PILOT CHEMICAL COMPANY
www.pilotchemical.com
2744 East Kemper Road • Cincinnati, OH 45241

Technical Bulletin:

MICELLES

What are micelles?

Micelles are colloidal aggregates of surfactant molecules. Micelles first form in a surfactant solution at a well-defined concentration known as the *Critical Micelle Concentration or CMC*.

Why do micelles form?

The driving force behind the formation of micelles (micellization) is the actual structure of the surfactant molecule. As detailed in the Surfactants Research Bulletin (RFF 705.10.01), a surfactant molecule comprises a hydrophilic head and a hydrophobic tail. In aqueous solution, these molecules will aggregate in ways which minimize the contact between the hydrophobic portion with the surrounding water.

What is the structure of a micelle?

There are three basic types of micelles involved in PC or HI&I products; small, spherical micelles containing less than 100 surfactant molecules (Figure 1), cylindrical, rod-like micelles (Figure 2) and large, flat or lamellar micelles (Figure 3, on the next page). (Note: there is a fourth type, the vesicle, which is important in biological systems).

Figure 1

Figure 2

Figure 3

The micellar structure of a given surfactant solution depends largely on three factors; the molecular shape of the surfactant, the concentration of the surfactant itself and the presence and concentrations of any other components of the system such as electrolytes (e.g. NaCl) or secondary surfactants.

Empirically speaking, at low concentrations of surfactant and electrolyte, spherical micelles predominate. As the surfactant and/or electrolyte concentration increases, the proportion of rod-like micelles in solution increases leading to a rise in viscosity (the "salt thickening" phenomenon). At a certain point, the rod-like micelles pack together forming a very high viscosity gel. Increasing the surfactant concentration further eventually results in the formation of the lamellar phase which is once again mobile. It is in this state that the so-called "high-active" materials exist. The concentrations at which these phase transitions occur is dependant on the surfactant.

Why are micelles so important?

Generally, a polar (hydrophilic) solvent will dissolve polar materials (solutes), a non-polar (hydrophobic) solvent will dissolve non-polar materials. For example, water (a very polar solvent) will dissolve sodium chloride (an ionic or very polar solute) but not oil (a non-polar solute). The opposite is true with hexane, a very non-polar solvent. A micellar solution, however, is unique in that it allows non-polar solutes to dissolve in a polar medium.

Because of the orientation of the surfactant molecules in a micelle in aqueous solution, there exists a hydrophobic region within the micelle. This hydrophobic regime will incorporate non-polar solutes, thus achieving solubility of oil in water. This leads directly to the use of surfactants as detergents as most soils encountered are non-polar.