Rafidain Journal of Science

https://rsci.uomosul.edu.iq

Vol. 34, No. 4, pp. 68-78, 2025 (December)

Investigation of the Ability of Micelle Formation of Two Ionic Surfactants in Presence of Metronidazole Drug

Bashar Z. Al-khiro
Department of Technical Pharmacy/ Mosul Medical Technical Institute/ Northern Technical University/ Iraq
Rabah A. Khalil
Department of Chemistry/ College of Science/ University of Mosul/ Iraq
Myasar M. Alkotaji
College of Pharmacy/ University of Nineveh/ Iraq

p-ISSN: 1608-9391
e -ISSN: 2664-2786

Article information

Received: 2/3/2025
Revised: 16/5/2025
Accepted: 26/5/2025

DOI: 10.33899/rjs.2025.190523

corresponding author:
Bashar Z. Al-khiro
Ba_zu_ab24@ntu.edu.iq
Rabah A. Khalil
Rakhalil64@yahoo.com
Myasar M. Alkotaji
Myasar.alkotaji@uoninevah.edu.iq

ABSTRACT

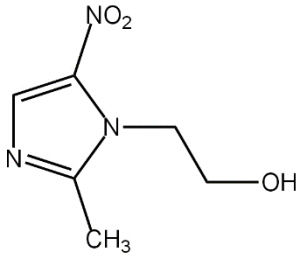
This document is concerning with the main driving factor for the formation of micelle, which may be introducing more evidence to promote the past works about this phenomenon. The variety of functional groups in the metronidazole (Met) drug as slightly soluble in water may give a good object for understanding the micellization when existed as an additive substance for determining the critical micelle concentration (CMC). Two ionic surfactants including anionic sodium dodecyl sulphate (SDS) and cationic cetyltrimethylammonium bromide (CTAB) more explored at different temperatures using electrical conductivity method. The results indicated that there is a positive effect on CMC of SDS as the CMC decreased with increasing Met concentration which then made reduction in ionization degree (α). Contrary, the CMC of CTAB was increased with increasing the amount of Met as working against the formation of micelle. The standard thermodynamics functions of micellization including enthalpy ΔH°, entropy ΔS°, and Gibbs free energy ΔG° were evaluated. It was noted that the sign of enthalpy and Gibbs free energy of micellization for two surfactants are negative, but the sign is positive of entropy for aggregation process of surfactants as there is no change due to presence of met. Intuitively, the CMCs of SDS and CTAB are directly proportional with temperature in presence and absence of Met due to the negative effect on the intermolecular force between molecules.

Keywords: Critical micelle concentration, metronidazole, cetyltrimethylammonium bromide, sodium dodecyl sulphate.

