Iraqi National Journal of Chemistry

Journal homepage:
http://journals.uobabylon.edu.iq/jouchem/

Study the mechanical and physical properties of an epoxy compound with Silicate Sodium

Safa D. Mohmmed[1], Ebtahag Z. Sulyman[2], Huda A. Abid[3] , Ekhlas Q. Hammadi[4]

[1-4]Department of Chemistry, College of Education for Girls, University of Mosul, Mosul, Iraq
[4]**Emails:** [1] DiaaSafa922@gmail.com, [2] ebthalim@uomosul.edu.iq, [3]h.a.abid@umosul.edu.iq , hasan2017ek@gmail.com

Abstract

This study illustrates the effect of adding sodium silicate as a reinforced material of different weight ratios (1%, 3%, 5%, 7%, 9%, and 11%) to epoxy resin to synthesize composite materials. The mechanical and physical properties, namely compressive strength, hardness, impact strength, and thermal conductivity, were employed on the prepared composites. All experiments were conducted with two temperatures of 22C° and 52C°, respectively, to demonstrate the effect of the temperatures of these properties on the resin behavior. The results showed that (compression strength and hardness) decreased with a rise within the weight ratios of sodium silicate. However, an increase in the impact strength and high values of thermal conductivity of epoxy were noticed with the rise in the weight ratios of sodium silicate.

Keywords: Sodium Silicate, Epoxy resin, Compressive Strength, Thermal Conductivity.

Introduction

Polymers are significant in human life, as most of today's industries rely on these chemical compounds. Plastic was considered the most common material used in the modern world. Recently, it has become fundamental to any person's lifestyle to be routinely used in many applications ranging from local instruments to advanced scientific and medical devices and instruments (1).

Polymeric materials characterized by high rust resistance and light weight have become suitable for most industrial applications. Polymers can be strengthened by adding low-cost filling materials to manufacture commercial composites (2).

Epoxy resin is one of the most important types of polymers widely used in industries due to its interesting properties, such as non-shrinkage, high thermal stability, and chemical resistance (3).

In 2001, Hamid investigated an overlapping material formed by supported-epoxy resin carbon fiber and fiberglass with a volumetric fraction (30%). This was folded in layers inside the material, each of five layers consisting of a carbon fiber and a layer of fiberglass inserted between them with a ratio (of 1:5). Followed by, adding another overlapping material layer includes epoxy resin supported by pure aluminum powder under the same volumetric fraction(4).

There has been an increasing interest in manufacturing potential reinforced resins in recent years. Chowdhury used epoxy resin reinforced with three distinct types of wood dust (sandalwood, saj wood, and rubberwood) individually of various weights in 2010. The researcher performed several tests (tensile test, impact resistance test, and strength test) and found that the mechanical properties of the epoxy material were improved when mixed with the wood powder. Another obvious finding from this study is that the Solidity values of the Saj duster samples are higher than those reinforced with sandal dust and rubber (5).

In 2012, Ali and co-workers studied the mechanical properties of (reinforced polyester and copper powder, and mechanical tests were carried out on it, such as bending resistance and impact testing(6).

Musa and co-workers published a paper in 2014 in which they studied the effect of adding glass powder in size (mµ35) and with different volume fractions (10%, 20%) to a mixture of (UPE/PU) with a weight ratio (90/10). The obtained results showed that the addition of glass powder to a polymer mixture has dramatically improved the mechanical properties represented by bending, hardness, impact strength, and Elastic modulus.

In this work, epoxy/sodium silicate composites were mixed together with different weight ratios to obtain high-performance materials. Physical features such as compressive strength, solidity, impact strength, and thermal conductivity were investigated at two temperatures 22C° and 52C°(7).

Practical Part

The materials used in the research:

Base material

Epoxy is the main material Equipped by accompany (Master Brace ADH 1420, density 1.55 kg/litter). (Tri ethylene tetra amine) the compound was used as a hardener manufactured by the BASF company. This hardener was added to the epoxy with a ratio (3:1) at room temperature to provide suitable samples for molding.

