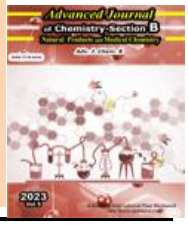
Advanced Journal of Chemistry-Section B
Natural Products and Medical Chemistry

Journal homepage: http://www.ajchem-b.com/



Original Research Article

Promethazine Hydrochloride Influence on the Micellization and the Surface Properties of Sodium Dodecyl Sulfate in Aqueous Solutions Containing Electrolytes at Various Temperatures

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ARTICLE INFO

Article history

Submitted: 2023-05-24
Revised: 2023-07-25
Accepted: 2023-08-08
Available online: 2023-08-20
Manuscript ID: AJCB-2305-1175
DOI: 10.48309/ajcb.2023.398501.1175

KEYWORDS

Promethazine hydrochloride
Micellization
Entropy
Heat capacity
Spontaneous

ABSTRACT

The micellization of sodium dodecyl sulphate (SDS) with promethazine hydrochloride (PMZ) in water/electrolyte environment was investigated using the conductivity measuring technique. In aqueous solutions of water, sodium chloride (NaCl), potassium chloride (KCl), and ammonium chloride (NH_4Cl) at various concentrations and temperatures, a number of physico-chemical parameters, including the critical micelle concentration (CMC), fraction of bound counter ions (β), and thermodynamic properties ($\Delta G°_m$, $\Delta H°m$, $\Delta S°m$, and($\Delta C°_m$), were determined for the SDS/PMZ mixture. The findings demonstrated that the CMC values decreased in the presence of PMZ and continued to decline monolitically in the electrolytic media (NaCl, KCl, and NH_4Cl), with the order being CMC_{NaCl} > CMC_{KCl} > CMC_{NH4Cl}. The SDS/PMZ mixture's CMC values changed with temperature. The negative values of $\Delta G°_m$ suggested that a spontaneous aggregation event existed in the SDS/PMZ system. The values of $\Delta H°m$ and$\Delta S°m$ showed that the PMZ molecule interacted with SDS via hydrogen bonds, ion-dipoles, and hydrophobic interactions. In addition, the system's standard molar heat capacity ($\Delta C°_m$) was assessed and established with the required reasons. These results might offer a solid scientific basis for the continued use of this model as medication delivery systems.

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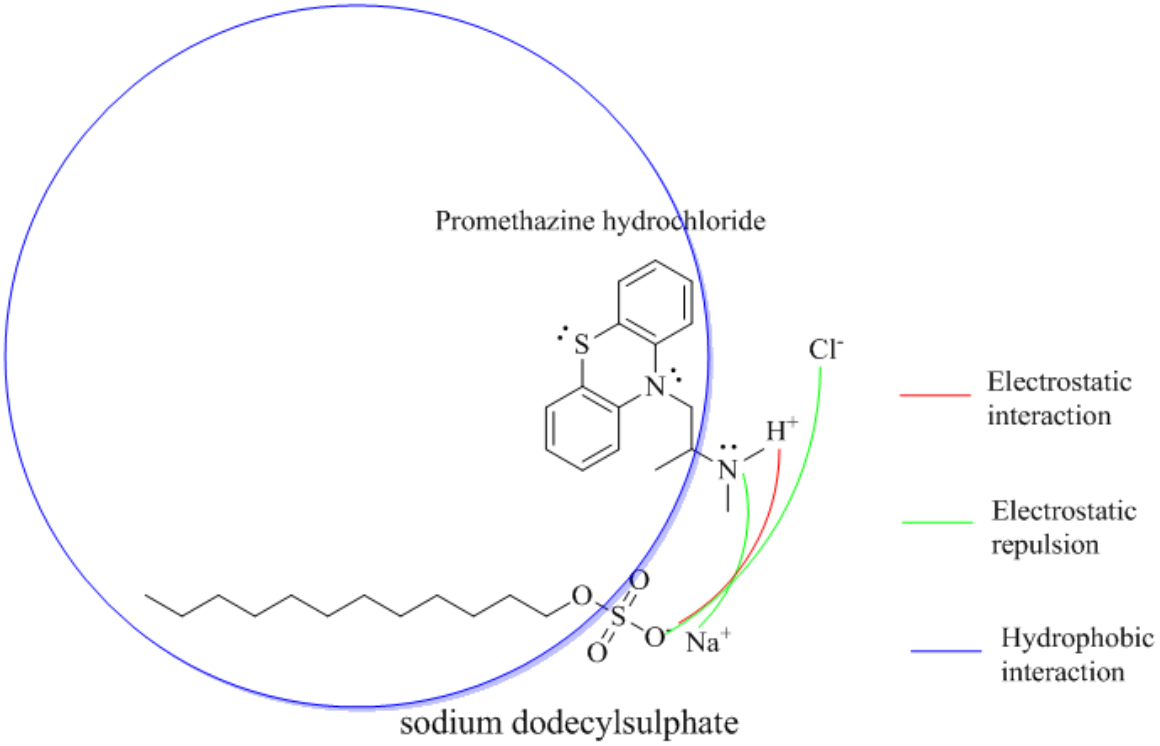
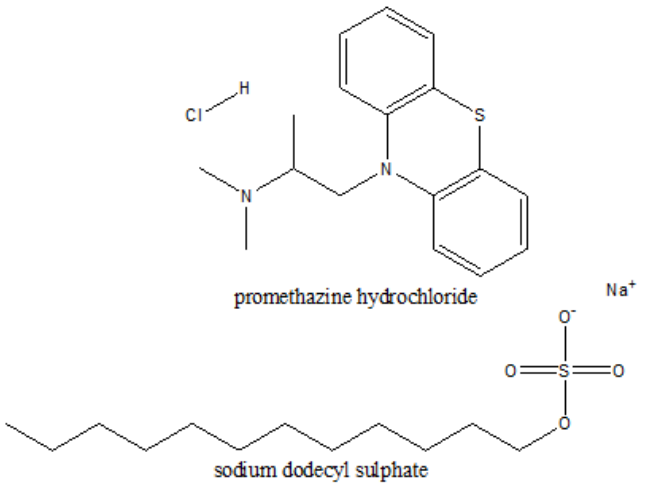
GRAPHICAL ABSTRACT



