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Interactions of Cationic Surfactant CTAB with Amino Acid Glycine at Different Temperatures by Conductance Measurement

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Abstract

The interaction behavior of Cetyl trimethyl ammonium bromide (CTAB) with aqueous solution containing 0.02M amino acid glycine has been studied conductometrically at 298.15K, 303.15K, 308.15K, 313.15K, 318.15K, 323.15K temperatures. The critical micelle concentration (CMC), Average degree of ionization (α), Degree of Counter-ion binding (β), Gibb's Free Energy of Micellization(ΔG°_{m}), Enthalpy of Micellization (ΔH°_{m}), Entropy of Micellization(ΔS°_{m}) for the present systems were explored at various temperatures. The combination of CTAB-Glycine favors the micellization over aqueous solution of CTAB. The value of Average degree of ionization decreases in presence of glycine indicates that glycine becomes more strongly bound to the micellar surface.

Keywords: Cationic surfactant, micelle, critical micelle concentration (CMC), amino acids.

Introduction

Surfactants are organic compounds possess both hydrophilic and hydrophobic properties. Due to this dual nature allows them to reduce surface tension and form aggregates like micelles in solution. At specific concentration surfactant molecules try to formaggregates called critical micelle concentration (CMC)[1,2]. Owing to their amphiphilic structure, cationic surfactants tend to form aggregates in suitable solvents. Micellar property of surfactants enhances employment in biotechnological, pharmaceutical processes[3]. Some cationic surfactants are used as antiseptic agents against fungi and bacteria, household products, synthesis of gold nanoparticles. Cationic surfactants

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bind to negatively charged DNA or RNA through electrostatic interactions, forming complexes that facilitate their entry into cells in gene delivery[4].

Amino acids are natural building blocks in protein synthesis. They are structure breakers in aqueous solutions, monomers of biopolymers. Interactions of amino acid- surfactant have wide range of applications in many industries. These interactions also increase the efficiency of insecticides and pesticides[5]. Decrease in CMCvalue affect the protein interactions in aqueous solution and due to hydrophobic-hydrophobic interactions enhances dielectric constant[6].

In the present work we evaluate various thermodynamic parameters, such as Gibb's Free Energy of Micellization(ΔG°_{m}), Enthalpy of Micellization(ΔH°_{m}), Entropy of Micellization(ΔS°_{m}) of aqueous solution of cationic surfactant CTAB in aqueous solution of glycine at 298.15 K, 303.15 K, 308.15 K, 313.15 K, 318.15 K and 323.15 K by conductance measurement.

Experimental

Cetyl trimethyl ammonium bromide (CTAB) of purity >99%, Glycine of purity >99% was purchased from LOBA chemie. Stock solutions of 0.02 M kg^{-1} Glycine and 0.1 M CTAB were prepared using deionized distilled water. Samples were weighed on (Shimadzu, Japan) balance with a precision of 10^{-3}g. All the solutions were prepared fresh. Conductivity meter (EQ-661, Equiptronics) with conductivity cell of cell constant 1.01 cm^{-1} at $(30 \pm 0.1)^{\circ}$C. The conductance of aqueous solution of CTAB and aqueous solution of Glycine was measured by addition of aliquot of known concentration of surfactant into amino acid solution.

Results and Discussion

The values of CMC of CTAB in aqueous and in 0.02M kg^{-1} aqueous solution ofGlycine at 298.15 K, 303.15 K, 308.15 K, 313.15 K, 318.15 K and 323.15 K are mentioned in Table 1. Plots of specific conductance (κ) against concentration (C) are given in Figure 1 and Figure 2. The CMC values obtained from the intersection of the straight lines of pre and post micellization curves.The CMC values of CTAB shows good agreement with the reported value[7]. In presence of Glycine,CMC value of CTAB decreases. This might be due to hydrophobic- hydrophobic interactions between amino acid and the aliphatic hydrocarbon chain of surfactant. However,CMC increases with rise in temperature. This may be due to surface activity increases with increase in temperature[8].

