Effect Of Addition Cobalt Ferrite (CoFe2O4) On Electrical Conductivity Of Polyvinyl alcohol(PVA)

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ABSTRACT: In the present work , effect of additionCobalt Ferrite ($CoFe_2O_4$) on some electrical properties of Polyvinyl alcohol (PVA) has been studied . for that purpose , many samples have been prepared by adding ($CoFe_2O_4$)on thePolyvinyl alcohol by different weight percentages from ($CoFe_2O_4$) with polymer and with different thickness . The experimental results showed that the D.C electrical conductivity increased with increasing concentration of additional ($CoFe_2O_4$) and increasing of temperature . Also the activation energy decreased with increasing of additional ($CoFe_2O_4$).

KEYWORDS:PVA-$CoFe_2O_4$, D.C electrical conductivity, Activation energy

I. INTRODUCTION

Electrical conduction is the process of the transfer of electric charges through a medium from one place to another under the influence of electric field. Electrical conduction is based on two factors [1]:First: The type of charge carrier (n) Charge carriers can be electrons, gaps, or ions automatically generated due to the addition of impurities - Second: Mobility (μ) Mobility depends on temperature (T) and the potential exerted (V).Polymers of special structure (alternating) have the properties of semiconductors, whereas most commercial polymers are insulator. Given that polymers are easily formed . Chemists and physician started mid the twentieth century to conduct studies designed to develop conductor polymers characterized by alternating double bonds [2]. In its stable state, alternating polymers are insulators or semiconductors because it is easy for electrons to transfer from one chain to another. These insulator polymers can be transformed into conductors by adding small molecules that have certain properties among polymer chains; these molecules are called Dopants, and the process of adding impurities is called Doping. Dopants can operate as oxidizing or reducing agents. Charge transfer complexes can be created between dopants and polymers that make these polymers conductors[3]. Magnetic nanocomposites have been prepared in different matrices as silicon oxide [4], aluminum oxide [5] and porous glass [6]. But nowadays great part of the investigations has focused to the development of processes for the incorporation of magnetic nanoparticles within polymeric matrices, motivated mainly by its interesting magnetic properties and their excellent manageability. Exists two methods for the formation of a composite mineral-polymer [7], simplest it is incorporating to polymer magnetic particles previously formed, grinding them and mixing them with polymer. The other method is the synthesis in-situ of nanoparticles within a polymeric matrix [8]. For this it is necessary that the matrix has functional groups that serve to form chelates with metallic ions. Between the polymers that can form chelates is the polyvinyl alcohol (PVA), it has the capacity to chelate ions, in addition to a simple procesability [9].

II. EXPERIMENTAL PART

The materials which used in this paper is polystyrene as matrix and Cobalt Ferrite as ($CoFe_2O_4$)a filler. The electronic balanced of accuracy 10^{-4} have been used to obtain a weight amount of ($CoFe_2O_4$) powder and polymer powder .The weight percentages of ($CoFe_2O_4$)are (0,1,3,5,7) wt% . Thickness ranged between (0.3-0.25) mm . The Casting Method has been used for prepared of thin film.The resistivity was measured over range of temperature from (298 to 438)^{o}K using Keithly electrometer type (616C) . The volume electrical conductivity defined by [10].

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

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= 2.5 cm^2.