1- Introduction

Surfactant systems play a critical role in drug delivery because of their ability to increase drug solubility, control drug release rate, reduce drug degradation and toxicity, and enhance drug uptake control [1]. Anionic surfactants like sodium dodecyl sulfate (SDS) are extensively used as emulsifiers and solubility enhancers in the pharmaceutical industry [2-5]. An anionic alkyl sulfate surfactant called SDS has the ability to dissolve hydrophobic materials, resulting in high local concentrations that resemble biological membrane systems. Because it exhibits bactericidal effects on a range of gram-positive and gram-negative species, SDS is an essential component of medicinal formulations. Therefore, it is extremely desired in pharmaceutical research to understand the physicochemical characteristics and behavior of SDS in solution and at interfaces with drug molecules.

The SDS behavior and its interactions with drug molecules can be studied to create drug delivery systems that are more efficient in terms of bioavailability and therapeutic efficacy. The promethazine hydrochloride (PMZ) molecule is made up of two aromatic rings joined by sulfur and nitrogen atoms and an aminopropyl chain. While the alkyl amine side chain acts as a hydrophilic head group, similar to a surfactant, the stiff tricyclic ring shape of PMZ serves as a hydrophobic group (Scheme1) [6].



Scheme 1 Molecular structure of promethazine hydrochloride (PMZ) and sodium dodecyl sulphate (SDS)

In this study, PMZ was chosen as a pharmaceutical compound having multiple uses, such as the management and prevention of nausea and vomiting, allergic reactions, and sensitivity to blood products. Furthermore, it is utilized as a sedative to help patients relax or fall asleep prior to and following surgery, as well as to cure a cold-related runny nose [7]. Indeed, by increasing the solubility and stability of poorly soluble medicines, increasing their absorption and bioavailability, and targeting particular tissues or cells for more efficient treatment, surfactant micelles can play a critical role in drug delivery systems [8-10]. Surfactant micelles' capacity to encapsulate medications and shield them from deterioration or removal can also lower the necessary dosage and lessen unfavorable side effects [11-13]. To maximize their effectiveness and safety, it is crucial to comprehend the physicochemical characteristics of surfactant micelles and how they interact with medications, electrolytes, and other delivery system components [14-20].

Studying the behavior of surfactants in diverse applications, such as medication administration, requires knowledge of their physicochemical properties. The self-assembly behavior of surfactants, which is essential for the creation of micelles, is largely determined by their thermodynamic properties, such as the critical micelle concentration (CMC). Surfactant dissociation in solution has an impact on how well they can dissolve medicines and control micelle drug release. Other additions, such polymers or electrolytes, can also change the characteristics of surfactants and have an impact on how they interact with medications [21]. As a result, thorough physicochemical investigations are required to improve drug delivery methods and completely comprehend how medicines behave in micellar medium.

Important metal ions in biological systems include sodium (Na^+) and potassium (K^+), with sodium being the most prevalent positively charged ion outside of cells and potassium being the primary positively charged ion inside cells. The kidneys also use ammonium ion to keep the body's acid-base balance in check. Salts like sodium chloride (NaCl) and potassium chloride (KCl) can help form larger micelles in the context of micelle growth by reducing the electrostatic repulsion between the polar head groups of surfactant molecules. This lowers the critical micelle concentration (CMC) and makes it possible for surfactant molecules to aggregate more effectively. The most widely used

techniques to assess the interaction of drug with surfactants include the UV-Visible spectroscopy, conductometry, potentiometry, and tensiometry [22-25]. Among these techniques, the conductivity method offers a sensitive, simple, non-destructive, and real-time approach to studying the micellization process of surfactants in the PMZ presence. Its advantages make it a valuable tool in understanding the physicochemical properties of surfactant systems and their potential applications in drug delivery and other fields.

