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Simultaneous SAXS/Rheology Measurements on the Lamellar Phase of a Nonionic Surfactant/Water System

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Introduction

In recent years, much attention has been paid to the effects of shear flow on the structure of a lamellar phase. In our previous studies, we have measured small-angle neutron scattering (SANS) on the lamellar phase of a nonionic surfactant $C_{16}H_{33}(OC_2H_4)_7OH$ ($C_{16}E_7$) in D_2O (40-55 wt%) at 70 °C [1]. When the shear rate increases from 0.1 to 1 s^{-1}, the repeat distance (*d*) is decreased significantly (down to about 40% of *d* at rest in the most significant case). This, together with other results including small-angle light scattering measurements, strongly suggests that the lamellar phase segregates into a concentrated lamellar region and a water-rich region. However, the segregation processes could not be elucidated because it takes about 5-10 min to obtain one SANS pattern. By using small-angle X-ray scattering (SAXS) with the CCD camera as a detector, on the other hand, a 2D scattering pattern can be obtained within a second. So we have constructed an apparatus for simultaneous SAXS/rheology measurements [2]. In the present study, we have improved the apparatus to measure SAXS for both radial and tangential configurations (see Fig. 1)

Experimental

A rheometer AR550 (TA Instruments) is modified for simultaneous SAXS/rheology experiments. Figure 1 shows schematic views of a sample cell. Details of the cell have been reported previously. In the present study, the thicknesses of the cupper jacket and the polycarbonate window have been reduced to make the X-ray path length as short as possible.

SAXS measurements were performed on the beamline 15A. The scattered beam was recorded using the CCD area detector covering the scattering vector range from 0.015 to 0.25 Å^{-1}.

Results

Figure 2 shows 2-D scattering patterns for the lamellar phase of a $C_{16}E_7$/water system. The tangential pattern at rest indicates that the lamellae are oriented along the velocity gradient direction, which may be caused by the sample loading. One hour after applying shear flow, however, the tangential pattern becomes isotropic whereas the radial pattern indicates strong orientation along the vorticity direction.

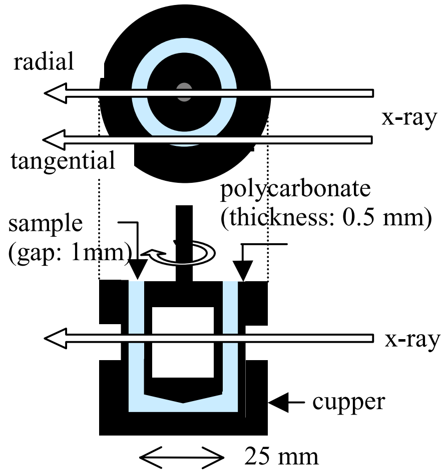

Fig. 1 Top (upper) and front (lower) views of a sample cell for simultaneous SAXS/rheology experiments.

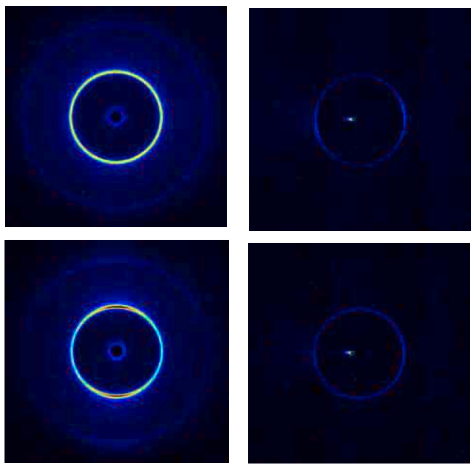

Fig. 2 2-D scattering patterns for the lamellar phase of a $C_{16}E_7$/water system (48 wt%, 70°C) at rest (top) and one hour after applying shear flow with the shear rate of 1 s^{-1} (bottom) for radial (left) and tangential (right) configurations. The flow direction is horizontal.

References

[1] T. Kato, K. Minewaki, Y. Kawabata, M. Imai, and Y. Takahashi, *Langmuir,* **20,** 3504 (2004).
[2] T. Kato, K. Miyazaki, Y. Kosaka, and Y. Kawabata, PF Activity Report (2004).

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