

Electrospun PVDF/MWCNT/OMMT hybrid nanocomposites: preparation and characterization

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Abstract Electrospinning technique was employed to prepare neat PVDF, nanoclay-PVDF and carbon nanotube (MWCNT)-PVDF nanocomposites, and nanoclay-carbon nanotube-PVDF hybrid nanocomposites. A mixture of dimethyl formamide/acetone (60/40) was used to fluidize the polymer and nanofillers. Electrospinning process was conducted under optimized conditions. Maximum modification was achieved at 0.15 wt% nanofiller. Rheological measurements on the prepared solutions revealed decreased material functions in the presence of nanoclay, whereas the rheological properties of MWCNT-PVDF solution did not show any significant reduction compared with those of neat PVDF solution. The behaviors of the hybrid nanocomposite solutions, though dependent on their composition and their material functions, increased with MWCNT concentration. These differences, together with variations in electrical properties of nanoclay and MWCNT, led to changes in morphology of the fiber during electrospinning process. Under electrospinning conditions designed for neat PVDF solution, mats with beads and with the highest fiber diameter were produced. Meanwhile, incorporation of both nanoclay and MWCNT into the solutions resulted in bead-free fibers with thinner diameter. Fourier transformed infrared spectrophotometry (FTIR) and X-ray diffractometry (XRD) were used to measure the β -phase crystalline content in electrospun mats. Complete agreement was found between the FTIR and XRD results. The lowest and highest β -phase contents were obtained for neat PVDF mat and hybrid nanocomposite mat containing

0.1 wt% clay, respectively. The mixing procedure of nanofillers and the PVDF solution was also found to be important. In case of hybrid nanocomposites, more β -crystals were formed when the nanoclay was first mixed in the absence of MWCNT.

Keywords Polyvinylidene fluoride (PVDF) · Multi-walled carbon nanotube · Nanoclay · Electrospinning · Hybrid nanocomposite

Introduction

Polyvinylidene fluoride (PVDF) is a semi-crystalline polymer, which has attracted much interest because of its potential applications as a piezoelectric, pyro-electric, and ferroelectric material [1, 2]. PVDF and its composites are widely used in applications such as transducers [3], actuators [4], sensors [5], batteries [6], membranes and energy harvestings [7]. PVDF displays five different crystal forms (TTTT for β -crystal, TGTG' for α - and δ -crystals, and T₃GT₃G' for γ - and ϵ -crystals) [8]. Packing of PVDF chains in all-trans β -crystal leads to the highest dipole moment. However, pure PVDF has no piezoelectric effect due to the existence of α -phase in its crystal structure [9]. Unfortunately, β -crystals are thermodynamically unstable and the most stable polymorph of PVDF is configured by α -crystals. Enhancement in content of polar β -crystallites and suppression of the non-polar α -crystallites of PVDF are of a great significance in improving properties of this polymer. Alpha crystals can be transformed into β -crystals by cold-drawing (stretching) of PVDF films [8], high pressure quenching of molten PVDF [10], casting a solution of PVDF [11], and applying high electric field (poling) on PVDF film [12].

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