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Micellar/Lamellar Phase Separation Processes in a Nonionic Surfactant/Water System

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界面活性剤が水と共に様々な相を形成することはよく知られているが、相転移の動的過程については十分な研究が行われていない。特に各相の構成単位が互いに大きく異なるミセル相からラメラ相への転移の機構は興味深い。われわれはミセルとラメラの中間的な構造を見出すことを期待して、ミセル相からミセル/ラメラ共存領域に温度ジャンプさせた後の相分離過程を、時分割小角 X 線・光散乱および光学顕微鏡を用いて追跡した。

1 Introduction

It is well known that surfactant-water systems form various kinds of mesophases. However, the kinetic pathway of the phase transition has not been much studied [1,2]. Particularly interesting is the micellar/lamellar transition because the building blocks of these two phases are very different. In the present study, we investigate the micellar (L_1)/lamellar (L_α) phase separation processes with the expectation that some sort of intermediate structures between L_1 and L_α structures may be found. To analyze the change in structures in nm and μm scale, time-resolved small-angle X-ray scattering (SAXS), small angle light scattering (SALS), and optical microscopy are used. A nonionic surfactant ($\text{C}_{16}\text{H}_{33}(\text{OC}_2\text{H}_4)_7\text{OH}$; C_{16}E_7)-water system was chosen because L_1/L_α phase separation occurs simply by increasing temperature and because the equilibrium structures in both phases have been studied extensively by us [3,4]

2 Experimental

SAXS measurements were performed by using the synchrotron radiation SAXS spectrometer installed at the BL-15A instruments at the photon factory (PF) of the High Energy Accelerator Research Organization (KEK), Tsukuba. SALS were measured by using a home-made apparatus. Optical microscope images were obtained on Olympus BHSP with a Mettler FP82HT hot stage.

3 Results and Discussion

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Figure 1 shows time evolution of optical microscope image after the temperature jump from 64°C (L_1) to 66°C (a) and 67°C (b) in the L_1/L_α coexistence region at 38.5 wt% of $C_{16}E_7$. In the case (a), the system approaches macroscopic phase separation as expected

although the rate of domain growth is slow. In the case (b), on the other hand, the domain first grows rapidly and then, the interface of the domain gradually disappears.

Figure 2 shows circular averaged SAXS intensities as a function of q ($= 4\pi\sin\theta/\lambda$) under the same condition as for Fig. 1. Figure 2(a) indicates coexistence of the L_1 (broad peak) and L_α (sharp peak) domains. In the case of the jump to 67°C (b), on the other hand, the SAXS pattern becomes similar to that of the L_α phase. However, the lamellar spacing is larger than that at the lower boundary of the L_α phase at 67°C. Moreover, the microscope observation under the cross Nichol suggest the system is optically isotropic.

Similar results have been obtained for other initial concentrations. These results suggest metastable structures exist in a narrow temperature range in the L_1/L_α coexistence region.

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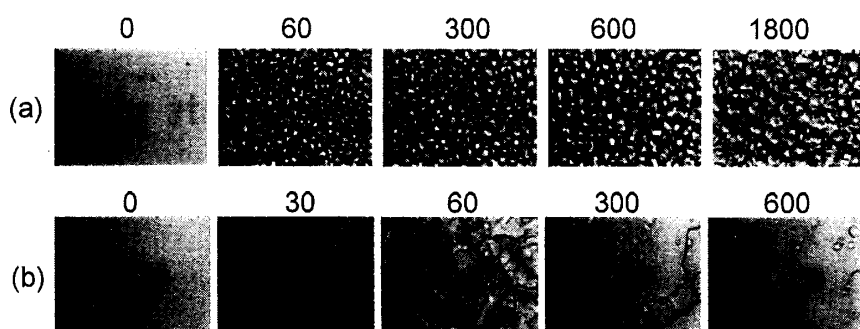


Fig. 1 Time evolution of optical microscope image after the temperature jump from 64°C in the L_1 phase to 66°C (a) and 67°C (b) in the L_1/L_α coexistence region at 38.5 wt% of $C_{16}E_7$. The numbers indicate the time (s) after the temperature jump. The scale bar indicates 10 μ m.

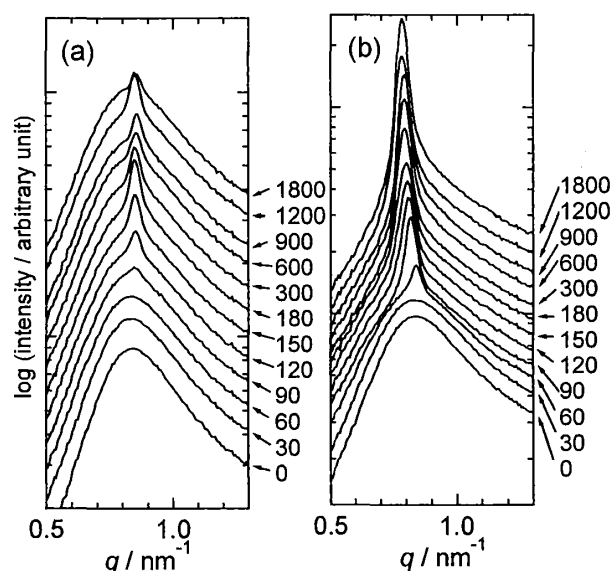


Fig. 2 SAXS intensities after the temperature jump from 64°C in the L_1 phase to 66°C (a) and 67°C (b) in the L_1/L_α coexistence region at 38.5 wt% of $C_{16}E_7$.