفة (1%, 2.5%, 5%, 7.5%, 10%, 12.5%, 15%).

ثانيأ: المجموعة الثانية تضمنت 7 عجنات تحتوي على المطاط الصناعي والكأولين العراقي بنسب وزنية مختلفة (1%, 2.5%, 5%, 7.5%, 10%, 12.5%, 15%).

ثالثأ: المجموعة الثالثة تحتوي 4 عجنات تتضمن مزج المالئات (السيليكا والكأولين) بنسب وزنية مختلفة.

اجريت عملية التحضير باستخدام عصارة ذات رولة مزدوجة وبعد اجراء الفحوصات بينت النتائج ان افضل نسبة وزنية لتحسين الخواص الفيزيائية والميكانيكية هي (phr7.5).

**الكلمات المفتاحية:** المطاط الصناعي (SBR)، اوكسيد السيليكا، الكأولين العراقي، خاصية الشد.

## Introduction

play very important role in modern technology. They are presently used in wide areas of application, such as cables , tire, domestic appliances, coatings, packaging materials, textile and sporting goods to transportations, building infrastructures, medical and optical devices.…. etc, due to their light weight, elastic and other properties. There are many types of rubber such as natural rubber (NR), synthetic rubber (SBR), nitrile rubber and…..etc. The properties of a particular rubber are determined by the compound composition. A mix of raw rubbers with additives, and the vulcanization process is important so as to adjust rubber with requirement application .The vulcanization is one of the key factors in the technology of rubbers. It involves the conversion of raw rubber into a network through the formation of crosslink between chains of rubber .This network is not sticky like raw rubber, does not harden due to cold weather or soften much except at very high temperatures ,it becomes and elastic , is highly resistant to abrasion ,and becomes tighter and the forces necessary to achieve a given deformation increase (Frederick, 1978; Hofmann1994 ; Mark, 1994).

This study deals with the physical and mechanical properties such as:

**Tensile properties** (tensile strength, modulus and elongation)

**a- Tensile strength** a rubber compound is defined as the maximum tensile stress applied in stretching a specimen of rubber compound to rupture**.**

**b- Elongation** is used to describe the ability of a rubber compound to stretch without breaking. It is equal to the difference between the final and initial lengths.The percentage are shown in the table below (Wypych, 1999).

**c-modulus** is the quantity of stress required for a given elongation (frequently 300%100), and is used as a supplement to modulus in comparative evaluations. This value is determined during the test (Wypych, 1999).

**Hardness** is one of the most important properties which determine the suitability of any rubber component for its intended use. It is defined as the relative resistance of the surface of material to indentation. Hardness is measured by an indenter of specified dimension under a specified load (Maurice Morton, 2011; al Dr. Utpal Kumar Niyogi, 2007).

## Experimental part

### Material

The material used in experimental part is shown in table(1)

**Table(1) The material used in experimental part**

| NO | Material | Properties | The material company made |
|---|---|---|---|
| 1 | SBR 1502 | 23% Styrene,77% Butadiene | Kumho CO. Koria |
| 2 | Reclaim rubber | | Iraqi |
| 3 | Silica | 70-230 mesh(0.063-0.200)Mm | Iraqi |
| 4 | Zinc oxide | Purity=99%<br>Particle size=0.5-1µm<br>Surface area=3-5$m^2$/gm | ChemTAL (Malaysia) SDN-BHD Malaysia |
| 5 | paraffin wax | | Merk U.N |
| 6 | Activator stearic acid | | Acidchem-International CO. Malaysia |
| 7 | Carbon black tabe N-375 | | Iran Carbon CO. Iran |
| 8 | process oil | | Daura Refinery Iraq |
| 9 | Accelerator (CBS). | | Al-Kiiubar CO. KSA |
| 10 | Sulfur | | Al-Meshrak CO. Iraq |
| 11 | Anti-Oxidant (TMQ). | | Shenyang Sunnyjoint Chemicals CO. China |
| 12 | Anti-Oxinant (6PPD). | | Shenyang Sunnyjoint Chemicals CO. China |
| 13 | Iraqi kaolin | Particle size=0.54-5.58 µm | Iraqi National Company for Geological Survey and Refinery |
| 14 | Retarder (CTP.100 | | Shenyang Sunnyjoint Chemicals CO. China |

