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Research Article

Study the Effect of Weight Gain on the Hardness and Diffusion Coefficient for Epoxy Reinforced with Different Ratios of Sand

Aawttif, A.Mohammed[†*]

[†]Department of Physics, Collage of Science, Baghdad University, Baghdad, Iraq

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Abstract

In this study the mechanical properties of polymer composites reinforced with natural particulates are investigated. The epoxy resin used as a matrix material is Ep-10 and the reinforcement material was natural sand with particle size (25)μm and having weight fraction of 10%, 15% ,20% and 25% respectively .Specimens of the matrix material and the four types of composite materials were subjected to hardness tests. Experimental tests results indicate that hardness of the composite materials is significantly higher than those of the matrix material. The enhancements in these properties are found to be directly proportional to the weight fraction of reinforcement materials .the samples then immersion in water and chemical solution (HCl, NaOH) with concentration(1N) for 0,1,4,8,12,16 and 20 days. The effect of the chemical solutions has been studied on some physical properties (weight gain, hardness and diffusion coefficient) of epoxy before and after reinforced, and the results revealed obvious change in its physical properties.

Keywords: *Epoxy, sand, hardness, weight gain*

Introduction

The industrial and technological development depends largely on the progress made in the field of materials, and as a result of this development .Which the world has witnessed in all fields need to find alternatives materials with multiple industrial uses have emerged so. Those alternatives be good specifications in terms of cost, light weight and properties in general, so it has been producing what is known composite materials) which is about participation two or more non-full to interact with each other, so they are not a new material chemical but every material represents a separate phase system (Moslem,A.I.,2003; Richardson. M.O.W., 1977). And study the mechanical properties of engineering materials of very important things that must be taken into consideration because it sets behavior of these materials under the influence of stress by hanging.

The study of mechanical properties of polymeric materials with the foundation of things important to the multiplicity of variables affecting the, each property and after that knowledge can choose the appropriate material for Applied purposes and depending on the nature and classification of material properties for mechanical materials depending on the nature of power shedding (Hull, D.,1981; Seymour,R.B.,1999). The hardness of the properties of the surface mechanical task which can be defined as resistant material for stitches and to be able to keep its surface tact under the influence of external loads property depends hardness, like other properties mechanical on the surface type and temperature conditions.

Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. The composition of sand is highly variable, depending on the local rock sources and conditions, but the most common constituent of sand in inland continental settings and non-tropical coastal settings is silica (SiO2), usually in the form of quartz, which, because of its chemical inertness and considerable hardness, is the most common mineral resistant to weathering and non-toxic (Sultana,R.*et al*,2013;Ibtithal,A.N. *et al*, 2011).

Experimental work

The material used in this work was Epoxy resin ,it is a viscous liquid with a certain specification, including high portability and lack of adhesion and contraction when drying. In this study Epoxy of type (Conbextra EP10) with density(1.4 gm / cm3) and turn the epoxy resin to solid-state after adding it hardener of type(MPDA) both supply by Fosrac Jordan Company . The polymeric material is prepared by mixing the epoxy resin with the hardener in (3:1) ratio at room temperature and after then Conducted for a number of hours treatment process to reduce the proportion of contractions and increasing interdependence between molecules.

*Corresponding author: **Aawttif, A.Mohammed**

Table (A): Some of epoxy resin polymer (Callister,W.D., 2003)

property	Unit
Density	1100(Kg/m^3)
Compression Strength	77(N/mm^2)
Tensile Strength	29(N/mm^2)
Flexural Strength	91(N/mm^2)

Sand collected were sieved to obtain one size of natural sand were used with particle size in the range 25 µm was dried at 50C° for 1 hours in a preheated oven. Sand and epoxy resin (density 1,4 gm/cm3) was mixed in a bowl very carefully with a stirrer for about half an hour prepare the composites .The mixer was then poured into the closed mould and kept it 24 hours for the purpose of completing the hardening process at room temperature. Sand was examined and shown in Table (B).

Four samples of epoxy having a composition of sand to epoxy in the ratio of 10:90, 15:85, 20:80 and 25:75 were prepared and were characterized by different standard methods.

