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The study of the bending property of the epoxy (Ep / MgO) and (Ep/SiO_2) composites in natural conditions and after immersion in chemical solution

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Abstract

In this paper, a polymer-based composite material was prepared by hand Lay-up method consisting of epoxy resin as a base material reinforced by magnesium oxide powder once and silicon dioxide powder again and with different weight ratios (3, 6, 9 and 12) wt %. The three-point bending test was performed in normal conditions and after immersion in sulfuric acid. The results showed that the bending value decreased with the increase of the weighted ratio of the reinforcement material (MgO, SiO_2). The Bending of samples reinforced by SiO_2 was found to be less than the bending of samples reinforced by particles (MgO). For example, the bending of the SiO_2 sample (0.32 mm) at the weighted ratio (3%) and for the MgO (0.18mm) sample at the weight ratio were the same weighted load (100 g). It was found that the bending values of all samples exceeded the value after immersion in sulfuric acid. For example, the percentage of weight (6%) at the load level (500 g) was changed from 1.16 mm in normal conditions to 1.48mm for the same weight ratio after immersion. In sulfuric acid diluted with 0.3N for 10 days at the same applied load.

Key words

MgO, SiO_2, Ep., bending property, H_2SO_4, normal condition.

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دراسة خاصية الانحناء لمتراكب (Ep /MgO) و(Ep/SiO_2) في الظروف الطبيعية وبعد الغمر في المحاليل الكيميائية

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الخلاصة

في هذا البحث تم تحضير مادة متراكبة ذات اساس بوليمري بطريقة القولبة اليدوية مكونة من راتنج الايبوكسي كمادة اساس مدعم بمسحوق اوكسيد المغنيسيوم مرة ومسحوق ثاني اوكسيد السليكون مرة اخرى وبنسب وزنية مختلفة Wt% (12, 9, 6, 3). وتم اجراء اختبار الانحناء ثلاثي النقط في الظروف الطبيعية وبعد الغمر في حامض الكبريتيك. بينت النتائج ان قيمة الانحناء تقل مع زيادة النسب الوزنية لمادة التدعيم (MgO,SiO_2). وجد ان الانحراف للعينات المدعمة بدقائق (SiO_2) اقل من الانحراف للعينات المدعمة بدقائق (MgO) فمثلا كان الانحراف لعينة SiO_2 (0.32 mm) عند الكسر الوزني (3%) و لعينة MgO (0.18mm) عند الكسر الوزني ذاتة عند مقدار الحمل المسلط ذاته (100 g). وتبين ان قيم الانحراف لجميع العينات قد زادت عن قيمتها بعد الغمر في حامض الكبريتيك فمثلا تغيرت عند النسبة المئوية الوزنية (6 %) عند مقدار الحمل (500 g) من (1.16 mm) في الظروف الطبيعية واصبحت (1.48 mm) للنسبة الوزنية ذاتها بعد الغمر بحامض الكبريتيك المخفف بعيارية 0.3 N لمدة 10 ايام عند مقدار الحمل المسلط ذاته.

Introduction

A complex known as a solid system is produced by mixing two or more different materials in form or composition. Polymer composite materials are the best materials because they are characterized by high mechanical properties as well as easy to manufacture. It is one of the most modern materials used in most technological and engineering applications. The most important requirements for the use of these materials are good durability, high performance, resistance to internal and external stresses, as well as resistance to the surrounding conditions of temperature, pressure, etc [1]. The researchers were interested in studying polymeric complexes supported by particles of MgO in particular for the characteristic of resistance to oxidation and bear to high temperatures and characterized by the fragility but it has the strength of compression and hardness and chemical inactivity [2].

In 2013, Shayma prepared the unsaturated polysaccharide resin reinforced by silicon dioxide and studied the mechanical and electrical properties at different weight ratios. The results showed that the tensile strength and bending strength of the base material was higher than the composite material. The elasticity coefficient of the composite material was higher than the base material and showed that the hardness of the composite material was much higher than the hardness of the base material, this improvement in properties increases with the increase of the silica weight fracture [3]. In 2014, the researcher, Rafqa, studied an composites polymer-based material. Epoxy resins were used as a base material and magnesium oxide powder (MgO) as a strengthening agent at different fractures and had a hardness test and bending test. The results showed that the value of the hardness increased by a nonlinear relationship with the increase of the weight fracture of the Particles well as the values of the bending coefficient of elasticity increased with the increase of the weight fracture [4].

