

Kinetics of Microphase Transition and Ordered Phase Alignment of Block Copolymer under Flow

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Introduction

In the processing of block copolymer, the properties of the product depends heavily on the nano-structures, and thus the physics of flow-induced alignment of the structures need be understood to manipulate the direction, rate and the degree of alignment. In this work, we focus on the flow induced alignment of the cylindrical nano-structure of a SEBS tri-block copolymer Kraton G1652M. Solvent casting were used to prepare samples for the investigation. The alignment of the cylindrical structure was investigated under oscillatory shear with different frequencies, strains and steady shear with different rates. Measurements of the orientation of the structure were done by small angle X-ray scattering.

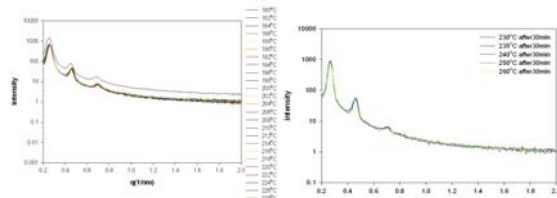


Figure 1a

Figure 1b

Fig. 1a and 1b show SAXS profiles for the samples at various temperature. When the temperature was situated between 180°C and 260°C, the scattering peaks of the sample were seen at the relative q -position of 1:31/2:71/2, reflecting well-ordered cylindrical microdomain structure.

Fig2a and 2b represent the intensity at different azimuthal angle ϕ of the first scattering peak extracted from the real time SAXS patterns for Kraton G1652M melt subjected to three different oscillatory shears at 220°C. The strain amplitude of the shears are fixed at 50% and the frequencies are 5 and 0.06rad/s respectively. The incident beam is parallel to the velocity gradient direction. These results reveal that shear with the frequency 5 rad/s gives the better alignment of cylindrical structure in terms of rate and the order that the structure reaches.

Fig.3a and 3b shows the evolutions of the intensity at different azimuthal angle ϕ of the first scattering peak extracted from the real time SAXS patterns for Kraton G1652M melt subject to one way shear at shear rate of 3.2s^{-1} and 0.03s^{-1} respectively. The figures show that higher shear rate leads faster alignment with a better order for the cylinder structure: when the melt of the copolymer was sheared at the rates of 3.2s^{-1} , nearly perfect alignment in the direction of velocity was achieved within 20; shear flow at 0.03s^{-1} can only result in such alignment after imposition of the shear for 10 minutes. Comparing the capability of flow in the alignment of the copolymer structure, one way shear

obviously prevails over oscillatory shear.

Conclusion

When subject to shear flow, the cylindrical nano-structure of Kraton G1652M are aligned in the direction of velocity. The rate of alignment and the order that the structure achieved by the flow depends on the intensity of the flow. For oscillatory shear, higher frequency and larger strain amplitude are more effective in the alignment, while for one way shear, higher shear rate can easily achieve a nearly perfect alignment. Comparison between these two types of shear flow, it is obvious that one way shear is more effective in alignment in terms of the time needed to reach alignment and the order of the alignment achieved.

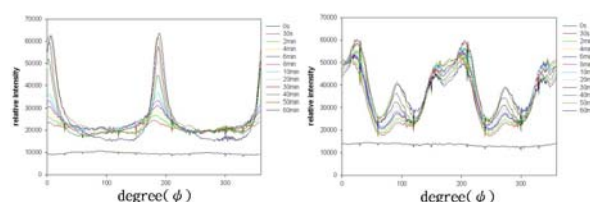


Figure 2a

Figure 2b

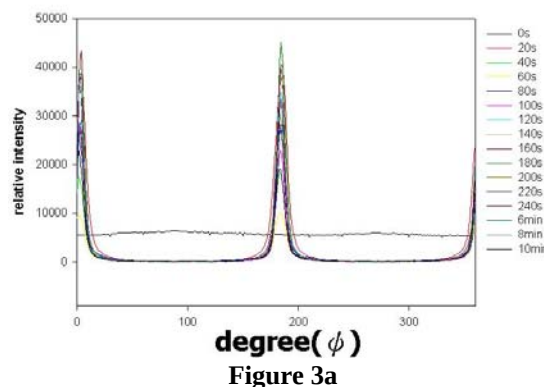


Figure 3a

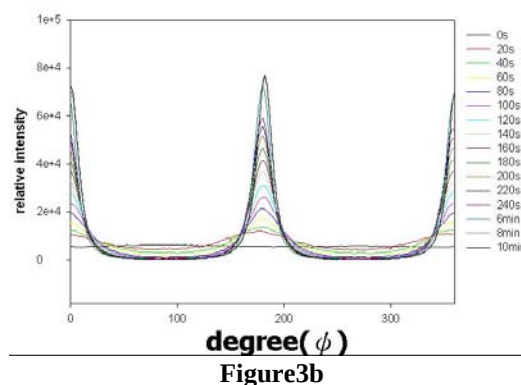


Figure 3b