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FORMATION OF CRITICAL MICELLES OF SLES IN AQUEOUS SYSTEMS AND IN THE PRESENCE OF ALCOHOLS USING ELECTRICAL CONDUCTIVITY MEASUREMENTS

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ABSTRACT

Electrical Conductivity measurements are considered an accurate method for determining the critical micelle concentration (CMC) of the SLES compound in its pure state and in the presence of organic additives such as (ethanol and pentanol) these additives alter the attractive and repulsive forces between micelle molecules which leads to either an increase or decrease in the value of the critical micelle concentration. The measurements were carried out under a temperature range of 298–313 K. The importance of this range lies in monitoring the effect of thermal energy on the decomposition or formation of Micelles. Furthermore, the Thermodynamic functions ($\Delta G°$, $\Delta H°$, $\Delta S°$) were calculated, and their effects on the studied compound were investigated in order to understand the physical mechanism of the ionic Aggregation process and the extent of its Spontaneity in Micelle formation under the studied conditions.

KEYWORDS: Electrical conductivity, alcohols, surfactants, micelles.

INTRODUCTION

Anionic surfactants are among the most important materials used in many industrial, pharmaceutical, and environmental applications. They are used in dispersion and emulsification processes because they have a high ability to reduce surface tension. These compounds consist of a hydrophilic part that carries a negative charge, giving the compound unique properties in its interaction with surfaces, and another hydrocarbon part that is hydrophobic (containing hydrocarbon chains).These compounds are characterized by their ability to form micelles at a concentration known as the critical micelle concentration, and CMC values are affected by several factors such as the type of solvent, temperature, and the presence of additives such as salts and alcohols. Sodium lauryl ether sulfate is considered one of the most important anionic surfactants. It is a clear, yellowish, viscous liquid with a mild odor. It is easily soluble in water and relatively stable over a range of temperatures. It helps in removing fats and emulsifying oils. Its common uses are in shampoos, face washes, bath products, and also in cosmetics. In general, it is considered a balanced compound between its effectiveness and gentleness on the skin.[1-6] Sodium Lauryl Ether Sulfate (SLES) is considered one of the most important anionic surfactants that enjoys wide interest in the fields of physical chemistry and industrial applications, due to its outstanding surface properties and its high ability to reduce the surface tension of aqueous solutions. This compound belongs to the ether sulfates class.[7,8] SLES is characterized by the presence of ethoxy groups which increase its solubility in water and reduce the severity of irritation, making it more suitable for use in personal care products such as shampoos and skin washes, as well as its use in various chemical industries.[9]

In recent years, there has been increasing interest in studying the behavior of SLES within complex systems, including the effects of organic solvents such as ethanol, thermal changes, and the thermodynamic properties of micelle formation. Many recent studies have also focused on understanding the mechanisms of molecular assembly and improving the performance of these materials in environmental and industrial applications, in line with the requirements of sustainable development and minimizing environmental impacts.

Accordingly, studying the physical and chemical properties of SLES, particularly its behavior in aqueous solutions and its susceptibility to various factors, is one of the most important topics that contributes to developing its applications and improving its efficiency in industrial and scientific fields.[10-12]

Expermental

used the electrical conductivity method to determine the value of the critical moiety concentration CMC for the SLES compound in the presence and absence of organic additives (ethanol and pentanol).Some physical properties change suddenly with changes in the concentration of additives, leading to the formation of micelles, i.e., micelle aggregation, where aggregations are affected by some changes (hydrophilic groups, length of hydrocarbon chain, additives, change in temperature).Changes in temperature are important in increasing or decreasing the value of the critical moiety concentration of negatively charged ionic surfactants, as they break the hydrogen bonds between water molecules and hydrophobic groups, which in turn leads to a decrease in the CMC value with increasing temperatures.The ethoxy group also increases solubility in water, thus reducing the repulsion between the polar heads and thus facilitating the aggregation process and the formation of micelles at lower concentrations. Several solutions were prepared for conductivity measurements with concentrations ranging between ($1*10^{-3}$- $1*10^{-2}$).

Figure (1) illustrates the effect of high temperatures on the critical methylation (CMC) concentration value of SLES in aqueous solution by measuring its electrical conductivity.