## Instruments

The equipment used in experimental part is shown in table(2)

**Table(2) The equipment used in experimental part**

| NO | Instruments | Important specifications(51) |
|---|---|---|
| 1 | Electronic Balanc | |
| 2 | Two roll mill | Capacity = 0.6Kg<br>Diameter of any roll = 165 mm<br>Front roll speed=25±1Cycle /minute<br>Back roll speed=30.5±1.4 Cycle/minute |
| 3 | Monsanto Rheometer ODR-2000 | Oscillation frequency = 1.667 HZ, 100 cycles/minute<br>Oscillation amplitude = ± 1º, ±3º<br>Air pressure= 60 psi (4.2 kg/ $cm^2$)<br>Temperature = calibrated range (100-200) ºC<br>Sample volume = Approximately $9cm^3$ |
| 4 | Platen Press | The maximum pressure of press is 4Mpa.<br>Platen dimensions are 457 mmx457 mm.<br>Closing speed is to be 200 mm per minute approximately.<br>The range of temperature (0-200) °C |
| 5 | Monsanto T10 Tensometer | Range of force = 1-10 KN<br>Accuracy force = ± 0.5% of applied load<br>Crosshead speed range = 0.5-1000 mm/minute<br>Accuracy speed = ±1% of set speed<br>Range of strain = 0.1-5000% |
| 6 | Densitron | Number of samples may be place one cassette = up to 30 samples<br>Test cycle time = 35±15 seconds per sample<br>Accuracy = ± 0.5%<br>Volume of sample = 5 - 9 $cm^3$<br>Air Pressure = 60-100 psi (4-7 bar |
| 7 | Dead load | |
| 8 | Croydon –Akron | Speed=500 Cycle for every 5minute |

## Mixing Process:-

Mixing operations in the General Company for the tire industry Babylon, located in the city of Najaf, are achieved according to ASTM D3182(Wypych1999). The rubber is mixed thought various chemicals process in several stages using (Two roll mills) fig(1) which consist of two canisters, one spin unlike other rapidly varying.

**Fig (1) Two roll mill**

**(mixing steps):**

The steps of processing recipe master batch with different mixing time are:

1. passing of (SBR 1502) rubber between the two rolls for several times with decreasing the distance between the two rolls to the extent of (0.5-1) mm at temperature of laboratory.
2. Adding reclaim rubber, and banding them for three minute.
3. During the process ,passing rubber pieces between rollers in horizontal and vertical state alternatively for several times for obtaining homogenous materials
4. Adding the zinc oxide and remixing for 2 minute, then stearic acid is added.
5. Adding the carbon black and DOP oil alternatively and remixing for 7 minutes.
6. Adding accelerator CBS and remixing for 5 minute, antioxidant is added .
7. Adding the reinforcing fillers blended with coupling agent, and remixing.
8. Finally, adding the sulphur with pre-blending.
9. continuing the mixing process for long time in order to get a good homogenization and to decrease mill opening to (0.5-1 mm) to increasing the homogeneity and the efficiency of mixing.

## Preparation methods

1- Table (3) included the compounds which contain the addition of different Concentration from

(a) silica or (b) kaolin .