INTRODUCTION

The hydrophobic effect of surfactant is caused by the repulsion between the hydrocarbonic group of surfactants with water which is the main driving force to form micelles spontaneously, to make the system more stable (Aramaki *et al.*, 1999). On the other hand, the electrostatic repulsions between head groups of ionic surfactants are mostly diminished in the formed micelle due to presence of free gegenions at Gouy-Chapman layer (Berezin *et al.*, 1973). Actually, one of the most significant characteristics of surface-active agents is enhancing the solubility of hydrophobic organo-compounds in water (Mosa and Qadir, 2008) by sorption within or on the surface of micelles. Such property is employed successfully in the aspects of micellar catalysis and drug delivery (Bhattacharjee *et al.*, 2013). An important property of surfactants which can be considered as a tool for characterizing these molecules is the critical micelle concentration (CMC). CMC could be defined as the threshold between micelle and not aggregated surfactant molecules which no micelle under this specific concentration. The value of CMC could give an idea about the ability of surfactants for the formation of three-dimensional shape of aggregate. On the other side, the presence of foreigner molecules as additives could certainly affect the amount of CMC of these amphiphilic molecules. In other words, the presence of an additive could certainly affect the value of CMC whether it is up or down depending on the type of functional group (Berezin *et al.*, 1973). Therefore, scientists have taken this criterion into consideration in order to have an idea about the effect of presence of additive on the micellization phenomenon (Bunton, 1977) of many types of surface-active agents. Such a study can be helpful for finding the suitable solution system of each substance in the selected surfactants (Khalil and Al-khiro, 2006). The effect of presence hydrocortisone-acetate as a hydrophobic additive on the CMC to SDS and CTAB at different pH and temperatures (Khalil and Hassan, 2010a). The results indicated that there is a change in the sign of enthalpy of micellization (ΔH°) from negative to positive for SDS, but still exothermic for CTAB. They also found there is a negative effect on CMC of both surfactants due to presence of hydrocortisone acetate as increased with increasing the concentration of the additive. The iceberg formation due to hydrophobic effect which resulted from the addition of such compound changed the enthalpy of micellization of SDS to endothermic process in contrast to that of CTAB situation as reflected the increases in CMC of those two surfactants (Khalil and Hashim, 2011). Studied the effect of presence of three polar aromatic amines on the CMC of ionic surfactants with no change in the sign of enthalpy was observed (Jiang et al., 2003). Recently, (Hammad and Khalil, 2024) investigated the effect of adding sodium hypochlorite on the CMC of each SDS and CTAB. They found that the sodium hypochlorite supports the micellization process for both surfactants due to minimizing the electrostatic repulsion between their head groups which then reduces the value of α, in addition to common ion effect which also supports the stability of CTAB. More recently, (Bawazir *et al.*, 2024), have been studied the influence of addition of sulfathiazole drug on the CMC value for SDS, CTAB, and triton X100. They found that CMC of ionic surfactants decreased with increasing the drug amount. The binding constant value indicated the tendency of medicine to solubilize in CTAB more than SDS micelles. The interaction between sulfathiazole with triton X100 was weak, therefore, no change in its CMC.

Metronidazole (Met) is one of popular an antibiotic for oral and topical therapy that treating infections caused by anaerobic bacteria (Löfmark *et al*., 2010), microaerophilic bacteria, and protozoal (Dingsdag and Hunter, 2018; Al-Sultan and Al-Jubouri, 2005). It is slightly soluble in water, acetone, alcohol, and methylene chloride (British Pharmacopeia, 2022) that contain a very interesting functional groups: Imidazole, nitro, and hydroxyl (Scheme 1) which provide a substantial information of ionic surfactant aggregation. It seems interesting to investigate the effect of the presence of Met on the micellization behaver of SDS and CTAB. According to the literature, there is no such study was observed.



Scheme 1: The chemical structure of Metronidazole.

EXPERIMENTAL

Met was provided by state drug industry (SDI), Samarra-Iraq in highly pure form. All other reagents were obtained as analytical grade commercial products from HiMedia Laboratories Pvt.Ltd., India. All solutions were prepared using conductivity water (4-5 $\mu S \cdot cm^{-1}$). WTW conductometer was used to measure the electrolytic conductivity of the solutions (formerly as specific conductivity) with accuracy±0.01 $\mu S \cdot cm^{-1}$. Water thermostated Hakke NK22 was employed to control the temperature within ±0.1°C. The CMCs were determined from plots of specific conductivity versus surfactant concentration. The measurements were repeated to check the reproducibility of the data.

RESULTS AND DISCUSSION

The study of presence the Met at a various concentration (1×10^{-5}, 5×10^{-5}, 1×10^{-4}, and 5×10^{-4}M) on the micellization of SDS has been determined at different temperatures (293.15, 298.15, 303.15, and 308.15K) by detecting the difference in electric conductance with SDS quantities, as shown in Fig. (1). The results indicate there is a direct proportion between CMC of SDS with temperature at presence and absence of Met as clearly shown at (Table 1) and Fig. (2). This may be attributed to the fact that when the temperature increases the intermolecular forces are reduced which then decreases the tendency of aggregations. On the other hand, the results (Table 1) and Fig. (2) show a positive effect on the CMC of SDS due to the presence of the Met as the CMC decreased with increasing the concentration of the additive. The reason for this may be related to the presence of alkaline imidazole ring at Met which should exist on the surface of micelles, which then decreases the CMC of anionic surfactant by reducing the repulsion force between surfactant head groups.