The critical micelle concentration (CMC) and micelle size can be determined using the conductometric method applied in this work, which analyzes the electrical conductivity of the solution as a function of surfactant concentration. Understanding how the medication interacts with the surfactant and the salt ions can be done by looking at how PMZ affects SDS micellization in the presence of various salts. Designing medication delivery systems with surfactants and electrolytes can benefit from this knowledge. Researchers can create more efficient drug delivery systems with increased solubilization, bioavailability, and targeted drug administration by comprehending how these components interact and how they alter the physicochemical features of the system. Overall, this work has the potential to offer significant new information about how salts and surfactants are used in pharmaceutical formulations.

2- Method

The experiment involves either introducing fixed amounts of electrolytes or gently incorporating SDS solutions into known concentrations of PMZ solutions at a steady temperature. Until equilibrium was attained, the conductivity of the mixture was assessed after each addition. The conductivity meter was calibrated with a 0.01 N potassium chloride solution, and measurements of conductivity were accurate to 0.5%. A circulating thermostated water bath was used to maintain the solution's temperature with 0.2 K accuracy. To evaluate the effects of electrolytes, SDS + PMZ solutions with the same electrolyte concentration were generated in both the presence and absence of electrolytes. The measured conductivities (K) against SDS concentration plots in water/(PMZ + water) mixed systems as the SDS concentration grew in the absence and presence of electrolytes were identified to yield the critical micelle concentration (CMC) values.

3- Results and Discussion

3.1. Determination of CMC and counterion of binding (β) of SDS and PMZ + SDS mixed system in H2O/ electrolytes solution

To calculate the critical micelle concentration (CMC) of ionic surfactants, the specific conductivity method is frequently utilized. This method involves measuring a surfactant solution's specific conductivity (K) at various concentrations. The CMC, or concentration at which micelles begin to form, is clearly indicated by a breakpoint in the K versus surfactant concentration. To calculate the CMC values in this study, the K values of SDS and SDS + PMZ mixed solutions were determined at various SDS concentrations and experimental circumstances. The representative plot of K vs. SDS concentration for the SDS and SDS/PMZ systems, respectively, is displayed in Figure 1(a) and (b).

