Neutron spin echo studies on bending modulus of bilayer membrane in DGI/SDS/D2O system

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Dynamics and bending modulus of *n*-dodecylglyceryl itaconate (DGI) bilayer membrane in a DGI/SDS/D_2O system were studied. The DGI membrane shows iridescent color from blue to red because of Bragg diffraction when the distance between the DGI membrane reach the order of 200 nanometer by the change in the concentrations of DGI and SDS. However, the reason why the distance is extended so large is still unclear. In order to make clear this, we investigated dynamics and bending modulus of DGI membrane using a neutron spin echo spectrometer and analyzed them along the Zilman and Granek model (Phys. Rev. Lett. **77**, 4788 (1996)).

In our experiment, DGI concentration was fixed at 1.6 wt % (44 mmol l^{-1}) and SDS concentration was changed and temperature was fixed at 56 - 58 °C. At lower concentration of SDS the color is red, however, the color shifts to blue with an increase of SDS concentration. We adopted red sample (No. 1, [SDS] = 4 $\times 10^{-4}$ wt % SDS, 1.1 $\times 10^{-2}$ mmol l^{-1}) and green one (No. 9, [SDS] = 2.7 $\times 10^{-3}$ wt %, 7.43 $\times 10^{-2}$ mmol l^{-1}), where the interplanar distance d was determined to be 240 nm and 220 nm for No. 1 and 9 samples, respectively.

Figs. 1 and 2 show dependence of intermediate correlation function $I(Q,t)/I(Q,0)$ on Fourier time t for No. 1 and 9 samples, respectively. The dotted lines are fitting lines by $I(Q,t)/I(Q,0) \propto exp[-(\Gamma_Q t)^{2/3}]$, which is obtained from Zilman and Granek model, where Γ is coefficient containing some parameters. It is expected that data scattering of No. 9 samples is arising from the beam line condition, not originated from sample.

Figs. 3 and 4 indicate the dependence of Γ_Q on wave number Q. According to the model, $\Gamma_Q \propto AQ^3$, where $A_Q = 0.0025\gamma k_B T^{3/2}\kappa^{-1/2}\eta^{-1}$, γ is almost constant ($\sim$ 1), κ is the bending modulus, η is the viscosity of fluid. The solid lines are fitting results on the basis of the model and the obtained indexes are 3.19 and 2.97 for No. 1 and 9 samples, respectively. The values are good agreement with that of the model. Next, from the obtained A, $\gamma = 1$, and η = viscosity of bulk water at the absolute temperature T, we obtained $\kappa = 6.7k_BT$ and $34.3k_BT$ for No.1 and 9 samples.

The experimental results can be thus described by the model. Let's discuss the reason why the addition of SDS reduce d. The obtained κ rapidly increases from $6.7k_BT$ and $34.3k_BT$. This may be explained by following scenario. In the solution, dissociated SDS molecules are adsorbed on the surface of bilayer membrane because of hydrophilic interaction and then the charge density on the surface is increased. At lower SDS concentration, the membrane is flexible and can fluctuate. However, with the addition of SDS the membrane becomes stiff and the amplitude of fluctuation becomes small. Thus, the interplanar distance is decreased. In order to understand full scenario, further experiment is required.

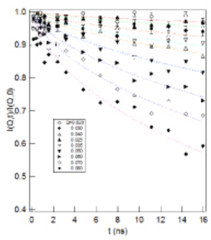

Figure 1: A plot of intermediate correlation function $I(Q, t)/I(Q, 0)$ as a function of Fourier time t for No. 1 sample. The dotted lines are fitting result using $I(Q, t)/I(Q, 0) \propto \exp[-(\Gamma_Q t)^{\alpha}]$.

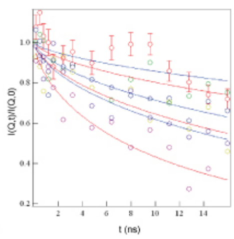

Figure 2: A plot of intermediate correlation function $I(Q, t)/I(Q, 0)$ as a function of Fourier time t for No. 9 sample. The dotted lines are fitting result using $I(Q, t)/I(Q, 0) \propto \exp[-(\Gamma_Q t)^{\alpha}]$.

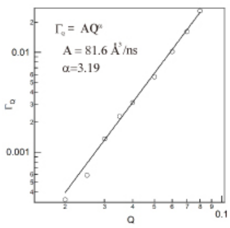

Figure 3: Dependence of Γ_Q on Q for No. 1 sample. The solid line shows the fitting result.

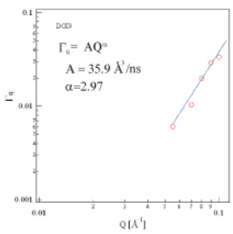

Figure 4: Dependence of Γ_Q on Q for No. 9 sample. The solid line shows the fitting result.

Fig. 1.