



Investment Jute Fiber as Environmental Waste to Reinforcement Polyester Resin, Epoxy Resin and its Mixtures Used in home applications.

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ABSTRACT

In this paper, the hand lay - up method was employed to prepare three models of polymeric materials and their compositions before and after reinforcement with different Volume fractions (0.5, 1, 1.5, 2, 2.5, 3) %. The First group (G1) consists of unsaturated polyester resin reinforced with Jute Fiber which that cut to a length (5mm) with volume fraction that above - mentioned, and the second group (G2) consists of epoxy resin reinforced with the same fiber, as for the third group (G3) ; consists of polymeric blend (75% epoxy + 25% unsaturated polyester resin) reinforced with the same fiber. Experimental results include, test of impact strength and thermal conductivity. For a different volume fractions of a samples (all samples), the results showed that impact strength increases with increasing volume fraction while thermal conductivity decreases by increasing it.

Introduction:

A composite material is the union of two materials to produce another new material that has new properties that cannot be obtained from the reactants themselves [1,2]. Polymer-based composites are intended for performance, durability, and resistance to applied stress and temperature [1]. Resin polymer composites reinforced with natural or synthetic fibers were used in the 30s of this century [3]. Due to the increasing economic requirements, there was a need for natural materials to replace synthetic materials such as jute and others to support polymeric materials, so their residues were used to support these materials [4]. Environmental waste is generated as a result of continuous daily human activity. Some natural and synthetic fibers are considered one such waste which is a renewable energy source. [5]. This research included the use of polymers of composite materials based on polyester resins, epoxy resins and their mixtures reinforced with jute fibers as part of the environmental waste in nature, and the study of some physical and mechanical properties.

The purpose of this research is to invest environmental waste (remains of the jute plant) in strengthening polymeric materials used in various household applications.

- **Experimental Part**
- **Materials Used**
- **Matrix Material**

1. Unsaturated Polyester Resin UPE

The resin is manufactured by SIR Saudi Arabia. The resin becomes solid after the addition of (2 g) per (100 g) hardened methyl ketone peroxide (MEKP) at laboratory temperature 27 °C. Polyester is a type of thermosetting polymer and its properties are shown in Table 1.

2. Epoxy Resin EP

The resin used in this study is Sika - 52 manufactured by Sika company , Australia. It solidifies when a solid (Metaphenylen Diamine (DPDA)) is added in a ratio of (2:1) at laboratory temperature. It is one of the types of thermosetting polymers and its properties are shown in Table 1.

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• **Reinforcement Material (Jute fiber) JF**

It is an environmentally friendly material with many excellent characteristics that make it suitable for use in engineering fields. The properties of jute fiber are shown in Table 1.

Table 1: Physical and mechanical properties of EP, UPE, Jute fiber.

Type	Density ($\frac{gm}{cm^3}$)	Thermal Conductivity ($\frac{W}{m^{\circ}C}$)	Tensile Strength (MPa)	Percent Elongation (%)
UPE	1.2	0.17	41.4-89.7	<2.6
EP	1.1	0.19	25	<6
Jute fiber	1.3	0.11	393	<8

• **Physical Structure of Epoxy Resin (EP) and unsaturated polyester resin (UPE) :**

Scanning electron microscope SEM was used to observe the formation of epoxy resin and unsaturated polyester resin (UPE) and its mixtures. Figure (1) introduced the SEM photograph of epoxy resin and unsaturated polyester resin (UPE) and its mixtures. It showed many magnifications that showed the regularity of polymer chains of Epoxy resin and unsaturated polyester resin (UPE) and its mixtures , which is a good basis and an ideal base for bonding with reinforced jute fiber and the other materials and mixtures.

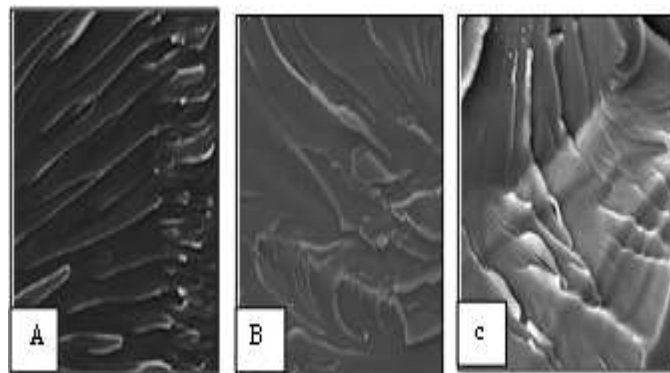


Figure (1) SEM photograph of : A. Epoxy Resin. B. Unsaturated polyester resin. C.Their Mixture .