In 2015, Salma et al. Studied the magnesium oxide-supported epoxy complexes and studied the effect of acid adsorption on some physical properties using sulfuric acid and 1M concentration for up to 10 weeks. The results of the hardness test before and after immersion showed that it increased with the increase of the weight fracture .the magnesium oxide and its pre-immersion value are higher than the value after immersion. The results of the insulation strength were found to decrease with the increase of the weight fractions of the material of the reinforcement and increase the immersion time [5]. In the (2016), Fuaad, prepared polymer complexes of unsaturated polystyrene resin supported by micro-magnesium and nano-oxide. In the following weights (3, 6, 9, 12, 15) wt %. The results showed that the value of hardness increased with increasing concentration of (MgO) in the compound for all cases (Adding nano-magnesium oxide to the resin once and the magnesium oxide once again and mixing them again). The bending results showed that the deviation was directly proportional to the load applied to all samples and the bending coefficient was reduced by increasing the concentration of MgO for all samples [6].

The aim of the research

The aims of the research are to:

- Composite material made of epoxy resins supported by micro particle of SiO_2 and MgO at different weight ratios (3, 6, 9 and 12) wt%.

- Studying the Bending property of composite materials which are tested in normal conditions and after immersion in sulfuric acid.
- A comparison of the composites with the above characteristic based on the type of additive whether the samples were particles MgO or SiO_2 particles at the above percentages.

Bending test

The bending test is one of the most important basic tests of complex materials to determine the properties of elasticity, elasticity, and bending resistance of a material that expresses its ability to withstand vertical forces on its longitudinal axis without breaking [7], where the sample is subjected to two types of stress compressive stress on the top surface of the sample and tensile stress on the surface of the bottom of the sample and sometimes overcome each other and thus cause the failure of the material as a whole. There are a number of important factors that affect this test is the rate and type of loading and distance between the predators and the dimensions of the cross section [8]. The bending strength in the three-point test method, ASTM (D790-68) which is one of the most common and easy tests. The elasticity factor E measured in N / mm^2 (or Mpa) can be calculated by the following relationship [9]:

$$E = \left(\frac{Mass}{Deflection}\right)\frac{g\,L^3}{48\,I} \qquad (1)$$

where: $\left(\frac{\text{Mass}}{\text{Deflection}}\right)$

It represents the slope of the straight line calculated from the Mass-Deflection curve. g: ground acceleration (9.81 m / sec^3), L: length of sample between assignors (m), I: represents the determination of the geometrical curve (m^4) given by the following equation [7]:

$$I = \frac{b\,d^3}{12} \qquad (2)$$

where: b: sample width (m), d: sample thickness (m).

Experimental

The practical part includes the following:

Materials

The following materials were used in this research:

1- Epoxy resins:- Which is a transparent liquid form type (Epoxy Sikadur ® 52 LP) And manufactured by US company (Sky Spring) of the United States, which solidifies after addition of the hardener of its type (Bisphenol A (epichlorohydrin) Oxiraine) the ratio of hardeners to epoxy is (2:1).

2- Magnesium oxide powder (MgO)):- The magnesium oxide powder used in this study is supplied by the US company (Sky Spring) with grain size 50 μm, density (3.358 g/cm^3) and purity (99%).

3- Silicon dioxide (SiO_2):- Silicon dioxide particle US company (Sky Spring) was used with grain size 100 μm, density (2.6 g / cm^3) and purity 99%.

