

Investigation of Chloro Pentaammine Cobalt(III) Chloride- Polyvinyl Alcohol Composites

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Abstract

Conductive polymer composites have been widely used in industrial applications, such as biomedical devices, self-heating materials, electrostatic dissipation and over current protectors. This paper investigate the study of the effects of Chloro Pentaammine Cobalt(III) Chloride complexes on Electrical properties of polyvinyl alcohol. samples were prepared using casting technique. The experimental Results show that the electrical conductivity of polyvinyl alcohol is increased with increasing the weight percentages of Chloro Pentaammine Cobalt(III) Chloride complexes and temperature. The activation energy of D.C electrical conductivity is decreased with increase of Chloro Pentaammine Cobalt(III) Chloride complexes concentration.

keywords: polyvinyl alcohol, conductivity, activation energy, Composites.

Introduction

Polymer composites with improved electrical properties have been widely used in various industries including electronics, biomedical devices, automotive and aerospace as anti-static, electromagnetic shielding and electrically conductive materials. The conventional method to enhance electrical conductivity of polymers is to compound the polymer with conductive fillers. In order to obtain materials with high conductivity, high loading of conductive filler is needed. This, however, not only increases the final cost and weight of the materials, but also often impairs the mechanical properties of the materials[1]. The enhancement in electrical conductivity of insulating polymers, by mixing them with specific conductive fillers, such as metallic particles/powder/fibers, carbon black, ionic conductive polymers, and intrinsically conductive polymeric powders have found wide range of applications including EM1 (Electromagnetic Interference)/RFI (Radio Frequency Interference) shielding applications (computer and cellular phone housings, etc) to automobile tires to sensing[2]. Conjugated polymers are remarkable materials that combine the optical and electronic properties of semiconductors with the mechanical properties and processing advantages of plastics. Although these materials are often thought of as homogeneous low-cost organic analogues to inorganic semiconductors[3].

Experimental Part

• Preparation of $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$

In the fume hood, completely dissolve 6 g of NH_4Cl in ~40 mls of concentrated ammonia in a 400 ml beaker. With continuous stirring, add 12 g of cobalt(II) chloride-hexahydrate in small portions. With continued stirring of the resulting brown slurry, slowly add 10 mls of 30% H_2O_2 . After the effervescence has stopped, slowly add ~30 mls of concentrated HCl. With continued stirring, heat on a hot plate and maintain 85 o C for 20 minutes. Cool mixture to room temperature in an ice bath and filter (using a Buchner funnel) the crystals of $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$.

• Materials and Methods

PVA as a matrix and $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$ as a filler. The electronic balanced of accuracy 10^{-4} have been used to obtained a weight amount of polymer and complex. The samples were prepared using casting technique thickness ranged between (205-655) μm The resistivity was measured over range of temperature from (50 to 80) $^\circ\text{C}$ using Keithly electrometer. The electrical conductivity σ_V was calculate by :[1]

$$\rho = \frac{RA}{L} \dots\dots\dots (1)$$

$$\sigma = \frac{1}{\rho} \dots\dots\dots (2)$$

Where :

A = guard electrode effective area.

R = volume resistance (Ohm) .

L = average thickness of sample (cm) .

The activation energy was calculated using equation :

$\sigma = \sigma_0 \exp(-E_a/k_B T)$(3)
 σ = electrical conductivity at T temperature
 σ_0 = electrical conductivity at absolute zero of temperature
 K_B = Boltzmann constant
 E_a = Activation Energy

