Communication

Investigations on Novel Ternary Green Polymer Composite

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Characterization on the Miscibility of PLLA/PEA = 99/1 Blend

The miscibility of the PLLA/PEA = 99/1 blend was confirmed by single Tg criterion. Figure S1 shows the DSC curves of neat PLLA and PLLA/PEA = 99/1 blend. All samples were first quenched to -70 °C from the molten state and then heated at a heating rate of 20 °C/min. For PLLA/PEA = 99/1 blend, only one Tg (arrow marked at 55.8 °C) is shown, indicating the miscibility of the PLLA/PEA = 99/1 blend. In addition, the Tg of the PLLA/PEA = 99/1 blend is lower than that of neat PLLA (arrow marked at 60.3 °C). This can suggest that the plasticizer effect of PEA is present in the blend and the chains of PLLA are plasticized by PEA.

Figure S1. DSC thermograms of neat PLLA and PLLA/PEA = 99/1 blend.

The detailed description and related analysis way of the Avrami equation

The isothermal crystallization results from neat PLLA to ternary PLLA/PEA/h-BN composites were analyzed by the Avrami equation [1] showing below as equation (1):
\[ 1 - X_t = \exp(-kt^n) \] (1)

in the Avrami equation, \( X_t \) is relative crystallinity at a given time \( t \), \( k \) is the crystallization rate constant, and \( n \) is the Avrami exponent relating to the crystallization mechanism. The Avrami equation can be further converted to the logarithmic form. The relevant kinetic parameters can be evaluated by the logarithmic form of the Avrami equation. The logarithmic form of the Avrami equation is shown in equation (2):

\[ \log[-\ln(1 - X_t)] = \log k + n \log t \] (2)

The rate constant \( k \) and the Avrami exponent \( n \) can be estimated by equation (2). When the \( \log[-\ln(1 - X_t)] \) versus \( \log(t) \) plot exhibits a linear relationship, \( k \) and \( n \) are the slope and intercept of the plot, respectively. Moreover, the crystallization half-time \( (t_{0.5}) \) can be calculated by equation (3):

\[ t_{0.5} = \left( \frac{\ln2}{k} \right)^\frac{1}{n} \] (3)

It should be noted that \( t_{0.5} \) is defined as the time when the crystallization proceeds to 50%. In general, the reciprocal of \( t_{0.5} \) can be correlated with the crystallization rate. When \( 1/t_{0.5} \) is large, the crystallization rate is higher.

Reference:

Reminders of sample preparation

All samples were further dried in 60°C is because that 60°C is close to but slightly above the boiling point of the solvent chloroform. This temperature can help the removal of the solvent better than the temperatures below the boiling point of chloroform. The solvent was removed for 4 days just to ensure that all prepared samples were solvent-free. In our case, if the solvent removal time is less than four days, residual solvents will still be found in the experiments. It should also be noted that all samples were heated to 200°C for 5 minutes before the crystallization measurement to eliminate any thermal history caused by the preparation process. The crystallization that may occur during the preparation process can be eliminated by this thermal treatment, so it will not affect the subsequent measurement of crystallization.