Preparation of bending test models

Hand Lay-up method was used in the process of preparing the samples for its ease and being suitable and low cost.A glass plate with a glass casting mold was used with special treatments for the purpose of non-adhesion of the models with the casting plate. The mixture of epoxy resins was mixed with MgO once and with another SiO_2 for 8-10 minutes, and then pour into the prepared molde. Then leave the mold for 48 hours for the purpose of completing the process of hardener. The samples are then placed in the

electric oven for 3 hours at 50 °C. The samples are then left to complete the polymerization process. After the previous operations, the composite materials are obtained with a thickness of (3 mm). The cutting and smoothing process is then carried out according to the standard specifications using a soft tooth strip saw. The samples are cleaned with zero-floured sheets and Fig.1 shows the ASTM measurement of the bending samples.

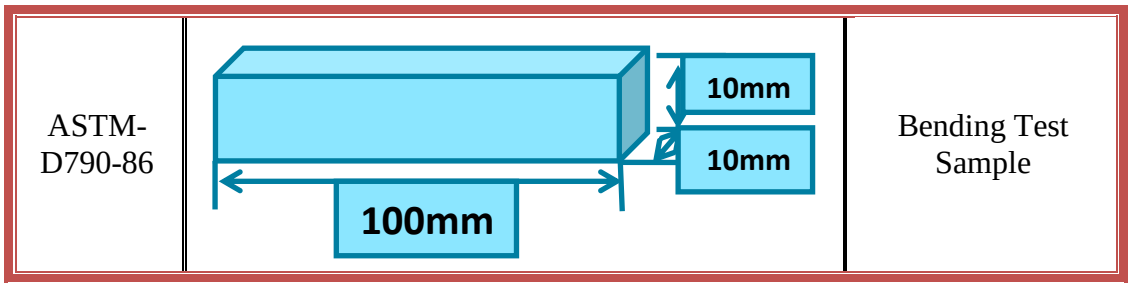

Fig. 1: Global measurement of bending samples.

Results and discussion

From Tables 1, 2 and Fig. 2 and 3, it can be notice that the bending of MgO Epoxy and SiO_2 Epoxy composite samples increases with the increase in the load as the material returns its normal condition, where the material retrieviy its original state after the elimination of the load exerted on it as the overlapping material will suffer the tension and elongation of polymer chains Without breaking the bonds as they fall within the elastic zone deformation. This indicates that the material is subject to the Hook's law and after calculating the ratio between the mass and the deflection which represent the slope can calculate the Young's modulus [9, 10].

From the above tables and figures, the value of the bending is inversely proportional to the weight ratios for reinforced material. The SiO_2 deflection was less than the deflection of MgO samples at the same weight ratios. The reason for the lower bending value of SiO_2 samples than for the rest of the samples is due to the high correlation between the components of the composite materials and the silica of the high-strength glass materials and because of the increase in the particle of the additives, it will reduce the amount of deflection and thus reduce the fragility of the complex material due to the density of the bonding and thus restricting its movement so that which increases the coefficient of elasticity. In addition, magnesium oxide-reinforced samples are less common at the same weight ratios for the rest of the samples. Leading to increased interstitial distances and reduced stacking and bonding and increased sliding of polymer chains to the base material and thus increased deflection [11, 12].

Table 1: Mass vairation with different concentrations of MgO in normal conditions and after immersion in H_2SO_4 acid for 10 days.

Mass (g)	Deflection (mm)							
	Wt MgO / 3%		6%		9%		12%	
	N.C	Immertion	N.C	Immertion	N.C	Immertion	N.C	Immertion
100	0.32	0.4	0.27	0.35	0.23	0.28	0.18	0.21
200	0.59	0.75	0.5	0.66	0.42	0.56	0.35	0.44
300	0.85	1.08	0.73	0.94	0.62	0.81	0.52	0.68
400	1.1	1.37	0.95	1.22	0.83	1.08	0.71	0.91
500	1.33	1.69	1.16	1.48	1.02	1.31	0.89	1.13
600	1.55	1.97	1.37	1.75	1.21	1.53	1.08	1.37
700	1.77	2.22	1.56	1.99	1.39	1.77	1.27	1.59
800	1.98	2.48	1.77	2.27	1.58	2.01	1.46	1.82
900	2.21	2.75	1.99	2.51	1.79	2.24	1.63	2.03
1000	2.45	2.98	2.21	2.73	1.98	2.48	1.83	2.25

*N.C = normal condition

**A.I.T(d)= after immersion time (day)

Table 2: Mass vairation with different concentrations of SiO_2 in normal conditions and after immersion in H_2SO_4 acid for 10 days.

