How to Cite:
Saadallah, D. R., & Sulyman, E. Z. (2022). Preparation and study of some mechanical and thermal properties of epoxy composites with natural styrene butadiene rubber (damaged tires). *International Journal of Health Sciences*, *6*(S1), 6278–6291. https://doi.org/10.53730/ijhs.v6nS1.6302

Preparation and study of some mechanical and thermal properties of epoxy composites with natural styrene butadiene rubber (damaged tires)

Dalia Rabie Saadallah
Department of Chemistry, College of Education for Girls, University of Mosul, Mosul, Iraq
Email: Dalya.20gep62@student.uomosul.edu.iq

Ebtahag Z. Sulyman
Department of Chemistry, College of Education for Girls, University of Mosul, Mosul, Iraq
Email: ebthalim@uomosul.edu.iq

***Abstract*---**A composite material was prepared from epoxy resin as a base material with the reinforcing materials (natural and synthetic styrene butane rubber) with different weight percentages and different results were obtained depending on the added weight percentages of the reinforcing material, and the effect was clear on the values of mechanical properties and thermal conductivity. The values of the hardness, shock and compressive strength increased after the reinforcing process, but the relationship was inverse between the hardness and compressibility with temperature. As for the shock resistance, it increased with an increase in temperature to 55 °C. As for the thermal conductivity, it decreased when adding natural styrene butadiene and increased by only one degree when adding synthetic styrene butadiene. It is noted that the results that appeared when adding natural styrene butadiene rubber as a reinforcement material is better than the reinforcement by means of synthetic styrene butadiene.

***Keywords*---**epoxy, natural styrene butadiene rubber, synthetic styrene butane rubber, thermal conductivity, mechanical Properties.

Introduction

Studies have developed in the polymeric materials used in coatings, especially epoxy. The importance of epoxy is due to its high mechanical and chemical

Manuscript submitted: 09 Feb 2022, Manuscript revised: 18 March 2022, Accepted for publication: 22 April 2022

properties, its high heat resistance, dimensional stability, and strong adhesion, where the combination of these properties leads to an increase in its use and diversity of applications (Anas, Rafie, 2013). The epoxy is called the continuous phase or the base in the polymeric composite material, where it is reinforced by using another phase such as fillers. As the efficiency of the composite also depends on the type and size of the fillers and the method of distribution in the composite. Which leads to a strong relationship between the properties of the microscopic composite and its apparent properties such as tensile, bending and shock resistance and many physical properties (Jassim, Wedad Hamdi, 2015). The researcher (Ahmed et al., 2017) conducted a scientific study of some mechanical and physical properties of a binary polymer mixture of (epoxy polyurethane resin) by weight of 15%, where the results showed that the direct relationship between flexibility, shock and thermal conductivity with an increase in age (0-28) days, on the contrary, the hardness decreases with increasing age , As for the researcher (Al-Rawi, Rua'a Issam Ibrahim, 2019), she studied some mechanical and physical properties of the epoxy composite reinforced with some fibers (glass fibers, carbon fibers). The researcher proved that when the weight ratios of carbon fibers and glass fibers increased, the mechanical properties of the material increased, and she also noticed that the epoxy composite containing glass fibers was the best compared to the composites containing carbon fibers, however, the researcher (Saleh, Fahd Maarouf, 2019) prepared and studied the thermal and optical properties of some phenolic resins and used them as hardeners for epoxy resin; by preparing phenolic resins of the rissol type through a condensation reaction using (DGEBPA) hardening agents for epoxy resin. An integrated study was conducted in which the amount of hardener was fixed and the hardening time was determined. Through the research, some measurements of the hardened resin were made with those resins prepared in the research. . As the researcher (Muhammad, Safa Zia 2021); By studying the mechanical and physical properties of epoxy when adding sulfur, the researcher added sulfur as a support material to the epoxy resin with specific weight ratios, and it was proved during the research that the hardness, compressibility and shock increased after the sulfur reinforcing process, but the thermal conductivity decreased after the sulfur reinforcing process.

Experimental part

First, the materials used

In this research, the following materials were used, from which the samples were manufactured:

1- The basic substance

The base material used in the research is epoxy resin (Sikadur-32 normal) with a density of 1.4 Kg/L with a white color. The hardener is 3-amino methyl-3,5,5-trimethyl hexyl amine of a dark gray color. The hardener is added to the epoxy in ratio (2:1) under normal conditions to obtain the samples required for molding.

