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ORIGINAL PAPER

Preparation and properties of polylactic acid/*N*-(2-hydroxyl) propyl-3-trimethyl ammonium chitosan chloride-intercalated saponite nanocomposites

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Abstract Water-soluble *N*-(2-hydroxyl) propyl-3-trimethyl ammonium chitosan chloride (HTCC) was prepared with 2,3-epoxypropyl trimethyl ammonium chloride (GTA) grafting to the amino groups of chitosan. Then, chitosan quaternary ammonium-intercalated saponite (HTCC–saponite) was synthesized with HTCC and saponite under ultrasonication. Moreover, polylactic acid (PLA)/HTCC–saponite nanocomposites were prepared by solution intercalation. The structure of HTCC was characterized by Fourier transform infrared (FTIR) and nuclear magnetic resonance (^{1}HNMR) spectra, which demonstrated HTCC was successfully synthesized. The degree of substitution (DS) of HTCC was 89.2 %, which also reflected the better water solubility of HTCC. The structure of HTCC–saponite was characterized by X-ray diffraction (XRD) and scanning electron microscope (SEM), which showed that HTCC–saponite has an intercalated or partially exfoliated structure. Furthermore, the structure, mechanical properties, thermal stability and crystallization of the PLA/HTCC–saponite nanocomposite were studied, respectively. The mechanical properties and thermal stability of the PLA/HTCC–saponite nanocomposites attained optimum properties when the content of HTCC–saponite was 0.5 wt %. The DSC results showed that HTCC–saponite increased the crystallization of PLA due to its heterogeneous nucleation effect. The antibacterial properties test showed the antibacterial properties of HTCC–saponite were endowed to the PLA-based nanocomposites.

Keywords PLA · Chitosan quaternary ammonium · Saponite · Solution intercalation

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Introduction

Polylactic acid (PLA) is a thermoplastic material belonging to the family of environmental-friendly biodegradable polymers which have been of great commercial interest in the development of novel materials in recent years [1–3]. PLA is used as a biocompatible polymer for applications in implants, surgical sutures and controlled drug delivery systems, and it also has a great potential for applications in agriculture and in the packaging and catering industry. So, PLA is undoubtedly one of the most promising candidates for further developments. However, its poor thermal stability, low degree of crystallinity, low crystallization rate, high brittleness and poor toughness limit its use to certain applications. Researches suggested [4] that the addition of a small amount of nanosized fillers (0.5–7 % by weight) did overcome the above drawbacks. Several works have been focused on the preparation and study of polymer-based nanocomposites [5–7]. A variety of nanofiller dispersion methods, such as in situ polymerization and solution intercalation method in N-dimethylacetamide [6], and melt intercalation technique using modified montmorillonite [8, 9] have been applied. Some studies found [10–12] that clay particles not only performed an excellent heterogeneous nucleation effect in the PLA matrix, but also increased the crystallization rate of PLA and promoted the cold crystallization process at low temperatures.