Effect of Polyurethane Resin Additives on the Impact Toughness of Epoxy Resin Reinforced with woven roving Glass Fiber (0^o-90^o)

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Abstract

Impact strength for Epoxy/Polyurethane, Blends and their composites with two layers of Glass fibers (0-90) are calculated.

The impact strength of the blends and composites decrease with increasing weight by weisht percentage of polyurethane . This result is attributed to the high elasticity of PU , and to the immiscibility between the polymer blends as well as the fiber delaminates .

تأثير اضافات راتنج البولي يوريثان في متانة الصدمة لراتنج الايبوكسي المسلح بحصيرة الالياف الزجاجية (0^o-90^o)

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الخلاصة

تم حساب مقاومة الصدمة لراتنج الايبوكسي والبولي يوريثان وخلائطهما غير المدعمة والمدعمة بطبقتين من الالياف الزجاجية (0^o-90^o) . اظهرت الخلائط البوليمرية والمتراكبات ان مقاومة الصدمة تقل بزيادة النسبة الوزنية للبولي يورثان (10% ، 20% ، 30%) وذلك بسبب المرونة العالية للبولي يوريثان اضافة الى عدم الامتزاج مابين البوليمرين المكونين للخلطة وتأثير الالتصاق بين الالياف والقالب البوليمري .

Introduction

Polymer composites are steadily increasing in importance as structural materials due primarily to their light weight and specific strength [1,2] . Most polymer composite materials were developed to improve mechanical properties such as strength , stiffness , toughness and wear resistance [3] . Mechanical properties are often the most important properties related to technological purposes , this is because virtually all service conditions involve some degree of mechanical loading [4] .

Blending of polymers are excellent methods for modification and improvement of polymer properties

[5,6] . Blends display widely varied behavior from brittle to strong and flexible [7] . Significant improvements in impact strength and toughness are usually noted for such blends [8] .

The mechanical properties of the composites depend on many factors including , binding materials , the number of the reinforcement layers , fibers percentage , and the stresses applied on the composites [9] .

Toughness is a measure of the ability of material or structure to withstand without failure , toughness (G_C) is normally quoted as :

Toughness (G_C) = Energy to Break/ area at notch section (KJ/m^2)

The toughness of most glass fibers reinforced plastics is many times greater than impact strength of the fibers or matrix [10,11] .

This work deals with impact strength property of pure epoxy and binary polymer blends epoxy / polyurethane and their composites which reinforced with two layers of woven roving glass fibers type (0^o-90^o) .

Experimental part

A hand layout method was used to prepare specimens as sheets of different thickness with layer of glass fibers .

1- Epoxy preparation

A clean disposable container was used to mix the required weight of epoxy resin type (EP10) conbextra supplied by Fostoc company (Jordan) and a sufficient amount of a curator (HY-956) .

2- Polyurethane Preparation

Polyurethane resin type (TEK-CAST) supplied TEKCAST industries new Rochelle NY 1080 (USA) was mixed with a sufficient amount of a hardener (Isocyanate) (HYG) for 10 minutes .

3- Epoxy / Polyurethane Blends Preparation

Three weight ratio of epoxy / polyurethane blends were prepared by adding the polyurethane to epoxy resin and mix them using mechanical mixer for 5 minutes (Table 1).

Table (1) Epoxy / Polyurethane blends ratio

Blend no.	EP/PU wt %
1	90/10
2	80/20
3	70/30

4- Composites Preparation

Sheets of epoxy – polyurethane blends reinforced with two layers of glass fibers type (0-90) were prepared .

5- Charpy Impact test

The samples were cut into sheets with dimension according to international specification as shown in the figure (1) .

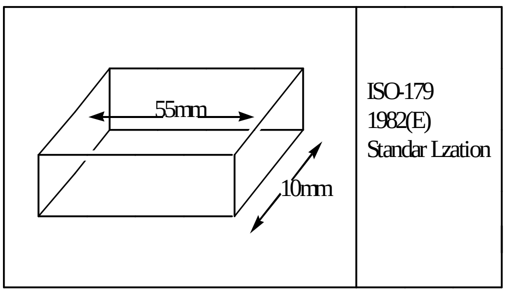


Figure (1) Show sample dimensions for Impact test

6- Optical microscopy

Morphology of samples was determined by using a polarizing microscope mode (OLYMPUS BH-2) with camera (OLYMPUS C-35 AD-4) . The investigation magnification was equal to 50X .

Results and Discussion

Impact strength (Gc) results for EP , PU and their blends are shown in Table (2) . Figure (2) shows that G_C decrease with increasing weight percentage of PU in the blends . High G_C value for EP shown in Table (2) could be attributed to high crossing links between the polymer chains which gives EP high strength during impact test . The epoxy specimen absorbs the collision energy of the pendulum during impact test and cracks propagate through the specimen . When enough energy is absorbed , the epoxy specimen will start to break and separated into pieces as shown in figure (3) .