2- Reinforcing materials

The following reinforcement material was used:

1- Natural styrene butadiene rubber (wasted car tires) in the form of powder (Sultan, Hammam Taha, 2018)

2- The styrene-butadiene synthetic rubber prepared by the cold process, which is called cold rubber, has a high conversion efficiency
(Mohammed, Akram, 1993)

The epoxy was used after adding the hardener to it in a ratio of (2:1) to become a gelatinous substance at room temperature in the process of preparing the samples, to identify the mechanical and physical properties of the epoxy alone and to make a comparison process in the results before and after the reinforcement process that the natural styrene-butadiene reinforcing materials used are treated with liquefied nitrogen in order to freeze and then grind by hand to obtain a powder of appropriate size. They are added as reinforcing materials in proportions (5%,10%,15%,20%,25%,30%,35%,40%,45). %,50%,55%,60%), after the reinforcing materials are added to the resin for hardening with mixing in order to complete the homogenization process, they are then placed in the molds designated for each measurement according to the specifications of each examination. After the casting process is completed, the molds are left for 24 hours to complete solidification at different temperatures (8,25, 55) ^{o}C to reduce stress and to obtain complete overlap and homogeneity.

Second: Prepare the samples

1- Hardness test samples
Use the Shore-D Durometer shore hardness device supplied by Wolpert-Germany, to measure the hardness of polymeric materials; the device consists of a needle in the middle and the method of examination is by placing the device perpendicular to the sample to be measured so that it is close to the surface of the sample, then the needle is inserted into the surface, then we wait for three seconds and the hardness value is taken from the device.

2- Impact test samples
The shock test samples were prepared according to the American Standard Specifications (ASTM-D256-87) with dimensions (10×10×55 mm^3) suitable for examination. The grooving depth in the models is (2mm) and the grooving angle is 45°, The absorbed energy required for the fracture to occur was obtained directly from the Charpy Impact Instrument, which is supplied by Tokyo Koki Seizosho, LTD.. Figure (1)

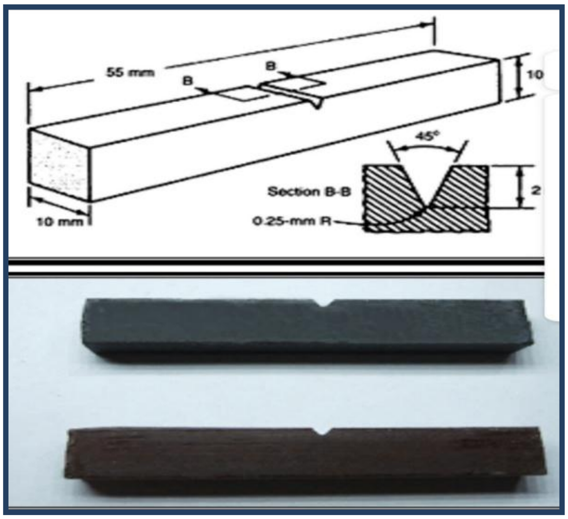

Figure 1: Shape and dimensions of the sample prepared for the shock resistance test

3- Compressive Resistance Test samples

Compressive test samples have been prepared according to the specification (ASTM-D618), which is in a cylindrical shape. A hydraulic piston is used (Testing Machine Co.LTD) supplied by Wolpert - Germany to determine the maximum compressive load that the model can bear and by dividing this load by the cross-sectional area of the sample before deformation was calculated. Compression resistance for all samples.

Figure (2): The shape of the sample prepared for the compressibility test

4- Models of thermal conductivity

Samples with a diameter of (11.23) cm and a thickness of (1 cm) are used in the test.

