Effect of acid solution on some Physical and Mechanical Properties of (Epoxy/polysulphide) Blends

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Abstract:
The aim of present investigation is to evaluate the mechanical properties , (tensile, impact, and hardness) properties and physical properties. Acid absorption for (epoxy/polysulphide) specimens were prepared by open molding technique , with different ratios (95-5),(90-10),(85-15), and (80-20)% weight ratio.
Impact strength (Charpy method) using showed a better value for (85-15)% ratio, so toughness increased and this optimum mixing ratio (OMR) was taken for tensile and hardness test before and after immersion in acid solution with different concentrations (0.1 N, 0.2 N, & 0.3 N) to evaluate tensile strength and Shore hardness D , 0.3 N had been affected all specimens more than (0.1 & 0.2)N, in each test Diffusion coefficient was calculated for each concentration.

Keywords: (Epoxy/ polysulphide) blend, Tensile Strength, Impact Strength, Diffusion Coefficient.

Introduction:
Polymer blends or (poly-alloys) as known as the result of mixing of two or more types of polymers, without any chemical reaction taking place, hence, no covalent bonding occurs between the components.[1]
There are many reason for blending polymers, as they offer a fast and cheap way to addition new materials exhibit a range of properties which varies between the properties of there components, blends can be satisfied according to their homogeneity as:
1- miscible polymer blend which means a mixture of polymers to form a single phase over a range of temperature , pressure and composition.
2- Homologous polymer blend , (a mixture of two or more fractions of the same polymer each of which has a different molar mass-distribution. [2]
3- Immiscible blend (inability of its mixture to form a single phase.
4- Compatible blends (immiscible polymer mixture, but exhibits macroscopically uniform physical properties). Modifying the polymer properties , may be adding a certain compatibilizer to the immiscible polymer blend to enhance some mechanical properties.[3]

Flory – Huggins Theory
Specific Models for the Enthalpy and Entropy terms are used to specify the polymer blends, which is developed by Flory-Huggins for polymer mixtures.
F-H relation has been expressed in several equivalent forms:

$$\frac{\Delta Gm}{RTV} = \left(\frac{\emptyset 1}{V1}\right) \ln \emptyset 1 + \left(\frac{\emptyset 2}{V2}\right) \ln \emptyset 2 + \Delta G_m$$

$$= RTV\left[\frac{\varphi 1}{V1} \ln \emptyset 1 + \frac{\varphi 2}{V2} \ln \emptyset 2\right] + \beta \emptyset 1 \emptyset 2 \text{ …….. (1)}$$

$$\frac{\varphi_{12}}{V1} = X'_{12} ; = X_{12} RT \left(\frac{V}{V_1}\right)$$

In Eq. 1 : R,T,V, Φ_i

are respectively gas constants temperature , molar volume, and fraction of component, I = 1,2,….
φ'_{12} : polymer-polymer interaction parameter, contain both enthalpy and entropy of the system.[4]
polymer-polymer adhesion plays a significant role in determining the ductility ; the interfacial thickness and strength of the adhesive bond increase as the volume of (X/V_1) approaches zero.
Properties of any polymer blend; their mechanical and physical properties are likely depended on the nature of components , fraction and interface region a process of adding synthetic elastomers to thermoset polymers in order to increase their toughness , the possibility of toughening Epoxy resins was first progressed in 1968, by adding a small amount of an elastomer as a second phase to perform blend with a new physical properties.
Impact strength of any blend is a function of energy absorbed ,charpy test was the widely used in which a hammer used to break the specimen to determine the energy absorbed by this specimen.
The impact strength is calculated by a relation :[5]

$$I.S = \frac{U(Juls)}{A(m^2)} \quad \text{... (2)}$$

Where I.S. : is impact strength, U is energy of fracture , A is the cross-section area of the sample.
Tensile strength indicates the maximum stress for a sample fracture; the higher stress of a material the higher stress can be exposed :

$$T.S = \frac{Max .load\ (N)}{A\ (m^2)} \quad \text{... (3)}$$

Where A : cross section of area.
Absorption of any solution in polymers and polymer blends obeys Fix's law, which states that "quantity of liquid absorbed until steady state is reached "; and mechanism of diffusion of liquid solution depends on types of liquid; thickness of sample; liquid temperature and time of immersion.[7]

2. Materials and Methods
2.1 Materials
2.1.1 Epoxy resin (Thortex) : was used with density 1.05 g/cm^3), high chemical resistance, good adhesion, and low shrinkage.
2.1.2 Polysulphide rubber is supplied in the shape of white dough that changes to elastic shape by adding PbO_3 black dough by ratio (1:1), with density 1.35 g/cm^3. It is used for cover the interior of the plane fuel, in painting and injection into cracks of concrete.

