Studying the Effect of Mixture of Pomegranate Peel and Licorice on the Mechanical Properties of Epoxy

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Abstract

Reinforcement process of epoxy has been widely used to improvement of mechanical properties. Therefore, this work is concerned with the reinforcement of epoxy by adding natural materials (Pomegranate peel and Licorice particles) at epoxy. Different percentages of particles (5, 10, 15 and 20%) were used. The mechanical testing were included tensile, bending, hardness and impact tests. Hardness of epoxy was increased at increasing of Pomegranate peel (PP) and Licorice (L) percentages. Impact resistance of epoxy with Pomegranate peel (PP) has reached the highest at (10%), while with Licorice (L) has reached the highest at (5%). The results of tensile strength represent that increases of tensile strength at all percentages of (L), while (PP) showed that decreases at (5%) and increases at others percentage. Bending strength of epoxy has increased as increasing of (PP) at all percentage that used, but it has increased at (5, 10 and 20%) of (L), while it has dropped at (15%).

Keywords: Mechanical Properties, Epoxy, Pomegranate peel, Licorice, Composite Materials, Natural materials.

1. Introduction

Nowadays, epoxy resins has been widely used in different material engineering technologies, such as adhesive, sealants, protective coating and matrices for composite materials in aerospace and others [1]. Because of high chemical and corrosion resistance, good mechanical and thermal properties, flexibility and good electrical properties of epoxy resins, it has been become a suitable material for engineering applications [1, 2]. Epoxy resins have also drawbacks, such as high water uptake, moisture absorption and brittle nature owing to their highly cross-linked structures, low wear resistance and high friction coefficient. A lot of applications have required materials with uncommon combinations of properties that cannot be found in metal alloys, ceramics, polymeric, and natural materials. A composite is a multiphase material that made by artificially and chemically dissimilar and separated by distinct interface. Composite materials have two termed; matrix and reinforcement phase. Matrix is continuous and surrounds the reinforcement material which divided into three types: particles, fibers and structures, which should be much stiffer and stronger than the matrix [3, 4 and 5]. Polymer is widely used as a matrix in composite materials. This is because of their strength and stiffness is less as compared to ceramic and metal and these drawbacks are overcome by reinforcing other materials with polymers. Also, polymer matrix composite processing has not need high pressure and high temperature. These reasons are making a polymer matrix composite is developing quickly and later becoming popular for engineering applications [6]. Later, natural materials are widely used as a reinforcement material. **Aseel Basim *et. al.*** studied the effect of natural materials (Rice Hush Ash, Carrot and Sawdust) on mechanical properties of epoxy. Hardness Shore D results showed that increase as increasing of natural materials in epoxy. Also, bending strength of epoxy was increasing as increasing of natural material percentage [7, 8]. **Shaimaa Hilal** studied reinforcement of mechanical properties of unsaturated polyester by natural materials (Grapes and Dates). Hardness Shore D results showed that increasing as increasing of natural materials percentage in unsaturated polyester. In other hand, impact strength results were decreasing as increasing of natural materials in unsaturated polyester. Tensile strength of unsaturated polyester was increasing with Dates but it was decreasing with Grapes [9]. **Fadhil A.Chyad** investigated the effect of waste ceramic materials (Iraqi Stones Dust Powders) on the mechanical properties of epoxy resin. Mechanical properties such as Young`s modulus, impact strength and shore hardness and fracture toughness has been increased as increase of percentage of particles, which percentage of (12%) has the highest value for impact strength and hardness and toughness [10].

In recent years, many researches have been presented for employing cellulose fillers such as coconut shell, wood, pineapple leaf, palm kernel shell, etc. as fillers in order to replace the made-up fillers through utilization of natural fillers or reinforcement in thermoplastic and thermoset polymer composites in an attempt to minimize the cost, increase productivity and improve the mechanical properties of the product [11].

Pomegranate peel and Licorice are natural materials that used in this work. After searching about these natural materials, it has not seen researches that investigated of influence of these materials on the mechanical properties of epoxy resin.

2. Experimental Work

2.1 Matrix material

Egyptian Epoxy resin of (Euxit 50KI) is used in this study. It is a liquid with low viscosity as compared with other materials and it's hardened by adding a hardener (Euxit 50KII) at ratio (1:3).

2.2 Reinforcement particles

Two types of particles were used in this work (Pomegranate peel and Licorice). The particles were received by vibratory sieve shaker to get a suitable size. The grain size used in this work was (53 µm). Different percentages of particles (5, 10, 15 and 20%) were added to epoxy resin matrix. The epoxy and natural materials were homogeneously mixed for (15 min) and then casting in the mold according to test specimens (tensile, bending, hardness and impact) as shown in figure (1).

