



## PREPARATION OF POLYMERIC COMPOSITES FROM SATURATED POLYESTERS GLASS POWDER (FLOURSCENT) AND STUDY OF ITS MECHANICAL PROPERTIES

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### ABSTRACT

In this study, polymeric composites were prepared from unsaturated polyester as a base material with glass powder (fluorescent) in different weight ratios (4, 6, 8, 10, and 11%) as a support material and after comparison before and after reinforcement of the prepared composites, an increase was found. In the values of mechanical properties (hardness, compressive strength), the shock resistance values decreased, but an increase in temperature leads to an increase in the values of shock resistance, as well as the values of compressive strength And it reduces the hardness value.

**Keywords:** Unsaturated polyester, fluorescent powder, mechanical properties.



## تحضير متراكبات بوليمرية من البولي استر غير المشبع ومسحوق الزجاج (الفلورسنت) ودراسة خواصها الميكانيكية

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## الخلاصة

تم في هذا البحث تحضير متراكبات بوليمرية من البولي استر غير المشبع كمادة أساس مع مسحوق الزجاج (الفلورسنت) بنسب وزنية مختلفة (4 و 6 و 8 و 10 و 11%) كمواد مدعمة وبعد المقارنة قبل وبعد التدعيم للمترابكات المحضرة وجد زيادة في قيم الخواص الميكانيكية (الصلادة، مقاومة الانضغاط)، اما قيم مقاومة الصدمة قد انخفضت لكن زيادة درجة الحرارة تؤدي الى زيادة قيم مقاومة الصدمة وكذلك قيم مقاومة الانضغاط وتقلل من قيمة الصلادة. الكلمات المفتاحية: البولي استر غير المشبع، مسحوق الزجاج (الفلورسنت)، الخواص الميكانيكية.

## INTRODUCTION

Composite materials possess some properties that are suitable for a number of industrial applications, so they have gained an important position among the engineering materials (Ives *et al.*, 1971). Composite materials generally are formed by combining two or more materials to obtain a material with engineering and physical properties that has better properties than the materials included in its composition. The composite material consists of three phases; the matrix phase and the Reinforcing phase the intermediate phase between them (the interphase) (Akovali, 2001). The interest in polymer-based composites increased due to their engineering capacities, especially in applications that requires high-quality resistance. The most important materials that are used as basic materials are the three types of polymeric materials that are thermoplastics, thermosetting and elastomers (Al Adam 1983; Mouzakis, 2008). Plastic composite materials reinforced with different types of supporting materials include two types of base materials, which are a thermoplastic base material and a thermo set base material. It should be noted that thermostats are stronger than thermoplastic materials which are widely used such today such as low-density polyethylene, high-density polyethylene, and polypropylene (Akovali, 2001). Unsaturated polyester resin is a thermally hardening resin and cannot be used alone in engineering applications, because it is a brittle material and does not have the appropriate efficiency, however, it can be strengthened with some strengthening materials such as glass fiber, carbon fiber, and glass waste powder particles affect some of the mechanical properties of the brittle unsaturated polyester. They also affect the fracture toughness. (Varga, *et al.*, 2010). Waste glass powders are a non-metallic and inorganic substance. This material is not burnt and does not decompose, so it is difficult to recover (Malik, 2000). Among the applications of these materials in corrosive media is their use in chemical industries such as tanks, pipelines, cleaning devices, because of their resistance to corrosive acid media such as (H<sub>2</sub>SO<sub>4</sub>) used in space and the automobile industries (Callister, 2005). The aim of the study: This study aims to prepare composite materials that show good resistance to shocks and high compressive strength, identify the behavior of polymeric materials under standard conditions, make a comparison between them and the polymeric material before reinforcement, and then study the mechanical properties (impact strength, hardness, compressive strength) for all samples before and after the reinforcement with fluorescent glass powder.

## MATERIALS AND METHODS

### The matrix

The unsaturated polyester made by (B-CHEM SRL) company was used as the matrix, which is in the form of yellowish glue at room temperature, it is a type of Thermosetting polymers, that turns from the semi-solid state to the solid state by the addition of the hardener (di benzoyl peroxide), which is at the form of white cream that is added to the unsaturated polyester resin in a ratio of 2:1 at room temperature (Mark,1999). Waste glass powder was also used in the form of powder, the powder was obtained after grinding and sifting by a 200-mesh sieve in the laboratory to obtain the granular size  $75\mu\text{m}$ . Suitable samples could be obtained for molding at room temperature.