Reinforcement material

As an environmental binder, sodium silicate has exceptional temperature stability and is frequently employed in the building field, demonstrating good temperature stability. It is a thick liquid with a specific gravity of 1.53 g/cm3. As a result, it is used to strengthen epoxy resin produced by MSDS.

Sample preparation

The hardener (triethylene amine) was mixed with epoxy resin in a ratio of 1:3 to afford a gelatinous substance at room temperature. In the process of preparing the models, Hand Lay-Up molding was employed before and after the reinforcement with sodium silicate in weight ratios (1%, 3%, 5%, 7%, 9%, and 11%). Then the resin was added to the reinforcing materials that placed in molds designated for each measurement. After the shaping process is complete, it was left for 24 hours at (22 and 52C°) to complete the solidification process to reduce stress or pressure, Intermolecular overlap and homogeneity during the shaping (8).

Preparing models

Compressive test

These models were prepared according to (ASTM-D618) specifications and are cylindrical in shape, using a hydraulic press (Testing Machine Co. LTD) supplied by (WoLPERT-Germany).

Hardness test

A Durometer Shore (Shore-D) device supplied by (WoLPERT-Germany) was used to measure the hardness of polymeric materials. The device consists of a compass with a needle located in the middle; this needle was stitched vertically on the surface of the model. After 3 seconds, the hardness values were collected automatically for the desired samples.

Impact test

Impact test models were prepared according to the standard specification (ASTM-D256-87) with dimensions (10*10*55 mm^3) as shown in figure 1. Samples can be tested with the notch angle (45°) and the depth of notch (2 mm), which the amount of energy absorbed in fracturing the test-piece is measured by using Charpy impact instrument supplied from Tokyo koki seizosho LTD.

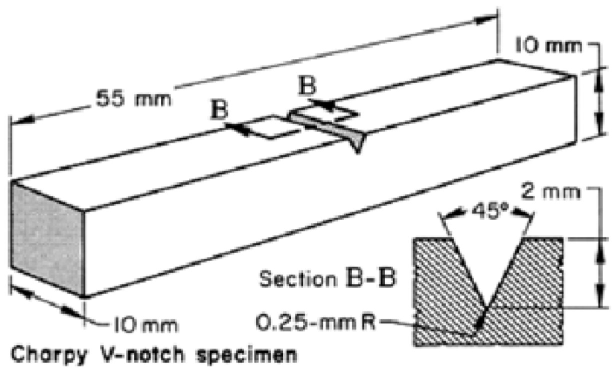

Figure 1: The shape and dimensions of the sample prepared for the impact strength test

Thermal Conductivity

Models were used in this test with a diameter of (112.5 mm) and a thickness of (5mm), as shown in figure 2. It is apparent from figure 3 that five circular shapes of prepared samples were carefully designed to examine its thermal conductivities.

