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Research Article

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Thermal and mechanical properties of poly(L-lactic acid)/ talc/ *1H*-benzotriazole composites

Yan-Hua Cai[1,2] and Ying Tang[*1, 2]

[1]*Chongqing Key Laboratory of Environmental Materials & Remediation Technologies, Chongqing University of Arts and Sciences, Yongchuan, Chongqing, P.R. China*
[2]*School of Materials and Chemical Engineering, Chongqing University of Arts and Sciences, Yongchuan, Chongqing, P.R. China*

ABSTRACT

In order to obtain more functional composites based on Poly(L-lactic acid)(PLLA), PLLA/Talc/ 1H-Benzotriazole(BTA) composites were fabricated by melting blend technology, and the thermal and mechanical properties of composites were investigated. The results showed that adding of Talc and BTA could improve the crystallization ability of PLLA. The melting behavior of PLLA/Talc/BTA composites under different conditions indicated that Talc and BTA, crystallization temperature and crystallization time significantly affected the melting behavior of PLLA. The stress strain of pure PLLA and PLLA/Talc/BTA composites showed that Talc and BTA make the PLLA become more brittle.

Keywords: Poly(L-lactic acid), 1H-Benzotriazole, Mechanical Properties, Crystallization

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INTRODUCTION

Compared to other degradation polymers, Poly(L-lactic acid)(PLLA) is more promising degradation polymer to be used in all field. Thus, more and more research results based on PLLA were reported [1-3], but there exists still many disadvantages to restrict the wider application of PLLA. In order to improve the properties of PLLA, adding functional additives is very useful method, and a large number of composites based on PLLA were fabricated. For example, Yu et al [4] reported that PLLA/PCL/OMMT composites were prepared by melting blend, and the obtained composites showed more enhanced mechanical properties than that of PLLA/PCL blends. Meantime, adding OMMT improved the thermal stability and crystalline abilities of composites.

1H-benzotriazole(BTA) is the very important organic compound, and widely used in chemical synthesis [5], materials [6], etc. Wan et al [7] reported that 27 benzotriazole derivatives were synthesized, and the compounds were assayed for antibacterial activities against three Gram positive bacterial strains and three Gram negative bacterial strains. The results showed that most of all synthesized compounds based on BTA exhibited potent antibacterial activity against the six bacterial strains.

Talc is the most common layered silicate, and widely used in polymer materials as functional additives [8-10]. However, study on PLLA composites with Talc and 1H-benzotriazole is not reported. Thus, in this paper, we fabricated PLLA/Talc/BTA composites by melt blending and hot-press forming process, and the thermal and mechanical properties of PLLA/Talc/BTA composites were investigated.

EXPERIMENTAL SECTION

Poly(L-lactic acid) (2002D) was purchased from Nature Works LLC, USA. The Talc and 1H-Benzotriazole were purchased from Chengdu Kelong Chemical Reagents Company, China.

The non-isothermal crystallization behavior of PLLA and PLLA/Talc/BTA composites was measured by differential scanning calorimeter (DSC) Q2000 (TA Instruments-Waters LLC, USA). The sample was heated to 190 ℃ and held at that temperature for 5 min to make sure that the polymer crystals were melted completely. Then the samples were cooled from the melt to 20 ℃ at different cooling rate. The melting behavior also was measured by DSC. Dumbbell-shaped tensile test specimens with dimensions of 25 mm×6 mm×1.0 mm were prepared by pneumatic-controlled impact shaping machine. Normal tensile tests were conducted on a D&G DX-10000 electronic tensile tester at the speed of 50 mm/min at room temperature.

Preparation of PLLA/Talc/BTA composites

Blending of PLLA, 5%Talc and 2%BTA was performed on a counter-rotating mixer, and the similar preparation process of PLLA/5%Talc/2%BTA composites has described in our previous paper [11].

RESULTS AND DISCUSSION

Non-isothermal crystallization of PLLA/Talc/BTA composites

Crystallization behavior is very important part of thermal behavior of PLLA and PLLA composites. Fig.1 and Fig.2 show that non-isothermal crystallization behavior of PLLA and PLLA/5%Talc/2%BTA composites, respectively. As shown in Fig.1, the crystallization peak of PLLA can be observed at cooling rate of 1 ℃/min, however, the crystallization peak of PLLA almost cannot be detected at other cooling rate, these results indicate the crystallization ability of neat PLLA is very weak. But crystallization peak of PLLA with Talc and BTA appears in the different cooling rate, what is more, the crystallization peaks are very obvious, which indicates adding of Talc and BTA could improve the crystallization ability of PLLA. Meantime, it is clear that the crystallization peak of PLLA/Talc/BTA composites shifts to lower temperature with increasing of cooling rate, and the crystallization peak becomes wider, the same phenomenon can be found in other literature [12]. This result also indicates that cooling rate significantly affects the crystallization behavior.

