Investigation of the Compression and Dielectric strength properties for Epoxy/Polyurethane Blends reinforced with glass fibers

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Abstract

Compression and dielectric strength properties of EP/PU blends composites reinforced with two layers of random direction glass fibers have been investigated. Hand lay up method was used to prepare sheets of EP/PU blends composites with different weight percentage of PU(12.5%,25% and37.5%). Results show that the compression value increase with the increasing of the weight percentage of PU in the blended matrix composite and became higher than for epoxy composite, while the results of the dielectric strength show that its values decrease with the increasing of the PU weight percentage in the blended matrix composite .

Keywords: composites, epoxy, polyurethane, glass fiber, mechanical properties, dielectric property.

Introduction

Thermoset polymers dominate as matrices in structural composite applications for reasons of good mechanical and thermal properties, good bonding to reinforcement, low cost, low viscosity and ease of processing [1]. The thermoset polyurethane is a very ductile, rubbery resin with a very high toughness and low Tg. he success of polyurethane is due to its ability to be produced in various forms from flexible to rigid structures [2]. Epoxy resins are widely used for high performance composites, especially in aerospace, military and sports industries [3]. Epoxy resins generally offer an increase on mechanical properties compared with polyesters and vinyl esters, but at a higher cost. Epoxies are stronger, stiffer, tougher, more durable, more solvent resistant, dielectric properties and have a higher maximum operating temperature than polyester thermosets, rubber polymers are added to epoxy resins to increase toughness [4-5]. Insulation system is the key element of each electric machine. Nowadays, there are two basic types of insulation systems which differ in the type of construction – Resin Rich and VPI(Vacuum Pressure Impregnation). Both of them use composite materials which can be modified to achieve required quality. The modification can be based on a change of electrical, mechanical or thermal properties of every component in the composite material [6]. Fiber-reinforced polymer composites are used widely in materials applications. Several kinds of fibers have been applied as reinforcing materials, including carbon fibers, glass fibers [7]. E-glass (electrical)-lower alkali content and stronger than A glass (alkali). Good tensile and compressive strength and stiffness, good electrical properties and relatively low cost [8-9]. Polymers are basically electrical insulators with low dielectric permittivity and often high dielectric strength. From the conducted analysis arises, that the recorded dielectric relaxations are related to both the polymer matrix and the presence of the reinforcing phase [10]. Polymeric laminated composites present high strength-to-weight and stiffness-to-weight ratios when compared with metallic materials. However, these laminated composites are susceptible to damage loads because they are obtained by layer stacking with not strong interfaces between the plies [11]. This characteristic explains the importance of improving the damage tolerance of these materials, for example, by modification of the resin system using adequate modifiers. In this way, the mechanical properties characterization is an important tool to evaluate these materials [12]. Flexural, compressive and tensile strengths of fiber reinforced composites are usually performed to characterize polymeric composites due to the ease of specimen preparation and testing [13].

Experimental Part

A hand layout method was used to prepare specimens as sheets reinforced with two layers of random glass fibers.

1-Epoxy resin preparation

A clean disposable container was used for maxing epoxy type (Cy-233 Araldite) and its hardener (HY 953)manufactured by company (Ciba-Geigy Swiss) with ratio 1:3 the content were mixed thoroughly by a fan type stirrer for (5) min. before using for sheet casting .

2-Polyurethan resin preparation

The same above procedure used to prepare polyurethane type (WEBAC1403, Tgb-Nr) and its hardener Isocyanides HYG, supplied by (WEBAC-HEMIE,GMBH-FAN), Germany, with weight ratio 1:2.

3- Polymer Blend Composites preparation

Five weight ratio of epoxy composite and polyurethane composite and their blends composites were prepared, the blends were preperd by adding the polyurethane to epoxy resin and mix them using mixer for (5) minutes as shown in Table (1). Each polymer and the blend was reinforced with two layers of chopped strand mat, randomly oriented, E-glass fiber, 450 g/m specific surface density supplied from molding LTD Comp. UK.

