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ARTICLE

Spectroscopic analysis of $CdCl_2$ doped PVA–PVP blend films

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Abstract: The changes in molecular chemical structure of polyvinyl alcohol (PVA) and polyvinyl pyrrolidone (PVP), caused by doping PVA–PVP blend with cadmium chloride ($CdCl_2$), have been studied using ultraviolet–visible (UV-Vis) spectroscopy, Fourier transform Raman spectroscopy and Fourier transform infrared (FTIR) spectroscopy. The formation of cadmium nano-structures and microstructures in $CdCl_2$-doped PVA–PVP blend has been visualized using scanning electron microscopy, in the range of doping levels varying from 0.5 up to 10.2 wt% (doping level in weight percentage). The incorporation of dopant in PVA–PVP blend is confirmed using energy dispersive X-ray spectroscopy. The optical absorbance (UV-Vis) spectra of PVA–PVP blend films doped with $CdCl_2$ from 0.5 up to 2.2 wt%, showed a prominent absorption hump with peak at the wavelength 370 nm, in addition to other intermediate energy bands caused by the interactions of $CdCl_2$ with molecules of PVA and PVP. The photo-luminescence (emission and fluorescence) spectra show significant quenching of fluorescence in $CdCl_2$-doped PVA–PVP blend films. Analysis of FTIR and Raman spectra suggest the possible modes of interaction of cadmium ions (Cd^{2+}) and chlorine ions (Cl^-) with reactive functional groups (C–N, hydroxyl and carbonyl groups) of polymeric molecules in the blend. A reaction scheme for interaction of $CdCl_2$ with PVA–PVP blend is proposed, on the basis of spectroscopic studies on these films.

Key words: PVA–PVP blend, cadmium chloride, FTIR, Raman, fluorescence, UV–visible spectroscopy.

Résumé : Nous utilisons la spectroscopie UV-visible (UV-vis), la spectroscopie Raman par transformée de Fourier et la spectroscopie infrarouge par transformée de Fourier (SITF/FTIR) pour étudier les changements dans la structure chimique moléculaire de l'alcool polyvinylique (APV/APV) et du polyvinylpyrrolidone (PVP), causés par le dopage du mélange APV–PVP) avec du chlorure de cadmium ($CdCl_2$). Nous visualisons la formation de nano et microstructures du mélange APV–PVP dopé au $CdCl_2$ à l'aide d'un microscope électronique à balayage, pour des fractions massiques de dopant allant de 0.5 à 10.2 %. L'incorporation du dopant dans le mélange APV–PVP est confirmée par analyse X dispersive en énergie. Le spectre d'absorbance optique (UV-Vis) des films APV–PVP de fraction massique de dopant de 0.5 à 2.2 % montre une bosse notable avec maximum à 370 nm, en plus des autres bandes d'énergie intermédiaire causées par l'interaction du $CdCl_2$ avec les molécules de APV et de PVP. Les spectres de photoluminescence montrent une diminution importante de fluorescence dans les films dopés. L'analyse des spectres SITF et Raman suggère des modes d'interaction possible entre les ions cadmium (Cd^{2+}) et chlorure (Cl^-) avec les groupes fonctionnels réactifs C–N, hydroxyle et carbonyle des molécules de polymère du mélange. Sur la base des études spectroscopiques rapportées ici, nous proposons un schéma de réaction de l'interaction du $CdCl_2$ avec le mélange APV–PVP. [Traduit par la Rédaction]

Mots-clés : mélange APV–PVP, chlorure de cadmium, SITF, Raman, fluorescence, spectroscopie dans l'UV et le visible.

1. Introduction

Experimental studies on the structure and properties of metal salt doped polymeric materials have assumed importance due to their potential applications (as solid polymeric electrolyte (SPE)) in batteries, fuel cells, display devices, and gas sensors [1–4]. Incorporation of metal salt in a polymeric system could result in microstructural changes in the host polymer, and consequently, this affects the physical and chemical properties of the polymeric material. Researchers have studied the effect of inorganic salts on the microstructure and properties of hydrophilic polymeric materials [5–8].

Poly vinylalcohol (PVA) is a semi-crystalline polymeric material, whereas polyvinyl pyrrolidone (PVP) is an amorphous polymeric material. PVA and PVP have been studied rigorously by many researchers, because they possess desirable properties like water solubility, charge storage capacity, and good film formation ability. The use of blending and doping techniques for preparing a polymeric material usually results in a new material with enhanced electrical conductivity (due to modified band structure) and changes in other physical properties. These changes depend on the chemical behavior of the dopant, mainly the way in which it interacts with polymeric molecules of the host [9, 10]. The doping of metal salts in a polymer blend is more complicated when compared to that in a homo-polymeric host, because the effect of dopant ions on each component of the blend needs to be considered. The effect of doping polymeric blends with different chemical agents (reduction or oxidation agents) has been a matter of contemporary research interest. In particular, the effects of metal ions on the structure and properties of polymeric blends have been investigated by several researchers [11–13].

Cadmium chloride ($CdCl_2$) is a hygroscopic, crystalline compound (inorganic metallic salt) comprising cadmium (Cd) and chlorine (Cl). It is highly soluble in water. Cadmium has a significant neutron absorption cross section, and is useful as a neutron shielding material. Hence, a polymeric material comprising cadmium salt as a dopant assumes significance as a radiation shielding material [14, 15]. It is to be noted that certain compounds of cadmium, when added to plastics, for example, polyvinyl chloride, results in stabilizing (light, heat, and weathering stabilization) of the compounded polymeric material [16]. Also, filling

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