THE UTILIZATION OF THE SURFACE TENSION MEASUREMENT FOR THE EVALUATION OF THE CRITICAL MICELLE CONCENTRATION OF CETYL TRIMETHYLAMMONIUM BROMIDE

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INTRODUCTION

It is well known that under a critical concentration, the surfactant is dispersed mostly in monomers. Above that concentration, however, the surfactant will aggregate and form micelles in the bulk solution. This concentration is defined as critical micelle concentration (CMC). Critical micelle concentration values can be determined by a number of techniques including surface tension, the electrical conductivity, light scattering, electron paramagnetic resonance and analytical ultracentrifugation [1,2]. Conductivity meters and tensiometers are the two most popular methods for determining CMC [2].

The surface tension method uses a surface tensiometer and measures the point at which the solution surface is saturated with a surfactant. The proportion of molecules presented at the surface of a liquid or as micelles in the bulk of liquid depends on their concentration. At low concentrations, surfactants occupy the surface of the liquid. As the surface becomes crowded with surfactant, additional molecules arrange into micelles, and surface tension becomes independent of the surfactant concentration (Figure 1) [1, 3].

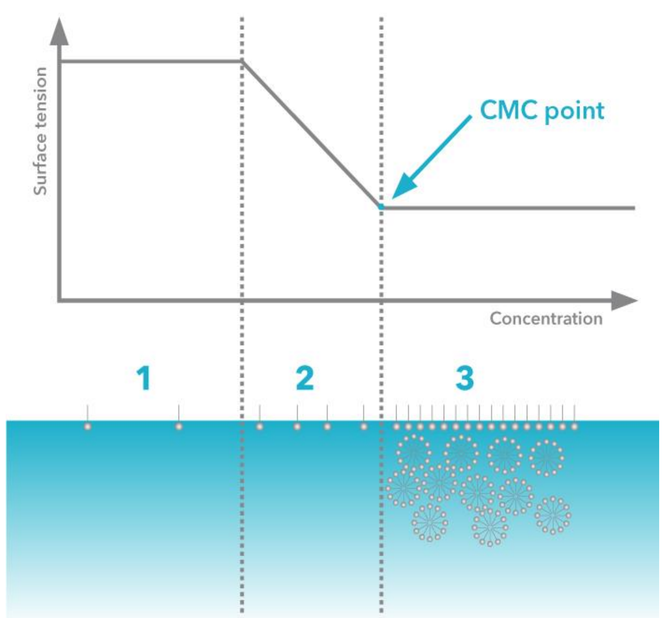

Figure 1: Relation between surfactant concentration and surface tension and CMC of surfactant [3]

MATERIALS AND METHODS

Cetyl trimethylammonium bromide (CTAB) (Sigma-Aldrich spol. s.r.o., Czech Republic) was dissolved in ultrapure water and acetate buffer with pH 5.5 to obtain a solution with concentration 600 mg/L and 500 mg/L, respectively. These stock solutions were subsequently diluted to a concentration of 500, 450, 400, 350, 300, 250, 200, 100 and 50 mg/L for ultrapure water and 400, 300, 250, 200, 175, 150, 125, 100, 75, 50, 25 and 10 mg/L for acetate buffer.

The surface tension measurement was performed using the processor tensiometer Krüss type K 100 (Krüss GmbH, Germany) with a thermostat. The equilibrium surface tension of all prepared solutions was evaluated using a ring method (Figure 2) at 25 °C three times for each concentration.

Figure 2: Ring [4]

RESULTS AND DISCUSSION

The results from the measurements of CTAB in ultrapure water are presented in Figure 3. The resulting curve was interposed with two linear line segments. The CMC value was calculated using the equations describing line segments (-0.07x + 58.2 = 0.003x + 34.701). The obtained CMC value of 321.9 mg/L (0.88 mM) corresponds with the results given by the manufacturer (0.92 – 1.0 mM) [5] and scientific literature (0.8 mM) [6].

Figure 4 shows the results of the evaluation of the surface tension of CTAB solutions in acetate buffer with pH 5.5. The resulting curve was interposed with two linear line segments. The CMC value was calculated using the equations describing line segments (-0.991x + 48.888 = -0.0012x + 40.565). The CMC value of CTAB in acetate buffer (85 mg/mL or 0.23 mM) is lower in comparison to CMC in ultrapure water. The lower value of CMC in acetate buffer can be explained by the electrolyte effect on micelle formation. The electrolyte neutralizes the charge at micelle surface, reduce the thickness of the ionic layer around the surfactant ionic heads and, therefore, the electrostatic repulsions between them, helping in this way the micellization process [6]. The similar effect can be observed in the presence of ionogenic drugs. The decreased value of CMC can cause a reduction in emulsifying efficiency of the surfactant.

