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ORIGINAL PAPER

Thermal properties and crystallization behaviors of polylactide/redwood flour or bamboo fiber composites

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Abstract A series of polylactide/redwood flour (PLA/RWF) and polylactide/bamboo fiber (PLA/BF) composites were successfully prepared using a solution mixing procedure. Fourier transform infrared spectroscopy (FTIR) and wide-angle X-ray diffraction (XRD) were employed to characterize these composites. Thermal properties and crystallization behaviors of PLA composites were determined by their respective techniques of differential scanning calorimetry (DSC) and polarized optical microscopy (POM). With the increasing content of fibers, the glass transition temperature (T_g), crystallization temperature (T_c), and melting temperature (T_m) of PLA/RWF composites decreased first and then increased, but T_g and T_m of PLA/BF composites increased first and decreased afterwards. It is suggested that fibers could improve the segmental mobility of PLA; meanwhile, the different morphologies, sizes, and densities of RWF and BF have different effects on thermal properties of composites. Under the increasing content of RWF, the crystallization rate of the composite increased first and decreased afterwards. When the content of RWF was 5%, the crystallization rate was at its maximum. It could be possible that the addition of fibers was able to nucleate PLA and increase the degree of crystallinity, but the excess content of fibers easily led to heterogeneous composites and subsequent poor crystallization behaviors. In a word, thermal properties and crystallization behaviors of PLA composites were regularly changing by increasing content of fibers.

Keywords PLA/RWF composites · PLA/BF composites · Content of fibers · Thermal properties · Crystallization behaviors

Introduction

During the past 30 years, biopolymers, such as polylactide (PLA), have become popular due to increased social and economic pressures to conserve petroleum resources [1–3]. However, PLA is not so widely used due to several drawbacks, such as brittleness and lower impact resistance compared to the conventional plastics [4–6]. Many approaches, such as blending PLA with some natural materials [7–9], synthetic polymers [10–12], and inorganic fillers [13, 14], have been proposed to improve its properties and simultaneously reduce its overall cost.

Various natural fibers, such as wood flour and bamboo fiber, have been used as reinforcement materials in polymers for a long time. They have many advantages, such as low density, high stiffness, easy availability, non-abrasiveness, and relatively low price. Therefore, numerous researchers have reported the preparation and property study of polylactide/wood flour and bamboo fiber composites. Rowell et al. [15] prepared polylactide (PLA)/pine wood flour (PWF) composites by a kinetic-mixer and an injection molding machine. They have concluded that the degree of crystallinity of the PLA–PWF composites increases significantly with the PWF content and the treatment of PWF with silane is found to have a positive effect on its nucleating ability. Shah et al. [16] reported that when up to 10 wt % added (based on wood flour mass), chitosan showed no significant effect

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