Table (1)
Epoxy/Polyurethane (EP/PU) blends weight ratio.

Sample no.	*(EP/PU)%*
1	100/0
2	87.5/12.5
3	75/25
4	62.5/37.5
5	0/100

4- Sample Cutting

A sufficient number of specimens were cut out of the sheets prepared, the dimension of the samples were cut accordance with the related international specification ASTM standard (D695). To minimize the deformation in the cut samples a diamond wavering blade was used.

5- Compression test

To determine the mechanical properties of the prepared specimens which with the dimension (30 mm length, 10 mm width and 3mm thickness) compression test was carry out at room temperature 25±2 of relative humidity 50±5, by hydraulic compressor type (Ley Bold Harris no. 36110) supplied by West Germany.

6- Dielectric Strength test

To determine the dielectric property for the prepared specimens which have a circle shape (30 mm diemeter and 3 mm thickness), dielectric strength test was carry out by using instrument (BAUR- PGO-S-3) oil tester Ölprüfgerät Spintermetre, supplied by West Germany .

Results and Discussion

1-Compression results

Under compression loading it is usually observed plastic defor-mation of the matrix and the buckling fibers tendency. In this case, the failure mechanism can involve microbuckling that frequently evolves to kink zones which leads to two-fracture plane formation. A laminate composite can also fail under axial compression by macroscopic shear of determined planes. In both case, it is important to consider that the failure in compression is dependent on the way that the loading is applied [14]. The Results of compression strength Fig.(1) shown that the increasing in weigth persantage of polyurethane in the blends composites lead to raising the compresstion strength values, to higher than of epoxy composite, can not stand with the applied load and soon break down occur to the samples. From the results in Table (2), Fig. (1) the compression strength of sample (1) is minimum value of compression strength due to epoxy resin which is brittle and reinforcing this resin with glass fibers increasing it‘s mechanical properties, this attributed to the fact that reinforcement imparted by the fiber allows stress to transfer from the matrix to the fibers , therefore the mechanical properties of composite mainly depends on both the matrix and the fiber characterization as well as on the interaction between matrix and fibers in interface region

[15] , while in sample (2) making a binary blend from (epoxy& polyurethane) increased the compression strength as a result of ductility behaviour of polyurethane making the blend could absorb more applied loads till fracture [16]. In samples (3, 4) increasing the percentage of polyurethane in binary blend lead to increasing the compression strength for the same reasons preceding, in sample (5) the compression strength recorded maximum value , this result attributed to disappearing of epoxy resin only polyurethane matrix reinforced with glass fibers which gave the composite best mechanical properties [17].

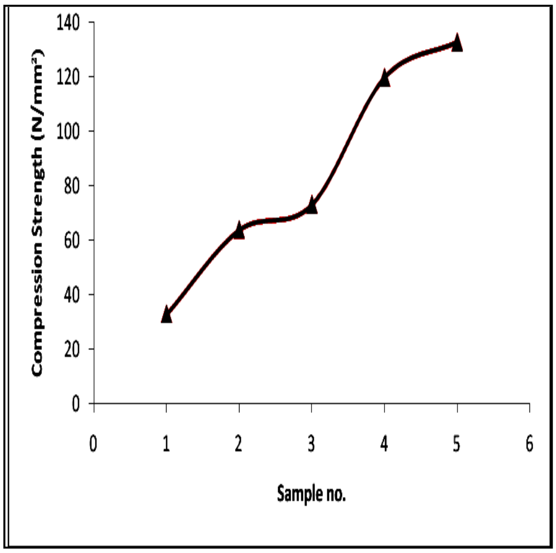

Fig.(1) Compression strength –Sample no. for blend composites.

Table (2)
Values of compression strength (Cs) for blend composites.

