Some Physical Behavior of Epoxy /Lead Composites for Various Doses of Radiation

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Abstract:
The study were to examine the feasibility of the effect of gamma irradiation on some physical properties, (elongation at break and tensile strength) using an Instron Tensile teste. A series of composites has been prepared by adding lead powder and lead shots with different masses to the epoxy resin. The effect of gamma irradiation on the tensile behavior of the points to a deterioration of the mechanical properties of composite due to the degradation and cross-linking reactions resulting from irradiation was examined. The observed results remarks that the changes in the color of epoxy composites, color varied from yellow up to dark brown gradually as a result of different radiation doses effect of radiation exposure to the composites.

Keywords: gamma irradiation, epoxy, degradation and cross-linking reactions.

1. Introduction

Detailed studies on γ-irradiated materials are needed to increase the variety of polymer blends. Ionizing radiation induces chemical reactions in polymers, which result in changes in both molecular structure and macroscopic properties. The study of the mechanical, thermal and morphological gamma radiation can easily give a uniform dose throughout the sample volume. It is also very easy to control the temperature of the samples in a Cobalt-60 Facility [1].
Polymer are becoming more and more important in industry, such as electronic component manufacture, aircraft structure, an insulation of the magnet coil, and coating .Composites are extensively used in structural components of spacecraft, such as in the truss structure, antennas, and solar-cell panels [2].
Polymer conductive compositions are suitable for use in electrical devices such as circuit over current protection devices.The short and long term performance of advanced composites, coatings and adhesives depends sensitively on the resin curing process. Gamma decay takes place when there is residual energy in the nucleus following alpha or beta decay, or after neutron capture (a type of nuclear reaction) in a nuclear reactor [3].

2. Material used:

2.1: Epoxy Resin

Epoxies are thermosetting hydrocarbon resins, which formed by mixing two-part epoxies. They are generally consist of: \Part A", a difunctional or higher epoxide (oxirane) molecule; and \Part B", (also called the catalyst or hardener) which can be a multifunctional amine or an acid anhydride. The two parts are mixed together and cured to form a hard, inert resin [4]. The mixing ratio is approximate 3:1 by weight. Initial curing takes 24 hours at room temperature. In general epoxies are attacked by strong mineral and oxidizing acids, hypo chlorites, low molecular weight polar organic materials and chlorinated aromatics. Standard epoxies are widely used in the manufacture of adhesives and fiber reinforced composites based on glass, aramid and carbon fibers. Glass reinforced materials are used widely to make printed circuit boards and electrical insulators. Chemical structure of Epoxy resin is shown in Figure (1).

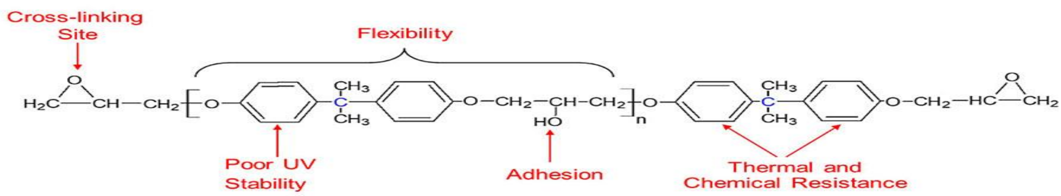

Figure 1: Chemical structure of Epoxy resin [5].

2.2: (EPLV) Low viscosity epoxy injection resin system properties:

The properties were obtained for Nitofil EPLV and at a temperature of 35°C and at seven days unless otherwise specified. [6].

2.3: Lead powder

Lead powder incorporated into a plasticizer is added to plastics to form sheets of lead loaded plastic. This material is used to make radiation protective clothing and aprons for the medical, scientific and nuclear industries. It also has sound insulating properties. Lead powder is also used as the basis for some corrosion resistant paints.

2.4: shot/Ball Lead

Lead is used for bullets and shot, chiefly because of its high density. Shot alloys have been given as 99.8 Pb, 0.2 As, or 94 Pb, 6 Sb [7].

