Effect of Cobalt Oxide Nanoparticles on the Nano-scale Free Volume and Optical Properties of Biodegradable CMC/PVA films

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Abstract

Chemically prepared cobalt oxide nanoparticles (NPs) were added to biodegradable Carboxymethyl cellulose (CMC) (20%) / Polyvinyl alcohol (PVA) (80%) blend films. The structural properties of these films were investigated by X-ray diffraction (XRD), Fourier transformation infrared spectroscopy (FTIR) and differential thermal analysis (DTA). Co_3O_4/ (CMC+PVA) films show a semi-crystalline structure and the degree of crystallinity decreases with adding Co_3O_4 NPs. FTIR confirms the good interaction between the blend chains and Co_3O_4 NPs. The melting temperature T_m for CMC/PVA is about 212 ^oC then decreased with increasing Co_3O_4 content, due to some decrease in the ordered association of the blend which results in a decrease in the blend crystallinity. Positron annihilation lifetime spectroscopy (PALS) measurements were carried out with a conventional fast–fast coincidence spectrometer. It was found that ortho–positronium lifetime τ_3 and free volume V_f increase while o-Ps intensity I_3 still constant as Co_3O_4 concentration increases. This is because adding Co_3O_4 NPs encourages the formation of o-Ps. The swelling ratio *SR%* as a function of Co_3O_4 concentration was also studied and its value increases with Co_3O_4 addition. The optical study illustrated the decrease of the transmittance *T* of the films from 87% to 35.5% with increasing Co_3O_4 content from 0 to 0.9 *wt%*. Also, both the direct and indirect optical band gaps of the films red-shifted from 4.05 to 3.75 eV and 3.3 to 2.75 eV, respectively. The influence of Co_3O_4 on the refractive index of the films is also reported.

Keywords: Polymer Nanocomposites; Co_3O_4 Nanoparticles; Positron annihilation; Free volume