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# Preparation and characterization of (PS-$CoCl_2$) and (PS-$MnCl_2$) Composites

D. Al-Khafagiy[1], Farhan Lafta Rashid[2], Ahmed Hashim[3] and Mohammed A. Mahdi[2]

[1]Babylon University, College of Engineering, Babylon, Iraq.

[2]Ministry of Science and Technology, Baghdad-Iraq.

[3]Babylon University, College of Education, Department of physics, Iraq.

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ABSTRACT

The present paper is focused on the modification of the properties of polystyrene by adding cobalt chloride and manganese chloride. The composites are prepared using casting technique with different percentages of fillers. The experimental results show that the D.C conductivity of composites increases with the increase of cobalt chloride and manganese chloride concentrations. The D.C electrical conductivity changes with increasing of temperature. Also the activation energy of electrical conductivity of (PS-$CoCl_2$) and (PS-$MnCl_2$) composites decreases with increasing cobalt chloride and manganese chloride concentrations.



## Introduction

Composites present many engineering advantages over synthetic polymers and copolymers: by adding fillers, that can be constituted by other polymers, ceramics, metals, or even air, a virtually infinite variety of materials with tailored physical properties and competitive costs can be produced. In these materials, an interfacial region is defined and usually described in terms of polymer/filler adhesion which plays a major role on the properties[1]. Composite materials, which are usually fabricated with an emphasis on properties such mechanical strength, have also been used in electronic applications. Integrated decoupling capacitors, angular acceleration accelerometers, acoustic emission sensors and electronic packing are some potential applications[2].

The amazing properties of polymers and polymeric composite materials led to their extensively used in a variety of engineering industries. These properties have great impact on the development of new products and replacement of metallic materials in many applications. Polymeric composite materials exhibit superior mechanical, thermal, cryogenic and dynamic properties that have great impact on the developing the automotive, aircraft, and aerospace applications[3], Khissi *et al*,[4] studied the D.C electrical conductivity of copolymer/carbon black composites.

They found that the conduction, in the high temperature region ($T > Tg$), is due to thermally activated tunneling of charge carriers in the band, and, in the low temperature range ($T < Tg$), conduction takes place through variable range hopping in the localized states near the Fermi level.

The present work deals with the effect of cobalt chloride and manganese chloride on the D.C electrical properties of polystyrene composite.

## Materials and Methods

The materials used in this paper are polystyrene as matrix and cobalt chloride and manganese chloride as fillers. The weight percentages of cobalt chloride and manganese chloride are (0,4,8 and 12)wt.%. The specimens were prepared using casting technique with thickness ranged between (210-640)µm. The resistivity was measured over a range of temperature from (30 to 80)$^o$C using Keithly electrometer .The electrical conductivity $\sigma_V$ was calculate by :

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

Where :

A = guard electrode effective area.

R = volume resistance (Ohm) .

L = average thickness of sample (cm) .

The activation energy was calculated using the following equation :

$$\sigma = \sigma_o \exp(-E_a/k_BT) \quad \text{......................}(2)$$

$\sigma$ = electrical conductivity at T temperature.

$\sigma_o$= electrical conductivity at absolute zero of temperature.

$K_B$ = Boltzmann constant.

$E_a$ = Activation Energy.

## Results and Discussion

The variations of electrical conductivity with weight percentages of cobalt chloride and manganese chloride at room temperature are shown in figures(1 and 2).

The figures show an the increase of the electrical conductivity with weight percentages of cobalt chloride and manganese chloride. This is related to the increase of ionic charges which can be increased due to the increase fillers content[5]

Tele:

E-mail addresses: engfarhan71@gmail.com

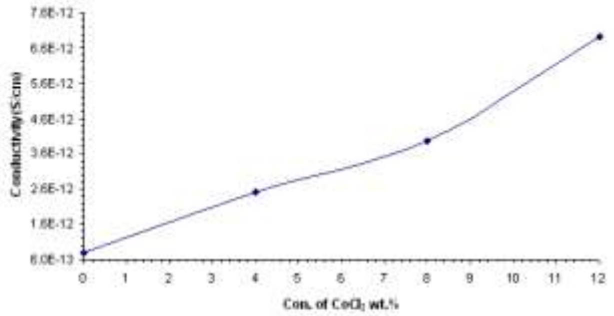


FIG.1
Variation of D.C electrical conductivity with $CoCl_2$ wt.% concentration of composite.

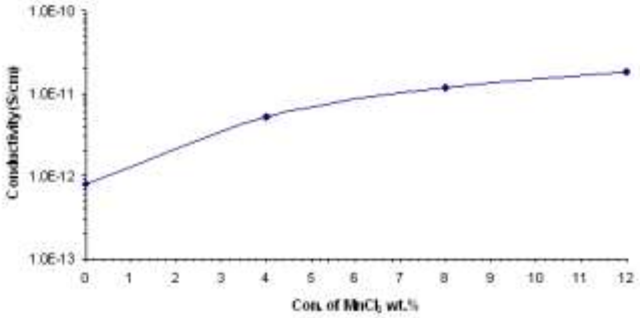


FIG.2
Variation of D.C electrical conductivity with $MnCl_2$ wt.% concentration for (PS-$MnCl_2$) composite.

Figures (3 and 4) show the variation of electrical conductivity of composites at different temperatures. The D.C conductivity increases with increase of the temperature, the increment in temperature provides an increase in free volume and segmental mobility. These two entities then permits free charges to hop from one site to another thus increase conductivity. The conductivity increases as temperature increases indicates more ions and electrons gained kinetic energy via., thermally activated hopping of charge carriers between trapped sites, which is temperature dependence. The sharp increase of D.C conductivity can be attributed to large heat energy absorbed by the samples and thus induce mobility of electrons. It is suggested that in this region, the band gap between valence band and conduction band reduces significantly and provides easiness for electrons to hopping from valence band to conduction band [6].

