Mechanism of detergency of oily soil

Suk kyung KIM and Motoko KOMAKI
(Department of Life Science, Ochanomizu University)

1. Introduction

Carboxylate soaps have been used for laundry for many centuries, but during the twentieth century fat shortages have led to the development of synthetic surfactants such as alkyl phenol sulfonate and alkyl ethoxylate. These new surfactants, when properly blended with organic and inorganic additives, can perform many detergent operations much better than the carboxylate soaps. This search for new detergents has stimulated over the past 20-30 years a great deal of research into the mechanism of detergent action.

"Soil" has been defined as matter out of place and "detergency" as to remove the matter to some other place. The soils are those on clothes, bed-linen, household fabrics, pots, pans, crockery, cutlery and so on. Almost invariably they consist of a mixture of liquid -fat and oil- and finely divided particulate soil. Fortunately the solid and liquid components are often removed independently, and even when they are not, as may happen when the proportion of fat is relatively high, the net effect can be explained by treating the two separately[1].

In this paper, particularly, mechanism of removal of oily soil is reported.

2. Mechanism of removal of oily soil

Schwartzs has listed three principal mechanisms for the removal of liquid oily soils by surfactants[2]. One is so-called rolling-up or roll-back mechanism that depends on the wetting properties of aqueous surfactant solutions. When surfactant increases the contact angle of the oil-water-solid system in the oil ($\theta_{sow} > 90°$) by adsorbing to the interfaces of water/solid and water/oil, the oil will be formed to droplet and displaced with water by hydraulic currents. If the contact angle is $\theta_{sow} > 90°$, the oil will remain on the solid.

The second mechanism is direct emulsification of a thick layer of oil. In the case of very low contact angle, it is possible to remove a large proportion of the oil by emulsifying it into the bath. The effect of mechanical action is very important in the emulsification process.

The third one, rather loosely called solubilization, applied to both oily and solid materials which are water-insoluble. Considerable proportions of the water-insoluble matter are capable of being dissolved in aqueous solutions of surfactant that are above their cmc but still rather dilute. One possibility is ordinary solubilization directly into surfactant micelles[3]. Another is the formation of an intermediate phase containing soil, surfactant, and water that is more readily removed than the original soil. Several workers have noted the formation of intermediate phases of lamella liquid crystal for various systems and conditions[4] [5].

Rolling-up is widely believed to be the dominant mechanism for high-temperature washing of cotton fabrics with common anionic detergent formations. However, although the oily soil is removed by rolling-up at high washing temperature where their viscosities are low, it may be removed by solubilization at low temperature. Moreover, rolling-up is inherently more difficult to achieve when adhesion between soil and fabric is strong,

such the case of oily soils on many synthetic fabrics.

3. Contribution of liquid crystal to detergency

At high concentrations, in the range of 10-100 times of the cmc, aqueous surfactant solutions solubilize organic substances. Lawrence dealt with interaction between soap and water and an added organic substance which contains a polar group and said that polar-polar group cryoscopic interaction (in the presence of water) is one of the fundamentals of detergency[1]. The succession of events is then: 1) Formation of a very viscous membrane around the dirt. 2) Penetration of solvated soap through this membrane into the soil. 3) Osmotic flow of water into the dirt and solvated soap complex. 4) Extrusion of myelin forms. 5) Solution of myelin tubes into the surrounding soap solution, aided by continued flow into the complex diluting it.

Polar oils are solubilized more than nonpolar oils. It is presumed that the surfactant moleculars form extended sheet and water is concentrated between the heads of surfactant moleculars[2].

Also, many papers reported that detergency was best when the oil was solubilized most rapidly into intermediate phases and/or rather concentrated phases such as liquid crystals initially present in the washing bath[6)~8)]. Jong-Choo Lim observed dynamic behavior in systems containing nonionic surfactants and mixed soil and presumed that once liquid crystalline formation begins, agitation breaks figures and disperses them in the washing bath, the result being good soil removal[9]. A direct connection between liquid crystal formation and detergency was provided by Kielman and Steen, who demonstrated that removal of a pure long-chain alcohol soil from polyester/cotton fabric was dramatically improved when an intermediate liquid crystalline phase developed[10].

4. Conclusion

The process of soil removal is extremely complex, so that the nature of the actual detachment and breaking up of soils of sticky consistency and strongly adherent character cannot be simply explained. And also modern detergents came to contain components more and more in order to enhance wash performance. Therefore, mechanism of detergency needs to be determined more systematically, considering the change of wash conditions.

< Reference>

1) T. G. Jones, A. S. C. Lawrence, chapter 4, 7 in "Surface Activity and Detergency", Durham, K., Ed.; Macmillan: London (1961)
2) A. M. Schwartz, "The physical chemistry of Detergency" in "Surface and Colloid Science", Vol. 5, E. Matijevic, Ed, Wiley, New York (1972)
3) B. J. Carroll, J. Colloid Interface Sci., 79, 126 (1981)
4) A. S. C. Lawrence, Nature (London) 189, 1491 (1959)
5) K. T. Raterman and J. A. J. Colloid Interface Sci., 98, 394 (1984)
6) K. H. Raney, W. J. Benton and C. A. Miller, J. Colloid Interface Sci., 282, 117 (1987)
7) K. H. Raney and C. A. Miller, J, Colloid Interface Sci., 119, 539 (1987)
8) F. Mori, J. C. Lim and C. A. Miller, Prog. Colloid Polym. Sci., 82, 114 (1990)
9) J. C. Lim and C. A. Miller, Langmuir, 7, 2021 (1991)
10) H. S. Kielman and B. J. F. van Steen, "Surface Active Agents", Society Chemical Industry: London (1979)