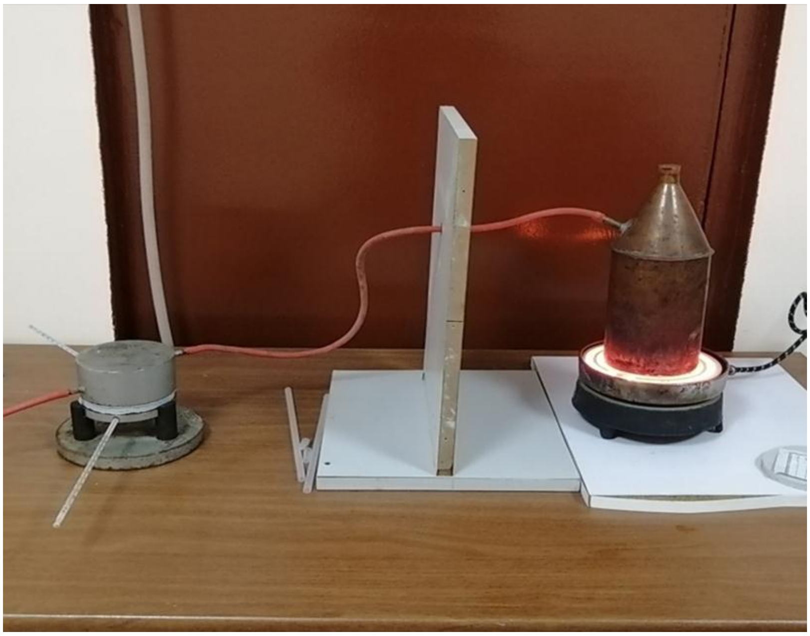

Figure (3): Thermal conductivity coefficient measuring device

Results and discussion

Hardness

Hardness is one of the very important mechanical properties for studying the surface of the material under study. It is defined as the material's resistance to scratching or the resistance to local deformations. The hardness of materials depends on the type of bonding force that binds molecules or atoms, and on the type of surface, whether it is (smooth or rough), as well as the temperature and the influencing conditions (Faeq, Ahmed, 2013).
Figure (4) and Table (1).

Table (1)

Composites At 25 C°	Reinforcement (KJ/m^2)	Composites At 25 C°	Reinforcement (KJ/m^2)
EP	83	EP	83
EP+ NSBR 5%	118	EP+ISBR 5%	83
EP+ NSBR 10%	121	EP+ISBR 10%	86
EP+ NSBR 15%	123	EP+ISBR 15%	83
EP+ NSBR 20%	123.5	EP+ISBR 20%	75
EP+ NSBR 25%	124	EP+ISBR 25%	73
EP+ NSBR 30%	123	EP+ISBR 30%	73
EP+ NSBR 35%	123	EP+ISBR 35%	70
EP+ NSBR 40%	122	EP+ISBR 40%	69
EP+ NSBR 45%	123	EP+ISBR 45%	68
EP+ NSBR 50%	125	EP+ISBR 50%	71
EP+ NSBR 55%	122	EP+ISBR 55%	65
EP+ NSBR 60%	121	EP+ISBR 60%	65

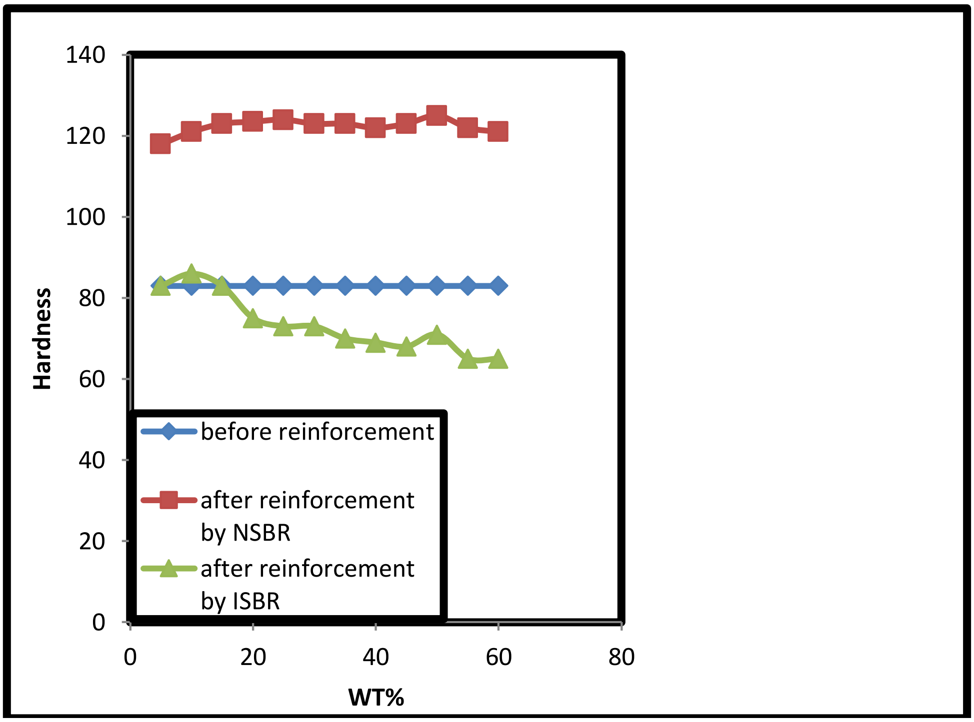

Figure (4): The relationship between weight ratios and hardness values before and after reinforcement at 25°C