### Reinforcing materials

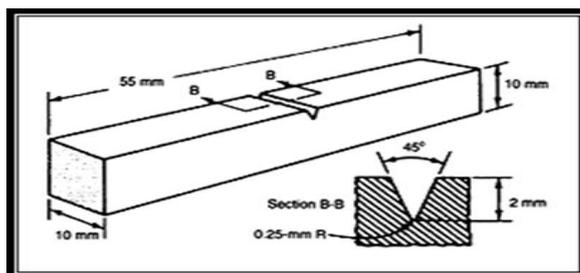
Reinforcing materials (Glass Powder that was sifted with a 200-mesh sieve) were used to reinforce the unsaturated polyester resin. The (damaged glass of candles) of the type (PARS LAMP 18W) from Iran was used.

### Preparation of samples

Three types of samples were prepared for the mechanical tests:

#### Impact test samples:

Impact test samples were prepared according to American standard (256-87ASTM-D) with dimensions  $(10 \times 55 \text{ mm} \times 10^3)$  for the examination. The grooving depth in the models is (2mm) with a notch angle of  $(45^\circ)$ . The absorbed energy required for the occurrence of the breakage was obtained directly from the Charpy Impact Instrument provided by (Tokyo Koki Seizosho, LTD) (Figure1), Illustrates the shape and dimensions of the sample prepared for the impact strength testing (Al-Bakri,2012).



**Figure (1):**Shape and dimensions of the sample.

#### Hardness testing samples

Non-standard models were used. Any model of composite material would be suitable for this test. The hardening device of the (Rockwell) hardness type was used, the penetration tool is a hardened steel ball with a diameter of (12.7mm) for the weight applied (60kg), equipped from the company (WOLPERT-Germany) for measuring the hardness of thermosetting polymer. The method of examination is to place the device perpendicular to the sample for which the hardness is to be measured in order for the needle to be inserted into the surface of the material and then wait for a period of three seconds after which the hardness value is taken from the device, and no less than three readings were taken from different places of the sample and then the average was taken (Al-Mosawi, 2009).

#### Samples of compressive resistance test:

The compressive resistance test models were prepared according to the specification (618ASTM-D) it is a cylindrical device using a hydraulic press of the type (Testing Machine Co.LTD) supplied by (WOLPERT - Germany) to determine the maximum compressive load the sample can bear, and by dividing the load by the cross-sectional area of the model before the deformation

occurs Compression strength calculation for all models was made, (Figure 2) shows the shape of the sample prepared for compressive resistance testing.



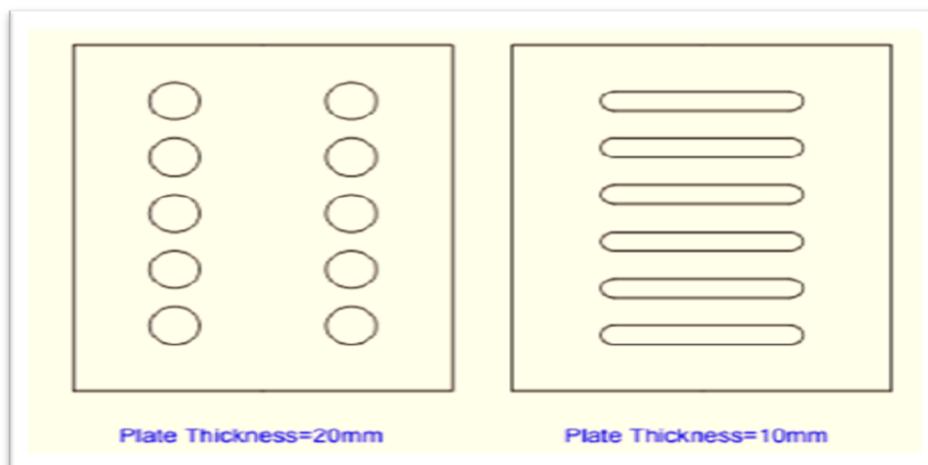
**Figure (2):**The shape of the sample prepared for compressive resistance testing.

### Preparation method

An unsaturated polyester resin was used with a hardener (di benzoyl peroxide) in a ratio of 2:1 to turn it into a solid material that solidifies at room temperature. Then samples were prepared of composite materials of unsaturated polyester reinforced with glass powder with weight ratios of (4, 6, 8, 10, and 11%).

Hand-Layup Molding was followed in the process of preparing samples before and after using the powder in reinforcement (**Sulyman et al., 2019**).