Results and Discussion

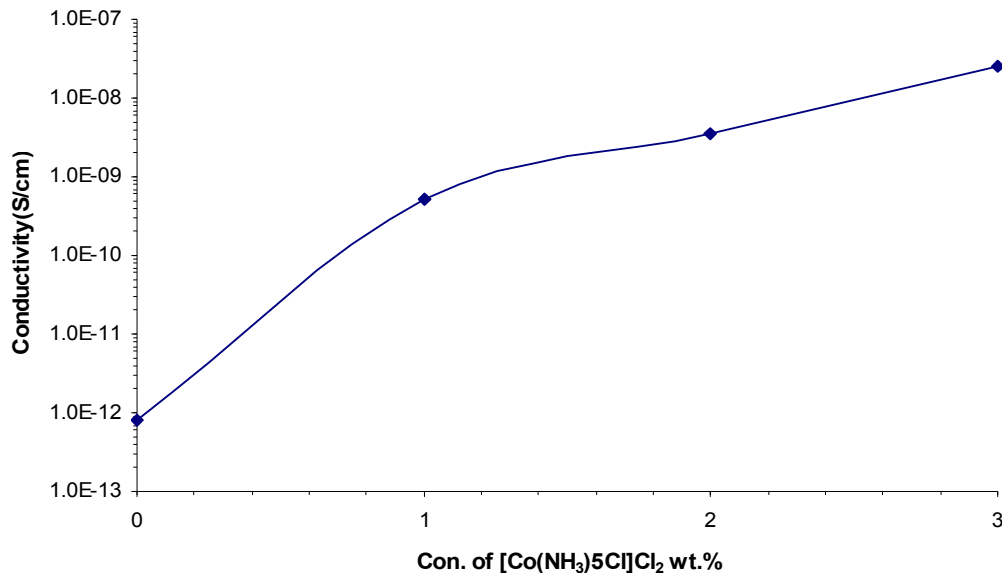


FIG. 1: Variation of electrical conductivity as function of the concentration of complexes

The variation of electrical conductivity as function of the concentration of complexes at temperature (50⁰C) is shown in figure(1). The electrical conductivity of composites increases with increase Chloro Pentaammine Cobalt(III) Chloride complexes particles concentration. This result may be attributed to the increasing in the ionic charge that can be due to increase the electrical conductivity with increase the Chloro Pentaammine Cobalt(III) Chloride complexes particles concentration. When the Chloro Pentaammine Cobalt(III) Chloride complexes particles concentration is higher the net work starts to connect to each other to form some kind of conductive path through the polymer matrix[4].

Figure (2) shows the variation of the electrical conductivity of composite with temperature of different concentration of complexes. The figure shows that the increase in temperature could result in increased polymer chain mobility and also causing more increased movement of the Chloro Pentaammine Cobalt(III) Chloride complexes particles that adhere (coat) to the polymer or are near the polymer chain trying to form percolation network. Hence a decrease in composite resistance (or increase in conductance) may be caused by more tunneling contribution as compared to percolation networks that would seem to be incompletely formed at such low content and would get disrupted with increasing temperature. As the Chloro Pentaammine Cobalt(III) Chloride complexes loading increases to 3 wt.% percolation networks are forming; hence an increase in temperature results in lesser mobility of the chains[3].

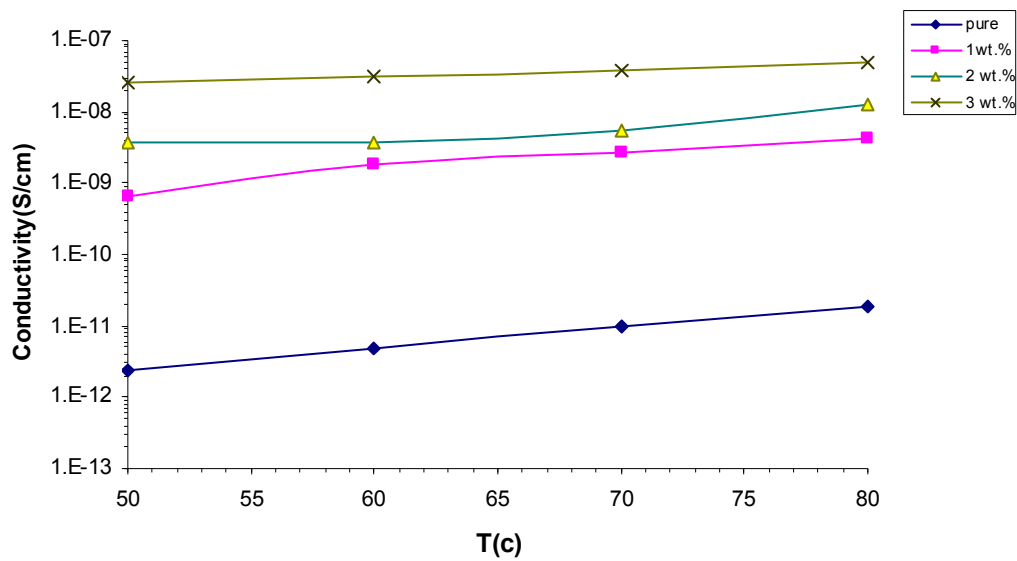


FIG.2: Variation of the electrical conductivity of (PVA-[Co(NH₃)₅Cl]Cl₂) composite with temperature

The relationship between the $\ln(\text{conductivity})$ and inverted absolute temperature of the composites is shown in figure(3). This figure shows that high values of activation energy these high values are attributed to the existence of free ions in the polymer[5]. The activation energy is related to the energy barrier preventing polymer chain movement from one location to another[6].

