Aggregate Formation and Air/Water Surface Adsorption of Short-Chain Phospholipids Mixture

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The aggregate formation and surface adsorption of aqueous binary mixture of short-chain phospholipids, dihexanoyl-phosphatidylcholine (DC₆PC) and dioctanoyl-phosphatidylcholine (DC₈PC) were examined by surface tension measurement as a function of the total molality and bulk composition. The concentration vs. composition diagram of aggregate formation was constructed by analyzing the surface tension data and taking account of the fact that DC₆PC and DC₈PC form spherical and worm-like micelles in the pure systems, respectively. The diagram demonstrated that the formation of worm-like micelles becomes more favorable by mixing DC₈PC with DC₆PC despite the fact that DC₆PC molecules do not form worm-like micelles by themselves. In addition, the phase diagram of adsorption, which shows the composition relation between the bulk solution and adsorbed film (Figure (a)) was also constructed in order to elucidate the miscibility of DC₆PC and DC₈PC in the adsorbed film. The excess Gibbs energy of adsorption calculated by applying the thermodynamic equation to the diagram like Figure (a) is negative (Figure (b)), suggesting an attractive interaction between the two species in the mixed adsorbed film. It was concluded that the attractive interaction between the trimethylammonium group of DC₆PC and phosphate group of DC₈PC becomes effective when the ends of the chain groups of two species match with each other, making both of the electrostatic interaction between head groups and the van der Waals interaction between hydrophobic tail groups more effective in the mixed films than pure films. Such a synergistic effect is also expected in the worm-like micelles, which have partly small curvature.

Figure (a) The phase diagram of adsorption at constant surface tension $\gamma=32$ mN m⁻¹, $X_2$ and $X_2^{H}$ are the bulk composition and composition of adsorbed film.
(b) Excess Gibbs energy of adsorption at $\gamma=32$, 35, and 40 mN m⁻¹.