Table (2) : Impact strength results of EP , PU , and their Blends

Sample type	Sample Width (m)	Sample thickness (m)	Fracture energy (Joule)	Toughness KJ/m2
EP 100%	0.01	0.00318	0.62	19.4968
EP90%/PU10%	0.01	0.0036	0.18	4.999
EP80%/PU20%	0.01	0.00363	0.166	4.573
EP70%/PU30%	0.01	0.00368	0.16	4.347
PU 100%	0.01	0.0037	0.1	2.673

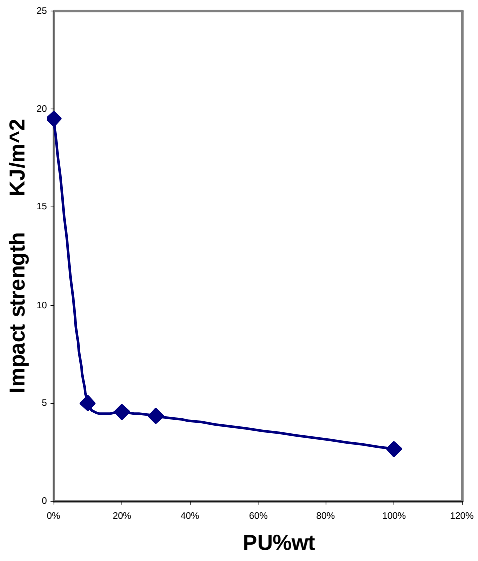


Figure (2) Impact strength for EP /PU and their blends as function of PU weight percentage

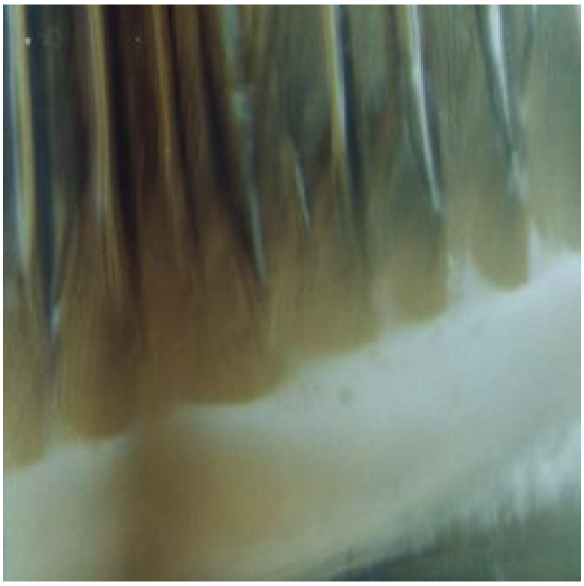


Figure (3) : The crack propagation in epoxy sample

The decreasing of Gc values of the blends when adding 10% , 20% and 30% may be due to the high elasticity of PU and the separation of phases . This is because of incompatible between two resins as shown in figure (4) and creating inter phases between polymer chains . This may lead to lower the density of crossing links between chains as shown in figure (5) . The presence of the inter phases will lead to crack propagation with less impact energy than before as shown before.

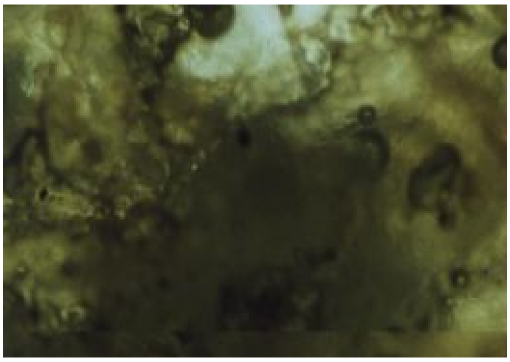


Figure (4) The immiscibility in (EP 90%/PU10%) sample

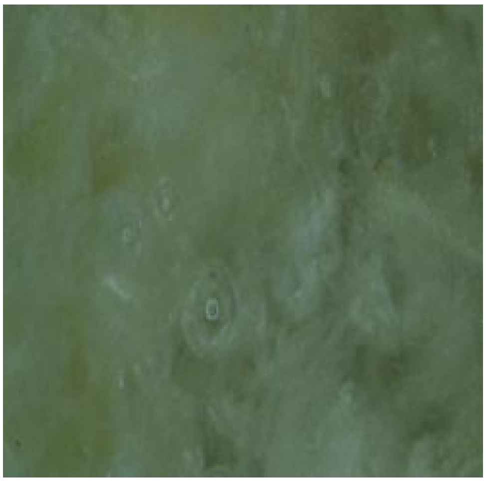


Figure (5) The interphases in (EP70%/PU30%) sample

The impact strength results for EP/PU blends reinforced by two layers of glass fibers are shown in figure (6) . The results for composites are higher than the impact strength of blends as shown in Table (3) . This could be explained by the presence of two layers of glass fibers which absorb the impact energy and than spread it into whole specimen . The energy required to break the sample has to have enough energy to cut the fiber , pull – out fiber from the matrix and to produce cracks as shown in figure (7) .