• **Physical Structure of Jute Fiber :** SEM was used to monitor the formation of jute fibers. Figure (2) show the SEM photograph of a group of fibers, the surface of the fibers and the cross-section of the fibers, respectively. From Figure (2-○A), it is observed that the fibers which are generally viewed in an naked eye are eventually joined by single 5 to 6 fibers. The left side of Figure (2-B) shows the single fibers. It has also been noted that the surface of jute fibers is not smooth, referring to Figure (2-C). So in the matrix, it can form a strong bond with some resins.

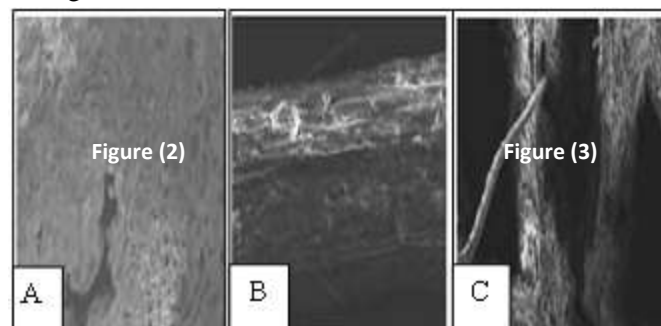


Figure (2) . A. SEM showing a bunch of jute fiber (x 50). **B.** SEM showing a single strand of jute fiber (x 250). **C.** SEM showing cross section of jute fiber (x 500).

• **Preparation of Samples :**

Samples of epoxy, polyester and its composite mixture reinforced with jute fibers (5 mm) were prepared. The manual casting method is used. The compressive strength test and the thermal conductivity of the samples were measure after preparation. A die made of aluminum with the required sample dimensions was used. We apply the law of volumetric fraction (equation (1)) of the added fibers (0, 0.5%, 1%, 1.5%, 2%, 2.5%, 3%) and weigh the fibers and determine their size, then determine the size and reinforcement of the epoxy and polyester fibers and their mixture according

to the mixing equations. Add the hardener with (2 gm) for every (100 gm) of epoxy and polyester and mix well for (2-3 minutes) and the mixture according to the proportions taken for it. Add the fibers by mixing to obtained a homogeneous mixture. The mixture is placed in the mold until it fills to the required mold to the required level. The sample is left for forty eight hours) in the mold until it becomes solid. The samples are placed in an electric oven for two hours at 50 °C) for the heat treatment process, then taken out of the oven and tested when they are ready.

$$Vf = \frac{1}{1 + \frac{1-\psi}{\psi} \times \frac{\rho_f}{\rho_m}} \dots\dots\dots (1)$$

Where ρ_f, ρ_m : density of the matrix material in addition to the density of the aiding material are measured in g/cm^3 .

• **Mechanical Tests:**

• **Impact strength :**

Charpy device (figure 3) was used to perform the impact test on the samples prepared for research. The hammer is raised to a high point (the highest point) and clamped, then the sample is placed in position at the bottom. Set the power meter to the zero point of power and release the pendulum using the lever attached to the meter. The potential energy will be converted into kinetic energy by swinging motion, and the pointer meter will read part of the energy value of the sample. This test was performed at room temperature; the impact strength test is calculated from the relationship (2) :

$$I.S = U / A \quad (J / m^2) \quad \dots\dots\dots (2)$$

Where I. S. is impact strength

U is The energy of the fracture in (J)

A is the Cross section area in (m^2).



Figure (3). Charpy device

Samples that are used in this test are shown in Figure (4).

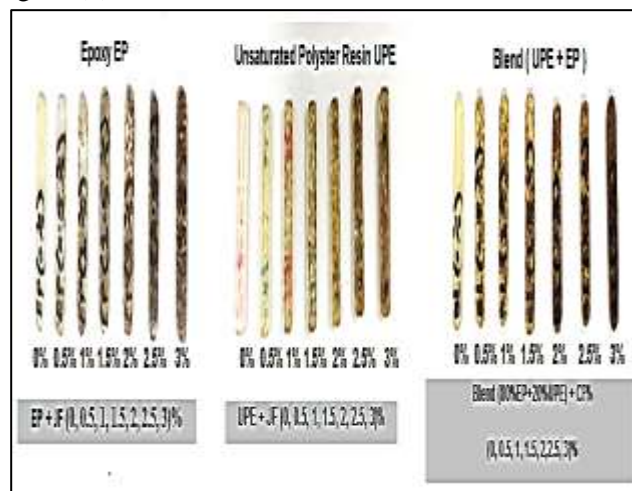


Figure (4). Samples used in impact strength test.

