Study the effect of acid immersion on the hardness of (Epoxy – Granite) composite

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Abstract:

This work has been done with using of epoxy resin mixed with Granite powder were weighted by percent volume (5,10,15, and 20)%and then mixed with epoxy polymer to compose polymer composite. Hand lay-up technique is used in fabrication of the composite samples. Hardness test was carried out for the proper samples in both normal condition and after immersion in HCL (1 M and 2 M) solutions for periods ranging up to 10 weeks. After comparing the results between the polymer and their composite, the hardness increased with increasing Granite weight percent, it was found that Hardness were greater for the composites before immersion compared with their values after immersion.

Key words: polymer composites, epoxy resin, Granite, Hardness, immersion

Introduction:

The properties of the composites are greatly influenced by the type of reinforcement in the system. In the case of particulate reinforced polymer composites, the properties depend on the shape and size of the filler, the amount that is compounded with the plastic, the bonding between the filler and the plastic, the toughness of the plastic and sometimes the toughness of the filler apart from its chemical composition. Low-cost particulate fillers are added to plastics in commercial production primarily for reasons of economy and improvement in molding characteristics [1]. Thermoset resins such as epoxy and unsaturated polyester have diversified application in innumerous fields. Epoxy is widely used as a matrix material for making many composites. However, it is brittle in nature and has poor resistance to crack propagation but the single matrix system has its own disadvantages, like brittleness, evolution of volatiles during cure and less resistance to crack propagation [2]. Polymer and composites is a rapidly growing field in polymer science and have attracted a lot of attention in both the academic and industrial communities. The fact that new materials can be developed with good properties in relatively less time Granite is primarily composed of feldspar; quartz along with various other minerals in varying percentage, its physical properties is a unique material. These properties lending uniqueness to granite are composite with epoxy. Granite has almost negligible porosity ranging between 0.2 to 4%.Granite is highly stable thermally, therefore shows no changes with the change in temperature. Granite is impervious to weathering from temperature and even from the air borne chemicals. It is the high resistance to chemical erosion that makes granite useful for making tanks to store highly caustic material. It is the hardest building stone and hardness of

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granite that lends it excellent wear [3]. Therefore we chose this material to make our samples. The absorption process for all polymer materials when humidity found in atmosphere or when these materials immerse in water or other solutions followed Fick's law in diffusion, i.e. absorption mass from the water or solutions increasing linearly with the square root of time gradually and slowly until saturate state [4].

Materials and Methods:

Epoxy resin (type THEROTEX 10) was used in this research which is a two component preparation of liquid epoxy resin based, with formulated amine hardeners. Granite powder was obtained from a locally available granite industry .The granite powder was first washed thoroughly with water and then dried at 100 ºC for 2-3 h before using it for preparation of composites. Granite powder were weighted by percent volume (5,10,15,20)% and then mixed with epoxy polymer .The epoxies consist of two parts, resin and hardener which need to be mixed in 2:1 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 (HCL) with molarity (M=1, M=2) for about 10weeks at room temperature .Excess water on the surface of the samples was removed before weighting. The samples weighted by using analytical balance (type: Sartorius, H51, made in Germany) of accuracy 10^{-4} gm. 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 [4].

$$M_t\ \% = \frac{W(t) - W_o}{W_o} \quad \text{---(1)}$$

At temperature well below the glass transition temperature T_g of the conditioned material, solvent absorption of most polymers correlates well with Fick's law. The diffusion coefficient D is independent of moisture concentration; it can be calculated from the following equation [5].

$$D = \frac{\pi}{16}\left(\frac{h(M2-M1)}{M\infty(t2-t1)\char94 0.5}\right) \text{----- (2)}$$

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 √t.

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.

Result and discussion:

Figures (1) represented the change in weight with the immersion times in HCL solutions (1M) and (2M) for pure and epoxy composites, the weight uptake increased linearly with the increasing of the immersion time in early stages until maximum content, then the curve show deviation as a" knee" with increasing the period of immersion for all the samples, because the absorbed acid diffuse through the material weaken 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.)[6-8]. The effect of acid to decrease the hydrogen bonding between polymer chain which is reflected by plasticization of resin [9].

