# Promoting Stereocomplex and Suppressing Homo-Crystal Formation in PLLA/PDLA by Plasticiser Addition

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Poly(lactic acid) (PLA) is a popular, environmentally friendly material, derived from renewable resources. It exists in two enantiomeric forms, L-lactic acid (PLLA) and D-lactic acid (PDLA). Each on their own can form homo crystallites (HC), and together, they can form stereocomplex crystallites (SC). SC has denser chain packing resulting in a higher melting temperature and better properties compared to HC. In this study, the effects of an organic monoglyceride (OMG) plasticizer are examined in PLLA/PDLA (50/50) blend by studying the isothermal crystallization of the blend with different concentrations of OMG using polarized optical microscope (POM) observation, differential scanning calorimetry (DSC) and time-resolved wide-angle X-ray diffraction (WAXD).

Film samples were prepared by solution casting of 50/50 blend of PLLA and PDLA, in addition to OMG, using dichloromethane (DCM) as solvent. Sample characterization is summarized in Table 1. A type of OMG was used as plasticizer which contains an organic acid as succinic and a saturated fatty acid as a stearic acid. This OMG is produced by Taiyo Kagaku Co., Ltd. under the name Chirabazol D, with a $M_w$ of 500 and $T_m$ = 67°C. The OMG was added with concentrations up to 5% of the total weight of the sample, in 0.5% increments.

Table 1. Sample Characterization

| | PLLA (NatureWorks) | PDLA (Purac) |
|---|---|---|
| Code | 2500HP | D130 |
| Optical Purity | 99.5% | >99.5% |
| Number-average molecular weight ($M_n$) | $1.74 \times 10^5$ | $1.41 \times 10^5$ |
| $M_w$/ $M_n$ | 2.22 | 2.03 |

In Fig. 1, the DSC results, after the isothermal crystallization at 170°C for 300 min, show three melting peaks, for the samples with OMG content of 3% or less. The first peak is ascribed to the melting of HC, and the second and third peaks are ascribed to the melting of SC. However, for the OMG content of 3.5% or higher, the DSC curves show the disappearance of the HC melting peak. This indicates the ability of OMG in promoting the exclusive formation of SC, while suppressing the formation of HC. This was also confirmed by the WAXD results, shown in Fig. 2, where the HC diffraction peaks were observed only in the samples containing 0% and 3% OMG. On the other hand, for the samples containing 4% and 5% OMG, only SC diffraction peaks were observed.

It is remarkable to observe the effects of OMG on the PLLA/PDLA (50/50) blend samples. The increase of OMG percentage in the sample promoted the exclusive formation of SC and enhanced its crystallinity. This will lead to better processing conditions due to the improved thermal and mechanical properties of the polymer.

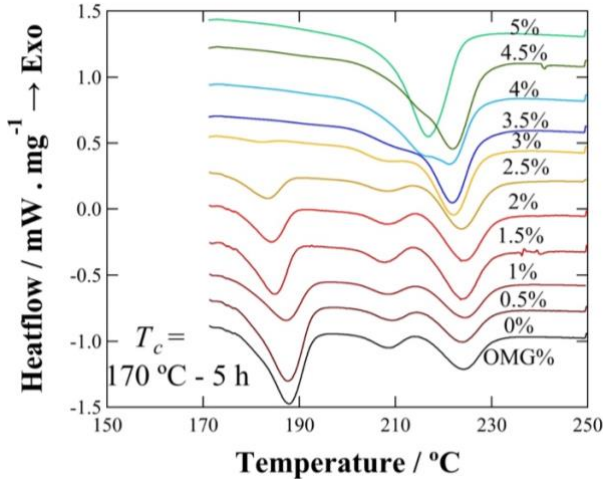


Fig. 1 DSC curves during the heating to 250°C (10°C /min) after the isothermal crystallization at 170°C for 300 min for the PLLA /PDLA (50/50) samples with different percentages of OMG.

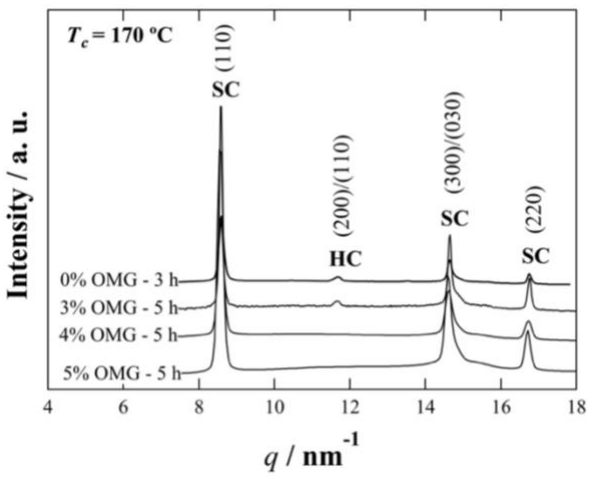


Fig. 2 WAXD profiles after the isothermal crystallization at 170°C for the PLLA/PDLA (50/50) + 0% OMG (after 3 h) and PLLA/PDLA (50/50) + 3%, 4% and 5% OMG (after 5 h).

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