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The Study Effect of Weight Fraction on Thermal and Electrical Conductivity for Unsaturated Polyester Composite Alone and Hybrid

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Abstract. In this research prepared two composite materials , the first prepared from unsaturated polyester resin (UP) , which is a matrix , and aluminum oxide (Al_2O_3) , and the second prepared from unsaturated polyester resin and aluminum oxide and copper oxide (CuO) , the two composites materials (Alone and Hybrid) of percentage weight (5,10,15)% . All samples were prepared by hand layup process, and study the electrical and thermal conductivity. The results showed decrease electrical conductivity from (10 - 2.39) $\times 10^{-15}$ for (Up+ Al_2O_3) and from (10 - 2.06)$\times 10^{-15}$ for (Up+ Al_2O_3+ CuO) .But increase thermal conductivity from(0.17 - 0.505) for (Up+ Al_2O_3) and from (0.17 - 0.489) for (Up+ Al_2O_3+ CuO).

Keywords. Thermal conductivity , Electrical conductivity, Hybride

INTRODUCTION

Polymer used in many electrical and mechanical application and often used as insulating material for electrical properties possess good as (Volume Resistivity) and inverse (Volume Conductivity) and (Impedance) and (Dielectric loss), and had groveled those characteristic for many studies. The electrical properties of the insulation materials used in many devices in different size depend on the type of use, and this characteristic effect by many factors as frequency, temperature, time, voltage used, additives materials and others [1].

The solid materials divided depend on the electrical conductivity three types conductor and insulator and by measuring the alternating conductivity for material you can get important about the nature of the the mechanical conductivity in this material whereat measuring the electrical conductivity as a function of frequency for alternating electric field measurements of the movement of charge in the insulation materials has become very important lately because provide information about the electron structure of these material and many studies about the electrical properties and put so many models for interpretation of experimental facts on electrical conductivity and, mechanical.

The experiments have shown that there are two types of charges carriers are electrons or ions and there are different mechanics can move charges carriers in the insulation under effect the electric applied [2].

The polymer electrical conductivity depend on the existence of free ions is non-associated chemically with macromolecular and don't share these molecules in the process of moving electric charges , so that the electrical conductivity in polymers depends greatly on the ion source by adding impurities with low weights.[3]

The thermal conductivity of materials is measure of the ability of material to conduct heat. There will only be a net flow of heat energy through of a length of materials when there is a difference in temperature between the ends of the materials .Thus the thermal conductivity is defined in terms of quantity of heat that will flow per second divided by the temperature gradient.[4]

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Dependent thermal conductivity in resin on several factors vectoring molecules, crystal size, purity, and in non-metallic materials including resins electron transport is weak and is method of heat transfer or there is no electronic transmission so that thermal conductivity is determined by structural vibrations this case caused by the resins less conductor temperature than metals [5]. The alumina oxide powder are industrially important ceramic oxide due to its mechanical and thermal properties as resistance and high thermal and mechanical resistance, high hardness and so he enters in many industrial application such as abrasive and electrical insulation refractory industry has used aluminum oxide, density of aluminum oxide equal (3.95 gm/cm3), size volume (30Mm), for the copper oxide were density (6.315gm/cm3) and the purity 99%. In this research prepared two composite materials , the first prepared from unsaturated polyester resin (UP) which is a matrix , aluminum oxide (Al_2O_3) with percentage weight (5,10,15)% , and the second prepared from unsaturated polyester resin, aluminum oxide and copper oxide (CuO) with percentage weight (5,10,15)%

Among the studies of thermal conductivity test the authors Abdullah. F. Abdul sadah , Ali. I. Almosawi, Ali. J. Salama, study of the effect of adding a silica (SiO_2) polyester resin is saturated and examine the influence of reinforcement to this material on coefficient of thermal conductivity (K) and a different size fraction .[6]

So among those who study testing thermal conductivity by S. Hadi, Abdul Nasser? We can study the effect of adding a third antimony oxides powder on the thermal conductivity of polymer composite material composed of epoxy glass fiber reinforced and has added a different weight ratio (10,20,30) results showed increase conductivity value after added as well as increasing the value added ratio increase conductivity [7].

