Study of DC Conductivity of Polyaniline Doped Zinc Oxide Nanocomposites

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Abstract

Polyaniline doped Zinc Oxide (PANI-ZnO) Nanocomposites were synthesized by chemical route method. PANI-ZnO Nanocomposites were found crystalline in nature, confirmed by X-Ray Diffraction (XRD). The DC conductivity of PANI-ZnO Nanocomposites were found to be increasing with respect to the temperature and with compared to the individual conductivity of PANI and ZnO

Keywords: *PANI-ZnO, DC Conductivity, XRD.*

Introduction

PANI, a conducting polymer, has increasing scientific and technological interests in the synthesis of a broad variety of promising materials due to its unique electrical and optical properties [1, 2]. PANI is widely used in the area of electrochemical materials, light-emitting diodes, biosensors, chemical sensors, and battery electrodes [3–5]. Recently, extensive research has been focused on the synthesis and potential applications in electronic devices to enhance the electrical properties of PANI [6]. PANI is one of the mostly studied conducting polymer because of its ease of polymerization, environmental stability and electrical conductivity. Recent studies are focused on the study of composites based on conducting PANI/metal nanoparticles for increased mechanical and electrical properties [7].

In this paper, PANI and its nanocomposites with ZnO nanorods were fabricated by in situ oxidative polymerization of aniline monomer with ammonium peroxydisulphate. All these composites have been analyzed using X-ray diffraction (XRD). The variation in *dc* conductivity of these composites was studied as a function of temperature and concentration.

Experimental

- **Preparation of PANI**

To prepare PANI, 0.2 M aniline hydrochloride and 0.25 M ammonium peroxydisulphate (APS) solutions were prepared in distilled water. Both solutions were left to cool for 1-2 h in refrigerator. Pre-cooled APS is added drop wise in aniline hydrochloride solution, maintained at a temperature in the range 0-4^{o}C in an ice bath, stirred for 2 h for oxidization and left for 24 h at rest to polymerize in refrigerator. Next day PANI precipitate was collected on a filter paper and washed with the 200 ml of 1M HCl and acetone till the filtrate became colorless. PANI (emeraldine) hydrochloride powder was dried in air and then in vacuum at 45^{o}C. Polyaniline prepared under these conditions was taken as standard sample.[8]

- **Preparation of PANI/ZnO composites**

The sample of PANI and zinc oxide composite was prepared by adding 0.1 M solution of 20 wt % of zinc oxide (dopant) to 0.2 M aniline hydrochloride (monomer) solution in distilled water. The solution was vigorously stirred for 1 h in order to keep the zinc oxide suspended in the solution. Also 0.25 M ammonium peroxydisulphate (APS) solution was prepared in distilled water. All the solutions were pre-cooled before mixing. The aqueous solution of APS (0.25 M) was added drop wise in the beaker containing the mixed solution of monomer and dopant, maintained at temperature in the range 0-4^{o}C in an ice bath. Then this solution was stirred for 2 h for oxidization and left for 24 h at rest to polymerize in refrigerator. Next day precipitate of the composite of PANI/zinc oxide was collected on a filter paper and washed with the 200 ml of 1M HCl and acetone till the filtrate became colorless. Precipitate of the sample was dried in air and then in vacuum at 45^{o}C. Following this procedure, five different samples of PANI/zinc oxide composites with 20, 40, 60 wt% of zinc oxide were prepared and named as PZ1, PZ2 and PZ3.

- **Preparation of sample:**

Sample code	Composition	Thickness(mm)
PZ1	80 % PANI+10 % ZnO	1.245
PZ2	60 % PANI+40%ZnO	1.379
PZ3	40 % PANI + 60% ZnO	1.441

