Characterization, Optical, and Nanoscale Free Volume Properties of Na-CMC/PAM/CNT Nanocomposites

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Abstract

Polyblend and nanocomposite films of sodium salt of carboxymethylcellulose (Na-CMC)/polyacrylamide (PAM) and Na-CMC/PAM modified with carbon nanotubes (CNT) were synthesized by the solution casting technique. The effect of PAM and CNT loading on the structural, optical, and nanoscale free volume properties of Na-CMC was studied. X-ray diffraction (XRD) and Fourier transform infrared (FTIR) spectroscopy exhibited the existence of strong interactions between Na-CMC and PAM and the non-destructive effect of CNT on Na-CMC/PAM structure. The HR-TEM revealed the multi-walled structure of CNT with a 7.06-nm wall thickness and a 6.92-nm wall inner diameter. Positron annihilation lifetime spectroscopy (PALS) was done, in a vacuum and at 30 ^{o}C to 200 ^{o}C, to investigate the nanoscale free volume properties by using a conventional fast-fast coincidence spectrometer. It was found that the o-Ps lifetime (τ_3) and free volume (V_h) increase with increasing CNT percentage in the Na-CMC/PAM blend. The distribution of the o-Ps lifetime was broadened with increasing CNT ratios. Furthermore, the glass transition temperature (T_g) increases with increasing loads of CNT. For the first time, a correlation was donebetween Urbach energy (E_U) and V_h. Finally, the results were represented and discussed in the frame of free volume properties. Optical measurements showed that the transmittance T% of Na-CMC/PAM was 91.12% and decreased to 68.42% and 36.45% after loading with 1.0 and 2.0 wt % CNT. In addition, the blend shows higher insulating properties compared with the individual polymers. The CNT incorporation reduces the band gap significantly and increases the E_U in the films.

Keywords: Carbon nanotube; Free volume, Na-CMC/PAM; Nanocomposites; Optical properties; Positron annihilation.