III. RESULTS AND DISCUSSION

Figure (1) shows electrical volume conductivity as a function of the concentration of $(CoFe_2O_4)$ at a temperature of (289^oK) .From the figure we note that the electrical conductivity is slightly increasing with increase the concentration of $(CoFe_2O_4)$. When increasing the focus more than that, the electrical conductivity to a large increase to the value (8.36×10^{-10} (Ohm.cm) $^{-1}$) at the concentration of $(CoFe_2O_4)$(1 wt%) and an increase in the concentration of $(CoFe_2O_4)$the conductivity reach to(5.51×10^{-9} (Ohm.cm) $^{-1}$) at the concentration (7wt%).The increase of conductivity with increasing of concentration of$(CoFe_2O_4)$caused by the increase of the charge carriers ions in which thy increased with increasing filler contact when the $(CoFe_2O_4)$ions at low concentrations are represented by small darker regions and become large when the Cobalt Ferrite $(CoFe_2O_4)$content increases but when the concentration of $(CoFe_2O_4)$ reaches to (5wt%), the network will be connected to each other containing the overlapping paths to allow the charge carriers to pass through, where the charge carriers with routes through which the electrical resistance be less [11,12,13].
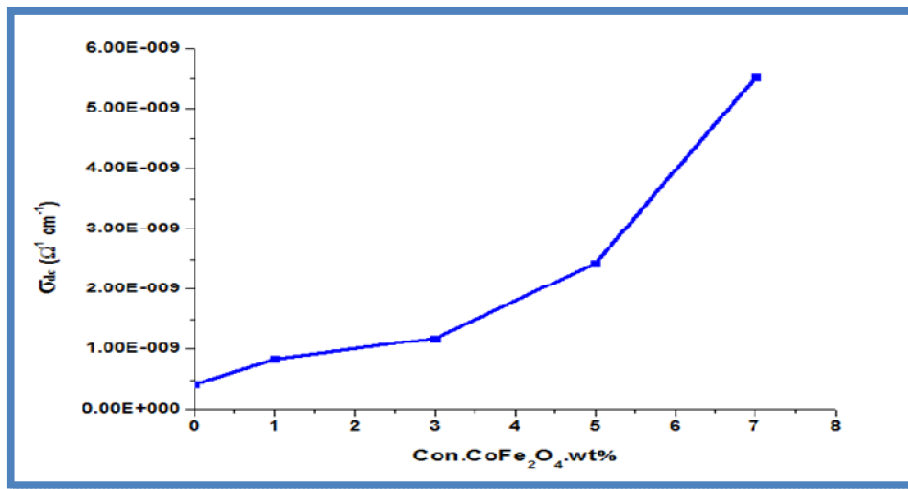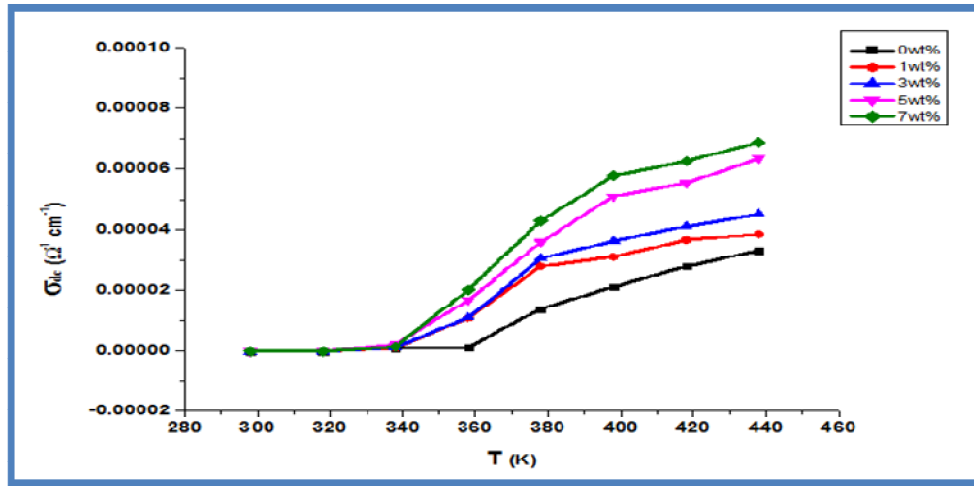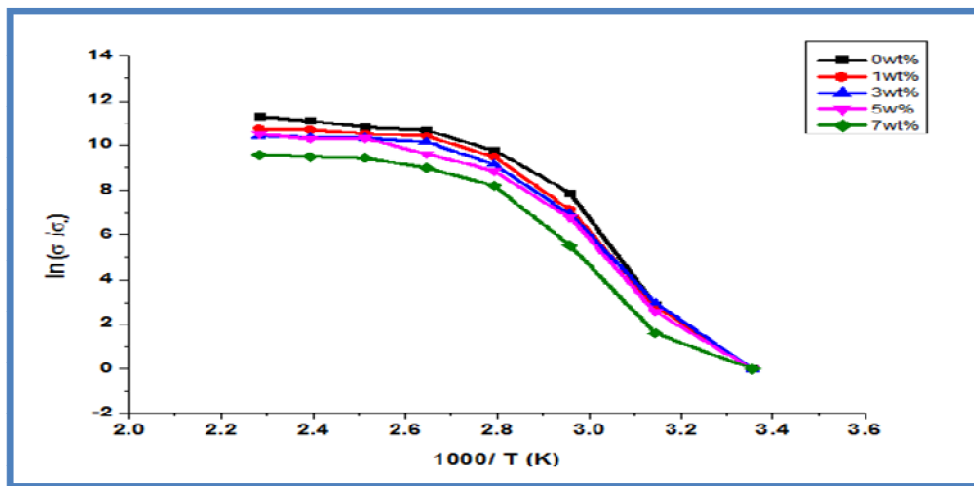

Figure (1) variation of D.C electrical conductivity with $(CoFe_2O_4)$ concentration for (PVA- $CoFe_2O_4$)composite at T=289oK .