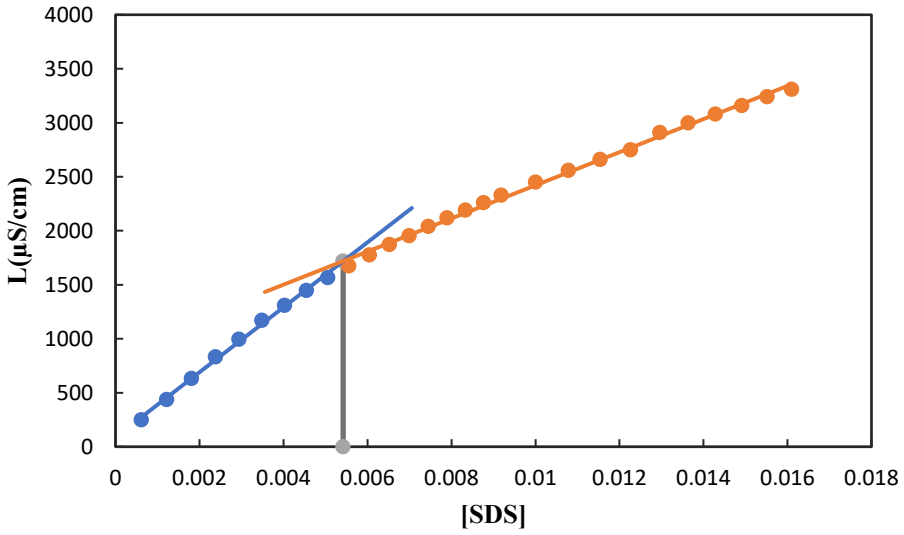


Fig. 1: The relationship between electric conductivity versus the molar concentration of SDS in presence 1×10^{-4} M of Met at 293.15° K.

Table 1: Influence of presence Met on the CMC of SDS at different temperatures.

[Met]	CMC×10³ (M)			
	293.15˚K	298.15˚K	303.15˚K	308.15˚K
0	6.184	6.340	6.516	6.609
1×10^{-5}	5.409	5.470	5.622	5.775
5×10^{-5}	5.185	5.296	5.354	5.439
1×10^{-4}	5.095	5.130	5.210	5.366
5×10^{-4}	4.937	5.051	5.167	5.306

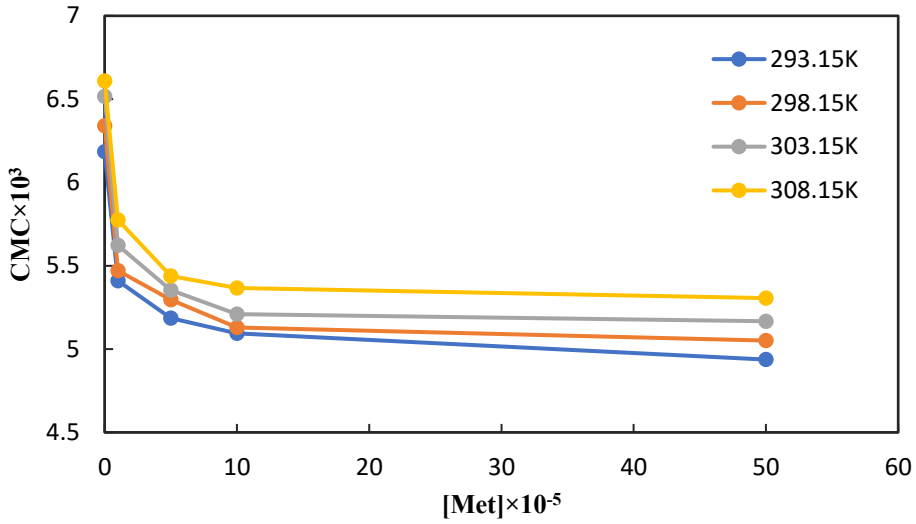


Fig. 2: The plot of CMC of SDS against the molar concentration of Met at different temperatures.