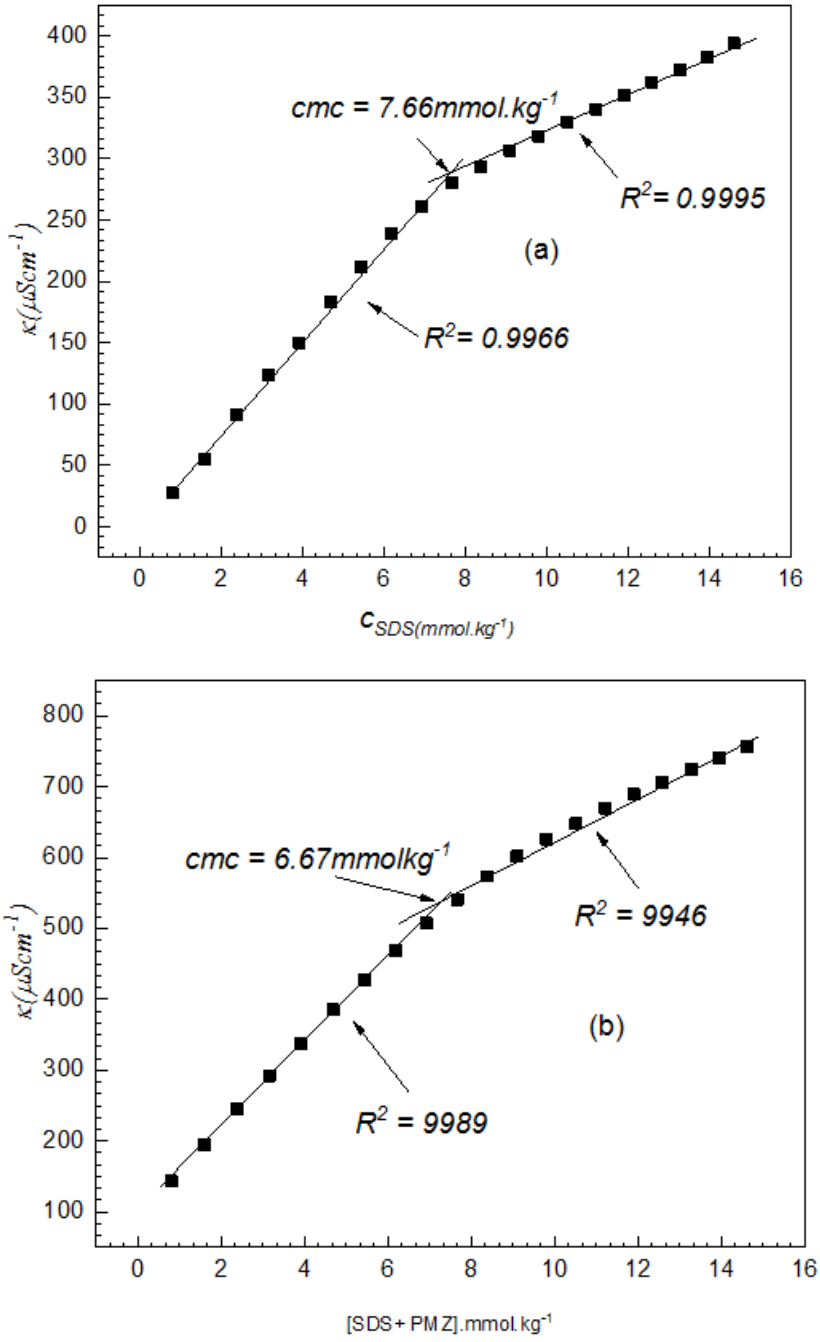


Fig. 1 A typical plot of specific conductivity (k) vs. content of sodium dodecyl sulphate (SDS) of (a) single surfactant (SDS) and (b) promethazine hydrochloride (PMZ) + surfactant (SDS) mixture in an aqueous environment at 298.15 k

The critical micelle concentration (CMC), which is a specific surfactant concentration, is clearly visible in both figures [26-29]. Higher surfactant concentrations cause a departure in the physicochemical properties due to the surfactant micelles' lower mobility, which is mediated by PMZ and counterions coupled to drug-induced micelles. The Helmholtz layer, which is created when Na^+ ions are present in the surfactant system, stabilizes the surfactant system

balancing the surface charge and reducing the intermolecular repulsion potential. At the CMC, the slope of the figure changes, suggesting a shift in the surfactant molecules' behavior. The ratio of slopes for the post-micellar and premicellar sections (S_2/S_1) was determined to measure the degree of ionization (α), which is the percentage of surfactant molecules that are ionized [26-30]. The already reported equation $\beta = (1 - \alpha)$ was then used to compute the counterion binding (β) [31].

Due to the presence of free ions from the mixture's PMZ and surfactant, the conductivity value rises noticeably with decreasing surfactant concentrations below the CMC. The conductivity by

value that is continuously rising at above the CMC is principally caused by the reduced mobility of surfactant micelles mediated by PMZ as well as for counterions coupled to drug-induced micelles. This is because increased surfactant concentrations allow the molecules of the surfactant to group together and form micelles, which decreases the amount of free ions in the solution and increases the amount of counterions attached to drug-mediated micelles. It appears that the PMZ presence in the SDS solution had an impact on the critical micelle concentrations (CMC) of the SDS, with the CMC values falling as PMZ concentrations raised up to 0.3 mmol/kg before starting to rise (Figure 2).

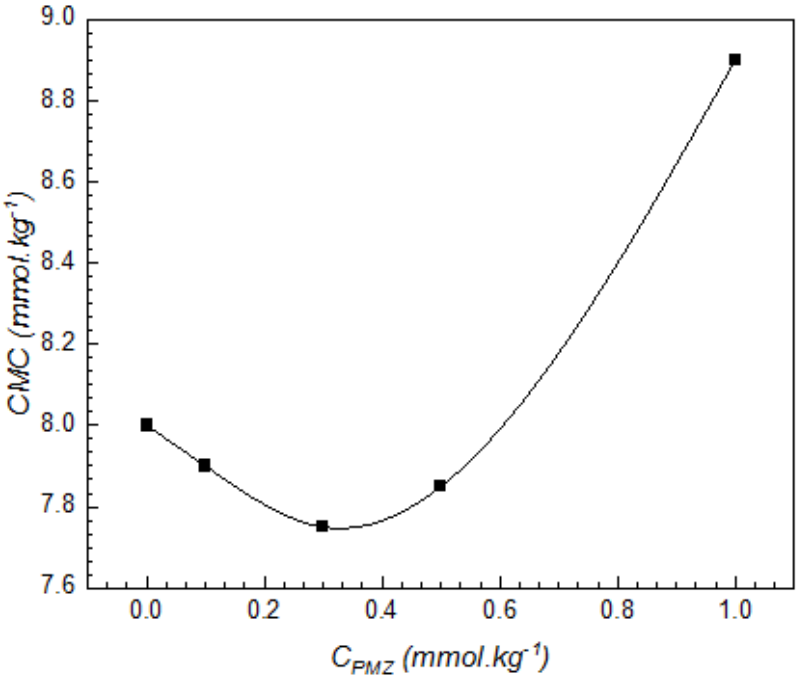


Fig. 2 A plot of critical micelle concentration (CMC) vs. varying concentration of promethazine hydrochloride (PMZ) drug + surfactant mixture in water at 298.15 k

It can be concluded from this that, within a particular concentration range, PMZ provided an environment that was conducive to SDS micellization. PMZ and SDS may have interacted favorably, judging by the drop in CMC levels that followed the addition of PMZ. In addition, it was discovered that PMZ is easily soluble in water and was completely soluble in the study's concentration range. The stabilizing effect of the surfactant system is achieved by neutralizing the surface charge and reducing the intermolecular repulsion potential of a Helmholtz layer formed

in the presence of surfactant micelles and Na^+ ions [32].

