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IMPROVING THE ELECTRICAL AND THERMAL INSULATION PROPERTIES OF UNSATURATED POLYESTER USING ENVIRONMENTALLY FRIENDLY MATERIALS

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1- Introduction :

Attention has recently focused on natural waste such as its fibers or peels and its various applications, as it has become a major requirement in the design of new products in various fields such as construction, packaging and others, as it is considered among the environmentally friendly green composite materials [1]. Natural fiber was used as a reinforcing material for polymeric-based composite materials Wrought and thermoset. These natural fibers are distinguished from their counterparts used in the traditional reinforcement of materials such as glass fibers, carbon, Kevlar, etc., in that they are widely available and light in weight, Low cost, Its high durability, Reduce skin and respiratory irritation, Low friction equipment, It has regenerative potential, ability to absorb noise and Biodegradability [2] .Our current research aims to study the effect of palm fiber reinforcement on unsaturated polyester And a volumetric fraction of (0%,10%,20%,30%) on Electrical and thermal insulating properties such as thermal conductivity and dielectric strength.

Keywords : Palm fiber , unsaturated polyester , dielectric strength , thermal conductivity.

2 - EXPERIMENTAL PART

2.1 - Used Materials

2.1.1 - Matrix Material (Unsaturated Polyester Resin)

The matrix material used in this study is unsaturated polyester resin (Siropol-8341) produced by the Saudi (SIR) Company for Resins. Density 1.2 – 1.5 (g /cm3). This resin turned into a solid-state by adding its hardener (Ethyl peroxide methyl ketone) at a rate of (2g) for each (100g) of polyester to interact at room temperature. Notice Figure (1).

Figure (1). Unsaturated polyester resin

2.1.2 - Reinforcement Materials (Palm fibers)

Palm fibers were used of the short type with a density of (1.4 g/cm3), then these fibers were cleaned, washed well with distilled water, dried in the sun, then cut by hand, and finally dried The fibers were dried for two days before use and kept in a drying oven at a temperature of 100 ^{o} C for six hours. Notice Figure (2).

Figure (2). Palm fibers after cutting**.**

3- Sample preparation :

Hand lay-up molding method was employed to prepare the samples. An aluminum mold manufactured with the dimensions required for the samples was used. The samples were prepared according to the volume fractions prepared for this research (0%,10%, 20%, 30%). 'Unsaturated polyester' (UPE) was blended with its hardener at a percentage of 100:2 (g) using a glass rod and gradually to ensure that no bubbles formed and to reach a state of homogeneity. Palm fibers were added to the unsaturated polyester continuously to obtain a volume fraction of fibers of (10%). This process was repeated for the other volume fractions. The volume fraction of the fiber (V_f), which is related to the weight fraction of the fiber (Ψ), can be calculated by using the following equation :

$$Vf = \frac{1}{1+\frac{1-\Psi}{\Psi} x \frac{\rho_f}{\rho_m}} \quad \text{……. (1)}$$

$$\Psi = \left(\frac{W_f}{W_c}\right) x100\% \quad \text{…….... (2)}$$

$$W_c = W_f + W_m \quad \text{……. (3)}$$

W_f , W_m , W_C: The weight of the overlay material, the base material, and the support material, respectively, is measured in (g) units.

ρ_f , ρ_m : Density of the basic material in addition to the density of the aiding material are measured in g/cm3.

The overlay is gently poured into the metal mold and then the sample is left inside the mold to solidify. Upon completion of the molding process, the sample is subjected to heat treatment. This is done by placing it inside a (Hot Air Oven) at a (50°C) and for (60 min) to complete the solidification process and get the best crosslinking of the polymeric chains and get rid of the stresses generated on the sample during the casting process. Figure (3) show samples used.

Figure (3). Samples used.

