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Study of critical micelle concentration of cetyltrimethylammonium bromide (CTAB) in pure water in presence and absence of magnesium sulphate and sodium sulphate by measuring conductivity meter

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Abstract

The precise measurement of specific conductivity of cetyltrimethylammonium bromide (CTAB) in distilled water at room temperature was reported and also the specific conductivity of cetyltrimethylammonium bromide was measured in the presence of magnesium sulphate and sodium sulphate using a conductivity meter. The critical micelle concentration of three systems was calculated. The comparison of cmc among them was also performed.

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Keywords: Conductivity meter; Cetyltrimethylammonium bromide; Specific conductivity; Critical micelle concentration; Sodium sulphate; Magnesium sulphate.

1. Introduction

Cetyltrimethylammonium bromide (CTAB) is a highly effective cationic surfactant in daily life. CTAB type of compound is found in high concentration in industrial products like detergents industries. The charge on the head group of CTAB is positive that is why the surfactant is said to be cationic surfactants. Due to the positive charge of the head group, cationic surfactants strongly adsorb on the negatively charged surfaces such as fabric, hair and cell membrane of bacteria. Therefore they are used as a fabric softeners, hair conditioners and antibacterial agents.

The IUPAC name of cetyltrimethylammoniumbromide is hexadecyltrimethylammonium bromide having molecular weight 364.45 and it has structure in Fig.1. The effect of inorganic salt is explained in terms of the shielding of the electrostatic repulsion by the counterions [1]. Chung *et al.*[1,2] studied the effect of KCl and alcohol on the cmc of cetylpyridinium Chloride (CPC). They observed the decrease in cmc with the addition of electrolyte and vice versa.

In this paper, we report a study of the aggregation process of CTAB at room temperature in absence and in presence of Sodium sulphate and Magnesium sulphate by conductivity method in aqueous media.

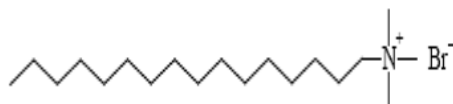


Figure 1: Cetyltrimethylammonium bromide

2. Experimental Section

Conductance measurements were carried out on a Pye-Unicam PW 9509 conductivity meter at a frequency of 2000 Hz using a dip-type cell with a cell constant of 1.15 cm^{-1} and having an uncertainty of 0.01 %. The cell was calibrated by the method of Lind and co-workers [3] using aqueous potassium chloride solution. Several independent solutions were prepared and runs were performed to ensure the reproducibility of the results. Due correction was made for the specific conductance of the solvent by subtracting the specific conductance of the relevant solvent medium from those of the surfactant solutions.

Cetyltrimethylammonium bromide (CTAB) was purchased from Loba Chemical, India. MgSO_4 and Na_2SO_4 were purchased from Ranbaxy Chemical, India. The water used in the experiments was doubly distilled. The solutions prepared at room temperature.

3. Results and Discussion

The specific conductivities of CTAB solution increase with increasing the concentration of CTAB. There is sharp break in which two straight lines intersect. That point of intersection is known as critical micelle concentration (cmc). The electrical conductivity of a cationic surfactant cetyltrimethylammonium bromide in distilled water was reported (Table 1).

The sodium ion (Na^+) is larger than the magnesium ion (Mg^{2+}) due to two effects. The elements sodium and magnesium are in the same Period, therefore outer electrons of the Mg atom experience greater effective nuclear charge and, more importantly, the magnesium cation, Mg^{2+} , has a greater cationic charge than the Na^+ cation. This second effect is by far the more significant. The conductivities of CTAB in presence of Na_2SO_4 is more than in presence of MgSO_4 because the smaller ions are strongly hydrated, so they need to pull more water molecules with them which makes them less mobile. Hence the conductivity values of CTAB in presence of Na_2SO_4 are high in comparison with MgSO_4 as shown in Table 1 (A&B).

