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Dynamic Mechanical Properties and Thermal Stability of Poly(lactic acid) and Poly(butylene succinate) Blends Composites

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Abstract

The blend of poly(lactic acid) (PLA) and poly(butylene succinate) (PBS) were prepared and extruded with various compositions and their molded properties were examined. Thermogravimetric analysis showed that thermal stability of the blends was higher than that of pure PLA and the weight loss of PLA/PBS (40/60 wt%) was lower than neat polymers. Differential scanning calorimetry thermograms of blends indicated that the thermal properties of PLA did not change noticeably when blended with PBS. The tensile strength and modulus of blends decreased with the increasing PBS content. But impact strength has improved about two times compared to pure PLA. Rheological results revealed that the addition of 10% and 20% of PBS increased the storage modulus, loss modulus and viscosity of the blend at nearly all frequencies, and decreased viscosity with increasing shear stress. Dynamic mechanical properties results showed the lowering of storage modulus of all blended PLA which indicated the increase of molecular mobility by adding PBS due to lower glass transition.

Keywords: PLA/PBS Blends; Thermal Stability; Dynamic Mechanical Properties

1 Introduction

In past few decades, a lot of attention has been focused on biomass based polyester derived from renewable resource [1]. Among a few commercially available biobased or partially biobased thermoplastic polymers, poly(lactic acid) (PLA) has been investigated extensively [2, 3]. It is a linear aliphatic thermoplastic polyester, produced from renewable resources with good biocompatibility, non-toxic byproducts, excellent transparency, and high strength and modulus [4-8]. Biodegradable PLA is perhaps the most important polyester in biomedical applications [9, 10]. PLA has attracted an increasing interest in various markets, such as packaging, textile [11-15], and automotive industries [16, 17]. It can be processed using injection-molding, compression-molding, extrusion, and thermoforming etc. Several drawbacks tended to limit its widespread applicability such as high cost, brittleness, toughness, and low heat distortion temperature. Thus

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in order to broaden the applications of PLA, material properties and processability has to be improved.

Modification of PLA by copolymerization or physical blending is a useful way to decrease the brittleness, toughness, and heat distortion temperature. Various additives such as plasticizers, toughening agents, reinforcing fillers and compatibilizers have been incorporated into PLA [18-23]. Many reports about blending of PLA with ductile polymers are available [24-26]. On the other hand, poly(butylene succinate) (PBS) is commercially available aliphatic polyester with high flexibility, good toughness, high elongation at break and lower glass transition temperature, and has a good biodegradability. But the low molecular weight PBS, with low melting point (114°C), low stiffness and strength, greatly limits its potential applications. Although many reports about PLA/PBS blends are reported in literature [27-31], the results have shown that the PLA/PBS blends that with 20 wt% of PBS has good compatibility. Liu et al., discussed the properties biocompatible fibers obtained by blending the cellulose nanowhiskers and the cellulose matrix, and latter the characteristics of wool/keratin hydroxyapatite were also investigated [32, 33]. Morphology and the mechanical properties of electrospun PA 6/66 nanofibers and the electric field analysis of spinneret design for needleless electrospinning of nanofibers were also investigated [34, 35]. In this study, PLA/PBS was blended with various compositions and was prepared by using a twin-screw extruder. Thermal, dynamic mechanical analysis, rheological, and mechanical properties in these blend systems were examined and studied by different characterization techniques. The thermal stability of the PLA/PBS blends and their rheological properties were used to understand the effect of the addition of PBS in the PLA to decrease the brittleness and increase elongation.

2 Experimental Methods

2.1 Materials

PLA polymer (4032D-grade, melting point of 170°C) in pellet form produced by Unic Technology (Suzhou) Co., LTD was used in this study. PBS Polymer (Molecular Weight 8000, melting point of 109°C) in pellet produced by Anqing Hexing chemical co., LTD was used to blend with PLA.

2.2 Blend Preparation and Injection Molding

The pellets of both PLA and PBS were initially dried in a vacuum oven at a temperature of 80°C for 12 h to remove water before processing through the extruder. Blends of various compositions were prepared as shown in Table 1 Measured quantities of each polymer were first mixed in a container before they were blended in a twin-screw extruder. The extruder was operated at 145-175°C at 80-100 rpm screw speed, then again placed in the oven at 60°C. Specimens of blended samples were obtained by injection molding into the standard test after drying at 60°C for at least 12 h under vacuum. The injection molding process parameters are as follows: Temperature at 160-195°C, injection pressure 1 MPa, dwell time: 9 sec and mold temperature of 40°C.