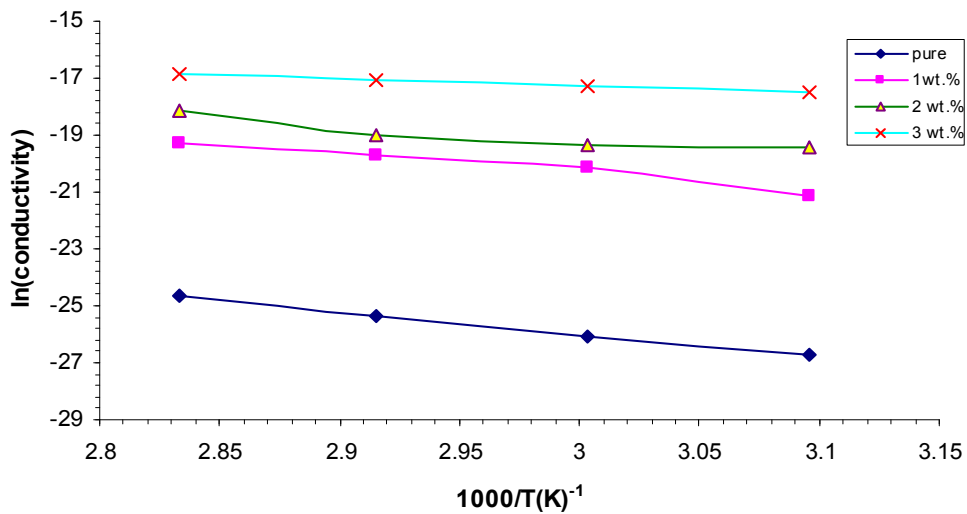


FIG.3: Variation of D.C electrical conductivity with reciprocal absolute temperature for composite.

The addition of low concentrations of complexes 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 concentrations of the Chloro Pentaammine Cobalt(III) Chloride complexes, the activation energy decreases as a result of the increase of local centers [7], as shown in figure(4)

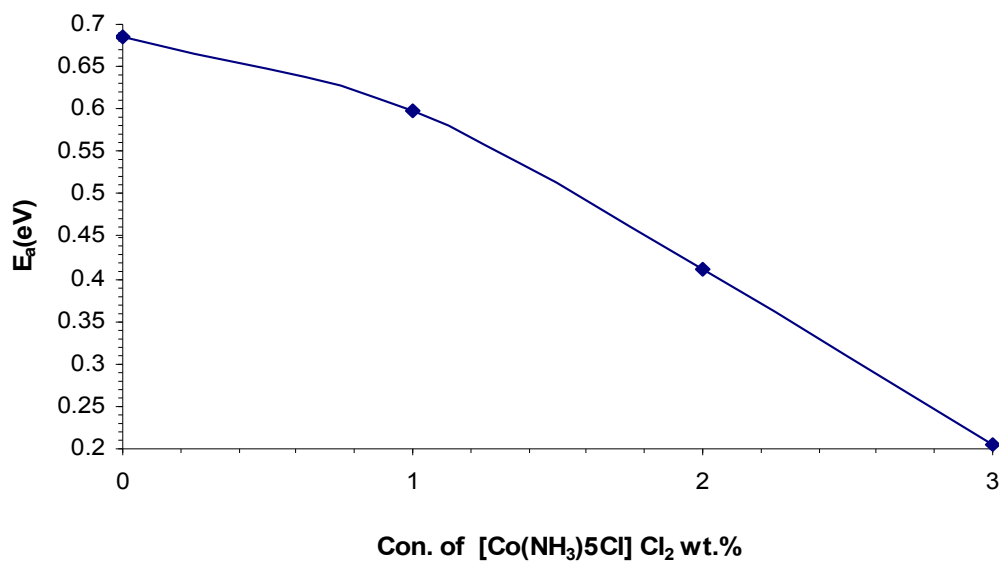


FIG.4: Variation activation energy for D.C electrical conductivity of composite with $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$ concentration .

Conclusions

1. The D.C electrical conductivity of the poly-vinyl alcohol increases by several order of magnitude with increasing the Chloro Pentaammine Cobalt(III) Chloride complexes concentrations and the temperature.
2. The activation energy of D.C electrical conductivity decreases with increasing Chloro Pentaammine Cobalt(III) Chloride complexes concentrations.

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