Mass (g)	Deflection (mm)							
	Wt SiO_2 / 3%		6%		9%		12%	
	N.C	Immertion	N.C	Immertion	N.C	Immertion	N.C	Immertion
100	0.23	0.29	0.18	0.22	0.14	0.18	0.11	0.13
200	0.45	0.54	0.36	0.43	0.3	0.35	0.23	0.28
300	0.67	0.77	0.55	0.62	0.45	0.5	0.37	0.41
400	0.88	0.98	0.74	0.81	0.62	0.66	0.51	0.57
500	1.11	1.19	0.93	0.99	0.78	0.83	0.65	0.71
600	1.32	1.41	1.12	1.18	0.95	0.99	0.79	0.87
700	1.53	1.61	1.31	1.37	1.12	1.16	0.94	1.03
800	1.74	1.82	1.51	1.57	1.29	1.35	1.1	1.19
900	1.97	2.03	1.72	1.78	1.48	1.54	1.25	1.36
1000	2.19	2.22	1.93	1.98	1.66	1.74	1.41	1.54

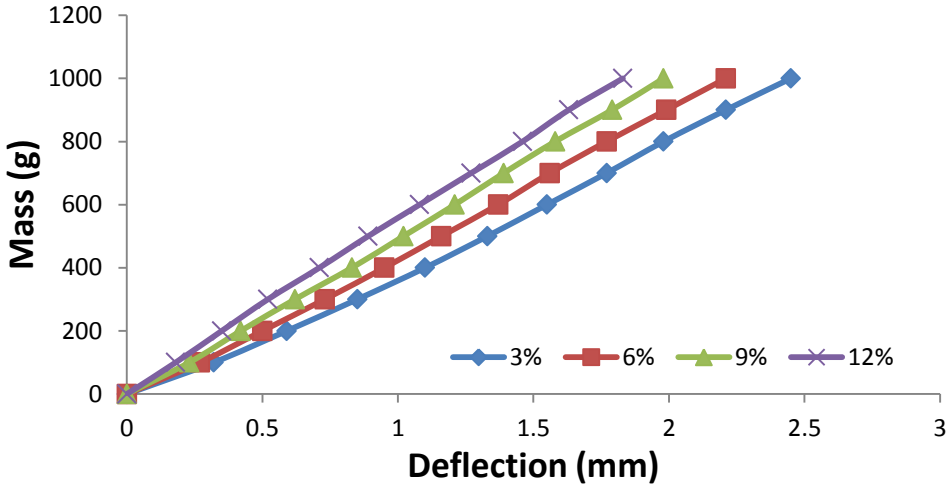

Fig. 2: Mass vairation with different concentrations of MgO in normal conditions.