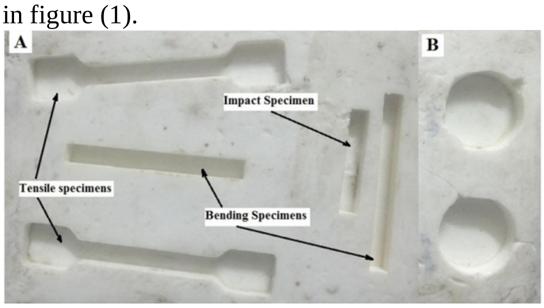

Figure 1: Molds for test specimens; a) Tensile, Bending and Impact; b) Hardness specimens

2.3 Mechanical Tests

2.3.1 Tensile Test

The test specimen was conducted as shown in figure (2). Tinius Olsen (H50KT) Testing Machine was used in this work. Nine conditions were used in this investigation, firstly, pure epoxy, secondly, epoxy with four percentages of (PP) and thirdly, epoxy with four percentages of (L); three samples were tested at each condition and average result is calculated.

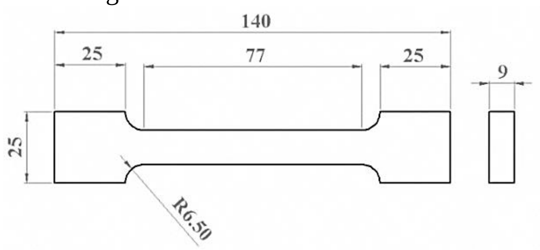

Figure 2: Tensile test specimen
(All dimension in mm)

2.3.2 Bending Test

Figure (3) shows the bending test specimen. Tinius Olsen (H50KT) Testing Machine was used in this research. Nine conditions were used in this research, firstly, pure epoxy, secondly, epoxy with four percentages of (PP) and thirdly, epoxy with four percentages of (L); three samples were tested at each condition and average result is calculated.

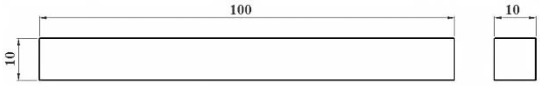

Figure 3: Bending test specimen
(All dimension in mm)

2.3.3 Hardness Test

Hardness test is considered by measuring the plastic deformation of the material suffered under the influence of external stress. Using Shore device (D) (Shore D No.DW53505) hardness test for measuring the hardness of polymeric materials was conducted in a manner stitches tool penetration and bitmap tool stitches inside surface article under a certain load, where the resistance moves straight to the counter measurement to determine the value of hardness to read directly from the screen of the device. The sample surface must be very flat and diameter is greater than (40 mm) and a thickness of more than (5 mm) as shown in figure (4). Nine conditions were used in this research, firstly, pure epoxy, secondly, epoxy with four percentages of (PP) and thirdly, epoxy with four percentages of (L); three samples were tested at each condition and average result is calculated.

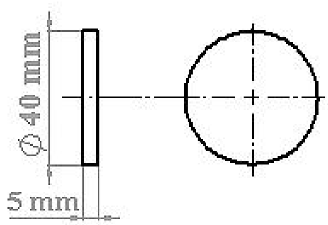

Figure 4: Hardness test specimen

2.3.4 Impact Test

Nine conditions were used in this research, firstly, pure epoxy, secondly, epoxy with four percentages of (PP) and thirdly, epoxy with four percentages of (L); three samples were tested at each condition and average result is calculated. Specimens were prepared for impact standard dimensions (as shown in figure (5)) and without notches according to (ISO - 179) using Charpy Impact device to test the impact. The device depends on the energy required to break account sample hammer device that strikes the samples at room temperature. The impact strength is calculated by applying the equation (1): [12]

$$G_c = U_c / A \qquad ...(1)$$

Where:
Gc is the Impact Strength (J/mm^2),
Uc is the Fracture Energy (joule), which is Determined from Charpy Impact Test Instrument
A is the Cross Section Area (mm^2).

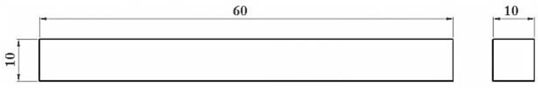

Figure 5: Impact test specimen
(All dimension in mm)

3. Results and Discussion

3.1 Hardness Results

Table (1) and Figure (6) show the hardness of natural materials (PP & L) with epoxy for all percentage (5, 10, 15 and 20%). The results showed that hardness of epoxy resin increases as increasing of (PP and L) which was the highest hardness at (5% of PP), (80.33 Shore D) and the lowest hardness at (15% of L), (68 Shore D). **Wafaa & Sewench** [13] have also the same behavior of increasing hardness as compared with pure epoxy, which studied plant fibers to reinforced epoxy.