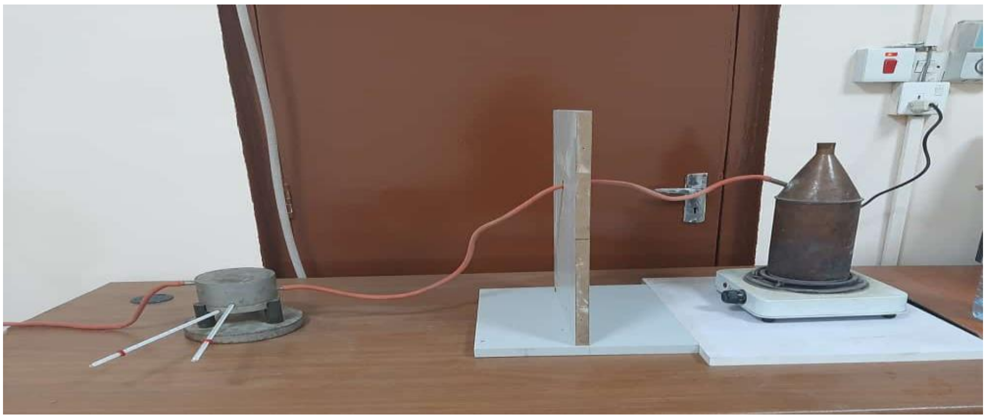

Figure 2: Thermal conductivity instrument

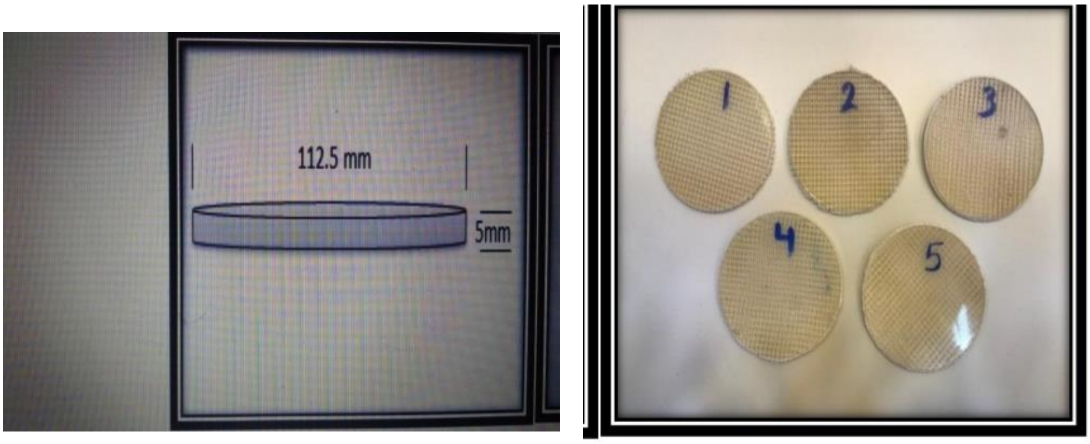

Figure 3: The shape and dimensions of the sample for thermal conductivity test

Results and discussion

1. **Compressive strength test**

Mechanical test measuring the maximum amount of compressive load a material can tolerate before fracturing, it usually measures by is measured (MPa) units. The high values of compressive strength indicate the large bonding forces between the particles of the material (9). The values can be calculated by the relation (10):

$$\mathrm{C\ (MPa)} = \frac{\mathrm{Force\ (N)}}{\mathrm{Area\ (m^2\ )}}$$

As illustrated in table 2, there is a drastic decline in the values of compressive strength before and after adding sodium silicate at both two temperatures from 112% to 28% and 109% to 53% respectively, however, the values of unreinforced epoxy samples levelled out at about 72% (22C°) and 112% (52C°) (11). Furthermore, these values have clearly illustrated in both figure 4 and 5 as line graphs.

Table1 : Compressive strength of epoxy before and after reinforcement at (22C° and 52C°)

Composites	Compressive strength at 22C°	Compressive strength at 52C°
EP	72	112
EP+Na_2SiO_3 /1%	112	109
EP+Na_2SiO_3 /3%	86	97
EP+Na_2SiO_3 /5%	66	87
EP+Na_2SiO_3 /7%	51	81
EP+Na_2SiO_3 /9%	28	63
EP+Na_2SiO_3 /11%	21	53

