Study on rheological property of mixed aqueous solutions of Phosphatidylcholine and Lysophosphatidylcholine

修士学位論文内容要旨

Abstract

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Lecithin are phospholipid substances which their structures consist of phosphoric acid with choline, glycerol and fatty acids. The main source of lecithin is egg yolk, milk, marine source, sunflowers or soybeans. They are useful material which is applied in several fields. For example, in food industry, lecithin are used for food textures, antioxidant, emulsifier or surfactant. Lecithin are used as zwitterionic surfactants, they have ability to self-assembly into a several of micellar structure in aqueous solution or organic solvent, depending on the chemical structure of lecithin, temperature, pH, light; for instance, spherical micelles, vesicle micelles, bilayer micelles or wormlike micelles.

Phosphatidylcholine (PC) is a major phospholipid component in lecithin. PC is commonly studied as surfactant or emulsifier because of PC structure consist of hydrophilic part (head group) and hydrophobic part (tail group) which can reduce surface tension. The hydrophobic head group of PC is choline, while the hydrophobic tail groups is fatty acid chains. Furthermore, PC can be used to produce Lysophosphatidylcholine (LPC) by the hydrolysis reaction with phospholipase A_2. From this reaction, the one mole of fatty acid of PC is removed, causing LPC has more hydrophobicity than PC.

From recent study, the researcher investigated the formation of wormlike micelle structure of lecithin mixtures which consist of PC and LPC in aqueous solution. They found that pure PC normally formed planar structure, while pure LPC will aggregate to form spherical micelle. However, the lecithin mixtures at total concentration about 56 mM or above could formed the wormlike structure at temperature more than 45 ˚C. Because the

alkyl chain of PC and LPC were melted at high temperature, resulting in high flexibility and molecular mobility. And further, PC and LPC would be bind each other and aggregated to form a new structure which show a high viscosity and transparent relate to a characteristic of wormlike structure. Moreover, they also found that after formation on heating, the wormlike micelles remained stable on cooling.

To our knowledge, this is the first report on the formation of phospholipid wormlike micelles without the addition of salts in aqueous solutions. Since, normally, lecithin will form reverse wormlike micelle with addition of salt in organic solvent. And there are only a few researches on zwitterionic worms. To get more information about this system, in present study, the rheological properties of mixed LPC and PC with different molar ratio in aqueous solution at varied temperature was determined. In addition, the reorganization of wormlike micelle based on LPC and PC was also investigated.

Firstly, LPC and PC system with different molar ratio was measured the rheological properties by falling ball method and oscillatory measurement. It is found by falling ball test that the mixture with high concentration of PC showed a high viscosity at low temperature and exhibited gel-like behavior. However, the viscosity decreased with increasing temperature since a reduction of micelle size and diminution of micellar network. On the other hand, the mixtures contained high concentration of LPC show the opposite tendency which showed a low in viscosity and transparent at low temperature and switched to a high in viscosity with increasing temperature. However, from oscillation frequency sweep test showed that an increase in viscosity with transparent correlated with a formation of wormlike structure. In the other word, only the sample with LPC: PC is 40:24 and 44:20 had ability to form a wormlike structure. For LPC: PC 40:24 system, the sample could form wormlike micelle at wide range of temperature (5-30 ˚C.), while LPC: PC =44:20 system could form only at 30 ˚C.

Second, the reorganization of wormlike micelle based on LPC and PC was measured. In this experiment, only the mixtures of LPC and PC with molar ratio were 40 to 24 and 44 to

20 which had ability to form a wormlike structure was investigated. The samples include LPC: PC = 40: 24 at 10-30 ˚C and LPC: PC = 44:20 at 30 ˚C. To prepare, the mixture was heated followed by cooled down and kept at specific temperature for 24 hours for equilibration of system. Further, the mixture was cut the length of wormlike structure by Silverson machine before rheological measurement. The viscosity of sample was determined as a function of time. From our result showed that both of samples at 30 ˚C presented a high in viscosity depend on time, indicating they had an ability to recover their structure. While the sample at 10-20 ˚C could not recover its structure, resulting in a low viscosity with time. In addition, steady-shear measurement also supported our result which showed a shear-thinning behavior at 30 ˚C which is a typically wormlike characteristic. On the other hand, the sample at 10-20 ˚C presented a Newtonian fluid behavior, indicating the formation of rod-like micelle.