

Characterization of Electrical Properties of (PVA-TiO₂) Composites

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Abstract

The aim of this paper study the D.C electrical conductivity of (poly-vinyl alcohol-titanium oxide) composite has been investigated at different temperature. For that purpose, the poly-vinyl alcohol samples with titanium oxide additive prepared with different percentages (0, 10, 15, and 20) wt. % and different thickness. The experimental results showed that the D.C electrical conductivity is increased with increasing the titanium oxide concentrations and temperature. Also the activation energy change with increasing titanium oxide concentration.

Keywords: Composites, poly-vinyl alcohol, Electrical Properties.

Introduction

Composites are widely used our day to day life. Due to their low weight and ability to be tailored for specific end use they have gained a considerable ground in the high performance applications, such as aerospace and automobile industry [2]. Filled polymer composites have a wide range of industrial applications-they are used in anti-static materials, self regulating heaters, over current and over temperature protection devices, and materials for electromagnetic radiation shielding [2]. The advantages of PVA such of high mechanical strength and water-soluble have played as main [3]. The

present work deals with the effect of titanium oxide additive on the D.C electrical properties of poly-vinyl alcohol composite.

Experimental Work

The materials which are used in this paper, is poly vinyl alcohol as matrix and titanium oxide as a filler. The weight percentages of titanium oxide are (0,10,15 and 20)wt.%. films of pure PVA and PVA doped with titanium oxide were prepared using casting technique thickness ranged between (256-613) μm The resistivity was measured over range of temperature from (30 to 80) $^{\circ}\text{C}$ using Keithly electrometer type (616C). The volume electrical conductivity σ_v defined by :

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

Where:

A = guard electrode effective area.

R = volume resistance (Ohm) .

L = average thickness of sample (cm) .

In this model the electrodes have circular area $A = D^2\pi/4$ where $D = 0.5 \text{ cm}^2$.

Results and Discussion

The effect of titanium oxide on electrical conductivity at temperature (30 $^{\circ}\text{C}$) is shown in figure(1). The conductivity remains almost constant at low titanium oxide concentration then it starts to increase when titanium oxide concentration is equal or larger then 12.5 wt.%. The figure shows that the increase in the D.C electrical conductivity for the sample of high titanium oxide concentration is about two order of magnitude as compare with the D.C electrical conductivity of neat PVA sample.

This behavior can be related to the fact that at high filler concentration the electrical properties of composite material may be dominated by the electrical properties of the filler whereas at low filler content both polymer and filler govern the electrical properties of the composite material. The electrical conductivity could also be increased as a result of increasing of charge carriers which can be increased due to increasing filler content [4].

Figure 1: Variation of D.C. electrical conductivity with TiO₂ wt. % concentration of composite

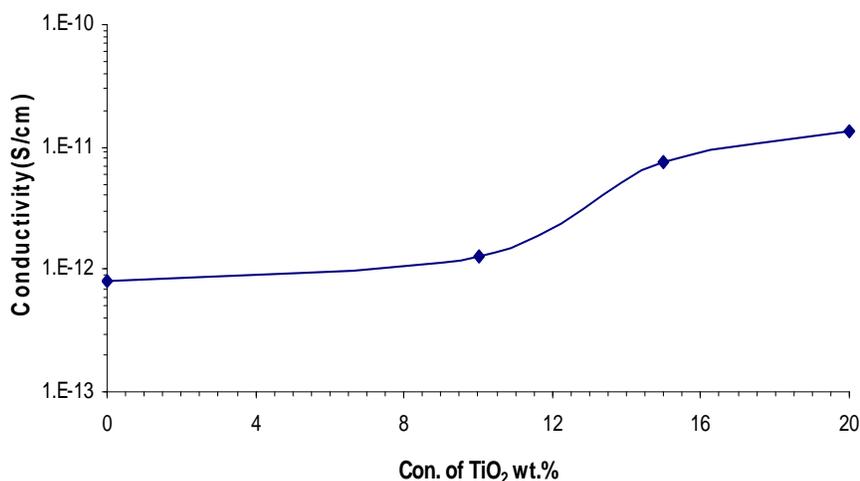


Figure (2) shows the variation of the bulk electrical conductivity for (PVA-TiO₂) composite with temperature. The figure shows that the bulk electrical conductivity increases with the increase of the temperature of (PVA- TiO₂) composites. This means that these materials have resistance of

negative thermal coefficient; that is, having the resistance decrease with the increase of temperature. This is because polymer chains and titanium oxide ions could act as traps for the moving charge carriers by hopping process [5], with the increase of temperature, the motion of polymer chains increase; as a result of the ions of titanium oxide move. Consequently, the trapped charge carriers are releasing and the conductivity for composite increase as a result for the increase of the charge carriers and mobility of these charges [6].

