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Critical Micellar Surfactants Concentration by Electrical Impedance Spectroscopy

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Abstract – The electrical impedance spectroscopy (EIS) is a powerful method to characterize the materials many electric properties, for example, and can be useful to verify the transition that features the micelle formation. We are thus undertaking an approach, through the impedance spectroscopy application, on how the electrical response of aqueous solutions of anionic and zwiterionic surfactants varies with the concentration to determine its critical micellar concentration (CMC) values.

The superficial tension is an important physico-chemical property of any substance in the condensed phase, which sets its colloidal behavior. In particular, from the morphogenesis point of view, it is the most important physico-chemical property of a substance. The superficial tension great importance compels its control, in biological and technological systems. This is possible due to substances that hold the property of, in small quantities, changing the water superficial tension value considerably.

The main structural characteristics are: polar group nature (chemical nature, charge presence and type), apolar group nature, number and dimension of each one, polar and apolar parts conformation and flexibility. Disposing of all these variables, it is possible to build a great number of molecular structures, which can present partition different properties of adsorption, micellization and auto-organization, in general, forming uncountable supra-molecular structures which properties are in turn very different and interesting.

The greater or smaller tendency towards micelas formation is evidenced by the critical micelar concentration - CMC, or be, the concentration above which micelas presence is detectable in a system. There are some simple rules that allow predicting CMC tense-active variation tendencies in water: it decreases with the tense-active molecule apolar part rise, it increases with the polar part growth. In case of ionic tense-actives, it decreases with the environment ionic force increase.

In this work, we use EIS to examine the dielectric response of three different aqueous surfactants solutions (sodium dodecyl sulfate (SDS), lithium dodecyl sulfate (LDS) and N-dodecyl-N,N-dimethyl-3-ammonio-1-propanesulfonate (DPS), chosen as examples of anionic, anionic and zwiterionic, respectively) for determination of its critical micellar concentration (CMC) values. In every case, impedance diagrams allow the critical micellar concentration evolution (CMC) determination, as a dissolved surfactant relative amount function.

By the use of a 1260 impedance/gain-phase analyzer (Solartron, UK), we determined the real and imaginary impedance parts of different solutions in the 1 Hz–1 MHz frequency range. As the electrodes were working, we used two 15 mm wide steel blades that were vertically dipped 2 cm apart in a beaker containing 25 mL of the interest solution, so that each blade was immersed to a depth of 22 mm into the solution.

The relation between Z' and Z" for surfactants successive additions SDS and LDS in water, respectively is presented in Figures 1a and 2a. Considering the values of such quantities in the point where Z" is maximum for different concentrations, we observed that the discontinuous point corresponded to the CMC of the surfactant. Therefore, through the Figures 1b and 2b, we can verify that the CMC held 7,99 mM for SDS and 7,80 mm for LDS, respectively.

Measures preliminaries point out an identical behavior to DPS, which is a ionic surfactant (CMC = 3,98 mM). Initial measures suggest that EIS can also be used in the SDS surfactant CMC determination in NaCl 0,1 M solution. In this case, a drastic decrease occurs in the surfactant CMC value (CMC = 1,02 mM), due to a larger cations concentration in Na^+ in solution.

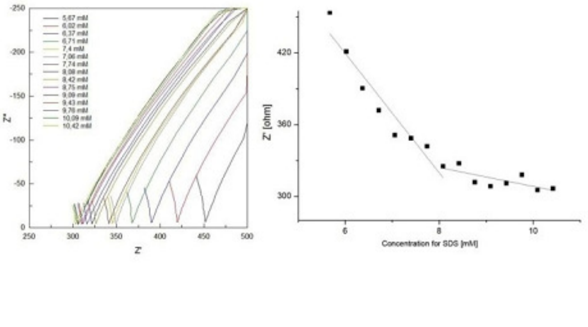

Figure 1: a) Z' versus Z" and b) Z' versus concentration for SDS's different concentrations.

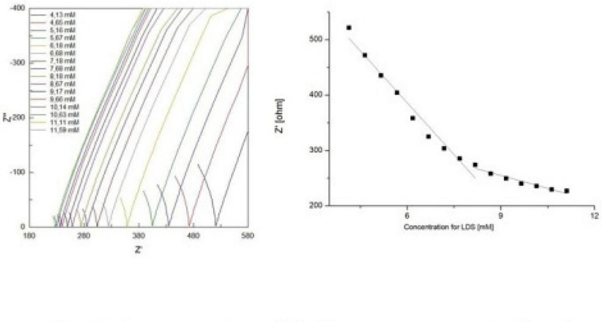

Figure 2: a) Z' versus Z" and b) Z' versus concentration for LDS's different concentrations.