Among the studies of electrical conductivity and thermal conductivity the authors Nasr Abdul Amir, who study the effect of adding silicon oxides (SiO_2) on electrical and thermal conductivity for unsaturated polyester resinIn different weight ratio the study showed decrease in electrical conductivity value after adding the powder and decrease the thermal conductivity after adding [8].

PREPARATION METHODS

Polymer composite material was prepared reinforced aluminum oxide and polymer material reinforced by copper oxide that material basically in unsaturated polyester resin adding these different weight fraction (5, 10, 15) % and the powders were added on following relations [9].

$$\psi = W_f / W_c \times 100\% \quad \text{.....(1)}$$

$$W_c = W_f + W_m \text{.....(2)}$$

ψ : The weight fraction for reinforcement materials

(Wf , Wm , WC) : weight fraction reinforcement materials and matrix material and composite material respectively.

Hand Layup method was used to prepare the samples use aluminum mould resin casting was mixed with aluminum oxide powders for composite material and then poured resin mixed with aluminum oxide and copper oxide for hybrid composite material and then casting the mould is rotated for obtained the homogenous casting and mixed the components in the mould after the casting process removed the bubbles formed by the vertical pressure at the level of the mould for the poured material by brush and the fish after leaving the samples for(24) hour and cutting the samples and standard specifications and has been casting process for samples at room temperature .

To calculate the coefficient of thermal conductivity of all samples used in research use (Disk Lee) , depend on the relationship

$$Q = -K\, dT/dx \quad \text{.....(3)}$$

dT/ dX : The heat gradient in (° C /m) and the negative sign means that heat travels from high temperature area to a lower temperature area.

Thermal conductivity value can be extracted through the following equations.[10]

$$IV = \pi r^2 e(T_A + T_B) + 2\pi re\left[d_A T_A + d_s\left(\frac{T_A+T_B}{2}\right) + d_B T_B + d_c T_c\right] \text{.....(4)}$$

$$K\left[\frac{T_B - T_A}{d_s}\right] = e\left[T_A + \frac{2}{r}\left(d_A + \frac{1}{4}d_s\right)T_A + \frac{1}{2r}d_s T_B\right] \text{.....(5)}$$

Where (e) represents the amount of heat energy passing through the disc material space unit per second , units ($w/m^2.^\circ C$).

I: represent the current passing through the convector coil .

V: voltage (volt)

R: radius (mm).
T_A, T_B , T_C , represent the heat of disk A,B,C . (°C).
d_S : thickness of sample(mm) .
Measuring the electrical conductivity has been using the following equations [7]

$$= \frac{1}{\rho}\ , \ (\Omega.\text{cm})^{-1} \text{……...……...…..} \ \textbf{(6)}$$

$$\rho = R\frac{A}{L} \quad where \{ A = b\ .\ t \} \text{……...…...} \ (7)$$

Where at :
σ: electrical conductivity
ρ : resistivity.
A: area
L: thickness of sample
R: resistance.

THE RESULTS AND DISCUSSION:

Thermal conductivity a function of weight fraction was studied whereat takes the unsaturated polyester resin without and with addition aluminum oxide (Al_2O_3) of percentage weight (5, 10, and 15) %. The results show from Fig 1.