Figure 2: Variation of D.C. electrical conductivity with temperature for (PVA-TiO₂) composite

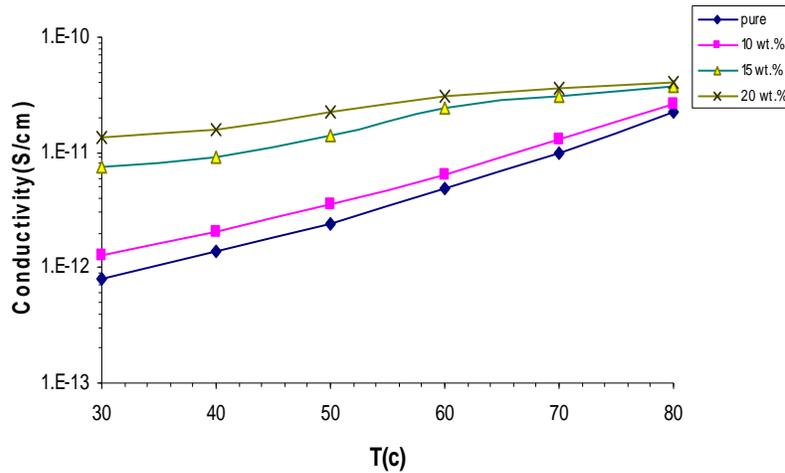
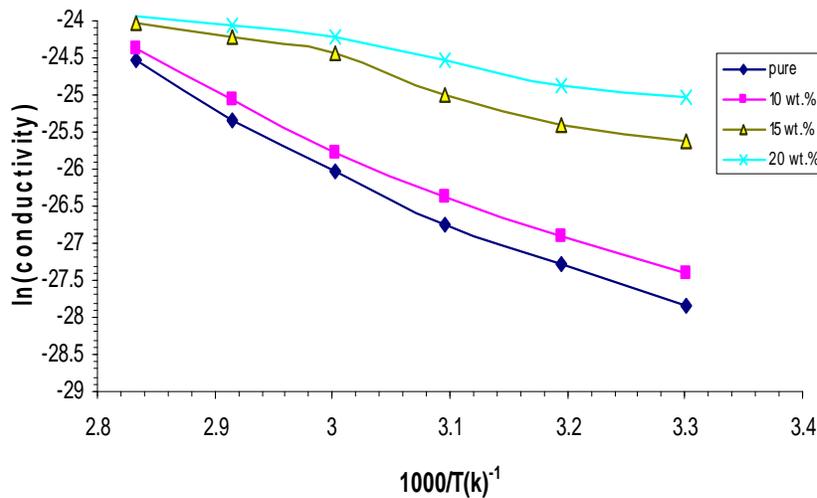


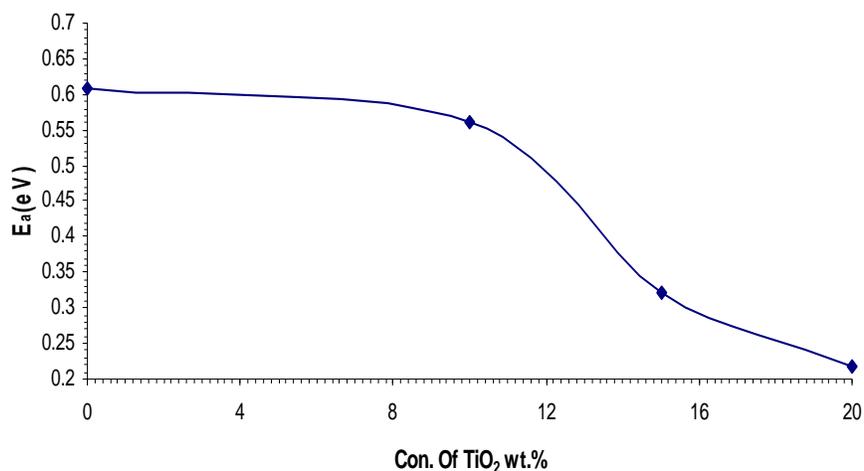
Figure (3) shows the variation of ln(conductivity) with inverted absolute temperature of the composites, it can be seen that there are high values of activation energy these high values are attributed to the existence of free ions in the polymer.

By adding low concentrations of titanium oxide, the values of the activation energy are decreasing of composites as a result of the impact of space charge [4] as shown in figure(4) .

Figure 3: Variation of D.C. electrical conductivity with resprocal absolute temperature for (PVA-TiO₂) composite



The addition of low concentrations creates local energy levels in the forbidden energy gap which act as traps for charge carriers, which move by hopping among these levels. By increasing the titanium oxide concentrations, the activation energy decreases as a result of the increase of local centers [7].

Figure 4: Variation activation energy for D.C. electrical conductivity with titanium oxide concentration of composite

Conclusions

1. The D.C electrical conductivity of the poly-vinyl alcohol increases by increasing the titanium oxide concentrations and the temperature.
2. The activation energy of D.C electrical conductivity decreases by increasing titanium oxide concentrations.

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