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Study of effect reinforcement by coconut fiber on some mechanical and physical properties of thermoset polymer

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Abstract

In this paper, a polymeric composite consisting of unsaturated polyester resin as a base material reinforced with coconut fiber was produced by volumetric fractions percentage (0%, 0.5%, 1%, 1.5%, 2%, 2.5%, 3%) of coconut fiber and at room temperature. The properties of compressive strength, hardness and thermal conductivity of the composite material were studied. The results showed an improvement in the mechanical properties (compressive strength and hardness) while the thermal conductivity values decreased with the increase of the volumetric fraction of the fibers. The heat insulation of the composite material is increased with the increase of the volumetric fracture of the fiber..

Keywords: Composite Material , Coconut Fiber , Unsaturated Polyester , Compressive Strength , Hardness , Thermal Conductivity.

1. Introduction

For need to manufacture materials for various industrial uses led to the emergence of alternatives with a good characteristics in terms of light weight , cost and durability , which can be used in various areas such as radars , cars , ships , aircraft and others , so produced composite materials that its material resulting from the merger of two materials has different properties to create new properties that cannot be obtained from the original materials [1,2]. Composite materials which have polymer - based are materials used in technological and engineering applications. The main requirements for their use are high performance , good durability , resistance to internal and external stresses and resistance to ambient conditions of pressure and temperature [1]. The composite materials of fiber - reinforced resin polymers were used in the mid - thirties of this century and at the beginning of the Second World War. Glass - reinforced polyester was used in the manufacture of radar domes and planes such as epoxy - Kevlar and epoxy - carbon In the marine industry , building industry and buildings , as well as in the medical and chemical industries [3]. The choice of ceramic , plastic , mineral or carbon additive is according to the type of use if it is industrial or structural. It is used in electrical and thermal fields and it is in different forms either in the form of continuous or non - continuous fiber or wool or Flakes or Particles or Fillers. The composite materials are used in various applications that depend not only on external properties and mechanical and physical properties but on their ability to change their properties according to the materials used [1]. The high cost of traditional reinforcement and construction materials, such as synthetic fiber , is the most important factor hindering researchers' work. Due to increased economic and environmental requirements , alternative natural materials such as cannabis , kaizaran , coconuts , pineapples , flax and others were needed to strengthen polymeric materials , so efforts have been directed towards the use of waste materials such as the use of their fibers and outer shell , The second stage is the exploitation of these wastes to support these materials. Therefore, the subject of recycling and reuse are the most important pillars of the industrial world today [4]. Environmental waste is a byproduct of human activity. Some natural fibers are one such waste, which is defined as a type of renewable energy source and a new



generation of support of polymers. The development of composite materials with natural fibers or environmentally friendly compounds rather than traditional industrial materials has been an important issue recently due to increased environmental awareness [5]. All of the above has led us to this research, which included the use of composite materials polymers with a basis of unsaturated polyester, which is supported by the fibers of the coconut fiber, which is part of environmental waste in nature and study some of the mechanical and physical properties of them. The main objective of this research is to invest the environmental waste (Coconut Fiber) to reinforcement polymeric material (Unsaturated Polyester Resin) (UPE). The research also aims to manufacture and study a thermoplastic polymeric compound consisting of unsaturated polyester as a base material supported by nut fiber India, also aims to study the effect of changing the volumetric fracture of these fibers on some mechanical and physical properties, which included the examination of the Compressive Strength, hardness and thermal conductivity of polymeric composite material that was prepared.

2. Experimental work

2.1. Matrix Material

Unsaturated Polyester Resin was used as a base material in the preparation of the polymeric composite material which manufactured by SIR Saudi Arabia company. It is in the form of a transparent pink liquid at room temperature. It is a type of thermosetting polymer, This resin turns from liquid state to solid state by the addition hardener (Methyl Ethyl Ketone Peroxide) which manufactured by the same company SIR, which is in the form of a transparent liquid added to the unsaturated polystyrene resin at (2 g) per (100 g) of resin at room temperature. Its density (1.2 g/cm^3).

2.2. Reinforcement Material

Coconut fiber used in this research as a reinforced material with a density of (1.2 g/cm^3) is a high quality fiber and widely used applications in the form of cut-off fibers, Its color is brown.