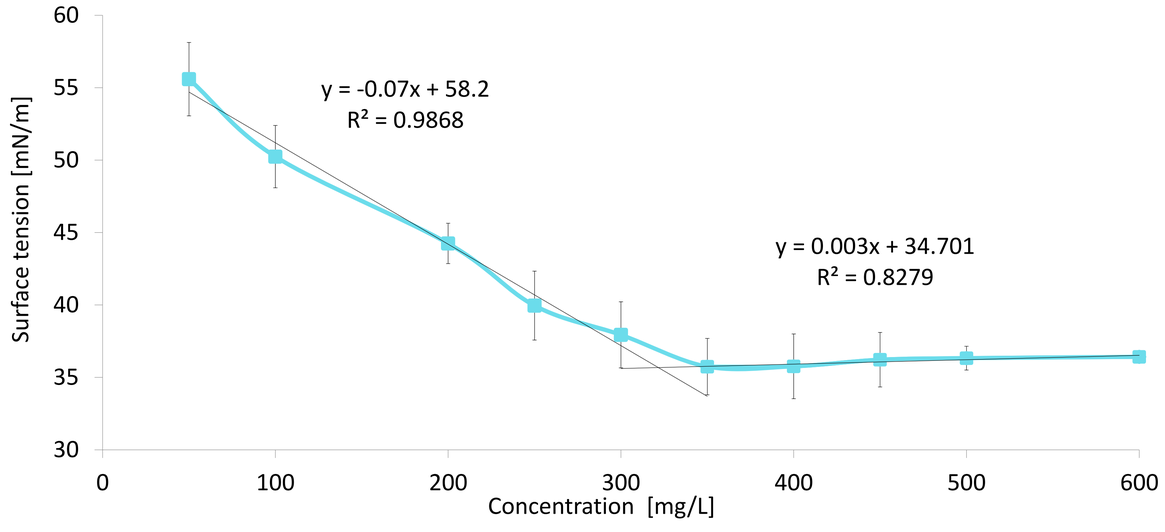

Figure 3: Relation between concentration and surface tension of CTAB in ultrapure water

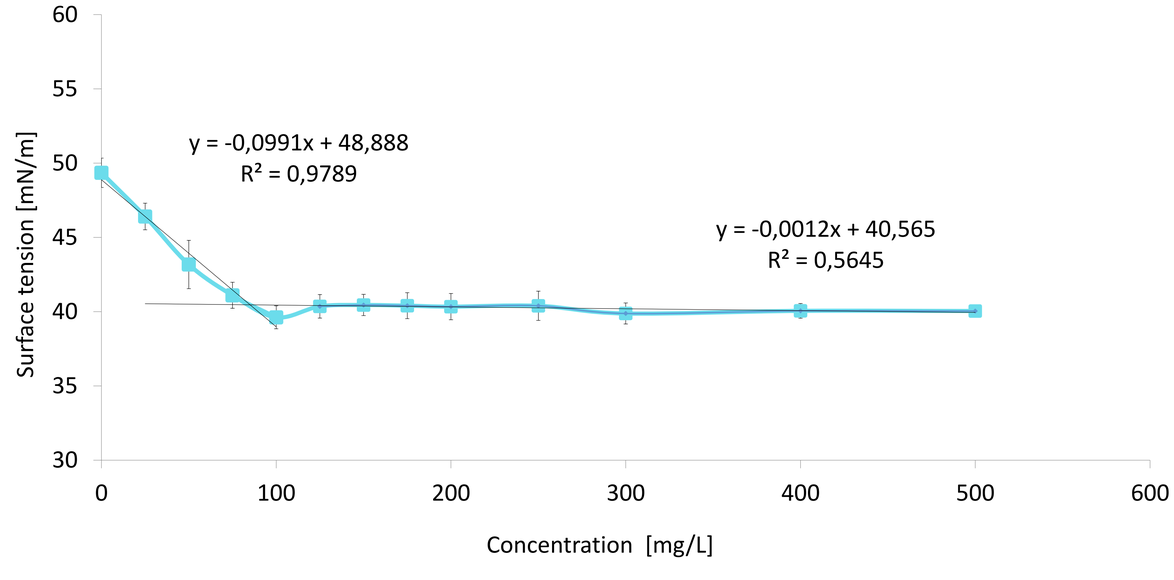

Figure 4: Relation between concentration and surface tension of CTAB in acetate buffer

CONCLUSION

The CMC value of CTAB was 0.88 mM and 0.23 mM for ultrapure water and acetate buffer, respectively. The lower value of CMC for acetate buffer can be explained by the electrolyte effect.

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