ZnO/PANI Nanocomposite Thin Films: Room Temperature LPG Sensor

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Abstract. The current paper portrays a new strategy relying on the use of facile and versatile solution-based approach to prepare inorganic semiconductor metal oxide-organic polymer nanocomposites thin films at room temperature. ZnO nanoparticles were combined with conducting (polyaniline) polymer via polymerization in acidic aqueous solution to obtain a new type of inorganic–organic composite nanostructure. ZnO/PANI nanocomposites have been chemically prepared and composites films are characterized for structural, morphological, optical properties by means of XRD, FT-IR, SEM, etc. A simple room temperature LPG sensing device based on the composite thin film of ZnO/PANI showed 38% sensitivity upon exposure of 4700 ppm of LPG.

Keywords: Chemical route, ZnO/PANI, Nanocomposite, LPG Sensor.

1. INTRODUCTION

The field of nanoparticle-polymer composites is attractive from the standpoint of integrating the key features of both polymers and nanoparticles into hybrid or composite materials. Various inorganic nanoparticles, mostly metal oxides, have been incorporated into conducting polymers to achieve desired properties. Maeda and Armes [1] did a series of pioneering work in colloidal conducting polymer nanocomposites (PNCs). Researchers have attempted to enhance the desired properties of PNCs and, thus, to extend their utility by reinforcing them with nanoscale materials to derive improved properties compared to the more conventional particulate-filled microcomposites.

2. EXPERIMENTAL

In a typical preparation of metal oxide-PANI composites thin film, 0.4 M aniline monomer solution was prepared in 1 M H_2SO_4. Then, an appropriate amount of oxide powder was put into the 0.5 M H_2SO_4 solution. After sufficient stirring, the both solutions were mixed with addition of 0.1 M ammonium per sulfate (APS) for polymerization purpose. The deposition is taken on well cleaned glass substartes at room temperature. Finally, the darkgreen thin films obtained were washed using deionized water for several times.

3. RESULTS AND DISCUSSION

3.1 Structural Studies:

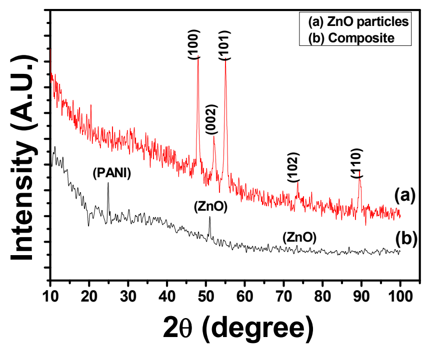

FIGURE.1 XRD patterns of (a) ZnO nanoparticles and (b) PANI/ZnO nanocomposite.

Fig. 1 (a) and (b) showed the XRD patterns of ZnO nanoparticles and PANI/ZnO nanocomposites, respectively; which revealed a single-phase nature with a hexagonal wurtzite structure of ZnO nanoparticles. While, crystal structure of the ZnO nanoparticles is customized by the presence of PANI in the composites. Fig.2 shows the FT-IR spectrum of PANI/ZnO nanocomposites. FT-IR analysis is supportive to formation of ZnO/PANI nanocomposite

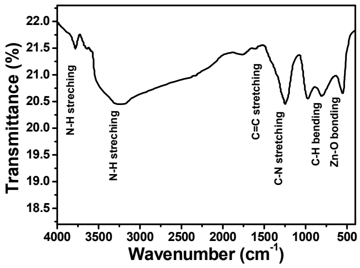

FIGURE.2 FT-IR spectrum of PANI/ZnO nanocomposites.

3.2 Morphological Studies:

Fig.3 shows SEM images of ZnO/PANI nanocomposite thin film at 20,000 × magnification along with magnified portion in outset. Nanostructures granual like morphology can be clearly seen.

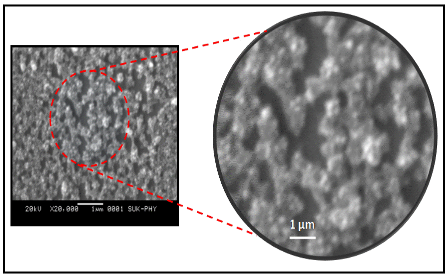

FIGURE.3 SEM image of PANI/ZnO nanocomposites.

3.3 Optical studies:

Fig.4. shows the plot of $(\alpha h\nu)^2$ versus photon energy ($h\nu$). The optical band gap of ZnO/PANI nanocomposite thin film is found to be ~ 2.5 eV, obtained by extrapolating the linear portion to α=0 .

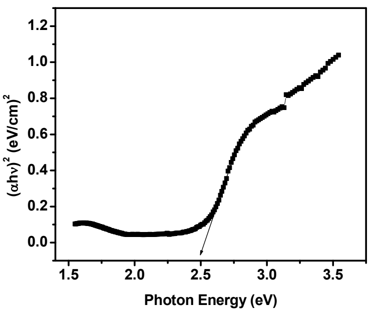

FIGURE.4 The variation of $(\alpha h\nu)^2$ versus photon energy ($h\nu$) of ZnO/PANI nanocomposite thin film.

3.4 LPG Sensing Studies:

The LPG sensing properties of PANI/ZnO nanocomposite electrodes were studied in a home-made gas sensor unit. The electrical resistances of nanocomposite electrodes in air (R_a) and in the presence of LPG (R_g) were measured at room temperature to evaluate the gas responses, S, defined as follows.

$$S(\%) = \frac{R_a - R_g}{R_a} \times 100\,\% \qquad (1)$$

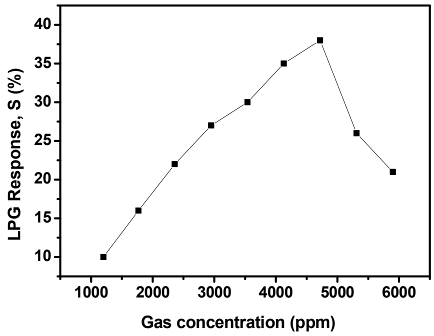

FIGURE.5 LPG response of PANI/ZnO nanocomposite electrode at room temperature with concentration of LPG.

Fig.5 shows the variation of gas response of the PANI/ZnO nanocomposite electrode at R.T. with different LPG concentrations. The LPG response increases with increase in gas concentration up to 4700 ppm with maximum gas response of 38%. Because the low gas concentration exposed on a fixed surface area of a sample, causes lower coverage of gas molecules on surface results lower surface reaction and increase in gas concentration increases the surface reaction due to a larger surface coverage. A further increase in surface reaction will be gradual when the saturation point of the coverage of molecules is reached and then gas response decreases.

CONCLUSION

PANI/ZnO nanocomposite thin films were successfully prepared chemically by solution route and employed as room temperature gas sensor electrode with 38% sensitivity at 4700 ppm for liquefied petroleum gas.

ACKNOWLEDGMENT

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