PHYSICAL CHEMISTRY 2014

12th International Conference
on Fundamental and Applied Aspects of
Physical Chemistry

The Conference is dedicated to the
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12th International Conference on
Fundamental and Applied Aspects of
Physical Chemistry

Organized by
The Society of Physical Chemists of
Serbia

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DETERMINATION OF TENSIDE MIXTURES EFFICIENCY: CONDUCTOMETRIC AND STALAGMOMETRIC INVESTIGATION

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ABSTRACT

The performances of mixtures of different surfactants: anionic (sodium lauryl ether sulfate (SLES) and ά-olefin sulfonates (AOS), amphoteric (coco betaine) and nonionic (coco amide, amine oxide, AO and various etoxylated alcohols, C12-C15-7EO, C10-7EO and C9-C11-7EO), were studied. The parameters measured were critical micelle concentration (CMC) and surface tension of particular tenside mixture. The combination of SLES/AOS/C9-C11-7EO/AO at ratio 75/15/7/3 achieved the lowest both the CMC and surface tension compared to the other examined tenside mixtures (SLES/AOS, SLES/AOS/coco betaine/AO, SLES/AOS/coco amide/AO, SLES/AOS/C12-C15-7EO/AO and SLES/AOS/C10-7EO/AO). This study showed that adding nonionic tenside (alcohol ethoxylate, C9-C11-7EO) improved SLES/AOS foaming properties, synergism in detergency between them. The reduction in the surface tension was obtained, thus indicated that alcohol ethoxylate, C12-C15-7EO, C10-7EO and C9-C11-7EO can be used to produce better cleaning products.

INTRODUCTION

Washing and cleaning in aqueous wash liquor is a complex process involving the cooperative interaction of numerous physical and chemical influences. In the broadest sense, washing can be defined as both the removal by water or aqueous surfactant solution of poorly soluble matter and the dissolution in water (soluble impurities from textile surfaces).
Surfactants (tensides or surface active agents) are amphiphilic molecules that possess both hydrophobic and hydrophilic properties. A typical surfactant molecule consists of a long hydrocarbon "tail" that dissolves in

hydrocarbon and other non-polar solvents, and a hydrophilic ″headgroup″ that dissolves in polar solvents (typically water) [1]. Because of its dual affinity, an amphiphilic molecule in different solvents show more or less marked tendency to the spontaneous: a) accumulate in the phase boundary surfaces by reducing the surface tension of the solution, and b) form aggregates of molecules (micelles). Namely, when a sufficient amount of surfactant is dissolved in water, several bulk solution properties are significantly changed, particularly the surface tension (which decreases) and the ability of the solution to solubilize hydrocarbons (which increases). These changes do not occur until a minimum bulk surfactant concentration is reached. This concentration is called the critical micelle concentration, CMC. Several experiments, show that below the CMC, the surfactant exists mainly as solvated monomeric species, whereas above the CMC these monomers undergo selfassembly to form roughly spherical structures (having an average diameter of ~5 nm). Micelles are the simplest of all selfassembly structures.

Generally, the main component for cleaner or detergents is a surfactant or mixture of surfactants (anionic and non-ionic) such as in the modern detergent formulations. Synergism between surfactants in detergent formulations will affect the surfactant properties such as detergency, foaming and wetting. For estimating detergency power and detergent concentration of use, it is very important to determine both, the critical micelle concentration and surface tension [2].

In this work, we investigated mixtures of different surfactants: anionic (sodium lauryl ether sulfate, SLES and ά-olefin sulfonates, AOS), amphoteric (coco betaine) and nonionic (and coco amide, amine oxide, AO and various etoxylated alcohols, C12-C15-7EO, C10-7EO and C9-C11-7EO). The CMC values and surface tension of various tenside mixtures were obtained from the conductometric and stalagmometric method.

EXPERIMENTAL

The conductivity measurements were applied to determine the CMC in various combinations of surfactant systems. Those measurements were carried out with digital conductivity meter SensION 5 (Hach, USA) with the accuracy $\pm$ 0.5 %, and with the 51975 conductivity probe that uses the 4−ring method. The conductometric method is based on the finding of a breaking point on the curve which describes the concentration dependence of electrical conductivity. The value of CMC is the intercept of two linear functions with mutually different slopes.