From the figure and the table, we choose a sample at a concentration of 5% of the fortified material (natural styrene butadiene) and a sample at a concentration of 1% of the fortified material (styrene butadiene industrial), where the highest values of hardness were recorded at those concentrations. Three samples are prepared at the same concentration and then the first sample is left 24 hours at (8) °C, the second sample at (25) °C, and the third at (55) °C, and then we measure the hardness. Figure (5)

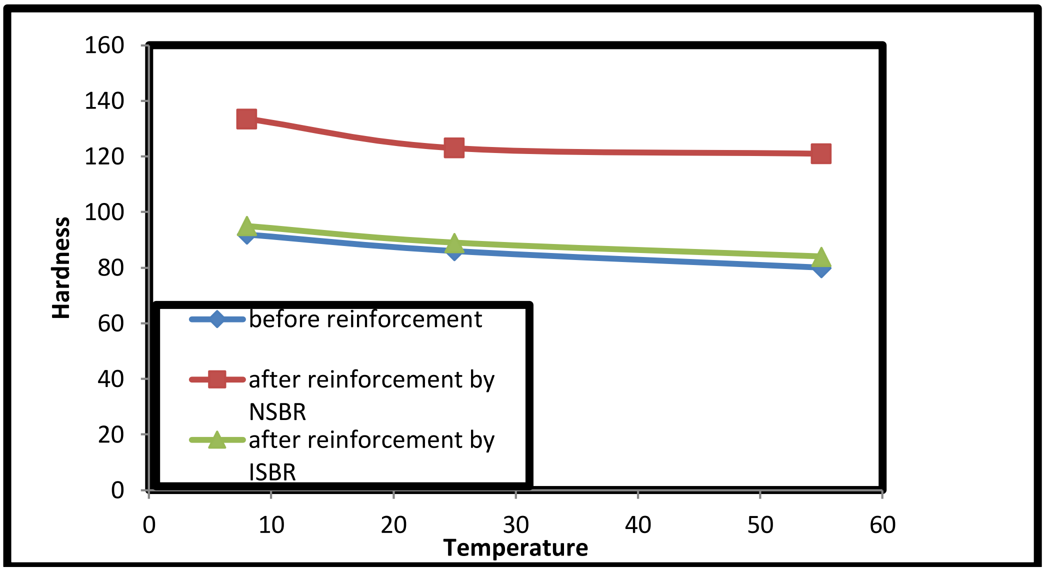

Figure (5): The relationship between hardness and temperature before and after reinforcement

The hardness values increased after reinforcing the epoxy with natural styrene butadiene rubber due to the increase in cross-linking between the epoxy resin and the reinforcing materials (Habib, Sabah Abbas, 2013) the hardness values increased after reinforcing with styrene butadiene synthetic rubber, but only when small concentrations of the reinforced material were added, It is also noted that the inverse relationship between hardness and temperature, the higher the temperature, the lower the hardness, and vice versa also, due to the viscosity of the material and to the quantity and type of the added reinforcement material, which leads to the appearance of gaps inside the material and causes a decrease in hardness (Husnia, 2012).

Compressibility

Compressibility It is the strongest stress that a material can bear under applied vertical pressure, and it can be calculated by the ratio of the load applied to it divided by the cross-sectional area as shown in the relationship: C(Mpa) = Force(N)/Area(m^2) ….
(AbdAl-Hussien, 2015). Figure (6) Table (3)

Table (2)

Composites At 25 C°	Reinforcement	Composites At 25 C°	Reinforcement
EP	60.50	EP	60.50
EP+NSBR 5%	63.69	EP+ISBR 5%	71.65
EP+NSBR 10%	70.06	EP+ISBR 10%	73.24
EP+NSBR 15%	79.61	EP+ISBR 15%	74.84
EP+NSBR 20%	79.61	EP+ISBR 20%	63.69

EP+NSBR 25%	87.57	EP+ISBR 25%	60.50
EP+NSBR 30%	87.57	EP+ISBR 30%	55.73
EP+NSBR 35%	89.17	EP+ ISBR 35%	47.70
EP+NSBR 40%	92.35	EP+ISBR 40%	38.21
EP+NSBR 45%	95.54	EP+ISBR 45%	31.84
EP+NSBR 50%	103.50	EP+ISBR 50%	15.92
EP+NSBR 55%	95.54	EP+ISBR 55%	15.28
EP+NSBR 60%	89.17	EP+ISBR 60%	12.73