3.2. Influence of salt on the micellization of SDS+PMZ mixture

Electrolytes are essential for maintaining the pH balance of the blood as well as promoting healthy neuron and muscle function. The presence of these salts, which are existed in the cellular membranes in various concentrations, can have an effect. Therefore, it is vital to look at the nature of distinct surfactant associations or drug-mediated surfactant associations when electrolytes are present and at various temperatures. To understand how surfactant interactions with pharmaceuticals are altered, sodium, potassium, and ammonium salts (NaCl, KCl, and NH_4Cl) were utilized in this study. Table 2 at 298.15K shows the CMC and β values of a pure SDS/PMZ + SDS mixture in an H_2O/electrolytes medium. In the transition from an aqueous to an electrolyte medium, the CMC values of the SDS + PMZ mixture decreases. The addition of electrolyte produces an environment that is conducive to the micellization of drug + surfactant mixtures. This type of result for medication + surfactant combinations was also found in earlier research [33, 34] when salts were included. The CMC value of SDS in water at 298 K was 7.80 mmol L^{-1}, according to Dutkiewicz *et al.* Furthermore, they demonstrated that the CMC value declined in a salt solution, where it did so monotonically as the salt concentration increases [35]. Using SDS in water and a 5 mmol.L^{-1} salt solution at 303.15 K, Hitoshi discovered that the CMC values were 8.6 and 6.6 mmol.L^{-1} [36]. In a different study, Khan *et al.* examined the interactions between the promethazine hydrochloride medication and the salt solution-based aerosol T (AOT) surfactant. They discovered that the interactions decreased the CMC [37]. The reduction in the strong electrical repulsion between the positively charged head groups of the ionic surfactant was the main cause of the decline in CMC values. The highly polarized counter ions of salt readily penetrate the monolayer of ionic amphiphiles [38-40]. In ionic micellar systems with electrolytes present, the electric double layer at the interface loses both thickness and potential [41]. As a result, these counter ions may reduce the electrical attraction between charged head groups, which could lead to a decrease in CMC values and an early beginning of micellization, or a low surfactant concentration. As presented in Table 2, the order of CMC NaCl > KCl > NH_4Cl applies to PMZ + SDS combinations in salt solutions with stable concentrations. Ammonium chloride (NH_4Cl) is more effective than potassium chloride (KCl) and sodium chloride (NaCl) for reducing CMC concentrations. Inorganic salts in the current system retain the same anions (Cl^-), but distinct cations (Na^+, K^+, and NH_4^+). The surfactant counterion effect is NH_4^+ > K^+ > Na^+, i.e. ammonium salts diminish the CMC the most, enhancing micellization. This is due to the fact that a sulfonate head group that is chaotropic can form close ion pairs with NH_4^+ and encourage surfactant micellization due to a screening effect brought on by greater electrostatic interactions between the surfactant head group and its counterion [42-46]. These findings suggest that the inclusion of ammonium or potassium ions reduces the number of molecules needed by the surfactant to saturate the air-water surface. However, compared to potassium and sodium ions, the ammonium ion has a greater effect on reducing electrostatic repulsion among surfactant head groups, necessitating the use of more molecules to saturate the surface [38, 40].

Table 2 Critical micelle concentration (CNC) as well as β values of surfactant and sodium dodecyl sulphate (SDS) + promethazine hydrochloride (PMZ) mixtures in aqueous and electrolytes solutions with 1.00 mmol/kg of PMZ

System	Medium	C_{salt} (mmol/kg)	T/ K	CMC (mmol/Kg)	β
SDS +PMZ	H_2O	0.00	298.15	8.26	0.45
		0.00	303.15	7.71	0.46
		0.00	308.15	6.67	0.46
		0.00	313.15	6.90	0.47
		0.00	318.15	7.80	0.48
SDS + PMZ	H_2O + NaCl	2.00	298.15	7.59	0.44
		2.00	303.15	7.34	0.43
		2.00	308.15	7.01	0.42
		2.00	313.15	6.71	0.41
		2.00	318.15	7.40	0.43
SDS + PMZ	H_2O + KCl	2.00	298.15	7.40	0.43
		2.00	303.15	7.15	0.42
		2.00	308.15	6.80	0.42
		2.00	313.15	6.00	0.41
		2.00	318.15	6.80	0.40
SDS +PMZ	H_2O + NH_4Cl	2.00	298.15	6.88	0.40
		2.00	303.15	6.41	0.41
		2.00	308.15	6.12	0.40
		2.00	313.15	5.61	0.38
		2.00	318.15	6.23	0.41

According to reports by Collins *et al.* [47] and Vlachy [48], the second behavior is constant; it is predicated on the development of close ion pairs between the counterion of a surfactant head group and the production of close ion pairs, which encourages a stronger screening effect. According to this theory, chaotropic salts like ammonium interact closely (closer than sodium) with chaotropic surfactant head groups like sulfonate adsorbed at the surface when they are provided [44-50]. The electrostatic repulsion between the head groups of surfactant molecules is reduced as a result of this closer connection, facilitating micellization formation [42, 45].