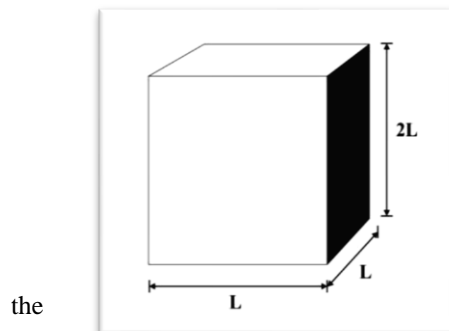
2.3. Preparation of Samples

In this study, samples were prepared from the composite substrate of unsaturated polyester, reinforced by of coconut fiber at a length of (5 mm). The hand lay up method was adopted by casting and the compression, hardness and thermal conductivity test was carried out for the purpose of evaluating the final models. A mold made of aluminum has been used with the required sample dimensions. All mixtures prepared at room temperature are mixed and the mixing phase continues for (8-10 minutes) so that the mixture is homogenized to distribute the reinforcement material homogeneously within the base material in order to avoid bubbles or aggregations during the mixing process then we pour the liquid mixture into the mold regularly until the mold is filled and according to the required level. The sample is left for (48 hours) in the mold to become completely solid at room temperature. The samples are then placed in an electric oven for two hours at ($50 \text{ }^\circ\text{C}$) for Heat treatment process according to the company's instructions. The process of preparation of the samples is done in several steps after the coconut fiber is sliced to reach short lengths at a rate of (5 mm) length and as follows :

- 1- By Apply volume fracture law V_f of fiber added (0, 0.5%, 1%, 1.5%, 2%, 2.5%, 3%), get weigh the fiber and find its size and then after that find the volume of unsaturated polyester and its hardener according to mixing rates.
- 2- Add the hardener with (2g) per (100g) of unsaturated polyester and mix well using the electric mixer for (2-3 minutes). Add the fiber with the mixing process until a homogeneous mixture is obtained and then pour the mixture into the mold for casting.
- 3- Leave the sample for 48 hours to complete Curing.
- 4- For post cure all samples were put in an oven for 2 hour at $50 \text{ }^\circ\text{C}$.
- 5- The samples are then removed from the convection oven and tested.

2.4. Mechanical Tests

Compressive Strength Test : Compression strength test on the samples was performed at room temperature by using (LARYEE Your Tasting Solution). In this test, compressive strength for all prepared samples are examined. When the sample is subjected to a compressive load until the failure, the compression test samples were tested and measured according to American standards (ASTM D695) [6]. Figure (1) represents a schematic diagram of the sample dimensions used in this test. This test is performed by applying a load at (5mm / min) at laboratory temperature, using the instrument diagram, the results are obtained directly. Figure (2) shows the samples of the compression test.



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Figure

Figure

compressive strength test.



(1). Dimensions of compression

(2). Samples used

strength test samples.

Hardness Test : The hardness of the samples was measured in (Shore D) method at laboratory temperature. This method is suitable for thermally thermoplastic materials. The sample used in this test should have a smooth surface and a thickness of not less than (3 mm) and diameter greater than (30 mm) and not have been subjected to mechanical vibrations previously. Therefore, the samples used in this test are thickness (5 mm) and diameter (40 mm). These dimensions are taken according to ASTM D2240 [7]. As shown in figure (3). Figure (4) shows samples used in this test.

The device used is a similar figure to the compass containing a needle in the middle. The method of the test involves placing the device vertically on the sample to measure the hardness so that must touch the surface of the sample to measure its strength to stitch the needle in the surface of the material is waiting for (5s) for all samples, The hardness values were taken in three different locations for each sample and the values take according to the reading rate.

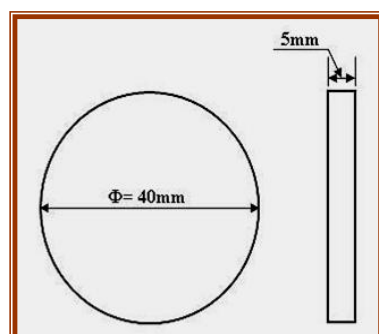


Figure (3). Dimensions of the hardness test samples. **Figure (4).** Samples used in hardness test.

2.5. Physical Tests

Thermal Conductivity test : For the purpose of conducting the thermal conductivity test one can use a Lee's Disk instrument, circular samples with diameter (40 mm) and thickness (5 mm) were cut according to international standards. Lee's Disk instrument factory by Griffin and George Figure (5). For the purpose of this test, the test sample (S) is placed between the two disks (A, B), and the heater

(H) placed between the disc (C,B). Heat transferred to the next disc until reaching the final disc. When thermal stability is achieved, the temperature of the three disks (T_A , T_B , T_C) is determined by using the placed syringes. In applying these two relationships, thermal conductivity can be calculated [8] :

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

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

Where e : represents the thermal energy passing through the unit of space in the time unit $\left(\frac{W}{m^2 \cdot C} \right)$. H : The time-rate of energy delivered in the device. T_A , T_B , T_C : represents the temperature of the disks respectively ($^{\circ}C$). d_A, d_B, d_C : Representing the thickness of copper disks (A,B,C) (mm). d_s : Sampling thickness (mm). I : Current in the circuit (Amp). V : Processed voltages for circuit (Volt). R : The radius of the copper disk (mm).

