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EXPERIMENTAL INVESTIGATION OF SOME PROPERTIES OF EPOXY REINFORCED BY EGG SHELL PARTICLES

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ABSTRACT

The egg shell powder used as a reinforcing material in composite materials because of their good mechanical properties and environmentally friendly. In this research, some experiments were carried out to the specimens to evaluate the properties such as tensile strength, elongation % at break, hardness, impact strength, flexural strength and water absorption. Polymer composite was fabricated by hand lay up to with (4, 8, 12 and 16) wt.% of egg shell powder obtains desirable properties. It was found that the maximum values of mechanical properties happened at (Ep+16% egg shell powder) and vice versa to water absorption property.

Keywords: Tensile Strength, Water Absorption, Epoxy resin, Egg shell powder.

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1. INTRODUCTION

The applications of the polymeric composite materials is very important in the development of the industry that due to specific properties especially strength and stiffness that represent the most parameters in the design (e.g. structural and biomedical applications) [1-3]. The addition of natural and synthetic materials especially with small particle size lead to improvement the mechanical properties of the composites for most applications [4, 5]. Ruaa H. AbdulRaheem (2018) studied the mechanical behavior of coconut shell (CS) particulate epoxy composites with weight fraction (5, 10, 15, 20 and 25) wt%. Epoxy and it was found that the composite specimens of (Epoxy+25% CS) give best mechanical properties [6]. Jawad, K. Oleiwi et. al., (2013), studied the addition of silica powder with different size and concentration on some properties of PMMA polymer. The results illustrated that the tensile and flexural properties increased with increasing the addition of reinforcing materials (SiO_2) [7]. Salih S.I. et al. (2015), evaluated the performance of acrylic resin enhanced by (nHA) and (ZrO_2) particles. The results showed that the concentration of (3 %) of nanofiller into resin lead to increase most mechanical properties [8].

Assel. B. Abdul- Hussein et. al. (2015 & 2014), studied the properties of epoxy reinforced by natural and synthetic powders (Rice Husk Ash, Carrot, Saw dust, $CaCO_3$, K_2CO_3 & Na_2CO_3) with different filler concentration. The results indicated that the hardness and flexural properties increased with increasing the filler content for all specimens especially for the specimens reinforced by Rice Husk Ash up to 6wt.%. And the percentage of improvement of hardness and flexural strength were (8 %) and (50%) respectively [9, 10]. Senthil J et. al. (2015), had studied the mechanical properties and water absorption of polymer composites reinforced with egg shell powder and Calcium Carbonate. The results indicated that the hardness and tensile properties increased with the increasing the egg shell powder [11]. Jawad K Oleiwi et. al. (2018), studied the effect of natural fibers reinforcing with acrylic resin. The results showed that with increase the natural fibers length lead to increase the impact properties. The fibers were cut into three lengths and used various concentrations, the results indicated that the fiber length have greater effect on the impact properties [12, 13].

Challa Ramesh et. al. (2014) had studied some properties of composite consist of polyamide as a matrix and the egg shell powder as a reinforcement. It was found that the mechanical properties increased with egg shell powder increased [14]. Salih S. I. et. al (2018), investigated some mechanical properties of acrylic resin reinforced with pomegranate peels and seeds dates Ajwa powder with different weight concentrations. The results showed that the improvement in most properties especially the fracture toughness for both types of natural reinforcement [15].

The main objectives of this work are to preparation of a composite materials made from epoxy polymer reinforced with Eggs shell powder at (4, 8, 12, and 16) wt%. and study effect weight fraction for Eggs shell powder on the some properties (tensile, flexural, impact hardness and water absorption) of the composite specimens.

2. EXPERIMENTAL PART

2.1. The Materials Used

The specimens are preparing from Epoxy resin (EP) as a matrix and Egg shell powder as a reinforcement material. Typical properties of a resin used in the current experimental work are listed in table (1) [16]. The average practical size of eggshell powder was 100μm and there are processes of washing with water, sun dried and in an oven at 100 °C for one hours. The values of weight fractions of this reinforcement were (4, 8, 12 and 16) Wt.%. Figure (2) shows shape of egg shells powder.

Table (1) Typical Properties of Epoxy resin [16].

