

Kinetics of Microphase Transition and Alignment of Block Copolymer Melt under Shear Flow

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Small angle X-ray Scattering was coupled with a shear device (Linkam CCS 450) to investigate the orientational and structural evolution of a triblock copolymer (Kraton G1652M). Samples with preoriented in the vorticity direction and those with random orientation were sheared at various rates to in situ capture the two dimensional SAXS patterns for the analyses of structural and orientational changes with time. Figure 1 shows the 2-D SAXS patterns at various shearing time periods when a randomly oriented specimens was subject to a sudden shear from a quiescent state at 3.2s^{-1} and 202°C , while Fig. 2 shows those of a specimens preoriented in the vorticity direction with the same experimental conditions. In Fig. 1, the first SAXS pattern manifests the random orientation with a circle of equal scattering strength. After 10 second of shearing, orientation in the velocity direction was observed though the degree of order was fair. Continuous shearing for 40 seconds achieved a better degree of order in orientation. The order did not preserve since 10 second more of shearing a pair of scattering peak appeared in the direction that perpendicular to the velocity direction to signify the coexistence of two populations with different orientations. As the shearing continued, the scattering peaks broadened though the population in the velocity orientation dominated. The SAXS patterns barely changed until shearing time reached 450 second when the population in the vorticity direction started to diminish and restore in a rotation manner. Figure 9 showed that the specimens preoriented in the vorticity direction rapidly changed its orientation to the velocity direction upon the implementation of shear. After 30 seconds of shearing good order of orientation was achieved. The SAXS patterns at shearing time of 50, 80, 90, 100, 110, and 120 second showed that the order of orientation was slightly reduced with an orientation wiggling around the velocity direction.

Figure 3 shows the 2-D SAXS patterns at various shearing time periods when a randomly oriented specimens was subject to a sudden shear from a quiescent state at 0.038s^{-1} and 202°C , while Fig. 4 shows those of a specimens preoriented in the vorticity direction with the same experimental conditions. As shown in Fig. 3, randomly oriented sample gradually concentrated the population that oriented in the direction of velocity at the expense of other orientation predominantly those oriented in the neighborhood of vorticity direction. When shearing

persisted for 90 seconds, an orientation that slightly deviated from the velocity direction was observed, the deviation remained until the shearing time reached 500 seconds and from then on, the orientation in the velocity direction was preserved and the order of orientation kept getting better as the shearing time increased. The sample preoriented in the vorticity direction behaved differently at the same shearing conditions. A slow rotation of the orientation from the vorticity direction to the velocity direction occurred upon shearing and the rotation continued until shearing time reached 180 seconds. At shearing time of 320 and 690 second, four and six scattering peaks appeared in the SAXS pattern. Then the axes of cylinders in the melt restored their orientation in the velocity direction with a growth in the order of the orientation.

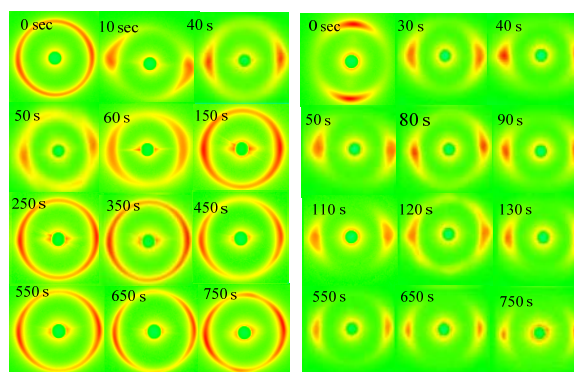


Fig. 1

Fig. 2

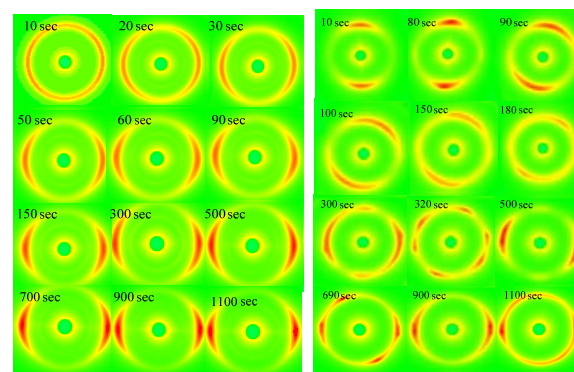


Fig. 3

Fig. 4