The resin was prepared by adding a hardener to the unsaturated polyester in a ratio of (1:2), then the resin was added to the hardeners, and then the mixture was placed in the molds designated for measurements, which were made according to the standard specifications for each examination, and after the completion of the pouring process, it was left for 24 hours at a temperature of (23°C) and (53°C) to complete the curing process, overlap, homogeneity between the particles, and reduce the internal stresses formed during the pouring process, (Figure3) shows a schematic diagram of the templates used in preparing samples.



**Figure(3):** Schematic diagram of the templates used in preparing the samples.

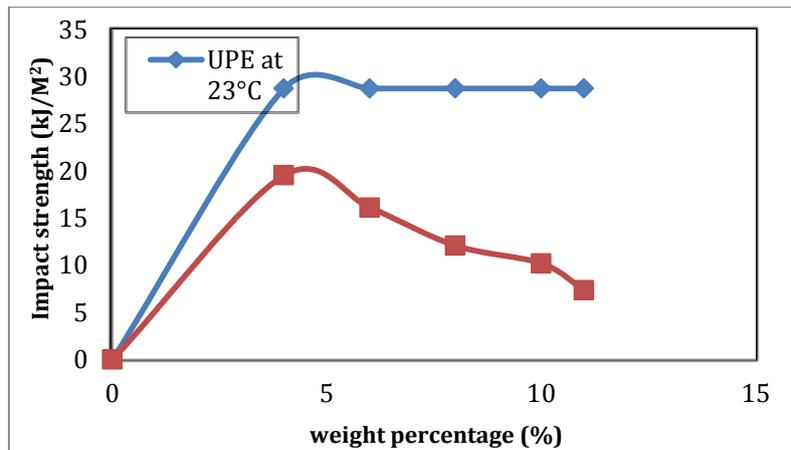
**RESULTS AND DISCUSSION**

**Impact strength**

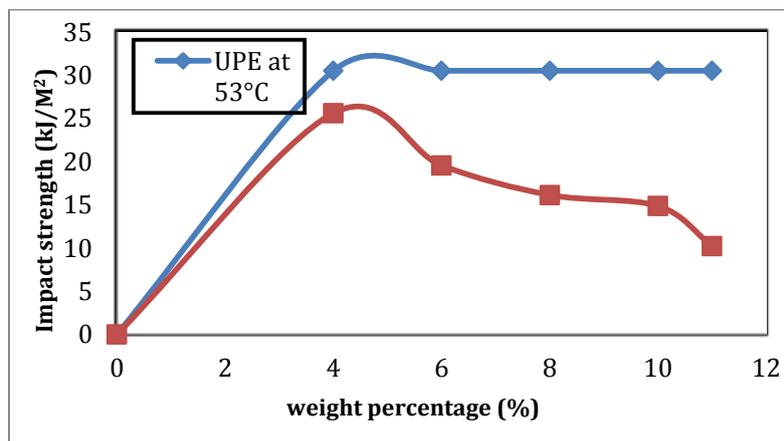
Examination of impact strength is one of the practical methods that give a correct indication of materials strength and resistance to fracture under stress at high velocity (Alrawi&AlHalim,2019). The impact strength is calculated using the equation:

$$I \cdot S = \frac{\text{energy of fracture (J)}}{\text{area of cross section (m}^2\text{)}} \dots\dots\dots(1)$$

From (Figure4) we notice that the impact strength decreases with the increase in the percentage of addition of damaged candle glass powder, this is an expected result because the glass is a brittle ceramic material, (Figure 5) shows the effect of the weight ratios of the unsaturated polyester support material on the impact resistance of polymeric composites at the processing temperature (23-53°C), (Table1) shows the effect of the weight ratios of the reinforcement material added to the unsaturated polyester on the impact resistance of polymeric composites at the processing temperature (23-53°C).



**Figure (4):** The relationship between impact strength (I.S) and the weight percentage of unsaturated polyesters before and after the reinforcement at 23°C.