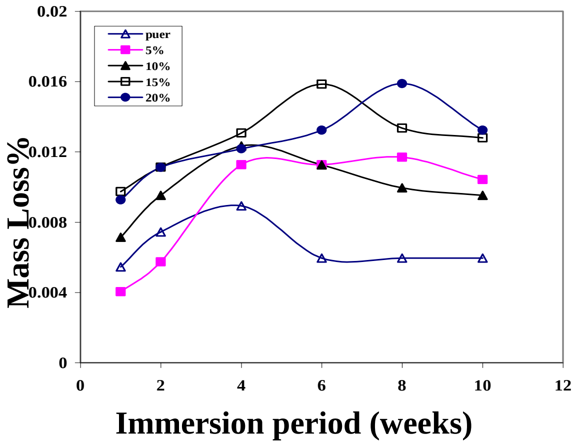

Fig.(1): weight gain versus time of immersion for Epoxy-Granite composites.

The plotted curves of (figures 2and 3) shows the 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 equation one. The calculated values of diffusivity were listed in (table1) that the reveals the vales of diffusion coefficient of the pure epoxy is higher than that of epoxy -Granite composites and decreasing with increasing the granite content. Figure 4 shows the diffusion coefficient as a function of Granite weight present .this can be explained as follows: when the polymeric matrix is viscous and the filler is partially incompatible with the 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 [10].

Table1: The values of diffusion coefficient for Epoxy-Granite composites at different Molarities of HCL acidic, after 10 weeks from the immersion in acidic

Granite wt.%	Diffusion coefficient (cm^2/sec) (1M HCL) $x10^{-9}$	Diffusion coefficient (cm^2/sec)(2M HCL) $x10^{-9}$
0	6.572	8.88
5	5.248	7.61
10	3.289	3.88
15	2.397	1.37
20	1.808	0.725

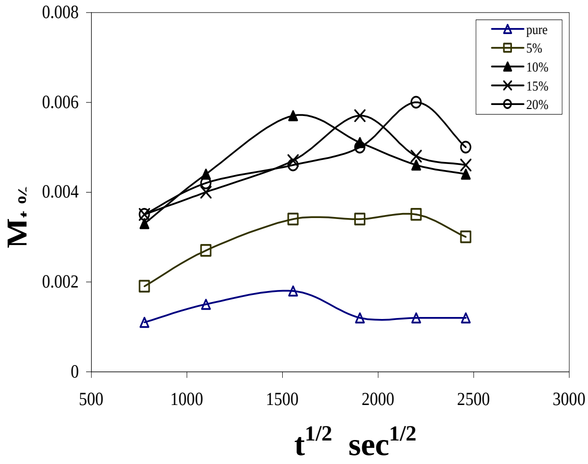

Fig.(2): weight gain M_t % versus square root of immersion time for Epoxy composites at 1M of HCL.

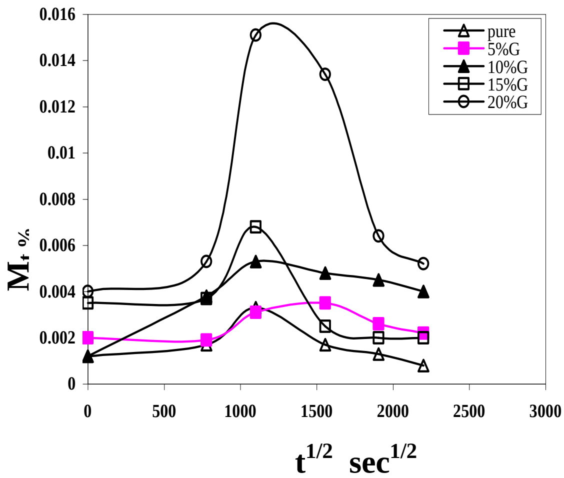

Fig. (3): weight gain M_t % versus square root of immersion time for Epoxy composites at 2M of HCL.