Table (B): Analysis of natural sand that used

Compound	Wt %
SiO2	36
Ca	28.82
SO3	1.081
MgO	0.636
P2O5	0.4054
Fe2O3	0.2742
TiO2	0.0806
Cl	0.03538

Weight gain

Weight gain test of the composite samples were carried out in n water and chemical solutions at room temperature. The specimens were taken into glass beakers containing 100 ml of (water ,HCL and NaOH) with concentration (1N) for chemical solutions, after then the samples carried out up to 1,4,8,12,16 and 20 days and wiped properly and dried then reweighed by electrical sensitive balance. The weight gain was measured by a weight difference methodology. The equation for weight gain was as follows(Abdual.H.P.S. *et al*,2011):

$$\text{Weight Gain \%} = ((Wa-Wb)/Wb)/ \times 100 \quad (1)$$

where, Wb indicates the weight of the sample after immersion and Wa represents the weight of the sample before immersion.

The coefficient of diffusion (D) is defined as the slope of the normalized weight gain against $\sqrt{t}$ and has the form (Parnas,R. *et al*,2006):

$$D = \pi (kb/4M\infty)^2 \quad (2)$$

where D is the diffusion coefficient, b is the thickness of the sample, M∞ is the saturation moisture mass, K is the slope of the curve between weight gain and immersion time

Brinell's Hardness test (BH)

Brinell hardness test was used to determine the hardness of the specimens. The equipment used is type a hydraulic piston type (6700-D) from WOLPERT Germany Company, impressing the indenter with diameter (5mm) under a load (500-1000N) into the surface of the specimen for a standard time, usually 15sec.After measure the indention diameter (d) the hardness is calculated from the following equation (Sun,Y.*et al*,2005):

$$BH=F/(1/2\ \pi\ D[\sqrt{D^{\wedge 2}}-d^{\wedge 2}] \quad (3)$$

Brinell hardness (Kg force),F: The applied load (KN),D: Indenter diameter (mm) and (d): Indention diameter (mm).

Results and Discussion

Figure (1) shows the variation of hardness for matrix material (pure epoxy) and composite material(epoxy+ natural sand) as a function of addition of different wt% of natural sand by applied equation(3). An important observation was the hardness increased with an increase in sand content . Hardness is the measure of resistant of solid matter to various kinds of permanent shape change when a force is applied. The increase in hardness values due to an increase interlacement and stacking, which reduces the movement of the polymer molecules, which led to increased resistance material to scratching and cutting becoming more and more resistance to deform plastically as the hardness of materials depends on the forces that link molecules in composite materials which results in a confined space working to increase the hardness. Macroscopic hardness is characterized by strong intermolecular bonds , but the behavior of solid materials under force is complex. Hardness is dependent on ductility, elastic stiffness, plasticity, strain, strength, toughness and viscosity.

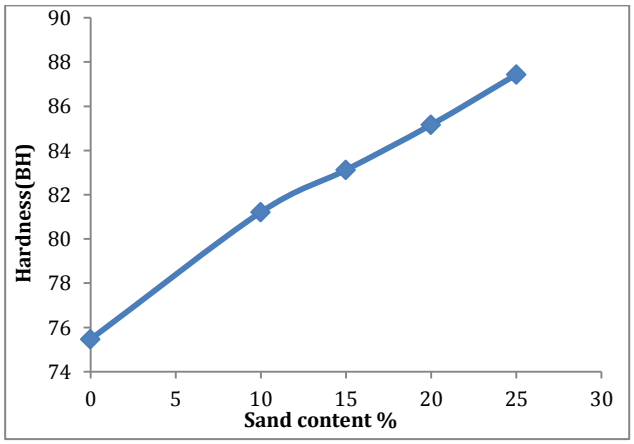

Figure (1) The variation of hardness (BH)as a function of sand content %

We noticed from figure (2) the behaviors of hardness of matrix material and composite material with different sand content at room temperature as a function of time immersion in water. According to the obtained results, we can see the hardness decreases with increasing time immersion which is attributed the water penetration inside polymers decreasing the connection between molecules of polymeric and then softening of manufactured material. Composite materials had many channels and capillary tube which allowed for water molecules to penetrate inside the materials and acting along the interface between epoxy and sand causing swells in the samples . Then the bonds between resin and sand will break , so the strength of the composite material will decrease. Also the effect of weight gain associated with the (phenolinether ,Amino and hydroxyl) group tend to decrease the hydrogen bonding between of polymer chain which is reflected by platization of resin(Abdual.H.P.S.,*et al*,2011; Dara,S.S.*et al*,2007;Davis,A.*et al*,1983; Shao.Y.*et al* ,2008).