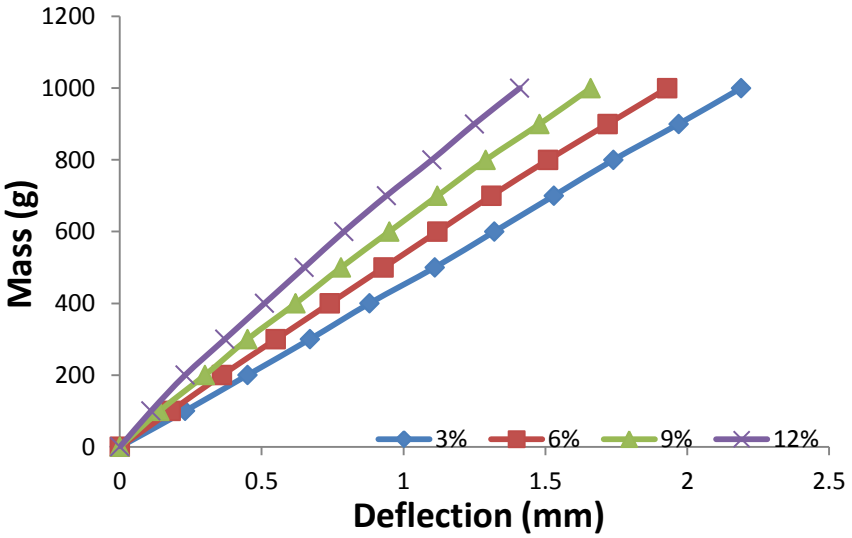

Fig. 3: Mass vairation with different concentrations of SiO_2 in normal conditions.

Figs. 4 and 5 show the mass relationship with the deflection after immersion with sulfuric acid diluted (0.3N) for 10 days for MgO and SiO_2 samples. We observe that the deflection values of all samples have exceeded their value in normal condition because of the negative role of the acid solution when reinforcing material substances are exposed to the chemical solutions that are spread in the base material, where the bonds are separated from one another, the material becomes more flexible, thus Increase its elasticity factor [13, 14]. For example, the deflection value of the MgO was 9% before immersion (0.62 mm) at the load applied (300 g) and became (0.81 mm) for the same weight after immersion with diluted sulfuric acid at the same weighted load [15].

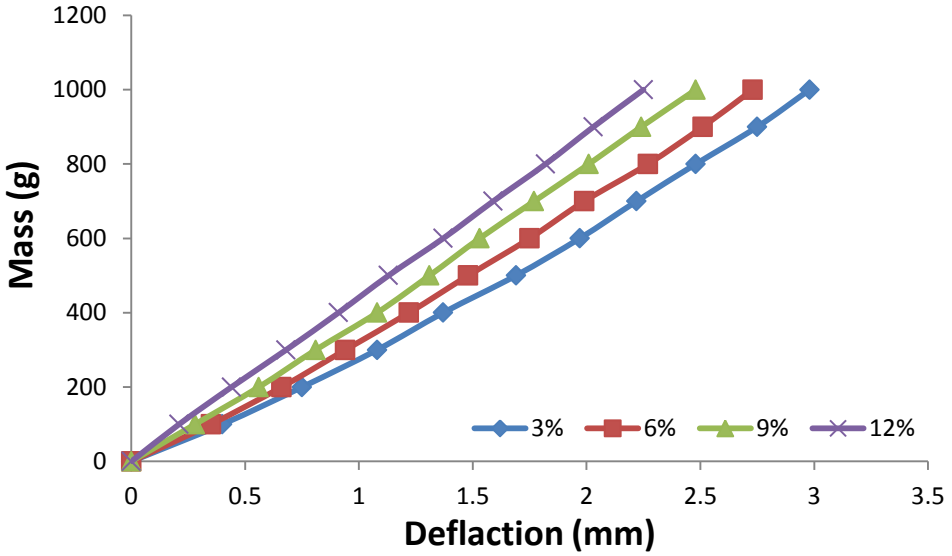

Fig. 4: Mass vairation with different concentrations of MgO after immersion in diluted sulfuric acid for 10 days.