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Table 1. Values of CMC of CTAB in Water

CMC measured (× 10^{-3})	Temperatures (K)					
	298.15	303.15	308.15	313.15	318.15	323.15
CTAB + Water	0.89	0.92	0.98	1.02	1.07	1.11
CTAB + Glycine	0.80	0.87	0.93	0.97	1.02	1.08

Table 2. Values of Average degree of ionization (α) and Degree of Counter-ion binding (β)

	Surfactant system	Temperatures (K)					
		298.15	303.15	308.15	313.15	318.15	323.15
Average degree of ionization(α)	CTAB + Water	0.287	0.327	0.352	0.392	0.437	0.491
	CTAB + Glycine	0.227	0.236	0.257	0.285	0.341	0.400
Degree of Counter-ion binding (β)	CTAB + Water	0.713	0.673	0.648	0.608	0.563	0.509
	CTAB + Glycine	0.773	0.767	0.743	0.715	0.659	0.600

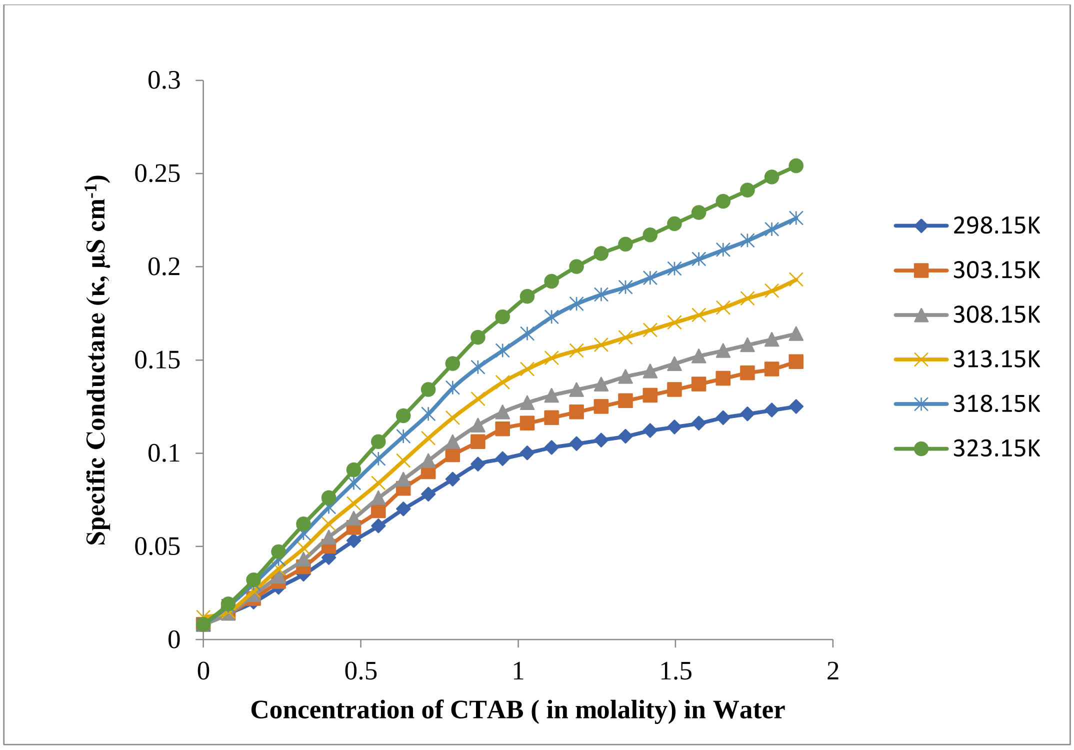

Figure 1. Plot of Specific conductance verses Concentration (κ) of CTAB added

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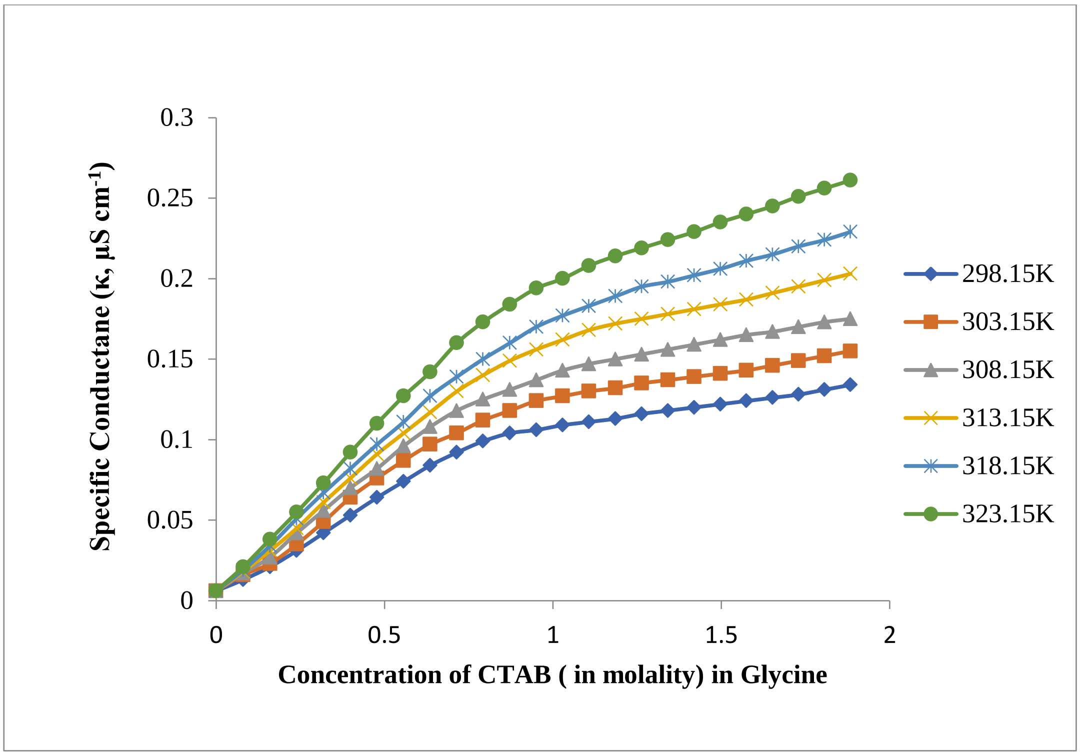

Figure 1. Plot of Specific conductance verses Concentration (κ) of CTAB added in Glycine

Table 3. Values of Thermodynamic parameters

Thermodynamic parameters	Surfactant system	Temperatures (K)					
		298.15	303.15	308.15	313.15	318.15	323.15
Gibb's Free Energy of Micellization ($-\Delta G^{\circ}_{m}$)KJ/mol	CTAB + Water	47.40	46.55	46.25	45.53	44.68	43.59
	CTAB + Glycine	49.51	49.50	49.23	48.93	47.70	46.39
Enthalpy of Micellization	CTAB + Water	11.40	11.50	11.71	11.80	11.83	11.80

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$(-\Delta H^{\circ}_{m})$ KJ/mol	CTAB + Glycine	13.10	13.47	13.76	13.98	13.96	13.89
Entropy of Micellization (ΔS°_{m}) KJ/ mol. K	CTAB + Water	0.119	0.115	0.112	0.107	0.103	0.098
	CTAB + Glycine	0.122	0.118	0.115	0.111	0.106	0.100

The Average degree of ionization(α)was calculated as the ratio of slopes of pre micellization and post micellization. The observed α values are in good agreement with reported values. As temperature increases αincreases. Thismight be due to thermal motion which facilitates ionization of surfactant[9]. The degree of counter ion binding (β)decreases due to lower counter-ion binding to the micelle surface.