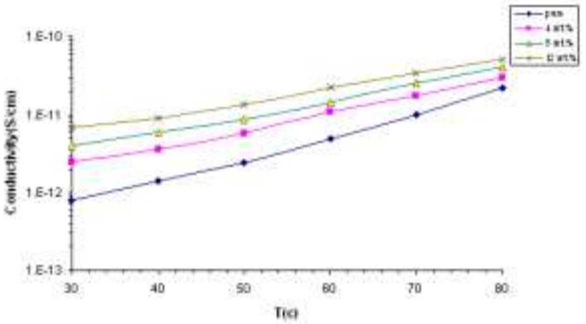


FIG.3
Variation of D.C electrical conductivity with temperature for(PS-$CoCl_2$) composite

Figures(5 and 6) show the variation of ln(conductivity) with the reciprocal of absolute temperature of the composites, using equation(2), was calculate the activation energy. The high activation energy values for neat sample and low concentrations cobalt chloride and manganese chloride samples can be attributed to the thermal movement of the ions and molecules, whereas the low activation energy values for the samples of higher cobalt chloride and manganese chloride contents can be attributed to the electronic conduction mechanism which is related to the decreasing of the distance between the cobalt chloride and manganese chloride particles[7] as shown in figures(7 and 8).

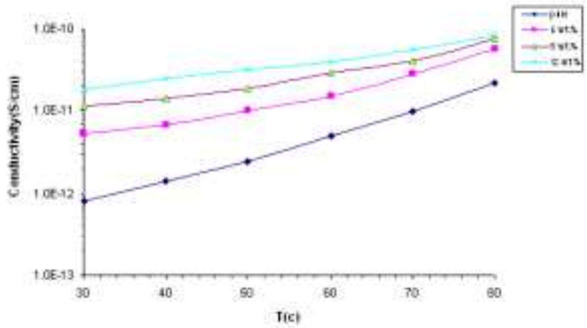


FIG.4
Variation of D.C electrical conductivity with temperature for (PS-$MnCl_2$) composite.

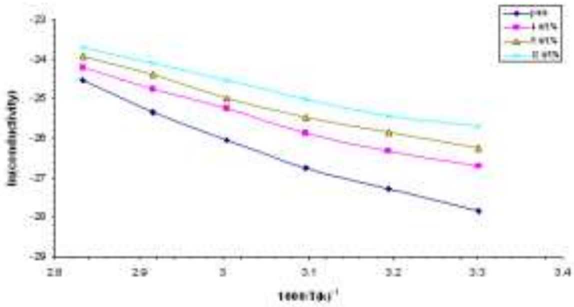


FIG.5
Variation of D.C electrical conductivity with resprocal absoute temperature for (PS-$CoCl_2$) composite.

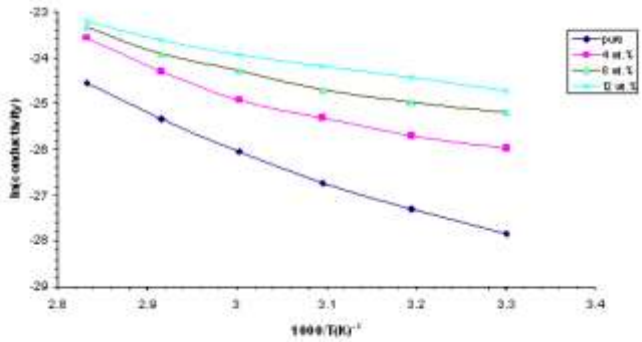


FIG.6
Variation of D.C electrical conductivity with resprocal absoute temperature for( PS-$MnCl_2$) composite.

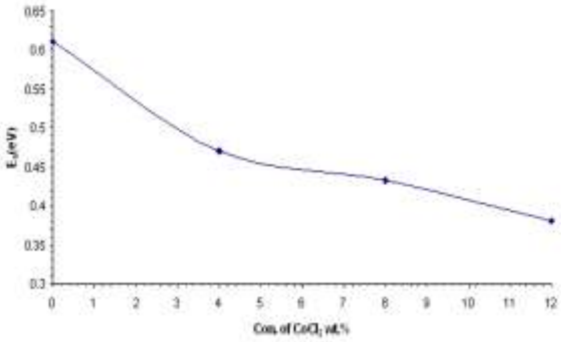


FIG.7
Variation activation energy for D.C electrical conductivity with $CoCl_2$ wt.% concentration for (PS-$CoCl_2$) composite

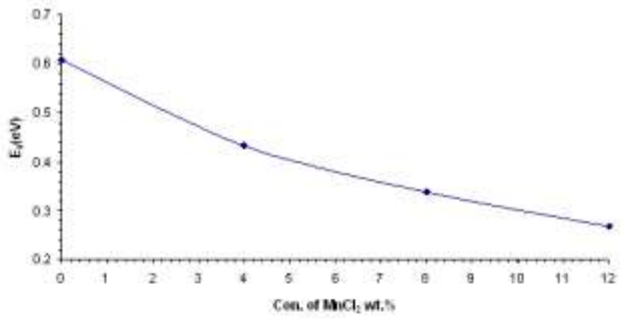


FIG 8
Variation activation energy for D.C electrical conductivity with $MnCl_2$ wt.% concentration for ($PS$-$MnCl_2$) composite

## Conclusions

1. The electrical conductivity of polystyrene increases with increasing the cobalt chloride and manganese chloride concentrations and the temperature.
2. The activation energy of D.C electrical conductivity decreases with increasing cobalt chloride and manganese chloride concentrations.

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