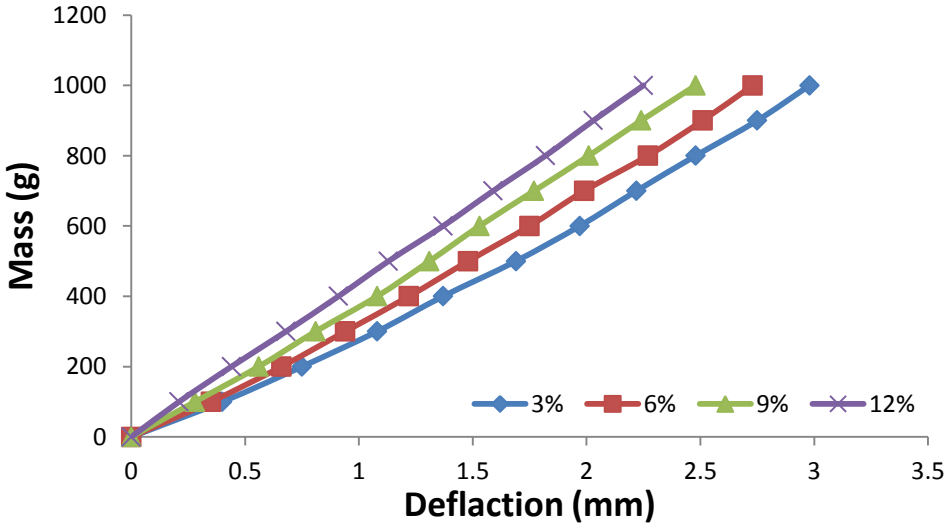

Fig. 5: Mass vairation with different concentrations of SiO_2 after immersion in diluted sulfuric acid for 10 days.

After calculating the slope of the samples of forms before and after immersion with sulfuric acid and then calculating the Young's modulus using Eqs. (1) and (2) and The results shown in Table 3 shows a change in the Young's modulus with the weight percentage of the magnesium oxide samples and the silicon dioxide samples and Note that the value of the Young's modulus of the reinforcing samples by SiO_2 and MgO particles increases by increasing the weight percentage [16, 17].

For example, the value of the Young's modulus was for MgO samples at 3 wt% concentration (1.38 GPa) and became (2.16 GPa) at the concentration of 12 %. For SiO_2 samples it was (1.74 GPa) at the weight ratio (3 %) and (2.89) at the weight ratio (12 %). Note that the highest values for the Young's modulus were for SiO_2 particles and MgO particles. For example, at the weight ratio (6 %), the Young's modulus of MgO (1.67 GPa) and SiO_2 (2.01 GPa). The reason for possession of the

samples reinforced by the second silicon oxide is the highest values for the Young's modulus when compared with MgO samples. This is due to the fact that the powder of SiO_2 particles of glass material with high fragility. And their homogeneous distribution within the base material will reduce the amount of deviation and thus increase the Young's modulus [18, 19].

Fig. 6 and 7 show the comparison of the Young's modulus value for all samples before and after immersion. Note that the value of the Young's modulus after immersion with sulfuric acid for the samples of all aggregates has been compared to its value in normal conditions (before immersion). For example, the value of the for the Young's modulus sample supported by particles of MgO (2.16 GPa) at the weight ratio (12 %) before immersion and became (1.76 GPa) after immersion at the same weight ratio, while the value of the Young's modulus for the sample reinforced by SiO_2 particles was (2.89 GPa) at the weight ratio (12 %) And became (2.64 GPa) at the same rate of weight and the reason for this is because the chemical solution of acid has caused the erosion and breakage of interlocking bonds and reduce this value by increasing the period of immersion [20, 21].

Table 3: The relationship between the Young's modulus and the weighted fracture of MgO and SiO_2 samples in normal conditions and after immersion in H_2SO_4 and for 10 day.

Group No.	**Sample Weight Fraction (%)**	**Young's Modulus (GPa)**	
		N.C	**Immertion 10 day in H_2SO_4 Solution**
G.1 EP+ Particles SiO_2	3	1.74	1.52
	6	2.01	1.77
	9	2.47	2.18
	12	2.89	2.64
G.2 EP + Particles MgO	3	1.38	1.19
	6	1.67	1.33
	9	1.91	1.58
	12	2.16	1.76