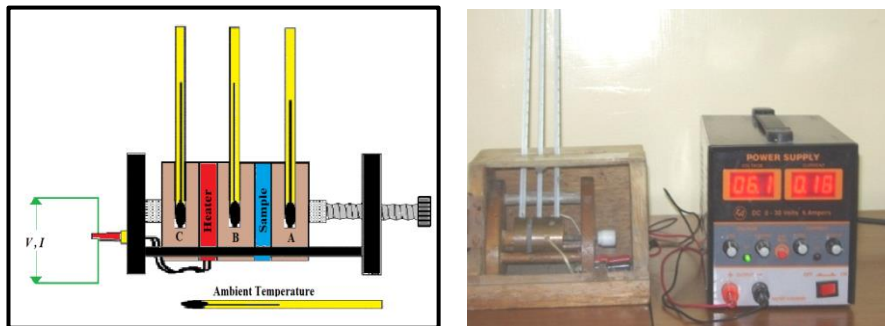


Figure (5). Thermal conductivity test device.

It is important to ensure that the surfaces of the disks are clean and the disks are well aligned to obtain the best heat transfer across them.

Figure (6) represents a diagram of the dimensions of the thermal conductivity test samples. While figure (7) shows samples of thermal conductivity test.

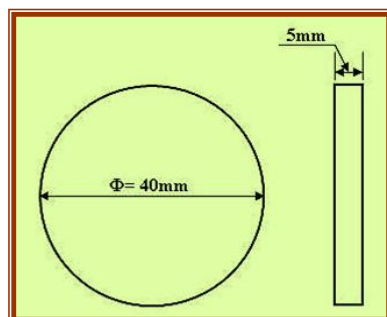


Figure (6). Dimensions of the thermal conductivity test samples.



Figure (7). Samples used in thermal conductivity test.

3. Results and discussion

3.1. Results and Discussion of Compression Strength Test

From the diagram of the device, the results of compressive strength were obtained directly. Figure (8) shows the relationship between the volume fraction of the coconut fiber and the compressive strength of the prepared samples. It is noted from this figure that the compressive strength is increased by increasing the volume fracture of fibers in the polymeric composite material. This is due to the role of these fibers, And these fibers greatly affect the transfer of stress as well as the shear strength of the composite materials. The presence of these fibers will also impede the movement of the

polymer chains within the composite and thus increase their strength. Resin penetration in coconut fiber will reduce the possibility of separation or withdrawal of fiber from the base material during pregnancy, this result is agree with [9].

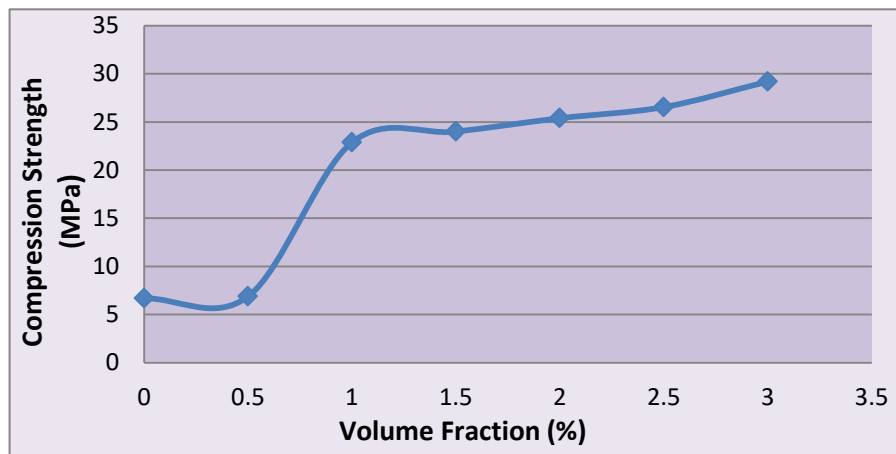


Figure (8). The relationship between volume fracture of coconut fiber and compressive strength of prepared samples.

3.2. Results and Discussion of Hardness Test

Hardness tests depend on the material's resistance to penetrations at its outer surface. There are different methods that represent the hardness guide, In this study, the Shore D hardness test was performed. Figure (9) represents the relationship between the volume fraction of the coconut fiber and the hardness values of the prepared samples. It is noted that the hardness values of the samples are increased with the increase of the volume fraction of the coconut fiber in the polymeric composite material because these fibers have high hardness, in other word the presence of fiber increases the resistance of the material to plastic deformation. By increasing the strength and bonding of the atoms or molecules, the material stiffens and thus increases its resistance to scratching, this is due to the distribution of the load on the fibers, which reduces the penetration rate of the surface of the composite material and raises the values of its hardness, this result agree with [10,11].