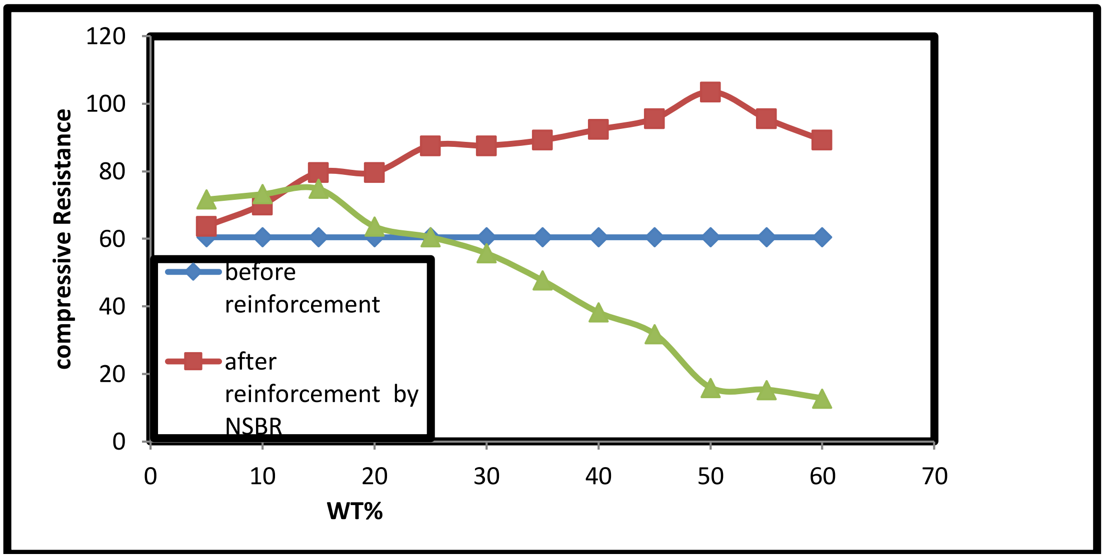

Figure (6): The relationship between weight ratios and compressive strength values before and after reinforcement at 25 °C

Then three samples are prepared at temperatures (8,25,55) °C in order to observe the effect of temperature.

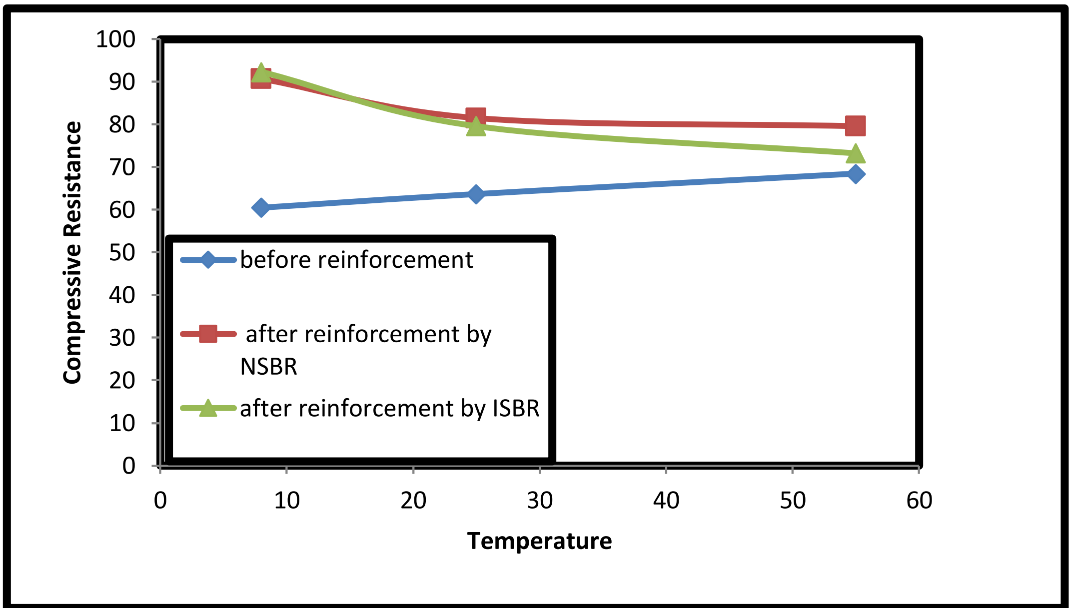

Figure (7): The relationship between temperature and compressibility values before and after reinforcement

The compressibility values increase after reinforcement with natural styrene butadiene rubber, but in varying proportions due to the distribution of the load on the rubber, as well as to the high efficiency of the bonding between the substrate and rubber. The few of the reinforced material and then start to decrease. The compressibility decreases with the increase in temperature due to the weakness of the base material and the strength of its bonding with the particles. The heat makes the resin softer, which weakens the resistance of the material to the compressive load (Mustafa, Abdel Hamid, Balqis, 2010).

