Effects of Shear Flow on Structures of Surfactant Lyotropic Phases

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In the past two decades, much attention has been paid to the effects of shear flow on the structure of the lyotropic phase composed of amphiphiles. Among them, 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 [1]. Although the onion formation has been reported for many systems, necessary conditions and mechanism of the transition have not yet been fully understood. A few years ago, we have found the lamellar-to-onion transition with *increasing* temperature under a constant shear rate in a nonionic surfactant system ($C_{16}E_7$/water) by using simultaneous measurements of shear stress/small-angle light scattering (rheo-SALS) and shear stress/small-angle X-ray scattering (rheo-SAXS) [2,3]. The lamellar-to-onion transition with *decreasing* temperature has been reported for other homologous systems, which can be expected from temperature dependence of the spontaneous curvature of monolayers. Our findings are apparently controversial with these results.

Recently, we have also found a system ($C_{14}E_5$/water) which exhibits re-entrant transition, i.e., the lamellar-onion-lamellar transition with varying temperature [4]. It is shown that the onion phase forms a closed loop in a temperature-concentration diagram at a constant shear rate. These results suggest that the re-entrant transition is a rather general phenomenon but either upper or lower transition can be observed for the most systems. To explain the re-entrant transition, we have derived a theoretical expression of the deformation energies stored in the edges and vertices of polyhedral onions as a function of temperature and concentration. We have also investigated the change in the lamellar orientation in the lamellar-to-onion and onion-to-lamellar transition processes near the upper and lower transition temperatures.

Finally, I will briefly mention our recent results on the effects of large-amplitude oscillatory shear (LAOS) on the grain growth of the bicontinuous inverse cubic phase of a nonionic surfactant ($C_{12}E_2$)/water system.

References
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