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Effect of Hcl acid on the physical properties of Hybrid / Epoxy nanocomposites

Ahmed. H. M. Alfalahi[1] , Balkees M. D. Aldabagh[2], Baraa. J. Rashad[1]
[1] *Department of physics, College of Education for Pure Sciences, University of Anbar, Iraq*
[2] *Department of Applied Sciences, University of Technology, Baghdad , Iraq*

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Name: **Ahmed. H. M. Alfalahi**
E-mail:

Tel:

ABSTRACT

In this research a nanocomposites were prepared from epoxy resin reinforced by Titanium dioxide (TiO2) and Zinc Oxide (ZnO) nanopowders with grain size (10-30nm) and (TiO2+ZnO) hybrid using Hand Lay – up molding. The spacimens were prepared according to (ASTM) specifications. Impact Strength, Bending Strength were studied pre and after immersion in HCL (0.5 N & 1 N). Effect and absorption of these solutions were studied also .The results showed that the [EP+ZnO] composite has higher impact strength (6.82 kJ/m2) compared with [EP+TiO2] (2.67kJ/m2), while the hybrid [EP+ (ZnO+TiO2)] composite has a value in between. While, the hybrid composite has a higher modulus of elasticity (1385.69 Mpa) followed by [EP+ZnO] (1256.25 Mpa), and higher than [EP+TiO_2] which owned (1029.35 Mpa) modulus of elasticity .After immersion in HCL, it showed that the impact strength, and young modulus were decreased for all samples. The hybrid composite was the least affecting by the acid solution. The higher absorption was for the [EP+TiO_2] composites.

1. Introduction

The industrial and technological development is largely depends on the progress in the field of materials and as a result of that have been witnessed by the world in all fields which need to find alternatives to substances with multiple industrial uses. Those are alternatives with specifications and high quality regarding cost and height weight properties in general for the purpose of adopting in industry such as aircraft, Ships, radar, automotive and other applications, therefore have been producing what is called the production of composite materials. [1].Nanotechnology is the manufacturing of useful materials, devices and systems through manipulation of matter on this miniscule scale. The ascending field of nanotechnology includes scientists from many different regulations that involves physicists, chemists, engineers and biologists, and with a wide range of applications such as in medicine, electronics, biomaterials and energy productions. [2].

Charpy impact test more common test using supported beam by swinging pendulum in calculating the impact strength for specimens using equation (1).

$$I.S = \frac{Uc}{A} \ \ldots\ldots\ldots.(1)$$

Where:
I.S: impact strength (J/mm^2)
U_c: energy of fracture (J)
A: cross section area (mm^2)

Three point test also a common test to evaluated young modulus and flexural strength using equation (2).

$$E = \frac{MgL^3}{48\ IS} \ \ldots\ldots\ldots.(2)$$

Where:
E: young modulus (Mpa)
M: mass applied
g: gravitational acceleration (m/s^2)
L: distance between supports
I: moment of inertia = $\frac{bd^3}{12}$
Where:
b: width & d: thickness of the specimen (mm)
S: deflection of specimen. [3].

Weight gain after immersion in liquids is given by equation (3).

$$W.G = \frac{m_1 - m_0}{m_0} \ X\ 100\ \% \ldots\ldots\ldots.(\ 3)$$

And diffusion coefficient can be calculate according to the second Fick’s law given by equation (4). [4].

$$D = \pi(\frac{kd}{4M\infty})^2 \ldots\ldots\ldots (4)$$

Where:
K: slope of straight line of the curve of W.G % and $\sqrt{time}$
d: thickness of specimens
$M\infty$: Maximum weight gain (g)

2. Experimental

2-1. Materials used: Epoxy resin type (polyprim – EP) was utilized as a matrix, it was a transparent liquid with density (≈1.03 g/cm^3), medium viscous, has an ability of a good adhesion, low shrinkage and it is cured by adding a hardener with (1:2) (hardener: matrix). Nano ZnO & TiO_2 powders used with grain size (10-30 nm) as a fillers with weight fraction (2% wt). Diluted HCL (0.5 & 1 N) was used as a corrosive media.

Hand Lay-up molding was used to prepare the following composites: 1- (EP+TiO2), 2- (EP+ZnO) and 3- [EP+ (TiO2+ZnO)] Hybrid composite.

Standard specifications were used to impact strength, young modulus and diffusion coefficient D.

