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Electrical Conductivity of Chemically Synthesized PANI/ZnS Composites

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Abstract: *Polyaniline synthesized by chemical oxidative polymerization of aniline. Subsequently, the nanocomposites of polyaniline/ZnS was prepared using different weight percentage of ZnS like 5% 10%, 15%, 20% & 25%. The dc electrical conductivity was measured using Four Probe method. The temperature dependent dc electrical conductivity increased with increase in weight percentages of ZnS in nanocomposite.*
Keywords: *Polyaniline, Chemical synthesis, ZnS, Electrical conductivity.*

I. Introduction

Among various conducting polymer polyaniline (PANI) is a unique and promising material for practical applications due to its good processability, environmental stability and reversible control of electrical properties by both charge transfer doping and protonation [1-2]. Conducting polymer nanocomposites have drawn the attention from decade years [3-5]. These materials exhibiting special mechanical, electronic, optical and magnetic properties [6-11]. Such new hybrid polymer composites cover a great range of applications including electrochromic devices, light emitting diodes, chromatography, secondary batteries, electronic discharge protection and gas sensors [12].

ZnO nanoparticles have received great attention because of their unique catalytic, electrical, gas sensing, optical properties and a large exciton bonding energy of 60MeV. Their non-toxicity, good electrical optical and piezoelectric behavior and other advantages such as their low cost and extensive applications in diverse areas are some of the reasons for this extensive attention. Zinc oxide has proven its diverse usage in different fields of application including solar cells, photo-catalysis, ultraviolet lasers, transparent conductive oxides, spintronics and gas sensors [13]. In the present work, we report about details of comparative studies on electrical properties of polyaniline/ZnS nanocomposite at different weight % of ZnS by chemical oxidization technique.

II. experimental part

2.1. Chemical Reagents

ZnS (LOBA Chemie) and aniline (LOBA Chemie) were used. 1 M sulphuric acid was prepared from concentrated sulphuric acid by suitable dilution. Oxidant Ammonium per sulphate (Aldrich) was used from Merck.

2.2. Synthesis of Polyaniline

Polymerization was carried out by the chemical oxidation of aniline in the presence of H_2SO_4 and APS (Ammonium per-sulphate) in 100ml distilled water both played the role as dopant and oxidant respectively. APS (0.4 mol) was dissolved in 100ml distilled water in a four-neck round bottom reaction flask and 0.4mol H_2SO_4 is also added under mechanical stirring for 2 hours. Aniline (0.4mol) was stirred with 0.4mol of H_2SO_4 in 100ml distilled water. The solution of APS in H_2SO_4 was then added drop-wise in the solution of aniline with vigorous stirring on a magnetic stirrer for 3 hours to initiate the aniline polymerization. The reaction was later carried out at room temperature for 6-7 hours with stirring. A dark green colored PAni suspension was obtained with precipitation. The synthesized PAni was obtained as finely dispersed particles, which were recovered from the polymerization mixture by centrifugation and washed with deionized water repeatedly until the washing liquid became completely colorless. Finally, the mixture was filtered using filtered assembly. After keeping overnight, the dark gray color precipitate was obtained. A precipitate of polyaniline was dried under at $60 - 80^oC$ for more than 8 hours.

2.3. Synthesis of PAni-ZnS Nanocomposites:

The synthesis steps of PAni/ZnS nanocomposite are similar to the synthesis method of PAni. Different amount of ZnS were dispersed into the APS solution and stirred for 1 hour prior to the addition of aniline. Aniline (0.4 mol) stirred with 0.4mol H_2SO_4 in 100 ml of distilled water were added drop-wised using burette into the APS- ZnS solution and stirred vigorously to form homogeneous dispersion [14]. For convenience, PAni Composites were prepared with different weight percentages of ZnS i.e. 5%, 10%, 15%, 20% &25%.Same synthesis conditions were maintained for all composites as that of pure PAni to compare.

III. Analytical technique

XRD spectra of all samples were taken on Philips PW - 3050/60 (Theta/Theta), Automatic X-ray diffractometer using Cu-Kα radiation of wavelength 1.5406 Å, continuous scan of 2o/ min., with an accuracy of 0.01 at 40 KV and 30 mA.

