Molecular Physics, 2014
http://dx.doi.org/10.1080/00268976.2014.905720

RESEARCH ARTICLE

Conductometric and fluorometric studies of sodium dodecyl sulphate in aqueous solution and in the presence of amino acids

Anwar Ali*, Nisar Ahmad Malik, Sahar Uzair and Maroof Ali

Department of Chemistry, Jamia Millia Islamia (Central University), New Delhi, India

(*Received 9 January 2014; accepted 13 March 2014*)

The critical micelle concentration (CMC) of sodium dodecyl sulphate (SDS) in pure water and in the presence of amino acids (0.01, 0.02 and 0.03 mol kg^{-1}), L-valine (Val) and L-leucine (Leu) was determined from conductometric and fluorometric methods using pyrene as luminescence probe. Depression in the CMC at low concentration of amino acids is attributed to the increased hydrophobic–hydrophobic interaction between the non-polar groups of the surfactant, while, at high concentration, amino acids bind strongly with the anion, DS^-, head groups of SDS, thereby, delaying the micelle formation, resulting in increased CMC. A pronounced decrease in the CMC, while a marked increase in λ^0_+, with decrease in the solvated radius (rather than crystal radius) of the counterions is observed. Negative values of ΔG^0_m and ΔH^0_m indicate that micellisation of SDS in the presence of amino acids is thermodynamically spontaneous and exothermic. Highest negative value of ΔH^0_m in 0.01 m Val, with lowest CMC value, shows that 0.01 m aqueous Val is the most suitable medium favouring the micellisation of SDS. Decrease in I_1/I_3 from Val to Leu confirms the relative hydrophobicity of two amino acids. The observed values of the packing parameter, P, of SDS in water and in aqueous amino acids suggest that micelles formed are spherical in nature.

Keywords: sodium dodecyl sulphate–amino acid interaction; thermodynamics of micellisation; conductivity; fluorescence

1. Introduction

During the last few years, there has been growing interest in the study of protein–surfactant interactions using different techniques, because surfactants modulate the functional properties of proteins [1,2]. For instance, studies of membrane proteins are frequently conducted with the protein dissolved in surfactant micelles and, thus, understanding of the physicochemical properties of the surfactants is of great significance [3]. Consequently, these interactions find wide applications in biotechnological, drug delivery, detergency, food and cosmetics and pharmaceutical processes [4,5]. As hydrophobic and hydrophilic groups are components of almost every biologically important system [6], and also of surfactants, it is well recognised that the hydrophobic and electrostatic interactions are primarily two driving forces responsible for the association between surfactants and proteins in aqueous solution [2,3]. However, investigations on protein–surfactant interactions are specially challenging due to the complexity of proteins [2,7], a direct study of these interactions is difficult. Several ions and water molecules surrounding these biomolecules under biological conditions further add to the complexity of such systems. Therefore, in order to understand fine details of the origin and nature of these interactions, it is relatively more convenient to study the interactions of the basic structural units of proteins (amino acids) with surfactants. Although the side chains of these building blocks (amino acids) differ in size, shape, charge, hydrogen-bonding capacity, hydrophobicity and chemical reactivity, they collectively contribute to the structure and function of proteins [8]. These biomolecules have common polar zwitterionic groups ($NH_3{}^+$, COO^-) at neutral pH and have large dipole moments. However, their side chains contain non-polar hydrophobic or polar groups. Thus, their unique chemical structure offers a convenient model employed for the study of protein–surfactant interactions. Amino acids are reported to behave as structure breakers in aqueous solutions due to the presence of peripheral charges [9] and undergo strong electrostatic interactions with charged species in aqueous solution [10]. Surfactants (or surface-active agents) are amphiphilic molecules, possess non-polar hydrophobic and polar hydrophilic groups, form colloidal-size aggregates (micelles) over a narrow concentration range called the critical micelle concentration (CMC). Micelle formation of a surfactant in solution involves contributions from both hydrophobic interaction between hydrophobic groups and the electrostatic interaction between the polar head groups of the surfactant. Consequently, the micellar properties of the surfactant solutions, such as CMC, aggregation number, N_{agg}, and micelle shape and size depend on the balance between hydrophobic and electrostatic interactions. Because of the fact that surfactants form micelles

* Corresponding author. Email: anwarali.chem@gmail.com, aali2@jmi.ac.in