2.5: lead powder and lead shots:

The lead powder and lead shots are used in this study. there were product In BDH (Poole, Chemical Reagent Co. England. UK.

Pb =207.19 Lead shot product about 100 mesh to dust No.29018

Pb =207.19 Lead powder product No. 29017 [8].

3. Sample Preparation:

3.1: Preparation of the epoxy

The mixing ratio is approximate 3:1 by weight. After the compounds were completely dissolved in the hardener, the hardener solution was mixed. The epoxy solution was then placed in a container of glass with dimensions of 20 mm in length, 6 mm in thickness, and 15 mm in width. Initial curing takes 24 hours at room temperature. The identical samples dimensions are (12.5, 1, 6 cm.) for all tests.

3.2: Preparation of the lead powder/ epoxy composites

By the same manner of the previous Preparation were prepared the lead/epoxy composites with five different weight(10,20,30,40,50)gm. of lead powder for several times irradiation. The irradiations were performed on five identical samples. The lead shots/epoxy composites were prepared with the same procedure, same weight, and the same times of irradiations.

4. Gamma irradiation tests:

Gamma cell 900 was used in this study to irradiation all the samples for (1, 2, 3, 4, 5.weeks).Co-60 Gamma cell was used as the irradiation source. Samples were irradiated with various doses. The dose rate of the cell is 0□1669 KGy/h. The samples were irradiated with the following doses: 28, 56, 84, 112, and 140 KGy.

5. Three-point flexure testing:

Three-point flexure testing was used to evaluate the elastic bending modulus of all the samples. These mechanical tests were performed at room temperature. The testing geometry of a three-point flexure experiment is illustrated in Figure (2) and the Instron Tensile tester (model 1121) .

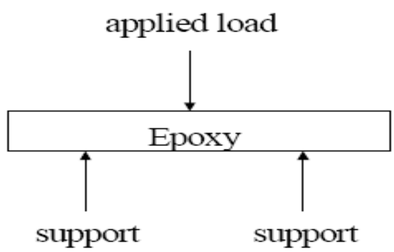

Fig 2: Three-point flexure geometry

A force-deflection curve was obtained for each specimen and used for analysis. A typical force-deflection curve is illustrated in Figure (3) [9].

The span length was 19.8mm.The cross-head speed was set at 2mm/min.

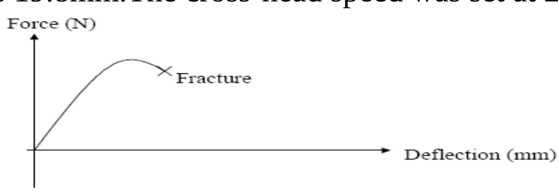

Fig. 3: Force-deflection curve from a three-point flexure testing.

6. Experimental details and data analysis:

Three-point flexure testing was used to evaluate the flexural strength and the deflection of the non-irradiated pure epoxy. Table (1) includes the values of flexural strength and the deflection for non-irradiated Pure Epoxy.

Table (2) includes the values of flexural strength and the deflection for Pure Epoxy irradiated for (1, 2,3,4,5 Weeks). The samples were irradiated with γ- rays at integral doses 28,56,84,112 and 140 kGy, respectively with a dose rate of 0.167 KGy/h in the presence of air, at room temperature, with a Co-60 source.

6.1: Results of flexural strength for Ep:

Many different rectangular specimens of polymeric composites have been used in this research, two types of lead powder, lead shots and epoxy.

Table (1) represents the results of flexural strength and the deflection for non-irradiated epoxy and Table (2) represents the results of flexural strength and the deflection for irradiated epoxy for five periods irradiation.

Table 1: Three-point flexure testing for non-irradiated Pure Epoxy.