All the surfactants mixtures were soluble in water. The surfactant mixture solutions were prepared in a standard 100 mL volumetric flask (w/v) and than diluted to desired concentration. The surface tension of each mixed surfactants were measured with a stalagmometer. The determination of the surface tension can be done by the drop-weight method or drop counting method, and we used drop counting method.

RESULTS AND DISCUSSION

In this study, the values of the CMC and surface tension of different tenside mixtures were obtained. We tested following mixture of surfactants: 1) two anionic surfactants (SLES and AOS) – SLES/AOS; 2) two anionic surfactants (SLES and AOS), one ampoteric (coco betaine) and one non-ionic (AO) – SLES/AOS/coco betaine/AO; 3) two anionic (SLES and AOS) and two non-ionic (coco amide and AO) – SLES/AOS/coco amide/AO; 4) two anionic (SLES and AOS) and two non-ionic (C12-C15-7EO and AO) – SLES/AOS/C12-C15-7EO/AO; 5) two anionic (SLES and AOS) and two non-ionic (C10-7EO and AO) – SLES/AOS/C10-7EO/AO; 6) two anionic (SLES and AOS) and two non-ionic (C9-C11-7EO and AO) – SLES/AOS/C9-C11-7EO/AO. The ratio of SLES/AOS is (80/20) and in the other experiment SLES/AOS/tenside/AO (75/15/7/3)

Representative plot of specific conductivity, κ, as a function of the concentration, c, for surfactant mixture SLES/ά-olefin sulfonates (in the ratio of 80/20 at 23 °C is shown in Figure 1.
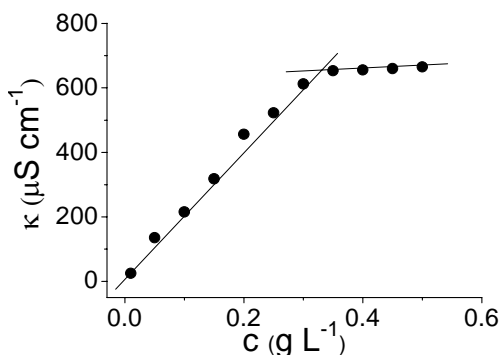

Figure 1.
Conductivity vs concentration at 23°C for SLES/ά-olefin.

For all examined mixtures of surfactants, each plot shows the single break point. The CMC is obtained from the intersection of the fitting lines of the κ–C plots above and below the break point [3]. For the criterion of the fit, the best correlation coefficient was chosen. The obtained values of the CMC of different tenside mixtures are all summarized in Table 1.

The values of surface tension of 0.1% water solutions of tenside mixtures are presented in Table 1. Using SLES/AOS mixture, the surface tension was found higher (35.3 mNm^{-1}) than with using other examined mixture probably because of the lower polar charge of the latter. Mixing both amphoteric tenside and nonionic tensides in the mixture of anionic surfactants (SLES/AOS), further reduced the surface tension compared by the SLES/AOS. This suggests a mixed micelle formation between anionic and nonionic surfactants. The best detergency was obtained for SLES/AOS/C9-C11-7E/AO from the ratio 75/15/7/3 with surface tension 22.8 mNm^{-1}.

Table 1. The CMC and surface tension of various tenside mixtures

Tenside mixture	CMC (g/L)	γ (mN/m)[*]
SLES/AOS	0.33	35.3
SLES/AOS/coco betaine/AO	0.28	29.2
SLES/AOS/coco amide/AO	0.25	29.0
SLES/AOS/C12-C15-7EO/AO	0.10	23.2
SLES/AOS/C10-7EO/AO	0.09	23.0
SLES/AOS/ C9-C11-7EO/AO	0.09	22.8

*For 0.1% water solutions of tenside mixture

CONCLUSION

Nonionic tenside have a great influence on the CMC of anionic surfactant mixture. Thus, mixture of tensides (anionic and nonionic) can be used in a lower concentration. Favorable detergency properties of nonionic surfactants derive largely from the following factors: a) low critical micelle concentration, CMC = 0.09 g L^{-1}, b) very good detergency performance and c) the low CMC values of nonionic surfactants indicate that they show high detergency performance even at relatively low concentrations.

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