	Density (gm/cm^3)	**Tensile modulus(Gpa)**	**Tensile strength (Mpa)**	**Flexural strength (Mpa)**
Epoxy resin	1.4	2.41	24-90	34-200

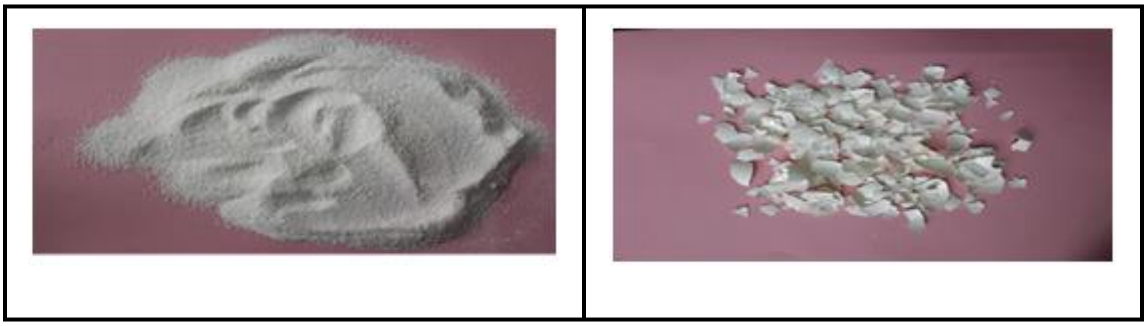


Figure (1) Shape of egg shells powder

2.2. Preparation of Composites

To prepare the samples we used the (Hand lay-Up Molding). The weight fraction for each of reinforced material and matrix materials relations were illustrated below [17-19].

$$Wp = \frac{wp}{wc}.100\% \quad \ldots\ldots \qquad (1)$$

$$Wm = \frac{wm}{wc}.100\% \qquad (2)$$

Where:

wp, wc, wm: the weight of reinforcement, composite and matrix .

W_p, W_m: Weight fraction of reinforced material and matrix materials respectively.

Note that the total the weight fraction and the volume fraction are illustrated below:

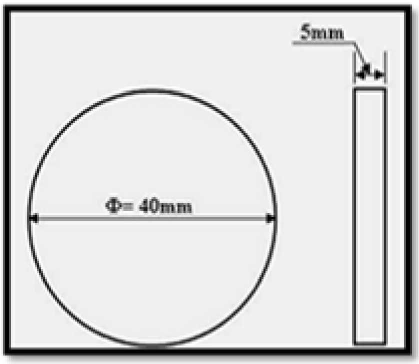
$$Wp + Wm = 1 \qquad (3)$$

$$Vp + Vm = 1 \qquad (4)$$

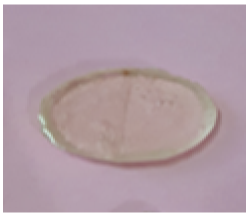
3. MECHANICAL TEST

3.1. Hardness Test

According the ASTM D-2240 standard, the hardness shore-D can be performed by Dorumeter hardness device 3120, manufactured in USA. The dimension of specimen were (40 mm) in a diameter and (5 mm) in a thickness. Figure (2) shows hardness device used [20-22]. The average of six readings for each specimen was being taken.



(a)

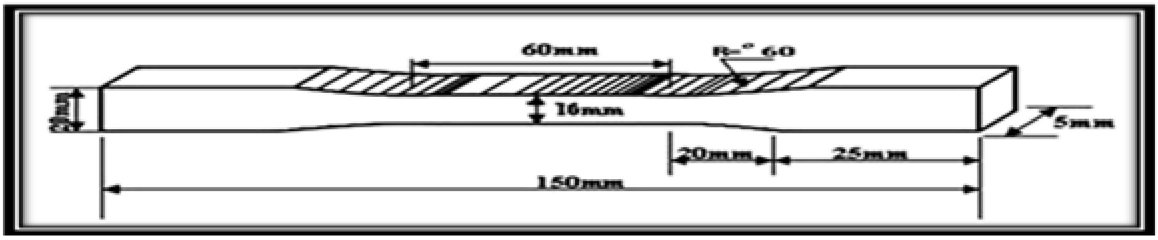


(b)

Figure (2): Hardness (Shore D) (a) standard specimen. [20], (b) Sample of experimental specimens.

3.2. Tension Test

According to ASTM D-638 standard the tension test can be performed. This test is done by universal testing machine type (LARYEE) with cross-head speed (2 mm/min.) and load capacity (50 KN). The shape of the specimen for this test was represented in figure (3) [23-25].