D.(mm)	F.(N)
0	0
1.4	20
3	40
4.4	60
6	80
7.6	100
9.6	120
12.6	140
15.4	150
17.4	146
19.4	140
23.4	124

Table 2: Pure Epoxy Irradiated For (1, 2,3,4,5 Weeks) of Three-point flexure testing

flexural strength and the deflection properties increase in the last period and the maximum strength at break also increases as shown in Fig.4. The deflection at break decreases as the irradiation doses increase as shown in Fig.4. To explain these behaviors, these variation due to the increasing of cross-linking bonds between the back bonds chains [10,11] .

Fig.4 represents the variation of flexural strength and the deflection with and without irradiation epoxy. This variation of flexural strength confirms the results observed by [12].

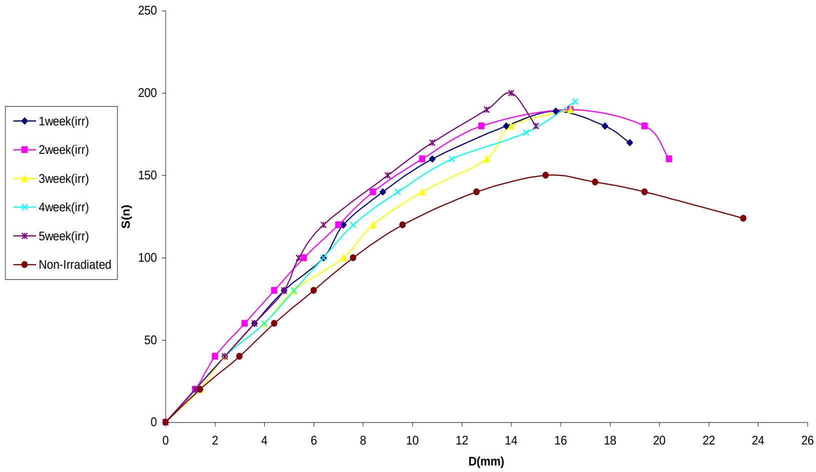

Fig 4: The relation between the flexural strength and the deflection with and without irradiation .

1W	2W	3W	4W	5W

6.2: Results of flexural strength for EP/Pb powder and shots composites.

The homogenous epoxy/lead powder composites with (10 gm.) lead powder which irradiated for one week is better flexural strength than the other samples of the epoxy/lead powder irradiated for longer times and the epoxy/lead shots with respect to the physical properties. The results of flexural strength and the deflection for epoxy/lead powder composites with (10 gm.) lead powder and epoxy/lead shots which irradiated one week, respectively.

D.(mm)	F.(N)
0	0
1.4	20
3	40
4.4	60
6	80
7.6	100
9.6	120
12.6	140
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19.4	140
23.4	124

D.(mm)	F.(N)	D.(mm)	F.(N)	D.(mm)	F.(N)	D.(mm)	F.(N)	D.(mm)	F.(N)
0	0	0	0	0	0	0	0	0	0
1.2	20	1.2	20	1.4	20	1.2	20	1.2	20
2.4	40	2	40	2.4	40	2.4	40	2.4	40
3.6	60	3.2	60	4	60	4	60	3.6	60
4.8	80	4.4	80	5.2	80	5.2	80	4.8	80
6.4	100	5.6	100	7.2	100	6.4	100	5.4	100
7.2	120	7	120	8.4	120	7.6	120	6.4	120
8.8	140	8.4	140	10.4	140	9.4	140	9	150
10.8	160	10.4	160	13	160	11.6	160	10.8	170

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flexural strength and the deflection properties increase in the last period and the maximum strength at break also increases as shown in Fig.4. The deflection at break decreases as the irradiation doses increase as shown in Fig.4. To explain these behaviors, these variation due to the increasing of cross-linking bonds between the back bonds chains [10,11] .

