# Variation Of Conductivity Of Composite Polyaniline with Frequency and Temperature

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**ABSTRACT**

*This paper studies the effect on electrical conductivity of* cadmium chloride doped polyaniline *with frequency and temperature. The ac electrical conductivities as a function of temperature and frequency was measured. The ac conductivity is temperature dependent and it follows the equation* $\sigma_{ac} = A\ \omega^{s}$. *The value of the frequency exponent "S" was calculated for all the investigated samples* .

**Keywords:**, *Ac conductivity*, Cadmium Chloride, Composites, *Polyaniline*

**Introduction:**

The small concentration of dopant anion results in semiconducting polymer with significant band gap where as the dopant concentration give rise to highly conductive polymers. Conductive polymer composites are attractive materials for use in existing and emerging technologies due to their light weight, low cost, and versatility compared with other standard semiconductors. They can be fabricated by filling an insulation polymer matrix with conducting particles such as metal flakes or metalized fibres, by chemical or electrochemical synthesis method to produce intrinsically conductive polymers [1]. Conductive polyaniline (PANI) has been studied extensively because of its ease of synthesis in aqueous media, its environmental stability and special electrical and other properties. PANI has become a suitable candidate for a variety of technological applications [2-4], such as solar cells, electromagnetic shielding, electrodes for rechargeable batteries, sensors, etc. These composites have the ability to enhance their material properties with desirable mechanical and physical characteristics. The present study focuses on the investigation of the ac conductivity as well as IR spectra of doped polyaniline, X-ray diffraction, Energy Dispersive Spectroscopy and Scanning electron microscopy.

**Materials and Methods:**

All the materials were obtained from well known companies. Regents Ammonium persulfate (APS) was obtained from Merk-Extra pure, Cadmium chloride was obtained from Research Lab Fine Chem. Industries of AR grade and Aniline Hydrochloride of Loba Chemie pvt. Ltd..

**Preparation of samples** :

All materials were used as provided. Aniline hydrochloride was dissolved in distilled water in a volumetric flask to 50mL of solution. Ammonium peroxydisulfate was dissolved in distilled water also to 50ml of solution. Both solutions were kept for an hour at room temperature then mixed in a beaker, briefly stirred, and left at rest to polymerize. Next day after the reaction was over, polyaniline in the form of powder was obtained. The precipitated polyaniline was filtered by conventional method. The polymer was washed with distilled water. The polyaniline samples obtained in powder form were dried first at room temperature for few hours and then finally dried in an oven kept at $60^{o}$C- $90^{0}$C for 1/2-1 hours. The dried polymer powder was then preserved for sample preparation.[5,6] PANI samples with Cadmium chloride were prepared in the aqueous medium with aniline hydrochloride.

**Measurement:**

**IR Spectra:** IR spectroscopy is important and useful technique for determining functional groups present in a compound. Studies were carried out in order to confirm the presence of Cadmium chloride in the polyaniline/doping concentration of polyaniline with different dopants. The powder samples were mixed in KBr to record the spectra. IR spectra of the samples was taken using a spectrometer (SHIMADZU IRAFFINITY1).The characteristic absorption bands thus obtained are shown in Figure 4. Result shows that ,there is a shift in the responses after doping the samples with Cadmium chloride.

**AC Measurement:**

The Measurements were carried out in the temperature range 308-358 K and in frequency range 20 Hz to 1MHz using AGILENT 4284A LCR precision meter. The thickness of the pellet was measured by DIGIMATIC micrometer.

The ac conductivity $\sigma_{ac}$ was calculated according to following relation.

$$\sigma_{ac} = t/ZA \qquad \text{------ (1)}$$

Where, t is the pellet thickness, A is the sample area and Z is the impedance of the pellet.

**Results and discussion** :

**Frequency dependence of ac conductivity** :

The frequency dependence of ac electrical conductivity $\sigma_{ac}$ was measured for all investigated pellets. The plots of log ω against log $\sigma_{ac(}$ ω) at different temperatures in the frequency range 20 Hz to 1MHz is shown in figure 1. It is observed that ac conductivity( $\sigma_{ac}$) increases with increasing frequency. According to [7]. the ac conductivity $\sigma_{ac}$ *of amorphous semiconductors is usually expressed as*

$$\sigma ac = \sigma_T - \sigma dc = A\,\omega^s \qquad (2)$$

Where ω is the angular frequency of the applied field (ω= 2πf), $\sigma_T$ is the total electrical conductivity including the frequency dependent conductivity under ac field, and dc conductivity. A is the constant which