4- Tests

4.1 - Thermal Conductivity test

Figure (4) shows the devise for thermal conductivity. In this test, a Lee's disk device shown in Figure (3-10) and manufactured by (Griffen & George) was used to conduct a thermal conductivity test for the prepared material samples and composites, as the heat is transferred from the heater to the next disk until it reaches the disk The last one, and it is possible to read the temperature of the three disks (TA, TB, TC) (°C) using thermometers placed inside them, respectively. By knowing the radius of the discs (r) (mm), thickness (ds) (mm), the amount of current (I) of (0.25 Ampere) and the potential difference (V) of (6 Volt), the thermal conductivity can be calculated using the two equations [3] :

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

$$H = IV = \pi r^2 e(T_A + T_B) + 2\pi re\left[d_A T_A + d_s \cdot \frac{1}{2}(T_A + T_B) + d_B T_B + d_C T_C\right] \quad \text{... (5)}$$

Figure (4). Thermal conductivity devise.

4.2 - Dielectric Strength Test

Dielectric strength is defined as the maximum electric field applied to the insulator without breakdown, and it is called the Dielectric Breakdown Voltage. The electrical insulating properties of materials used as electrical insulators depend on [4]. Insulation resistance depends on several factors, some of which are related to the composition of the insulator such as the type of the insulator and the defects and impurities present in it, and some of them are related to external factors such as the shape of the electrodes used in applying the electric voltage and the nature of the external surface and measurement conditions such as temperature, humidity, frequency of the source and the time period when applying the voltage to insulator [5]. In

general, the breakdown voltage occurs as a result of a sudden increase in the current when the voltage exceeds a certain critical value, which is (VBR) as in Figure (5). Before reaching this value, there is a small current that passes due to the few free electrons that are present in the conduction band.) at a certain temperature, and when the collapse occurs, it occurs very quickly, in solid materials it may reach (10-8 s).The electrical insulation durability device shown in Figure (3-11) consists of :

A- A voltage converter with a range of (0-60 kV) of the type (BAVR - PGO - S - 3) of German origin and a frequency of (50 Hz). B- A liquid with high electrical insulation strength (transformer oil 40 kV/mm), and it must be replaced to ensure that it does not ionize, which leads to inaccuracy in the measurement. The reason for its use is that it prevents accidental spark transmission (Flashover), in addition to the rapid increase in its ignition temperature. C- Electrodes made of spherical lead with a diameter of (2 mm) with good electrical conductivity.

The sample for which the strength of the electrical insulation is to be measured is placed between the electrodes of the brass immersed in the oil, making sure that the electrodes are in contact with the surface of the sample. By applying a voltage to the sample, the electrical breakdown occurs at a certain value that can be known by means of a digital meter present in the device. After knowing the thickness of the sample by means of a micrometer, one can Calculate the dielectric strength from Equation (6) [6] :

$$E_{BR} = h/V_{BR} \quad \text{…….. (6)}$$

Figure (5). Dielectric strength device.

5 - Results and discussion

5.1 - Dielectric Strength Test

The results shown in Table (1) and Figure (6) regarding the values of the electrical insulation strength showed that the electrical insulation strength decreases for all samples when they are reinforced with palm fibers. The reason for this is due to the fact that the leakage currents increase with the increase in reinforcement rates as a result of the electrical breakdown and the emergence of the effect of penetration and cracking in the insulator, which depends on the voltage frequency and the long impact time, and although polymers such as epoxy resin and unsaturated polyester are poor electrical conductors, they can They become charged bodies with stable charges as a result of the electric field being applied to them. The electric potential works on the emergence of moving charges within the superimposed sample that are able to

move from one side to the other, and the source of these charges is either from within the superimposed material as a result of its liberation from its stability due to the energy acquired from the applied electric field, or it may be a result of the transmission of electric charges through the moisture that act as carriers for these charges.

Volume Fraction (%) Palm	Dielectric Strength (Kv/mm)
0	19.51
10	17
20	15.9
30	15.85

Table (1). Volume Fraction (%) Palm with Dielectric Strength (Kv/mm).

