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Structure and performance of ZnO/PVC nanocomposites

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ABSTRACT

ZnO/PVC nanocomposites films have been prepared by the solvent casting method and investigated by various techniques. All results show good dispersion of ZnO nanoparticles in the polymeric matrix. XRD revealed that pure PVC films are partially crystalline with hallow peak but ZnO nanoparticles have wurtzite structure and the nanocomposite films were almost the same as those of ZnO with decrease in the degree of crystallization, causing increase in the amorphous region. FT-IR presented the same spectra for nanocomposites in the wavenumber range 700–3100 cm^{-1}, weak band located at 500–700 cm^{-1},which can be attributed to stretching of Zn–O bond and an increase of the bending band of O–H at 1631 cm^{-1} was observed. The surface of the films was analyzed by SEM, which becomes rough with some small aggregates compared with pure PVC with good distribution in the entire surface region with bright spots. TEM revealed a regular crystalline lattice superimposed on an amorphous background due to carbon support and PVC matrix and the structure of these particles is hexagonal. In addition, the nanocomposites films have higher glass transition temperature, specific heat and thermal stability relative to those of pure PVC because of strong interaction among ZnO nanoparticles and PVC.

1. Introduction

Nanocomposites are a special class of materials having unique physical properties and wide application potential in diverse areas [1–4]. Novel properties of nanocomposites can be obtained by successfully imparting the characteristics of parent constituents to a single material. These nanocomposites materials differ from both the pure polymers and metal nanoparticles in some physical and chemical properties. Encapsulation of nanoparticles inside the shell of polymers is the most popular and interesting approach to synthesize nanocomposites. Accordingly, a number of different metal and metal oxide particles have so far been encapsulated into the shell of polymers, giving rise to a host of nanocomposites [5–8].

Polymer nanocomposites have attracted a great deal of attention in recent years due to their exceptional properties. These materials consisting of zinc oxide (ZnO) and polymers have the good properties of zinc oxide, good mechanic processing, and flexibility polymer. Especially, hybrid materials consisting of soluble polymers with excellent mechanical properties and nice filming can be used in large areas.

ZnO is an odd material with novel applications due to its optical, electrical and thermal properties [9]. Nano-ZnO, as one of the multifunctional inorganic nanoparticles, has drawn increasing attention in recent years due to its many significant properties, such as chemical stability, low dielectric constant, high luminous transmittance, high catalysis activity, effective antibacterial and bactericide, and intensive ultraviolet and infrared absorption [10–14].

The introduction of nano-ZnO into PVC could improve the structural, mechanical and thermal properties of pure PVC owing to its small size, large specific area, quantum effect and a strong interfacial interaction. Consequently, nano-ZnO/PVC nanocomposites could be widely applied in coating, rubbers, plastics, fibers and other applications.

Polymeric materials are of special interest because in combination with suitable metal salts (lithium ions and/or ZnO), they give complexes that are useful for the development of advanced high energy electrochemical devices, e.g. batteries, fuel cells, electrochemical display devices and photoelectrochemical cells with ease of fabrication into thin films of desirable sizes [15].

In the present paper, we spotlight on the improvements of the structural, optical and thermal properties of PVC and their complexes film with the addition of different concentrations of ZnO nanoparticles to use the final product in some technical applications.

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2. Experimental

2.1. Materials and methods

A known amount (2 g) of polyvinyl chloride (PVC; Fluka, Italy) was dissolved in 100 ml tetrahydrofurane (THF) as a solvent and stirred by a magnetic stirrer for about 6 h at 60 °C to form a homogenous solution. This step was repeated with the addition of a required quantity (0, 2.5, 5, 10, 15 and 20 wt%) of ZnO nanopowder (ALDRICH, USA) using diameter <100 nm as a filler to the solution of PVC. The mixture was stirred for 24 h and then poured into a Petri-dish and left for slow drying in an oven at 60 °C for 48 h to form nanocomposite films and to ensure removal of the solvent traces. After drying, the films were peeled from