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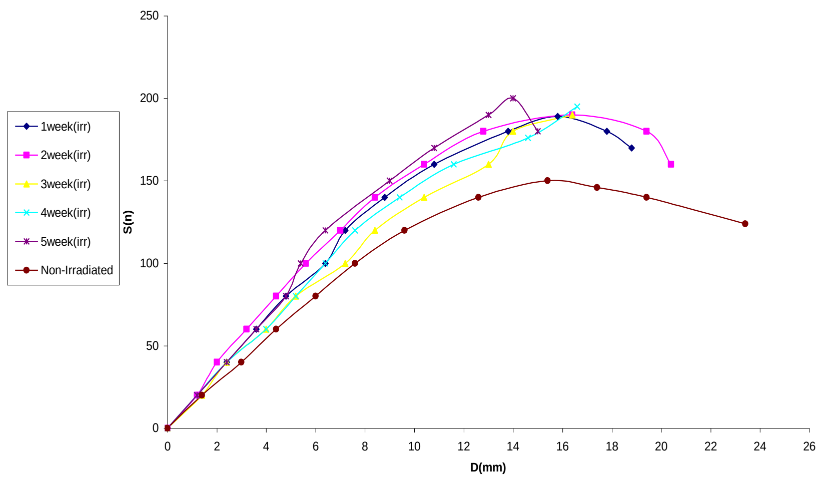

Fig 4: The relation between the flexural strength and the deflection with and without irradiation .

6.2: Results of flexural strength for EP/Pb powder and shots composites.

1W/10gm Pb		1W/20gm Pb		1W/30 gm Pb		1W/40gm Pb		1W/50gm Pb	
D.(mm)	F.(N)	D.(mm)	F.(N)	D.(mm)	F.(N)	D.(mm)	F.(N)	D.(mm)	F.(N)
0	0	0	0	0	0	0	0	0	0
1.2	20	1.6	20	1.2	20	1.2	20	1.2	20
2.4	40	3.2	40	2	40	2	40	1.8	40
3.6	60	4.8	60	3.2	60	3.2	60	3.14	60
4.8	80	5	80	4	80	4.4	80	4.24	80
6	100	7.8	100	5.6	100	6	100	5.51	100
7.6	120	10	120	6.8	120	7.6	120	6.45	120
9.2	140	10.4	130	8.4	140	10.4	140	7.6	136
12.4	156	12	140	10.8	156	11.2	144	10.8	160
14.4	156	14	155	12.8	158	12.6	144	15.2	160
16.4	148	15	150	14.4	140	13.4	140	19.27	140

The homogenous epoxy/lead powder composites with (10 gm.) lead powder which irradiated for one week is better flexural strength than the other samples of the epoxy/lead powder irradiated for longer times and the epoxy/lead shots with respect to the physical properties. The results of flexural strength and the deflection for epoxy/lead powder composites with (10 gm.) lead powder and epoxy/lead shots which irradiated one week, respectively.

Table 3: Epoxy/Lead shots blend irradiated for (1Weeks) with different masses of Pb (10,20,30,40,50 gm) of Three-point flexure testing

1W/10gm Pb		1W/20gm Pb		1W/30 gm Pb		1W/40gm Pb		1W/50gm Pb	
D.(mm)	F.(N)	D.(mm)	F.(N)	D.(mm)	F.(N)	D.(mm)	F.(N)	D.(mm)	F.(N)
0	0	0	0	0	0	0	0	0	0
1.2	20	1.6	20	1.2	20	1.2	20	1.2	20
2.4	40	3.2	40	2	40	2	40	1.8	40
3.6	60	4.8	60	3.2	60	3.2	60	3.14	60
4.8	80	5	80	4	80	4.4	80	4.24	80
6	100	7.8	100	5.6	100	6	100	5.51	100
7.6	120	10	120	6.8	120	7.6	120	6.45	120
9.2	140	10.4	130	8.4	140	10.4	140	7.6	136
12.4	156	12	140	10.8	156	11.2	144	10.8	160
14.4	156	14	155	12.8	158	12.6	144	15.2	160
16.4	148	15	150	14.4	140	13.4	140	19.27	140
18.4	140	16	140			14.6	120	21.67	120
20.4	124							24.4	100
								27.8	92