Figure (2) shows the behavior of electrical volume conductivity of the composite with the temperature. Note that the electrical conductivity increase with increasing temperature that any of this material has positive thermal coefficient .The interpretation of this is that the polymeric chains and$(CoFe_2O_4)$particles act as traps the charge carriers which transited by hopping process. On increasing the temperature, segments of the polymer being to move , releasing the trapped charges. The released of trapped charges is intimately associated with molecular motion. The increase of current with temperature is attributed to two main parameters , charge carriers and mobility of these charges.The increase of temperature will increase the number of charge carriersexponentially. The mobility depends on the structure and the temperature [14,15].

Figure(2) variation of D.C electrical conductivity with temperature for (PVA- CoFe$_2$O$_4$) composite.

Figure (3) shows the relationship between $\ln(\sigma/\sigma_{\cdot})$ and inverted absolute temperature of the (PVA- CoFe$_2$O$_4$) composites . From the calculations the values to the activation energy ranges between $(1.48\times10^{-3} – 1.77\times10^{-3})$ev for (PVA- CoFe$_2O_4$) composites these values are due to the presence of free ions in the commercial polymers and the addition of low concentration of (CoFe$_2$O$_4$) reduced the activation energy values of all samples of (PVA- CoFe$_2$O$_4$) composites the result of the space charge effect in the contact regions where the shipment in addition to the concentration of low-power levels localized in the forbidden energy gap act as traps to charge carriers and charge carriers were moving by hopping[16] .

Figure(3) the relationship between $\ln(\sigma/\sigma_{\cdot})$ and inverted absolute temperature of the(PVA-CoFe$_2$O$_4$) composites .

The concentration increasing of (CoFe$_2$O$_4$)leads to the lowering the activation energy values , as shown in the figure (4) , it is clear that the mechanism of conductivity in the samples at low filler concentration is hopping.
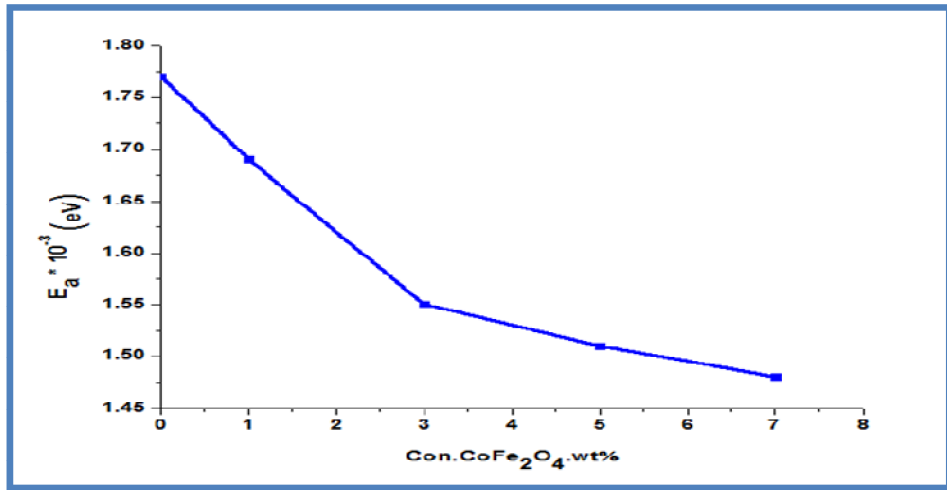
Figure (4) Variation of activation energy for D.C electrical conductivity with CoFe$_2$O$_4$ concentration for (PVA- CoFe$_2$O$_4$) composite

The low value of activation energy (1.48×10^{-3} ev) at higher (CoFe$_2$O$_4$)concentration . The amount of interconnecting network is increased , this enhance the conduction between (CoFe$_2$O$_4$)particles and lead to decrease of the activation energy[17].

IV. CONCLUSION

1. The D.C electrical conductivity of the Polyvinyl alcohol(PVA) increases with increasing of (CoFe$_2$O$_4$) concentrations and temperature .

2. The activation energy of D.C electrical conductivity is decreases with increasing the (CoFe$_2$O$_4$)concentrations .

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