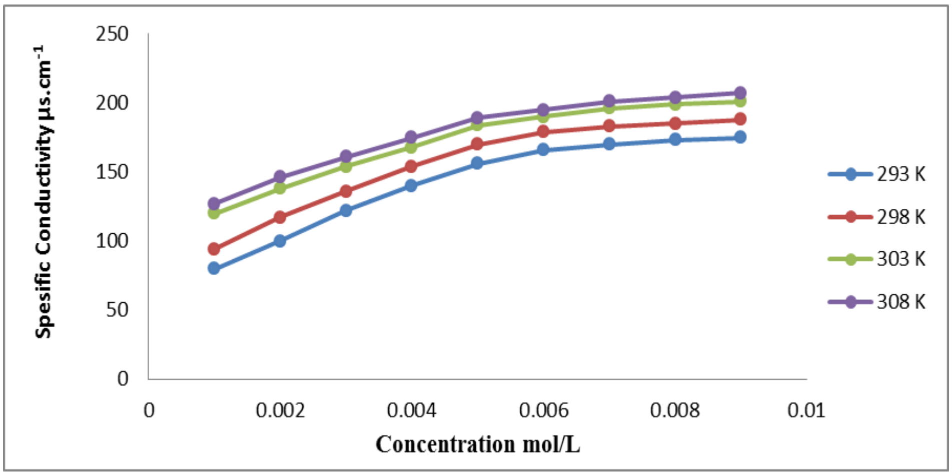

Figure (1): Specific conductivity versus concentration for SLES in aqueous solution at different temperatures.

The Critical Micelle Concentration (CMC) value was extracted from the graph and shows strong agreement with previously reported literature [13] . The CMC values at various temperatures are summarized in Table (1) below.

Table (1): CMC values for SLES surfactant at various temperature.

Temp. (K)	SLES CMC M	Ln CMC
293	0.0064	-5.05145
298	0.0061	-5.09946
303	0.0060	-5.11599
308	0.0058	-5.14989

Thermodynamic variables were calculated over a temperature range of (293-308 K). Table (2) below shows the values of the thermodynamic variables obtained from studying aqueous solutions of the surfactant SLES in the pure state.

Table 2: Values of thermodynamic variables of the surfactant SLES at different temperatures.

	T=293K	T = 298K	T =303K	T = 308K
ΔG°_{m} (KJ. Mol^{-1})	-12.3053	-12.6342	-12.8879	-13.1873
ΔH°_{m} (KJ. Mol^{-1})	42.8009	46.6320	47.8881	48.8993
ΔS°_{m} ($KJ.Mol^{-1}.K^{-1}$)	0.1880	0.1988	0.2005	0.2015

Effect of adding alcohols (ethanol, butanol) to the surfactant (anion) SLES in an aqueous medium

Alcohols such as (Ethanol, Butanol) are considered solvents that have the ability and capacity to change the properties of some solutions of surfactants when mixed in different proportions. One of these reasons leading to the change in properties is hydrophobic interactions, hydrogen bonds and association with water molecules (hydration). The process of hydrolysis and formation of new compounds related to the alcoholic compounds under study leads to a change in many chemical and physical properties such as density, viscosity, electrical conductivity, surface tension, etc. [(14)] . The effect of adding ethanol and butanol at different temperatures (293K –308K) as shown in the figures below in an aqueous medium. It is known that alcohols added to surfactants suffer from association with micelles in the surface area, causing a reduction in the surface area of the ionic vertical groups of surfactants.[14]