Shock resistance

It is the ability of the material to resist fracture under the influence of the load and it is a measure of the durability of the material and it is possible to improve the shock values by adding reinforcing materials (fillers) and arranging the polymeric chains well and completely homogeneously (Mosawi, 2012)

Table (3)

Composites At 25 C°	Reinforcement	Composites At 25 C°	Reinforcement
EP	2.129	EP	2.129
EP+NSBR 5%	3.76	EP+ISBR 5%	2.129
EP+NSBR 10%	3.73	EP+ISBR 10%	2.443
EP+NSBR 15%	4.01	EP+ISBR 15%	2.129
EP+NSBR 20%	4.01	EP+ISBR 20%	2.684
EP+NSBR 25%	4.56	EP+ISBR 25%	2.734
EP+NSBR 30%	3.73	EP+ISBR 30%	2.734

EP+NSBR 35%	4.26	EP+ISBR 35%	2.984
EP+NSBR 40%	4.91	EP+ISBR 40%	2.441
EP+NSBR 45%	4.62	EP+ISBR 45%	1.524
EP+NSBR 50%	5.05	EP+ISBR 50%	1.234
EP+NSBR 55%	4.62	EP+ISBR 55%	1.234
EP+NSBR 60%	4.04	EP+ISBR 60%	1.181

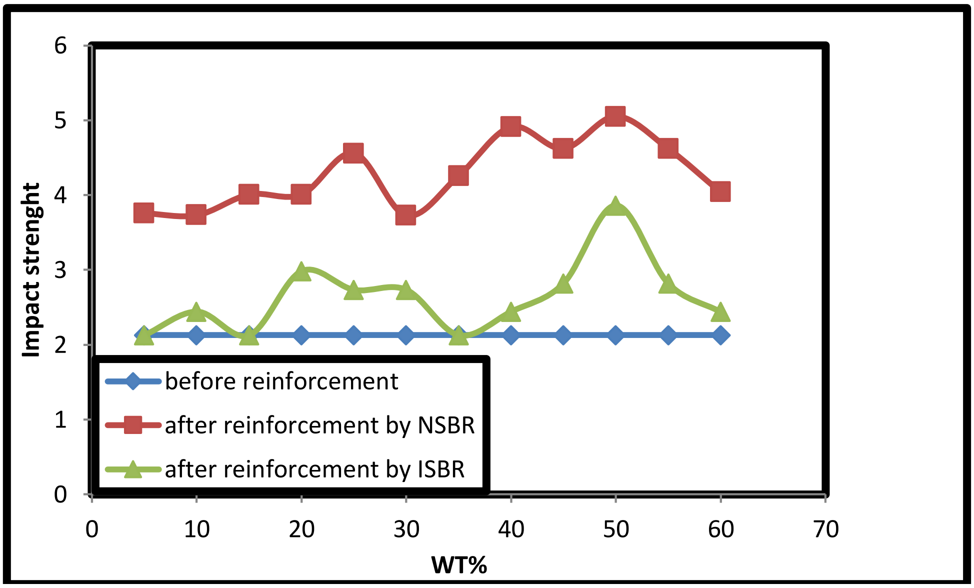

Figure (8) The relationship between weight ratios and shock values before and after reinforcement at 25°C

We notice from the figure that when natural and synthetic styrenebutene was added as a reinforcement material, the shock values increased in a different way, differing according to the forms of the reinforcing materials and their durability and on the distribution of applied stresses, as well as the process of distributing rubber within the substrate has a significant impact on the shock values (satish, 2010). Then three samples were taken and left 24 hours at different temperatures (8,25,55) °C. Figure (9)