• **Physical Tests:**

• **Thermal Conductivity Tests:**

The device used in this test is a Lee disk (figure 5). The device consists of three copper discs and a heater. Heat is transferred from the heater to the following discs through the sampler. The temperatures of the discs (TA, TB, TC) are measured by thermometers. The surfaces of these discs must be in good contact with each other to obtain the best heat

transfer. The thermal conductivity values are calculated using the following equation (3) :

$$H = IV = \pi r^2 e(T_A + T_B) + 2 \pi r e \left[d_A T_A + d_s \cdot \frac{1}{2} (T_A + T_B) + d_B T_B + d_C T_C \right] \dots (3)$$

$$K \left(\frac{T_B - T_A}{T_s} \right) = e \left[T_A + \frac{2}{r} \left(d_A + \frac{1}{4} d_s \right) T_A + \frac{1}{2r} d_s d_B \right] \dots (4)$$

Where H: Time rate of energy applied to the coil.

(T_A, T_B, T_C : represent the temperature of the (A, B, C) discs, respectively, in C°.

(d_A, d_B, d_C): represent the thickness of the copper discs (A, B, C) = (mm).

ds: pattern thickness (mm).

I : the current in the circuit (Amp).

V: the voltage supplied to the circuit (Volt).

r : radius of any of the disks (mm).

K : the thermal conductivity coefficient (W/m.°C).



Figure (5). Lee disc device

Figure (5) shows the samples that are used in this test .

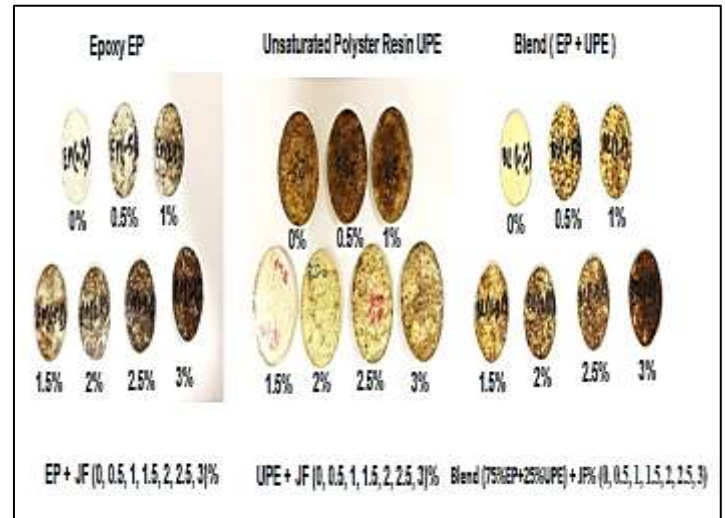


Figure (6). Samples used in thermal conductivity test.

• Results and discussion

• Discussing the results of the impact strength test :

The results in Figure (7) indicated a significant improvement in the impact strength of all the samples examined. The reason for this is due to the presence of those supporting fibers that bear the impact force applied to the material in a significant manner, as these fibers work to distribute the external influencing kinetic stress imposed on the largest volume of the test sample and reduce the possibility of stress concentration in its central region so that the fibers hinder the growth of the Fracture; This agrees with the researcher [6]. Note from the above figure that the samples of the third group (G3) achieved the best shock resistance values compared to the shock resistance values of both the first and second group samples (G1, G2). The reason for this is due to the nature of the interlocking patterns of the polymeric mixture, which is distinguished by its high flexibility and durability from the nature of the polymeric chains of both unsaturated polyester and epoxy, that is, by absorbing the shocks resulting from the external (kinetic) pressures applied to it. The reason for this is that the addition of unsaturated polyester to the epoxy gives this type of specimen some elasticity and thus will absorb extra energy to break compared to the unsaturated polyester and epoxy samples separately, which need less energy to fracture due to the presence of epoxy. fragility and this is consistent with the researcher [7].

