Lamellar-to-onion transitions with increasing temperature under shear flow studied by rheo-SALS and rheo-SAXS

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In the past 20 years, much attention has been paid to the effects of shear flow on the structure of the lyotropic phase. Among them, the lamellar phase has become of interest because the shear induced state is sometimes not simply related to an existing equilibrium. The most striking result may be the transition from the lamellar phase to the "onion phase" where all the space is filled by multilamellar vesicles alone. Although this type of transition has been reported for various surfactant systems, transition mechanism has not yet been established. Recently, we have found the lamellar-to-onion transition with increasing temperature under constant shear rate in the lamellar phase of a nonionic surfactant $C_{16}E_7$/water system by using small-angle light and X-ray scattering. The 2-D SAXS patterns suggest enhancement of the parallel orientation of lamellae just before the transition, followed by enhancement of the perpendicular orientation and suppress of the parallel orientation. These results support transition mechanism proposed by Zilman and Granek (1999) although the critical shear rate for onion formation predicted by them is about 10^6 times larger than the experimental one.

The lamellar-to-onion transition with decreasing temperature has been reported for $C_{10}E_3$ and $C_{12}E_4$ systems, which is explained in terms of increase (less negative) in the saddle-spray modulus of bilayers with the temperature elevation. Our findings are apparently controversial with these results. Very recently, however, we have found both types of transition, i.e., lamellar-onion-lamellar transition with varying temperature in a $C_{14}E_5$/water system. Investigation of transition processes in this system may give more general information on the condition of onion formation and the transition mechanism.