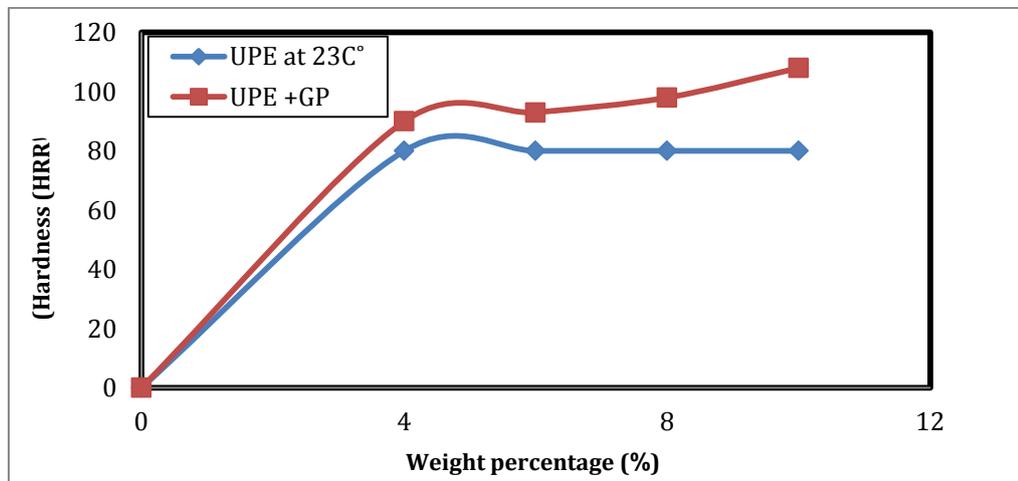
**Figure (5):** The relationship between impact strength (I.S) and the weight percentage of unsaturated polyesters Before and after the reinforcement at 53°C.

**Table (1):** Impact strength values (I.S) for unsaturated polyester before and after reinforcement with different weight ratios at temperatures of 23 and 53°C.

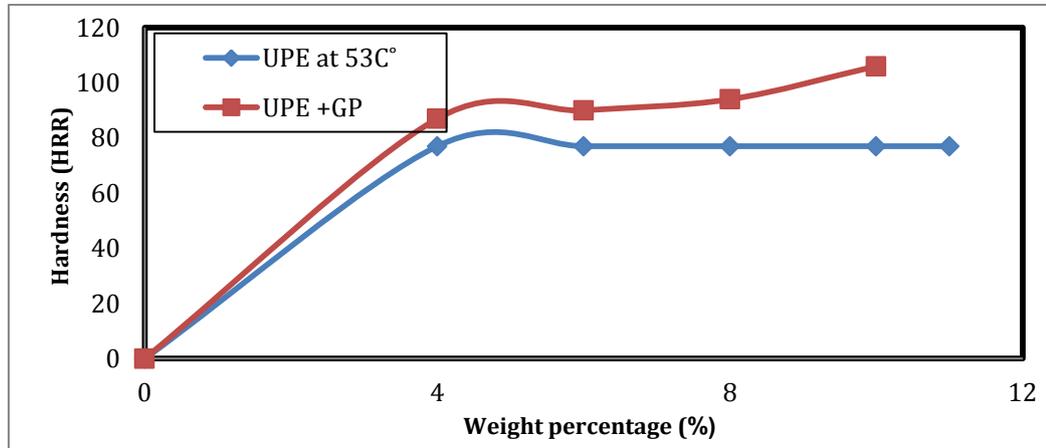
Composite at 23°C	Impact strength (KJ/m <sup>2</sup> )	Composite at 53°C	Impact strength (KJ/m <sup>2</sup> )
UPE	28.76	UPE	30.5
UPE+ GP 4%	19.54	UPE+ GP 4%	25.6
UPE+ GP 6%	16.12	UPE+ GP 6%	19.54
UPE+ GP 8%	12.08	UPE+ GP 8%	16.12
UPE+ GP 10%	10.2	UPE+ GP 10%	14.84
UPE+ GP 11%	7.34	UPE+ GP 11%	10.2

### HARDNESS

The hardness property is one of the most important mechanical properties of the material, it's considered as a measurement of plastic deformation, in which the material suffer from an influence of an external stress, imposed on it by its exposure to scratching and penetration with tools that are stiffer than it during its use in various applications (Anothony&David, 1983), through research It was found that the higher the percentage of addition of damaged candle glass powder, the higher the hardness value. The reason behind that is that the glass is a ceramic material that gives hardness to the base material (polyester). As a result of the physical contact between the glass particles and the polymeric chains, the penetration resistance of the composite material is decreased. (Figure 6 and 7) shows the effect of the weight ratios of the support material added to the unsaturated polyester on the hardness value of polymeric composites at the processing temperature (23-53°C), (Table 2) hardness values of unsaturated polyesters before and after the reinforcement with deferent weight ratios the temperature varies between 23 and 53°C.



**Figure(6):** The relationship between Rockwell hardness (RHH) values and the weight percentage for the unsaturated polyesters before and after reinforcing at a temperature of 23°C.



