Influence of Zinc Oxide Nanoparticles on the Optical, Dielectric and Electromagnetic Interference Shielding Performance of Polystyrene Films

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ABSTRACT

In the present work, Zinc oxide (ZnO) nanoparticles are synthesized using solvothermal technique. Polystyrene-ZnO (PS/ZnO) nanocomposite films are synthesized by solution casting procedure. PS/ZnO films are analyzed by XRD, FTIR and UV-Vis spectroscopic techniques. The addition of ZnO into the PS film is found to decrease the optical band gap (OBG) from 4.07 eV to 1.86 eV. Frequency dependence of dielectric constant (ε’), loss tangent (tanδ), ac conductivity (σac) and electromagnetic (EM) interference shielding effectiveness (SE) studies have been undertaken on the pure PS and PS/ZnO films. Insertion of ZnO into pure PS polymer matrix is found to enhance ε’, tanδ, σac and SE considerably. The ε’ and tanδ were reduced with an enhancement in the frequency. σac of PS/ZnO nanocomposites was enhanced with rise in frequency and electrical conduction process in PS/ZnO film is in agreement with an electron-hopping model. EM interference SE is reduced with rise in the frequency. PS/ZnO films were proven as a favorable functional substance for the absorbing of EM waves at lower frequencies.

KEYWORDS

Dielectric Properties, Electrical Conductivity, Electromagnetic Shielding, Nanocomposites, Optical Properties

1. INTRODUCTION

Nanocomposites have been recognized as one of the utmost favorable and speedily emerging research areas. Electrical, mechanical and optical characteristics of the nanocomposites are found to differ from those of the component materials. Nanocomposites represent a novel class of nanostructures with technological significance. Recently, organic/inorganic nanocomposites

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have attracted considerable attention owing to their uses in optoelectronic devices (Arango et al., 2000; Samal et al., 2008). Organic/inorganic nanocomposites consist of organic polymer with inorganic nanoscale fillers. They contain the benefits of the inorganic materials such as thermal stability, rigidity etc. and those of the organic polymers like flexibility, processability etc. This leads to materials with quite innovative features.

The widespread advance of mobile communication in current civilization is becoming a thoughtful reason for concern, particularly with reference to the electromagnetic interferences (EMI). Mainly, EM interferences are unwanted signals released by modern electronic apparatus that disturb the performance of other electronic equipment and also cause harm to living organisms (Chung, 2001; Madhu et al., 2014) EM interference SE is essential to guard the electronics instrument from EM interference which is released by radio transmitting devices, phones, computer circuit, electric engines and power lines etc. Recently, polymer/inorganic nanocomposites were extensively examined in the region of EM interference shielding, due to their distinctive collective characteristics of electrical conductivity, lightweight, low density, flexibility and corrosion resistance, which are superior to those of metallic substances (Madhu et al., 2016).

Organic/inorganic nanocomposites, which exhibit cooperative properties of both organic polymers and inorganic particles are favorable candidates for EM interference shielding applications. EM interference shielding effectiveness (SE) of the blends can be enhanced by using appropriate inorganic fillers. Among the inorganic fillers, zinc oxide possesses notable optical and electrical properties (Rajan et al., 2014; Ozgur et al., 2005; Pearton, 2003). Large numbers of investigations have presented on polymer/ZnO composites (Xiong et al., 2001; Beek et al., 2005, Khrenov, Klapper et al., 2005; Hung et al., 2005; Li et al., 2007). Recently substantial amount of interest was concentrated on fabrication of ZnO/polymer nanocomposites using various polymer structures. Yao Tu et al. synthesized ZnO-Polystyrene nanocomposite films using uniform solutions of the ligand-altered ZnO and polystyrene and analyzed the nanocomposite films for UV shielding applications (Tu, Zhou, Jin et al., 2010). Among the polymers, polystyrene (PS) polymer is found to possess fascinating properties, which are suitable for preparing nanocomposites. Addition of ZnO filler into polymer matrices is found to alter the electrical, optical and mechanical characteristics (Tu, Zhou, Jin et al., 2010). Composite substances consisting of PS and ZnO are expected to possess the beneficial properties of ZnO with the flexibility and processability of PS polymer. Though there are few reports on the preparation and numerous properties of this kind of nanocomposites substances, there are no thorough investigations on the dielectric response, ac conductivity and EM interference shielding analysis on the PS/ZnO nanocomposite films.

In the current work, films of PS/ZnO composite are synthesized via solution casting method. Detailed structural, optical, dielectric, ac conductivity and EM interference shielding investigations have been carried out on the fabricated PS/ZnO nanocomposite films.

2. EXPERIMENTAL

ZnO nanoparticles were synthesized using the solvothermal reaction of zinc acetate in an alcohol. In the present studies, Zinc acetate dehydrate is made to dissolve in methanol and potassium hydroxide (KOH) solution is synthesized via dissolving KOH in methanol. This KOH solution is poured slowly into the solution of zinc acetate at 50°C with constant stirring. Nanocrystalline particles begins to precipitate and solution turns to turbid. The nanocrystalline ZnO particles are precipitated at bottom and surplus mother liquor is eliminated. Resultant precipitate is washed thoroughly using methanol and dried at room-temperature for duration of 24 hrs.

The PS/ZnO nanocomposite films are synthesized using solution casting method. The 1 wt. % ZnO is made to dissolve in 10 ml of Tetraethylammonium (TEA) and 1 g PS is melted in a 40 ml of solution of chloroform. Nanocrystalline solution is combined with a solution of PS and agitated for
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