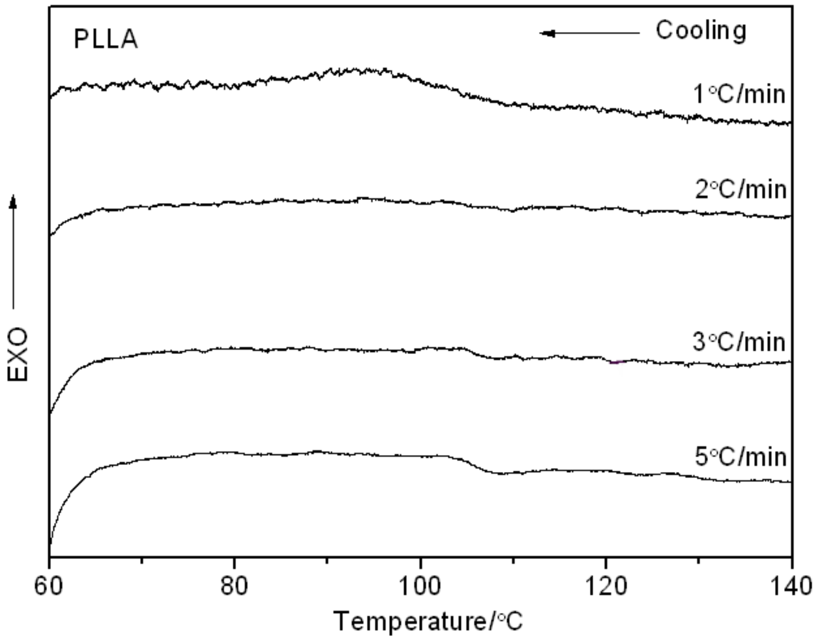

Figure.1 Non-isothermal crystallization of PLLA at different cooling rate

Melting behavior of PLLA/Talc/BTA composites

Firstly, the melting behavior of PLLA/5%Talc/2%BTA composites after crystallization at 100℃ for different time was investigated. It is clear that there exist double melting peaks as that reported by other literature [13], With increasing of crystallization time, the ratio of area between high-temperature melting peak and low-temperature melting peak decrease, which shows that increasing of crystallization time makes crystalline degree of PLLA/Talc/BTA composites increase, the crystalline degree decreases during second heating accordingly. Moreover, low-temperature melting peak shifts to higher temperature with increasing of crystallization time.

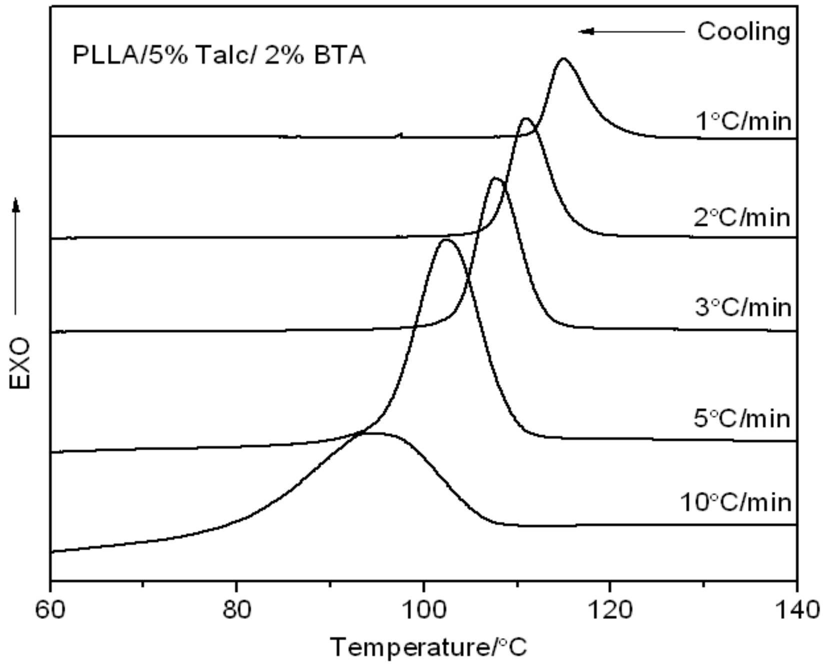

Figure.2 Non-isothermal crystallization of PLLA/Talc/BTA composites at different cooling rate

