ISSN 1061-933X, Colloid Journal, 2013, Vol. 75, No. 4, pp. 357–365. © Pleiades Publishing, Ltd., 2013.

Study of Mixed Micellar Aqueous Solutions of Sodium Dodecyl Sulfate and Amino Acids[1]

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Received September 12, 2012

Abstract—Thermodynamic properties of sodium dodecyl sulfate (SDS) in micellar aqueous solutions of L-serine and L-threonine were determined by fluorescence spectroscopy and dynamic light scattering techniques. The values of Gibbs free energy, enthalpy and entropy of the process of micelle formation were calculated using the critical micelle concentration and degree of dissociation. Changes in critical micelle concentration of SDS with the addition of amino acids were examined by both conductivity and pyrene I_1/I_3 ratio methods at different temperatures. The pyrene fluorescence spectra were used to study the change of micropolarity produced by the interaction of SDS with amino acids. The aggregation behavior of SDS was explained in terms of structural changes in mixed solutions. The data on dynamic light scattering suggest that size of SDS micelles was influenced by the presence of amino acids.

DOI: 10.1134/S1061933X13040029

INTRODUCTION

Surfactants are the amphiphilic molecules which undergo special type of self-assembly process, and the phenomenon is known as micellization. The nature of both the hydrophobic tails and hydrophilic head groups of surfactants controls the physical properties of the micelles, among which the critical micellar concentration (cmc) and aggregation number (N_{agg}) are most important [1]. The physicochemical properties of a given aqueous surfactant solution can be modified by external means, such as changes in temperature/pressure and/or addition of different modifiers (e.g., cosolvents, cosurfactants, electrolytes, polar organics, nonpolar organics, etc.) [1–17]. For this reason, the knowledge of thermodynamic parameters of micellization in presence of additives is of utmost importance for a complete understanding of the effect of structural and environmental factors on the critical micelle concentration.

Amino acids (AAs) are zwitterionic biomolecules and are not only nutrients but also regulators of biological cell and biomembrane. In fact, besides their commercial and biochemical relevance, AAs are ideal compounds to be studied as model biomolecules, because they are monomers of proteins and their charged nature reproduces the behaviour of many charged biomolecules. They have common charged terminal groups (NH^{+3}, COO^{-}) together with the hydrophobic or polar side groups. Due to the presence of peripheral charges [18], they are considered to be strong structure-breakers in aqueous solutions and they are involved in electrostatic interactions with ionic species in aqueous solution. Evidence of strong interaction of AAs with ionic surfactants has been reported in our previous study [19]. Protein–surfactant interactions have been widely studied due to their importance in food processing, as well as in pharmaceutical production, medicinal and cosmetic laboratories because of their ability to impart significant changes to the interfacial, rheological, and physicochemical properties of protein–surfactant systems. Generally, the binding of a surfactant, especially ionic surfactant, to a single protein forming a complex [20–23], occurs in response to several thermodynamic driving forces. This binding of surfactant to protein can unfold and denature the native structure of most globular proteins [24–26].

Extensive studies on the modification of aggregation properties of surfactants owing to change in the nature of the solvent have been under close scrutiny for many years [27–35]. Despite these efforts, broad and intensive studies of thermodynamics of micellization of SDS in the presence of AAs are relatively few. Conductometric studies by Bakshi et al. [36] on the effect of glycine, alanine, valine and methionine on the cmc of SDS at a single temperature and by Ali and Ansari [37] on the effect of glycine, alanine, and glycylglycine on micellization of SDS in aqueous medium at different temperatures have been reported. The chosen surfactant SDS is reported to act as a more potent protein denaturant than urea and guanidine hydrochloride [38]. It is commonly used to solubilize biological

[1] The article is published in the original.