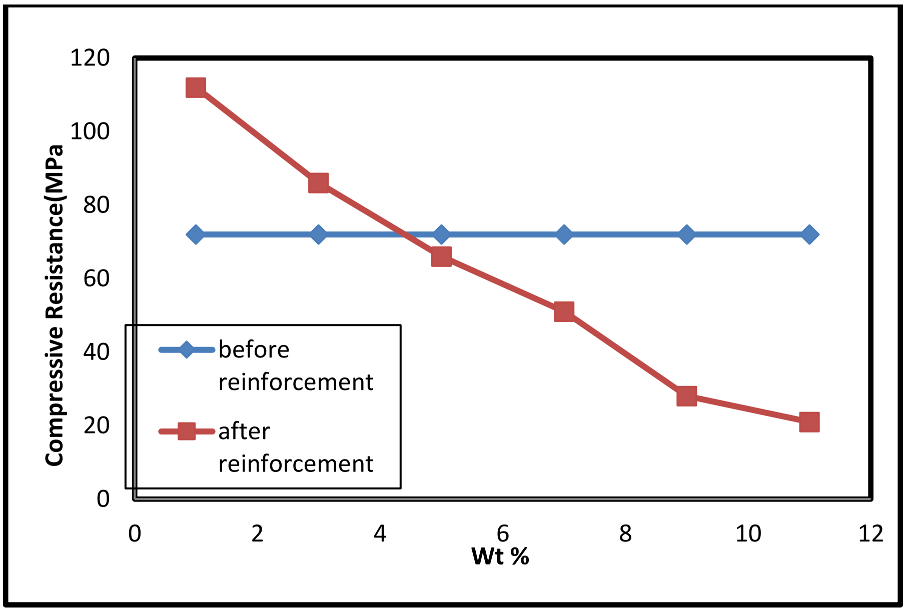

Figure 4: Relation between compression strength and weight ratios of epoxy before and after reinforcement at 22C°

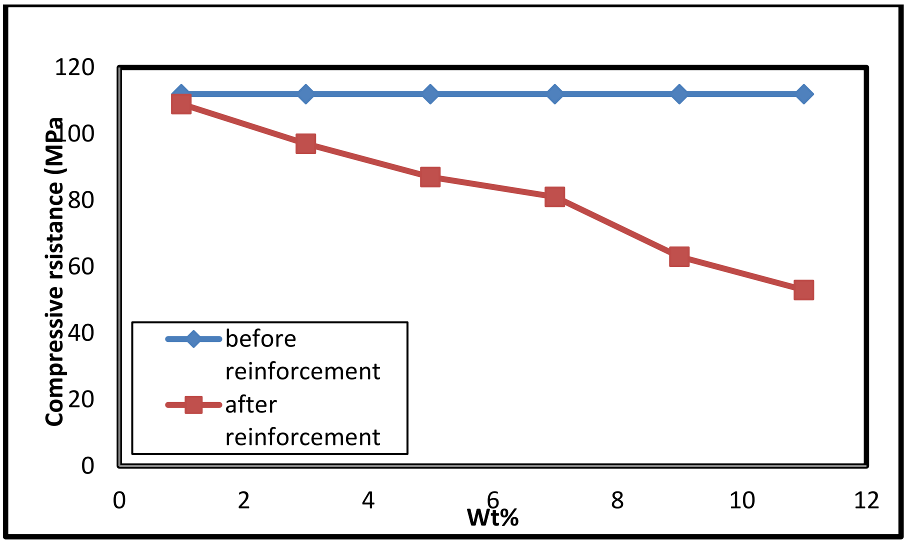

Figure 5: Relation between compression strength and weight ratios of epoxy before and after reinforcement at 52C°

2. Impact strength

It represents the material's ability to resist fraction under the effect of an unexpected load as well as a measurement of the material's durability. High values of Impact strength is a feature of the most durable materials. As a result, a range of impact strength values was set using the Charpy instrument (12). The following equation was used to calculate these data:

$$I = \frac{\text{energy of fracture (J)}}{\text{area of cross section } (m^2)}$$

These resins have low values of impact strength, as shown in table 2 and figures 6 and 7. These values were observed to be slightly increase after being mixed with sodium silicate from 1% to 6% (22C°) and 1.4% to 1.8% (52C°). This is because the silicate bears the majority of the impact energy that is applied to the material (13).

Table2 : Impact strength values of epoxy with different weight ratios at (22C°) and (52C°)

Composites	Impact strength KJ/m² at 22C°	Impact strength KJ/m² at 52C°
EP	1.4	1.6
EP+Na_2SiO_3 /1%	1	1.4
EP+Na_2SiO_3 /3%	3	1.4
EP+Na_2SiO_3 /5%	4	1.5
EP+Na_2SiO_3 /7%	5	1.6
EP+Na_2SiO_3 /9%	5	1.7
EP+Na_2SiO_3 /11%	6	1.8

