Preparation of Nanocomposites Polypyrrole and Zinc Oxide Thin Film Characterization and its Application of Gas Sensor

S. Sakthivel and A. Boopathi

Thin film Physics and Nano Science Laboratory, PG and Research Department of Physics Rajah Serfoji Govt. College (Autonomous), Thanjavur - 613 005, Tamilnadu, INDIA. email: Sakthivel.sunmugam@yahoo.com.


ABSTRACT

Polypyrrole/Zinc oxide (ZnO) Nanocomposites were synthesised by chemical oxidative polymerization of Pyrrole with ZnO nanoparticles. The synthesised Nanocomposites of Polypyrrole/ZnO material is used to prepare thin film on glass substrates by spin coating method. The prepared Nanocomposites thin films were characterized by Fourier transform infrared (FTIR) spectroscopy, X-ray diffraction (XRD), and Scanning electron microscopy (SEM).

Keywords: Polypyrrole, Zinc oxide, Polymer Nanocomposites, XRD, SEM.

1. INTRODUCTION

Development of organic/inorganic nanocomposites often achieved by grafting synthetic polymers on inorganic particles or by adding modified nanoparticles (NPs) into polymer matrices, is intended to produce composite materials with improved mechanical and other properties. Nanocomposites made up of inorganic nanoparticles and organic polymers represent a new class of materials that exhibit improved performance when compared with their microparticle counterparts. Surface modification of inorganic nanoparticles has attracted a great deal of attention because it produces excellent integration and an improved interface between nanoparticles and polymer matrices. The organic/inorganic nanocomposite materials unique feature of include low weight and easy formability and good mechanical and optical properties. Such materials can lead to improvement in several areas, such as optical, mechanical, electrical, magnetic, rheological, and fire retardancy properties. In recently several organic semiconductors such as polypyrrole (PPy), polyaniline (PANI), polythiophene (PTH) have been used for detecting toxic gases. As one kind of conducting polymer polypyrrole...
and its derivatives have attracted considerable attention for their easy polymerization and good environmental and thermal stability. This type of polypyrrole derivatives can provide high stability to certain gases. The conducting polymer and metal oxide inorganic material composites are very useful for sensor applications, metal oxides like SnO2, WO3, ZnO etc. have been studied extensively and emerged as economical sensors for monitoring toxic gases.

In particular ZnO is widely used for sensor applications because of its excellent sensitivity towards gas pollutant. However, there are some significant disadvantages of ZnO are their high operating temperature, which increases power consumption and reduces sensor life and also poor selectivity is the most serious problem for inorganic and organic conducting polymer sensing material. So need for analysing and overcome the low stability, poor selectivity and high cost problems have an intensively investigated in this composite material field.

In this paper PPy/ZnO nanocomposites were synthesised and prepared by direct chemical oxidative polymerization method. The prepared PPy/ZnO nanocomposite material used to prepare thin film PPy/ZnO composite. The nanocomposite thin films were characterized by vibrational functional group study of FTIR, structural characterized of XRD and surfaces morphological study of SEM.

2. EXPERIMENTAL

a. Materials

All chemical are used were analytical purity. Pyrrole as a monomer of Polypyrrole was purchased from sigma Aldrich. Ammonium persulphate (APS) and Zinc Oxide nano powder is obtained from Marck chemicals. Double distilled (DD) water was used as a solvent. The Pyrrole monomer distilled twice before under reduced pressure.

b. Preparation of PPy/ZnO Nanocomposite

Preparation of PPy/ZnO nano composite material by using In-situ chemical oxidative polymerization. Determined quantity of ZnO nano sized material was mixed with pyrrole monomer. The monomer solution was prepared with double distilled water of monomer concentration 1.5M. The ZnO pyrrole mixer solutions were fully stirred by complete dispersed ZnO nano particles to Pyrrole. The oxidant solutions were prepared at another bath containing for ammonium persulphate concentration 1.5M to double distilled water. Now the monomer and composite solution was kept continues stirring conditions and the addition of oxidant with determined level slowly drop by drop addition to that stirrer monomer solution, this process take maximum 30 minutes but polymerization start at after 1 minutes for addition of first drop of oxidant. The fully addition of oxidant after that solution completely free for rest at one to two hours to take a full polymerization oxidant and monomer formation of polymer. After that we note dark greenish color PANI/ZnO nano composite were precipitate bottom of the reaction bath. The precipitated were collected and washed several times in methanol, acetone solution and ringed with distilled water for several time this process removing the un polymerized
monomer and oxidant content. The washed composite material was drying vacuum oven for 6 hour at above room temperature.

