PLA-CELLULOSE WHISKER-BASED NANOCOMPOSITES PREPARED BY REACTIVE EXTRUSION

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ABSTRACT

Biopolymers have received, in the last decade, special scientific and commercial attention due to environmental issues and trends towards an understanding that petroleum resources are finite. Poly(lactic acid) (PLA) stands out among several biopolymers as it is a high modulus thermoplastic and can be easily processed by conventional techniques. Nevertheless, PLA properties should be improved depending on the application. Blend and/or nanocomposite preparation is an efficient methodology to obtain materials with outstanding properties. Recently, highly crystalline cellulose particles have been shown to enhance polymer composite properties[1]. However, important characteristics should still be improved in these polymer nanocomposites, such as low compatibility between fillers and common hydrophobic biopolymers, which generated poor dispersion throughout the matrix. Based on these findings, the study herewith is targeted at preparing PLA/poly(ethylene glycol) (PEG)/cellulose whisker nanocomposites by reactive extrusion using a tin-based catalyst which promotes the transreaction between hydroxyl groups from cellulose whiskers (CW) and/or PEG chains and ester moiety from PLA[2]. Tin(II) 2-ethylhexanoate and PEG with molecular weight of 4,000 g/mol were used as reagents for this purpose. The blends and nanocomposites were prepared in a twin-screw micro-compounder at 180°C for 5 minutes. In the case of reactive extrusion, first PEG and the catalyst were pre-mixed for two hours in chloroform, and subsequently, the dispersion was solvent cast. Then, this mixture was added to PLA in the micro-compounder. The material structures were characterized by Fourier transform infrared spectroscopy and the properties were evaluated by differential scanning calorimetry and mechanical tests. The results show that the presence of PEG as well as the order of the component addition highly affect the final material characteristics and that PEG and CW addition increased the PLA crystallinity degree. Also, the PEG effect on PLA mechanical properties was dependent on its weight composition, i.e., at low PEG concentration (5 wt%), PEG chains were not able to plasticize PLA and no significant changes were obtained in the elastic modulus, tensile strength and elongation at break. On the other hand, when 20 wt% PEG was added to PLA, the elastic modulus and the tensile strength decreased 97% and 69%, respectively, and the elongation at break increased 10 times in relation to that of pure PLA. Cellulose whiskers were added to PLA/PEG blends to overcome this significant modulus decrease. Interesting and opposite behaviors were observed in the nanocomposites. The addition of 1 wt% CW to the PLA/PEG (95/5) blend caused a 32% decrease in the elastic modulus and 8% in the tensile strength, however, when 1 wt% CW was added to the PLA/PEG (80/20) blend, the elastic modulus remained constant and a 36% increase in the tensile strength, without decreasing the elongation at break, was obtained.

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References:

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