Result and Discussion

- **XRD analysis**

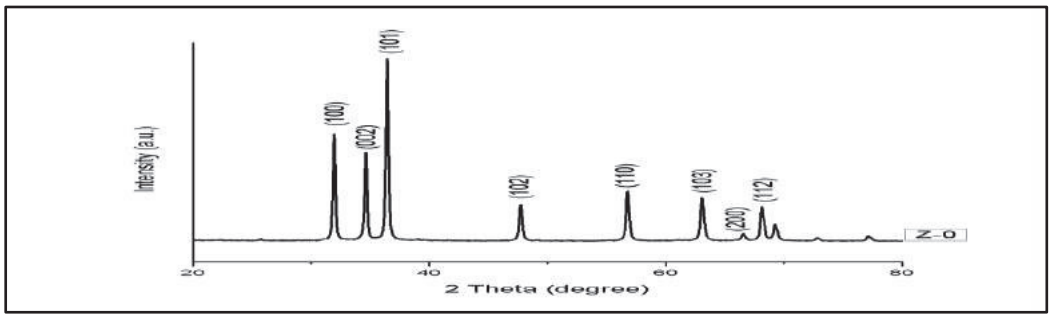

Figure 1. XRD of pristine ZnO

Figure 3.1. shows XRD pattern of pristine material ZnO, The XRD pattern of pristine zinc oxide (ZnO) nanostructure synthesized by liquid phase method via solid state method calcinated at 800^{o}C as shown in figure 1.The crystalline nature with 2θ peak lying at (100), (002), (101), (102), (110) and (103) planes. All the peaks match well the standard hexagonal wurtize structure of zinc oxide (ZnO) with lattice constants a = b = 0.3249 nm and c = 0.5206 nm [JCPDS card no. 36-1451]. All the peaks are perfectly match with pure ZnO structure, which indicates the high purity of the obtained ZnO nanoparticle. The average crystalline size was found to be 37.32 nm calculated by Deye-Scherrer formula.

- **dc conductivity**

The powder of PANI/zinc oxide composites are crushed finely in agate pestle-mortar. This powder is pressed to form pellets of thickness is nearly 1.5 mm by applying pressure of 10 tons and coated with silver paint on both sides of the surfaces to obtain better contacts.

The log of current (I) – log of voltage (V) characteristics of PANI/ZnO composite with 20 wt% of ZnO at various temperatures is shown in fig.2. It was observed that, ln(I) increases with increase on ln(V). It was also manifested, the nature of graph is nearly straight line with constant slope i.e. it obey Ohm's law (linear ohmic material) on logarithmic scale.

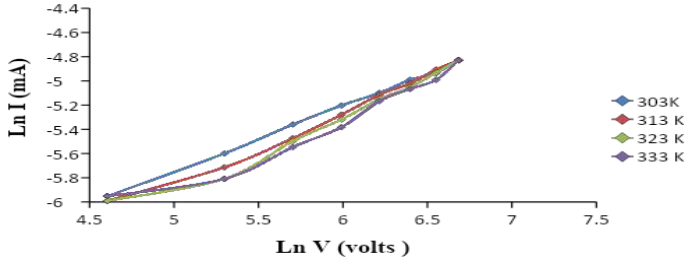

Fig. 2 – I-V characteristics of PANI/ZnO composites (20 wt%) at various temperatures

From fig 3, it was observed that as temperature increases, ln(σ)increases. This variation is maximum for PZ1 sample. Due to increase of temperature, more and more charges in PZ1 samples become free and contribute to the conductivity and electrical conductivity increases. Slope of the PZ1 sample curve is maximum among the samples. As doping of ZnO in PANI increases, electrical conductivity increases and becomes maximum for 80% PANI +20% ZnO sample (PZ1 sample) and further increase in doping of ZnO in PANI, conductivity decreases. This decrease may be due to collisions of more free charges with the vibrating local atoms in the sample as collision increases the obstacle to the motion of free charges. Values of electrical conductivity for different compositions of PANI and ZnO are exhibited.

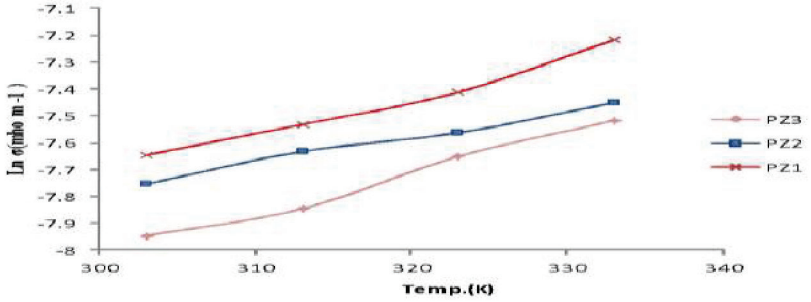

Fig. 3 – ln conductivity of PANI/ZnO composites verses temperature

Conclusions

In summary, the composites of polyaniline with ZnO via oxidative polymerization of aniline hydrochloride in the presence of different wt% of ZnO with ammonium persulphate as an oxidant have been synthesized. Detailed characterizations of the composites were carried out using XRD.

The study on electrical properties of conducting polymer PANI is carried out as a comparison to PANI/ZnO composites measured under low and high temperature dependence. The electrical properties of the conducting polymer (PANI/ZnO) composites show strong dependence on the reaction method and ZnO percentages. PANI/ZnO composites show lower dc electrical conductivity as compared to PANI and it decreases regularly with increasing content of ZnO.

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