Table 4: Epoxy/Lead powder blend irradiated for (1Week) with different masses of **Pb (10,20,30,40,50 gm) of Three-point flexure testing.**

18.4 140 16 140 14.6 120 21.67 120
20.4 124 24.4 100
27.8 92
1W/10gm Pb 1W/20gm Pb 1W/30 gm Pb 1W/40gm Pb 1W/50gm Pb

D.(mm)	F.(N)	D.(mm)	F.(N)	D.(m m)	F.(N)	D.(mm)	F.(N)	D.(mm)	F.(N)
0	0	0	0	0	0	0	0	0	0
2	20	0.8	20	1.8	20	2	20	0.8	20
3.6	40	2	40	3.6	40	3.6	40	2	40
5.6	60	3.2	60	5.2	60	5.6	60	3.2	60
7.6	80	4	80	6.8	80	7.6	80	4	80
10	100	5.2	100	9.2	100	9.6	100	5.2	100
12.4	120	6.4	120	12	120	14.8	120	6.4	120
14.8	122	7.6	140	14	126	16.8	120	8.4	140
17.6	116	8.8	160	16	126	19.2	112	10.4	160
21.6	112	10	180	18	120	24	104	12.4	168
23.8	108	11.6	200	20	112			15.4	160

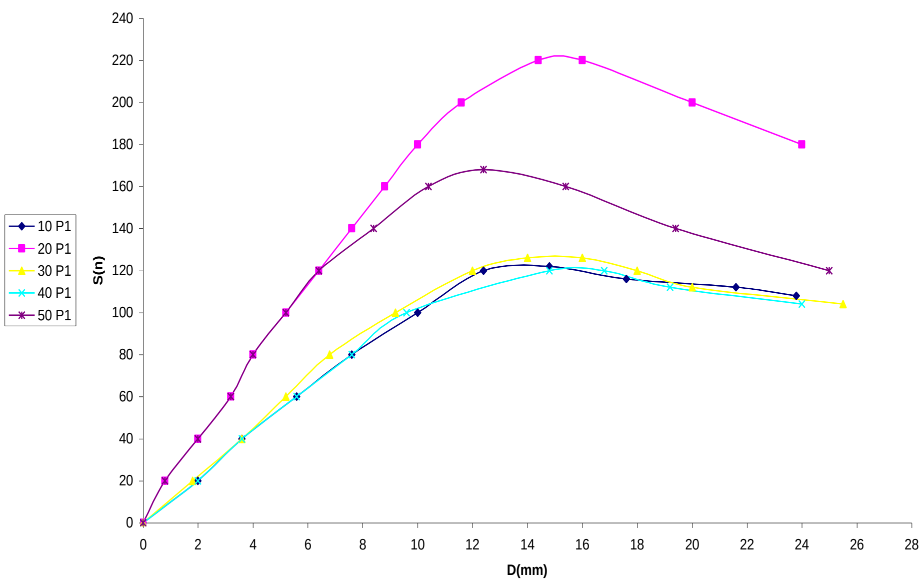

Fig.5: The relation between the flexural strength and the deflection of epoxy/lead powder composites irradiated for 28.05 kGy (1Week).

The epoxy/lead shots are lightly variation. The distribution of the lead shots of the composites and the heterogeneous affected in the physical properties of the shots composites .These variations due at least to the unhomogeneous of the composites as shown in figure 5, 6.