The concept of hardness can be counted a measure of the plastic deformation of the material can suffer when under the influence external stress and so the addition of particles raise the hardness of material due to increased resistance to deform plastically.

Table (1) Hardness results

Materials	Conditions	Test 1	Test 2	Test 3	Average
Pure	0%	50	54	55	**53**
PP	5%	81	79	81	**80.33**
	10%	78	76	77	**77**
	15%	80	80	80	**80**
	20%	72	72	74	**72.67**
L	5%	81	78	78	**79**
	10%	74	72	70	**72**
	15%	70	68	66	**68**
	20%	76	77	76	**76.33**

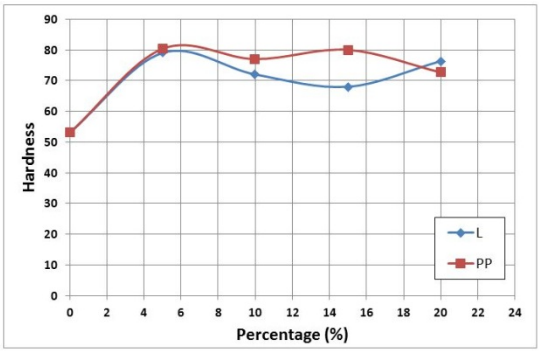

Figure 6: Hardness results

3.2 Impact Results

Table (2) and Figure (7) show impact results of epoxy and with (PP and L) for percentages (5%, 10%, 15% and 20%). The results showed different behavior between PP and L, impact energy of epoxy increases as increasing of L gradually until (10%) and then dropping to (20%), while, impact energy of epoxy increases as increases of PP which (5%) percentage was presented a higher impact strength and decreases at other percentages. As general, impact strength of epoxy increases as increases of PP and L percentages. This behavior matches with reference [13] which studied plant fibers to reinforce epoxy.

As known the impact test is a measure of a given material's toughness. The obtained results may be concerned with typical distribution of natural materials within the matrix and interfacial bonding between them leads to significant increase in the energy absorbing capacity of the composite.

Table (2) Impact results

Materials	Conditions	Test 1	Test 2	Test 3	Average energy (J)	Impact Strength (J/mm^2)
Pure	0%	0.28	0.3	0.32	0.3	**0.003**
PP	5%	0.5	0.47	0.38	0.45	**0.0045**
	10%	0.69	0.74	0.82	0.75	**0.0075**
	15%	0.51	0.57	0.57	0.55	**0.0055**
	20%	0.42	0.38	0.4	0.4	**0.004**
L	5%	0.71	0.66	0.73	0.7	**0.007**
	10%	0.64	0.61	0.58	0.61	**0.0061**
	15%	0.52	0.53	0.6	0.55	**0.0055**
	20%	0.62	0.61	0.57	0.6	**0.006**

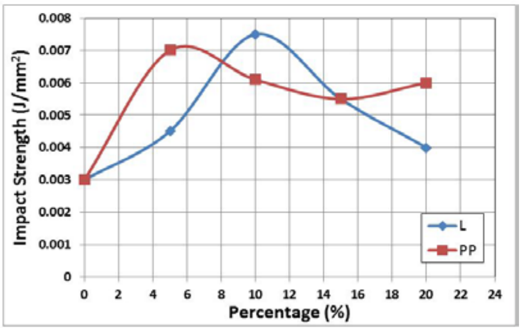

Figure 7: Impact strength results

3.3 Bending Results

Table (3) and Figure (8) illustrate the bending strength of epoxy resin at different percentages (5, 10, 15 and 20%) of (PP & L). The results showed that bending strength of epoxy resin increases as increasing of (PP) at all percentages, while bending strength of (L) with epoxy shows different behavior which was the highest bending strength at (5%) and the lowest bending strength at (15%) which are lower than bending strength of epoxy resin. These results demonstrate that using of (PP) as a natural materials in epoxy resin is bitter than of using (L), especially, percentage more than (5%).

These results have been given more flexibility as compared with epoxy resin. The results of natural materials composites have higher value of flexural strength than pure epoxy due to compatibility between matrix and natural materials. The presence of the compatible between natural materials and epoxy resin had a very significant effect on increasing the composites flexural strengths.

