Studying the Impact Strength of (Epoxy with TiO_2 and MgO) Composite

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Received on: 5/1/2011
Accepted on: 5/5/2011

Abstract

This work has been done with using of epoxy resin mixed with polystyrene (90/10) % to compose binary blend. Two types of powder (TiO_2, MgO) in two volume fractions of (10, 15) % were used as reinforcement materials to the prepared polymer (B).Hand lay-up technique is used in fabrication of the composite samples. Impact test was carried out for the proper samples in both normal condition and after immersion in water, KOH (0.5 N), HCL (0.5 N) solutions for periods ranging up to 8 weeks. After comparing the results between the polymer blend and their composite, it was found that Impact Strength were greater for the matrix (B) after immersion compared with their values before immersion while the results of the composite before immersion show that (B+10%MgO) has higher impact strength (11.333) KJ/m^2 .

Keywords: polymer blend, epoxy resin, polystyrene, impact strength

دراسة مقاومة الصدمة للمادة المتراكبة (الايبوكسي / أوكسيدالتيتانيومTiO_2 و اوكسيدالمغنيسيوم MgO)

الخلاصه

اجري هذا البحث بأستخدام راتنج الايبوكسي والذي مزج مع البولي ستايرين بنسبة% (10/ 90)لتكوين خليط ثنائي بوليمري .تم استخدام نوعين من المساحيق اوكسيد المغنيسيوم(MgO) واوكسيد التيتانيوم (TiO_2)و بكسرين حجمين% (10,15)لتدعيم الخليط البوليمري .استخدمت تقنية القولبه اليدوية في تصنيع نماذج البحث .تم دراسة اختبار الصدمة للنماذج المحضرة في الظروف قبل وبعد الغمر في الماء والمحاليل الكيمائية HCL(0.5)N,KOH(0.5)Nلفتره تصل الى 8 اسابيع. بعد مقارنة النتائج بين الخليط البوليمري والمواد المتراكبه , وجد ان مقاومه الصدمه للخليط البوليمري تمتلك اعلى قيمه مقارنة مع القيمه قبل الغمر. بينما اظهرت النتائج قبل الغمر بأن (B+10%MgO) يمتلك اعلى مقاومة صدمة (11.333) KJ/m^2. خلط البوليمرات، الأيبوكسي، بوليستايرين، متانة الصدمة

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https://doi.org/10.30684/etj.29.10.9
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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].

Polymer blends 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 and with a minimum investment has encouraged the blending of polymers [3].Polymer blend (PB) is a mixture of at least two polymers or copolymers (polymeric material synthesized from more than single monomer). There are two types of blends miscible and immiscible, which lead finally to form polymer alloys [4].

There are several reasons for blending polymers [4]: Extending engineering resin performance by diluting it with a low cost polymer, developing materials with a full set of desired properties, forming a high performance blend from synergistically interacting polymers and adjusting the composition of the blend to customer specification.

Gupta A.K. and Jafarri S. H.[5] studied the impact and dynamic properties of rubber-modified binary blends of polypropylene (pp). Ethylene vinyl acetate copolymer (EVA) and ethylene propylene diene terpolymer(EPDM) were used for impact improvement of PP . The results indicated that EPDM was better than EVA as an impact modifier of PP (EPDM was found to a etter impact modifier for PP by increasing the impact strength of PP by a factor of up to about 20, whereas the EVA showed only two times the improvement in impact properties of PP).

Nikhil Gupta et.al[6] studied the effect of filler addition on the compressive and impact properties of glass fiber reinforced epoxy .the results show that addition of filler particles in small volume fractions led to the decrease in compressive strength of the composite specimens. However, impact strength by such addition increased considerably.

Sankarprasad Bhuniya and Basudam Adhikari [7] used hydroxyl-terminated silicon-modified polyurethane (SIMPU) oligomers as toughening agents for epoxy resins and evaluated the impact strength for it. The results showed that 15 phr SIMPU led to better impact strength of epoxy resins than the others without the deterioration of the tensile properties. The impact strength increased continuously and reached a maximum value (five times greater than that of the virgin resin) at a critical modifier concentration (20 phr).

Alka Gupta et. al [8] studied the effect of composition on the mechanical and electrical properties of the reactive blends (Epoxy/Polycaprolactam) ,such as tensile properties ,flexural properties, Izod impact strength, Rockwell hardness and volume resistively. It was observed that the degree of cure and crosslink density of the reactive blends increased with increasing DGEBA (epoxy resin diglycidyl ether of bisphenol-A)content from 50 to 80 wt %. Because of this, the heat of reaction and heat deflection temperature increased concomitantly with increasing DGEBA content in the reactive blend. Tensile properties, flexural properties, izod impact strength, Rockwell hardness, and volume resistively of the reactive blends increased with increasing DGEBA content from 50 to 80 wt %in reactive blend.