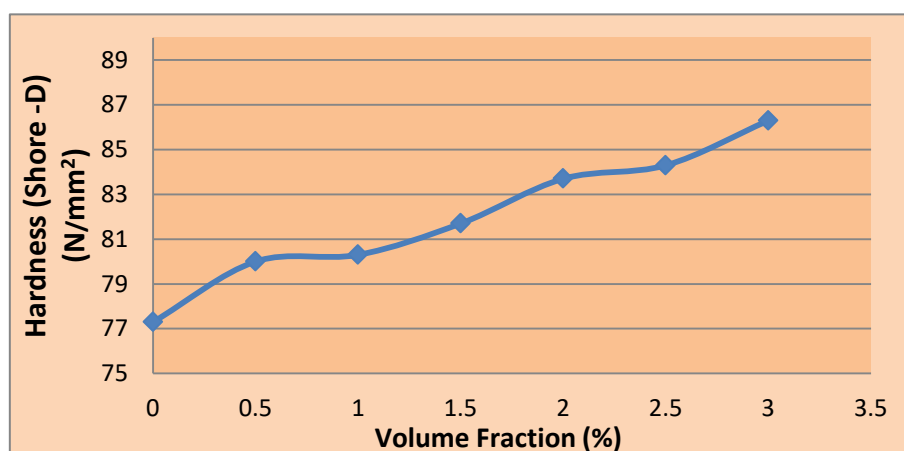


Figure (9) The relationship between the volume fraction of the coconut fiber and the hardness values of the prepared samples.

3.3. Results and Discussion of Thermal Conductivity Test

Figure (10) illustrates the relationship between the volume fraction of coconut fiber and the values of thermal conductivity, one can note a decrease in the heat coupling coefficient with increasing volume fraction of coconut fiber in the polymeric composite material, this means that the prepared samples become more heat-neutral, this is due to the fact that coconut fiber is considered a heat insulation material due to the nature of this fiber because it does not contain electronic abundance or ionic decomposition to facilitate the transfer of phonons, which is the only means of heat transfer in polymer composites and insulating materials. The ability of insulation here depends on the presence of fine fiber filaments, which leads to the transfer of thermal energy in two ways (conduction and pregnancy). The elastic waves (phonons) pass through the base material and the solid part of this fiber by the vibrational movement of the atoms and by the covalent effect. When the phonons reach the capillary part of the fiber, the phonons are blocked in their movement because of the different structural structure of this medium (because it has atoms and bonds different from the former), which will lead to lower values of thermal conductivity. Other reasons attributed to the low thermal conductivity values are due to the presence of thousands of branched and interconnected compounds and the irregularity of regularity in the composite structure, this impedes the flow of heat in one direction and moves it to the other, but is distributed in different directions.

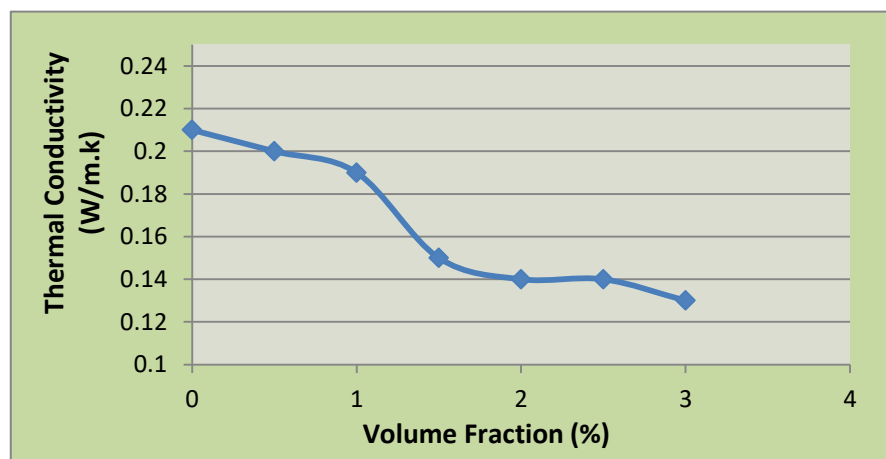


Figure (10). The relationship between the volume fraction of the coconut fiber and the thermal conductivity values of the prepared samples.

4. Conclusions

The addition of coconut fiber has resulted in the improvement of the mechanical and physical properties of the composite material prepared. The values of mechanical properties (compressive strength and hardness) are increased with the increase of the volume fraction of the added fibers. The thermal conductivity values shall be reduced with the increase of the volume fraction of the added fiber, which means an improvement in the thermal insulation properties of the material.

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