2.2 Mold Preparation:

Both of Epoxy and polysulphide resins mixed with a hardener with ratio 3:1 to form a tough , flexible resin then mixed together with different ratios (95-9)%, (90-10)%,(85-15)%, (80-20)%, and (75-25)%, respectively .

The optimum mixing ratio (OMR) was selected based on the best adhesion between polymers and highest impact strength value for the blend.

Diffusion coefficient (D) was calculated for a specimen in H_2SO_4 (0.1, 0.2, & 0.3) using Fix's 2nd law :

$$D = \pi \left(\frac{kb}{4M_\infty}\right)^2 \ldots (4)$$

Where k : is slop of the curve (weight gain v_s root square of time), b: thickness of the sample, M_∞ : maximum weight gain.

3. Results and Discussion

Impact strength was calculated for each blend ratio for Epoxy and polysulphade to equation (2) , fig. (1) showed the relation between impact strength and ratio of blending to indicate the best toughened blend ; from this figure it was shown that the best value for impact strength was (15% Polysulphade; 85% Epoxy), the (OMR) optimum mixing ratio was 15% wt. for polysulphade and it is going to be considered as abases for further test (Tensile, hardness, liquid absorption). The failure in the blend under impact test destroying all bonds and forces between molecules and crack then grows dangly and quickly. [9]

Fig. (2) showed the changing of impact strength for the (OMR) blend with different concentrations of (H_2SO_4) solutions (0.1, 0.2, & 0.3) N, it was reached with increasing acid concentration, the transport of liquid causes polymers to swell depending on chemical nature and interface region and cause of Fickians lows the rate of diffusion can be much smaller than that of polymer relaxation due to physical change in polymer-solvent system when swelling increases, free volume increases due to chain mobility which facilates transport process. [10,11]

The percentage of absorptivity for specimen in (H_2SO_4 : 0.1, 0.2, & 0.3) was calculated as a diffusion coefficient D using equation (4), and fig (3) showed the relation between weight gain % vs root square of time.

Table (1) shows values of diffusion coefficient of the (OMR) blend in different concentration of H_2SO_4 solution.

Table 1. D values * 10^{-12} (m^2/sec)

H_2SO_4 solution	D *10^{-12} m^2/sec
0.1 N	0.0322
0.2 N	0.052
0.3 N	0.058

Tensile test is the most widely mechanical property specially for polymer blends, it indicates how the tensile strength change depending on characteristic of each polymer, fig (4) shows the Ultimate tensile strength for the (OMR) blend before and after immersion in aggressive acid (H_2SO_4), 0.3 N had been affected the specimens more than (0.1N&0.2N) ; as in acid solution react with blend, depending on where the molecules of the polymers are able to create secondary bond with the solution so the swelling occurs.[12]

Shore D hardness ; indicate that the best result were achieved for the blend (85-15)%, and when this (OMR) blend soaked in acid solution (H_2SO_4) for 12 week , this solution works on degrading the surface of the material leading to its failure, as diffusion of aggressive liquids through polymer lead to break bonds. Fig 5.Showed the change in hardness values for specimen.

Conclusion:

1. (85-15)% blending ratio (epoxy/ polysulphide) showed better impact strength (toughness).
2. 0.3 N of H_2SO_4 acid solution had been affected the specimen more than 0.1 &0.2 N.
3. Tensile strength & Shore hardness were decreased by acid solution for 12 week immersion .
4. Diffusion coefficient D was higher for 0.3 N. acid solution.