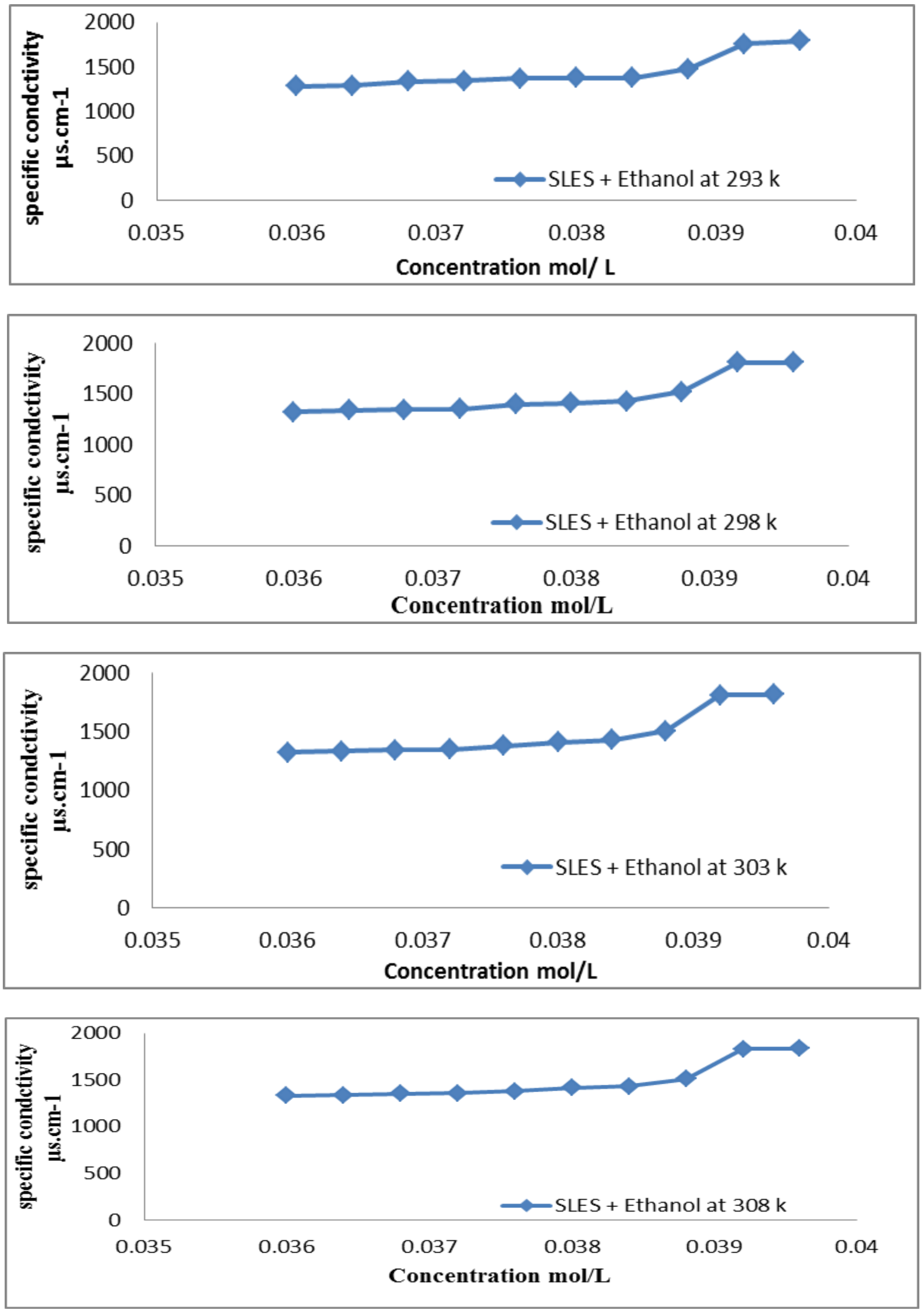

Figure (3) Measurement of specific conductivity versus concentration of the surfactant SLES with added ethanol at different temperatures.