Thermodynamic parameters ΔG°_{m}, ΔH°_{m} and ΔS°_{m} was mentioned in Table 2. The relation between standard Gibb's free energy of micellization per surfactant molecule involved can be given as[10]

$$\Delta G^{\circ}_{m} = RT\,(2-\alpha)\ln X_{CMC} \quad (1)$$

From the Table3, ΔG°_{m} is negative suggest that the process of micellization is spontaneous. More negative values ΔG°_{m} indicates the process of micellization is more favorable in presence of Glycine.

The Enthalpy change and Entropy change for micellization process can be obtained by Gibb's-Helmholtz equation[11],

$$\Delta H^{\circ}_{m} = -\,(2-\alpha)\,RT\,(d\ln X_{CMC} / dT) \quad (2)$$

And

$$\Delta S^{\circ}_{m} = (\Delta H^{\circ}_{m} - \Delta G^{\circ}_{m}) / T \quad (3)$$

The enthalpy and entropy of micellization ΔH°_{m} and ΔS°_{m} is a function of temperature. Increase in ΔH°_{m}values suggests that the micellization in presence Glycine is more exothermic process. Positive values of entropy indicatemicellization is spontaneous process and increase in entropy of micellization might be more favors in presence of glycine and increase in breakdown of the structured molecules surrounded by hydrophobic group of CTAB[12–14].

Conclusions

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In the presence of amino acid, the value of CMC declines. This may be due to hydrophobic-hydrophobic interactions between surfactant and amino acid in presence of Glycine. The Gibb's free energy of micellization and entropy of micellization are negative, explores micellization of CTAB in presence of Glycine is more exothermic and spontaneous. The spontaneity of the process is illustrated by entropy gain.

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