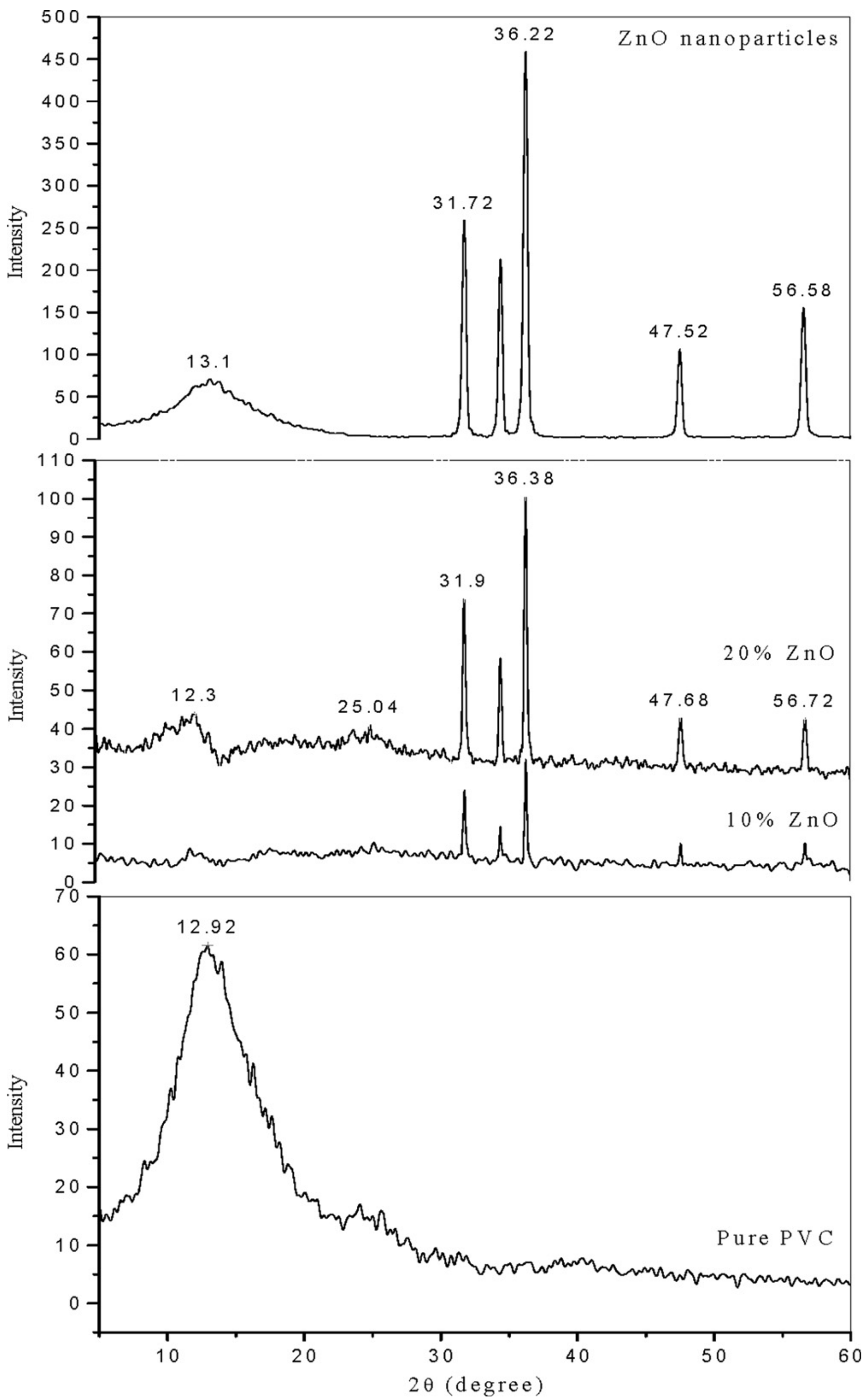

Fig. 1. X-ray diffraction scans of pure PVC, pure ZnO and PVC filled with different concentrations of ZnO nanopowder.