Morphology transition of surfactant meso-structures induced by addition of colloidal particles

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界面活性剤／水系のラメラ相の膜間にコロイド粒子を添加することによって起こる構造変化を、小角中性子散乱実験にて観察した。その結果、コロイド粒子の存在はラメラ膜のゆらぎを抑制し、膜間の規則性を高めることが分かった。よってコロイド粒子は膜間に実効的な斥力相互作用を及ぼしていると考えられる。さらにコロイド粒子を添加すると、ラメラ相からミセル相へと転移した。この現象は、コロイド粒子の存在によってゆらぎを抑制されたラメラ膜が、そのフラストレーションを解消する為にミセル相へ転移したと説明できる。

1 Introduction

The soft matter forms a variety of mesoscopic structures using a large number of the internal degrees of freedom. These structures easily transform to other morphologies by applying external fields, such as shear flow and electric field. In this study, we proposed a new type of the external field, i.e.; addition of guests, which affects the meso-structure through their entropic interactions between host meso-structure and guests. For example, the most familiar entropic interaction is depletion effect[1], which is an attractive interaction between host particles caused by the reduction of the free volume of the guests. Another example is the lamellar-lamellar phase separation induced by the polymer chains confined between lamellar slits[2]. In this context, we have investigated the effect of colloidal particles on the lamellar membranes[3].

2 Experiments

We used nonionic surfactant $C_{12}E_5$ and polystyrene colloidal particles with the diameter of 20 nm. The colloidal particles were confined between the lamellar slits having the inter-lamellar distance of $\sim$ 100 nm (volume fraction of surfactant ϕ_{C12E5}=0.031). The morphological change of surfactant meso-phases induced by the addition of colloidal particles was followed by small-angle neutron scattering (SANS) using SANS-U instrument at JRR3-M at Tokai.

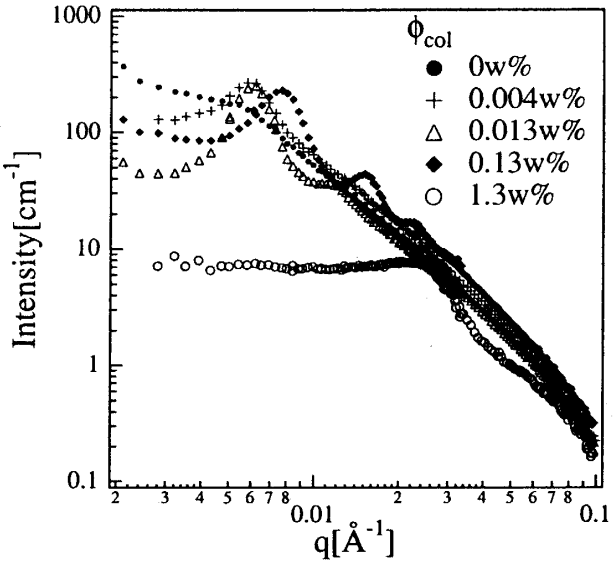

Fig.1 SANS profile of lamellar phase confining colloidal particles at ϕ_{C12E5}=0.031 as a function of ϕ_{col}.

3 Results & Discussion

Fig.1 shows a series of SANS profiles as a function of volume fraction of colloidal particle ϕ_{col}. It should be noted that the scattering profile without guests doesn't have characteristic lamellar peaks due to the large membrane fluctuations. The addition of a small number of colloidal particles brings emergence of first Bragg peak and sharpens it. Thus, the existence of the particles suppresses the undulation fluctuations. This indicates that the colloidal particles brings repulsive inter-membrane interactions.

By the further addition of colloidal particles, the SANS profile suddenly changed at ϕ_{col}=1.3w%. The new scattering profile could be described by a model scattering function of a prolate micelles. Thus, the lamellar to micelle transition is induced by the addition of the colloidal particles.

We interpret observed phenomena as follows. The existence of the particles suppresses the undulation of membranes, resulting in the reduction of the membrane free volume. This frustration brings the morphological transition from the lamellar membranes to micelles.

References

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