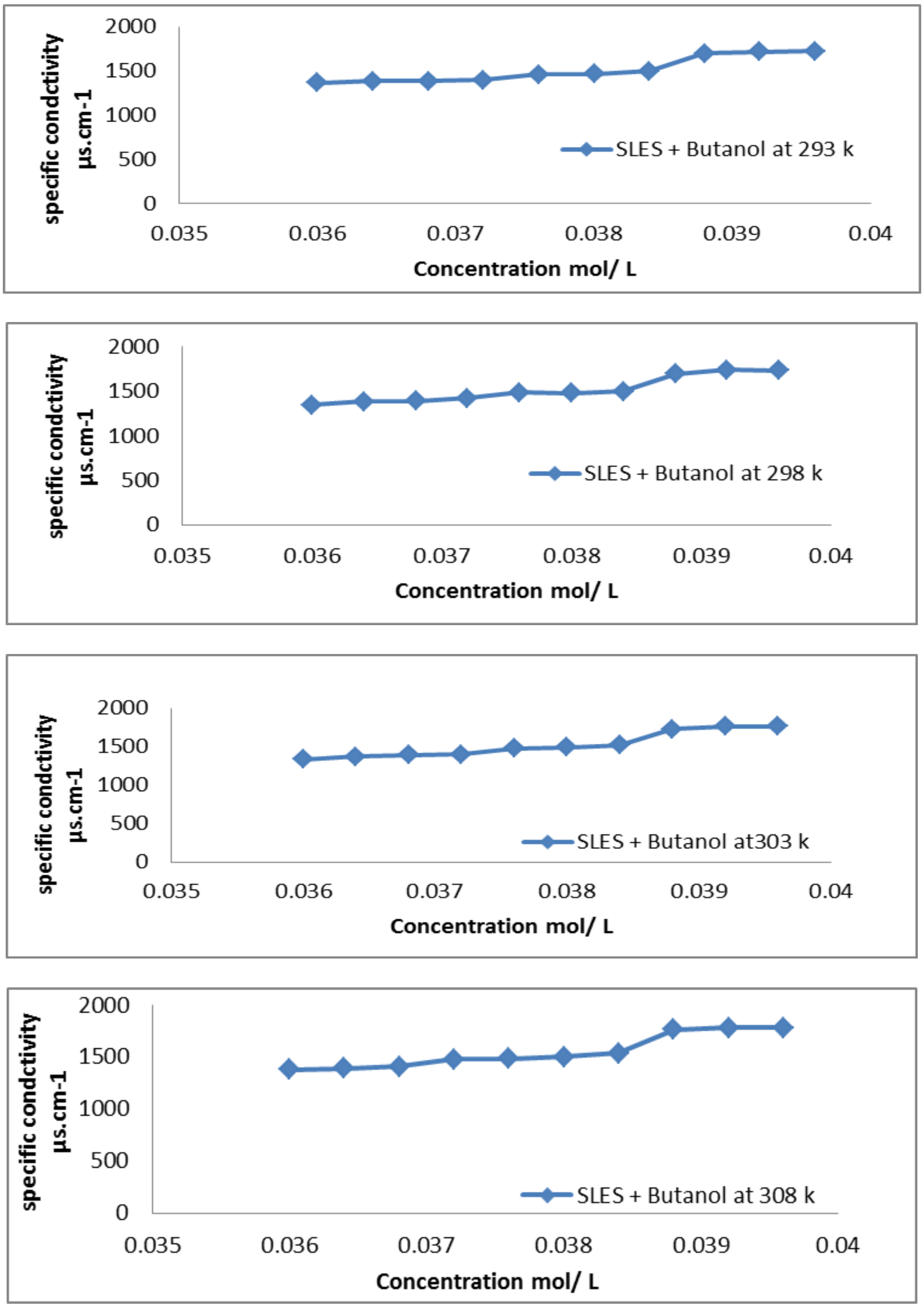

Figure 4: Measurement of specific conductivity versus concentration of the surfactant SLES with added butanol alcohol at different temperatures.

The relationship between the amount of ethanol added and the specific conductivity at 293K can be seen from the previous figures. The CMC value is approximately (0.0384M), which decreases with the addition of butanol (0.0376M). These are the values at which mycelial aggregation begins.The reason for this is that adding alcohols leads to an increase in the viscosity of the solution, and thus the formation of micelles (Worme Like) 15)) and an increase in the entanglement between the chains in the solution, as the alcohol molecules penetrate between the worm-like micelle molecules, which leads to interferences between the hydrocarbon chains (hydrophobic interference) of the SLES and the hydrophobic end of the alcohols (ethanol and butanol). These interferences lead to the aggregation of micelles, which leads to the rapid formation of CMC and a decrease in its value.Polar heads also play a role in the aggregation of molecules through the interaction between the polar groups in SLES and the hydroxyl group of alcohols. These interactions lead to an increase in aggregation and the rapid formation of hydrophilic groups and the appearance of CMC on the curve. On the other hand, there is what is called self-aggrandizement for molecules with positive and negative charges, and this is what is found in the SLES molecule, which sometimes acts as neutral molecules (Amphiphilic Molecules).

This leads us to a more profound phenomenon: the various ionic interactions present in the solution, which play a role in micelle formation. Reviewing the previous figures, it is evident that adding different alcohols, such as ethanol and butanol, to an aqueous SLES solution results in a decrease in the CMC value, as shown in the table below.This is due to the hydrophobic interaction between the hydrocarbon chains of the alcohols. Additionally, the surfactant SLES contains an ethoxy group, which increases water solubility and leads to repulsion between the surface heads, thus facilitating the aggregation of micelles at low concentrations.

Table (3) shows the critical methyl concentration (CMC) values for the surfactant SLES with added alcohol (ethanol and butanol) at different temperatures.

T(K)	CMC SLES + Ethanol	Ln CMC SLES + Ethanol	CMC SLES + Butanol	Ln CMC SLES + Butanol
293 K	0.0384	-3.2596	0.0376	-3.2807
298 K	0.0380	-3.2701	0.0368	-3.3022
303 K	0.0376	-3.2807	0.0364	-3.3131
308 K	0.0372	-3.2914	0.0360	-3.3242

Adding small amounts of organic alcohol gives tangible and obvious changes to the CMC value of an ionic surfactant such as (SLES) due to one of two changes: either breaking the hydrogen bonds between the organic material and the solvent or forming bonds between the hydrocarbon parts of the solvents **[15,16]**.The ability of solvents to form hydrogen bonds is important for mouse formation, and it has been found in the literature that water alone is not necessary for aggregation [16], but thermodynamic variables also play an important role in the hydrophobic interaction process. Thermodynamic variables were calculated over a temperature range of 293–308 K. Table (4) shows the values of the thermodynamic variables obtained from studying the effect of adding ethanol and butanol to the surfactant SLES.