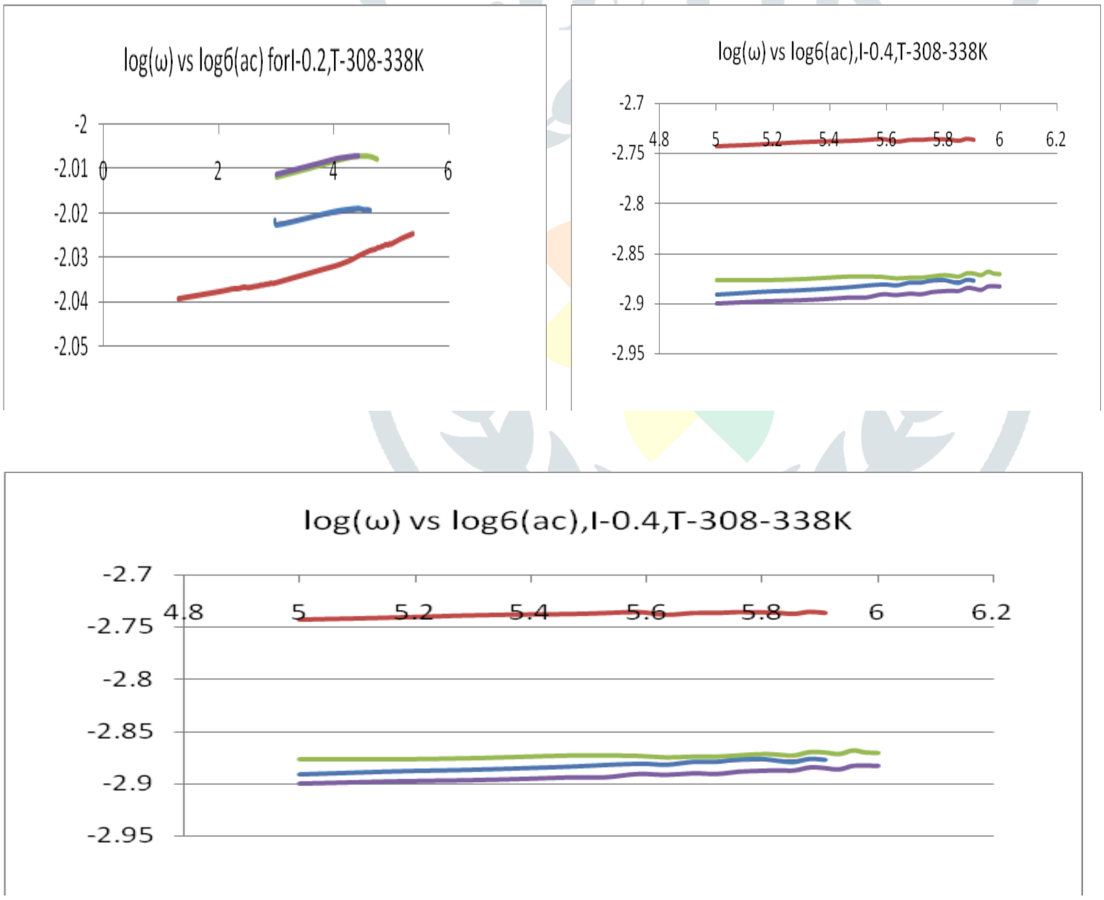



Fig.1- The variation of ac electrical conductivity with frequency (log ω versus log σac) for all doped polyaniline composite pellet in the temperature range 308 to 338 K.

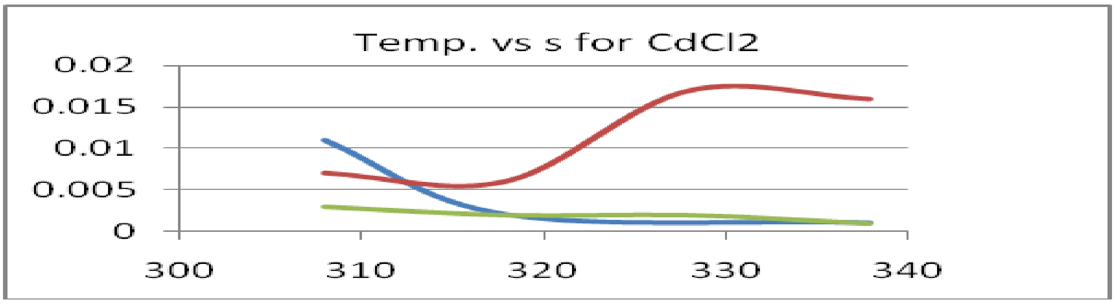



Figure 2: Variation of s with temp.(experimentally)