The ionization degree (α) and the amount of the counterion binding with micelles (β) were calculated from the ratio of the slopes of two intersecting lines (The upper orange line is slope A and the lower blue line is sloping B as illustrated in Fig. (1)) and the relation of (β = 1-α), respectively, as listed at (Tables 2 and 3). These generally show there is somewhat upward in α values at presence and absence of Met with temperature due to increase of kinetic energy of molecules and then reduces the molecular interactions between them. Interestingly, the variation of β values with Met concentrations did not follow a limited sequence which revealed to a competition between gegenions with Met molecules to locate in the surface of micelles, providing more stability of spherical shape.

Table 2: The values of slope A and slope B of SDS micellization in presence of Met at different temperatures.

[Met]	293.15˚K		298.15˚K		303.15˚K		308.15˚K	
	$Slope_A$	$Slope_B$	$Slope_A$	$Slope_B$	$Slope_A$	$Slope_B$	$Slope_A$	$Slope_B$
0	137189	300613	140609	285194	149957	276192	154990	259511
1×10^{-5}	148065	314548	149253	311614	152151	306699	144862	318548
5×10^{-5}	148833	324144	153504	312481	149901	322186	154978	315253
1×10^{-4}	149931	322982	151095	325393	153129	325978	148493	329326
5×10^{-4}	153941	319958	153046	319147	152050	327679	148550	328886

Table 3: The values of (α) and (β) of SDS in presence of Met at different temperatures.

[Met]	293.15˚K		298.15˚K		303.15˚K		308.15˚K	
	α	β	α	β	α	β	α	β
0	0.45636	0.54364	0.49303	0.50697	0.54294	0.45706	0.59724	0.40276
1×10^{-5}	0.47072	0.52928	0.47897	0.52103	0.49609	0.50391	0.45476	0.54524
5×10^{-5}	0.45916	0.54084	0.49124	0.50876	0.46526	0.53474	0.49160	0.50840
1×10^{-4}	0.46421	0.53579	0.46435	0.53565	0.46975	0.53025	0.45090	0.54910
5×10^{-4}	0.48113	0.51887	0.47955	0.52045	0.46402	0.53598	0.45168	0.54832

The influence of existence of Met on the micellization thermodynamic functions of SDS including enthalpies (ΔH˚), entropies (ΔS˚), and free energies (ΔG˚) at several temperatures were estimated using following mass action model equations (Zana, 1996; Abo Gabal *et al.*, 2023):

$$lnX_{CMC} = Intercept + \frac{\Delta H^{\circ}}{(2-\alpha)R} \times \frac{1}{T} \quad \ldots (1)$$

$$\Delta G^{\circ} = (2-\alpha)RTlnX_{CMC} \quad \ldots\ldots\ldots (2)$$

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

Where X_{CMC} is the mole fraction of micellization which is estimated by dividing the concentration of surfactant at CMC by the sum of the concentrations of surfactant at CMC, additive and solvent (water). According to the first equation, it must be plotted lnX_{CMC} versus 1/T Fig. (3) to calculate the enthalpy value from the slope of this relationship. The results are written in (Table 4). The values of ΔH˚, ΔG˚, ΔS˚, and -TΔS˚ for SDS at different amount of Met and temperatures are illustrated in (Table 5). The quantities of thermodynamic functions show that the micellization process of SDS are being more spontaneous and exothermic at the presence of the Met. On the other hand, the sign of ΔS˚ is positive and its values increase with increasing the Met concentration due to liberating the sodium ion from micelles and breaking the intermolecular force between water molecules. Finally, the amount of term -TΔS˚ is larger than ΔH˚ value which reflected to contribute it of spontaneity of process.

