EFFECT OF IRRADIATION ON COMPRESSIVE STRENGTH OF EPOXY REINFORCED WITH GLASS FIBERS

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Abstract

The compressive strength was investigated for epoxy resin type (DGEBA) before and after reinforcing with glass fibers (woven roven, chopped strand mat, and two types together as a sandwich composite), with different volume fractions was prepared. The samples have been irradiation with γ-ray with a Co^{60} source for (1055 hrs) with irradiation dose (0-156) KGray at room temperature ($20\pm2C^{o}$).The compressive strength calculated for all samples after irradiation. The results showed that the compressive strength of epoxy samples increased after reinforcing with glass fibers, and increased with increasing of volume fractions while the compressive strength was decreased for all samples after irradiated with γ-ray.

الخلاصة

تم في هذا البحث دراسة متانة الانضغاطية لنماذج الايبوكسي نوع (DGEBA) قبل وبعد التدعيم بالالياف الزجاجية (المتعامدة، العشوائية الاتجاه، والنوعين معا على شكل متراكب متوالف) بكسور حجمية مختلفة.
شععت النماذج باشعة كاما بمصدر CO^{60} لمدة (١٠٥٥ساعة) بطاقة اشعاع (0-156) K Gray بدرجة حرارة ($٢٠\pm٢C^{o}$).وتم حساب متانة الانضغاطية بعد تشعيعها باشعة كاما.
اظهرت النتائج ان متانة الانضغاطية تزداد لنماذج الايبوكسي بعد تدعيمها بالالياف الزجاجية وتزداد بزيادة الكسر الحجمي للالياف الزجاجية في التراكب.بينما اظهرت النتائج ان متانة الانضغاطية تقل للنماذج كافة بعد تشعيعها باشعة كاما.

Introduction

Polymers found their way in a large number of applications by virtue of their lower density. Their light weight makes them suitable for weight sensitive structure applications. High cost of polymers is sometimes a limiting factor in their use for commercial applications [1]. Composite materials are materials which are made by artificially combining two or more components, thus interfaces are present in a composite material and they tend to govern the properties of a composite material [2]. The structure and the properties of the fiber –matrix interface play a major role in the mechanical and physical properties of composite materials.

In the fiber –matrix interfacial shear strength is one of the most important parameters in determining the strength and toughness of a unidirectional composite since the load working on the composite is transmitted to the fiber through the interface [3]. Since the irradiation –induced cross linking phenomenon of polymer was discovered by charlesby and Dole [4, 5] in the early (1950), the effect of high energy irradiation on the structure and properties of polymers has arose considerable attention. As it can significantly improve physical properties (memory effect, creep, and thermal resistance), irradiation has been employed in commercial applications such as in the manufacture of cable insulation (shrink

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tubes) and polymer foams [6]. The modification of polymers by irradiation either cross link or to break molecules is a significant industrial process throughout the world. Extensive studies have been under taken to understand the mechanism of irradiation damage. Many widely used polymers suffer main chain scission and a loss in mechanical strength such polymers are known as the degrading polymers. On the other hand, many polymers are found to posses enhanced molecular ordering after being irradiation [7, 8]. Degradation and cross linking both could be the consequences of irradiation depending on the conditions of irradiation. And the chemical structure of the polymer, either cross linking or degradation occurs and the one which predominates determines the net effect [9].
The aim of this work is to study the effect of gamma radiation on mechanical properties of polymer composite reinforced with different types of glass fibers with different volume fractions.

Experimental

1. The epoxy resin used in this paper was (DGEBA) with it's hardener in ratio (3:1), and left at room temperature (20± 2C^{o}) transformed to a hard shape after (24 hours).
2. Hand lay- up molding used to prepare epoxy composite reinforced with :
   - A- Woven roven glass fibers with (0^{o}-90^{o}) direction from (Mowding LTD.UK).
   - B- Chopped strand mat glass fibers (random) from (Mowding LTD.UK).
   - C- The two types together as a sandwich composite.
3. The volume fraction used for each type was (45, 50, 55, and 60) %.
4. The samples were cut with standard dimension (ASTM-D695).
5. The compressive strength determined for all samples as follow:

$$Cs = \frac{Fc}{A} \quad \ldots\ldots\ldots\ldots (1)\ [10].$$

When:
Cs: compressive strength N/mm2
Fc: maximum applied compressive load.
A: cross- section area of compression. (A = b x d)
b: width of the samples
d: thickness of the samples.

6. The samples irradiated with γ – ray with Co^{60} source for (1055 hrs) with irradiation dose (0-156) K Gray.
7. The compressive strength determined for all samples after irradiation and compared the results before and after irradiation.

Result and Discussion

Organic polymers have been one of the popular materials for their excellent characteristics such as low density, easiness for coloring, low prices and so on. Since they are often used under terrestrial sunlight, many studies on photo degradation of polymer materials are required for various applications of them [11].
The results in table (1) showed that the reinforcing of epoxy resin with glass fibers increased the compressive strength for all samples in different types because of increasing the volume fraction of glass fibers leading to increased in mechanical

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properties according to the length, diameter and direction of the fibers [12].

Therefore the epoxy composite reinforced with woven roven (0^o-90^o) glass fibers has maximum compressive strength due to the length and direction of the fibers making the fibers absorbed the most applied loads leading to increase in mechanical properties [13].

Gamma rays are electromagnetic radiation; a common name for γ-rays as particles is photons with energy E ≥1 Mev when the γ-rays fall on the polymer composite affect on the:

a- the matrix (epoxy)

b- the interface (region between the matrix and glass fibers)

But the γ-ray did not affect on glass fibers because of the strong bond connected between glass atoms with energy greater than energy of γ-ray therefore the γ-ray can not break the bonds between glass atoms [14].

