Thermal and Mechanical Properties of Cellulose Nanofiber Reinforced Semi-Crystalline PLA

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INTRODUCTION

Polylactic acid (PLA) is a versatile polymer made from renewable agricultural raw materials, which are fermented to produce lactic acid. PLA can be processed similarly to polyolefins or other thermoplastics. The main drawback of PLA for industrial application is the time required to crystallize resulting in longer injection molding cycles compared to, e.g. polypropylene. The present study consisted of evaluating the thermal and mechanical properties of cellulose nanofiber reinforced semi-crystalline PLA in order to assess the possibility to reduce the molding cycle time by accelerating crystallization while improving the thermal and mechanical properties.

MATERIALS AND METHODS

MFC was dispersed in PLA dissolved in dichloromethane. The mixture was dried at room temperature followed by vacuum-drying and a kneader was used to obtain a homogeneous compound. The compound was hot pressed into sheets and cooled by liquid N_2 to obtain completely amorphous samples. Some of them were subjected to annealing to obtain samples with different degrees of crystallinity. The thermal and mechanical properties were evaluated by dynamic mechanical analysis (DMA). The crystallization behavior of PLA was investigated by differential scanning calorimetry (DSC).

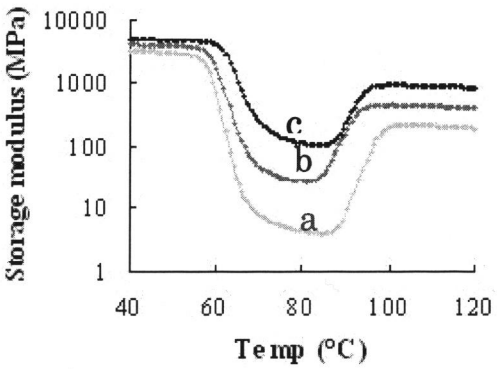

Fig. 1 Temperature dependence of storage modulus of: a) neat PLA, b) 5wt% MFC/PLA, and c) 20wt%MFC/PLA composites

RESULTS AND DISCUSSION

Fig. 1 shows the temperature dependence of storage modulus of neat PLA and MFC/PLA composites. At glassy state, the storage modulus is almost the same for all samples until the softening temperature. The addition of MFC at a fiber content of 20wt% increased the softening temperature of neat PLA from 58°C to 62°C and improved the storage modulus by 27 times at 80°C (rubbery state). The similar result reported in a previous study[1].

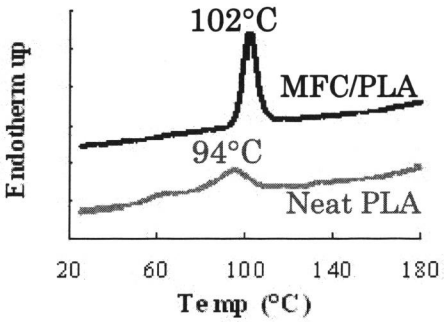

Fig. 2 DSC thermograms of neat PLA and 5wt%MFC/PLA on cooling cycle.

Fig. 2 shows the DSC thermograms of PLA and MFC/PLA composite. During the cooling cycle, the melt crystallization peak of MFC/PLA composite is higher and occurs earlier than neat PLA, indicating that the presence of MFC accelerates the crystallization.

These experiments showed that the reinforcement effect of MFC in PLA composite is effective to improve the thermal and mechanical properties. Moreover, the presence of MFC can act as nucleating agent in PLA crystallization and is expected to reduce the cycle time in injection molding of PLA.

REFERENCE

1) Iwatake A, Nogi M, Yano H. Cellulose nanofiber reinforced polylactic acid. *Comp Sci Tech* 2008. In press