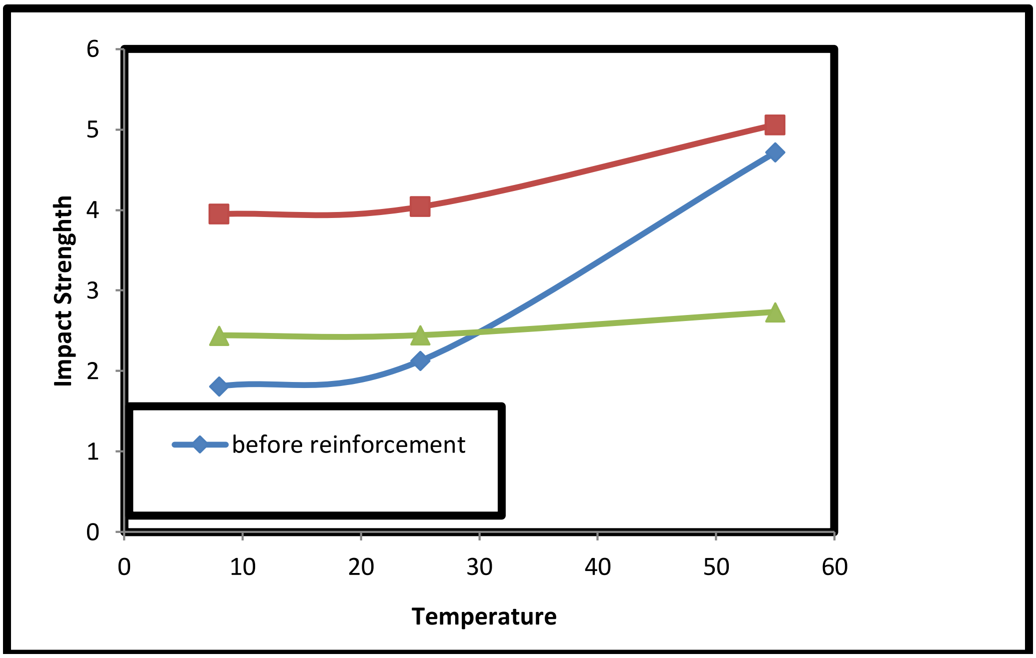

Figure (9): The relationship between temperature and shock values before and after the strengthening process

We note that the shock values have a direct relationship with the temperature, so the shock values increase with the increase in temperature, due to the breaking of bonds between the particles of the material and its sliding movement, so the possibility of absorbing part of the energy increases, which leads to an increase in the full energy of the fracture. (Wadallah, Esraa Saad, 2020).

Heat conduction

Heat is a type of energy like other energies such as kinetic energy and electrical energy. When heat is generated, this means that the generated heat is as much as the work done, as the heat is transferred from the hottest place to the coldest place (Ali, Belqis, 2009). That is why thermal conductivity is defined as the amount of mobile heat. During one second it is divided by the regression of the temperature (Akram, Sinai, 2009). Figure (10)

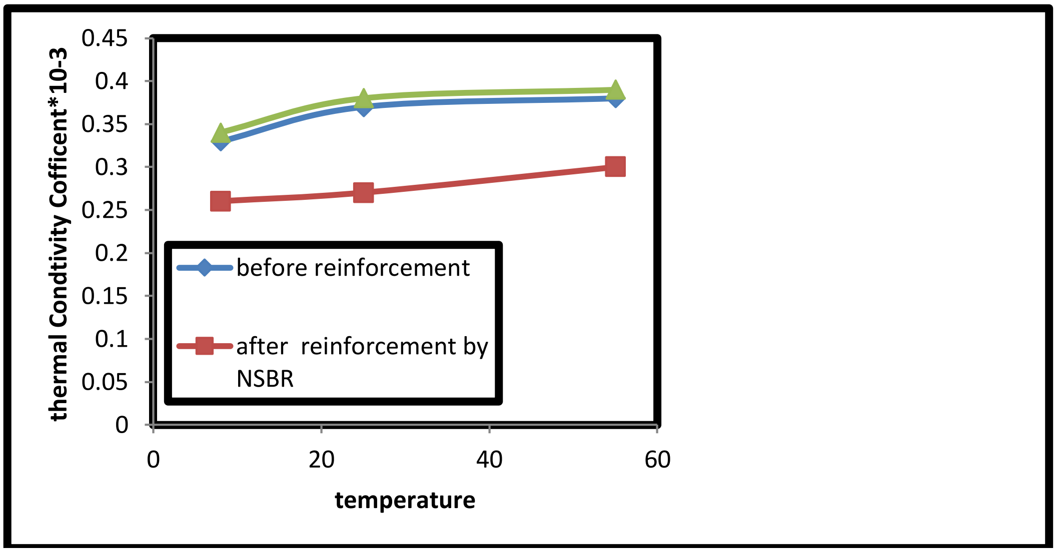

Figure (10): The relationship between temperature and thermal conductivity coefficient values before and after the strengthening process

The thermal conductivity value decreases when reinforcing with natural styrene butadiene (wasted car tires) because the additives have a lower conductivity coefficient than epoxy resin (Gargis, Ayad Giad, 2013). However, the thermal conductivity increases when industrial styrene butadiene is added because the conductivity coefficient is greater than that of epoxy resin.

