The Influence of Cd(ZnO) on the Structure, Optical and Thermal Stabilities of Polyvinyl Chloride Nanocomposites

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The doping of nanomaterials into polymers creates novel nanocomposite materials with desired properties. The influence of these nanoscale fillers on the structure and optical and thermal stabilities of polymer are the crucial clue to introduce these novel nanocomposites to service life applications. In this work, cadmium doped zinc oxide ($Cd_{0.5}Zn_{0.5}O$) nanopowders with a uniform particle size of around 10 nm have been synthesized, purified, and blended with polyvinyl chloride (PVC) by solution mixing to prepare PVC/$Cd_{0.5}Zn_{0.5}O$ nanocomposite films. The structure and morphology of PVC/$Cd_{0.5}Zn_{0.5}O$ nanocomposite films have been characterized using transmission electron microscopy. The results showed that as the amount of nanoscale fillers increases the nanocrystals tend to aggregates and the size of these aggregates increases from 25 to 100 nm. The UV–vis spectra showed that the prepared PVC/$Cd_{0.5}Zn_{0.5}O$ nanocomposite films are highly transparent. The transparency at higher concentrations slightly decreased as a consequence of light scattering due to large aggregates. The thermogravimetric results showed that a small amount of $Cd_{0.5}Zn_{0.5}O$ nanopowders (<0.6 wt%) without further surface modification can greatly improve the thermal stability of PVC. POLYM. COMPOS., 32:1143–1147, 2011. © 2011 Society of Plastics Engineers

INTRODUCTION

The dispersion of nanoscale inorganic fillers into an organic polymer to form polymer nanocomposites has drawn enormous attention in recent years [1]. Combining the properties of the polymer matrix and the inorganic filler create a new, economic way to obtain desired high performance materials [2]. Significant progresses have been made in this area during the past decade. A variety of polymer/inorganic filler nanocomposites that offer attractive mechanical, thermal, optical, and electric properties have been investigated extensively [3, 4].

ZnO is an important and attractive semiconducting material. It has drawn enormous research attention due to its distinguished properties in optics, photonics, and electronics [5]. Its wide bandgap energy (3.4 eV) at room temperature is ideal for short-wavelength optoelectronic applications. When compared with other wide bandgap semiconductors, ZnO has several advantages [6]. It has a high exciton binding energy (60 meV), much higher than that of GaN (25 meV), as a light-emitter, which can ensure efficient excitonic emission at room temperature. Hence, it is possible to modify the physical properties of ZnO on mixing with CdO. Most of the recent works have been focused on the preparation of $Cd_xZn_{1-x}O$ alloys [7, 8]. $Cd_xZn_{1-x}O$ alloy would be a good candidate because of the small direct bandgap of CdO, which shows a red shift of the luminescence peak with respect to that of ZnO [9]. It is also much more resistant to radiation damage. Moreover, $Cd_xZn_{1-x}O$ can be simply obtained through wet chemistry, which offers it a potential viable route to achieve uniform dispersion in polymer matrices through solution mixing. As the size decreases to the regime in between the bulk and isolated molecules, the properties of the semiconductor nanocrystals may have mechanical, optical, electrical, and thermal properties quite different from the bulk, known as the quantum size effect [10]. Another factor accounting for these differences in the fundamental behavior induced by the crystal size is the large surface to the volume ratio, which also results in some properties being dominated by the surface rather than the crystalline core. In the past decade, significant research in the physical chemistry of semiconductor nanocrystals has been pursued to explore the above unique characteristics [11]. It is believed that the unique characteristics of nanopowders may also give rise to new opportunities for functional polymer/semiconductor nanocomposites [12].

In this study, transparent polyvinyl chloride (PVC)/cadmium doped zinc oxide ($Cd_{0.5}Zn_{0.5}O$) nanocomposite films based on $Cd_{0.5}Zn_{0.5}O$ nanocrystals without surface modification have been successfully prepared. The UV

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