(a)

(b)

Figure (3): Tensile test (a) standard specimen [23], (b) Sample experimental specimen.

3.3. Impact Test

Impact resistance is calculated for samples from the following relationship [26, 27].

$$Gc = \frac{Uc}{A} \quad (5)$$

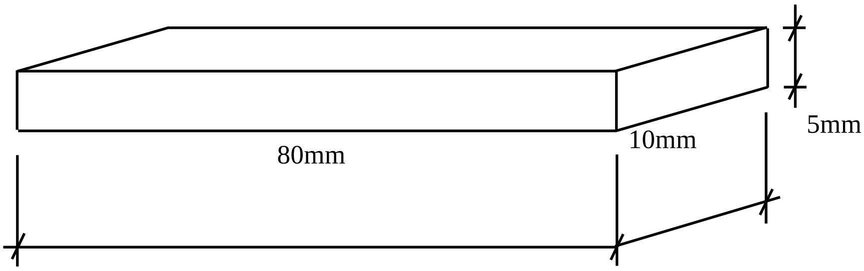
Where:

G_c- Impact strength J/m^2.

Uc- Energy of impact J.

A- Specimen area of cross- section m^2.

The (ISO- 180) standard is used for this test. The dimensions of impact specimen were (80mm to length, 10mm to width and 5mm to thickness). The shape of the impact specimen represented in figure (4) [26].



(a)

(b)

Figure (4): Impact test (a) standard specimen [26]. (b) Sample experimental specimen.

3.4. Flexural Strength

The ASTM D-790 is used for this test by three- point bending test machine (Lybold Harris No.36110). The dimensions of flexural specimen were (100mm to length, 10mm to width and 5mm to thickness. The shape of flexural specimen represented figure (5) [28].

The flexural strength is calculated according to the equations [28-30] .

$$S=3FL/2bd^2 \quad (6)$$

Where:

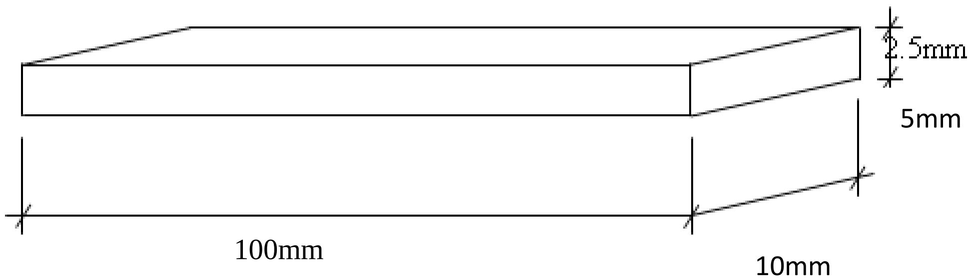
S: flexural strength----------N/mm².

F: maximum load --------N.

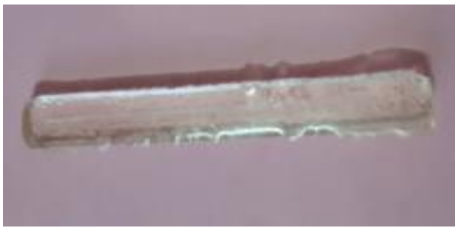
L: the supporting width in (mm).

B: the width of test specimen in (mm).

D: the height of test specimen in (mm).



(a)



(b)

Figure 5 Flexural strength (a) standard specimen [28]. (b) Sample experimental specimen.

4. PHYSICAL TESTS

4.1. Absorption Test

The ASTM D-570 was done to the composite specimen in order to evaluate the water absorption [31]. In this test the water absorption depend on the weighing the composite samples. The following equation represents water absorption percentage [32, 33].

$$W (\%) = [(W_2 - W_1) / W_1] \times 100\% \ldots \quad (7)$$

Where:

W_1 : dry weight specimens.

W_2 : wet weight specimens.

5. RESULTS AND DISCUSSION

5.1. Mechanical tests

5.1.1. Hardness results

Figure (6) represent the hardness verse the filler content of egg shell powder. From this figure it is clear there are increasing in hardness as increasing in filler content, that due to the properties of egg shell powder as comparing with epoxy matrix, in addition to good bonding between particles and matrix [34-36].

