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ELECTRICAL CONDUCTIVITY & ACTIVATION OF CONDUCTIVITY OF SYNTHESIZED TETRAHEDRAL CRYSTAL

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Abstract - This investigation involved the synthesis and Electrical characterization of Crystals of p-dimethylaminobenzaldehyde and o-phenylenediamine Ligand with Cu(II), Fe(III) and Ni(II) metal. An electrical conductivity of all crystals was measure at different temperature. Crystals were combined and form a tabulate of 6 mm diameter. It was heated at a 1oC / min. From the conductivity of crystals resistivity was also carried out and hence Specific resistivity was also carried out from the size of tabulate. Activation energy (E) of all crystals were calculated using the available data.

Keyword - Electrical Conduction, Electrical Conductivity, Specific Resistivity, Activation Energy.

I. INTRODUCTION

Many attempts have been made to synthesize new materials which can be used as semiconductors [1,2]. Some of the organic compounds do show good conductivity, photo conductivity etc. [3,4]. The band gap and the conductivity of such compound should fall within the required range and should be also easy to prepare. The main drawback of organic compounds is low carrier mobility. The reasons for this are: (a) organic compounds form molecular crystals and the force between the adjacent molecules are relatively weak. There is ultimately little electrical coupling between adjacent molecule and thus electrons find it difficult to jump from one molecules to another. (b) meny of these are amorphous in nature. The lack of ordered structure in such materials has the effect of scattering electrons when they try to flow through it and hence lowers the conductivity. To measure electrical conductivity of such types of crystals a tabulation form of crystals were required[5,6].

II. EXPERIMENTAL

A. Materials

The ligand which is a Schiff base obtained from p-dimethylaminobenzaldehyde and o-phenylenediamine were used. The stock solution of $CuCl_2$, $FeCl_3$, $NiCl_2$, were prepared.

B. Preparation of Schiff base

p- dimethylaminobenzaldehyde (1.4919 gm 0.1 mol) solution in ethanol and o-phenylenediamine (1.0814 gm 0.1 mol) solution in hot water were taken in round bottomed flask, 50 ml absolute ethanol was added and the mixture was refluxed for 3 hour. The refluxed mixture was put in ice bath, and then orange colored precipitate was obtained. It was suctioned filtered and washed with distilled water. Schiff base obtained was dried and kept in vacuum desiccators. The pure Schiff base was recrystallized from absolute ethanol

C. Preparation of crystals

The crystals were prepared by mixing Schiff base (0.1mol) in hot ethanol solution to (0.1mol) metal chloride salt solution prepared in distilled water. The Schiff base solution was added slowly with continuous stirring to metal solution. It was refluxed for 2 hours and after refluxation, the mixture was heated for 10 minutes till the contents was reduced to half. Then the crystals precipitated out after being cooled. The precipitate was filtered and washed with the distilled water. All crystals were dried and kept in vacuum desiccators.

D. Electrical Conductivity Measurement

To measure electrical conductivity of all crystal a crystal were combined and form a tabulate of 6 mm diameter. Tabulate form of crystal was prepared at S. K. Patel college of Pharmaceutical Education and Research, Ganpat University, Kherva, Gujarat. A rotary Tablet machine was used to prepare tabulate of crystals with hydrostatic pressure. A machine required minimum quantity of 100mg and maximum of 1000mg. An electrical conductivity of all crystals was measured at Department of Chemistry, S. P. University, V. V. Nagar, Gujarat. High resistance electrometer was used to measure electrical conductivity. The instrument works in a dynamic mode. The temperature was varied for measurement of conductivity of all crystals.

III. RESULT AND DISCUSSION

An electrical conductivity of all crystal was measure at different temperature. A uniform thin layer of silver paste was applied on both the sides of the pallet of crystals, providing electrical contacts. Average diameter and thickness of each pallet were measured and found 6 mm. The pallet was firmly pressed between two circular metal disks functioning as electrodes. The other ends of electrodes were passed through the pallet holder for connections. The entire assembly was placed in a furnace. It was heated at a 1^oC / min. Examination of result presented in Table – 1 reveals that the electrical conductivity of all crystals from 10^{-5} to 10^{-6} Ω^{-1} cm^{-1} at 25^oC. Thus the conductivity of all crystal increases with increases with temperature, slowly initially and very rapidly after some point between 400^oK to 500^oK depending upon the nature of material used to prepare crystal. The plots of electrical conductivity versus 1/T shown in figure 1 to figure 3 for all the samples are found to be near about linear in the higher temperature range, the temperature at which this occure designated as the break temperature. It is worth nothing that the electrical conductivity of crystals is highly dependent on the nature of material structure, the nature of metal and the size and shape of the ligand associate with crystal. In the present cases there would be linear structure of the crystal because the crystal formed through metal and schiffbase. However the results of our electrical conductivity measurments of all of the crystals reveal that they can be ranked as semiconducting materials with high resistance.

It was indicated earlier that the conductivity of semiconducting material is related to temperature exponentially [6].

$$\sigma = \sigma_0 \exp(-E/KT)$$

Where, K = Boltzmann constant (0.8625 x 10^{-4} ev deg^{-1})

T = absolute temperature

σ_0 = Conductivity at infinite temperature,

E = activation energy.

The relation is relation is written in a different form as follows:

$$\log \sigma = \log \sigma_0 + (-E/2.303\ KT)$$

According to the relation, plot of log σ vs. 1/T would be linear with a negative slope. Such plots were made on the basis of each set of data.

