STUDY SOME PHYICAL AND MECHANICAL PROPERTIES OF RUBBER BY UISING CONDUCTIVE CARBON BLACK

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ABSTRACT

Aim of this Reasch to Study Some Physical and Mechanical Properties of rubber such as(the Electrical conductivity ,hardness,tensile strength at break,Modulus of elasticity at elon.300%,Elon.at break,Torque,Scorch time(Ts2)) for taypes of rubber for example natural rubber (NR) and industrial rubber (butadiene-BR) by using conductive carbon black with addition

Loading level (10,20,30,40,50 pphr) from conductive carbon type(N_{375}) . also using fixed quantities from ($CaCO_3$) and metals oxides e.g (Fe2O3) and (ZnO) are not effecting on mechanical properties for final product where giving the experimental results that improvement of electrical conductivity and mechanical properties for Natural rubber(NR) more than of thes properties in industrial rubber(butadiene- BR) as same as for loading level of conductive carbon

Key words : conductive carbon black,electrical conductivity,natural rubber, butadiene rubber,tensile strength

Aim of Reasch: study Some Physical and Mechanical Properties of (NR) rubber (BR) rubber

دراسة بعض الخواص الفيزياوية والميكانيكية للمطاط باستعمال الكاربون الموصل

الخلاصة :

يهدف هذا البحث الى دراسة بعض الخواص الفيزياوية والميكانيكية مثل (الموصلية الكهربائية، الصلادة، قوة الشد عند القطع، معامل المرونة عند استطالة 300%،الاستطالة عند القطع،العزم ،زمن البقاء–Ts2) لانواع المطاط مثل المطاط الطبيعي (NR) والمطاط الصناعي (البيوتادايين– BR) باضافة مقادير (10,20,30,40,50 pphr) من الكاربون الموصل نوع N_{375} كذالك تم استعمال كميات ثابتة من كاربونات الكالسيوم $caco_3$ والاكاسيد المعدنية مثل اوكسيد الحديد الاحمر $Fe2O_3$ للمساعدة في تحسين هذه المواصفات ولكلا النوعين من المطاط بحيث لاتؤثر على المواصفات الميكانيكية للمنتج النهائي حيث أعطت النتائج العملية تحسن الموصلية الكهربائية والمواصفات المكانيكية للمطاط الطبيعي (NR) اكثر من مواصفات المطاط الصناعي (البيوتادايين–BR) ولنفس الكمية من الكاربون الموصل

INTRODUCTION:

It is well known that polymers are insulators. However, this idea has been changed after the discovery of Heeger, MacDiarmid and Shirakawa who have found that polymers can be reproduced to be conductive almost like metals. They have showed that oxidation of polyacetylene with chlorine, bromine or iodine made polyacetylene 10^9 times more conductive than it was originally. Accordingly, these scientists have won the 2000 Nobel Prize in chemistry. This discovery has opened promising fields in science and technology, such as the use of these materials in the fabrication of light emitting diode instead of the semiconductors, or as anti-static substances for photographic films for computer screen against electromagnetic radiation. In addition, conductive polymers have been used in the fabrication of solar cells, mobile telephone and television screens. These applications and others confirm that this discovery is as important as the discovery and design of Laser or the discovery of the superconductivity phenomenon or the use of semiconductors in electronic industry. [K.P.SAU-1997,Ahmed M]

THEORIES OF PRODUCTION CONDUCTIVE RUBBER :

Three main theories generally account for the underlying mechanism of electrical conduction through composites having a random distribution of conductive fillers :

1) conduction path theory in this theory the conductive filler forms a few continuous chains (conductive networks) in the rubber matrix. Through this continuous network, charged species (electrons) move from one end to the other under an applied electrical field. This movement of electrons causes the phenomenon of electrical conduction.

2) Electron tunnelling theory In this theory, the electrical conduction is believed to take place not only by interparticle contact but also by electrons being able to jump (hop) across a gap or tunnel through energy barriers between conducting elements in the polymer matrix. There is a threshold value for these gaps (a few nanometers) which is equivalent to interparticle contact. The basic difference between this theory and conduction path theory lies in the fact that the percolation limit is more probable at lower concentrations of conductive filler than that in conductive path theory .

3) Electric field radiation theory according to this theory it is assumed that an emission current is caused to flow by the high electric field being generated between conducting elements separated by a gap of a few nanometers]. The basic difference between this theory and the two other theories is that, when the conduction path theory and tunnelling effect theory describe the conduction as

ohmic in nature, the electron field radiation theory points to non-ohmic conduction behaviour for the system. Applicability of electric field radiation theory is believed to be valid at concentrations less than the critical limit [K.P.SAU-1997,S.EGwaily-2001].

