Comparative Analysis of Electrical Conductivity and Tensiometry Methods for Measuring Critical Micelle Concentration (CMC) of Surfactants CAHS and SDS: Impact of Water Type on CMC Measurements

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1 Introduction

Surfactant foams play a crucial role in different operations in porous media, like soil remediation. Surfactants have the ability to reduce the surface tension between two immiscible phases, such as oil and water, and act as major foaming agents [1]. This work is part of the ANR project BBFOAM aiming to characterize the foam flow in a porous medium, in the presence of pollutants. For surfactant analysis, determining the critical micelle concentration (CMC) is of paramount importance. The CMC is the concentration at which surfactant molecules begin to self-assemble and form micelles, which significantly affect their surface tension and electrical properties [2]. In this study, we assess two commonly used methods for measuring the CMC of surfactants: conductimetry (electrical conductivity measurement), and tensiometry (surface tension measurements) [3]. Two different types of water: tap, and deionized water, used in laboratory and field applications were employed to investigate the influence of water type on CMC measurements. Two types of surfactants were used: Sodium Dodecyl Sulfate (SDS), an anionic surfactant, and Cocamidopropyl hydroxysultaine (CAHS), a zwitterionic surfactant.

2 Experiments

2.1 *Conductimetry*

This method measured the fluid electrical conductivity of both surfactant solutions in tap and deionized water, with different concentrations, using a conductivity meter. The conductivity measurement was carried out for various concentrations of solutions, with min 0.1g/L to max 3g/L, in triplicate and the mean value was calculated. The surfactant concentration was plotted against the electrical conductivity (see Figure 1). We fit the data with a linear fit, in order to identify the CMC, as the point on the plot corresponding to a change of slope.

2.2 *Tensiometry*

We measured the surface tension of SDS and CAHS solutions with different concentrations as above. It is performed by using the Drop Shape Analyzer system (DSA-100 from Kruss). The Interfacial tension (IFT) is calculated from the shadow of the digital image captured by the camera using the drop shape analysis [3]. The IFT was plotted, following the same principle as in previous method.

3 Discussion and Results

3.1 *Deionized water*

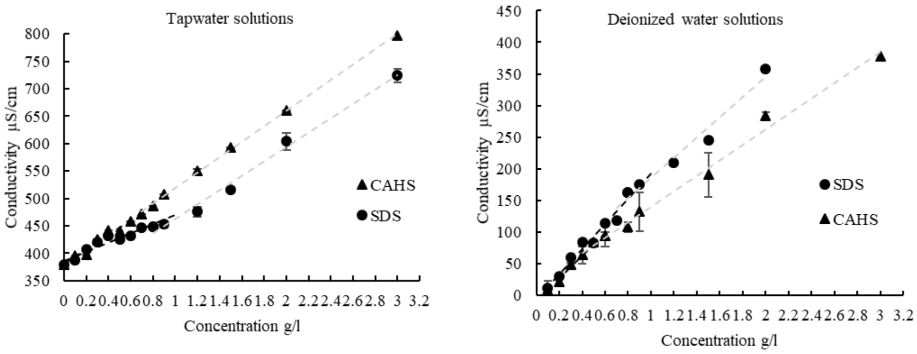
Using conductimetry, the measured CMC for CAHS is 0.48 g/L and 0.85 g/L for SDS (Figure 1b). In tensiometry, the measured CMC is 0.55 g/L for CAHS and 0.79 g/L for SDS (Figure 2b). The variations in the calculated values are expected among different techniques, as they measure different physical properties associated with the surface absorption or aggregation behavior of the micelles.

3.2 *Tap water*

Using the conductimetry, we were not able to determine the CMC of the tested surfactants, because no detectable change in the slope of the line was detected (Figure 1a). For tensiometry, the measured CMC is 0.59 g/L for CAHS, and 0.42 g/L for SDS. The difference in values raised between the deionized and tap aqueous solutions referred to the effect of ions exist in the tap water solution. The results are in Table **1**.

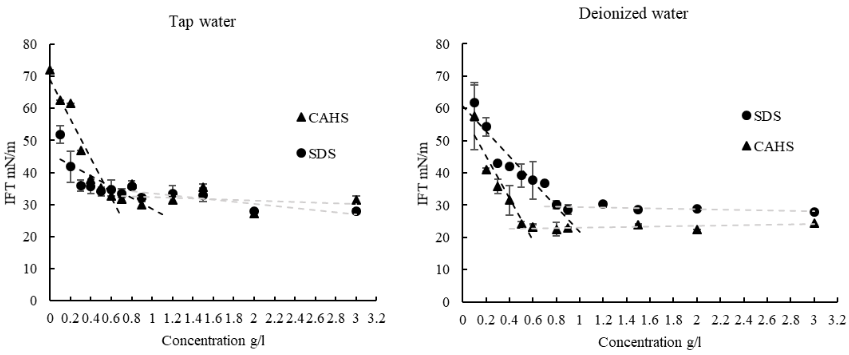
Table 1. CMC values for the surfactants (CAHS and SDS) by different techniques and in different water types.

Method / Water type	CMC CAHS by conductimetry	CMC CAHS by tensiometry	CMC SDS by conductimetry	CMC SDS by tensiometry	CMC SDS literature	CMC CAHS literature
Deionized water	0.48 g/L	0.55 g/L	0.85 g/L	0.79 g/L	2.2 g/L [4]	0.7 g/L [5]
Tap water	invalid	0.59 g/L	invalid	0.42 g/L	-	-



(a) (b)

Figure 1. Conductivity vs. concentration for surfactants in tap water (a) and deionized water (b) solutions



(a) (b)

Figure 2. Surface tension (IFT) vs. concentration for surfactants in tap water (a) and deionized water (b) solutions.

4 Conclusion

The results underline the influence of the water type on choosing the CMC determination method, with a recommendation to use both methods when working with deionized water, and the unfeasibility of the conductimetry when using tap water. The results also showed that the tensiometry method expresses higher sensitivity to micelle formation than conductimetry. Further chemical analysis is needed to better understand the effect of these ions on the CMC.

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6 References

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