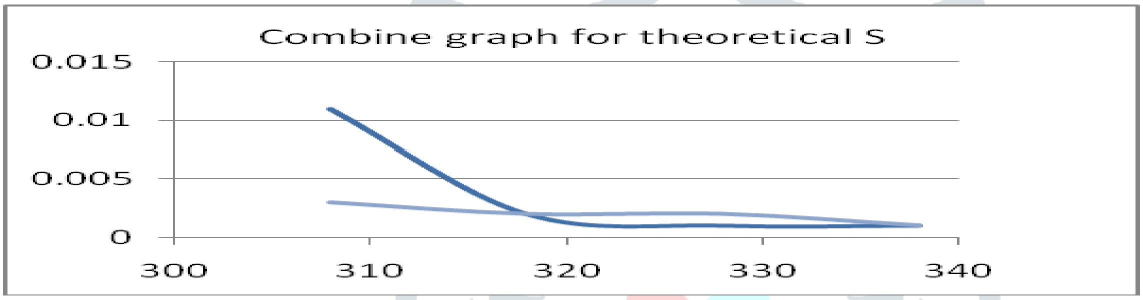
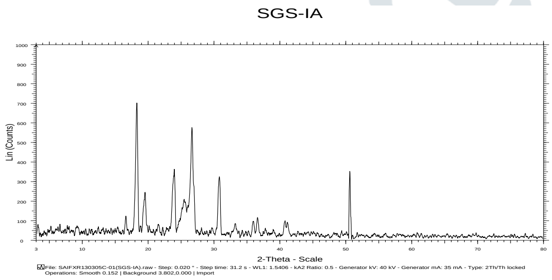



Figure 3: Variation of s with temperature (theoretically)

*XRD:*



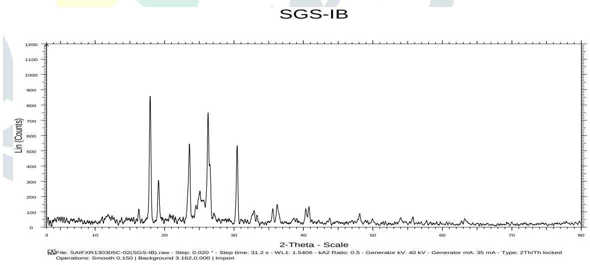
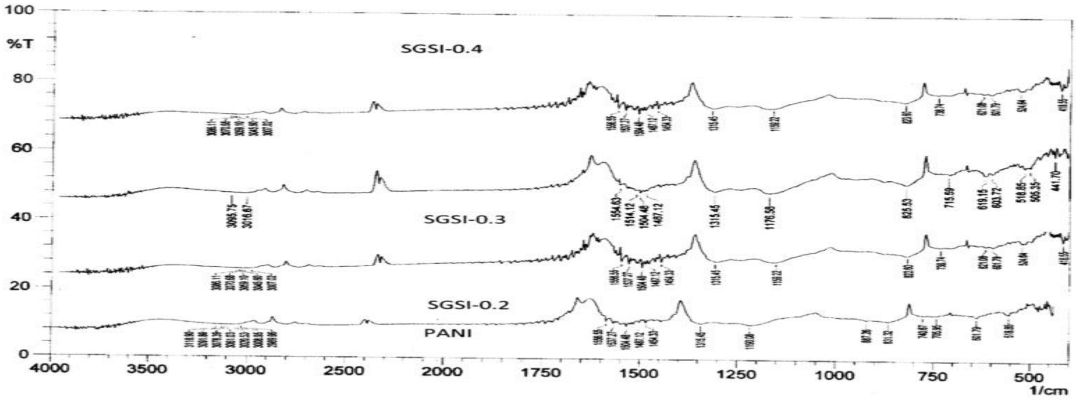




Figure 3.1(a) Figure 3.1(b)

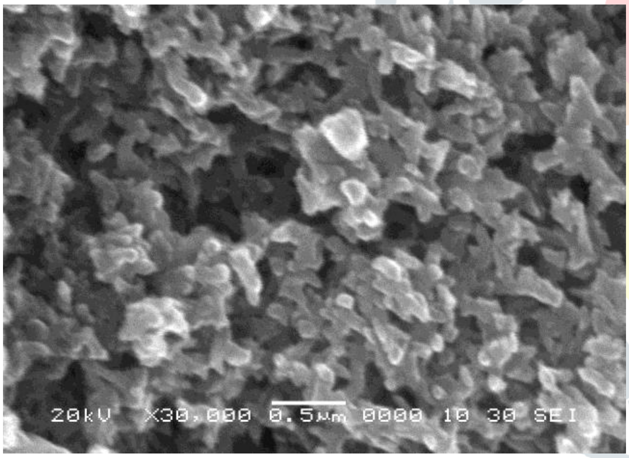
PANI+ Cadmium chloride ($CdCl_2$): Figure 3.1(a) and 3.1(b) shows the XRD pattern of $CdCl_2$ doped polyaniline. The sharpness in the peak shows semi crystalline nature of the $CdCl_2$ doped polyaniline. The X-RD spectra for doped polyaniline show large variation in the peak. The incorporation of $CdCl_2$ in polyaniline, increases crystallinity which indicates the well dispersion of cadmium chloride in polymer matrix. The characteristic peak of polyaniline has been shifted slightly in these composites.

