Interplay between liquid-liquid phase separation and crystallization and its effects on the morphology and crystallization kinetics in iPP/PB blends

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Introduction

Polymer blending is a very easy and effective way to improve mechanical and thermal properties of polyolefins. The properties of polymer blends depends on the miscibility and interaction of the components. To understand the fundamental physics of polymer blending is an important issue in controlling the morphology and property of products in plastic industry.

Polypropylene (PP) and polybutene-1 (PB-1) are both crystallizable polymers and widely used in industrial uses. The iPP/PB blends are partially miscible and have an UCST (upper critical solution temperature) diagram which exhibit an upper critical solution temperature much higher than the degradation temperature of the mixture. iPP has a melting temperature higher than that of PB-1. When iPP/PB blends were heated to temperature above the melting temperature, liquid–liquid phase separation occurred through the spinodal decomposition mechanism. When cooled to temperatures below the melting points, liquid-liquid phase separation was found to take place simultaneously with crystallization, which affect the blend morphology and properties of the final products greatly.

In this study, the miscibility, the interplay of phase separation and the crystallization process and its effects on the morphology and crystallization kinetics in iPP/PB blends were studied by means of SEM, FTIR and DSC.

Experiments and Data

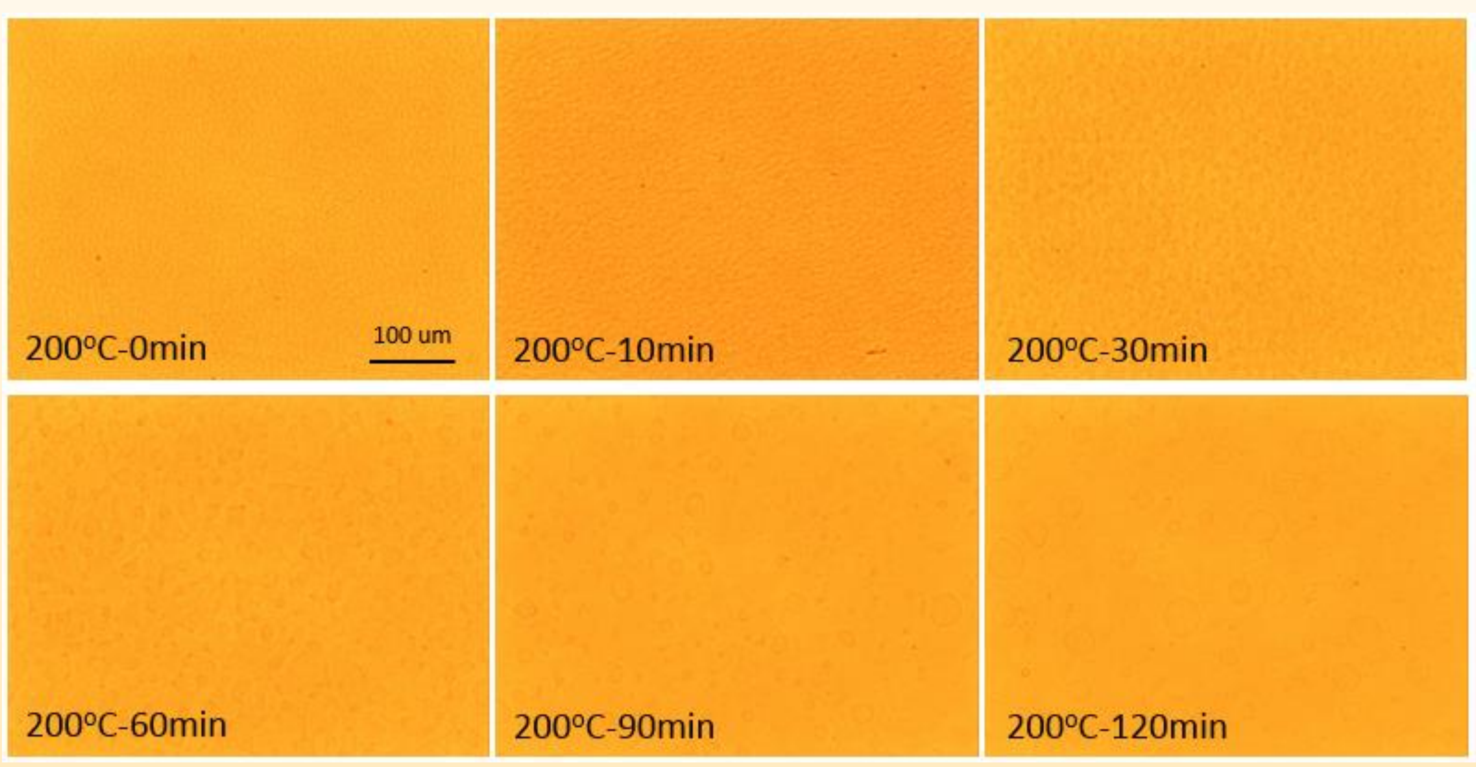
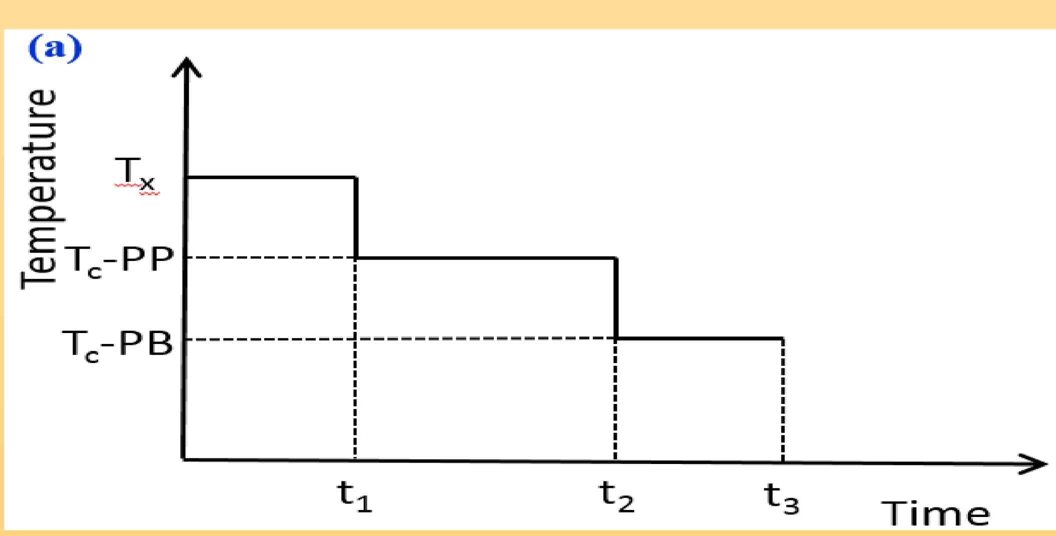