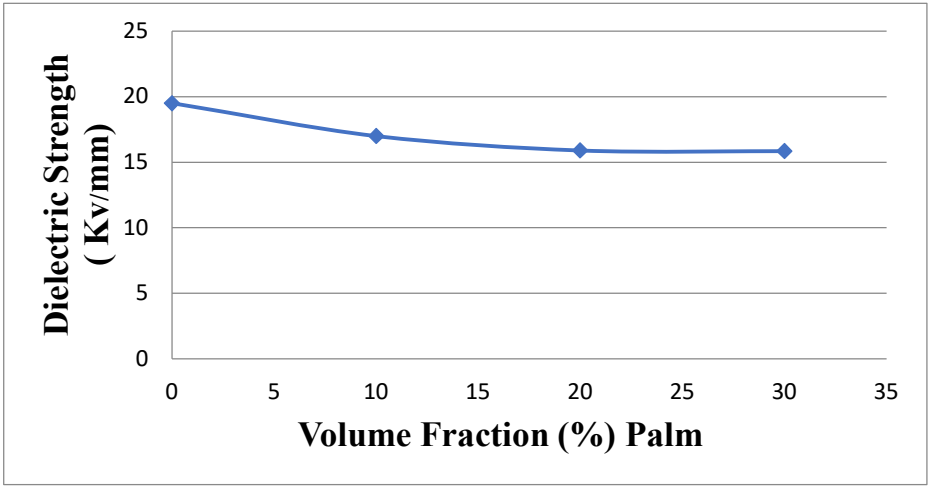

Figure (6). The Relation between dielectric strength and volume fraction %

5.2 - Thermal Conductivity test

The results shown in Table (2) and Figure (7) regarding the thermal conductivity values showed that the thermal conductivity decreases for all samples when they are reinforced with palm fibers. The reason for this is attributed to the presence of those reinforced fibers that are intertwined and randomly regular in the composition of the overlay, which impedes the flow of heat in one direction and its transfer to the other side.

in different directions to be dissipated inside the body of the model; This agrees with the researcher. The ability to isolate here depends on the ability of the fine fiber filaments to transfer thermal energy, as the elastic waves (phonons) travel through the base material and the rigid part of the support fibers by the vibrational movement of the atoms, and upon the arrival of the phonons to the capillary part of the Reinforcement fibers suffer from obstruction in their movement due to the different structural structure of this medium because it has atoms and bonds that differ from the previous medium, which leads to a decrease in the values of thermal conductivity and thus a decrease in thermal conductivity.

Volume Fraction (%) Palm	Thermal Conductivity (W/m.˚C)
0	0.21
10	0.2
20	0.19
30	0.15

Table (2). Volume Fraction (%) Palm with Thermal Conductivity (W/m.˚C).

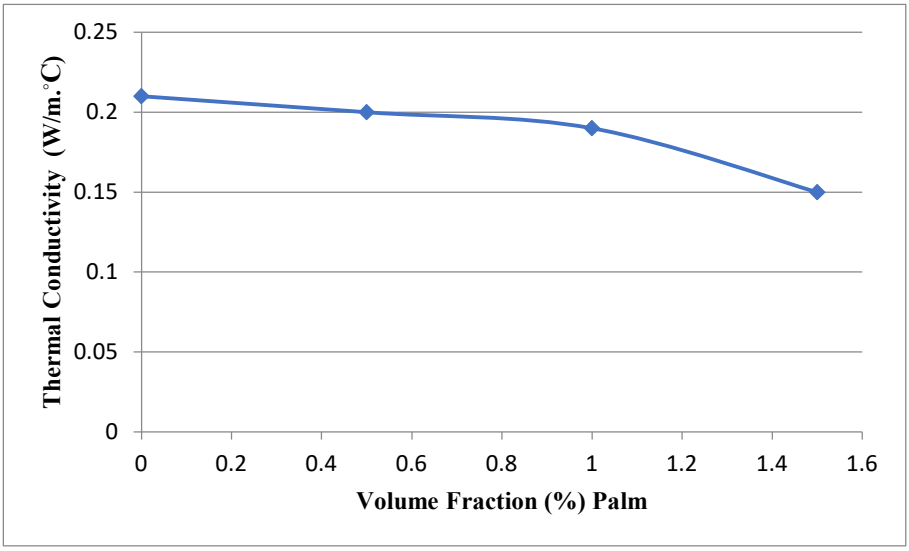

Figure (7). The Relation between thermal conductivity and volume fraction %

6 - Conclusion

- Thermal and electrical insulation capacity of the prepared overlays increases as a result of adding the above-mentioned fibers.
- Dielectric strength is adversely affected by the addition of the above-mentioned reinforced fibers.
- according to the above; Palm fibers can be used in some structural applications such as sofas and wall insulators that require good thermal and electrical insulation properties.

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