A study of the effect of acid immersion on some physical properties of (Epoxy – MgO) composites

Salma M. Hassan[1], Jinan M. H. Jabir[1], Rifqa A. Salman[2]

[1]Department of Physics, College of Science, University of Baghdad, Iraq

[2]Department of Physics, College of Science for Women, University of Baghdad

E-mail: Alnaji_Jinan@yahoo.com

Abstract

In this study a polymeric composite material was prepared by hand lay-up technique from epoxy resin as a matrix and magnesium oxide (MgO) as a reinforcement with different weight fraction (5,10,15, and 20)% to resin. Then the prepared samples were immersed under normal condition in H_2So_4(1 M) solution, for periods ranging up to 10 weeks. The result revealed that the diffusion coefficient decreasing as the concentration of MgO increase. Also we studied Hardness for the prepared samples before and after immersion. The result revealed that the hardness values increase as the concentration of MgO increase, while the hardness for the samples after immersion in H_2SO_4 decreased as compared to those before immersion. In addition, the dielectric strength decreasing by increasing the MgO concentration with time immersion.

دراسة تأثير الغمر بالحامض على بعض الخواص الفيزيائية لمتراكبات (الايبوكسي - اوكسيد المغنيسيوم)

سلمى محمد حسن[1], جنان محمد حسن جابر[1], رفقة عامر سلمان[2]

[1]قسم الفيزياء, كلية العلوم, جامعة بغداد

[2]قسم الفيزياء, كلية العلوم للبنات, جامعة بغداد

الخلاصة

تم في هذه الدراسة تحضير مادة متراكبة ذات اساس بوليمري باستخدام تقنية القولبة اليدوية وقد حضرت المادة المتراكبة من راتنج الايبوكسي كمادة اساس بمسحوق اوكسيد المغنيسيوم (MgO) وبكسور وزنية مختلفة (5,10,15 and 20)% ثم غمر النماذج المحضرة بالظروف الاعتيادية بمحلول حامض الكبريتيك(H_2SO_4) وبتركيز (1M) لفترة تصل الى 10اسابيع. حيث اظهرت النتائج ان معامل الانتشار يقل بزيادة نسبة دقائق التدعيم المضافة (MgO). وكذلك تم دراسة اختبار الصلادة للنماذج المحضرة قبل وبعد الغمر حيث اظهرت النتائج ان قيم الصلادة تزداد بزيادة الكسور الوزنية لاوكسيد المغنيسيوم كما ان قيم الصلادة للنماذج قبل الغمر تمتلك اعلى قيم مقارنة مع قيم الصلادة بعد الغمر. اما متانة العزل فاظهرت النتائج انها تقل بزيادة كل من الكسور الوزنية المضافة ومدة الغمر.

Introduction

Throughout history, humanity has used composite materials to achieve combinations of properties that could not be achieved with individual materials[1]. A composite is a structural material that consists of two or more combined constituents that are combined at a macroscopic level and are not soluble in each other. One constituent is called the reinforcing phase and the one in which it is embedded is called the matrix. The reinforcing phase material may be in

the form of fibers, particles, or flakes. The matrix phase materials are generally continuous [2].

Composites area rapidly growing field in polymerscience and have attracted a lot ofattention in both the academic andindustrial communities. The fact thatnew materials can be developed withgood properties in relatively less timeand with a minimum investment hasencouraged the blending of polymers[3].

Nikhil Gupta et.al studied theeffect of filler addition on themechanical properties of reinforced epoxy .the results show that addition of filler and then mixed with epoxy polymer.The epoxies consist of two parts, resin and hardener which need to be mixed in 3:1 volumes to forms the epoxy polymer.cubic specimens were cut from each sample with dimensions of (10*10*30) mm^3. All samples were immersed in chemical solution (H_2SO_4) with normality (N=1,) for about 10 weeks at room temperature. Excess water on the surface of the samples was removed before weighting. The samples weighted accuracy 10^{-4} g. The weighting process was carried out in a very short time period to minimize the effects of discontinuity in the immersion process. The weight gain percentage (M_t %) was calculated by using the following equation [5].

Increase in weight% = (Wet weight - Reconditioned weight) / Reconditioned weight *100

$$M_t \ \% = \frac{W(t) - W_0}{W_0}$$

At temperature well below the glass transition temperature T_g of the conditioned material, solvent absorption of most polymers correlates well with Fickslaw. The diffusion coefficient D is independent of moisture concentration, it can be

particles led to the decrease in mechanical properties[4].

