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ORIGINAL ARTICLE

Interaction of Cetrimide with Nonionic Surfactants—Triton X-100 and Brij-35: A Conductometric and Tensiometric Study

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Abstract Conductometric and surface tension techniques were employed to study the different mole fractions of nonionic surfactants (TX-100 and Brij-35) with cetrimide. The standard Gibbs energies of micellization ($\Delta G_{\mathrm{m}}^{0}$) and the Gibbs energies of transfer ($\Delta G_{\mathrm{trans}}^{0}$) in the mixture of surfactants were also calculated; the micellization becomes more spontaneous on increasing the amount of nonionic surfactants in the mixture. It was observed that the values of excess surface concentration (Γ_{max}) in surfactant mixtures decrease in comparison to the pure surfactants but the values of minimum area per surfactant molecule (A_{min}) increase in surfactant mixtures than in the pure ones. It was also observed that the values of the interaction parameter (β) are negative at all mole fractions. A gradual decrease in β with temperature is observed indicating the synergism between the two components and is attributed to the decrease in the electrostatic repulsion between the charged heads of the cationic surfactant as the nonionic surfactant is being intercalated into the micelle. The activity coefficients were found out to be less than unity confirming nonideality of the system and the negative values of excess free energy of mixing confirm that the mixed micelles formed were stable.

Keywords Nonionic surfactants · Micellization · Interaction parameter · Activity coefficients · Conductance · Surface tension

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Introduction

Mixed surfactant systems exhibit unique properties different than the individual ones. They are being used as models for the study of molecular interactions on complex supramolecular aggregates, ion transport and drug delivery; they can also mimic biological systems and have several functions that prompted researchers to investigate them thoroughly. The technological applications of mixed surfactants are immense as they are being used in pharmaceuticals, food, detergency, cosmetic industries, micellar solubilization, or enhanced oil recovery [1–3]. For instance, in skin care applications, surfactant mixtures are able to reduce the skin irritations as the total surfactant concentration is drastically decreased. Cleaning formulations use surfactant mixtures to maximize solubilization and to increase the water hardness tolerance, nonionic surfactants are added [4, 5]. Lowering of critical micelle concentration (CMC) by surfactant mixtures leads to less impact on the environment, making them ecologically viable [6]. Mixed surfactants are advantageous because of better performance as they lower the cost of purification as compared to single surfactants [1]. The synergistic (attractive) interactions between surfactant mixtures are important for applications such as foaming, emulsification, detergency, and solubilization [7]. The surfactant mixtures—nonionic/nonionic [8], anionic/nonionic [9, 10],