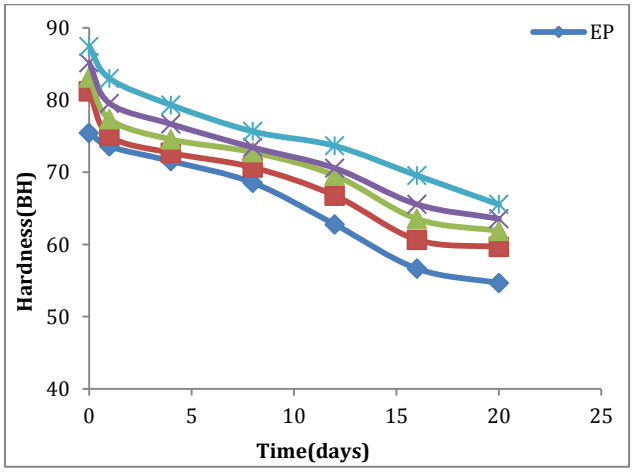

Figure (2) The variation of hardness (BH) as a function of time immersion in water

The variation of hardness for the matrix material and composite material according to time immersion in chemical solution(Hcl) and(NaOH) are shown in figures(3,4) at room temperature. It was found the resistant polymer depends on the nature of the polymer and on the type and nature of the medium in which immersed in it. After immersing the samples in (Hcl) and (NaOH) with concentration(1N). The matrix material and composite material were conducted after different periods of time it was observed that all the samples had shown the passage of a significant decrease in hardness values. The reason for this is because the chemical solutions working on the dissolution of the leading material to failure, as it leads the proliferation of these solutions through the material to break ties and the emergence of bubbles which is one of the phenomena of distortion inform, because inter chemical solutions in the mixture leads to the weakness of the link between epoxy and other additives(sand) which in turn works on increase the porosity and thus increasing the absorption material to chemical solvents which works the latter to increase the plasticity of material(Dara,S.S.*et al*,2007;Davis,A.*et al*,1983; Shao.Y.*et al* ,2008) .

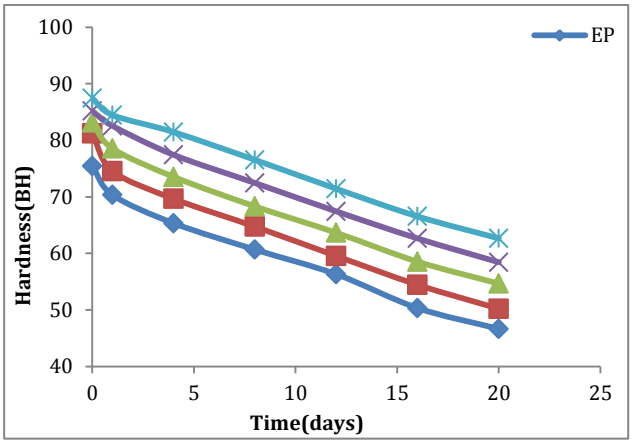

Figure (3) The variation of hardness (BH) as a function of time immersion in Hcl

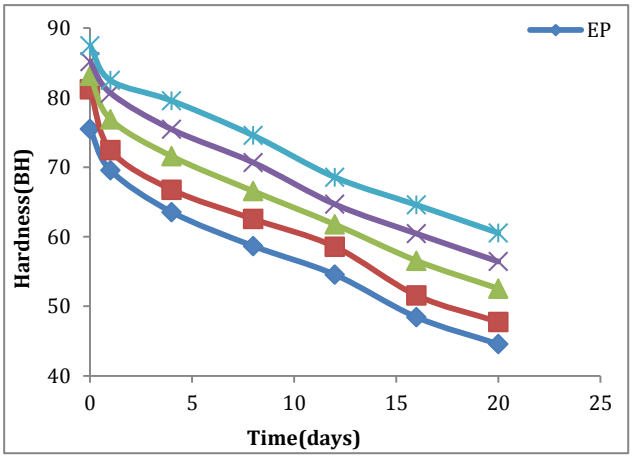

Figure (4) The variation of hardness (BH) as a function of time immersion in NaOH