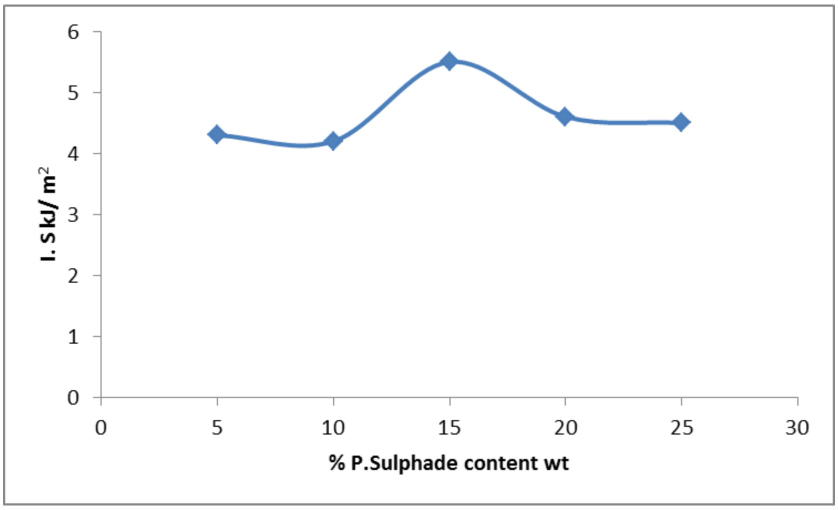

Fig (1): Charpy Impact Strength for (Epoxy/ polysulphide) blends

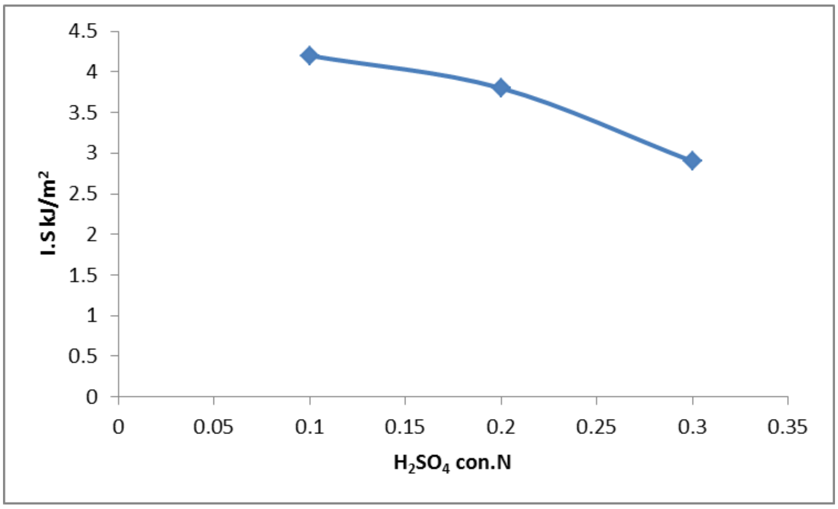

Fig (2) : impact strength vs H_2SO_4 con. (for 12 weeks) % (OMR) blend.

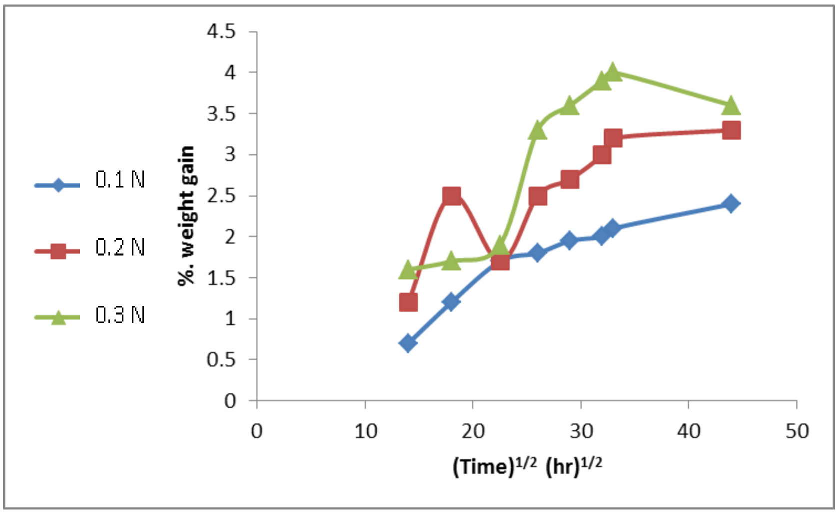

Fig 3. Weight gain % vs root square time for (OMR) blends immersed in (0.1.0.2&0.3 N) H_2SO_4 Solution for 12 week