In water, the *cmc*s of CTAB were reported [4] to be 1.007 mM from conductometry, and 1.102 mM from tensiometry respectively at 308.15 K which verifies our experimental data of *cmc* of CTAB at room temperature (Table 2). Figures (2-4) show the *cmc* of CTAB in absence and in presence of Na_2SO_4 and MgSO_4 . Also, the *cmc* values of CTAB in absence and presence of Na_2SO_4 and MgSO_4 at room temperature are shown in Table 2. As the salt is added, the electrostatic repulsive force between ionic head groups of the surfactant molecules is reduced by shielding of micelle charge, so that spherical micelles are more closely packed by the surfactant ions [5,6], hence a decrease in the *cmc* values after adding salts. It is observed that salts decrease the *cmc* of ionic surfactants [7] due to screening of the electrostatic repulsion among the polar head groups and movement of the hydrophobic alkyl chain away from aqueous environment, so that less electrical work is required to form micelles.

Salts decrease the *cmc* in the order: $\text{MgSO}_4 < \text{Na}_2\text{SO}_4$. Here Mg^{++} is least effective in decreasing the *cmc* due to small size and large hydrated radius and would act as a water-structure promoter decreasing the availability of water to the micelles. Therefore, upon addition of MgSO_4 and Na_2SO_4 in CTAB, Na_2SO_4 is more effective in reducing the *cmc* of CTAB. Hence in our case Na_2SO_4 decreases the *cmc* of CTAB more than MgSO_4 (Table 2).

Table 1: Conductance of CTAB in distilled water at room temperature.

Solvent	Concentration (mol/ltr)	Conductance (ohm ⁻¹ cm ⁻¹)
Distilled Water	0.00436	0.283
	0.00313	0.251
	0.00224	0.226
	0.00161	0.205
	0.00115	0.185
	0.00083	0.174
	0.00059	0.160
	0.00042	0.151
	0.00030	0.142
	0.00022	0.136
	0.00015	0.128
	0.00011	0.121

Table 1A: Conductance of CTAB in presence of Na₂SO₄ -Water at room temperature.

Solvent	Concentration (mol/ltr)	Conductance (ohm ⁻¹ cm ⁻¹)
Na ₂ SO ₄ -Water	0.00600	1.820
	0.00503	1.812
	0.00410	1.805
	0.00310	1.790
	0.00262	1.793
	0.00210	1.789
	0.00169	1.786
	0.00136	1.783
	0.00108	1.781
	0.00088	1.779
	0.00068	1.778
	0.00055	1.777
	0.00044	1.776
	0.00035	1.771
	0.00028	1.768
	0.00018	1.764

Table 1B: Conductance of CTAB in presence of MgSO₄ -Water at room temperature.

Solvent	Concentration (mol/ltr)	Conductance (ohm ⁻¹ cm ⁻¹)
MgSO ₄ -Water	0.00671	1.867
	0.00537	1.829
	0.00429	1.790
	0.00343	1.758
	0.00275	1.739
	0.00171	1.704
	0.00140	1.691
	0.00112	1.684
	0.00091	1.677
	0.00075	1.672
	0.00057	1.661
	0.00046	1.651
	0.00036	1.646