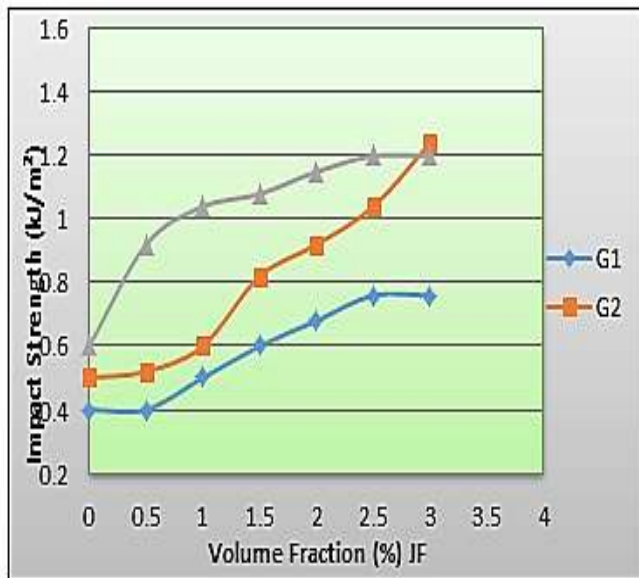


Figure (7). Volume fracture relationship with Impact strength

• Discussion of the results of the thermal conductivity test :

The results indicated in Figure (8) refers to decrease in thermal conductivity for all samples when reinforced with jute fibers. The reason for this is the presence of those intertwined and reinforced fibers, and this impedes the flow of heat in one direction, rather it is transmitted to other directions, and this agrees with the researcher [4]. By noting the figure above; The thermal conductivity values of the samples of the first and second group (G1, G2) were the lowest values compared to the samples of the third group (G3), and the lowest values were for the samples of the first group (G1). The reason for this is due to the nature of the polymer chain consisting of unsaturated polyester and epoxy, which is constrained if compared to the polymer chain of polymeric mixtures, which is more free to move [8, 9].

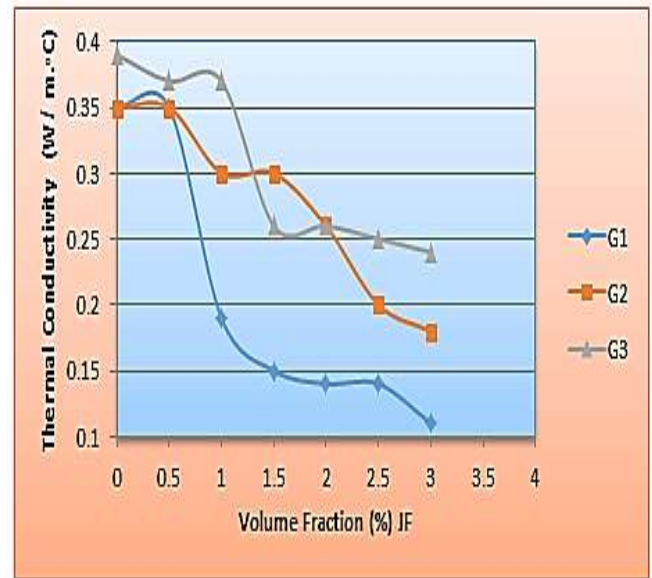


Figure (8). Volume fraction relationship with Thermal conductivity

• Conclusions

- 1- The Addition jute fibers improved the impact strength, and it increased with the increase in the volume fraction.
- 2- Thermal conductivity results decreased by increased volume fraction of fibers, this refers to improvement the properties of thermal insulation for the material.

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إستثمار مخلفات ألياف الجوت لتدعيم راتنجات البولي أستر غير المشبع والإيبوكسي وخليطهما المستخدمة في التطبيقات المنزلية

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الخلاصة :

في هذه الورقة البحثية، تم استخدام طريقة القوالب اليدوية المشهورة لتحضير ثلاثة نماذج مختبرية من المواد البوليمرية (الراتنجات) ومتراباتها قبل وبعد التدعيم بالكسور الحجمية المختلفة التالية (0.5، 1، 1.5، 2، 2.5، 3) % . إذ تضمنت المجموعة الأولى (G1) كلاً من راتنج البولي أستر غير المشبع غير المدعم والمدعم بألياف الجوت المقطعة بطول (5 ملي متر) مع الكسور الحجمية المذكور أعلاه ، وتتكون المجموعة الثانية (G2) من راتنج الإيبوكسي غير المدعم والمدعم بنفس الكسور الحجمية المذكورة اعلاه ، اما بالنسبة للمجموعة الثالثة (G3) ؛ فتتكون من مزيج بوليمر (75 % إيبوكسي + 25 % راتنجات بولي أستر غير مشبعة) غير المدعم والمدعم بنفس الكسور الحجمية المذكورة. تم اجراء الفحوصات المختبرية (اختبارات مقاومة الصدمة والتوصيلية الحرارية). أوضحت النتائج بأن مقاومة الصدمة تزداد بزيادة الكسر الحجمي بينما تقل التوصيلية الحرارية بزيادة الكسور الحجمية كافة.

الكلمات المفتاحية : الياف الجوت ، راتنج البولي أستر غير المشبع ، راتنج الايبوكسي ، مقاومة الصدمة ، التوصيلية الحرارية.