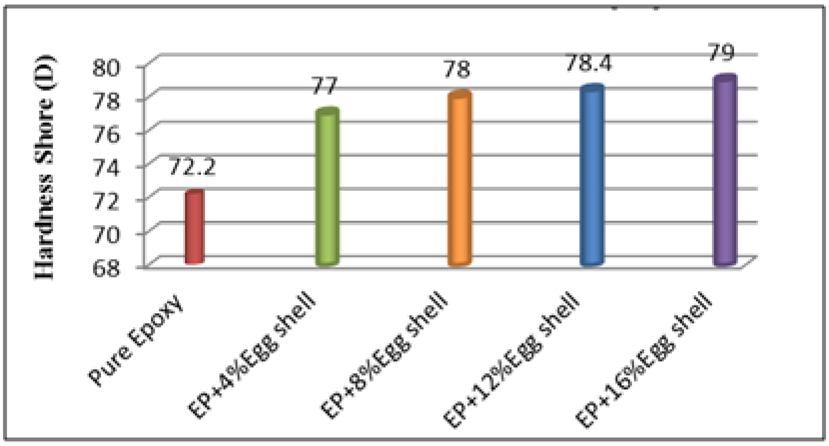


Figure (6) Relationship between Hardness and the concentration of egg shell powder.

5.1.2 Tensile strength

Figures (7) and (8) shows the tensile strength and elongation percentage at break values for the Epoxy resin reinforced with egg shell powder. It is clear from figure (7) that there are decreasing in tensile strength of the specimen with addition of 4wt% and 8wt% filler content and then started to increase as a filler concentration increase. The reason of decreased in property may due to low interfacial bonding and filler distribution within the epoxy and may be some errors in preparation of specimens. Figure (8) shows the effect between the weight concentration of Egg shell powder in epoxy resin and the elongation percentage of the specimens. The decreased in the elongation percentage give indicate that the reinforcing material is incapable to the transfer stress from this reinforcement to matrix [37-39].

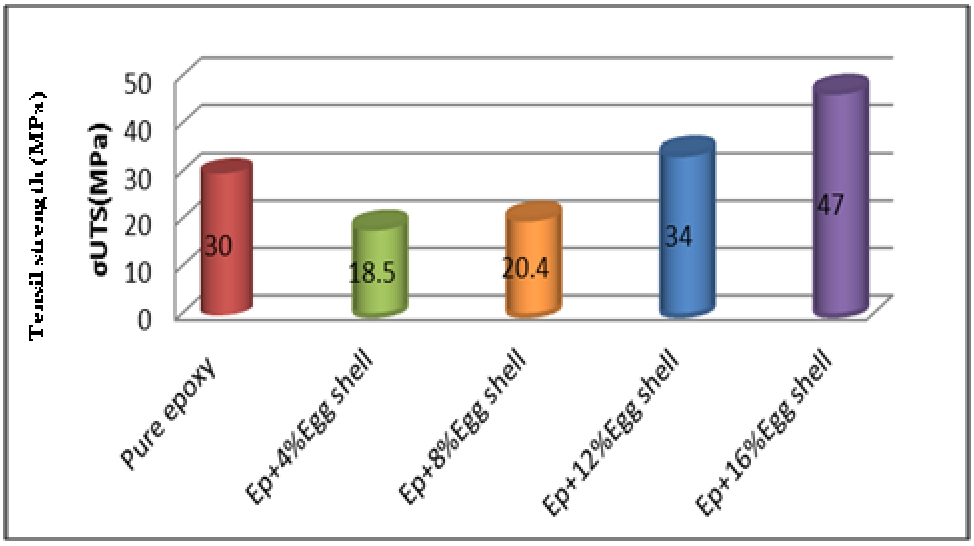


Figure (7): Tensile strength of the composite samples as a function of egg shell powder.