H. V. Ramakrishna and S. K Rai [9] used Granite Powder as Filler for Polybutylene Terepthalate Toughened Epoxy Resin and study the effect of the silane coupling agent on the properties of these composites and the chemical resistance and water absorption of these composites. The composites with 50% granite powder showed better properties.

Hernández, M. et.al [10] study the impact properties of Polypropylene /Styrene-Butadiene-Styrene Block Copolymer (PP/SBS) Blends. Concentrations of SBS were 15, 30 and 40 %wt. Impact measurements exhibited that pure PP has extremely low impact strength. Improved impact strength can be achieved by blending PP with SBS.

The aim of this research is to modify the mechanical properties of epoxy resin to reduce their brittleness by mixing with polystyrene and study the effect of chemical solution (H_2O, KOH and HCl) on the prepared samples.

Experimental part

Epoxy Resin (EP)

Epoxy resin (type EUXIT 50) was used in this research which is a two component preparation of liquid epoxy resin based, with formulated amine hardeners. Epoxy resin is primarily low viscosity (high fluid), which penetrates in to the smallest capillaries and pores.

Table (3-1) shows the properties of epoxy resin used in this work.

Polystyrene (PS)

General purpose polystyrene PS 125 which was supplied from Sabic Company is manufactured by continuous mass polymerization of styrene monomer. It is a crystal-like, hard and brittle

Polymer with the following characteristics;

• Medium flow with excellent clarity.

• Higher Vicat and heat deflection temperatures allow its use in many different applications.

It is recommended for the manufacture of a variety of packaging items, namely jewelry and gift boxes; medical supplies such as Petri dishes, test tubes and specimen jars, etc.

Titanium Dioxide (TiO_2)

Titanium dioxide (TiO_2) is the most widely used as white pigment; it was manufacture by Riedel-de Haen (Germany). It has a specific gravity of 4.25 g/cm^3 and particle size 100 µm.

Magnesium Oxide

Magnesium oxide (MgO), which is produced by heating magnesium chloride (MgCl) with lime ($CaCO_3$), which manufacture by B.D.H, Ltd (British), it is a white powder with a specific gravity of 3.58 g/cm^3 and particle size 100µm.

Preparing of polymer blend and composites

Five samples were prepared as following:-

1-The first mold included a mixture of epoxy (a transparent liquid which transforms in to solid state after adding the hardener to it in a percentage of 3:1) with polystyrene which dissolved by adding chloroform. The process was done as following: epoxy resin was mixed with hardener gradually, and then dissolved polystyrene added to it. The percentage of mixing was 90%EP and 10%PS .after that, the mixture is lay – up in mold was made of vulcanized iron with dimensions (15 * 13.5 * 3) cm.

2- The same preparation of polymer blend (as show above) before casting reinforced with (10, 15) %MgO or (10, 15) %TiO_2 then lay-up in mold when the solidification process is finished the sample was cut down in to standard dimensions according to (ISO-179).

Volume fraction (Φ) is combined with the weight fraction (Ψ) by the relation [11]:

$$\Phi = \frac{1}{1 + \frac{1-\Psi}{\Psi} * \frac{\rho_f}{\rho_m}} \quad \ldots\ldots (1)$$

Where

ρ_f , ρ_m: the density of the filler and the matrix respectively.

The density of the blend was determined using the relation:

$$\rho_m = X_1\rho_1 + X_2\rho_2 \quad \ldots\ldots\ldots (2)$$

Where

ρ_m: the density of the matrix (polymer blend).

ρ_1, ρ_2: the density of the first and the second polymer respectively.

x_1, x_2 the percentages of the first and the second polymer respectively.

Immersion of Samples in Solutions:

The samples of impact test are immersed for a period (8) weeks in water and chemical solution (KOH, HCL) with normality (N=0.5) to study the effect of these solution on the samples. The samples are extracted from H_2O, KOH, and HCL after period (2) weeks and tested. This process repeated after period 4, 6 and 8 weeks.

Impact Test Instrument

The prepared specimens were tested by Charpy impact test instrument manufactured by the Testing Machines AMITYVILLE INC New York, was used for the sake of performing impact test on the prepared samples. This instrument consists mainly of pendulum and energy gauge. Charpy impact test consists of standard test piece that would be broken with one flow of a swinging hammer. The technique of the instrument is done through lifting up the hammer to the highest point and fixing it well, and then the sample is placed in its position. The potential energy by a swinging movement will change to kinetic energy which will lose part of it in breaking the sample; therefore, the pointer gauge will read breaking energy value of the sample. Impact strength is calculated from the relation [12].

$$I.S = U/A \ (J/m^2) \quad \ldots\ldots\ldots (3)$$

Where

I.S. = impact strength

U = Energy of fracture in (joule)

A = Cross section area in (m^2)

Experimental results and discussion

The conventional charpy impact test was used to evaluate the impact strength of (Ep/Ps) blend with weight ratio (90/10) % and it composite reinforced with TiO_2 and MgO particles with different ratio (10, 15 pphr) respectively.