The literature review of the work

- *In* 2006 ,*MURILO F. C. et al ... Characterization of Conductive Natural Rubber by Cyclic Voltammetry and Electrochemical Impedance* Spectroscopy. They found the Natural rubber (NR) is an excellent insulator and is commonly used in the electric and electronic industry. On the other hand, a blending of NR with carbon black powder produces conductive materials with the qualities of the insulator composite. Studies of conductivity, cyclic voltammetry and electrochemical impedance spectroscopy were carried out to characterize the new material, showing good enhancement for the electron transfer processes. The charge-transfer resistances were 0.75 and 5.1 kΩ for the KPO and KPO, respectively. This values shows that the charge transfer resistance increases about 6.8 times. The conducting additive used KPO (15%) (Eeonomer夂 P20-5DB/S) and KP20

(25%) (Eeonomer夂 KP20-7DNF) by Eeonyx Co. (USA). This composite are a new generation of polymers modified with carbon black.[MURILO F.C-2006]

- In (2009) *J.-R. Huang* et al.*: work on Antifouling Properties of Conductive Rubber Coatings Used for Fishing Nets*. The purpose of the present study is to develop a new conductive coating for application on fishing nets that can be used as an anode, while submersed in the sea, to generate free chlorine which will in turn inhibit marine biofouling, The results of the laboratory electrical resistivity tests show that conductive rubber with polyaniline displays the greatest electrical conduction. The simultaneous addition of carbon black and polyaniline showed no benefit over polyaniline alone.[jer-Ruey Huang.et-2009]

- In 1997; K. P. SAU. et al.: Conductive rubber composites from different blends of ethylene–propylene–diene rubber and nitrile rubber. showed that The incorporation of conductive filler (carbon black) increases the conductivity of insulating rubber matrices.[K.P.SAU-1997]

EXPREMENTAL WORK:

The name of instrument were used in testing samples according to the following :

A: meters are testing samples before curing process

1- The Mooney Viscometer is widely used throughout the rubber industry as a standard instrument for determining the relative viscosity of rubber**.** The viscometer measures the force, or torque, required to rotate a metal disk, or rotor, within a shallow cylindrical cavity filled with rubber compound (ASTM D-1646).

2- The oscillating disk rheometer (ODR) measures the complete curing characteristics of an elastomer compound, from a green (uncured) stock to a fully cured vulcanizate, at a specified temperature (ASTM D-2084). Data from the ODR are often used in conjunction with Mooney viscosity and scorch to characterize the processing and curing behavior of elastomer compounds.and show the Time scorch (TS2)(time for torque to increase 2 dN.m above ML(*ML, Minimum torque* – A measure of the viscosity of the uncured compound.). Mooney Viscometer measurements are usually made at processing temperatures, while ODR measurements are usually made at curing temperatures.

B :Testing curing samples

1- Tansometer -10 may be used to test the tensile strength at break (Mpa)
And elongation at break (%) , modulus of elasticity at elongation (300%)(Mpa)
These test according to ASTM D413 ,ASTM D 624-54

2- Destron meter may be used to test the specific weight (-) according to ASTM D 1817-66

3-Wallace Bead Load Hardness may be used to test the Hardness (IRHD) according to ASTM D 1415 [ASTM standard,part 28-1971]

4-Resistance/ Resistivity meter may be used to test electrical conductivity by measument volume resistivity (ohm.cm) according to ASTM D 257 [ASTM standard May-1997]

And design the rubber compaounding for two types of rubber used in the following tables

Table No(1)

Materials name	Pphr	Wt. N_1	Wt. N_2	Wt. N_3	Wt. N_4	Wt. N_5
NR	100	140	131	123	115.8	109.4
Carbon black (N375)	10,20,30, 40,50	14	26.2	36.87	46.32	54.73
$CaCO_3$	20	28	26.2	24.58	23.16	21.89
Red Iron oxide	2	2.8	2.62	2.458	2.316	2.189
ZnO	3	4.2	3.93	3.68	3.47	3.28
Process oil	3	4.2	3.93	3.68	3.47	3.28
Stearic acid	1	1.4	1.31	1.23	1.158	1.094
TMQ	0.4	0.56	0.52	0.49	0.463	0.437
6PPD	0.8	1.12	1.05	0.98	0.926	0.875
C.B.S.	1.5	2.1	1.96	1.845	1.737	1.642
Sulfer	1	1.4	1.31	1.23	1.158	1.094
Total		200gm	200gm	200gm	200gm	200gm
Curing condition	Time : 15 ,60 min temp. : 150 C°					

Table No (2)

Materials name	Pphr	Wt. B_1	Wt. B_2	Wt. B_3	Wt. B_4	Wt. B_5
BR(cis)	100	140	131	123	115.8	109.4
Carbon black (N375)	10,20,30,40,50	14	26.2	36.87	46.32	54.73
$CaCO_3$	20	28	26.2	24.58	23.16	21.89
Red Iron oxide	2	2.8	2.62	2.458	2.316	2.189
ZnO	3	4.2	3.93	3.68	3.47	3.28
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Sulfer	1	1.4	1.31	1.23	1.158	1.094
Total		200gm	200gm	200gm	200gm	200gm
Curing condition	Time : 20,60 min , temp : 150 C^o					

RESULTS AND DISCUSSION:

The experimental results and their discussion. were achieved by testing standard specimens for each test from NR and BR.

1- ELECTRICAL CONDUCTIVITY AND RESISTIVITY RESULTS:

The electrical conductivity results are presented in the forms curves as shown in fig . (1) and fig.(2)show the resistivity results. These curves give indication about the variation in conductivity. It is observed that the electrical properties improved with increasing the carbon black level and the increasing of conductivity in the NR rubber it is greater than from conductivity of BR rubber because NR rubber has best Mechaical properties