c. Preparation of PANI/ZnO Nanocomposite Thin film

The prepared PPy/ZnO nanocomposite materials were used in the thin film preparation. The PPy/ZnO composite thin film prepared by spin coating technique, the spinning solution was prepared by using a organic solvent of NMP. The determined quantity of PPy/ZnO nano composite material dissolved in organic solvent. The Composite material dissolved solution were filtered and then using a thin film preparation. The well cleaned substrate were kept in the spinner, the spinner rotating at constant speed of 3000 rpm, before spin coating solution draped over the substrate and rotating at constant rotations of spinner for 45 seconds. The evenly coated thin film taken in out to the spinner base then drying at oven at 70°C for two hour. The prepared PPy/ZnO nano composite thin film was using a characterization studies.

d. Characterization of PPy/ZnO Nano composite Thin film

The vibrational properties of the PPy/ZnO thin film were analyzed by Fourier transform infrared spectroscopy (FTIR) Perkin Elmer make model spectrum RXI spectroscopy in the wave number range of 400-2000 Cm⁻¹. The crystalline structural study of PPy/ZnO thin film were determined using Rigaku X- ray diffractometer (XRD) [2θ = 10-90°, Cu-Kα = 40 kV, 15 mA]. The top view surface morphology of PPy/ZnO thin film structure were analyzed by VEGA3 TESCAN (SEM HV: 5.0 kV) scanning electron microscope (SEM).

3. RESULTS AND DISCUSSIONS

3.1 FTIR spectroscopy Analysis

The FTIR transmission spectra of PPy/ZnO nano composite thin film as shown in figure 1. The FTIR spectra were recorded in the range of 4000 cm⁻¹ to 400 cm⁻¹, the observed peak of 3495 cm⁻¹ can be attributed to the N-H stretching vibrations. The confirmation of PPy through FTIR spectral line as an main characterizing peaks at 1495 cm⁻¹, 1502cm⁻¹ and 1524cm⁻¹ that’s corresponding to the fundamental vibrations of pyolpyrrole ring. The band at 1285 cm⁻¹ which can be attributed to aromatic C-H stretching vibrations. The peaks at 1675 cm⁻¹ and 796 cm⁻¹ represents C=N and C-N bonds, the band of C-H in plane deformation vibration is situated at 1010 cm⁻¹ the out of plane ring deformation of C-C and C-H at peak 685 cm⁻¹. In our FTIR spectral line corresponding vibrational change to compare of polypyrrole vibrational spectral wavelength and intensity of peaks also. It is clear that the peak shift of PPy-ZnO nanocomposite which indicate ZnO nano particles are diffusing to the PPy ring.
3.2 XRD Spectral analysis

The X-ray diffraction pattern of PPy/ZnO nano composite thin film as shown in figure 2. The XRD spectral line showed a broad and amorphous nature of polymer present in the thin film. Some diffracted intense peaks also presenting in the spectral line that’s indicating ZnO nano particles presenting to the thin film. The diffracted lines are corresponding to the ZnO crystalline phase are indicating to the figure for corresponding hkl values mach JCPDS 79.0208\textsuperscript{11,12}.

3.3 Scanning Electron Microscope Analysis

The typical SEM image of PPy/ZnO nanocomposite thin film as shown in figure 3. The surface morphology clearly showing uniform coating of polymer material and uneven distributions of ZnO nano particles over the surfaces. The ZnO nano particle not dissolving to the monomer solution because of several type of ZnO formation as showing in figure like rot type, spherical and needle shape and etc.
4. CONCLUSION

The nanocomposite of PPy/ZnO material successfully synthesised and prepared by novel in-situ chemical polymerization method and prepared nanocomposite material used for PPy/ZnO thin film by sol-gel spin coating technique. The prepared PPy/ZnO thin film were characterized by functional group study of FTIR, structural characterization of XRD and morphological characterizations of SEM had also studied. All the characterizations are clearly indicated that PPy/ZnO nanocomposite thin film is very useful for sensor applications.

REFERENCES