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Effect of ZnO Filler on Structural and Optical Properties of Polyaniline-ZnO Nanocomposites

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Abstract

PANI based nanocomposite filled with ZnO nanoparticles was prepared by chemical synthesis method. Aniline hydrochloride with ammonium persulphate was used as oxidant. The structural investigation of prepared nanocomposite was carried out by X-ray diffraction technique (XRD). XRD pattern confirmed the Wurtzite structure of ZnO nanoparticles. The UV- Vis spectra of PANI-ZnO nanocomposite was studied to investigate the optical behavior after doping ZnO nanoparticles in to the polymer matrix. The addition of ZnO nanoparticles gives to the red shift of π-π^* transition of PANI. Chemical bond and stretching vibrations assigned to different peaks were evaluated by FTIR spectra.

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Keywords: *PANI-ZnO nanocomposite, Chemical Polymerization, XRD, UV-vis, FTIR*

1. Introduction

Inorganic semiconductor nanoparticles are an important class of nanomaterials as they exhibit size-dependent electronic and optical properties with applications in light emitting diodes and other optoelectronic devices [1, 2]. The addition of semiconductor nanoparticles or filler to polymers allows the modification of the polymers physical

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properties [3]. The resulting thermal, mechanical, optical, magnetic or conducting properties of the nanocomposites are influenced by the filler properties as well as from the fillers surface properties [4]. Specific interest was developed the polymeric nanocomposite with good thermo mechanical properties, rheological characteristics and thermal stability for energy and environmental applications [5, 6]. Due to the inorganic fillers at nanoscale exhibit quite different electronic and optical properties from those of their bulk state, it was expected to obtain a new composite material that has been synergetic or complementary behaviors between the polymer and inorganic material. Various studies concerning metal oxides nanoparticles like ZnO, TiO_2, SnO_2 etc. Among the metal oxide nanoparticles (NPs), zinc oxide (ZnO) a wurtzite n-type semiconductor and which have potential material for bio sensing and gas sensing because of their unusual properties, like direct band gap (3.37 eV), high exciton binding energy (60 meV), and good resistivity (10^{-3} to 10^{5} Ω cm), including high surface area, high catalytic efficiency, nontoxicity, chemical stability, and strong adsorption ability (high isoelectric point ~9.5) [7-10]. There are also several conducting polymers like polythiophene, polypyrrole and polyaniline. Among the conducting polymers polyaniline (PANI) based nanocomposites was used for detecting gases, however, the poor selectivity was the main disadvantages of pure inorganic and organic materials. New and interesting properties can be achieved by combining organic and inorganic materials. Therefore, conductive polymers (PANI) and metal oxide (ZnO) nanocomposites have brought out more fields of application, such as biosensors, gas sensors, conductive paints, drug delivery, and rechargeable batteries [11-14]. Nowadays, more and more multifunctional PANI nano-structures are being prepared by blending PANI with inorganic electrical, optical and magnetic nano-particles to form nano-composites, such as PANI/nano-ZnO fibers, PANI/vanadium oxide nano-sheets, PANI/CdS microwires, PANI/Fe_3O_4 nano-particles, PANI/Au nanofibers, and PANI/TiO_2 nano-composites, etc [15-18] . In literature, there are some reports available concerning the synthesis of polyaniline/metal oxide nanocomposites in gas sensing applications. Composites systems having high conductivity at ambient temperature find unique applications in rechargeable batteries such as lithium batteries[19]. Huyen *et al.* [20] synthesize PANI/TiO_2 nanocomposites and studies the effect of TiO_2 on the sensing features. In this paper an effort has been made to synthesized PANI/ZnO nanocomposites by chemical synthesis method with varying concentration of ZnO nanoparticles. Further, prepared nanocomposites were characterized by various techniques to study the structural and optical properties.

2. Experimental details

2.1 Synthesis of ZnO nanoparticles

Zinc oxide nanoparticles were synthesized by co-precipitation method using zinc nitrate and sodium hydroxide precursors. In this experiment, a 1 M aqueous solution of zinc nitrate ($Zn(NO_3)_2 \cdot 6H2O$) was kept under constant stirring using a magnetic stirrer to completely dissolve for 30 min and 1 M aqueous solution of sodium hydroxide (NaOH) was also prepared in the same way with stirring of 30 min. After complete dissolution of Zinc nitrate, and 1 M of NaOH aqueous solution was added under high speed constant stirring, drop by drop (slowly for 60 min) touching the walls of the vessel. The reaction was allowed to proceed for 150 min after complete addition of sodium hydroxide. The beaker was sealed at this condition for 12 h. After the completion of the reaction, the solution was allowed to settle for overnight and further, the supernatant solution was separated carefully. The remaining solution was centrifuged for 30 min, and the precipitate was removed. Thus, precipitated ZnO NPs were cleaned three times with deionized water and ethanol to remove the by-products which were bound with the nanoparticles and then dried in electrical oven at about 120°C. The prepared ZnO nanoparticles were used for further characterizations and composite.

2.2 Synthesis of PANI-ZnO nanocomposite

Chemical polymerization was employed for the synthesis of PANI–ZnO nanocomposite. 5 gram of aniline hydrochloride was added in 200 ml double distilled water and stirred 30 min for homogeneous mixture then kept in ice bath (10^0C) for 3 h. The obtained solution was given name as A. ZnO nanopowder (2 wt %) was dispersed in the above mentioned solution A. 10 gm of APS was dissolved in 50 ml of double distilled water kept for 3 h in ice bath. The obtained solution was given name as B. The solution B was added drop wise to the solution A and the