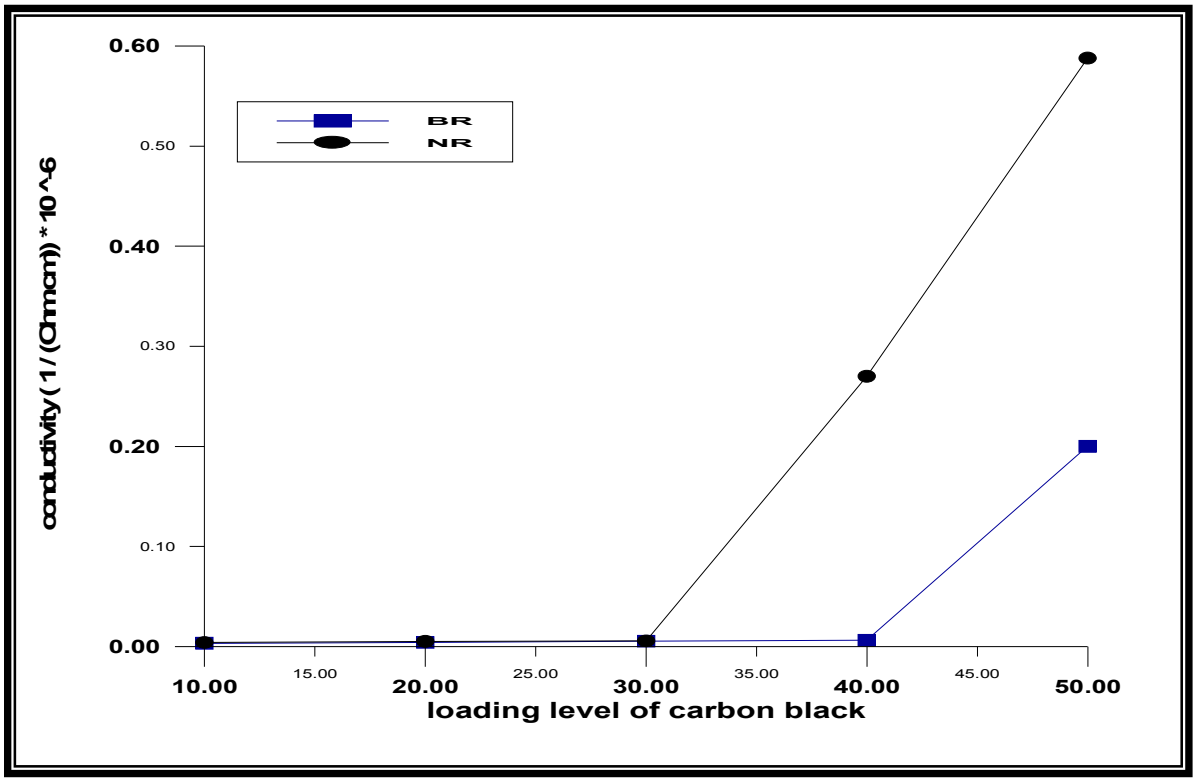


Figure (1) electrical conductivity

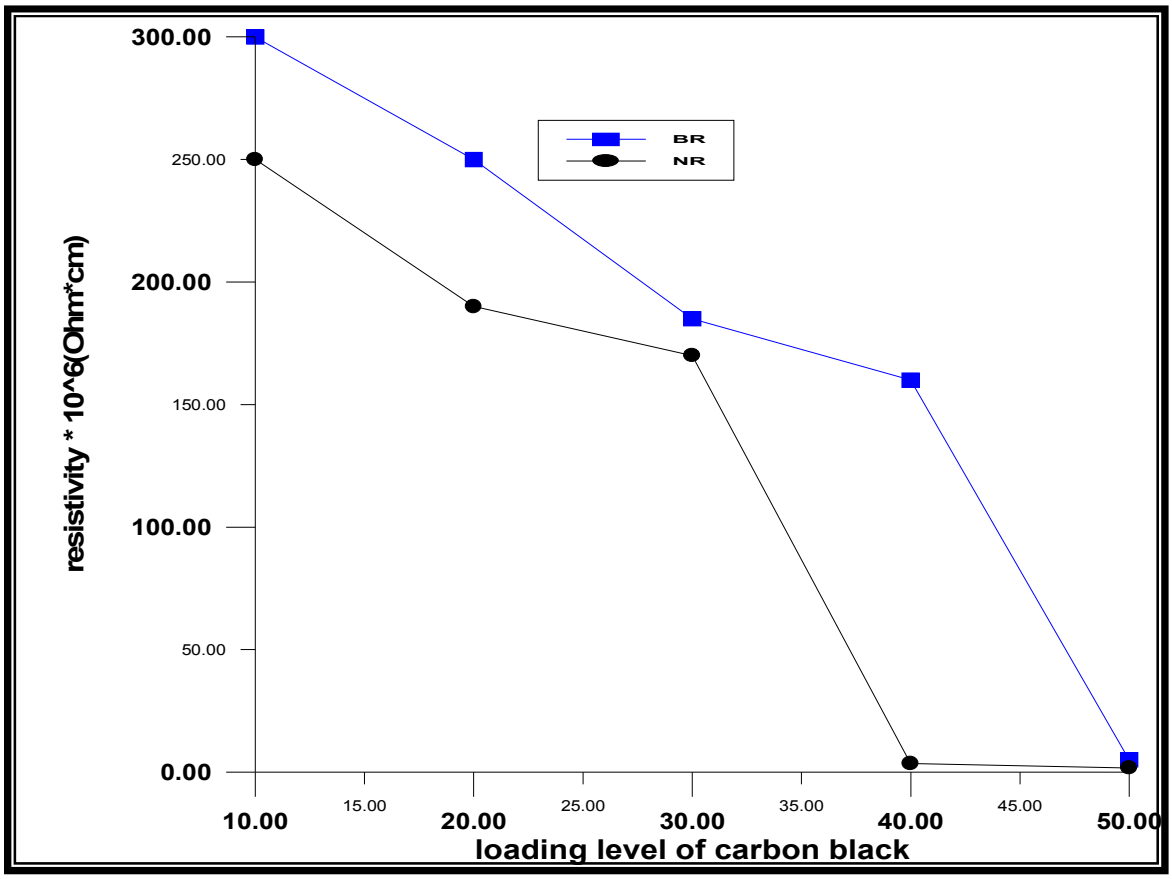


Figure (2) resistivity result

2- MECHANICAL TESTS:

Hardness Reaults:

Figure (3) shows the variation of Hardness with loading level of carbon black. It is observed that the hardness increases with increasing the carbon black level.

