Phase Behaviour of Lipid Bilayers formed by mixtures of DMPC and DHPC studied by Small Angle X-ray Scattering

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1. Introduction

Bilayered mixed micelles (bicelles) of the two lipids DMPC and DHPC dispersed in an aqueous medium are thought to form discoidal aggregates with a thickness of ca. 40 Å. In a magnetic field, liquid crystalline like properties have been reported over a wide range of concentration, composition and temperature [1]. Bicelles are magnetically orientable thus yielding residual anisotropic properties in solution NMR. Such lipid aggregates have recently been used as model membranes for the incorporation of biomolecules and several structural NMR studies have been published in this field [1]. However, no systematic investigations of the structure and phase behavior of the lipid matrix itself have been done so far. We have used small angle X-ray scattering (SAXS) to study the spatial ordering of the bicelles as function of their concentration and temperature in the absence of a magnetic field.

2. Experiment

The DMPC / DHPC bicelles have been prepared at a molar ratio of 3:1 at concentrations between 1 and 30 wt.% in 0.02M Tris buffer solution containing 0.1M KCl at pH=7.5. SAXS measurements were done at RIKEN beamline BL45 using a CCD camera/ image intensifier detector system. The wavelength of radiation was 1 Å and the sample-to-detector distance was 0.5 m. The sample temperature was varied between 20 and 40 °C.

3. Results and Discussion

At a temperature of 40 °C we have observed powder-like diffraction rings at concentrations lower than 3 wt.% as well as at 24 wt.% and higher (Fig. 1). This indicates a stacking of the bicelles with random orientation of the stacks. From the analysis of the position and width of the first order Bragg peaks we can estimate the average interbicellar distance d and the correlation length ($\xi = 2\pi/FWHM$) in the stacks to d = 65 Å, ξ = 47 nm for the 1 wt.% sample and to d = 70 Å, ξ = 23 nm for the 30 wt.% sample. The sample at 30wt.% was stable under the given conditions whereas the bicelles below 5 wt.% were not stable and formed some white precipitation. At intermediate concentrations no Bragg scattering occurred, indicating the existence of single, unstacked bicelles.

The unexpected strong interparticle interaction with close stacking that we observed at low concentrations is consistent with the finding from our NMR experiments, that the bicelles at very low concentrations show a better alignment in a magnetic field than at higher concentration. At 20 °C, *i.e.* below the lipid bilayer phase transition temperature, we observed no Bragg scattering at any concentration.

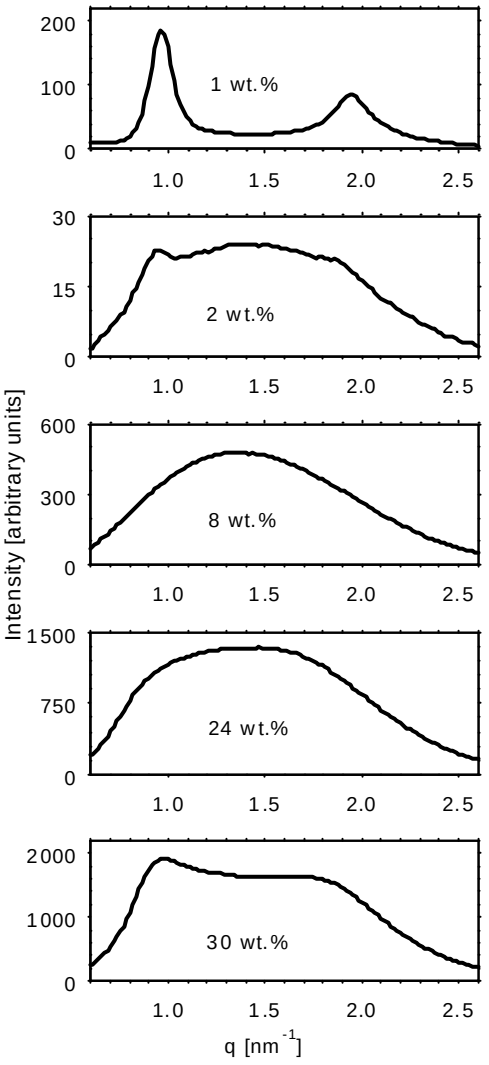

Fig. 1. Circular averaged SAXS profiles as a function of the lipid concentration measured from 3/1 bicelles of DMPC/DHPC at a temperature of 40 °C. Scattering vector $q=(4\pi/\lambda)\sin(\theta/2)$ with λ representing the wavelength of radiation and θ the scattering angle.

References

[1] C.R. Sanders and R.S. Prosser, Structure **6** (1998) 1227 and further references cited therein.