Figures (1-1) to (1-3) represent the change in impact strength with the immersion times in water, (0.5 N) KOH, (0.5N) HCL solutions for the

blend and composite materials. The best result of this study under L.C where achieved with the composite materials consist of binary blend reinforced with (10%)TiO_2 and blend reinforced with (10%)MgO whereas lower value of the impact strength was displayed with composite reinforced with volume fraction (15%)TiO_2,MgO and polymer blend receptivity.

Incorporation of rigid filler may enhance or deteriorate the impact properties of composites. Impact strength is an indication of tolerability for a sudden impact. When a composite is subjected to an impact, rapid crack propagation is initiated through the material. When such crack propagation encounters a filler particle in the filled composite, the filler can absorb the energy and stop the crack propagation if filler-matrix interaction is strong. On other hand, if the interfacial adhesion is poor, the filler particle cannot resist crack propagation as effectively as the polymer alone and consequently a catastrophic crack propagates, lowering the impact strength of the composite as loading increases. In the filled composites, as filler loading increases the tendency for agglomerates also increase. As filler agglomeration increases, interfacial adhesion becomes weaker leading to weaker interfacial
regions. These agglomerate acts as stress concentration in the impact strength with increasing filler contain [9].

As show from figure (1-1) for sample immersed in water there is enhanced in the value of impact strength for all samples after periods 4 weeks then there is gradually decreased in the value of impact strength after periods (6-8) weeks.

The increase in the values of impact strength after immersion was related to the plasticization effect [13].

From figure (1-2) for sample immersed in KOH solution it can be seen that a slight reduction in the value of impact strength for binary blend reinforced with (15%)MgO there is decreasing in the values of impact strength for all samples that immersed for 4 weeks except for sample which consist of blend reinforced with (10%)MgO and (10%)TiO_2 ,and after period 8 weeks decreasing in the values of impact strength have been shown.

The variation in the values of impact strength can be observed after immersion of samples in (0.5N) HCL solution figure (1-3). The value of impact strength decreases for all samples after periods of two weeks except for polymer blend where the values of impact strength increase. The reason behind decrease in the values of the impact strength after immersed was due to the absorption of moisture which leads to the degradation of interfacial adhesion between filler and matrix [13].

Conclusions

The following conclusion can be drawn from the present work:

1-The result of impact test shows that the blend polymer (EP/PS) reinforced with (10%)MgO has the highest values of impact strength at normal condition .

2- In general, the tests results are affected by all the chemical solutions.

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Table (1-1) Properties of Epoxy:

Specific gravity	**1.05**
Mix ratio	**3:1**
Compression strength(Mpa)	**85**
young's modulus (Mpa)	**2800**
Glass temperature ^{o} c	**57**

Table (1-2) Shows the properties of Polystyrene (Ps125):

Typical Properties	Unit	Value	ASTM Method
Density	**g/cm^3**	**1.05**	**D-792**
Flexural modulus	**(MPa)**	**3529**	**D-790**
Ultimate tensile strength	**(MPa)**	**43**	**D-638**