**Table (2-3) compounds which were contained the addition different Concentration from (a) silica or (b) kaolin**

| Material | A1 ratio of Material 100phr | A2 ratio of Material 99 phr with 1phr filler | A3 ratio of Material 97.5 phr with 2.5phr filler | A4 ratio of Material 95phr with 5phr filler | A5 Ratio of Material 92.5phr with 7.5phr filler | A6 ratio of Material 90phr with 10phr filler | A7 ratio of Material 87.5phr with 12.5phr filler | A8 ratio of Material 85phr with 15phr filler |
|---|---|---|---|---|---|---|---|---|
| SBR1502 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Reclaim rubber | 5.5 | 5.445 | 5.3625 | 5.225 | 5.0875 | 4.95 | 4.8125 | 4.675 |
| Stearic acid | 1.28 | 1.2672 | 1.248 | 1.216 | 1.184 | 1.152 | 1.12 | 1.088 |
| Zinc oxide | 1.92 | 1.90 | 1.872 | 1.824 | 1.776 | 1.728 | 1.68 | 1.632 |
| TMQ | 0.64 | 0.6336 | 0.624 | 0.608 | 0.592 | 0.576 | 0.56 | 0.544 |
| 6PPD | 1.28 | 1.2672 | 1.248 | 1.216 | 1.184 | 1.152 | 1.12 | 1.088 |
| Carbon black N375 | 80.64 | 79.833 | 78.624 | 76.608 | 74.592 | 72.576 | 70.56 | 68.544 |
| process oil | 23.8 | 23.562 | 23.205 | 22.61 | 22.015 | 21.42 | 20.825 | 20.23 |
| Paraffinic oil | 1.28 | 1.2672 | 1.248 | 1.216 | 1.184 | 1.152 | 1.12 | 1.088 |
| Silica or kaolin | 0 phr | 1.212 | 3.0277 | 6.0539 | 9.8011 | 12.1068 | 15.1335 | 18.161 |
| CBS | 2.088 | 2.067 | 2.0358 | 1.9836 | 1.9314 | 1.8792 | 1.827 | 1.774 |
| Sulfur | 2.47 | 2.445 | 2.408 | 2.3465 | 2.284 | 2.223 | 2.161 | 2.099 |
| CTP-100 | 0.166 | 0.1643 | 0.161 | 0.157 | 0.153 | 0.149 | 0.145 | 0.141 |
| Total | 221.064 | 221.064 | 221.064 | 221.064 | 221.064 | 221.064 | 221.064 | 221.064 |

2- Table (4) included the compounds which contain mixture of different concentration from (a) silica and (b) Iraqi kaolin.

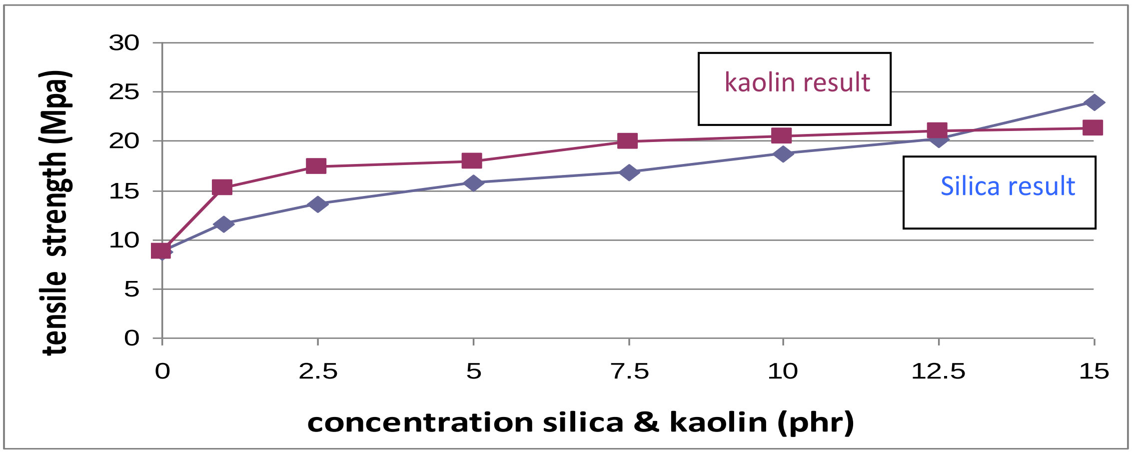
**Table(4) the compounds which were are mixture of different concentrations from (a) silica and (b) Iraqi kaolin.**

| NO | mix Conc. |
|---|---|
| 1 | 12.5 silica+2.5 kaolin |
| 2 | 10 silica+5 kaolin |
| 3 | 5silica+10 kaolin |
| 4 | 2.5 silica+12.5 kaolin |