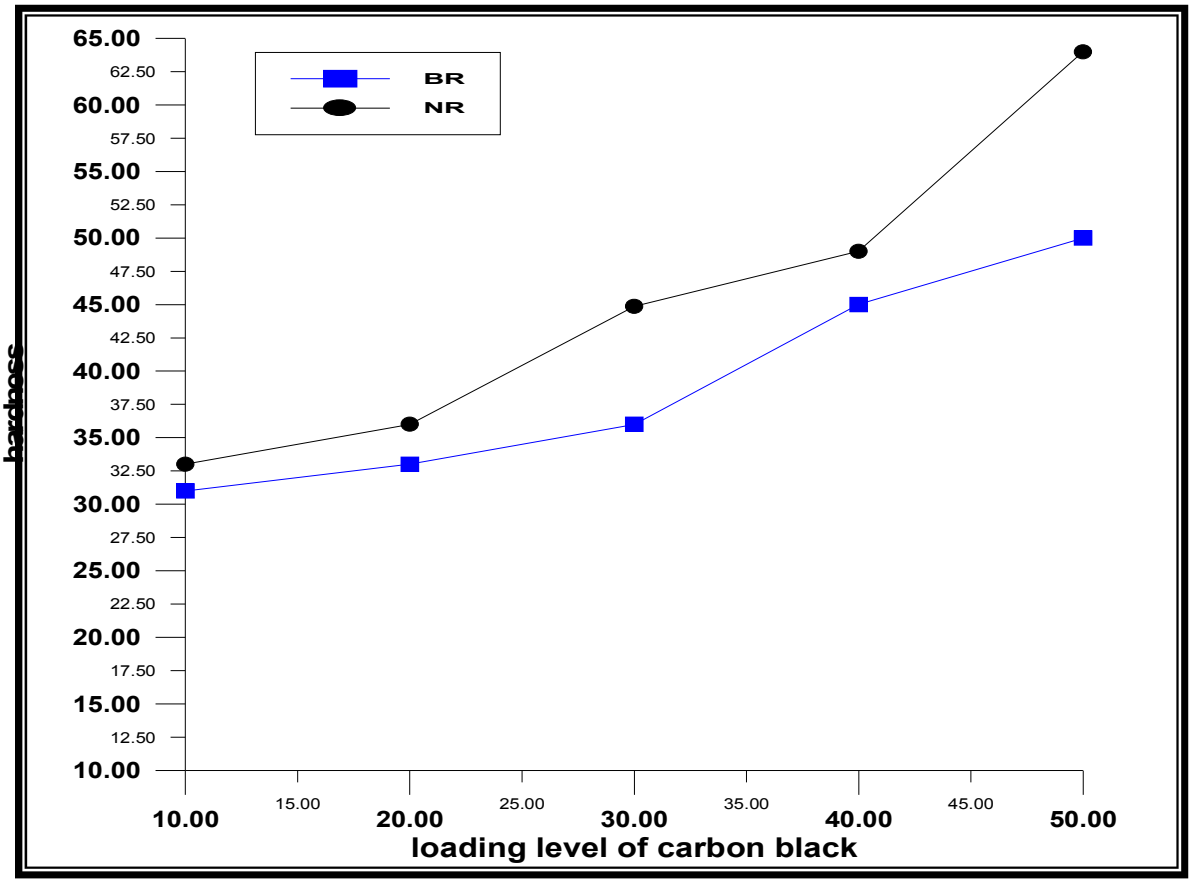


Figure (3) Hardness result

TENSILE STRENGTH (AT BREAK) RESULTS:

Figure (4) shows the variation of the break stress with loading level of carbon black. It is observed that the tensile stress increases with increasing the carbon black level.