2-2. The tests:

2-2-a: Impact: Charpy impact instrument type AMITYVILLEING New York, was used for performing impact test on the specimens, cut according to (ISO-179). To calculate impact strength, equation (1) was used. [5].

2-2-b: Bending: Using three-points bending test and equation (2) we have calculate the young modulus for specimens cut with (ASTM-D790). [6].

2-2-c: Diffusivity of liquids: The test was carried out according to (ASTM-D570) to evaluate the weight gain for 10 weeks in diluted HCL (0.5N & 1N) using equation (3), and diffusion coefficient D using equation (4). [7].

3. Results and Discussion:

3-1. Impact test: From Figures (1 & 2) the observed that the (EP+nano ZnO) composite owned higher impact strength (6.82 kJ/m^2) compared with [EP+hybrid (TiO_2+ZnO)] which has (4kJ/m^2) and the lowest value for [(EP+ TiO_2) (2.67 kJ/m^2)]. ZnO owned high adhesion force with polymers, so it have good toughness and capability of absorbing energy and this adhesion is because of low contact angle with polymer. [8].However the filler acts a crack resistance propagation, so the specimen needs a lot of energy of break. [9].

In general after immersion in HCL solutions the impact strength decreased and that was due to effect of acid solution which causes a breakage of polymer chains and weakened the matrix and interface region. [10].

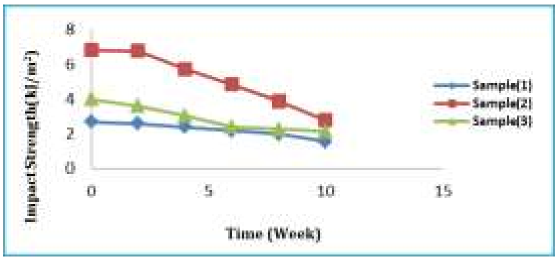

Fig.1. Variation of impact strength with time of immersion in HCL (0.5N)

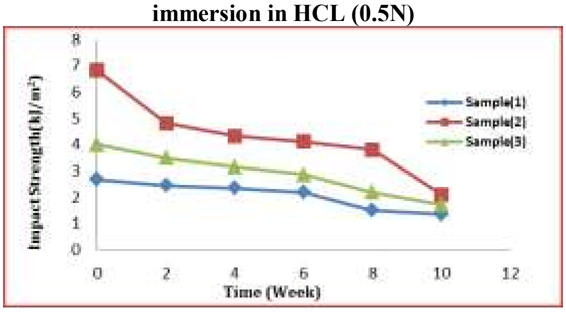

Fig.2. Variation of impact strength with time of immersion in HCL (1N)

3-2. Bending test

Figures (3 & 4) shows the variation of young modulus with time of immersion in HCL for 10 weeks. [EP+hybrid (TiO_2+ZnO)] owned higher value for young modulus (1385.69 Mpa) compared with (EP+TiO_2) which owned (1029.35 Mpa) and (EP+ZnO) had a value in between (1256.25 Mpa). Also all the young modulus values were affected by HCL solutions and decreased with time. [11].The decline of the young modulus value is because of shrinkage occurs in the interface region and swilling of the samples and a new cracks were appeared on the surface of the material and increasing of diffusivity the HCL solution inside the specimen causing absorption, ductility, and degradation of the composite. [12].

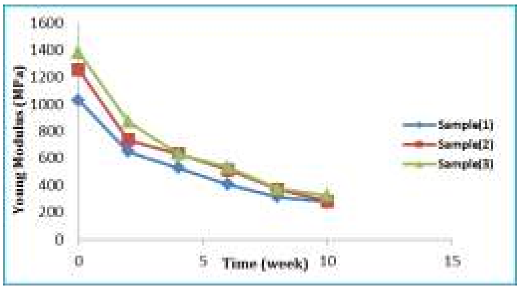

Fig.3. Variation of young modulus with time of immersion in HCL (0.5N)

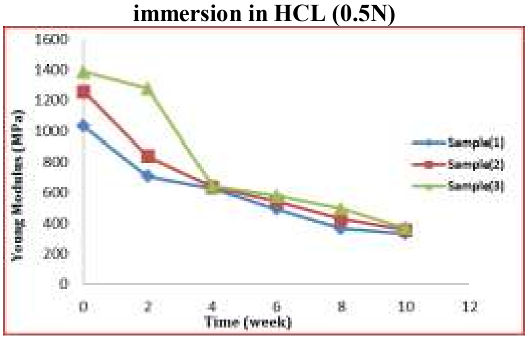

Fig.4. Variation of young modulus with time of immersion in HCL (1N)

3-3. Diffusivity: Figures (5 & 6) show the mechanism of HCL absorption by the composites, with square root of the time. (EP+TiO_2) owned a higher weight gain of HCL solution, compared with (EP+hybrid) and (EP+ZnO) the lowest one. The higher porosity for TiO_2 raising the ability of absorbing HCL solution higher than ZnO, so the diffusion coefficient D is larger. [13].Table (1) Showed values of Diffusion coefficient of the materials used.