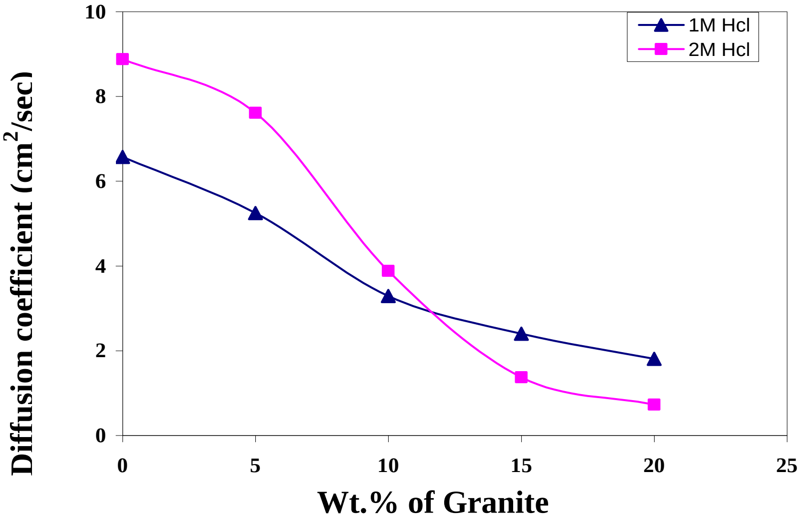

Fig. 4: shows the diffusion coefficient as a function of Granite weight present

In this work we also study the hardness by using the Shore D, the test was used to evaluate the hardness of samples before and after immersion in 1and 2M of HCL and with different weight present of Granite, we found the values of hardness was increased with increasing of Granite content, and decreasing with increasing the acidity of the immersed solution. this can be explained as follows: when the acid attack the surfaces of the samples , the mass loss due to the deterioration of Granite specimens[3], figure 5 show the variation of the value of hardness as a function of wt.% of Granite in different acidic media of HCL.

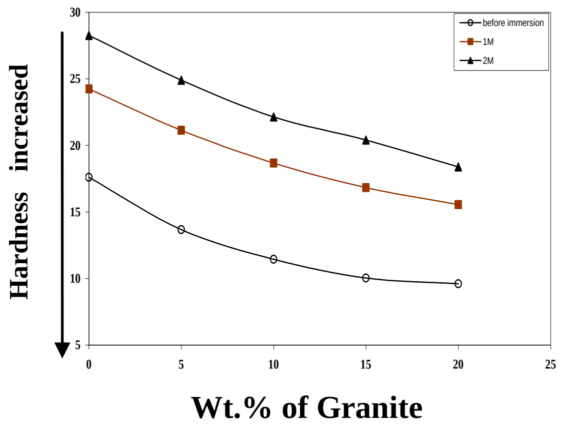

Fig. 5: show the variation of the value of hardness as a function of wt. % of Granite in different acidic media of HCL.

Conclusion:

It is concluded that the diffusion coefficient was decreasing with increasing in Wt.% of Granite and increased with increasing the acidity of the immersed solution , and we found the value of hardness was higher for samples before immersed and it increased by increasing in Granite content.(note: the smaller value of hardness that's mean higher hardness.)

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دراسة تأثير الغمر بالمحاليل الكيميائية على صلادة متراكبات (الايبوكسي-كرانيت)

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الخلاصة:

اجري هذا البحث باستخدام راتنج الايبوكسي والذي مزج مع الكرانيت بنسب خلط (5،10،15،20) % نسبة وزنية لتكوين متراكبات بوليمرية. استخدمت تقنية القولبة اليدوية في تصنيع نماذج البحث. تم دراسة اختبار الصلادة للنماذج المحضرة في الظروف قبل وبعد الغمر في المحاليل الكيميائية (1،2) مولاري لحامض الهيدروكلوريك لفترة تصل الى 10 اسابيع ، بعد مقارنة النتائج بين البوليمر النقي والمدعم بالكرانيت وجد ان الصلادة تزداد بزيادة نسبة الكرانيت في النماذج . كما اظهرت النتائج ان قيم الصلادة للنماذج قبل الغمر تمتلك اعلى قيمة مقارنة مع قيم الصلادة بعد الغمر كما تم حساب معامل الانتشار وقد وجد ان معامل الانتشار يقل بزيادة نسبة الكرانيت في النماذج.