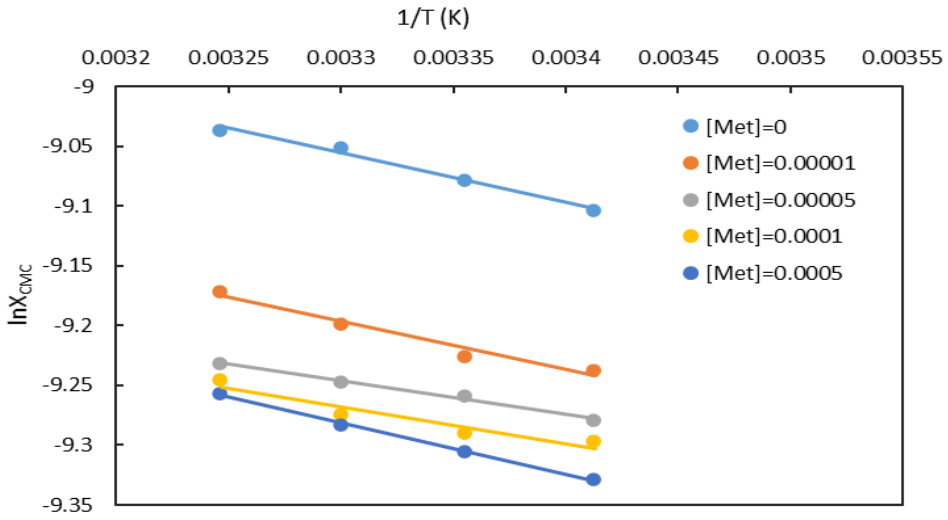


Fig. 3: The relationship between lnX_{CMC} of SDS micellization with 1/T (K) at different concentrations of Met.

Table 4: The values of slopes, intercepts, and standard error for the relationship between lnX_{CMC} with 1/T (K) of SDS in presence of Met at different temperatures.

[Met]	Slope	Intercept	R^2	r	S.E.
0	-409.84	-7.7031	0.987	0.994	0.00410
1×10^{-5}	-402.94	-7.8671	0.966	0.983	0.00661
5×10^{-5}	-278.87	-8.3259	0.987	0.993	0.00285
1×10^{-4}	-307.09	-8.2545	0.910	0.954	0.00845
5×10^{-4}	-430.94	-7.8589	0.997	0.999	0.00198

Table 5: The effect of presence Met on the thermodynamic functions of aggregation for SDS at different temperatures.

[Met]	Temp. K°	ΔH° KJ/mol.	ΔG° KJ/mol.	ΔS° J/mol.K.	-TΔS° KJ/mol.
0	293.15	-5.2598	-34.249	98.888	-28.989
	298.15	-5.1349	-33.913	96.521	-28.778
	303.15	-4.9648	-33.239	93.267	-28.274
	308.15	-4.7798	-32.477	89.882	-27.697
1×10^{-5}	293.15	-5.1231	-34.429	99.970	-29.306
	298.15	-5.0955	-34.786	99.581	-29.690
	303.15	-5.0381	-34.867	98.396	-29.829
	308.15	-5.1766	-36.310	101.03	-31.133
5×10^{-5}	293.15	-3.5725	-34.849	106.69	-31.276
	298.15	-3.4981	-34.626	104.40	-31.128
	303.15	-3.5584	-35.770	106.26	-32.212
	308.15	-3.4973	-35.676	104.42	-32.178
1×10^{-4}	293.15	-3.9211	-34.800	105.33	-30.879
	298.15	-3.9208	-35.364	105.46	-31.443
	303.15	-3.9070	-35.771	105.11	-31.864
	308.15	-3.9551	-36.692	106.24	-32.737
5×10^{-4}	293.15	-5.4418	-34.533	99.237	-29.091
	298.15	-5.4475	-35.073	99.363	-29.625
	303.15	-5.5031	-35.937	100.39	-30.434
	308.15	-5.5474	-36.718	101.15	-31.171

In a similar manner, the effect of the presence of the Met on the CMC of CTAB was investigated at different concentrations and temperatures as explained in Fig. (4). (Table 6) introduces the difference in the CMC of cationic surfactant at presence and absence of Met with temperature variation. The CMC values of CTAB become higher with increasing both temperature and Met concentration.