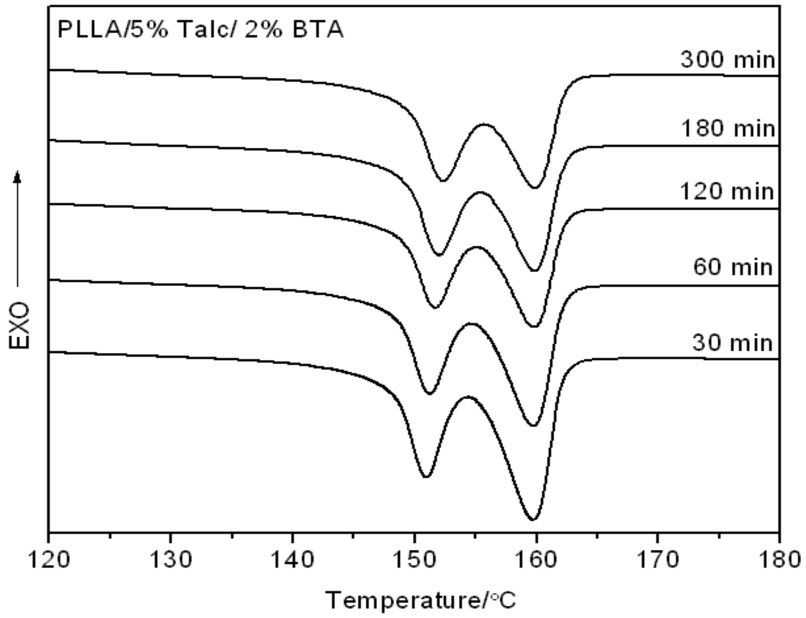

Figure.3 Melting behavior of PLLA/Talc/BTA composites after crystallization at 100 ℃ for different time

Then, we also investigated the melting behavior of PLLA/Talc/BTA composites at different crystallization temperature for 1h (See Fig.4). With increasing of crystallization temperature, low-temperature melting peak shifts to high temperature, and high-temperature melting peak moves to low temperature, at last, the double-melting peaks changes to the single melting peak at 120 ℃. What is more, the increasing of crystallization temperature makes crystal of composites become more prefect, the similar results also could be observed in Fig.5. Fig.5 shows the melting behavior of composites after crystallization different temperature and different time, though PLLA/Talc/BTA composites crystal for long time at 100 ℃, the degree of crystallization is still very low, and there exist double melting peaks. However, the high crystallization temperature could make PLLA/Talc/BTA composites have single melting peak after crystallization for some time.

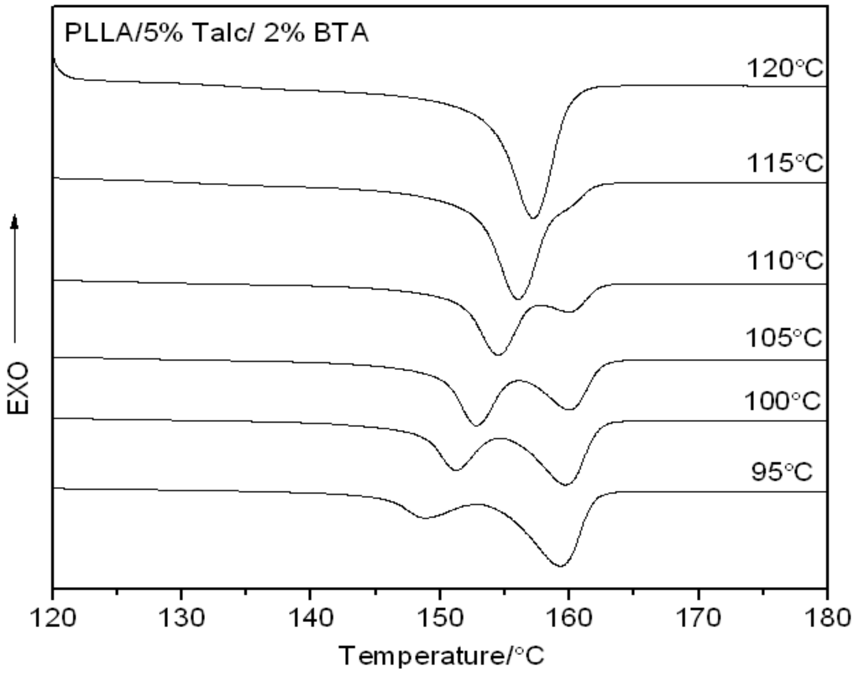

Figure.4 Melting behavior of PLLA/Talc/BTA composites at different crystallization temperature for 1h