Since sodium salt is less chaotropic than ammonium, it interacts with SDS less. Because of this, sodium salts' screning action is less effective and causes micellization at a higher surfactant concentration than it does for salts like ammonium, which are more chaotropic [45, 48, 49].

3.3. Effects of temperature on the micellization of PMZ + SDS system in the presence and absence of salts

It was found that there has been a noticeable effect of temperature variation on the micellization behavior of PMZ + SDS systems in water and salts solution. The temperature range (298.15-318.15 K) was selected in the current study covering both room temperature (around 298.15 K) and body temperature (310.15 K). Temperature-dependent of CMC are shown in Figures 3 displaying a non-linear pattern. For the PMZ + SDS system in salt solutions medium, the CMC values initially go down, attain a minimum, and then rise gradually with the temperature enhancement (Figure 3).

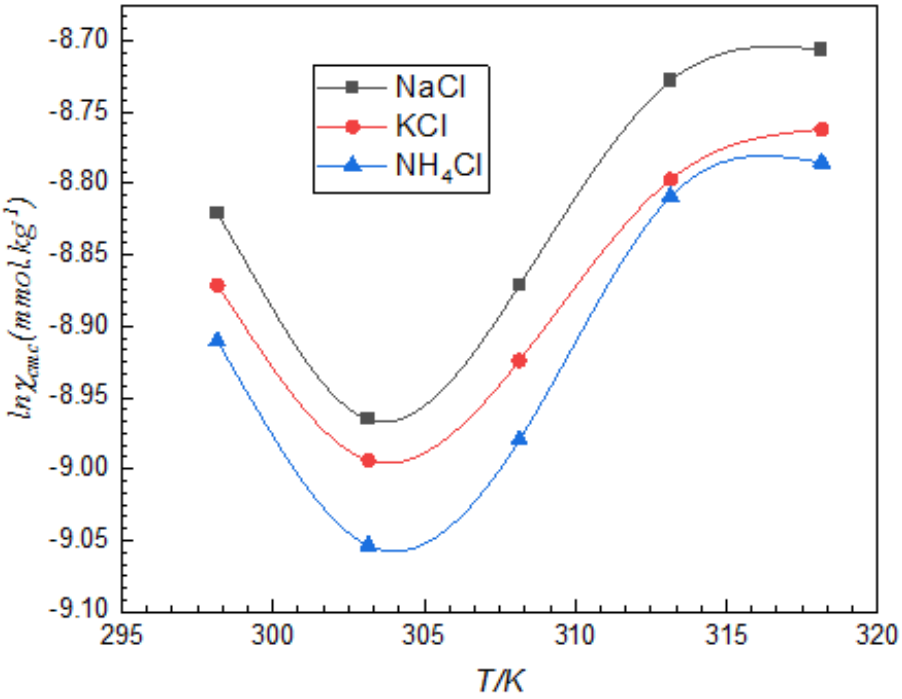


Fig. 3 Plot of the second-order polynomial fitting curve if lnXcmc against T for promethazine hydrochloride (PMZ) + sodium dodecyl sulphate (SDS) in electrolyte medium

The modulation of various types of hydrations around the hydrophobic/hydrophilic moieties of the surfactant can be used to explain how CMC changes as a function of temperature. Both hydrophilic and hydrophobic hydrations are achievable in the surfactant's monomeric form, but they are not possible in the surfactant's micellized form (SDS). With the rise in temperature, it has been seen that both types of hydrations are diminished. According to many researchers, micellization is supported by a decrease in hydrophilic hydration, whereas hydrophobic hydration is the opposite [51, 52]. Due to this, two main issues have been taken into account as the temperature rises: (a) de-solvation of ionic/polar head groups of SDS promotes micelle formation, resulting in a decrease in CMC values; and (b) disruption of the ordered water structure/hydrogen bonds neighboring nonpolar parts of surfactant/PMZ + surfactant reduces aggregation, resulting in an increase in CMC values [51-53]. These two problems therefore regulate the CMC fluctuation over the investigated range of temperatures. At a lower temperature, the initial factor regulates the aggregation of pure surfactant in a water/salt medium, whereas the second factor regulates at a higher temperature. The progressive decrease in CMC values for PMZ + SDS systems might be mostly explained by the leading effect of the H_2O molecules declining arrangement around the hydrophobic chain of SDS. In addition, it was indicated that the hydrophobic chain of micellized surfactants structural shift may have an impact on the CMC variation over the investigated temperature range. Even though anionic surfactant contains carbon atoms, the C-C bond alignment associated with the surfactant polar head may be along, the major molecular axes, resulting in the early formation of the micelle and a decrease in CMC values [54,55]. The formation of a micelle is delayed, which results in an increase in CMC values, if the arrangement of C-C bonds

attached to the surfactant head does not display along the major molecular axes.