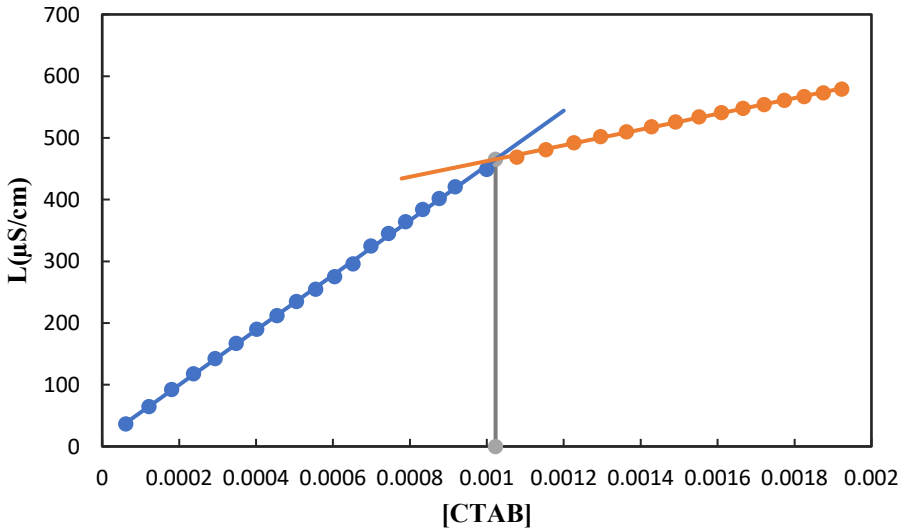


Fig. 4: The relationship between electric conductivity against the molar concentration of CTAB in presence 1×10^{-4} M of Met at 293.15° K.

Table 6: Influence of presence Met on the CMC of CTAB at different temperatures.

[Met]	CMC×10⁴ (M)			
	293.15°K	298.15°K	303.15°K	308.15°K
0	9.290	9.530	9.740	10.27
1×10^{-5}	9.320	9.590	9.801	10.30
5×10^{-5}	9.380	9.647	9.866	10.38
1×10^{-4}	9.416	9.710	9.982	10.40
5×10^{-4}	9.430	9.752	10.02	10.41

Indeed, the same results were gotten from the SDS measurements with various temperatures, but the relationship with Met quantities is opposite to that of an anionic SDS surfactant. The orientation of Met molecule as containing aromatic imidazole ring on the surface of CTAB micelle (Berezin *et al.*, 1973) which concentrated at the surface of micelle and the steric effect of the quaternary ammonium head group reflected the increase of its CMC, as shown in Fig. (5). The results recommend the possibility to use an aqueous solution of SDS as a green solvent for analytical determination of Met in a similar manner to that of β-lactam antibiotics and benzocaine (Khalil and Al-Khayat, 2008; Khalil and Hussain, 2010b).