Conclusions

The values of the mechanical properties (shock, hardness, compressibility) change positively after the reinforcement process with natural and synthetic styrene butadiene rubber. Except for the shock, it increases slightly at only low concentrations of the synthetic styrene butadiene reinforced material and decreases at high concentrations. The compressibility and hardness increase clearly and differently with both types of rubber. As for the thermal conductivity, its value decreases when reinforced with natural rubber and rises slightly when the resin is treated with synthetic rubber.

References

1. Jassem, Wedad Hamdi, (2015) “Preparation of epoxy compounds and eggshell powder for use in coating surfaces.” Baghdad University, College of Education for Pure Sciences, Department of Physics.
2. Al-Rawi, Rua’a Essam, (2019), “Studying some mechanical and physical properties of an epoxy composite reinforced with glass and carbon fibers.” Master’s thesis, University of Mosul, College of Education for Girls, Department of Chemistry.
3. Ahmad, Adnan Raad, Erhaiem, Seif Sabah, Abdul Majeed, Moayed Faeq, (2017) “A practical study of some mechanical and physical properties of a binary polymer mixture of (epoxy-polyurethane resin)” Tikrit Journal of Engineering Sciences, Vol. 24, No. 2,93-86

4. Saleh, Fahad Maarouf, (2019) “Preparation and study of the thermal and optical properties of some phenolic resins” Master’s thesis, University of Basra, College of Science, Department of Chemistry,
5. Muhammad, Safa Zia, (2021) “Study of the mechanical and physical properties of epoxy when sulfur is added” Mosul University, College of Education for Girls, Department of Chemistry.
6. Sultan Humam Taha, (2018) “Thermodynamic and kinetic study of adsorption of new azo dyes derived from 4-aminoanti-paparin on activated carbon prepared from mixtures ((asphalt: polymer)) and the development of the rheological properties of these mixtures”, PhD thesis, University of Mosul, College Education for pure sciences, Department of Chemistry
7. Muhammad, Akram Aziz, (1993), The Chemistry of Plastics, University of Mosul
8. Faeq Hammad, Ahmed Hassan, (2013), "Studying the wear resistance and hardness properties of polymeric mixtures", Anbar University Journal for Pure Sciences, Volume VII, Issue One
9. Habib, Sabah Abbas, (2013) “Improving the mechanical specifications of a mixture of natural rubber and recycled rubber using novolac” Babylon University Journal, Engineering Sciences, Issue 4, Volume 21.
10. Husnia. H(2012)”Effect of Temperature on Mechanical and Thermal Properties of Polyester Matrix Reinforced by Oridinary Glass Powder”University of Mosul, College of Education ,Department of physics.
11. 11-Abd Al-Hussien,H.J.,”Effect of immersion in chemical Solution on the mechanical and physical properties for composite material reinforced by nano alumina particales ,Iraqi Journal of Science ,5.3:1952-1963,2015.
12. 12- Ibtihaj Zaki, Roaa Essam, (2019) “Using reinforcement with carbon fibers to improve the mechanical properties of epoxy resin” Mosul University, College of Education for Girls, Department of Chemistry
13. 13- Mustafa, Abdel-Hamid, Belqis, “Studying the effect of heat on some mechanical properties of single and hybrid composites.” Ibn Al-Haytham Journal for Pure and Applied Sciences, Volume 24, Issue 2, 2011.
14. Al Mosawi,A.I.,”Effect reinforcement minutes Mgo on the thermal and mechanical qualities of epoxy resin “The Iraqi Journal for Mechanical and Material engineering,11.3(2011).
15. 15-Waad Allah, Esraa Saad, (2020) “Preparation and study of some mechanical and thermal properties of the composite of unsaturated polyester with polyethylene and fluorescent powder” Master’s thesis, Mosul University, College of Education for Girls, Department of Chemistry.
16. 16-Satish, Kg, Siddeswarapp, B.and Kaleemulla Mohamed, (2010) “Characterization of In-Plane Mechanical Properties of Laminate Hybrid Composites”, Journal of Minerals and Materials Characterization and Engineering, Vol.9, No.2, PP.110
17. 17- Ali Hassan, Belqis Muhammad, (2009) “Studying the effect of temperature and ultraviolet rays on the thermal conductivity values of hybrid composite materials” Journal of Engineering and Technology, Volume 27, Issue 9

18. 18- JarJis, Ayad Jyad, (2013) "Studying the effect of polymer granules on some thermal and mechanical properties of PTFE Portland cement paste" Mosul University, College of Science, Volume 16, Issue 4, 19-25.
19. 19- Akram Atta, Sinai Ibrahim (2009) “Measuring the thermal conductivity of epoxy and unsaturated polyester composites reinforced with hybrid layers of Kevlar and carbon fibers” Baghdad University, College of Science, Department of Physics.