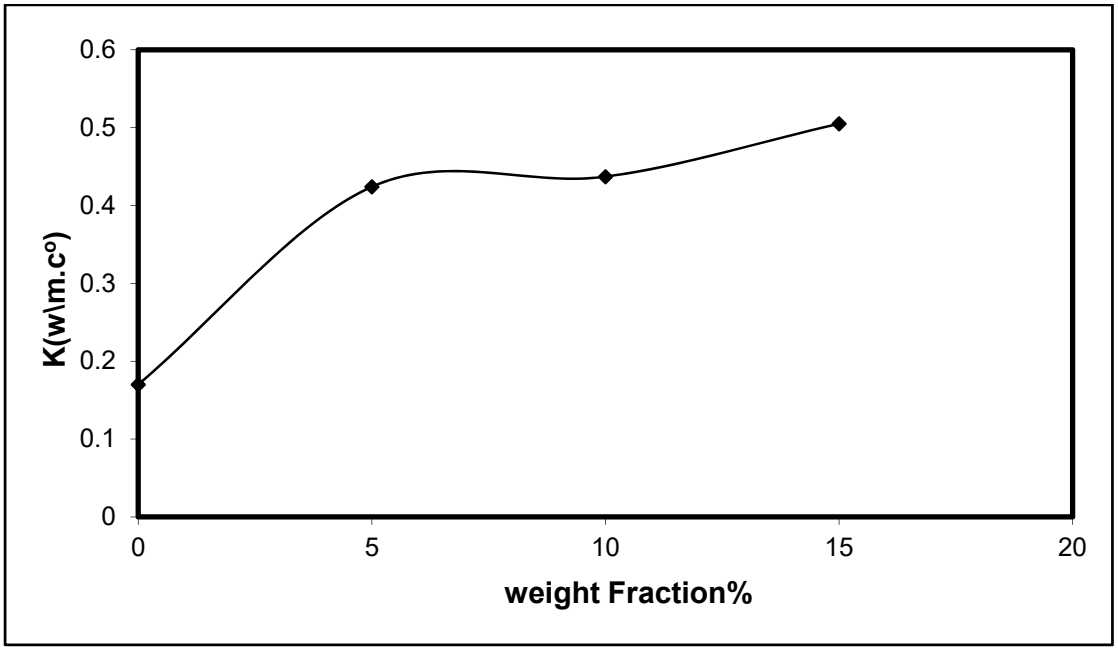

FIGURE 1. The relationship between the thermal conductivity for un saturated polyester after and before reinforced and weight fraction for alone composite material (Up + Al_2O_3).

In this figure it was found that the increasing the value of coefficient thermal conductivity composite materials alone (Up+ Al_2O_3) from (0.17 - 0.505) and from Fig 2, It observed increase coefficient thermal conductivity for hybrid composite materials (Up+ Al_2O_3+CuO) from (0.17 - 0.489) because the existence powders substance that higher thermal conductivity compared the alone polyester.

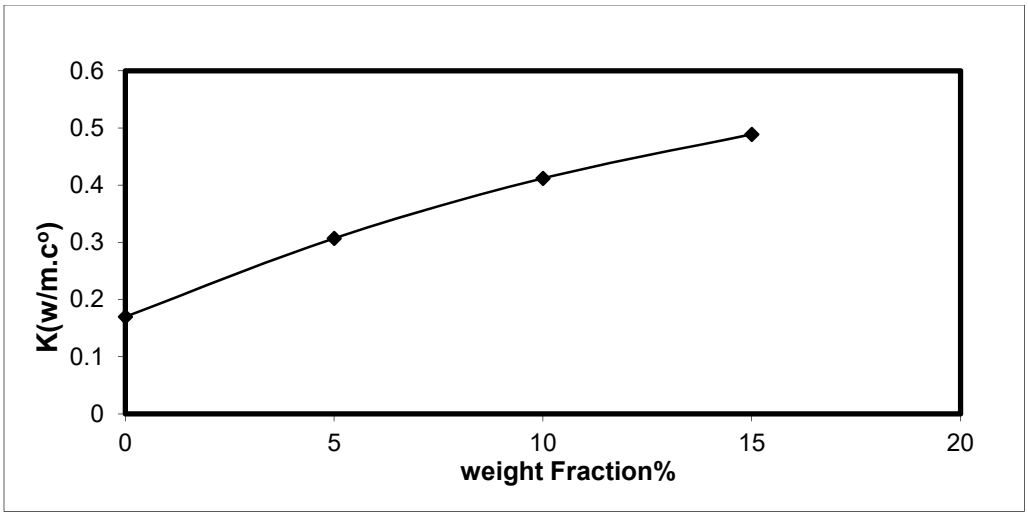

FIGURE 2. The relationship between the thermal conductivity for un saturated polyester after and before reinforced and weight fraction for alone composite material (Up + Al_2O_3 + CuO)