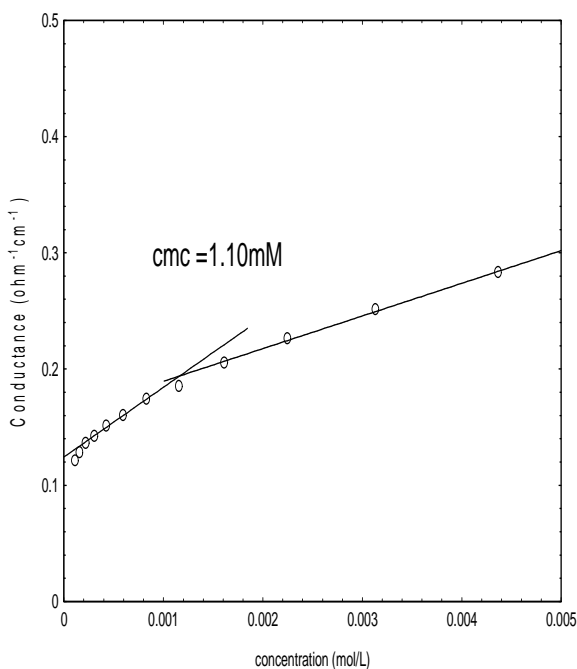


Fig. 2

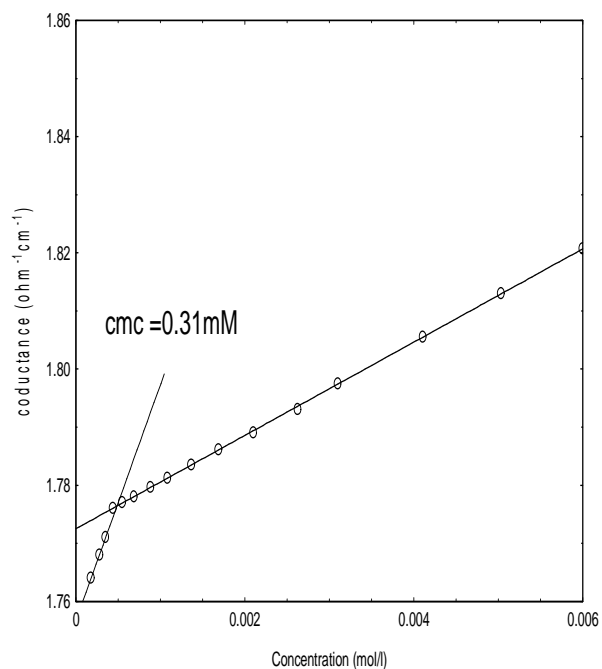


Fig.3

Figure 2: Specific conductivities of CTAB as a function of the concentration in distilled water at room temperature.

Figure 3: Specific conductivities of CTAB as a function of the concentration in Na₂SO₄-water at room temperature.

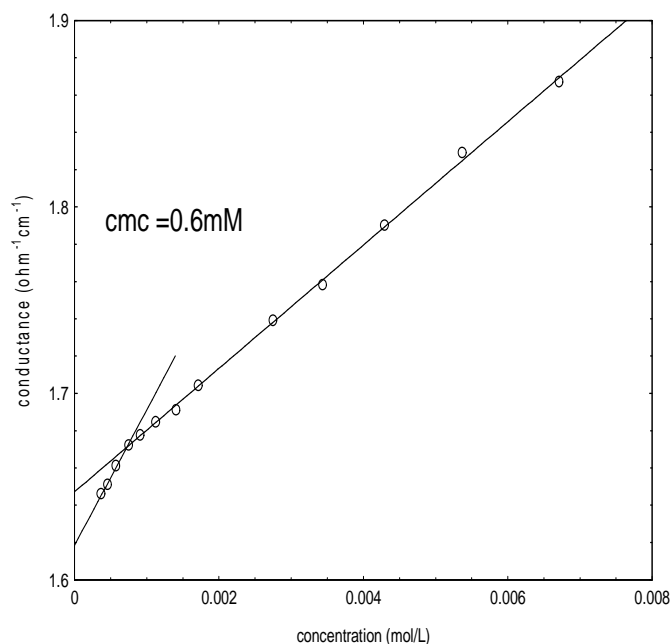


Figure 4: Specific conductivities of CTAB as a function of the concentration in MgSO₄-Water at room temperature.

Table 2: Critical micelle concentration (cmc) obtained from conductometry of CTAB in absence and presence of Na₂SO₄ and MgSO₄ in aqueous media at room temperature.

Distilled water cmc (mM)	Na ₂ SO ₄ -Water cmc (mM)	MgSO ₄ -Water cmc (mM)
1.10	0.31	0.63

4. Conclusion

The following conclusions have been drawn from above result and discussions. The results showed an increase in conductivity of cetyltrimethylammonium bromide with addition of salts. The conductance of cetyltrimethylammonium bromide is found more in presence of Na₂SO₄ than MgSO₄ in aqueous media whereas in the presence of Na₂SO₄, the cmc of cetyltrimethylammonium bromide decreases more in comparison with presence of MgSO₄.

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