Figures (5,6) shows the behavior of weight gain with time immersion in chemical solutions for matrix material and composite materials at room temperature by using equation(1). It reveals that weight gain depend on sand content and time of immersion. The percentage of weight gain of composite material increased with an increase in immersion time. The matrix material absorpted the chemical solutions molecules for the reason to attractive the polarity groups of the chemical solutions molecules and will increase the weight gain with increases the numbers of polarity groups, and when the composite materials have been immersed in chemical solutions for long time, the capillarity action conducts the chemical solutions molecules to the material and fills in the voids and cracks in the composite materials, and chemical solutions filled voids at the interface result in interfacial de-bonding. It is noted that all composite

materials have significantly higher percentage of weight gain than the matrix material. The percentage of weight gain in the composite material will directly density, this can be demonstrated by low density with presence of voids inside the composite material, this may be due to formation of micro-channels which contribute to the higher weight gain and also provide a way for water and chemical solutions to pass through pores on the surface and the weight of composite materials will be increase by trapping the chemical solutions inside the voids[Davis,A.*et al*,1983; Sreekumar,P.A.*et al*,2009; Huda,A.A., 2012].

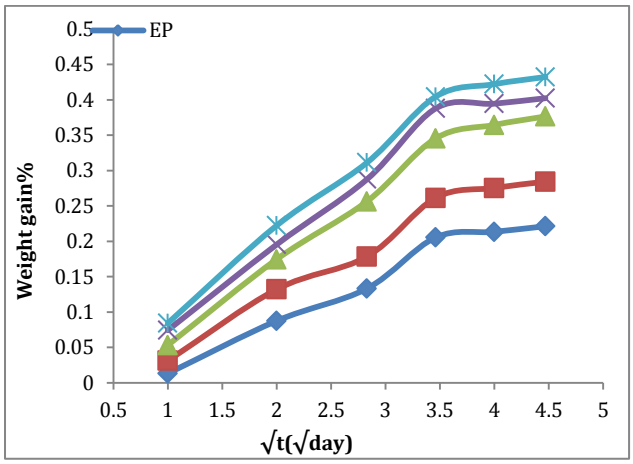

Figure (5) The variation of weight gain as a function of time immersion in Hcl

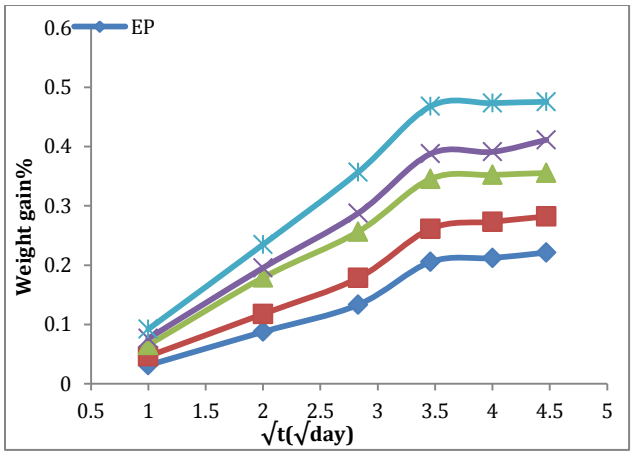

Figure (6) The variation of weight gain as a function of time immersion in NaOH.

As we can see from the table (3) the values of the diffusion coefficient of the composite material and the matrix material after immersing in chemical solution by applied equation (2). We can see the values of diffusion coefficient of samples decreases with increase weight fraction of sand that immersing in the chemical solution, and that attributed to some deflation and saturation is not enough to material between the resin and the reinforcement material during.

Table (3): The results of diffusion coefficient for all samples after immersion in chemical solution

Samples	Hcl	NaOH
EP	16.9×10^{-8}	16.3×10^{-8}
EP+10% sand	15×10^{-8}	14.5×10^{-8}
EP+15% sand	10.6×10^{-8}	9.3×10^{-8}
EP+20% sand	9.1×10^{-8}	8.1×10^{-8}
EP+25% sand	8.4×10^{-8}	7.7×10^{-8}

The molding process of the overlapping material, and then small incisions arise on the surface and show gaps in the material basis. When the samples exposure to the chemical solution then the will be spread in the basis material, especially the gaps formed during the molding stage, thus resulting in absorption processes, chemical reaction, and plasticity .Finally the dissolution of the basis material at the immersion for long periods. This effect also notes the increasing immersion time of the samples in the chemical solution (Huda,A.A.,2012).

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