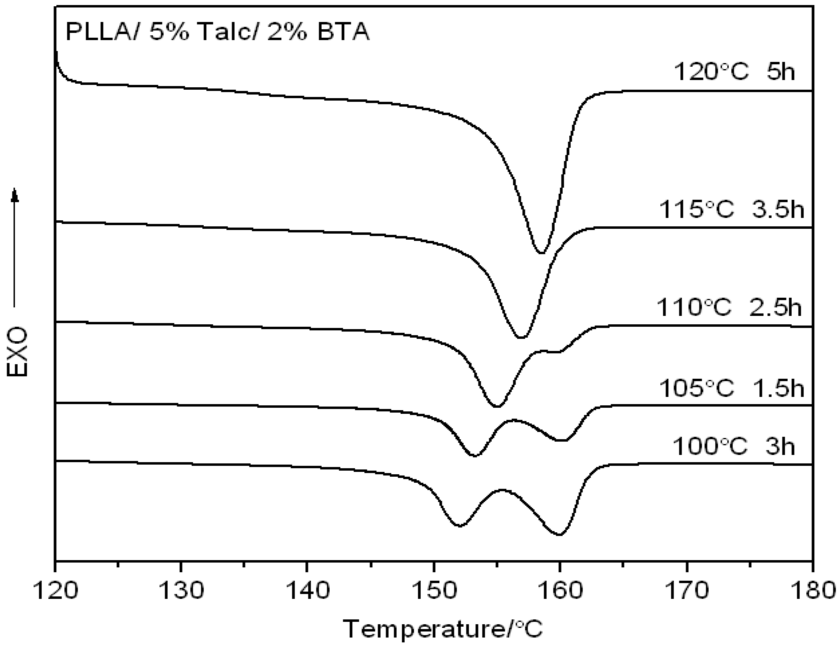

Figure.5 Melting behavior of PLLA/Talc/BTA composites after crystallization different temperature and different time

Mechanical Properties

Fig.6 is the stress strain curve of pure PLLA and PLLA/5%Talc/2%BTA. From the Fig.6 , the effect of adding Talc and BTA can be seen clearly and directly. Comparing with neat PLLA, the tensile strength and modulus of PLLA/Talc/BTA composites change from 49.8 MPa and 2329.4 MPa to 48.2 MPa and 2400.1 MPa, respectively, and the elongations at break of composites decreases from 3.13% to 2.23%, which indicates that Talc and BTA make the PLLA become more brittle, the reason could be that Talc and BTA improve the crystallization of PLLA, and increase the degree of crystallization. However, brittle properties would make the application of PLLA become difficult. Thus, decreasing of content of Talc and BTA may make PLLA become a flexile materials, on the other hand, to some extent, low loading Talc and BTA also can improve the crystallization of PLLA.

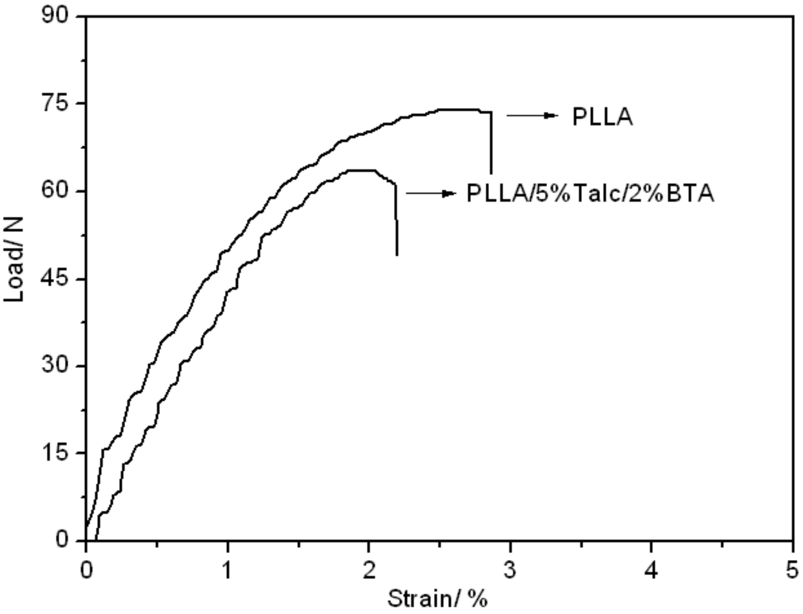

Figure.6 Stress strain curves of pure PLLA and PLLA/Talc/BTA composites

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