

# Phase separation induced by surfactants

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Water and oil do not mix. However, by adding surfactants such as soaps and detergents, the interfacial tension between water and oil is significantly reduced, and macroscopically transparent and homogeneous state is exhibited. Furthermore, many studies have revealed that nanostructures such as micelles and bi-connected structures are formed in solution at this time. In contrast, little attention has been paid to the action of surfactants on mixed solutions of water and hydrophilic organic solvents, which are originally well mixed.

Fig. 1(a) shows the phase diagram of D<sub>2</sub>O/2,6-dimethylpyridine (2,6-DMP) mixtures with and without surfactants, which was obtained by our previous research. This mixture exhibits LCST-type critical behavior and undergoes phase separation above 28°C. It was found that the addition of sodium dodecyl sulfate (SDS), an ionic surfactant, reduced the two-phase region. That is, it can be said that SDS works as a surfactant in order to increase the compatibility of the mixture. On the other hand, when pentaethylene glycol monododecyl ether (C<sub>12</sub>E<sub>5</sub>), a nonionic surfactant, was added to the D<sub>2</sub>O/2,6-DMP mixtures, it was found that the two-phase region expanded. In other words, it was suggested that C<sub>12</sub>E<sub>5</sub> acts "oppositely to surfactants" (inducing liquid-liquid phase separation) in the mixture. Similar results were also seen with the water/acetonitrile (AN) mixtures (see Fig. 1(b)).

As for the reason why surfactants induce phase separation, we currently think as follows; in D<sub>2</sub>O/2,6-DMP or D<sub>2</sub>O/AN mixtures, C<sub>12</sub>E<sub>5</sub> forms a bilayer membrane in which no oil is incorporated on the hydrophobic group side. At this time, by assuming that the hydrophilic groups on the surface of the bilayer membrane of C<sub>12</sub>E<sub>5</sub> selectively attract water molecules in the mixture, water molecules should be pulled away from 2,6-DMP or AN. In this manner, it

is considered that the mutual solubility of the mixture decreases by adding C<sub>12</sub>E<sub>5</sub>.

To verify this assumption, we performed the contrast variation SANS measurements for water/2,6-DMP-d9/C<sub>12</sub>E<sub>5</sub> mixtures. Figure 2 shows the SANS profile for the mixture in the vicinity of the critical point. Under contrast matching conditions, a SANS profile arising from the lipid bilayer membrane can be confirmed. In addition, SANS profiles arising from concentration fluctuations of water/2,6-DMP can be confirmed under conditions away from the matching point. We are currently investigating the reason why C<sub>12</sub>E<sub>5</sub> induces phase separation while carefully analyzing these profiles.

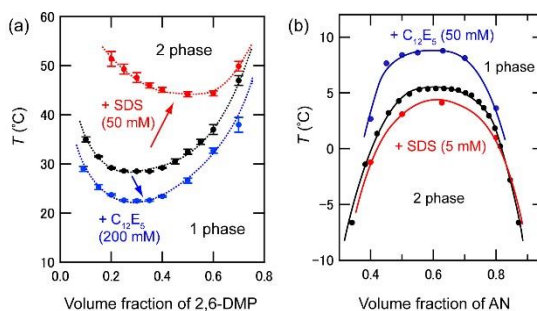


Figure 1: Phase Diagrams of D<sub>2</sub>O/2,6-DMP or D<sub>2</sub>O/AN mixtures with and without surfactants.

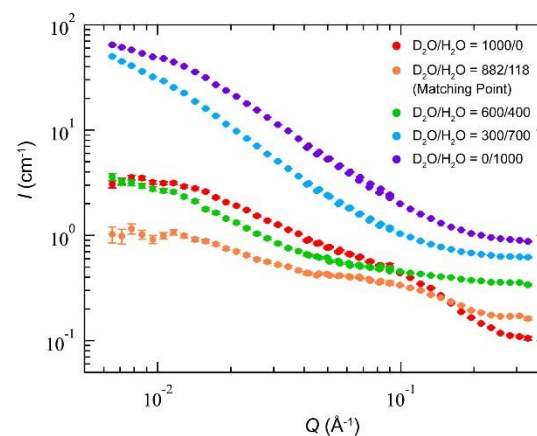


Figure 2: SANS profiles for water/2,6-DMP/C<sub>12</sub>E<sub>5</sub>.