## Results and Discussion

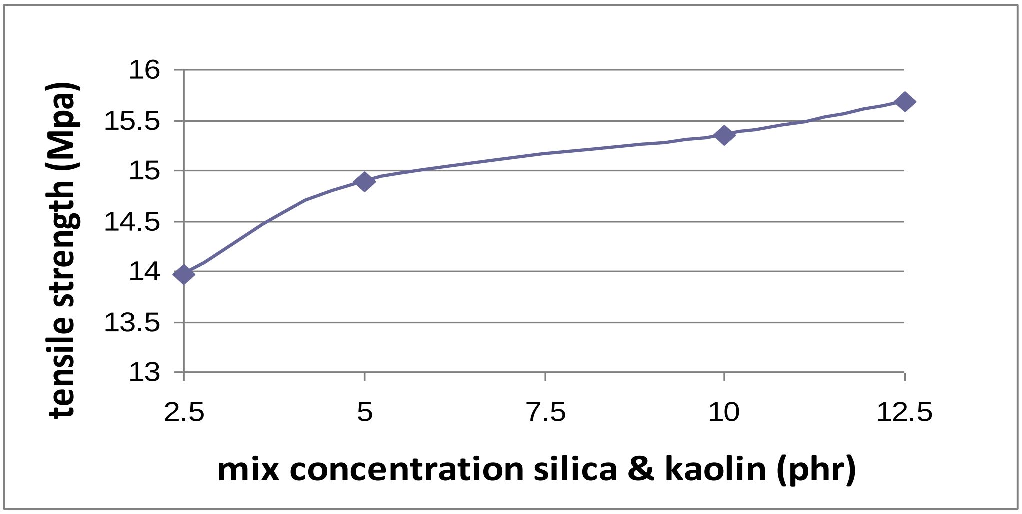
## Tensile strength

The Study of tensile strength of sampling deals with silica and kaolin whose two mechanical properties shown in fig (2) show increasing of the percentages of silica and kaolin when the tensile strength increases. The figure also shows more increase in the value of tensile strength when varetrather than kaolin,is used as filler .Fig.(2) shows the addition effect of the percentages filler ( silica & kaolin ) on the tensile strength of SBR compound.




**Fig(2) Effect of Iraqi kaolin and silica concentration on tensile strength of the compounds**

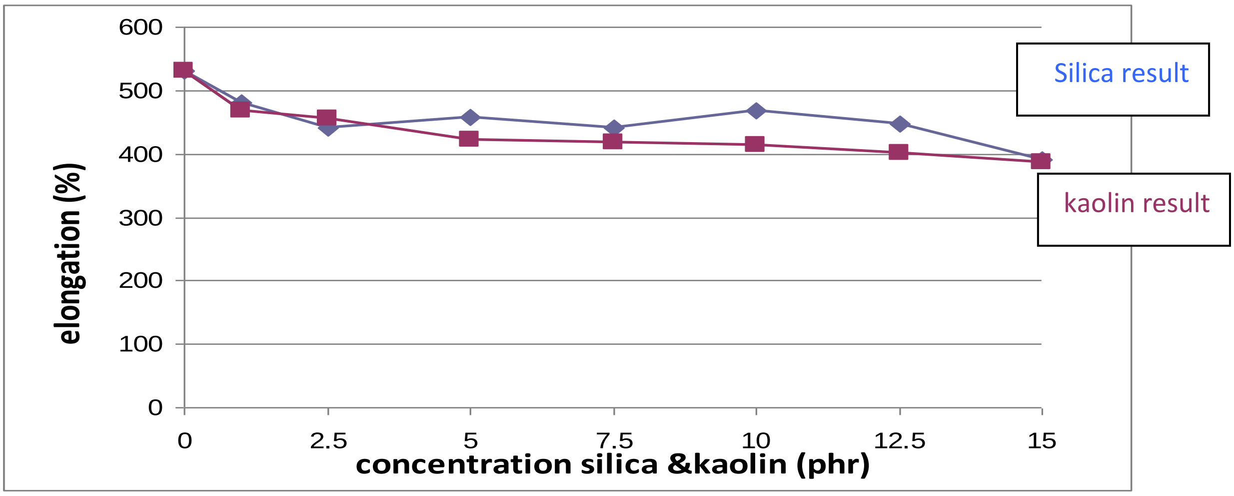
Fig(2) shows that the tensile strength increased progressively with the increasing silica level from (0-15 phr).In value (0 phr), tensile strength is (8.69 Mpa),When you add silica in adifferent concentration (1-15phr) the increase starts until they were(11.56 Mpa) when is (1phr)) and (24.01Mpa) when (15phr) The increase is due to the fact that silicate particles are filling the spaces between the rubber chains formed. Also increasing the concentration of silica level leads to the increase of tensile due to the relation between silica and crosslink density. When the crosslink density increases, the elastomer becomes more elastic and the motion of rubber chains becomes more elastic (Wypych, 199) the tensile strength increases. Also when kaolin is used the tensile strength increases from (15.21 Mpa) in(1phr) to (21.31 Mpa) in (15phr) due to bonds coupling between the particles of kaolin and rubber matrix (Robert Brentin al Phil Sarnacke, 2011). fillers work to fill the spaces between the polymer chains branching leads to decrease the distance intra least be free of size and polymer crystallization (1983, عبد ال ادا كوركيس)·The research suggests that silicas working to improve the mechanical properties when added to polymer compositions, where it works to increase the tensile strength, modulus and decrease the elongation (Garcia, 2004; Keuenate & Tongpool, 2004; Botelho& Scherbakoff, 2000). Tensile strength also increases when mix concentration of silica and Iraqi kaolin is used. The percentage show in fig (3).