Sample no.	(EP/PU) %+GF	Area (mm^2)	F (N)	Cs (N/mm^2)
1	100/0	30	990	33
2	87.5/12.5	30	1920	64
3	75/25	30	2199	73.3
4	62.5/37.5	30	3600	120
5	0/100	30	3990	133

2-Dielectric Strength Results

From the results in Table (3), Fig. (2) at applied electric field [v= 0.5 volt] the dielectric strength of sample (1) is too large due to dielectric strength of epoxy resin [18] while in samples (2,3,4) the dielectric strength started to decrease with increasing the percentage of polyurethane. This result attributed to that the dielectric strength of polyurethane is less than dielectric strength of epoxy resin [19], and this result supported by dielectric strength of sample (5) when there is only polyurethane reinforced with glass fibers, which decreased rapidly due to disappearing epoxy of epoxy resin making sample (5) approached the break down early [20] for the same samples in tab (3) when applied electric field [v = 5 volt], the dielectric strength increased for all samples in comparison with dielectric strength when [v = 0.5 volt] .This result attributed to that when the applied electric field [v = 5 volt] is sufficiently high, free volume increases, and oriented with the direction of the electric field, that lead to start moving for the polymer backbone (main chain), which makes the movement of molecular chains easy and hence they take place in conduction process, and the electrons may become accelerated to velocities that can liberate additional electrons during collisions with neutral atoms or molecules in a process called (Avalanche break down) , this break down occurs quite typically in nanoseconds, resulting in formation of an electrically conductive path and a disruptive discharge through the material as a result the break down voltage increasing the dielectric strength [21].

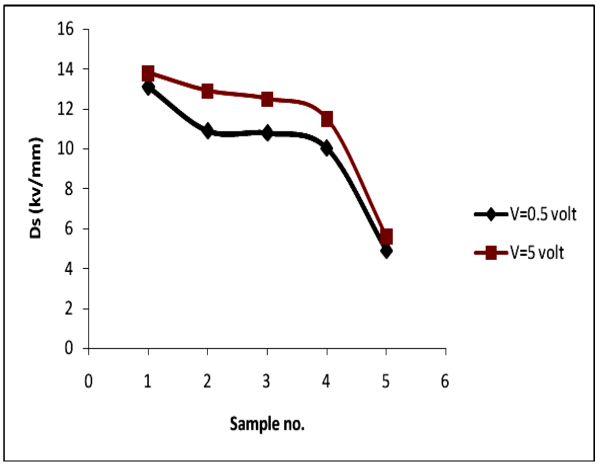

Fig.(2) Dielectric strength-Sample no. for blend composites.

Table (3)
Dielectric strength (Ds) for blend composites.

Sample no.	*(EP/PU) %+GF*	*d (mm) thickness*	*b (break down) at v=0.5volt*	*b (break down)at v=5volt*	*Ds=b/d (kv/mm) v=0.5 volt*	*Ds=b/d (kv/mm) v=5 volt*
1	100/0	3	39.3	41.4	13.1	13.8
2	87.5/12.5	3	32.7	38.7	10.9	12.9
3	75/25	3	32.4	37.5	10.8	12.5
4	62.5/37.5	3	30.09	34.5	10.03	11.5
5	0/100	3	14.7	16.8	4.9	5.6

Conclusion

In this work three weight percentage of EP/PU blend composites reinforced with random gless fibers.Compression values enhanced with the grow of PU ratio in the blend composite. Dielectric strength values decrease with the grow of PU ratio in the blend composite.

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الخلاصة

تم بحث خصائص الانضغاطية ومتانة العزل الكهربائي لخلائط ايبوكسي/ بولي يوريثان المتراكبة المسلحة بطبقتين من الياف الزجاج العشوائية الاتجاه. استعملت طريقة التشكيل اليدوي لتحضير صفائح من الخلائط المتراكبة من الايبوكسي والبولي يوريثان وبنسب وزنية مختلفة للبولي يوريثان (١٢,٥% و ٢٥% و ٣٧,٥%).

اظهرت النتائج ان قيمة الانضغاطية تزداد مع زيادة النسبة الوزنية للبولي يوريثان في الخليط المتراكب لتصبح اعلى منها لمتراكب الايبوكسي ، بينما اظهرت نتائج العزل الكهربائي ان قيمها تقل مع زيادة النسبة الوزنية في الخليط المتراكب.