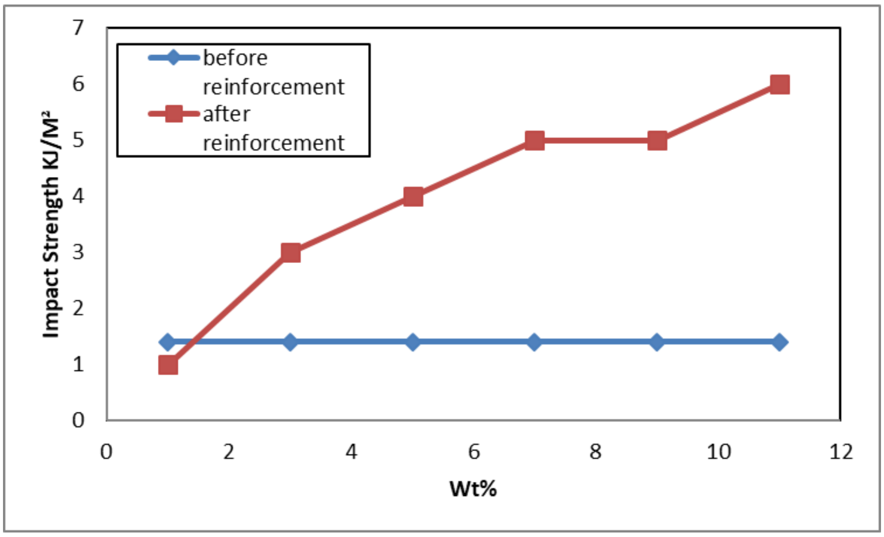

Figure 6: The Relation between Impact strength and weight ratios for Epoxy before and after reinforcement at 22 C°

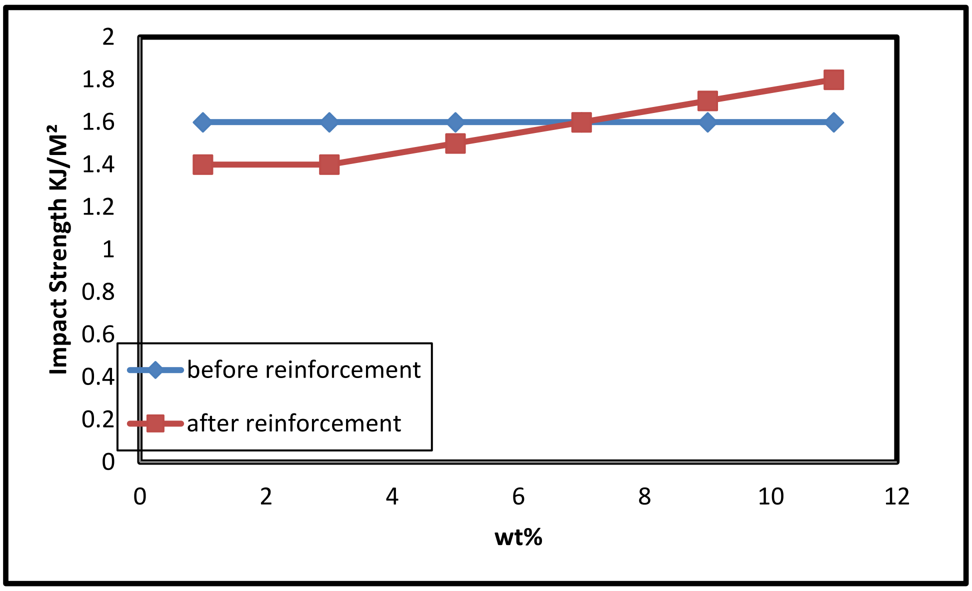

Figure 7: The Relation between Impact strength and weight ratios for Epoxy before and after reinforcement at 52C°

3. Hardness

The hardness test measures a material's resistance to scratching. There are various types of hardness tests used in international standards to determine the hardness of plastic materials, the most well-known of which are Brinell and Rockwell hardness (9). The hardness of materials is determined by factors such as the type of surface, high temperature and thermal treatment, and the type of bonding strength between molecules or atoms (14).