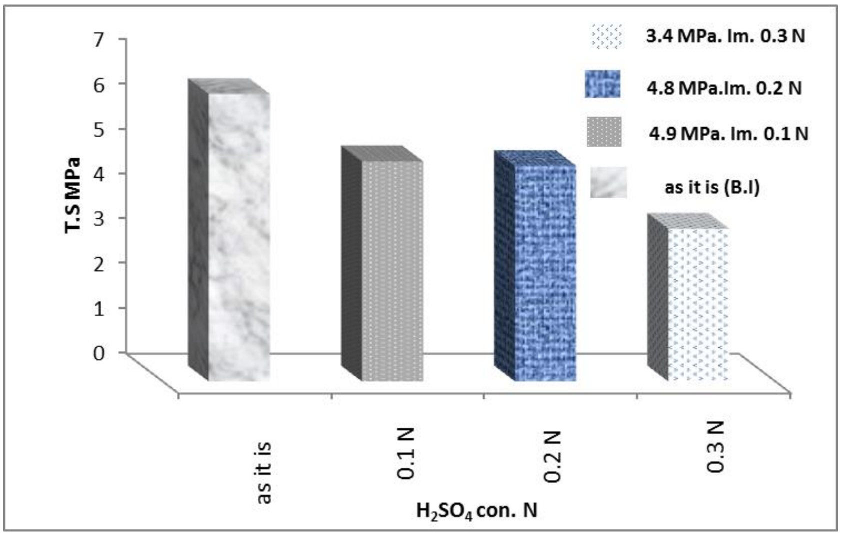

Fig 4. Tensile Strength vs H_2SO_4 Solution for (OMR) blend after immersion for 12 week

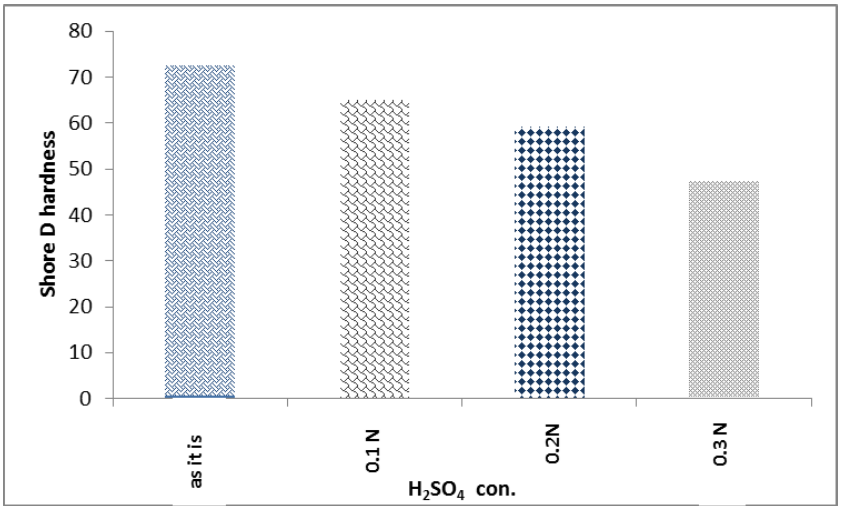

Fig 5.Shore (D) Hardness vs H_2SO_4 Solution for (OMR) blend after immersion for 12 week

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تأثير المحلول الحامضي على بعض الخصائص الفيزيائية والميكانيكية لخليط (الايبوكسي – بولي سلفايد)

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الملخص

الهدف من دراسة البحث الحالي لدراسة الخصائص الميكانيكية (الشد ، الصدمة ، الصلادة) والخصائص الفيزيائية . امتصاص الحامض لعينات خليط (الايبوكسي _ بولي سلفايد) المحضرة بنسب وزنية (95-5) ، (90-10) ، (85-15) ، (80-20) % .

بينت مقاومة الصدمة (طريقة جاربي) المستخدمة افضل نسبة كانت لقيمة النسبة (85-15) % حيث تزداد المتانة لنسب الخلط المثلى التي اخذت لاختبار الشد والصلادة قبل وبعد الغمر في المحلول الحامضي لمختلف التراكيز ذو قيم معيارية (0.1 ، 0.2 ، 0.3) لحساب مقاومة الشد وكذلك صلادة شور (D) ، معيارية 0.3 تتأثر اكثر من العينات الاخرى لمعيارية (0.1 ، 0.2) .

وقد تم حساب اختبار معامل الانتشار لكل التراكيز.