Structure and compressibility of worm-like lamellar domain in a hydrated solid phase

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In a binary system consisting of surfactant and water, a hydrated solid phase is formed below the Kraft temperature, where the hydrophobic tails extend to the length with all trans. The hydrated solid phase is a two-phase coexistence of excess water and lamellar structure L_β of bilayers whose hydrophilic tails are " solid-like " gel and interdigitated. So far, we have investigated the structural formation of the hydrated solid phase in the $C_{16}E_6$/water and $C_{16}E_7$/water system [$C_{16}H_{33}(OC_2H_4)_{6,7}OH$] by means of small angle X-ray and neutron scattering (SAXS, SANS) and optical microscope. We found clearly different structures in nm $\sim$ μm scale, even though those surfactants are slightly different from each other in the hydrophilic segment length. Figure 1a shows vesicle structures and worm-like lamellar domains observed in the $C_{16}E_7$ system and $C_{16}E_6$ system, respectively. In this study, to clarify the formation process of the lamellar domains, we performed SANS experiments. Especially here, we report the hyper-swollen lamellar structure in the $C_{16}E_7$ system.

The SANS experiments were carried out using the SANS-U spectrometer. The momentum transfer q ranged over $0.003 \leq q \leq 0.2$ Å^{-1}. The Krafft temperatures are 287 K for the $C_{16}E_7$ system. Temperature was jumped from 289 K to 277 $\sim$ 287 K. The concentration of $C_{16}E_7$ is 10 wt %, respectively.

Figure 1b shows a typical SANS profile obtained at 279 K in the $C_{16}E_7$ system at about 1 hour after temperature quench. Bragg peaks can be clearly seen, and they correspond to a swollen lamellar structure whose repeat distance is 84 nm. These Bragg peaks in such a low-Q region only appear below 279 K and at least above 281 K, they never appear. Coincidentally, from the microscope experiments, we found that below 279 K, small pieces of lamellar domains as shown in the inset of Figure 1b coexist for a few hours. It has been considered that lamellar domains hardly fuse each other because of the low temperature and they become quasi-equilibrium state. From all evidences, at present, we conclude that this hyper-swollen lamellar structure might be related to those small pieces of lamellar domains.

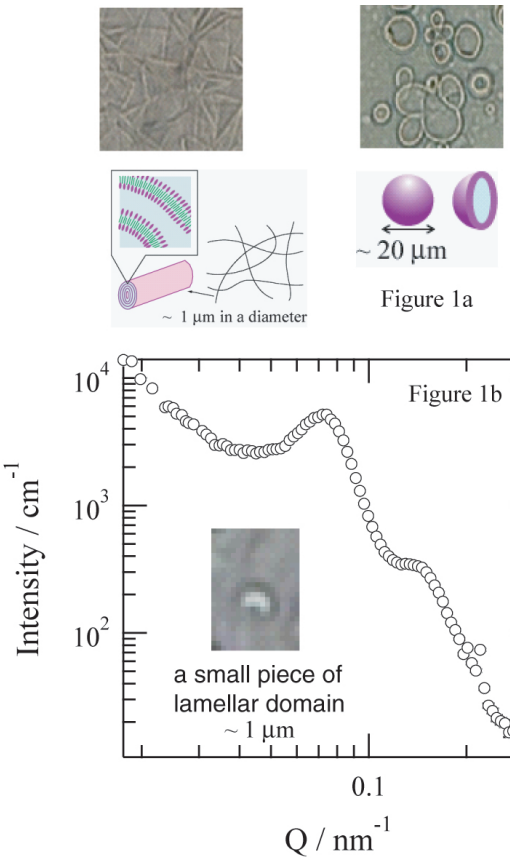

Fig. 1. The SANS profile obtained at 279 K in the $C_{16}E_7$/water system. A swollen lamellar structures whose repeat distance is 80 nm is formed.