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Study of structural morphology, thermal degradation and surface charge decay in PU + PSF + CNTs polymer hybrid nanocomposite

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ABSTRACT

Polyurethane (PU)/Polysulfone (PSF)/Multi Wall Carbon Nanotubes (CNTs) hybrid nanocomposite films were prepared by solution grown method with different wt% of functionalized CNTs. The structural and thermal properties of PU, PSF and PU + PSF + CNTs nanocomposite films were studied by various techniques such as scanning electron microscopy (SEM), X-ray diffraction (XRD), FTIR and TGA/DTG. The dispersion of CNTs in polymer was studied by SEM spectra, which indicates the presence of CNTs on the surface of the polymeric material. XRD results show the increases of crystallinity with different weight percentage of CNTs in polymer matrix. FTIR spectra reveal the position of different chemical bonds in pure and hybrid nanocomposite films. TGA and DTG show that the thermal stability of hybrid nanocomposite is better than PU and PSF due to reinforcement of CNTs in PU–PSF matrix. Surface charge decay study represents the charge stability in hybrid nanocomposite is due the localization of charge carriers in deeper traps.

1. Introduction

CNTs exhibit excellent thermal properties and have become one of the most promising nanofillers as reinforcement of nanocomposites exhibiting multi-functional, high performance polymer characteristics to their combination of low density, high aspect ratio, high stiffness, and high strength, as well as great thermal properties.

In general, the incorporation of CNTs in polymers increases the glass transition, melting and thermal decomposition temperatures of the polymer matrix due to their constraining effects on the polymer segments and chains. This is an important effect as it improves the thermal endurance of the polymer composites [1,2]. It is reported that by adding 1 wt% CNTs to epoxy, the glass transition temperature increased from 63 to 88 °C and, similarly, by adding 1 wt% SWCNTs to poly (methyl methacrylate) (PMMA) the glass transition temperature increase by 40 °C [3,4]. Particularly, the addition of CNTs to high temperature thermoplastics such as those having sulfone group (polysulfone, polyether sulfone, polyphonysulfone) offers the promise of enhanced thermal stability [5].

The study of time dependence of charge decay is of immense importance to verify the ohmic conduction in neutralization of space charge due to localization of electronic carriers in traps and to understand the charge transport through the bulk of polymer. Since charge stability is a key parameter for electrets for its industrials application, therefore, it is necessary to choose stable electrets to develop electrets-based devices [6]. The isothermal charge decay is very important method to observe the charge stability of electrets. The surface charge decay behaviour of several polymer was studies in different condition of electrets preparation method, however, this study on nanocomposite material is not yet been reported in literature.

However, there is a great challenge in maximizing the advantage of CNTs as effective reinforcements in composites by improving the dispersion of CNTs in polymer matrices to enhancing the properties of CNTs and polymer matrices thermal properties of polymer matrix. When CNTs is disperse in polymers as a reinforcement to enhance and modify their original characteristics [7–10]. A multiwall carbon nanotube causes' significant agglomeration because of the van der Waals' attraction. This characteristic of Multiwall carbon nanotubes could be barrier for its application with other polymers. To increase the application range of CNTs should not form aggregates in polymer

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matrix to maximize the advantages of CNTs as effective reinforcements in high strength material. It should be well dispersed to avoid the slippage [11]. There are several techniques to improve the dispersion of CNTs in polymer matrices, such as by optimum physical blending, in situ polymerization and chemical fictionalizations [12–17]. The high power dispersion methods, such as ultrasound and high speed shearing, are the simplest and most convenient methods to improve the dispersion of CNTs in a polymer matrix. Recently, Qian et al. [18] made use of a simple solution-evaporation method assisted by high energy sonication to prepare polystyrene (PS)/CNTs composite films, in which CNTs were dispersed homogeneously in the PS matrix. Similarly, Sandler et al. [19] dispersed CNTs in epoxy under high speed stirring (2000 rpm) for 1 h, and proved that intense stirring was an effective process to achieve dispersed CNTs uniformly in epoxy. Besides, adding a proper compatibilizer to polymer/CNTs composites is also another efficient method. Xie et al. [20] prepared polypropylene (PP)/CNTs composites compatibilized with maleic anhydride grafted styrene–(ethylene-co-butylene)–styrene copolymer (MA-SEBS) by using a combination of ball milling and melt mixing. However, dispersion of CNTs into two polymers of different surface energy and different structure is not yet been reported particularly in case of polyurethane and polysulfone as polymer matrix. The functionalized multiwall carbon nanotubes could be achieved by attaching the