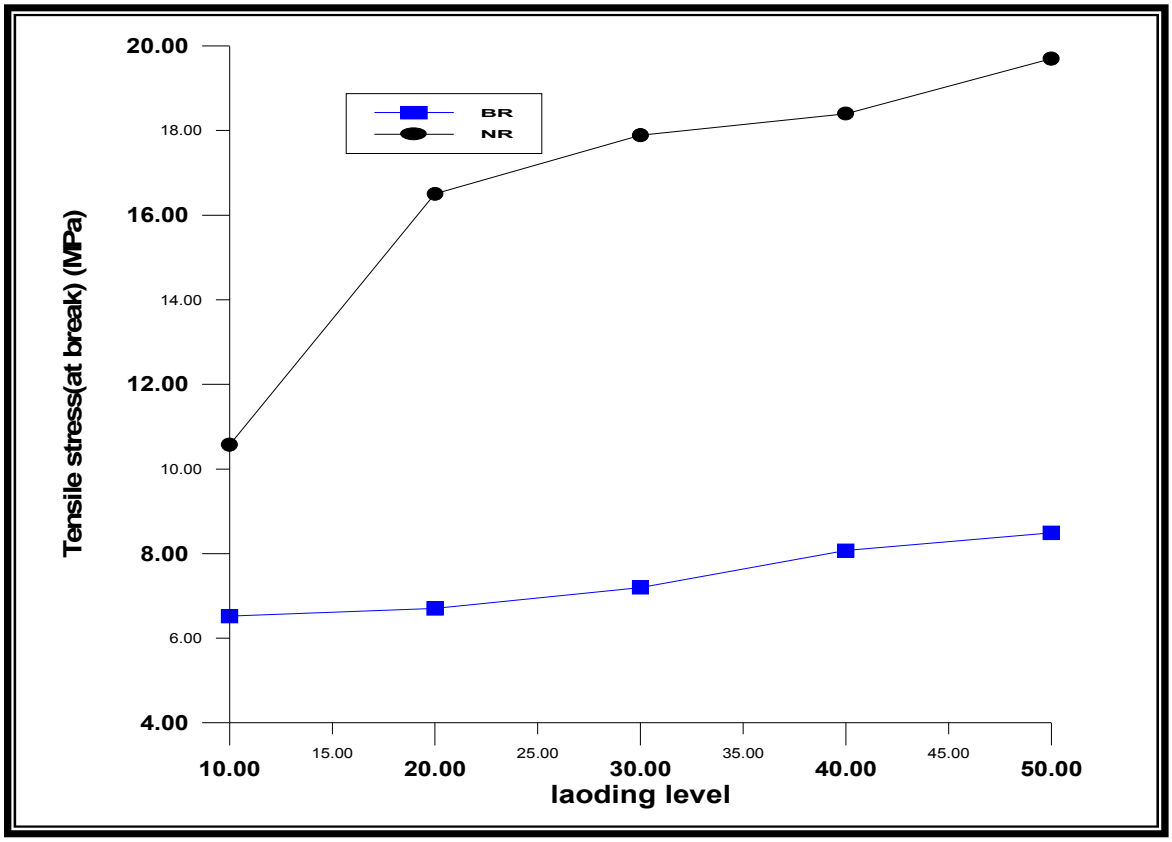


Figure (4) tensile stress at break result

MODULUS OF ELASTICITY (MOD300%)

Figure (5) shows the variation of stress at mod 300% with loading level of carbon black. It is observed that the tensile stress increases with increasing the carbon black level at mod 300%.

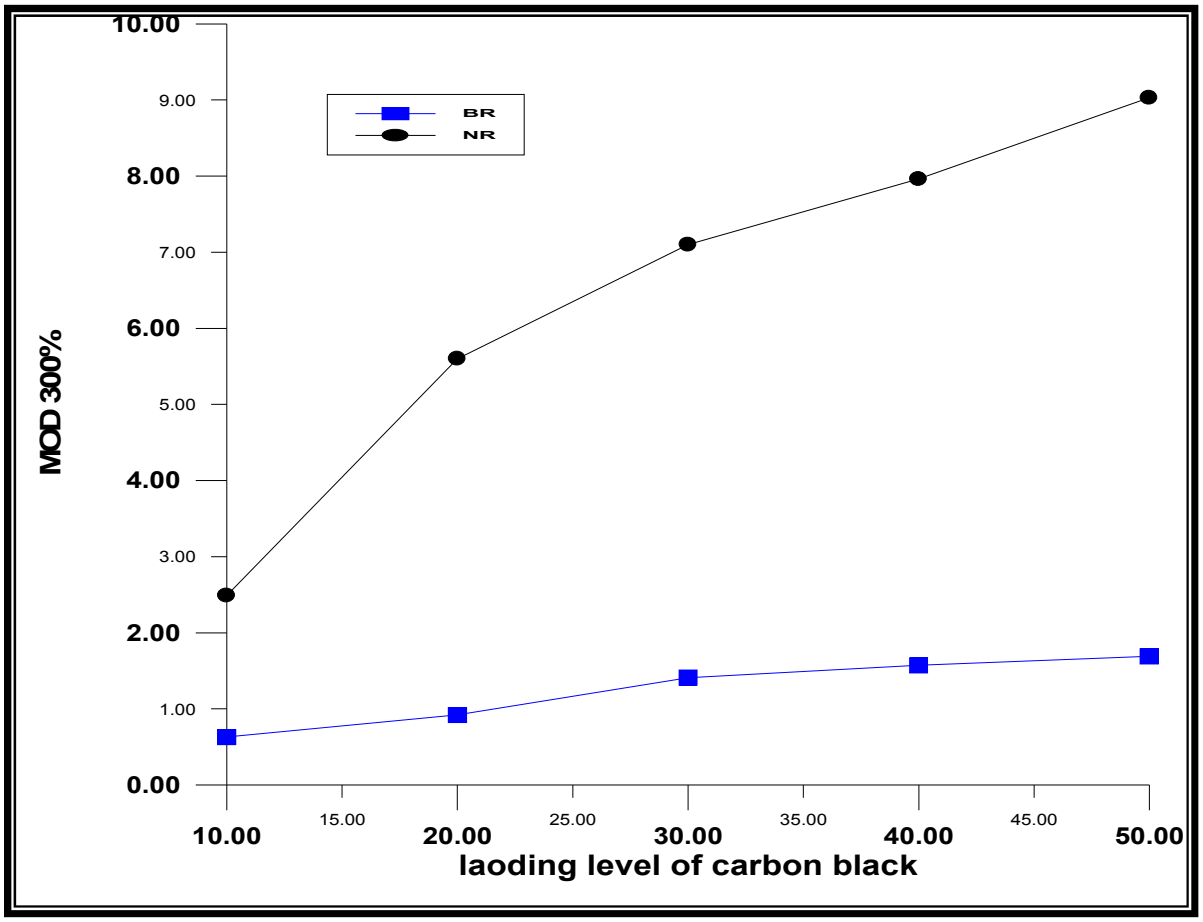


Figure (5) mod 300% result

ELONGATION RESULTS

Figure (6) shows the variation of elongation(%) with loading level of carbon black. It is observed that the elongation(%) decreases with increasing the carbon black level.