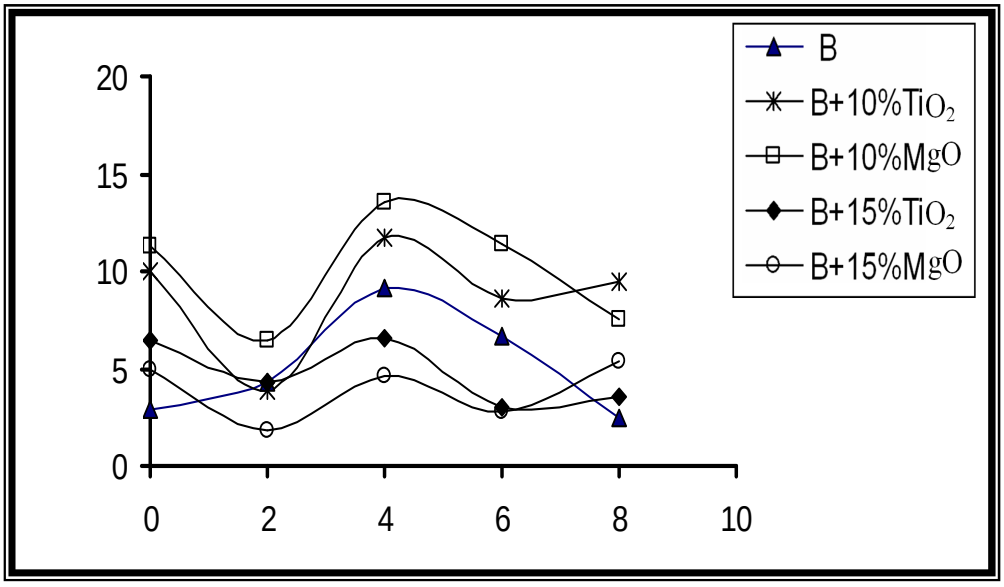

Figure (1-1): The variation in impact strength with time of immersion in water

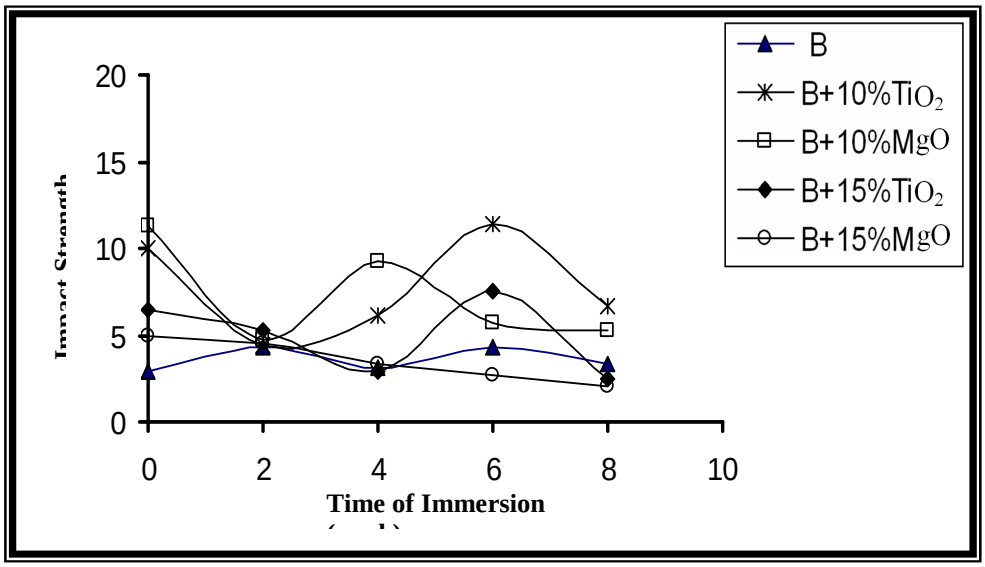

Figure (1-2): The variation in impact strength with time of immersion in KOH.

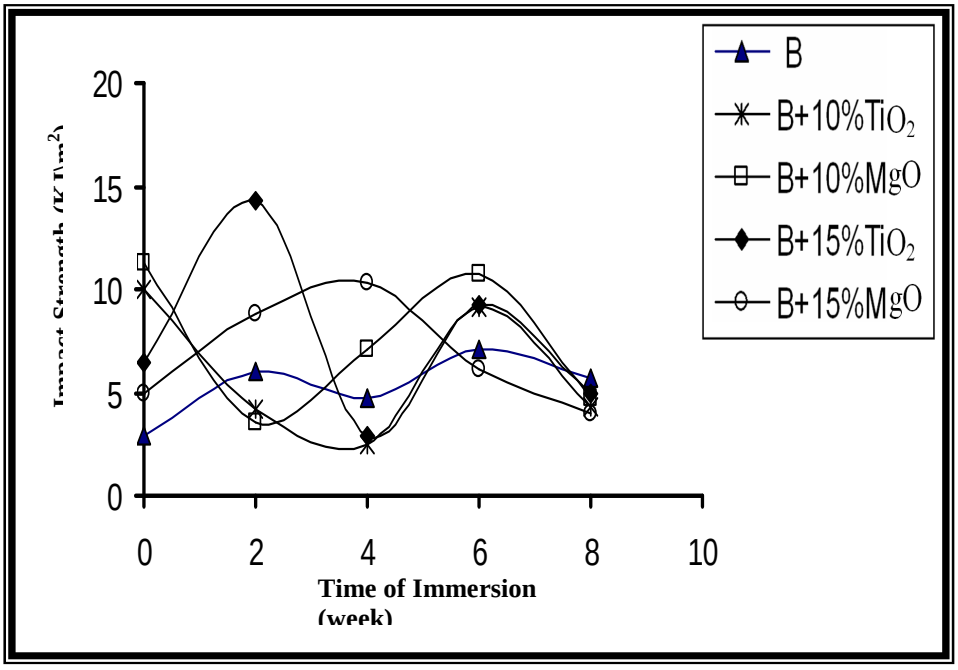

Figure (1-3): The variation in impact strength with time of immersion in HCL.