**Fig(3) effect mix concentration on tensile strength**

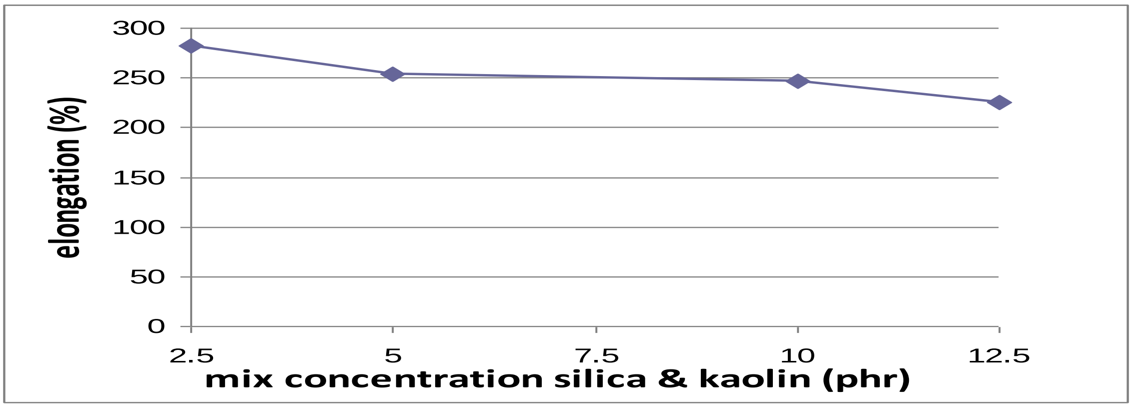
the reason behind increase of the tensile strength is attributed to the structures forces because of the possibility of a reaction chemical between fillers and system polymer, as well as once upon a time result.

## Elongation at break




**fig(4) Effect of Iraqi kaolin and silica concentration on elongation of the compounds**

Figure (4),the elongation at break decreases when silica level and kaolin increase the elongation ratio without any addition is (530.5%) while after adding silica by (1phr) it is (481.5%) but after adding kaolin it is (469.32%) and continues to decrease at (15phr) to silica (391.5%) and kaolin(386.51%). This observation is attributed to increase in crosslink density with the increasing silica level leading to reduction in molecular chain mobility. kaolin reduces the elongation at break due to coupling bonds between the particles of kaolin and rubber matrix (Robert Brentin and Phil Sarnacke, 2011). More over elongation was studied but in this way we used mix concentration of silica and Iraqi kaolin see fig (5).




**Fig(5) effect mix concentration on elongation**

The percentage of elongation is considered when it is cut from a change in length as a result of exposure to stress that the percentage of elongation is one expression of tension and elongation change in length ratio to the original length of the sample formats (Collins & Bares1973; Tsou., 2005). The percentage of elongation at break depend on many factors including: density, degree tangles, and the proportion of fillers used and it does depend on the increase in the percentage of the degree of crystallization reduce the percentage of elongation.