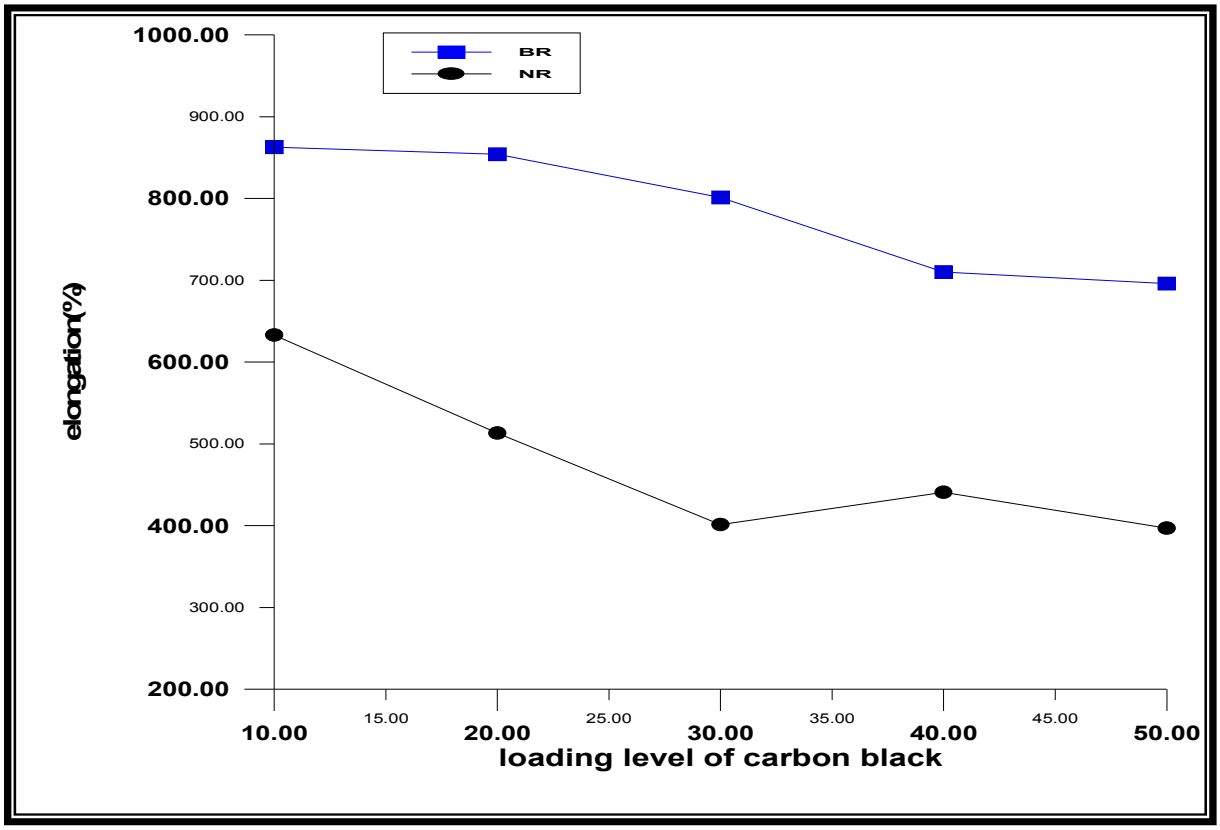


Figure (6) Elongation(%) results

TORQUE REAULTS

Figure (7) shows the variation of torque with loading level of carbon black. It is observed that the torque increases with increasing the carbon black level.