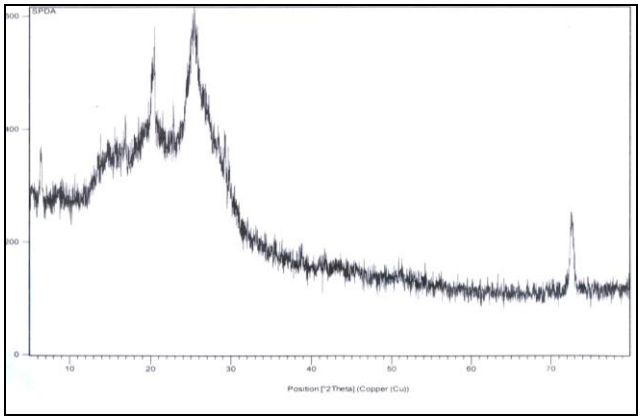

Fig.1. XRD of Pure PAni

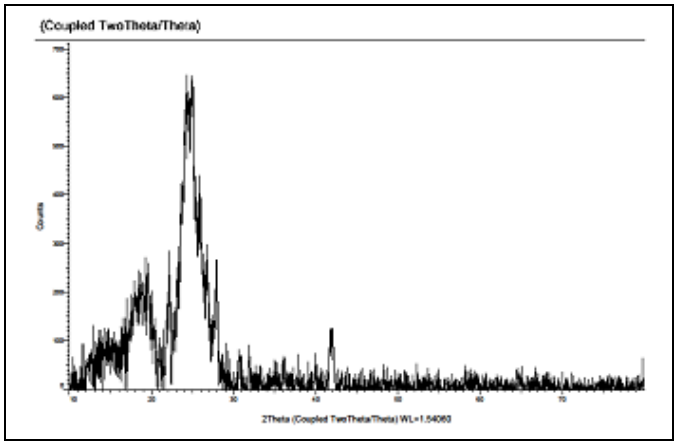

Fig.2. XRD of Pani/ZnS nanocomposite (25%)

IV. Results and discussion

The X-ray diffraction patterns of Pure PAni do not shows sharp peaks and suggest generally amorphous nature. However, it display one broad peak in the range at $2\theta = 20$ to 25^0 with the 'd' spacing of 3.50. The XRD peak for PAni/ZnS nanocomposite at (25% wt ratio of ZnS) shows maximum'd' value ,more extensive with greater degree of crystallity than pure PAni. The crystalline size of the crystalline particle can be determined using Debye Scherer formula [_0.9λ/BCosθ_]. The degree of crystallite increased in the nanocomposite hence the maximum electrical conductivity reported.

V. Electricity conductivity

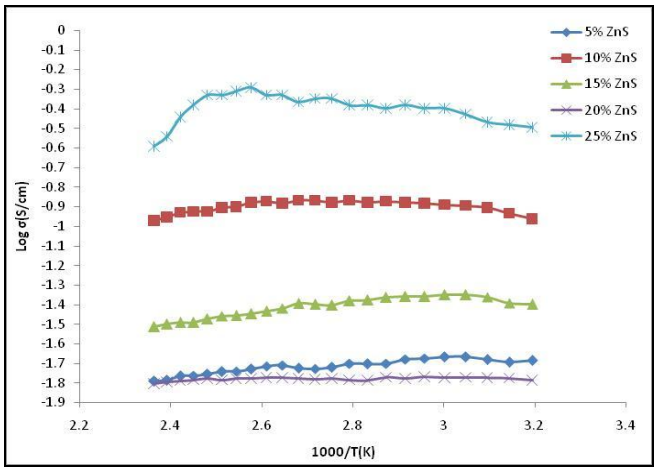

Fig.3. Electrical conductivity of PAni/ZnS Nanocomposite with different wt % of ZnS.

The DC electrical conductivity of PAni-ZnS nanocomposites (Fig.3.) is significantly higher in (25%ZnS) nanocomposite. The electrical conductivity of the Polyaniline substantially increased with the ZnS incorporation with different wt %.The conductivity depends on external factors such as compactness, delocalized length and microparticles orientation. The higher conductivity at (25%) PAni/ZnS nanocomposite is due to compactness of microparticles on the surface, maximum delocalization length and strong coupling through the grain boundary [15-16]. The lowered electrical conductivity in (10 to 20) percentage of PAni/ZnS nanocomposite$_2$ is due to random orientation of microparticle, weak coupling through the grain boundary and formation of agglomerates.

5.1. Temperature dependent electrical conductivity:

It is observed that the D.C. electrical conductivity (S/cm) of PAni/ZnS nanocomposite with different wt % of ZnS gets increases. As the suitable concentration of ZnS (25 % wt ratio) in the nanocomposite agglomeration reduced great amount and hence 25% PAni/ZnS nanocomposite shows maximum electrical conductivity. The maximum value of electrical conductivity obtained in 25% nanocomposite is 5.097×10^{-3} S/cm & pure PAni 0.6456×10^{-3}S/cm [17].The decreasing conductivity with increasing temperature in remaining composite is owing to chemical change, its degradation or evaporation of dopant and formation of agglomeration [18-19]. The increase in conductivity in 25 % nanocomposite is attributed to polymer chain mobility and activation of dopant.

VI. Conclusions

The polyaniline/ZnS nanocomposite was successfully synthesized by chemical oxidative polymerization technique. From the comparative studies on the electrical properties of PAni/ZnS nanocomposite at different wt ratio of ZnS suggested that the D.C. electrical conductivity at 115^0C is maximum at suitable wt ratio of ZnS (25%) than the other nanocomposite. The maximum value of electrical conductivity is 5.097 S/cm.

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