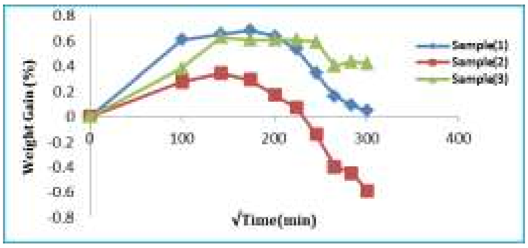

Fig.5. Weight gain % with $\sqrt{time}$ of immersion in HCL (0.5N)

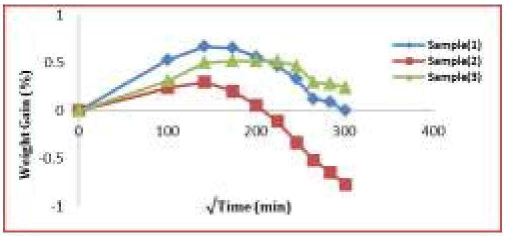

Fig.6. Weight gain % with $\sqrt{time}$ of immersion in HCL (1N)

Table 1: value of Diffusion Coefficient (D) in HCl Solutions for the materials used

Solutions	D $*10^{-11}$ (m^2.min)		
	Sample(1) EP+TiO_2	Sample(2) EP+ZnO	Sample(3) EP+TiO_2+ZnO
HCl (0.5N)	D_1=151	D_2=144	D_3=80
HCl (1N)	D_4=181	D_5=149	D_6=82

Conclusions

1. (EP+nano ZnO) composite had a higher impact strength & young modulus compared with other composites.
2. (EP+TiO_2) composite owned a higher absorption of HCL solutions.
3. HCL solution cause a degradation in ((EP+ZnO) in both (0.5N & 1N) compared with other composites.

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تأثير حامض HCL على الخواص الفيزيائية لمتراكبات الايبوكسي الهجينة

احمد حماد مناجد الفلاحي[1] ، بلقيس محمد ضياء الدباغ[2] ، براء جمال رشاد[1]

[1]قسم الفيزياء ، كلية التربية للعلوم الصرفة ، جامعة الأنبار ، رمادي ، العراق

[2]قسم العلوم التطبيقية ، الجامعة التكنلوجية ، بغداد ، العراق

الملخص

تم في هذا البحث تحضير متراكبات نانوية من راتنج الايبوكسي المدعم بالمساحيق النانوية دايوكسيد التيتانيومTiO_2 و أوكسيد الخارصين ZnO بحجم حبيبي (10-30nm) والهجين (TiO_2+ZnO) باستخدام طريقة القولبة اليدوية. حضرت النماذج طبقاً للمواصفات القياسية (ASTM). درست متانة الصدمة، متانة الانحناء قبل وبعد الغمر في حامض HCL (0.5,1N) ودرس كذلك تأثير امتصاص هذه المحاليل. أظهرت النتائج ان المتراكب (Ep+ZnO) يمتلك اعلى متانة صدمة ($6.82\ kj/m^2$) مقارنة بالمتراكب (Ep+TiO_2)($2.67\ kj/m^2$)، بينما المتراكب الهجين [Ep+(TiO_2+ZnO)] يمتلك قيمة وسط. بينما المتراكب الهجين يمتلك اعلى معامل مرونة (1385.69Mpa) يليه المتراكب [(Ep+ZnO)(1256.25Mpa)] واعلى من المتراكب [(Ep+TiO_2) الذي امتلك (1029.35Mpa)]. بعد الغمر بالحامض Hcl اظهرت النتائج ان متانة الصدمة ومعامل يونك قد تناقصا ولجميع النماذج وان المتراكب الهجين كان الأقل تأثرا بمحلول الحامض وان أعلى امتصاصية كانت للمتراكب (Ep+TiO_2) .