Also note from the two Fig (1,2) increase the value of thermal conductivity from both alone and hybrid composite materials with increase the weight fraction , the fact the ceramic materials are heat insulating materials as compare with plastics but the ceramic material have a crystal structure have atoms are organized according to the three dimensional crystal network are connected by chains transversely and irregular , the irregularity and there spaces between the chains all this tends to make the process of thermal energy transfer from one ender to another difficult process of crystalline material [11,12]

It could explain why increase thermal conductivity by adding powders to un saturated polyester is high stacking density added powders leading to fewer gaps already exist in composite material (during manufacturing) and lead to a lack of air spaces that are as medium and leads to improvement in the value of thermal conductivity [13]

From Fig (3, 4) which illustrate the relationship between electrical conductivity and weight fraction for alone and hybrid composite materials .The results showed decrease in the value of electrical conductivity from (10- 2.39)$\times 10^{-15}$ for the alone composite material (Up+ Al_2O_3) and from (10- 2.06) $\times 10^{-15}$ for the hybrid composite material when you add powders the decrease increase when the weight fraction increase reason oxides existence which are electrically insulating increase the insulation with the oxides increase [14].

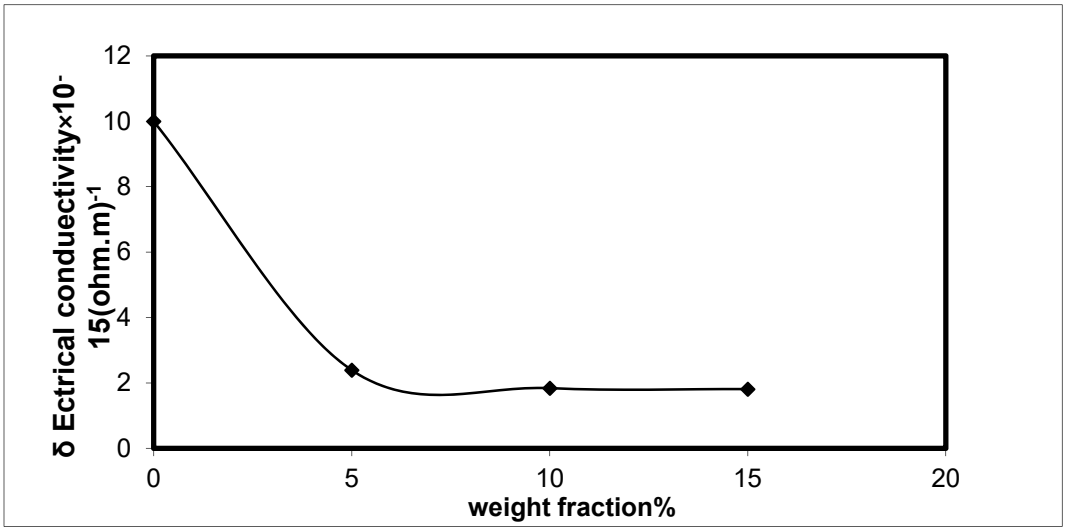

FIGURE 3. the relationship between electrical conductivity for unsaturated polyester after and before reinforced and weight fraction for alone composite material (Up+ Al_2O_3)