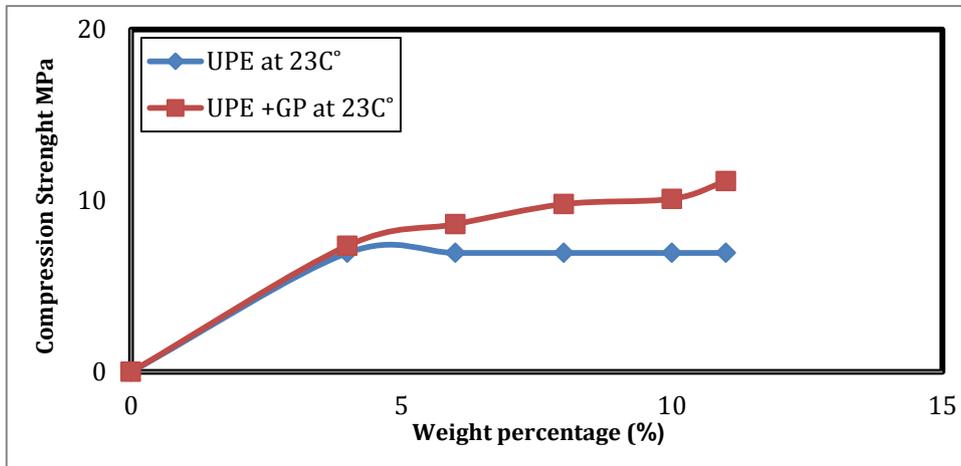
**Figure(7):** The relationship between Rockwell hardness (RHH) values and the weight percentage for the unsaturated polyesters before and after reinforcing at a temperature of 53°C.

**Table (2):** Hardness values of unsaturated polyesters before and after the reinforcement with deferent weight ratios the temperature varies between 23and 53°C.

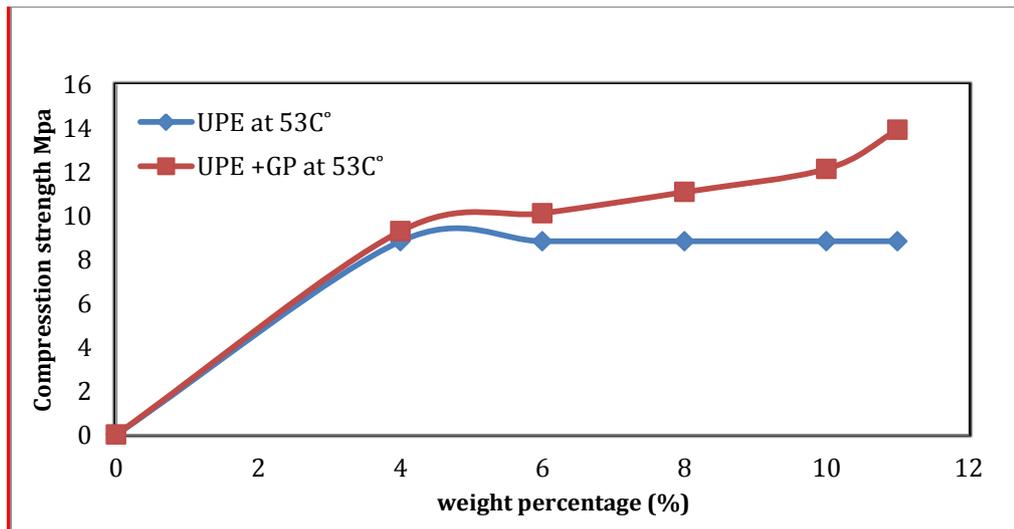
Composite at 23°C	Hardness Rockwell(HRR)	Composite at 53°C	Hardness Rockwell (HRR)
UPE 23°C	80	UPE 53°C	77
UPE+GP 4%	90	UPE+ GP 4%	87
UPE+ GP 6%	93	UPE+ GP 6%	90
UPE+ GP 8%	98	UPE+ GP 8%	94
UPE+ GP 10%	108	UPE+ GP 10%	106
UPE+ GP 11%	113	UPE+ GP 11%	109

### Compressive resistance test

It is one of the most important tests to know the durability and strength of the polymer. There are number of materials that may be brittle in tension condition, but appear ductile in compression. Therefore, compressive resistance testing is used to determine the submissive strength as well as the compressive strength (Sulymanet *al.*, 2019).It is defined as the amount of mechanical stress that a solid material endures under perpendicular stress. Without breaking or shattering or changing in its shape after the stress is removed. This test is widely used to examine fragile materials such as glass, concrete pieces, rocks, mastic iron and heat-hardened polymers due to the fact that these materials have more strength in compression than in tension condition, test samples used are cubic or cylindrical (Sulyman&Sulyman, 2020),(Figure 9 and 8) shows the effect of the weight ratios of the support material added to the unsaturated polyester on the value of the compressive strength of polymeric composites at the processing temperature (23-53°C), (Table 3) Compression strength of unsaturated polyester before and after reinforcing in differentproportion weights at 23 and 53°C.