Table (3) Bending results

Materials	Conditions	Test 1	Test 2	Test 3	Ultimate strength average value (MPa)
Pure	0%	2.77	2.89	2.8	2.82
PP	5%	5.51	5.01	5.17	5.23
	10%	4.46	4.98	5.08	4.84
	15%	4.31	4.41	4.24	4.32
	20%	4.22	4.45	4.23	4.3
L	5%	5.11	5.41	5.17	5.23
	10%	3.48	3.51	3.51	3.5
	15%	1.53	1.49	1.51	1.51
	20%	3.65	3.58	3.57	3.6

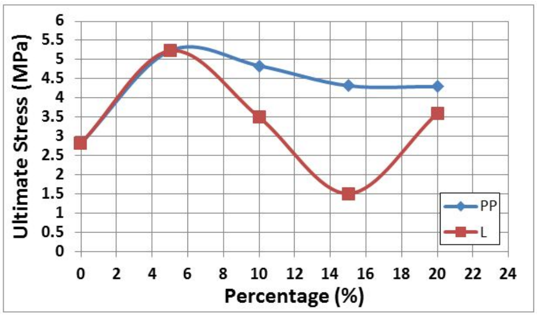

Figure 8: Bending results

3.4 Tensile Results

Table (4) and Figure (9) illustrate tensile strength of epoxy resin with percentages of (PP &L) at (5, 10, 15, and 20%). The results showed that tensile strength of epoxy resin increases as increasing of percentage of (L) which was the highest tensile strength at (5%) with (26 MPa). While, the tensile strength of epoxy resin with (PP) was increasing at (10, 15 and 20%). This behavior in results matches with **Harith I. Jaffer *et. al.*** which studied tensile properties of epoxy reinforced by Rice Husk fibers [14]. The cause behind such behavior is demonstrated as due to the nature of bonding force between the matrix and particles which is strong bonding that does not allow cracks or any defects in quick manner and in turn the composite material will have high tensile strength [15].

Table (4) Tensile results

Materials	Conditions	Test 1	Test 2	Test 3	Ultimate tensile strength average value (MPa)
Pure	0%	6.78	6.74	6.85	6.79
PP	5%	6.26	6.24	6.16	6.22
	10%	16.82	16.88	17.00	16.9
	15%	16.12	16.20	15.98	16.1
	20%	15.20	14.98	15.12	15.1
L	5%	26.21	25.98	25.81	26
	10%	15.38	15.51	16.21	15.7
	15%	21.05	21.41	22.04	21.5
	20%	12.3	12.5	12.1	12.3

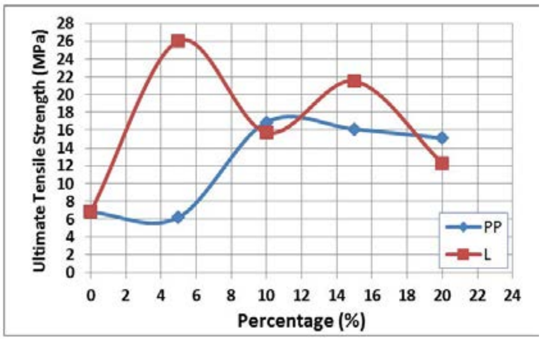

Figure 9: Tensile results

4. Conclusion:

From the results of the present study, the following conclusions can be drawn:

1. The hardness of epoxy resin is improved with natural materials (PP or L).

2. Impact strength of epoxy is enhanced by using of (PP & L).

3. Flexibility which measured by bending strength of epoxy is improved with (PP) and better than (L), especially, more than (10%).

4. Tensile strength of epoxy with (PP) is better than with (L) at (5%), on other hand, more than (10%) have similar behavior.

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دراسة تأثير اضافة خليط قشور الرمان وعرق السوس على الخواص الميكانيكية للايبوكسي

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الخلاصة:
استخدمت عملية تقوية الايبوكسي على نطاق واسع لتحسين الخواص الميكانيكية. لذلك تعلقت الدراسة بتقوية الايبوكسي بأضافة المواد المواد الطبيعية (دقائق قشور الرمان وعرق السوس) الى الايبوكسي. استخدمت نسب مختلفة من الدقائق (5, 10, 15 و 20%). الاختبارات الميكانيكية تظمنت اختبارات الشد , الانحناء , الصلادة و الصدمة. تزداد صلادة الايبوكسي بزيادة نسبة قشور الرمان وعرق السوس. وصلت مقاومة الصدمة للايبوكسي اقصى قيمة عند (10%) من قشور الرمان بينما وصلت القيمة القصوى لمقاومة الصدمة عند (5%) من عرق السوس. بينت نتنائج مقاومة الشد زيادة عند كل نسب عرق السوس بينما تتناقص عند (5%) وازدات عند باقي النسب من قشور الرمان. مقاومة الانحناء للايبوكسي تزداد بزيادة قشور الرمان عند كل النسب في حين تزداد مقاومة الانحناء عند (5 , 10 و 20%) من عرق السوس وتنخفض عند (15%).