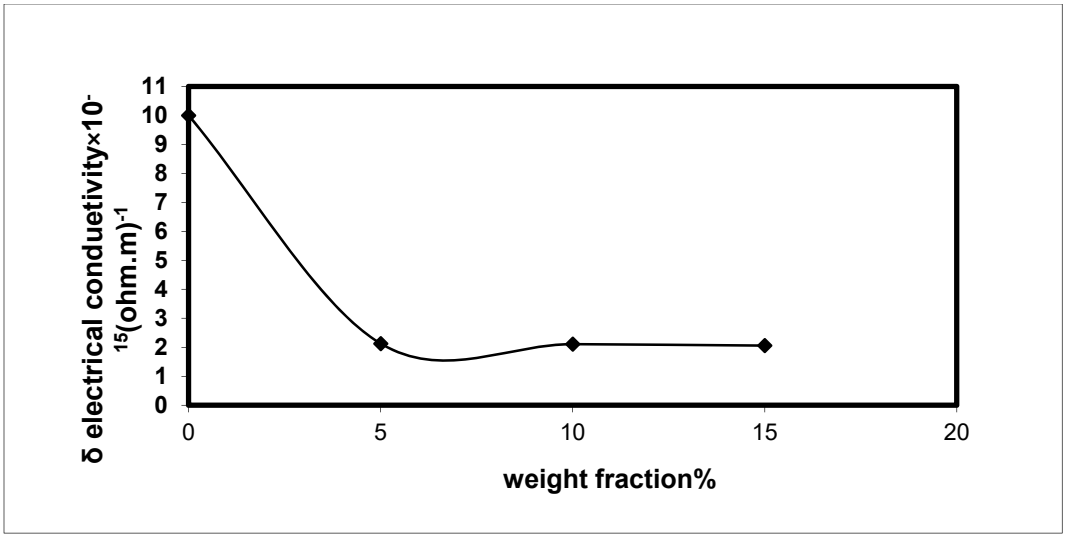

FIGURE 4. The relationship between electrical conductivity for unsaturated polyester after and before reinforced and weight fraction for hybrid composite material (Up+ Al_2O_3 + CuO)

CONCLUSIONS:

1- Increase the thermal conductivity for the alone and hybrid composite materials after added the oxides and increase when increase oxides add for the alone and hybrid materials.

2-The results showed for the electrical conductivity decrease in the value of electrical conductivity and increase the decrease when increases the values of oxides add for both alone and hybrid composite materials.

REFERENCES

1. S. F.Khor, Z. A. Talib, H. A. A. Sidek, W. M. Daud, and B. H. Ng, American Journal of Applied Sciences, 6(5), 1010-1011, (2009).
2. P. Gonon, A. Sylvestre, J. Teysseyre and C. Prior, Materials Science and Engineering: B, 83(1), 158-164. (2001).
3. H. Yang, H. Wang, F. Xiang and X. Yao, Journal of the Ceramic Society of Japan, 116(1351), 418-421, (2008).
4. F.P. Incropera and D. P. Dewitt, "*Introduction to heat transfer* " ,3rd ed , John wiely & Sons, New York. NY. (1996).
5. A. H. Halem, "*improvement prpperties of reinforced plastic materials*", M.SC Thesis, Engineering college, Babylon University, Iraq, (1999).
6. A. I. Al-Mosawi, A. J. Salaman, F. Abdul sadah Abdullah, Journal of kufa- physics, 3(2), 29-34, (2011)
7. S. H. Abdul-Nasser, Iraqi journal of mechanical and material engineering, 11(3), 541-549, (2011).
8. Nasser Abd Alameer, Iraqi journal of mechanical and material engineering, 13(1), 161-167, (2013).
9. A.M.Cllieu & D.J.Powney "*The mechanical and thermal properties* " , Butter and Tanner , London ,(1973).
10. D.m.price " *Thermal conductivity of PTEF & PTEF composites* " ,North American thermal analysis , florida , (2000).
11. Abdul Raheem K.Abid Ali, Ahmed Hashim, Marwa Abdul Muhsien *" Effect of addition lithium fluoride on some electrical properties of poly- methylmethacrylate*", the Iraq journal for mechanical and material engineering, special issue (A), 2nd conference of engineering college, Babylon university, (2010), pp:102-108.
12. S.M.Kulkarni and D.Anuradha, Bulletien of materials science, 25(2), 137-140, (2002).
13. M. Szczepanik, J. Stabik,M. Łazarczyk, and A. Dybowska, Archives of Materials Science and Engineering, 37(1), 37-44, (2009).