As shown in Table 4, it can be noticed that the hardness values of the reinforced resin with sodium silicate slightly decrease with the rise in weight ratios of the silicate at 22C° and 52C°. These results have compared to the resin without reinforcement with sodium silicate; they remained steady at about 45% and 60% at 22C° and 52C° respectively. Thus, hardness is considered a measurement of the deformation of the plastic by undergoing an external stress is applied. The elasticity of resins increases with a rise in the temperature leading to the weakness of the bonds between the resin and sodium silicate, therefore, the hardness values reduce. Consequently, this trend will reduce its resistance to scratching. The line graphs (figure 8 and 9) compare percentages between the combination of resin with sodium silicate and no reinforcement at 22 C° and 52C° (15).

Table3: Hardness values of epoxy before and after reinforcement at 22C° and 52C°

Composites	**Hardness resistance at 22C°**	**Hardness resistance at 52C°**
EP	45	60
EP+Na_2SiO_3 /1%	126.5	124
EP+Na_2SiO_3 /3%	125.5	123
EP+Na_2SiO_3 /5%	116.8	119
EP+Na_2SiO_3 /7%	116	117
EP+Na_2SiO_3 /9%	114.8	117
EP+Na_2SiO3 /11%	89.5	96

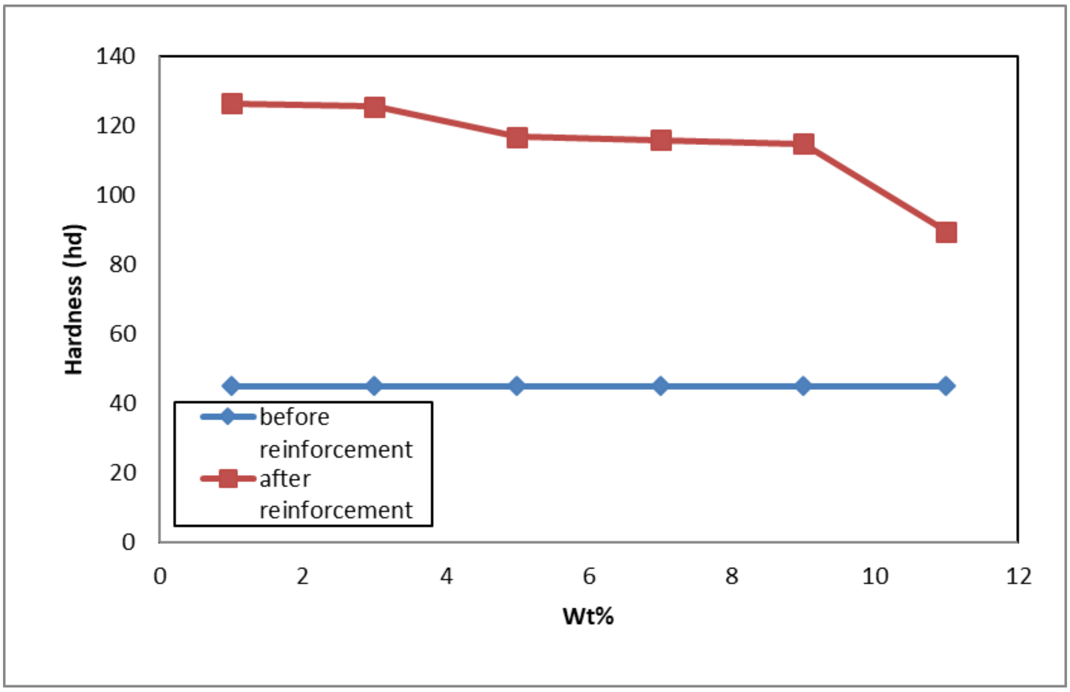