Table 4: values of thermodynamic variables at different temperatures for the surfactant SLES with added alcohols (ethanol, butanol).

T(K)	ΔG°_{m} (KJ. Mol^{-1})		ΔH°_{m} (KJ. Mol^{-1})		ΔS(KJ.Mol^{-1}.K^{-1})	
	SLES + Ethanol	SLES + Butanol	SLES + Ethanol	SLES + Butanol	SLES + Ethanol	SLES + Butanol
293 K	-7.9403	-7.9917	1.49887	1.99849	-0.0219844	0.02045
298 K	-8.1019	-8.1814	1.55046	2.06728	-0.0219846	0.02051
303 K	-8.2645	-8.3461	1.60293	2.13724	-0.0219853	0.02041
308 K	-8.4283	-8.5123	1.65626	2.20835	-0.0219871	0.02046

From the table above, it is evident that the value of ΔG°m represents the sum of the two values (ΔH°m) and (-TSΔm), which decreases with increasing temperature. Also, the sum of the temperature (T) and (-TΔS°m) has a value greater than the enthalpy (ΔH°m) alone. This indicates that the process is controlled by entropy. The high value of (ΔH°m) is due to the high energy required to release the solvent molecules from the water layer surrounding the micelles responsible for the hydrophilic groups present in the amphiphilic molecule of the surfactant. In addition, energy is released due to the micelles binding to the hydrocarbon chains present in the solution and the reconstitution of hydrogen bonds of water with the micelles. The micelle assembly process is highly dependent on entropy, as the number of water molecules around the micelle formation network decreases, which causes an increase in Δ S°m and a decrease in the value of ΔG°m, according to the Gibbs-Helmholtz equation, sinceΔH°m and ΔS°m have an opposite effect on the value of ΔG°m.[18]

REFERENCES

1. Rosen, M. J, & Kunjappu, J. T. (2012), Surfactants and Interfacial Phenomena.
2. Myers, D. (2020). Surfactant Science and Technology.
3. Tadros, T. F. (2018). Applied Surfactants, Principles and applications.
4. Holmberg, K. et al. (2021). Surfactants and Polymers in Aqueous Solution.
5. Kumar, N., et al, (2022). Behavior of Anionic surfactants in aqueous systems. Journal of Molecular Liquids.
6. Zhang, L., et al. (2023). micellization and thermodynamics of SLES systems. Colloids and Surfaces a.
7. Chen, X., et al. (2021). Effect of alcohols on Micellar properties. Journal of Surfactants and Detergents.
8. Li, Y., et al, (2022). Conductivity studies of surfactants. Journal of Chemical thermodynamics.
9. Ahmed, S., et al. (2023), Surfactant aggregation behavior. Langmuir.

10. Khan, M. S., et al. (2024). Influence of temperature on CMC. Colloids and Surfaces.
11. Zhang et al., 2023, Colloids and Surfaces.
12. Chen et al., 2021, Journal of Surfactants and Detergents.
13. Tyowua, AT. Wuanna, RA. Yiase, sg. (2012).Manipulation of Concentration-Conductivity Data of Sodium dodecyl Sulphate and Sodium Dodecylbenzene Sulphonate in KCl Solution in Relation to Micellisation Parameters, Chemical Sciences Journal, CSJ-79.
14. Tanaka,F.(2010).Theory of Wormlike Micelles: Topological Force Accelerates Relaxation, Langmuir, 26: p. 5374- 5381.
15. Khalil, R. A. and Alsamarrai L. H.(2015). Study The Effect of Ethanol on The Formation of The Wormlike Micelle For A Mixture of Ionic Surfactants, 12: 2117-2121.
16. Chetouani, A. Tennouga, L.Mansri1,A.Medjahed,K.and Warad, I.(2015).The micelle formation of cationic and anionic surfactants in aqueous medium: Determination of CMC and thermodynamic parameters at different temperatures, 6(10): 2711–2716.
17. Nowicki, J. Tuczak, J. and Stanczyk, D. (2016). Dual Functionality of Amphiphilic 18-alkyl-3-methylimidazolium hydrogen sulfate ionic liquids surfactant with catalytic function, 6: 11591-11601.