



Tough and tunable shape memory PLA/PAE melt-blends actuated by temperature

Zhenfang Li¹ · Kangning Li¹ · Haihua He¹ · Yufen Zhou¹ · Zhicai He²

Received: 24 August 2018 / Accepted: 19 March 2019 / Published online: 2 April 2019
© Iran Polymer and Petrochemical Institute 2019

Abstract

Development of shape memory materials are very important due to their scientific and technological values. Typically, poly(lactic acid) (PLA) has received increasing attentions because of shape memory properties and biodegradability, however, its semi-crystalline structure restricts its shape recovery ratio and toughness both. Herein, we report a reinforced PLA-based elastomer material prepared by physical blending with different weight ratios of polyamide elastomer (PAE). After the modification, PLA/PAE elastomers show excellent shape recovery (> 99%) from ~25 to ~70 °C and toughness (impact strength ~50 kJ/m²). By regulating the weight ratio of PAE at 10 wt%, the resulting PLA/PAE elastomers showed relative low glass transition temperature (T_g) at ~61 °C versus pure PLA (~65 °C). Besides, the storage modulus (E') decreased to ~8000 MPa (at 10 wt% PAE) indicated that PAE weakened the PLA crystallinity and promoted its toughness. Comparing with pure PLA, PLA/PAE elastomers showed almost 45% decrease on loss modulus (E''), which indicated that elasticity and shape recovery behavior have been promoted. With the increase of PAE ratio in PLA/PAE elastomers, the initial recovery temperature of blends showed decreasing trend, which indicated that blends are more helpful for shape recovery actuated by temperature. This work provided a new PLA/PAE elastomer with stronger toughness and faster thermo-induced shape recovery that may show great potential for fundamental research and biomedical applications.

Keywords Poly(lactic acid) · Polyamide elastomer · Physical blend · Shape memory · Toughness · Repeatability

Introduction

Shape memory polymers (SMP) have received increasing attentions recently due to the ability to recover the initial shapes from a temporary state via external stimulations such as temperature, light, electricity, magnetism, and chemicals [1–3]. Such properties endow these materials tremendous potential applications including surgical sutures, biological

scaffold, medical devices, drug delivery, sensors, and actuators [4–6].

Some of the typical eco-friendly polymers including polylactide (PLA) polyurethane (PU), poly(ϵ -caprolactone) (PCL), polyhydroxyalkanoate (PHA), polynorbarnene (PNB) and their derivative have been extensively studied [4, 7, 8]. Particularly, PLA is a semi-crystalline thermoplastic polymer exhibiting excellent chemical stability, degradability and biocompatibility with a large sources from food crops fermentation that make PLA receive a wide attention. It is important that PLA shows a distinct glass transition temperature (T_g) at 60–70 °C and melting temperature (T_m) at 150–170 °C.

As a typical SMP, the crystalline part in PLA act as a stationary phase and the amorphous part as a switching phase when transition temperature (T_{trans}) is above T_g . In general, the stationary phase is linked by net-points through chemical bonds or physical interactions (entanglement, semi-/interpenetration network), and the switching phase requires polymer chains to have a certain flexibility and deformability [9–11]. The polymer chains show entangled states at

Electronic supplementary material The online version of this article (<https://doi.org/10.1007/s13726-019-00706-6>) contains supplementary material, which is available to authorized users.

✉ Zhenfang Li
lizhenfang65@163.com

✉ Zhicai He
hezhicai@tzc.edu.cn

¹ School of Pharmaceutical and Material Engineering, Jin Hua Polytechnic, Jin Hua 321007, People's Republic of China

² School of Pharmaceutical and Materials Engineering, Taizhou University, Taizhou 318000, Zhejiang, People's Republic of China