Figure 8: The Relation between hardness and weight ratios

for Epoxy before and after reinforcement at 22C°

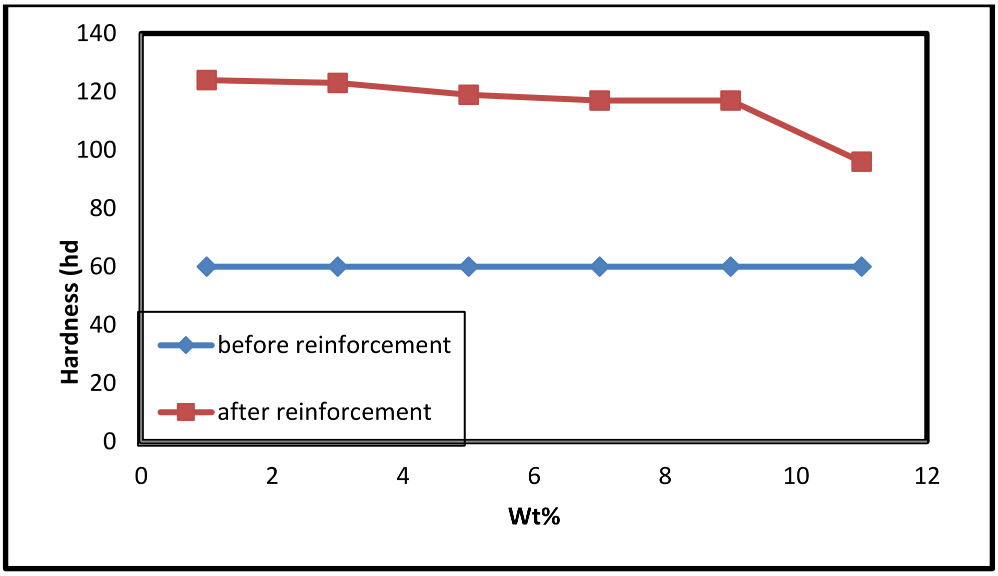

Figure 9: The Relation between hardness and weight ratios for Epoxy before and after reinforcement at 52C°

4. Thermal Conductivity

The molecules in the hot side gain kinetic energy, which increases the amplitude of their vibrations around their sites. This leads to collide with their neighbors of molecules, which acquire energy to transfer to other molecules, and so on. Thus, conductivity happens through the vibrating of molecules in insulating materials that have no free electrons (15).
The values of thermal conductivity can be calculated from the following law (16):

$$\lambda \, . \frac{1}{4} \pi D^2 \left(\frac{T_2 - T_1}{d} \right) = \text{mass of disc. CS. PN\textbackslash QN. 1 / 60}$$

As shown in figure 10, it can be noticed that the thermal conductivity values of epoxy reinforced with sodium silicate increases with a slight rise in weight ratios of silicate because of the thermal conductivity of sodium silicate. However, reinforced epoxy with silicate levelled out by $9*10^{-4}$ (17).

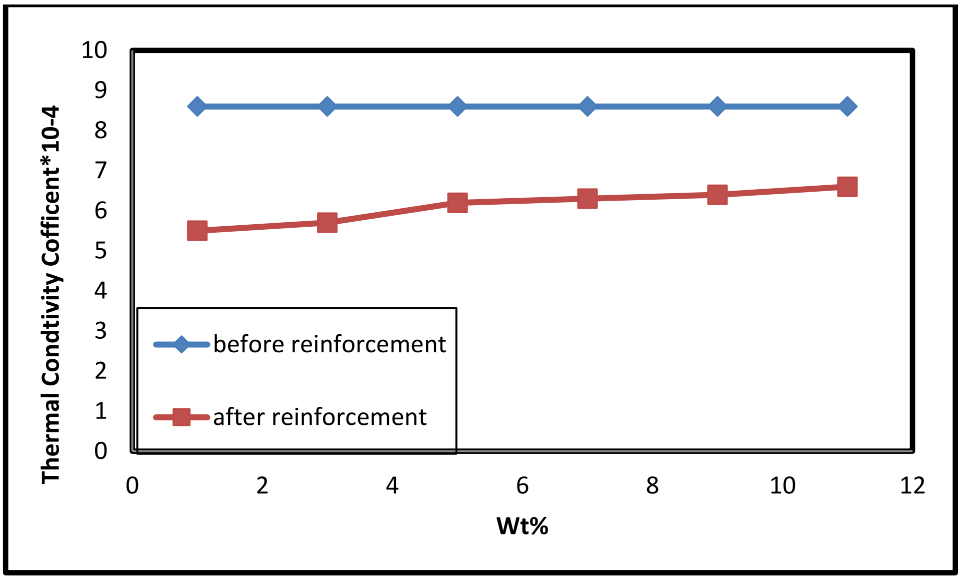

Figure 10: Thermal conductivity curves of epoxy before and after reinforcement

Conclusion:

In summary, the present study has focused on the possibility of preparation new resins, which reinforced with sodium silicate at two different temperatures. The ready availability and experimental simplicity associated with the use of sodium silicate with epoxy resin is noteworthy in such polymeric field. It found that the addition of sodium silicate to epoxy resin lead to obvious changes in the physical features. In terms of compression strength and solidity, it shows lower values with a rise in the weight ratios of sodium silicate, however, it clearly increases with comparing with the weight ratios of sodium silicate. Lastly, if found that adding sodium silicate lead to slightly increase in thermal conductivity.

Reference

1-Ali, H. M ., Rasool, R. A., Moustafa ,S. Y., "Reinforcement Effect of Alumina and Silica on the Mechanical Properties of Mixture Polyesters (Unsaturated Polyester/ Polyurethane)". *Rafidain Journal of Science*, 29, 2, 2020, 51-63.

2-Nikhil, G., Balraj S. B. and Eyassu W. , "Effect of filler addition on the compressive and impact properties of glass fiber reinforced epoxy ,Bull Mater .Sci 24 ,2(2001): 219-223.

3-Jassim, W. H. "Preparation of the epoxy/chicken eggshell composites to use in surfaces coating." Ibn AL-Haitham Journal For Pure and Applied Science 29.1 (2017).

4--Helal , R. H., " Study of the Greep , Compression and Dry Adhesive Wear Resistance of Plastic Composite Materials " , MSc .Thesis , Department of applied Science , University of Tech nology , 2001.

5-Debabrata C., "Study on Mechanical Behaviour of Wood Dust Filled Polymer Composites ", Department of Mechanical Engineering , National Institute of Technology,2010

6-Mohammed ,A. R., "Study the Effect of Direction ,Volume Freaction and temperature on the bending Strength Properties of Polymer laminates reinforced by E – glass fiber" , MSc. Thesis , Al-Qadisiyah University , 2019.

7-Musa ,B. H., " Effect of glass powder on some mechanical properties of Polymer matrix composite material " , J. Al-Nah .Uni. 17. 2: 108-115.

8-Ibrahiem ,R. E., Sulyman, E. Z., "Preparation Polymeric Composites from Epoxy with Randomly Woven Fibre Glass and Studies the Mechanical Properties." Rafidain Journal of Science 28.3 (2019): 104-115

9-Salman ,A. J. , "Effect of fibre reinforcement on thermal conductivity and the mechanics of the Wings are heat – hardened, Al-Qadisiyah Journal of Engineering Sciences, 4 , 1, 2011.

10-Callister, W.D., " Materials Science and Engineering " , John Wiley and Sons .Inc. 8 th edition ,2009.

11-Assi, A.D., Abboud ,H.H. , Jawad, Z. F. ,"Study of the mechanical properties of Polyester unsaturated reinforced with titanium powder, Babylon University Journal ,engineering Sciences , 23, 1, 2015.

12-Gilham ,Z.. H. ,"The effect of alumina minute Strengthening on mechanical properties for a composite material with a foundation, Babylon University Journal, Pure and applied sciences and engineering , 26, 2,2018

13-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).

14-Al-Rawai, K. R., Salman ,R. A. ,"Study some of the mechanical properties of the overlap Epoxy-Mgo", Ai-Nahrain University Journal , 17.1(2014):10-14.

15-Sahib, M. A. , "Study the Effect of temperature difference on some mechanical and thermal properties for an overlay of polyethylene high –density glass fiber- backed", Al- Nahrain University Journal , 15.3 (2012) :11-21.

16-Cantab, M. A., Lond,B.Sc., "Practical Physics " , Bradfield College, pp 96-97,1952.

17-Bogomolov, V. N., Kartenko, N. F., Kurdyukov, D. A., Parfen'eva, L. S., Smirnov, I. A., Sharenkova, N. V., and Jezowski, A., Thermal conductivity of the opal-epoxy resin nanocomposite. Physics of the solid state, 45(5) (2003): 957-960.