Experimental part

Epoxy resin type (Quick mast 105) was used in this research which is a two component preparation of liquid epoxy resin based, with formulated amine hardeners. MgO powder((Riedel – Dehaen AG,particle size 150µm,purity99.99, made in Germany) was obtained from aldrch available granite industry. MgO powder were weighted by percent volume (5,10,15 and 20)%

calculated from the following equation[6].

$$D = \frac{\pi}{16}\left(\frac{h(M2-M1)}{M_\infty(t2-t1)^{0.5}}\right) \qquad (1)$$

Where M_∞ is the equilibrium moisture content (maximum solution content), $M_1$is the moisture uptake after t_1, M_2 is the moisture uptake after time $t_2$and h is the sample thickness.

The term $\left(\frac{M2-M1}{\sqrt{t2-t1}}\right)$ is the slop of the linear portion of the plot of M against $\sqrt{t}$[6].

The prepared specimens were tested by (Shore D Hardness tester TH210) before and after immersion to study the effect acidic medium on the hardness of samples.

Results and discussion

Fig.1 represents the change in weight with the immersion time in H_2SO_4 solutions (1M) for pure and epoxy composites, the weight uptake increased linearly with the increase in the immersion time in early stages until maximum content, then the curve shows deviation as a" knee" with increasing the period of immersion for all the samples. This is because the absorbed acid diffuse through the material weakens the cross-links of the

polymers and dissolved the polymer molecules then the samples suffered from weight loss and bubbles appear on the surface of the samples. (the mass loss due to deterioration of the

surface of samples) [7-9]. The effect of acid to decrease the hydrogen bonding between polymer chain which is reflected by plastization of resin [10].
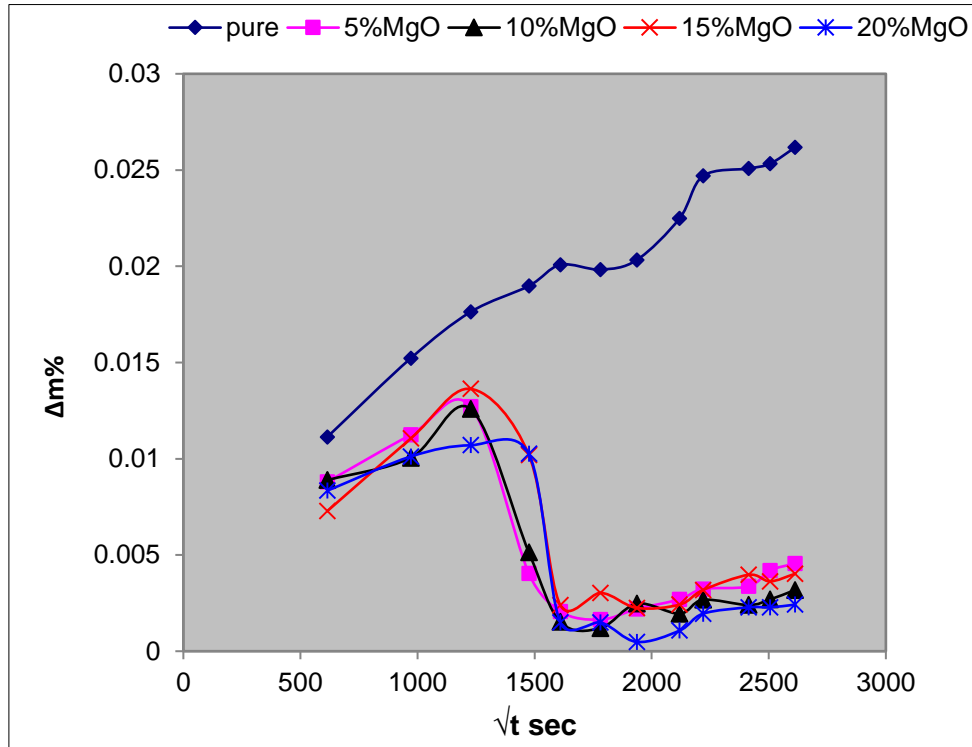

Fig. 1: The change in weight with the immersion time in H_2SO_4 solutions.

The plotted curves of weight gain M_t against the square root of the immersion time for the test sample. Diffusion coefficient was calculated from the relation between weight gain and diffusivity from Eq.(1). The calculated values of diffusivity were listed in Table1 which reveals that the values of diffusion coefficient of the pure epoxy is higher than that of epoxy -MgO composites, and increasing with increasing the MgO content be explained as follows. When the polymeric matrix is viscous and the filler is partially incompatible this leads matrix voids tend to occur at the interface which lead to an in increase in free volume of the system, also voids can occur because air gets trapped between layers during the lay-up process [11], but when increased

the MgO content to the 20% the diffusion coefficient decreasing because the MgO particle will in closed these voids.

Table 1: Values of diffusion coefficient for Epoxy-MgO composites at 1M of H_2SO_4 acidic, after 10 weeks from the immersion in acidic media.