**Modulus at 300%**

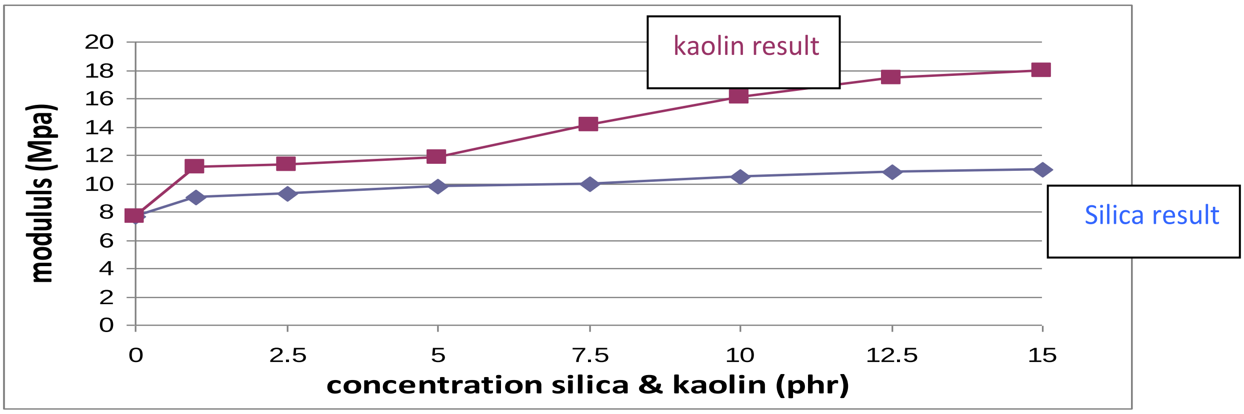
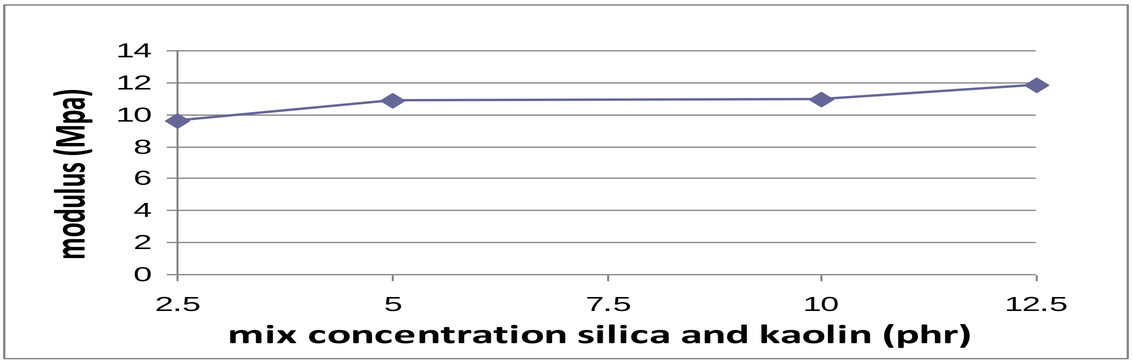