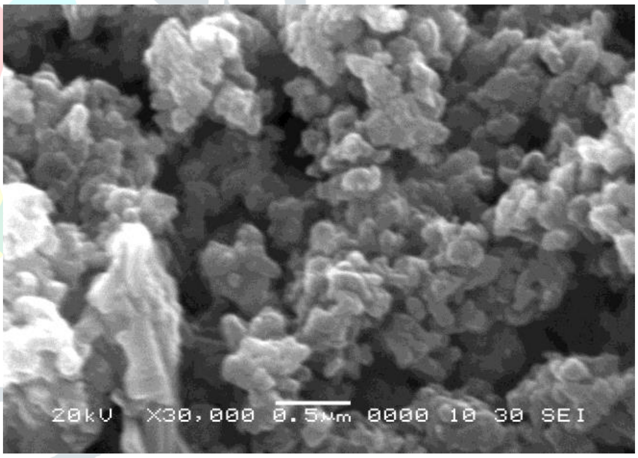
Figure 4: IR Spectra of pure polyaniline and doped polyaniline



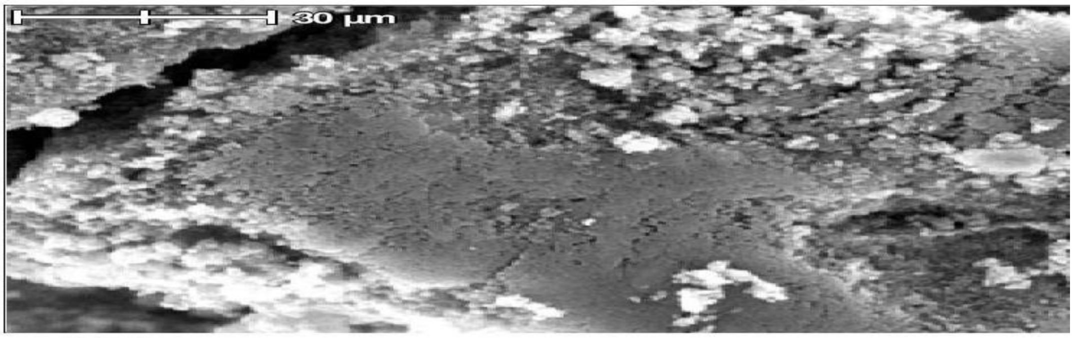

**Scanning Electron Microscopy:**

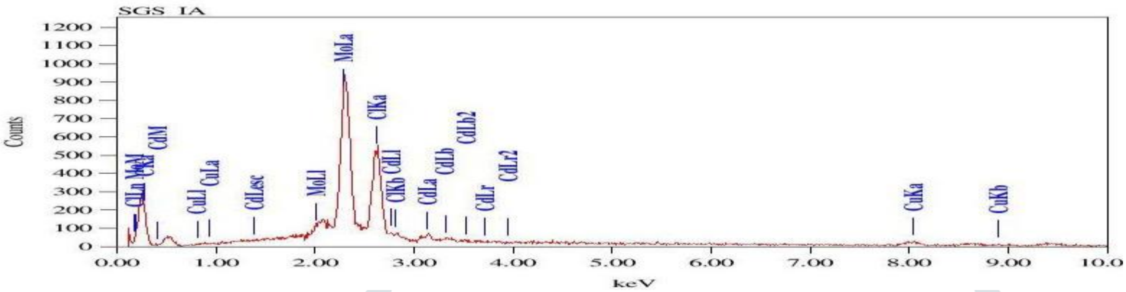
SEM images shows that the particles of this semiconductor can easily be synthesized by precipitation method. From the SEM image it is observed that, grains are well resolved. The morphology of the materials shows agglomerated form of particles and are of irregular nature. From the Energy Dispersive Spectroscopy (EDAX) analysis at different portion of the SEM image it is also confirmed that dopants were uniformly distributed in the polymer matrix.




EDAX:




The presence of cadmium chloride is confirmed from EDAX . spectrum

**Conclusion** :

The ac electrical conductivity of cadmium chloride doped polyaniline pellets of different wt % have been investigated in the frequency range 20 Hz -1MHz and temperature range 308-358 K. From the above studies, it is observed that the $\sigma ac$ is frequency and temperature dependent and it follows the equation 2. The ac conductivity follows linearity with frequency . The temperature dependence of frequency exponent 's' was found to decrease with increasing temperature.

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