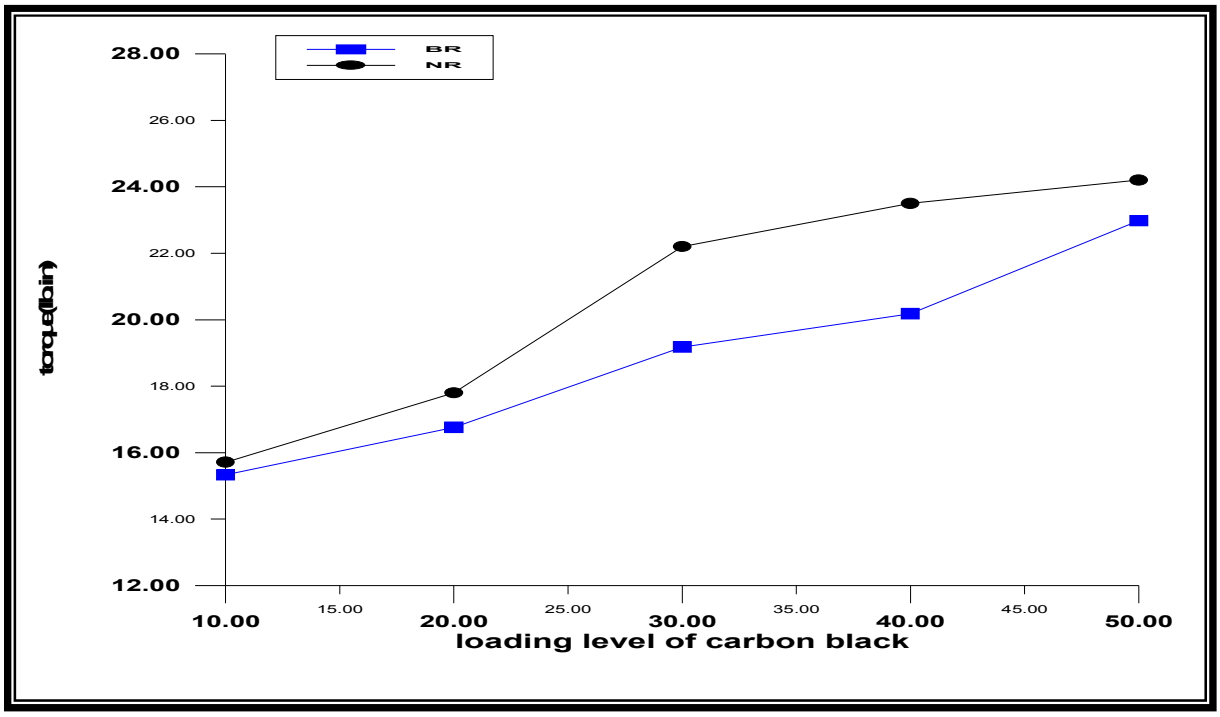


Figure (7) Torque results

TS_2 REAULTS:

Figure (8) shows the variation of Time scorch (TS2)(time for torque to increase 2 dN.m above ML(*ML, Minimum torque* – A measure of the viscosity of the uncured compound.) with loading level of carbon black. It is observed that the TS2 decreases with increasing the carbon black level and these resuslts indication to improve mechanical properties

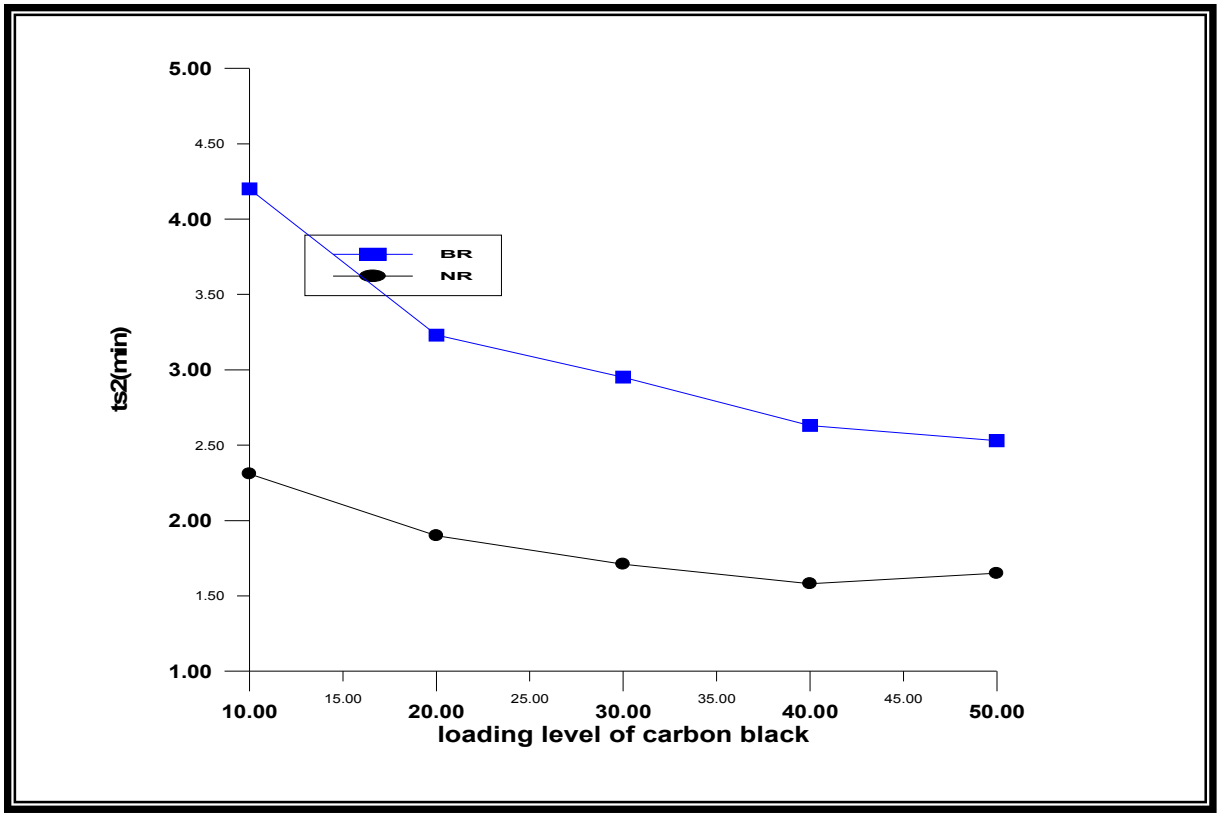


Figure (8) ts2 result

SPESFIC WEIGHT:

Figure (9) shows the variation of specific weight with loading level of carbon black. It is observed that the specific weight increases with increasing the carbon black level.