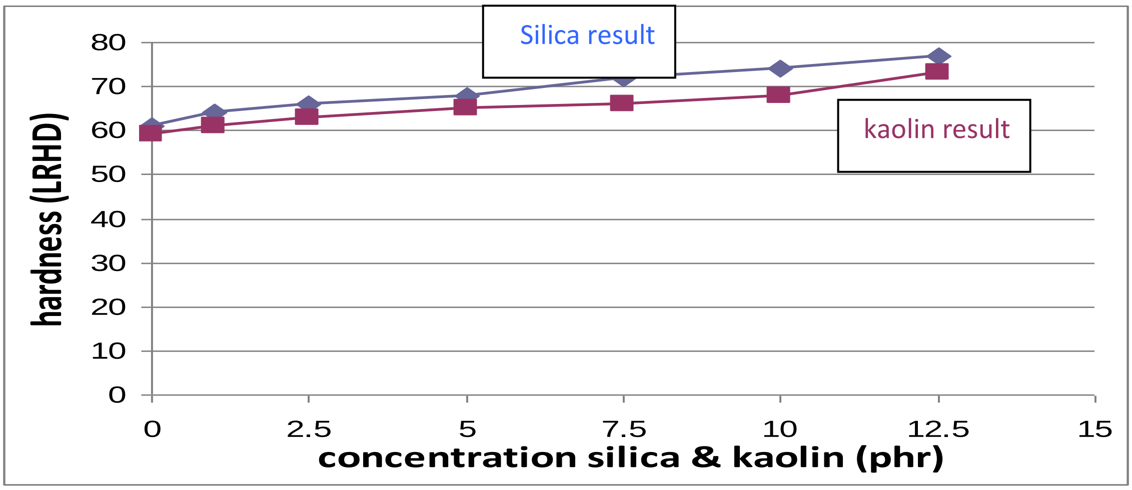

**Fig. (6) Effect of Iraqi kaolin and silica concentration on modules of the compounds**

Figure (6),the Modulus at 300% increases silica level and kaolin increase.Where modulus in(0 phr) is (7.69Mpa) while adding silica by (1phr) be (9Mpa) but kaolin be (11.12Mpa) and continues to increase at (15phr) to silica (11Mpa) and kaolin(17.93Mpa). The reason behind the increase of modulus is the weakness of hardness filler (kaolin) as well as the interaction between the fillers and system polymer due to the fact that the stress caused by the external force is transmitted to the filler through the polymer system (El-Sabbagh2007). Though were already studied in this study we use mix concentration of silica and Iraqi kaolin as show in fig (7).




**Fig(7) effect mix concentration on modulus**

## Hardness




**Fig(8) Effect of Iraqi kaolin and silica concentration on hardness of the compounds**

The results show that hardness increases with the increase of silica and kaolin level due to the increase crosslinking efficiency and crosslink density with the increase of silica level. The effect of kaolin on hardness of the compounds is due to the increase of the hardness because the mechanical bonding between rubber matrix and the particles of kaolin(Robert Brentin al Phil Sarnacke, 2011). When we compare the use of silica and kaolin in sulfur vulcanization of the rubbers, the hardness in (0phr) is (57 IRHD) but when we use silica (61 IRHD) at (1phr) the hardness with kaolin is (59IRHD) at (1phr) .The results of adding silica and kaolin increase hardness but addition of silica is the best reason for this due to the hardness of silica which increases the hardness of the rubber mixture where the hardness ratio at (15phr) is (77 IRHD) but addition of kaolin leads to hardness ration at (15 phr) equal (73 IRHD) .

## References

ASTM D3182, Standard Practice for Rubber—Materials, Equipment, and Procedures for Mixing Standard Compounds and Preparing Standard Vulcanized Sheets.

Botelho , E. C. ; Scherbakoff , N. and Rezende , M. C. , Materials Research , 3 (2) , pp. 19 (2000) .

Collins.E.A,J.Bares,F.Billmeyer"experiment in polymer science,John wiley and son,N.Y,(1973).

El-Sabbagh S.H. and A. A. Yehia, Detection of Crosslink Density by Different Methods for Natural Rubber Blended with SBR and NBR, Egypt. J. Solids, Vol. 30, No. 2, P.P.157-172, (2007).

Frederick R. Eirich , Science and Technology of rubber, Academic Press, INC, New York , (1978).

Garcia.m and et al,"prlyropylene/SIO2 Nanocomposites with lmproved mechanical properties",Reviews on advanced materials,seiece,p.(169-175),16(2004)

Hofmann, W. Rubber Technology Hand Book, Hanser Publishers, New York, (1994).

J.E. Mark, Science and Technology of Rubber, Academic Press, San Diego, 2nd Ed, (1994).

Keuenate J.,Tongpool.R.,Panyathanmaporn. T., "Optical mechanical properties of polypropylene modified by metal oxide", surface and Interface Analysis,.(1044-1047),36,(2004).

Maurice Morton, Rubber Technology, Litton Educational Publishing ,INC, USA , (September 2011).

Robert Brentin and Phil Sarnacke, Rubber Compounds, , OMNI TECH International, LTD, Midland,USA, P. 28, September (2011).

Tsou.A.H,"Encyclopedia of polymer science and Technology" John and son, lnc(2005).

Utpal Kumar Niyogi , Polymer Additives and Compounding, Additives for Rubbers , Shri Ram Institute for Industrial Research19 , University Road Delhi, P.P. 1-2, (July 2007)

Wypych, G. Hand book of Fillers, ChemTec Publishing, New York (1999).

Wypych, G. Hand book of Fillers, ChemTec Publishing, New York (1999).

- عبد ال ادم كوركيس وكاشف الغطاء حسين علي,"كيمياء الجزيئات الكبيرة المحدث,اصدار جامعة البصرة10، .(1983),