3.4. Thermodynamic evaluation of SDS and SDS +PMZ mixture

To comprehend the micellization phenomena, the interactions between the medication and surfactant, and the impact of various additives, thermodynamic parameters are crucial tools. Furthermore, better drug delivery and release rates can be attained using the values of various thermodynamic parameters in the drug formulation process. Drug delivery and release rates are functions of the molecular interactions between a drug and surfactants, which can be explained in terms of thermodynamic parameters. Using the pseudo-phase partition model [56-58] and the micellization Gibb free energy ($\Delta G°_m$) values, the spontaneity or non-spontaneity of micellization can be determined by the following relation:

$$\Delta G_m^0 = (1+\beta)RT \ln \chi_{cmc} \quad (1)$$

Where, χ_{cmc} is the CMC value expressed on a mole fraction basis, defined as:

$$\chi_{cmc} = \frac{CMC}{CMC + [PMZ] + 55.56} \quad (2)$$

The following equation was used to estimate the enthalpy of micellization $\Delta H°m$, for both PMZ-mediated and pure SDS-mediated micellization:

$$\Delta H_m^0 = -(1+\beta)RT^2(\partial \ln \chi_{cmc})/\partial T \quad (3)$$

The dependent on temperature by χ_{cmc} is demonstrated to be a parabolic arc through relation:

$$\ln \chi_{cmc} = A + BT + CT^2 \quad (4)$$

Where, the variables A, B, and C are determined through least squares regression analysis. Figure 3 displays the plot of the polynomial fitting arc of ln χ_{cmc} versus T, which was then used to determine the system's $\Delta H°m$ [59, 60]:

$$\Delta H_m^0 = -(1+\beta)RT^2[B+2CT] \quad (5)$$

The estimated $\Delta G°_m$ and $\Delta H°m$ values were then applied for the measurement of the entropy ($\Delta S°m$) in similar circumstances according to the equation [61-62]:

$$\Delta S_m^0 = (\Delta H_m^0 - \Delta G_m^0)/T \quad (6)$$

Thermodynamic parameters for both pure surfactants and medication + surfactant combinations in water and salt solutions (NaCl, KCl, and NH_4Cl) are listed in Table 3. As the $\Delta G°_m$ values are observed to be negative, this provides information regarding the association spontaneity (Table 3).

The magnitudes of negative $\Delta G°_m$ values are greater (relatively) in the presence of electrolytes, indicating an increase in the dynamic forces between the constituents. In addition to hydrophobic interaction, electrostatic relation greatly contributes to the anticipated micellization, as shown by the negative values of $\Delta H°m$ and the positive values of $\Delta S°m$. The standard enthalpy changes ($\Delta H°m$) for a single ionic surfactant system were previously measured for both the negative and positive directions [63-66]. Positive values of $\Delta H°m$ (endothermic process) were obtained when the amphiphilic drug PMZ was present in the surfactant solution in an aqueous system. These values are practically steadily decreasing toward negative (exothermic process) as the temperature is increased (Table 3). According to a report, the acquired positive values of enthalpies are ($\Delta H°m$) may be the result of the water structure (H-bonding) rupturing on the exterior of hydrophobic parts, indicating the significance of nonpolar interactions regarding the micellization of the surfactant [67,68].

Table 3 Values of ΔG_m^0, ΔH_m^0, ΔS_m^0, and ΔC_m^0, for pure surfactant promethazine hydrochloride (PMH) + Sodium dodecyl/ sulphate (SDS) and (PMZ + SDS + electrolytes) mixture with 1.0 mmol/kg of PMH in water/electrolytes mixture at various temperature