MgO wt%	Diffusion coefficient (cm²/sec) (1M H_2SO_4) x10⁻⁸
0	0.2704
5	0.368
10	0.367
15	1.137
20	0.21

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In this work we studied the hardness by using the Shore D. The test was used to evaluate the hardness of samples before and after immersion in 1M of H_2SO_4 and with different weight present of MgO. We found the values of hardness was increased with increasing of MgO content, and

decreasing for immersion samples in acidic. This is because the acid attack the surfaces of the samples, and the mass loss due to the deterioration of MgO specimens[12]. Fig. 2 shows the variation of the value of hardness as a function of wt% of MgO in acidic media of H_2SO_4.
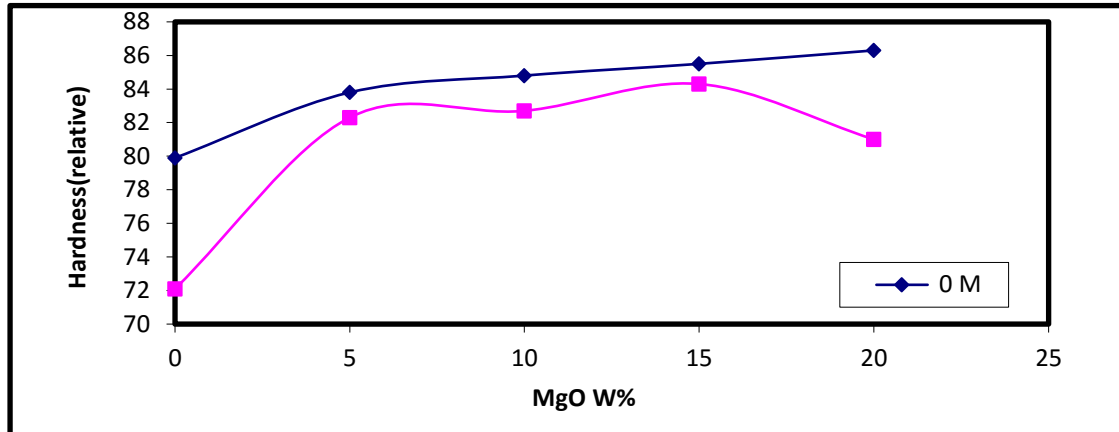

Fig. 2: The variation of hardness of the composite samples as a function of MgO wt%, before and after.

Fig. 3 shows the vibration of dielectric strength as a function of MgO content before and after immersion in H_2SO_4. It may be seen that the dielectric strength was higher for the composite before immersion in acid. The sample with 10% MgO show higher value of dielectric strength, and when increased the MgO the samples reached to the

saturation, that's mean the increased MgO wt. % contractions more than 10% enhanced the conductivity and the MgO particle will make path for current through the sample therefore the dielectric strength decreasing. And with H_2SO_4 is decreasing the dielectric strength and the changed in values was probably stable.
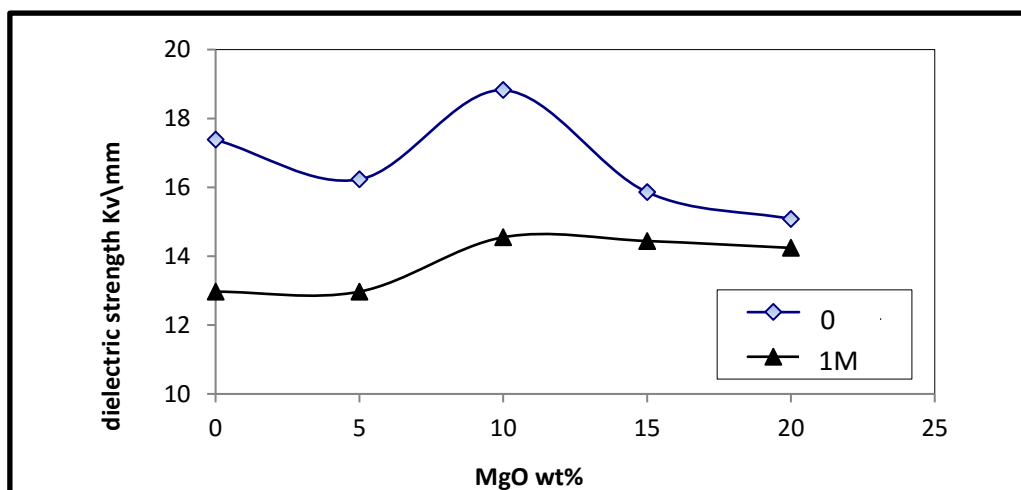

Fig. 3: The variation of dielectric strength as a function of MgO wt.% content.

Conclusions

It is concluded that the diffusion coefficient was increased with increasing in wt.% of MgO, and we found the value of hardness was higher for samples before immersing and it increased by increasing in MgO content. The dielectric strength decreased with immersion acid and increasing in MgO wt.% content.

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