Morphological and thermal study of electrospinning nanocomposite systems

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Abstract
Electrospinning technique is a very simple and versatile process by which polymer nanofibers with diameters ranging from a few nanometers to several micrometers (more typically 50–500 nm) can be produced using an electrostatically driven jet of polymer solution (or polymer melt). Polymer nanofibers possess unique characteristics, such as: extraordinary high surface area per unit mass (for instance, nanofibers with 100 nm diameter have a specific surface of 1000m^2/g), coupled with remarkable high porosity, excellent structural mechanical properties, high axial strength combined with extreme flexibility, low basis weight, and cost effectiveness, among others. Choice of the polymer solutions, co-processing of polymer mixtures, chemical cross-linking of the formed nanofibers, etc., can provide a variety of pathways for controlling the chemical composition of electrospun nanofibers with a wide range of properties. The electrospinning technique also provides the capacity to lace together a variety of types of nanoparticles or nanofillers to be encapsulated into an electrospun nanofiber matrix. Another interesting aspect of using nanofibers is that it is feasible to modify not only their morphology and their content but also their surface structure to carry various functionalities.
In this scenario we focused our work on the possibility to produce nanocomposite systems consisting of poly(lactide acid) (PLA) loaded by different clays by electrospinning technique. As fillers, we chose to use a lamellar and a fibrous clay: Cloisite30B and SepioliteCD1, respectively. The first filler is a commercial organomodified clay characterized by a repetitive multilamellar structure, while the second one is a fibrous clay characterized by a multichannel structure. We foresee that Cloisite30B should exfoliate within the polymer matrix, while SepioliteCD1 should orientate along the axial arrangement of nanofibers for the action of the electrostatically driven jet. In both cases, we attend a nanometric dispersion of clays within polymer matrix. We produced nanofibers by electrospinning of PLA and PLA-clay solution and we studied the role of molecular weight and the cristallinity (hence L and D isomer content) of PLA as variables of process in order to obtain nanocomposite systems. Morphological characterization by scanning electron microscopy (SEM) on prepared nanocomposites showed that it is possible to obtain electrospinning nanofibers of PLA and selected nanoclays. SEM magnifications pointed out that it is possible to disperse Cloisite30B in two PLA grades characterized by different molecular weight: in both cases a clay nanometric dispersion is mapped. In the case, it is necessary to use a crystalline polymer (higher L isomer content) characterized by a lower molecular weight of SepioliteCD1 in order to have a good clay dispersion within the polymer matrix. Moreover, it is demonstrated that it is possible to modulate the nanofiber diameter varying the flow rate, as process variable. Thermal characterization by differential scanning calorimetry (DSC) evidenced a variation of PLA cristallinity due to clay nucleating effect. While the thermogravimetric analysis in nitrogen and in air pointed out a higher stability of electrospun nanocomposite systems in terms of maximum temperature of degradation and final residue.

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