System	Medium	C_{salt}	T/K	ΔG_m^0	ΔH_m^0	ΔS_m^0	ΔC_m^0
		$(mmolkg^{-1})$		$(KJmol^{-1})$	$(KJmol^{-1})$	$(Jmol^{-1})$	$(Jmol^{-1}K^{-1})$
SDS	H_2O	0.00	298.15	-33.11	28.23	0.35	
			303.15	-32.45	12.34	0.21	-13.45
			308.15	-33.11	-4.78	0.14	
			313.15	-33.05	-20.71	0.09	
			318.15	-33.16	-39.17	-0.16	
SDS+PMZ	H_2O	0.00	298.13	-31.53	15.94	105.82	
			303.15	-32.69	89.37	108.12	
			308.15	-33.77	20.41	109.65	-3.21
			313.15	-34.42	-46.65	109.77	
			318.15	-34.73	-112.49	108.80	
SDS+PMZ	H_2O+NaCl	2.00	298.15	-31.76	65.78	106.75	
			303.15	-32.19	36.84	106.32	
			308.15	-32.66	9.23	106.02	
			313.15	-33.12	-17.14	105.71	-5.44
			318.15	-33.75	-43.22	105.96	
SDS+PMZ	H_2O+KCl	2.00	298.15	-31.63	74.72	106.35	
			303.15	-32.06	48.77	105.92	
			308.15	-32.78	24.15	106.43	
			313.15	-33.53	33.91	115.35	-4.84
			318.15	-33.36	-22.41	104.78	
SDS+PMZ	H_2O+NH_4Cl	2.00	298.15	-31.22	86.59	105.00	
			303.15	-32.22	54.48	106.48	
			308.15	-32.69	22.65	106.15	-6.20
			313.15	-33.06	-7.67	105.53	
			318.15	-33.92	-37.54	106.51	

According to Nusselder and Engberts [69], negative values of $\Delta H°m$ indicate the presence of London-dispersion forces, which drive surfactant monomers to aggregate. Standard enthalpy values ($\Delta H°m$) of PMZ + SDS mixtures with NaCl/KCl/NH_4Cl are positive at lower temperatures and change to the negative values with increasing temperature, with the magnitude of the increasing negative values (Table 3). Hence, the endothermic and exothermic processes at lower and higher temperatures, respectively, are the $\Delta H°m$ values that signify the micellization of the PMZ + SDS system in the presence of electrolyte.

The standard entropy ($\Delta S°m$) values of the PMZ + SDS system in water, on the other hand, are extremely positive, and are observed to decrease with temperature in the H_2O/ NaCl/KCl/NH_4Cl medium indicating that this system is entropy dominated. In the presence of NH_4Cl, the positivity is greatly increased, which enhances micellization. Several literary works have claimed that two very important evidences are what actually cause positive entropy levels (Table 3). Initially, the development of a substantial network of water entities near the nonpolar region in an aqueous environment encouraged the rise in entropy values and aided the effortless transition of the hydrophobic

components from H_2O to the interior of micelles "hydrophobic interaction." Second, there is a greater rotational movement of the nonpolar chain in the micellar hydrophobic core on the inferior side than in watery media [70].

3.5. Measurement of molar heat capacity

The molar heat capacity ($\Delta C°_m$) values of micellization provide information that may be used to examine the activities and functions of macromolecules like proteins, which aids in the understanding of the physicochemical characteristics associated with macromolecules. The following relation can be used to calculate the$\Delta C°_m$ values of micellization for the association of pure surfactant and (surfactant + drug) [71, 72]:

$$\Delta C_m^0 = \left(\frac{\partial H_m^0}{\partial T} \right)_p \quad (7)$$

Table 3 lists the variations in the$\Delta C°_m$ values for the micellization of pure surfactant and PMZ + SDS mixtures. The $\Delta C°_m$ values were found to be negative for both pure surfactant and the PMZ + SDS mixture in water. Their negative values suggest that as heat increases, $\Delta H°m$becomes more negative, leading to greater bond creation or decreased bond break at higher temperatures. In the presence of salts (NaCl/KCl/NH_4Cl), all the $\Delta C°_m$ values are negative. This is the typical pattern for self-aggregating amphiphiles, and it is explained by the removal of sizable portions of non-polar surface from water contact during micelle formation when SDS micelles is binding with PMZ.

Conclusion

This study demonstrates the effects of temperature and drug concentration (PMZ) on the micellization behavior of the ionic surfactant SDS in the presence of salts. When temperature increases, the CMC values initially decrease, reach a minimum, and then progressively increase at fixed concentration of drug/salts + drug. The CMC values drop with the addition of drug and drug + salts (compared to when they are not present), and they follow the pattern CMC_{NaCl}> CMC_{KCl}> CMC_{NH4Cl}. In the presence of salt/PMZ, these CMC values strongly suggest favorable and early aggregation. All cases had negative observed $\Delta G°_m$ values, which represent the spontaneity of micellization. The identified physicochemical properties demonstrate that the binding interactions between the medication under study and SDS are exothermic and hydrophobic. The $\Delta C°_m$ values show a change in the conformations of surfactant (SDS) micelles in the presence of PMZ under various conditions. This study reveals that the variables between PMZ and SDS that are being investigated can interact in a desirable way.

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HOW TO CITE THIS ARTICLE
Olaseni Segun Esan, Owolabi Mutolib Bankole, Ogbonna Chinedu Chrisly. Promethazine Hydrochloride Influence on the Micellization and the Surface Properties of Sodium Dodecyl Sulfate in Aqueous Solutions Containing Electrolytes at Various Temperatures , Adv. J. Chem. B, 2023;5(3) 271-288
DOI: 10.48309/ajcb.2023.398501.1175
URL: https://www.ajchem-b.com/article_177542.html