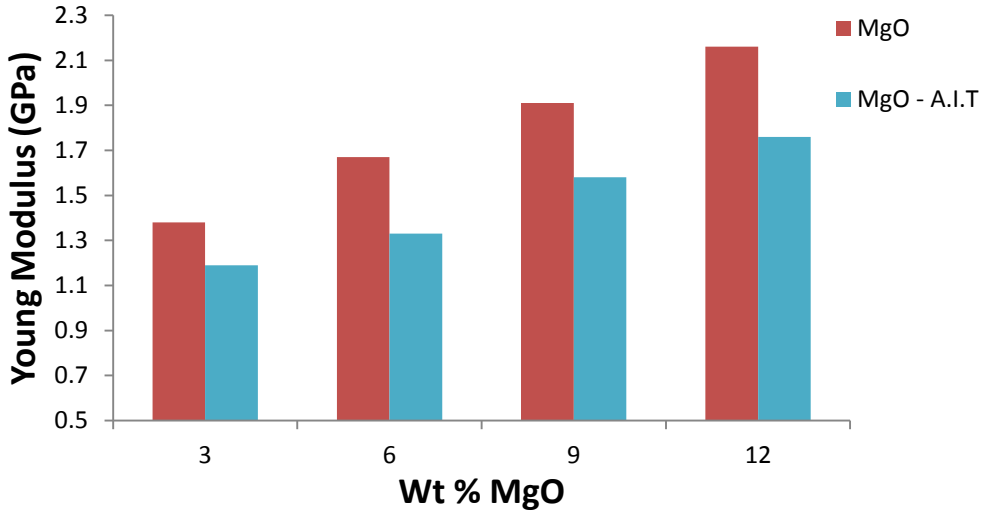

Fig. 6: Comparison of Young's modulus values with different weight fraction of MgO in normal conditions and after immersing in diluted sulfuric acid for 10 days.
***A.I.T=after immersion time**

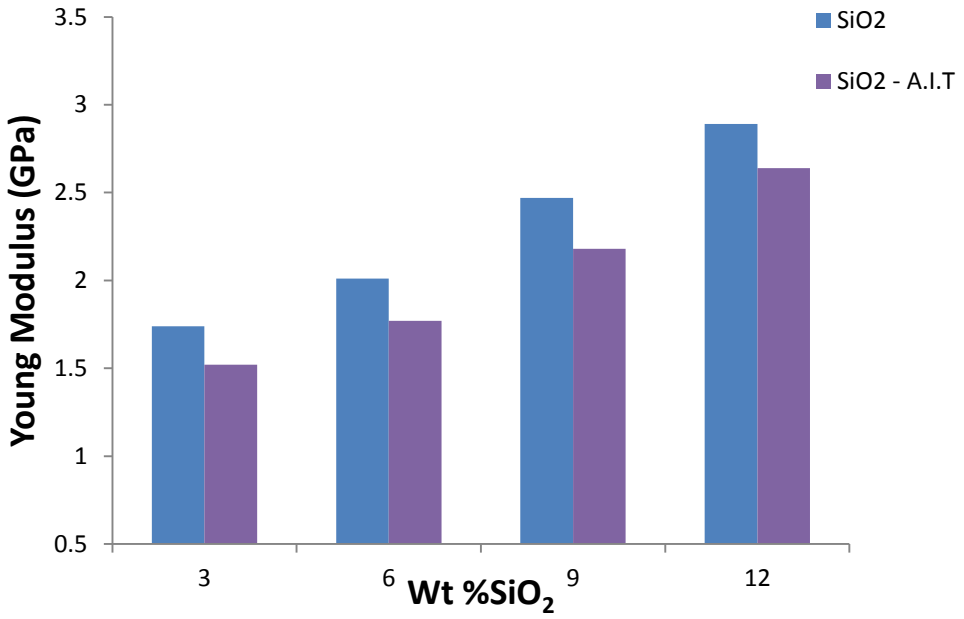

Fig. 7: Comparison of Young's modulus values with different weight fraction of SiO_2 in normal conditions and after immersing in diluted sulfuric acid for 10 days.

Conclusion

1 - The value of the deflection is directly proportional to the applied load and inversel with the weighted percentages of SiO_2, MgO and the deviation is increased by increasing the immersion time in the diluted sulfuric acid by 0.3 N and for 10 days.

2- The Young's modulus increases by increasing the concentration of MgO, SiO_2 and all sample groups. Its value in SiO_2 samples is greater than is attenuated in MgO samples. After the samples were immersed with 0.3N the diluted sulfuric acid, The Young's modulus value of the samples is lower than that of the samples Natural.

3-The effect of SiO_2 particles was higher Young's modulus and small defection while the MgO has inversly effect.

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