Figure 1. Optical microscopy pictures of morphological evolution of iPP/PB-5/5 blend annealed at 200 ºC.

Figure 1 shows the morphological evolution with time of iPP/PB-5/5 blends annealed at 200 ºC. The size of phase domain grows gradually indicating that the melt blends go through a liquid-liquid phase separation process. Besides, it has been confirmed that the higher the temperature, the faster the phase separation process for the iPP/PB blends system we studied.



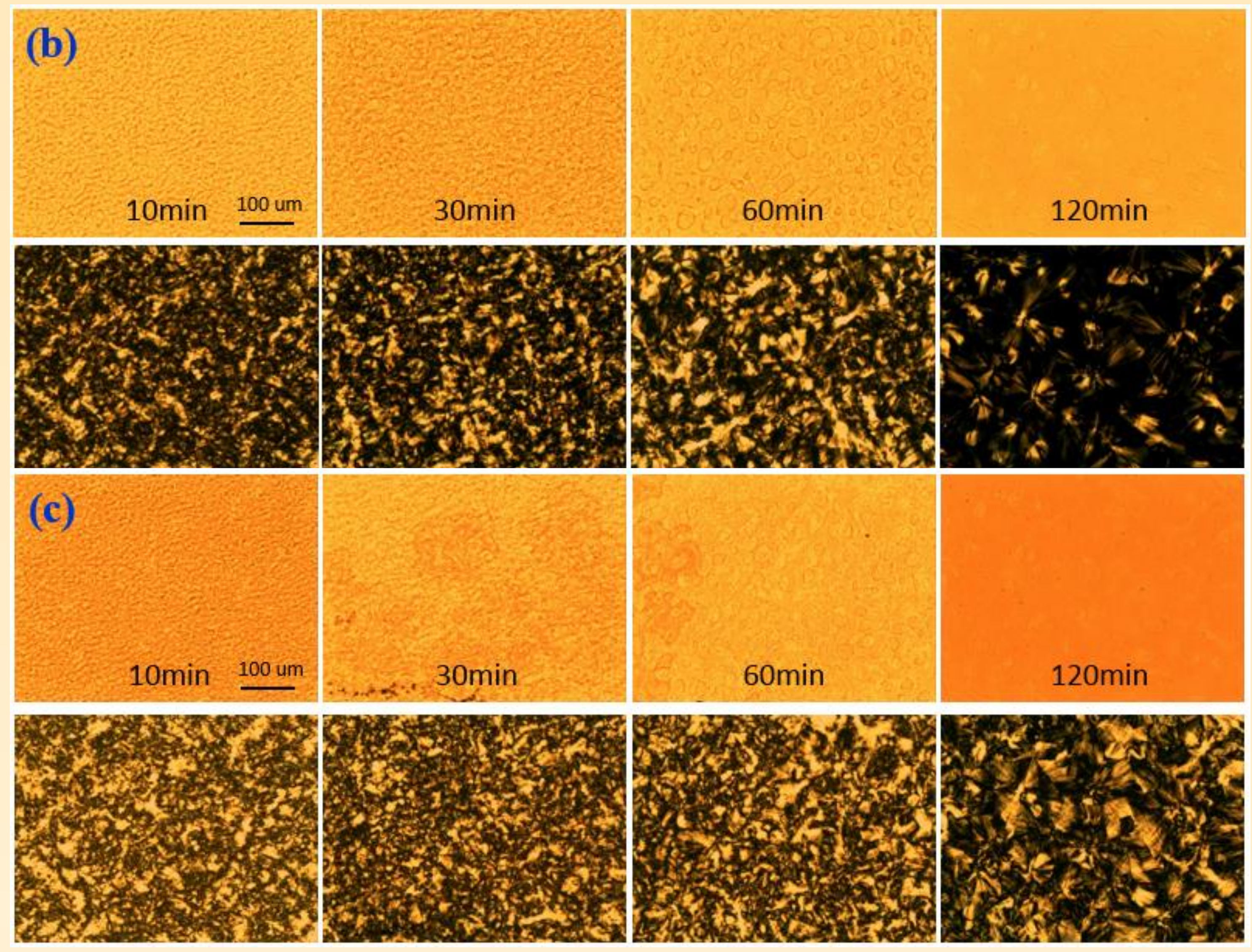


Figure 2. (a) Thermal histories of two-step crystallization conditions. (b) Optical (upper row) and polarized optical (lower row) microscopy pictures of iPP/PB-5/5 blends after isothermal crystallization at 120 ºC for 60min after annealing at 200 ºC for 10min, 30min, 60min and 120min, respectively. (c) The corresponding pictures of (b) after cooling to 95 ºC for 60min for PB-1 to crystallization.

Figure 2 shows the themal histories of two-step crystallization experiments and the morphologies of the blends after different thermal treatment.

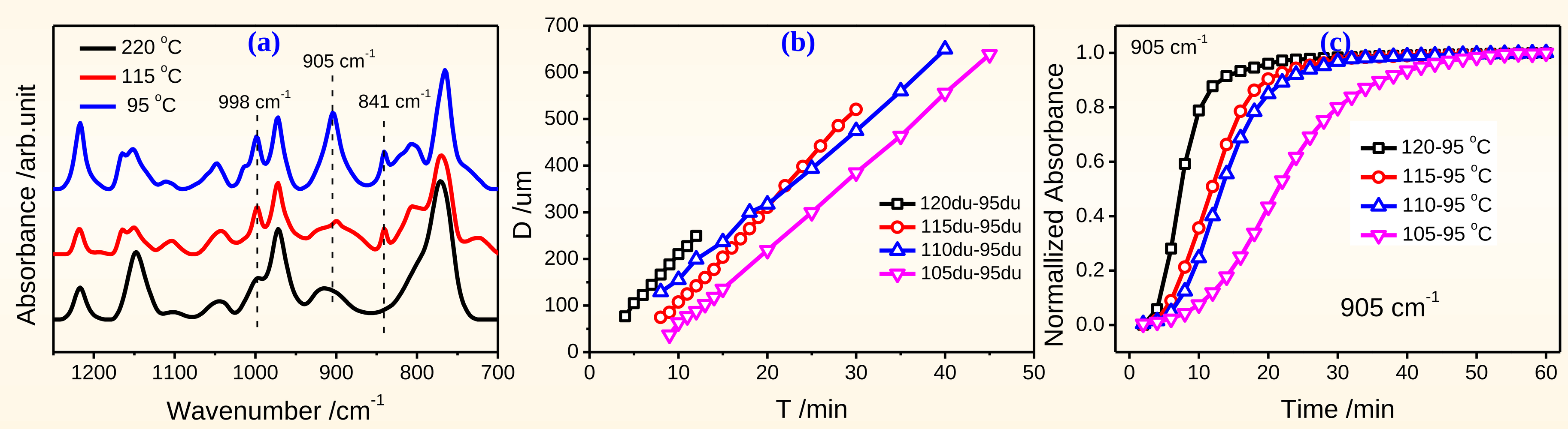


Figure 3. (a) FTIR spectrum of iPP/PB-2/8 blends at different temperatures. (b) The growth rate of the PB-1 spherulites calculated by the POM pictures. (c) The crystallization kinetics calculated by the integrated intensity of 905 cm^{-1}.

Figure 3 shows the information of crystallization kinetics of PB-1 in iPP/PB-2/8 blends. The growth rate of spherulites and crystallinity are calculated from POM pictures and FTIR spectrum, respectively.

Conclusion

In this study, a typical polyolefin blends which two components are both crystallizable, iPP/PB blends is studied to explore the interplay between liquid-liquid phase separation and crystallization and its effects on the morphology and crystallization kinetics. Results show that iPP/PB blends always exhibit phase separation phenomenon at the temperature ranges which the experiments can reached and high temperature can accelerate the process, which is ascribed to the combined effects of driving force and the motion ability. The phase separation process has significant influences on the morphologies and crystallization kinetics of the components. When cooled to temperatures below the melting points of PB-1, liquid-liquid phase separation together with the crystallization of iPP and PB-1 occurred simultaneously, making the condition more complicated. The morphology and structure certainly determine the properties of products and the relationship between them needs more efforts in the future.

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