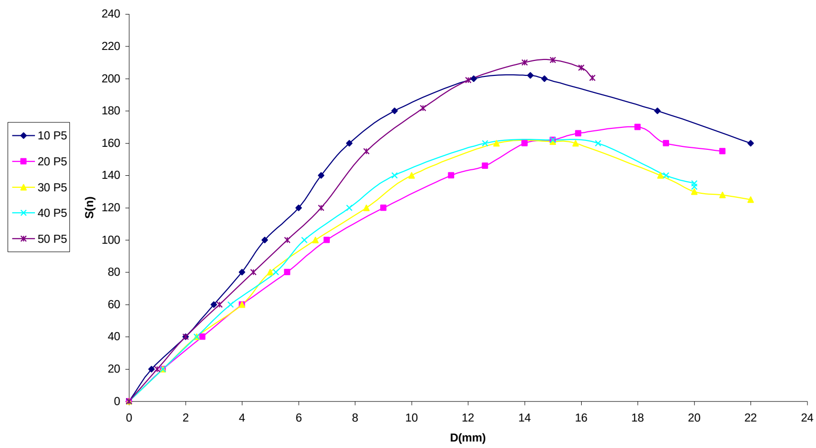

Fig.6: The relation between the flexural strength and the deflection of epoxy/lead shots composites irradiated for 28.05 kGy (1Week).

The composites of epoxy /lead powder with (40 gm.Pb. powder) and (50 gm. Pb shots) appears to be better flexural strength and deflection than the other samples for fifth period irradiation which represents the last period of irradiated samples as shown in table (5)and figures(7).

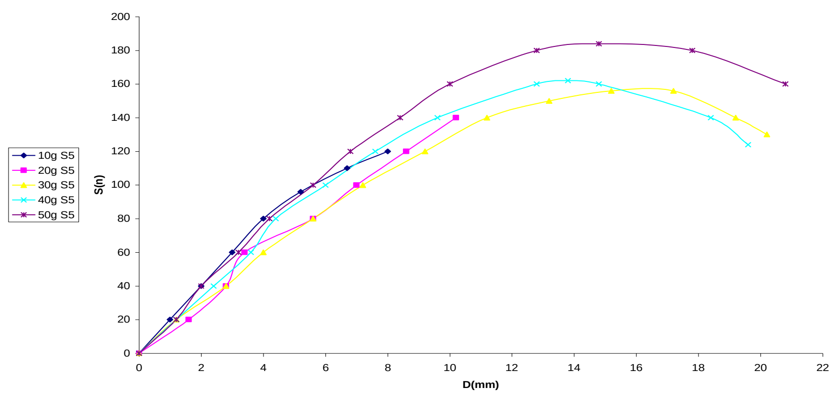

Fig.7: The relation between the flexural strength and the deflection of epoxy/lead shots composites irradiated for 140.274 kGy (5Weeks).

Table (6) represents the deflection as a function of irradiation dose for epoxy. These results show that the deflection decreases as the irradiation dose increases, because a slightly higher dose degradated the bonds to unacceptable values, hence, resulting in changing the physical properties of the composites. These results confirm the other previous research [12,13].

Table 6: Maximum Deflection as a function of dose for pure Epoxy.

Dose KGY	Max. Deflection(mm)
0	23.4
28.055	18.8
56.11	20.4
84.16	19.4
112.22	16.6
140.27	15

7. Conclusion:

The research shows that the effect of γ irradiation on the flexural strength and the deflection behavior of epoxy and its composites that the composites present a high degradation resistance at low doses. The deflection at break decreases as the irradiation doses increase. To explain these behaviors, these variation due to the increasing cross-linking bonds between the back bonds chains.

The flexural strength and the deflection properties of the composites with (50 gm.Pb powder) and (30 gm. Pb shots) shows better properties than the other composites samples, but the difference in the maximum strength is less than the other composites .This period appears that the behavior of lead shots blends is approximately better than the other composites with respect to the same type. The deflection as a function of irradiation dose for epoxy. These results show that the deflection decreases as the doses increases because a slightly higher dose may cause the properties to degrade to unacceptable values. This tends to embrittle the material. These results confirm the other previous research. The behavior of the flexural of epoxy variation is due to the cross linking reactions produced in the components of the composites as a result of irradiation. . Crosslinking is equivalent to degradation, that is, crosslinking is a process by which two radicals or molecules of the same type are combined[14]. A significant difference exists between the various weights of the lead powder for the previous samples, which due to the oxidative degradation of material at or near the surface of these samples.

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