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RESEARCH ARTICLE

Effect of magnesium oxide additions on electrical conductivity of polyester resin

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Abstract

In the present work, effect of addition magnesium oxide macro particles on electrical conductivity of unsaturated polyester resin has been studied. For that purpose, eight samples have been prepared by adding magnesium oxide particles on the unsaturated polyester by different weight fractions from these oxide particles with polymer. The experimental results showed that the D.C electrical conductivity changed with increasing the concentration of additional oxide particles.

1. INTRODUCTION

For a conductor havening a cross section area (A) and a current (i) passing through it because of electric field intensity (E) or a potential difference (V) across it, the current density is given[1]:

$$i = -\sigma A \frac{dv}{dx} \qquad (3)$$

The ratio of the current density (J) to the electric intensity is called the electrical conductivity of the martial and is represented by (σ).

$$\sigma = \frac{J}{E} \qquad (2)$$

Electrical conductivity varies between different materials by over 27 orders of magnitude, the greatest variation of any physical property as shown in Figure 1 where Metals: σ > 105 (Ω.m)-1, Semiconductors: 10-6 < σ < 105 (Ω.m)-1, Insulators: σ < 10-6 (Ω.m)-1 [2].

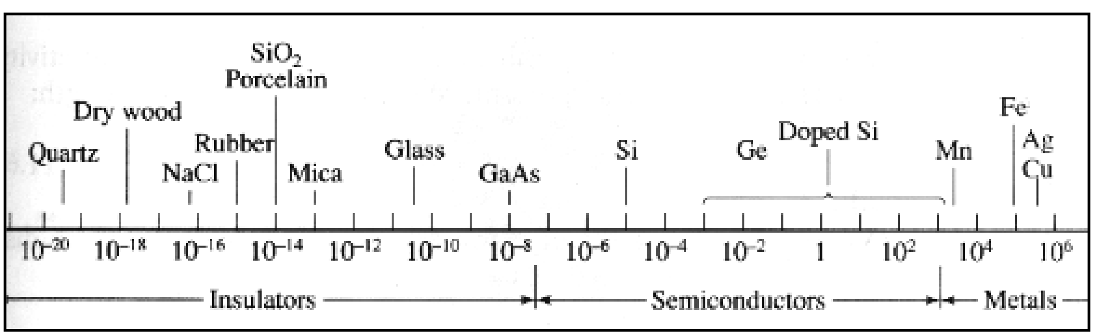

Figure 1 electrical conductivity of materials

If we replace (E) by $(-\frac{dv}{dx})$, and (J) by ($\frac{i}{A}$) in equation (2), we obtain:

$$i = -\sigma A \frac{dv}{dx} \qquad (3)$$

For a conductor of length (L) and constant cross section area (A) in which there is a current (i) due to a potentials (Va) and (Vb) at its terminal and having a conductivity (σ) ,Eq.(3) can be integrated [3]:

$$idx = -\sigma AdV$$

$$i\int_{O}^{L} dx = -\sigma A\int_{V_a}^{V_b} dV$$

$$iL = \sigma A(V_a - V_b)$$

$$i = \frac{\sigma A}{L}(V_a - V_b) \qquad (4)$$

Eq. (4) is the desired relation between the current in the conductor and the potential difference between its terminals. The factor (σ A/L) is called the conductance of the wire[4]. In practice the reciprocal of the conductance, called the resistance. Resistance is represented by the letter(R).for homogeneous conductor of constant cross section and for which (σ) is constant[5],

$$R = \frac{L}{\sigma A} \qquad (5)$$

The reciprocal of the conductivity called the resistivity and denoted (ρ)

$$\rho = \frac{1}{\sigma} \qquad (6)$$

In terms of of resistivity ,Eq.(5) becomes

$$R = \frac{\rho L}{A} \qquad (7)$$

The resistivity of all conducting materials is affected by their temperature .the relationship between temperature and resistivity is given by an equation of the form[6]:

$$\rho = \rho_o + at + bt^2 + \qquad (8)$$

Where : ρ_o is the resistivity at 0OC; a , b, etc., are constants characteristics of a particular material and (t) is the centigrade temperature. for temperature which are not too great, the terms in (t_2) and high powers may be neglected and Eq.(8) becomes[7]:

$$\rho = \rho_o + at \qquad (9)$$

It is convenient to put Eq.(10) in the form

$$\rho = \rho_o + \frac{\rho_o at}{\rho_o} \qquad (10)$$

$$\rho = \rho_o(1 + \alpha t) \qquad (11)$$

$$\alpha = \frac{a}{\rho_o} = \frac{\rho - \rho_o}{\rho_o t} \qquad (12)$$

The quantity (α) is called the temperature coefficient of resistivity and is the fractional increase in resistivity per degree increase in temperature. Since the resistance of a given conductor is proportional to its resistivity, Eq.(9) may also be written

$$R = R_o(1+\alpha t) \quad (13)$$

Where; Ro is the resistance at 0OC and (R) is the resistance at to C

2. EXPERIMENTAL

Unsaturated polyester resin (SIROPOL 8340-PI) as a matrix and magnesium oxide particles with (0.5 µm) size as a filler were used. The electronic balanced of accuracy 10-4 have been used to obtain a weight fraction of magnesium oxide powder and polymer. These mixed by Hand Layup and the Microscopic Examination used to obtain homogenized mixture .The weight fraction of magnesium oxide are (0, 5, ,10,15, 20,25, 30,35,40) wt.% . The mixtures of different magnesium oxide percentages and polymer have been treated with 75 ºC at two hours. The samples were disc shape of a diameter about 30 mm and thickness ranged between (1.93-2.2) mm . The resistivity was measured over range of temperature from (30 to 90) ºC using Keithly electrometer type (616C) . The volume electrical conductivity σ_v defined by :

$$\sigma_v = \frac{1}{\rho_v} = \frac{L}{RA} \quad (14)$$

In this model the electrodes have circular area A= $D^2\pi/4$ where D= 1.1 cm^2 .

3. RESULTS AND DISCUSSION

Figure 2 shows electrical conductivity as a function of the weight percent of Magnesium oxide at a temperature of 30ºC .From the figure, it is shown that the increasing in the weight fraction of Magnesium oxide leads to decrease the conductivity slightly to reach aprecent of Magnesium oxide(20wt.%) . Where the value of the conductivity of this concentration (1×10^{-16}(ohm.cm)$^{-1}$) when increasing the focus more than that, the electrical conductivity to a large decrease to the value (7×10^{-18}(ohm.cm)$^{-1}$) at the concentration of Magnesium oxide (40wt.%) .

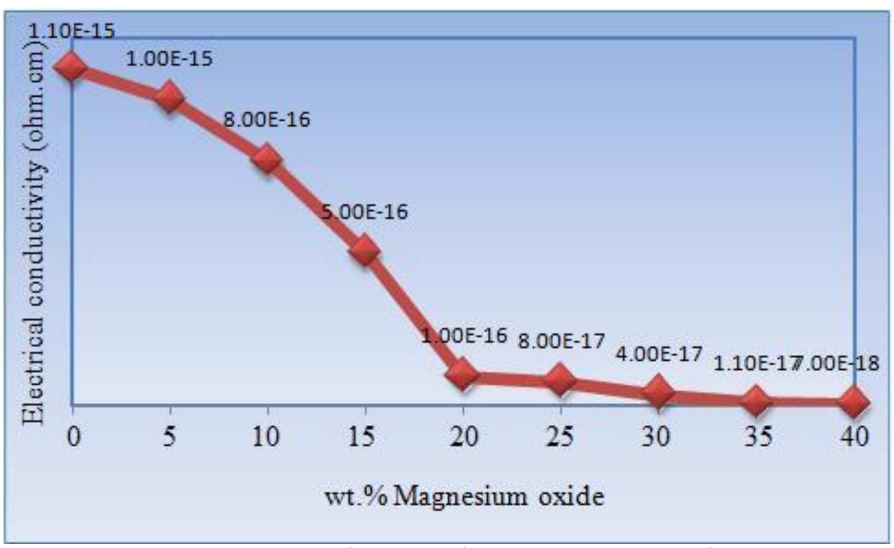

Figure 2 : Electrical conductivity as a function of the weight percent of Magnesium oxide

4. Conclusions

The effect of simultaneous presence of Magnesium oxide on the electrical conductivity of unsaturated polyester was studied. It can be concluded from the results that presence of Magnesium oxide will decrease the electrical conductivity of the unsaturated polyester and increasing concentrations of Magnesium oxide deteriorates the electrical conductivity very much.

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