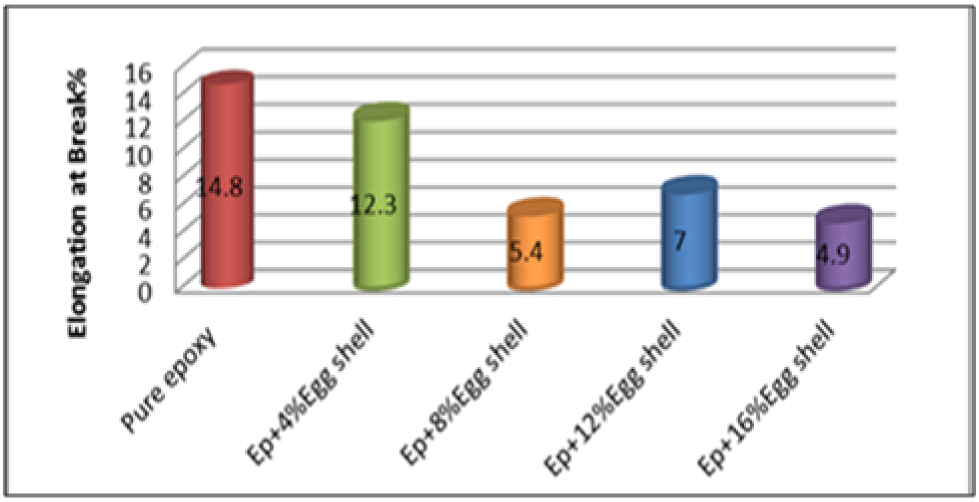


Figure (8) Relationship between percentage elongation of the composite samples and egg shell powder

5.1.3. Impact strength

Figures (9) show the impact strength (Gc) for each composite materials. The results indicated that the highest value of impact strength happened for the specimen with 16 wt% of egg shell powder. The decreasing in the impact property is due to increasing in stress concentration for the specimens and may be some errors in the preparation of the specimens [40, 41].

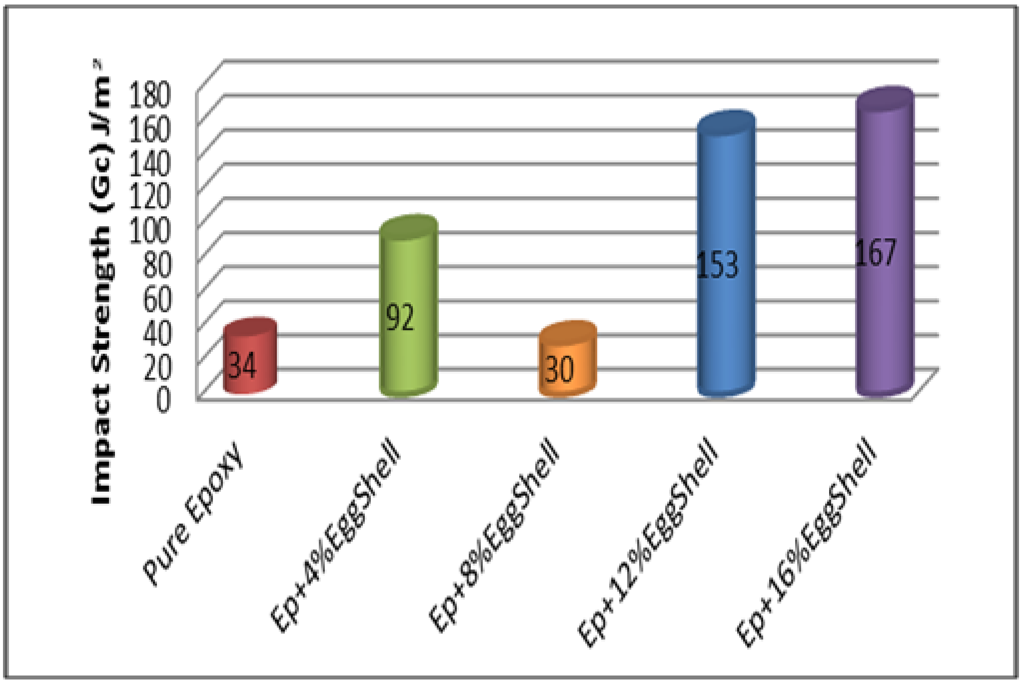


Figure (9) Impact strength of the samples verse egg shell powder

5.1.4. Flexural strength

Figure (10) shows the values of flexural strength for the Epoxy resin reinforced with egg shell powder. It can be seen from this figure that the strength increased with the addition of egg shell powder and the lowest value happened at 8 wt%. This is due to the reinforcing filler which reduce the strain and deformation that due to low interfacial bonding and filler distribution within the epoxy [42-45].