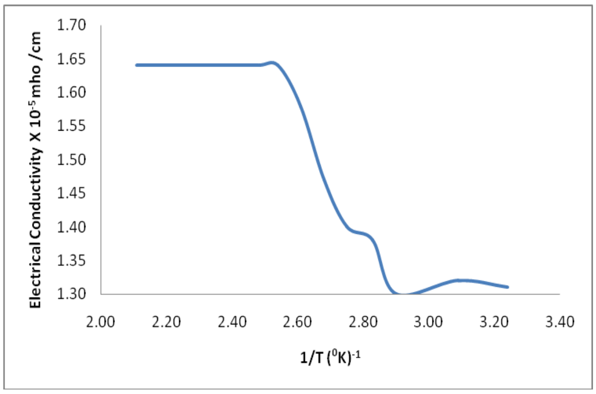

Fig.1 - Electrical conductivity curve of Cu(II) crystal

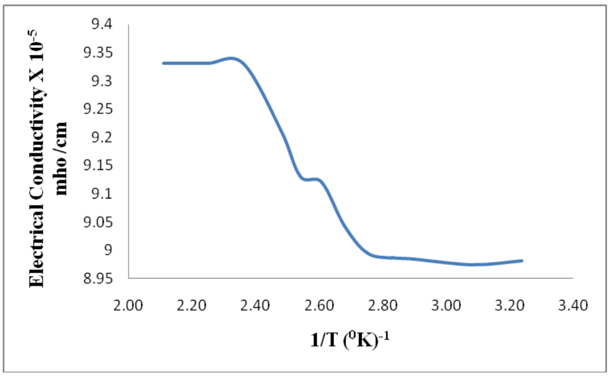

Fig.2 - Electrical conductivity curve of Fe(III) crystal

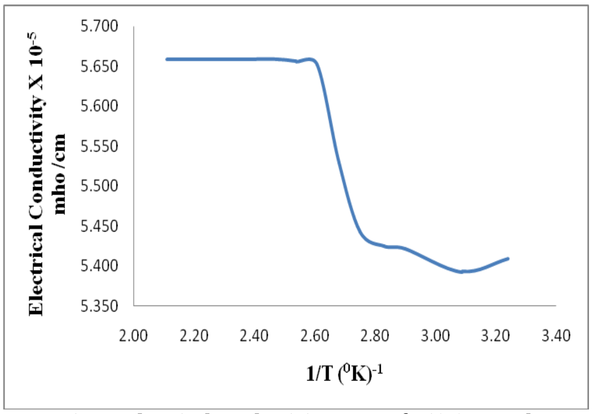

Fig.3 - Electrical conductivity curve of Ni(II) crystal

Table I - Electrical Conductivity of Crystals at Temperature

$1/T\ (^0K)^{-1}$	Electrical conductivity σ (mho per cm)of crystals (at temperature)			Activation Energy (E) of Crystals In eV		
	Crystal of Cu(II)	Crystal of Fe(III)	Crystal of Ni(II)	Crystal of Cu(II)	Crystal of Fe(III)	Crystal of Ni(II)
3.24	$1.31x10^{-5}$	$8.982x10^{-6}$	$5.409x10^{-5}$	0.0067	0.0007	0.0067
3.09	$1.32x10^{-5}$	$8.975x10^{-6}$	$5.393x10^{-5}$	0.0072	0.0007	0.0072
2.19	$1.30x10^{-5}$	$8.985x10^{-6}$	$5.422x10^{-5}$	0.0063	0.0007	0.0063
2.83	$1.38x10^{-5}$	$8.987x10^{-6}$	$5.425x10^{-5}$	0.0062	0.0007	0.0062
2.75	$1.40x10^{-5}$	$8.996x10^{-6}$	$5.443x10^{-5}$	0.0056	0.0006	0.0056
2.68	$1.47x10^{-5}$	$9.044x10^{-6}$	$5.530x10^{-5}$	0.0029	0.0005	0.0029
2.61	$1.58x10^{-5}$	$9.120x10^{-6}$	$5.652x10^{-5}$	-0.0009	0.0004	-0.0009
2.54	$1.64x10^{-5}$	$9.131x10^{-6}$	$5.656x10^{-5}$	-0.0010	0.0004	-0.0010
2.48	$1.64x10^{-5}$	$9.213x10^{-6}$	$5.659x10^{-5}$	-0.0011	0.0002	-0.0011
2.36	$1.64x10^{-5}$	$9.131x10^{-6}$	$5.659x10^{-5}$	-0.0011	0.0004	-0.0011
2.25	$1.64x10^{-5}$	$9.331x10^{-6}$	$5.659x10^{-5}$	-0.0011	0.0000	-0.0011
2.15	$1.64x10^{-5}$	$9.331x10^{-6}$	$5.659x10^{-5}$	-0.0011	0.0000	-0.0011
2.11	$1.64x10^{-5}$	$9.331x10^{-6}$	$5.659x10^{-5}$	-0.0011	0.0000	-0.0011

- **Value of Activation Energy of Conductivity of Cu(II) crystal = 0.0058 eV**
- **Value of Activation Energy of Conductivity of Fe(III) crystal = 0.00051 eV**
- **Value of Activation Energy of Conductivity of Ni(II) crystal = 0.0058 eV**

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