The γ-rays absorbed through the matrix (polymer) excited the functional groups of polymer chains breaking the bonds between them reducing the cross-link locations changing the chemical structure of the polymer leading to reducing in mechanical properties, this process is called "photo degradation" [7, 15] while the γ-rays penetrated the matrix they reach a weak region called (interface region), the bond in this region so weak and can break easily by γ-rays [8, 16].

Finally all the samples suffered from "photo coloring" because their colors changed from transparent to dark yellow as a result of photo degradation [15].

Conclusions:

1. The compressive strength of epoxy resin increased after reinforcing with glass fibers.
2. The length and direction of glass fibers play a major role in mechanical properties of the composite.
3. Increasing the volume fraction of glass fibers in composites increased the mechanical properties of the composite.
4. the compressive strength of epoxy samples and epoxy composites reinforced with different glass fibers decreased after irradiation with γ-ray due to photo degradation of polymer chains.
5. The colors of samples changed from transparent to dark yellow due to the change in the chemical structure of polymer chains.

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Table (1): values of compressive strength for the samples before and after irradiation

Type of samples	Vf	symbol	Cs N/mm^2 before irradiation	Cs N/mm^2 after irradiation
Epoxy without addition	0	A	53.846	48.076
Ep + G.f (0o90o)	45	B1	77.399	51.599
Ep + G.f (0o90o)	50	B2	143.613	83.092
Ep + G.f (0o90o)	55	B3	146.198	87.789
Ep + G.f (0o90o)	60	B4	182.186	170.830
Ep +G.f (chopped)	45	C1	55.809	43.406
Ep + G.f (chopped)	50	C2	72.098	54.112
Ep + G.f (chopped)	55	C3	78.463	62.049
Ep + G.f (chopped)	60	C4	159.663	126.050
Ep + G.f (sandwich)	45	D1	74.448	52.247
Ep + G.f (sandwich)	50	D2	77.808	59.767
Ep + G.f (sandwich)	55	D3	117.521	68.418
Ep + G.f (sandwich)	60	D4	154.818	105.574

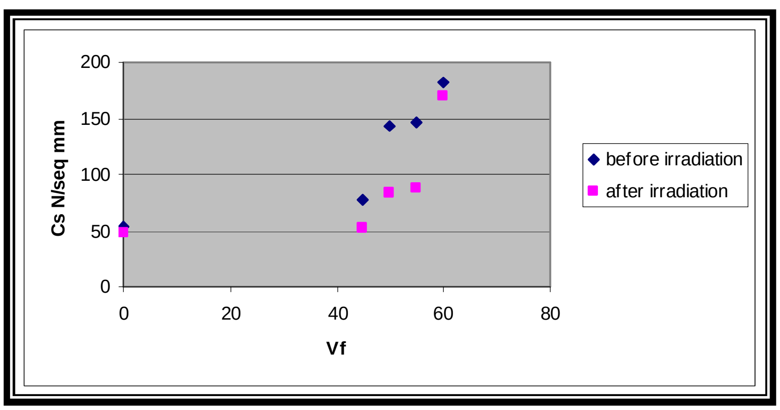

Figure (1): changing the compression strength with volume fraction of epoxy composite reinforced with woven roven glass fibers.

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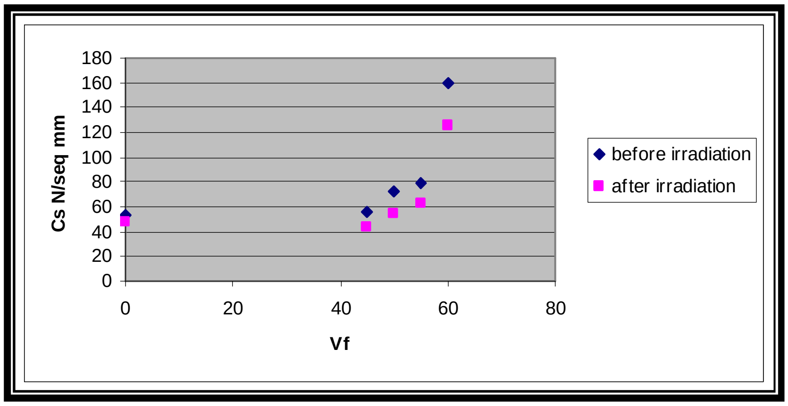

Figure (2): changing the compression strength with volume fraction of epoxy composite reinforced with chopped strand mat glass fibers.

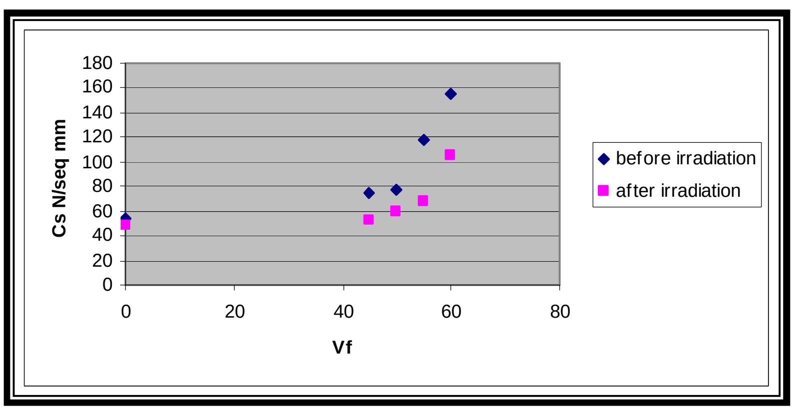

Figure (3): changing the compression strength with volume fraction of sandwich epoxy composite.