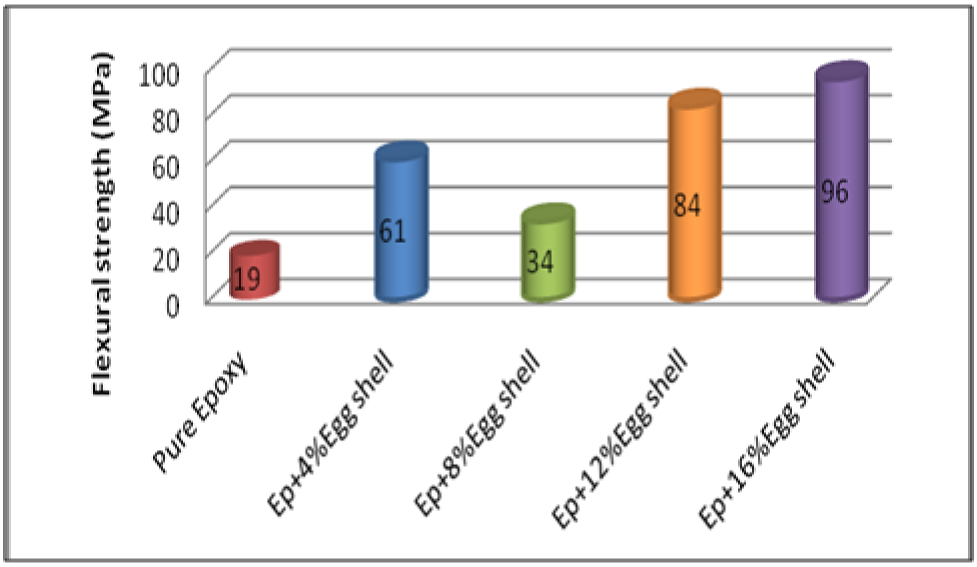


Figure (10) Flexural strength of the samples verse egg shell powder

5.2. Physical tests

5.2.1. Water Absorption

Figures 11 shows the values of water absorption for the Epoxy resin reinforced with egg shell powder. The results showed that the water absorption feature gives high resistance to water with increasing Egg shell particles. This is why the overlay is more resistant to water, allowing for good paint for tables in the kitchen and boats that due to the properties of egg shell powder [45-47].

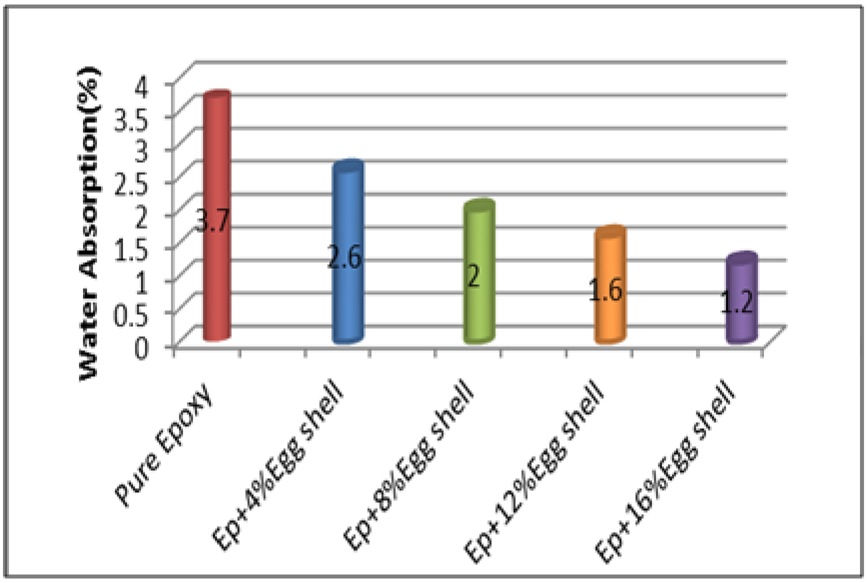


Figure (11) Water Absorption of the samples verse egg shell powder.

6. CONCLUSIONS

The conclusions drawn from the present work are:

- The hardness shore D of the composite specimen increased with the increasing the filler content.
- The maximum value of measured mechanical properties (tensile strength, flexural strength, impact strength, and hardness) happened for (Ep+16% Egg shell powder) specimen.
- The minimum value of water absorption and elongation percentage at break happened for (Ep+16% Egg shell powder) specimen.
- The absorption to water of the samples decreased with increasing the reinforcement.

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