Structural Formation of Uni-Lamellar Vesicles in a Mixture System of Long- and Short-Chain Lipids

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It has been well known that natural swelling of a dry phospholipid film usually produces large multi-lamellar vesicles [1]. These mimic biomembranes produced from synthetic phospholipid molecules have been extensively studied to understand the actual behavior of real biomembranes. Living cells and their organelle, however, exist as uni-lamellar vesicles (ULVs). Therefore, effective methods to create the ULVs have been studied so far [2].

For a phospholipid mixture system consisting of long- and short-chain lipids, it was reported that bilayered micelles with 10-100 Å diameter, so-called bicelle, are spontaneously formed at low temperature, and they fuse into vesicles at high temperature. Especially, ULVs with 100-1000 Å diameter are formed only when the bilayers are charged [3]. This suggests that the electrostatic interaction is important for the ULV formation in the lipid-mixture system. The mechanism of the ULV formation, however, has not been studied well. Therefore, we have performed small-angle neutron scattering (SANS) experiments on the lipid-mixture system to investigate the effect of the electrostatic interaction on the ULV formation.

In this study, we have performed SANS experiments on a typical lipid mixture system, dimyristoylphosphatidylcholine (DMPC) and dihexanoylphosphatidylcholine (DHPC) mixture system, at SANS-U, JRR-3M, JAEA, Tokai, Japan [4]. Since multivalent cations adhere onto the hydrophilic part of lipid molecules, the lipid mixture was dissolved in $CaCl_2$ aqueous solution of 3 mM to obtain charged bilayers. The experiments were performed for the lipid mixtures with different NaCl concentration, that is, the shielding length of the electrostatic interaction. The obtained results are shown in Fig. 1. The SANS profiles for 0 and 50 mM NaCl are very similar, irrespective of the existence of the salt. It is found from the form factor of a ULV, *i.e.* the profiles in the low-q region, that its diameter for 50 mM (about 1200 Å) is almost the same as that for 0 mM. On the other hand, the low-q profile was drastically changed and a new Bragg peak corresponding to a multi-lamellar structure with repeat distance of about 75 Å was observed for 100 mM NaCl. From these results, we concluded that the electrostatic interaction has a little effect on the shape of the ULV, but contributes much to its stability.

References

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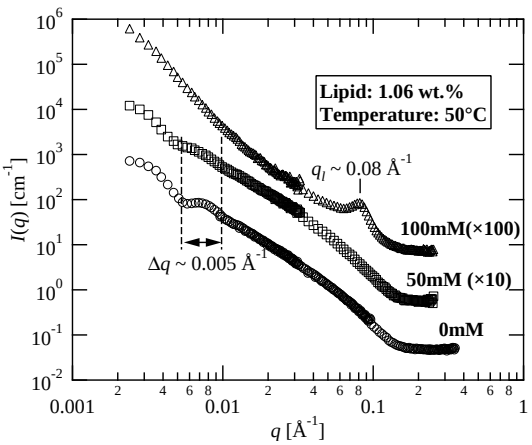

Fig. 1. Dependence of a SANS profile on NaCl concentration.