**Figure(8):** The relationship between compression strength (C.S) and the weight percentage of the unsaturated polyesters before and after reinforcing at a temperature of 23°C.



**Figure(9):** The relationship between compression strength (C.S) and the weight percentage of the unsaturated polyesters before and after reinforcing at a temperature of 53°C.

**Table (3):** Compression strength of unsaturated polyester before and after reinforcing in different proportion weights at 23 and 53°C.

Composite at 23°C	Compression strength Mpa	Composite at 53°C	compression strength Mpa
UPE 23°C	6.96	UPE 53°C	8.84
UPE+GP 4%	7.37	UPE+GP 4%	9.3
UPE+GP6%	8.63	UPE+GP6%	10.12
UPE+GP 8%	9.8	UPE+GP 8%	11.09
UPE+GP 10%	10.11	UPE+GP 10%	12.15
UPE+GP 11%	11.15	UPE+GP 11%	13.94

## CONCLUSIONS

The hardness increases with the increase in the addition of damaged candle glass powder. Impact resistance decreases with the increase in the addition of damaged candle glass powder. The compression strength increases with the addition of the damaged glass powder.

## REFERENCES

1. Akovali, G. (2001). *Handbook of Composite Fabrication*. Rapra Technology Ltd, United Kingdom.
2. Al Adam, C. A. & Kashif Alghata, H. A. (1983). *Polymers Technology and Chemistry*. Basra University Press, Basra, Iraq.
3. Al-Bakri, H. A. (2012). Study of some mechanical properties for polymeric composite material reinforced by fibers. *Al-Rafidain Science Journal*, 23(1), 114-129.
5. Alrawi, R. & Al Halim, I. Z. (2019). Study of some mechanical properties for epoxy composite reinforced with glass fiber and carbon fiber. *Al-Rafidain Sciences Journal*, 28(3), 105-115.
6. Davis, A. (1983). *Weathering of Polymer*. Applied Science Publishers, New York, USA.
7. Callister, W.D. (2005). *Materials Science and Engineering*. 5<sup>th</sup> ed., John Wiley and Sons, New York, USA.
8. Ives, G.C., Mead, G.A. & Riley, M.M. (1971). *Hand Book of Plastic Test Method*. Fietcher & Son.
9. Karunanayake, L. (2007). The effect of glass powder on some mechanical properties of engineering polymer. *Journal National foundation*, 35(1), 13-17.
10. Malik, M., Choudhary, V. & Varma, I.K. (2000). Current status of unsaturated polyester resins. *Macromolecular Chemistry and Physics*, 40(2-3), 139-165.
11. Mark, J. E., (1999). *Polymer Data Handbook*. 2<sup>nd</sup> ed., Oxford University Press, New York, USA, 1264.
12. Mouzaki, D. E., Zoga, A. and Galiotis, C. (2008). Accelerated environmental ageing study of polyester/ glass fiber reinforced composites (GFRPCs). *Composites Part B-Engineering*, 39(3), 467-475.
13. Subhash, N.V.S.S. (2013). *Tribology of Alumina Nano Composites*. MSc. Thesis, National Institute of Technology Rourke, India, 37.
14. Sulyman, E. Z., Hamid, A.S., Thaer, A.H. (2019). Preparation of polymeric aggregate of unsaturated polyester with sawdust and studying its physical and mechanical properties. *International Journal of Research in Pharmaceutical Sciences*, 10(3), 2280-2289.
15. Sulyman, E. Z. & Sulyman, N. Z. (2020). Preparation of polymeric composites from polypropylene and palm fronds and the study of some of their physical properties. *Baghdad Science Journal*, 17(3), 772-779.
16. Varga, C., Miskolczi, N., Bartha, L. and Lipoczi, G., (2010). Improving the mechanical properties of glass-fiber-reinforced polyester composites by modification of fiber surface. *Materials and Design*, 3(1), 185-193.