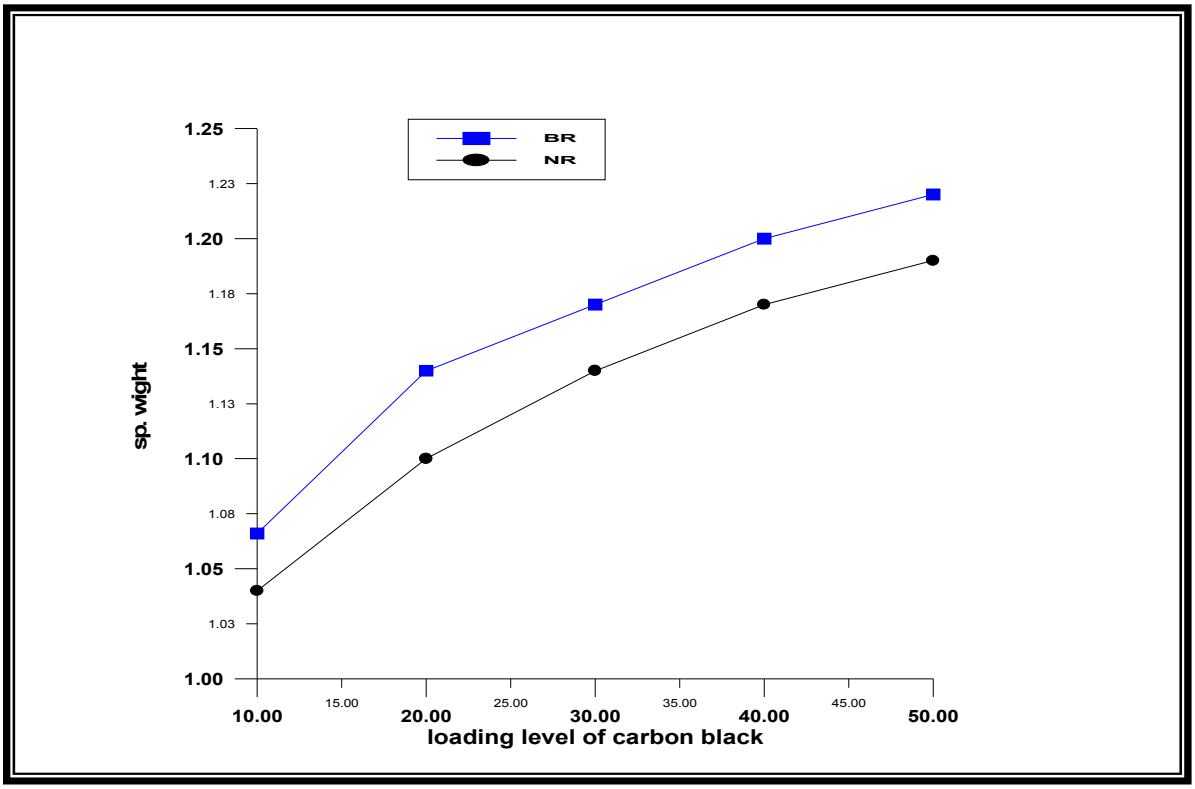
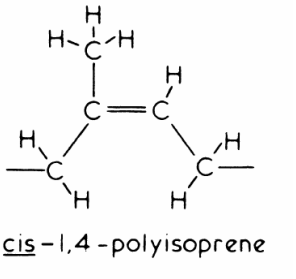


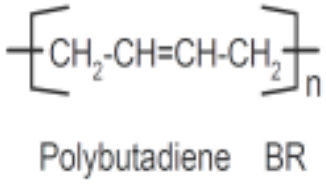
Figure (9) specific weight result

2- DISCUSSION:

- The results show increases in electrical conductivity, the conductive filler (carbon black) forms a few continuous chains (conductive networks) in the rubber matrix. Through this continuous network, charged species (electrons) move from one end to the other under an applied electrical field. The electrical conduction is take place not only by interparticle contact but also by electrons being able to jump (hop) across a gap through energy barriers between conducting elements in the polymer matrix. There is a threshold value for these gaps (a few nanometers) which is equivalent to interparticle contact.

Results show the (NR) rubber is best than (BR) rubber because of structure NR rubber repeat unit's which produce spaces more than (BR) rubber so that the conductive fillers could penetrate and made conductive network .





Repeat units for NR, BR

- The MECHANICAL TESTS results show that the hardness, tensile stress, stress at mod 300% , Torque, specific weight, increases with increasing the carbon black loading . And the (NR) rubber is best than (BR) rubber because of NR polymer is nearly 100% cis-1,4 polyisoprene with Molecular weight ranging from 1 to 2.5 x 10^6. Due to its high structural regularity, natural rubber tends to crystallize spontaneously at low temperatures or when it is stretched. The strain-induced crystallization gives natural rubber high tensile strength and resistance to cutting, tearing, and abrasion latex [peter A Ciullo-1999].

And another reason for This increase in the mechanical properties is due to the fillers and carbon black that added which made increase in intermolecular interaction force in rubber chains make it more hardness.

The variation of Time scorch (TS2) that define (time for torque to increase 2 dN.m above ML(ML, Minimum torque – A measure of the viscosity of the uncured compound.) with loading level of carbon black. It is observed that the TS2 decreases with increasing the carbon black level.

It is observed that the elongation (%) decreases with increasing the carbon black level, because the fillers which added increased intermolecular interaction force in rubber chains that mean reduce the stretch , elongation (%) .

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