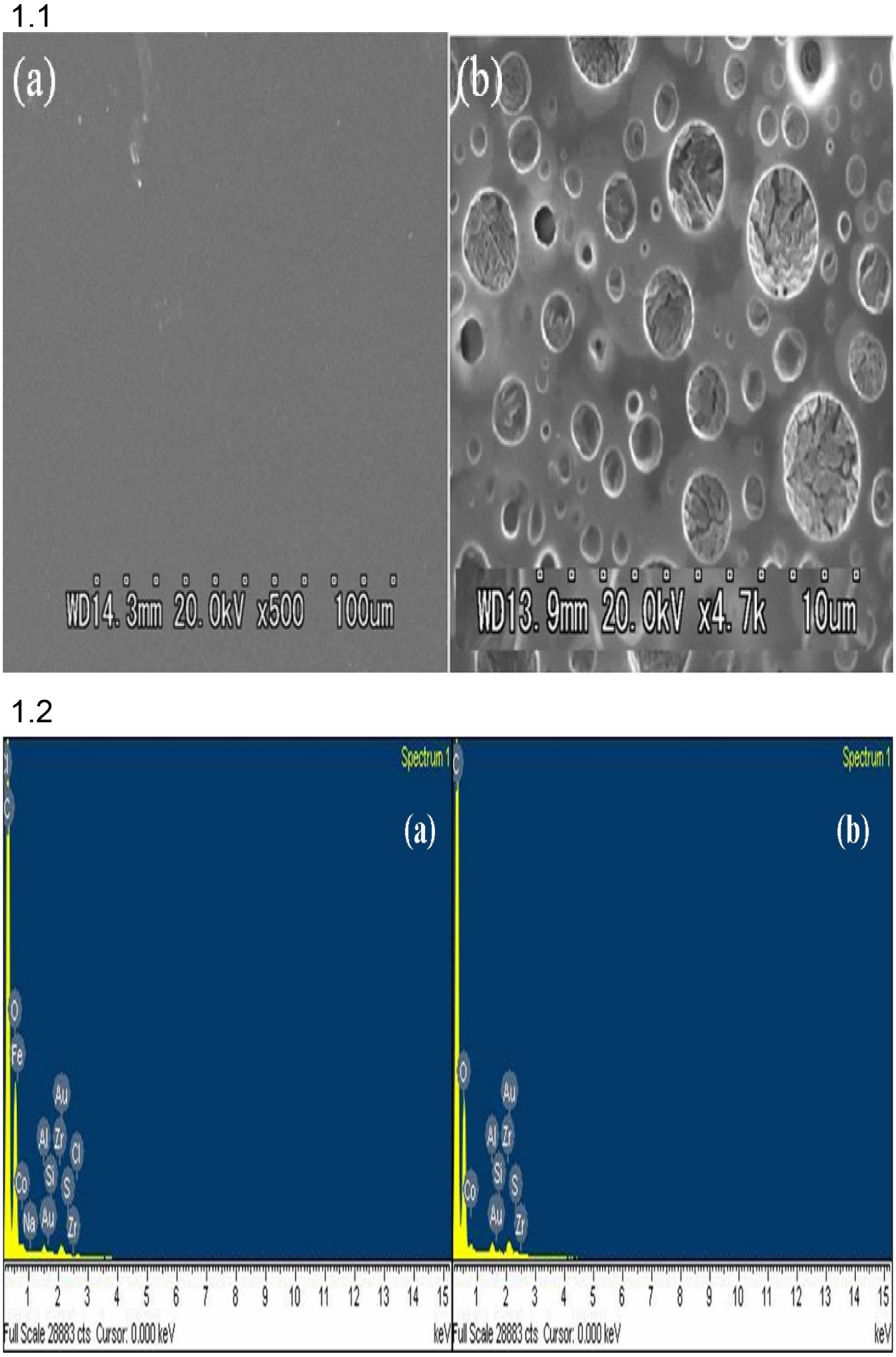

Fig. 1. 1 SEM images of (a) PU + PSF and (b) PU + PSF + CNTs (7%) hybrid nanocomposites. 2 EDX images of (a) PU + PSF and (b) PU + PSF + CNTs (7%) hybrid nanocomposites.