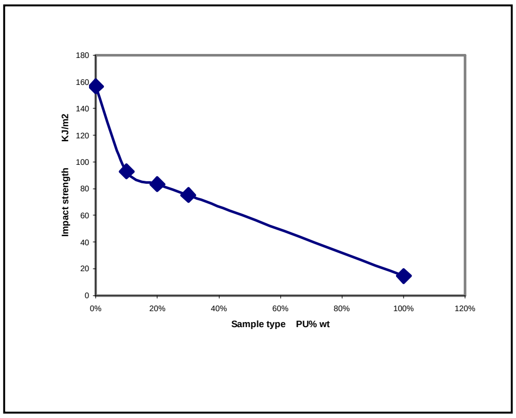


Figure (6) Impact strength for EP/PU composites as function f PU weight percentage

Table (3): Impact Strength results of EP/PU blends reinforced with 2 layers of Glass fibers

Sample type	Sample Width (m)	Sample thickness (m)	Fracture energy (Joule)	Toughness KJ/m2
EP100%+GF	0.01	0.0016	2.6	156.626
EP90%+PU 10%+GF	0.01	0.00181	1.68	92.817
EP80%+PU 20%+GF	0.01	0.00264	2.2	83.333
EP70%+PU 30%+GF	0.01	0.00266	2	75.187
PU100%+ GF	0.01	0.00298	0.435	14.597

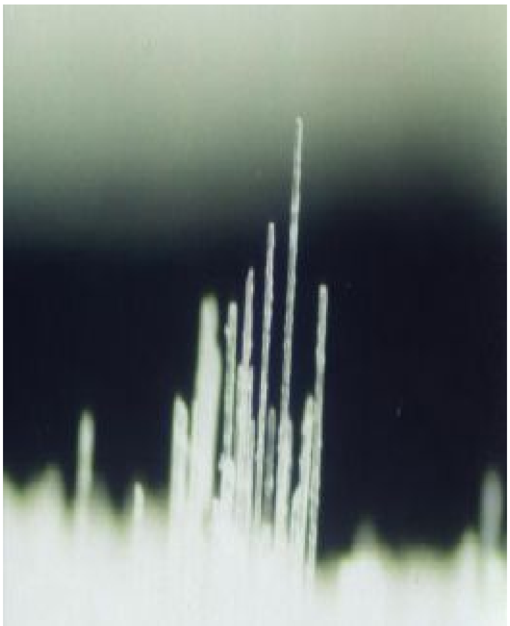
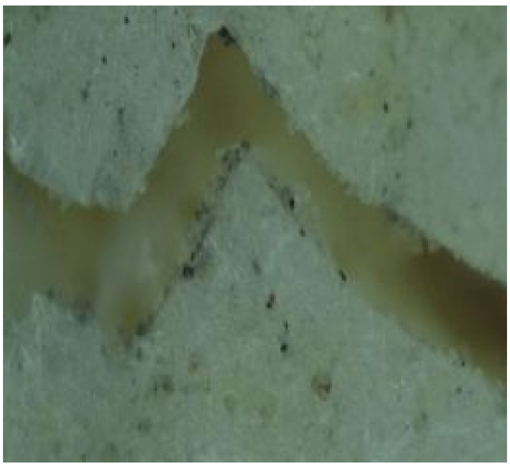
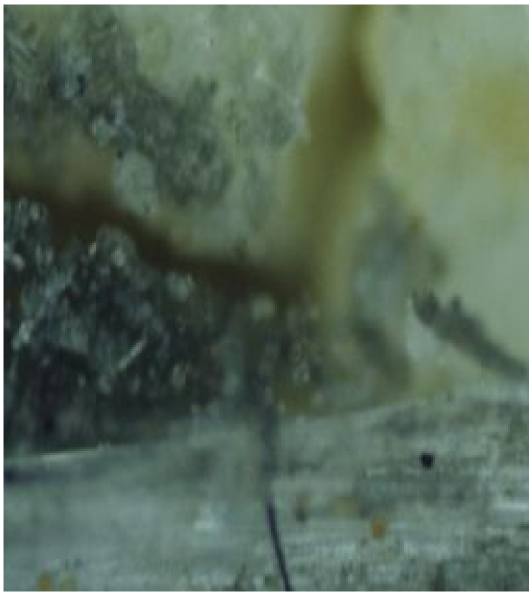


Figure (7) The pull-out fiber from epoxy matrix composite

The results show that polyurethane reinforced with two layers has lower impact strength than epoxy reinforced with two layers of glass fibers because the polyurethane have high elasticity result from motion of the polymer chains which lead to buckling the sample during applying stresses (impact) and does not break the specimens as shown in figure (8) .



(a)



(b)

Figure (8-a,b) The crack propagation in polyurethane matrix composite

Impact strength results for EP/PU composites as shown in Table (3) decreases with increasing polyurethane and this may be attributed to the immiscibility between two polymers which lead to less ability of adhesion between polymers and glass fibers . This immiscibility leads to creat vacancies and interphases between the fibers and the blends and speed the crack propagation as shown in figure (9) .

As a conclusion the inter phase properties play important role for the composites as the stresses will transfer from the matrix to the reinforcement materials (glass fibers) through these inter phases . The mechanism of the transfer of the stresses will depend primary on how much strong is the binding between the matrix and their reinforcement.

Figure (9) The interfaces between fibers and its matrix

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