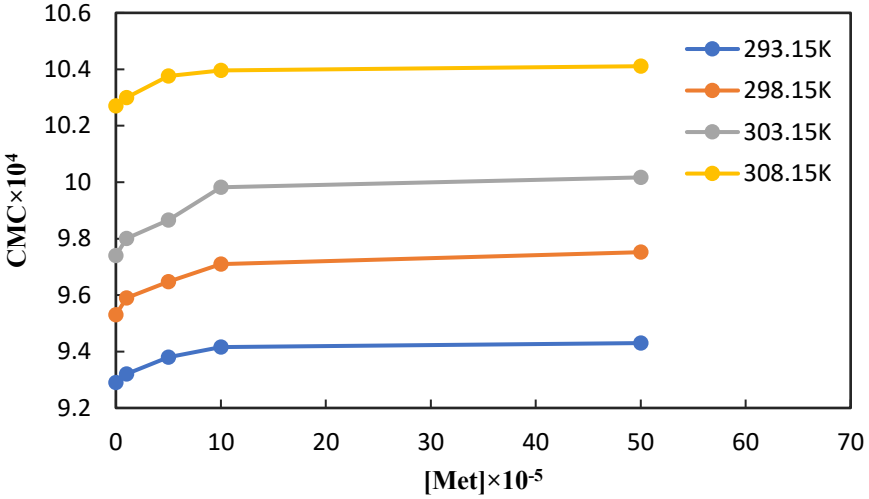


Fig. 5: The plot of CMC of CTAB versus the molar concentration of Met at different temperatures.

(Table 8) exhibits the estimated values of α and β of CTAB in presence of different concentration of Met at different temperatures according to the data of (Table 7). Interestingly, these show an agreement between the results of (Table 8) with that of SDS (Table 3). In general mode, these show that the degree of ionizing of CTAB is increased with increasing temperature which may be related to the existence of hydroxyl and nitro groups in the structure of Met that work against iceberg phenomenon. In other words, those specific groups interact with water by hydrogen bonding which then they reduce the tendency for the micelle formation and certainly affect α. Again, there is no fixed relationship between each α and β with concentration of Met which may be due to the above-mentioned SDS.

Table 7: The values of slope A and slope B of CTAB micellization in presence of Met at different temperatures.

[Met]	293.15°K		298.15°K		303.15°K		308.15°K	
	$Slope_A$	$Slope_B$	$Slope_A$	$Slope_B$	$Slope_A$	$Slope_B$	$Slope_A$	$Slope_B$
0	112411	435362	113981	444052	122314	447564	122969	443824
1×10^{-5}	109877	435587	111770	434869	123605	444222	123890	444437
5×10^{-5}	107800	435290	119441	434716	126740	440948	125961	440206
1×10^{-4}	113016	425466	110018	438774	118703	439179	124836	439110
5×10^{-4}	112720	431828	116019	429441	120693	433680	122834	438713

Table 8: The values of (α) and (β) of CTAB in presence of Met at different temperatures.

[Met]	293.15˚K		298.15˚K		303.15˚K		308.15˚K	
	α	β	α	β	α	β	α	β
0	0.2582	0.7418	0.2567	0.7433	0.2733	0.7267	0.2771	0.7229
1×10^{-5}	0.2523	0.7478	0.2570	0.7430	0.2783	0.7218	0.2788	0.7212
5×10^{-5}	0.2477	0.7524	0.2748	0.7252	0.2874	0.7126	0.2861	0.7139
1×10^{-4}	0.2656	0.7344	0.2507	0.7493	0.2703	0.7297	0.2843	0.7157
5×10^{-4}	0.2610	0.7390	0.2702	0.7298	0.2783	0.7217	0.2799	0.7200

The quantities of thermodynamic functions of CTAB at presence and absence of Met various with heat are listed in (Table 10). They have been calculated from plotting the mole fraction of micellizing process vs. inversing temperature at different amounts of Met, as shown and written in Fig. (6) and (Table 9), respectively. The values and the sign of each ΔH˚ and ΔG˚ indicating that the aggregation process of CTAB become more spontaneous with decreasing heat which reflected in α and β quantities. The -TΔS˚ term is more contribution than ΔH˚ in the value of ΔG˚.

Table 9: The values of slopes, intercepts, and standard error for the relationship between $\ln X_{CMC}$ with 1/T (K) of CTAB in presence of Met at different temperatures.

[Met]	Slope	Intercept	R^2	r	S.E.
0	-580.62	-9.0228	0.949	0.974	0.01183
1×10^{-5}	-579.28	-9.0226	0.964	0.982	0.00987
5×10^{-5}	-585.50	-8.9953	0.962	0.981	0.01015
1×10^{-4}	-585.27	-8.9900	0.991	0.995	0.00496
5×10^{-4}	-583.86	-8.9921	0.994	0.997	0.00387

Table 10: The effect of presence Met on the thermodynamic functions of aggregation for CTAB at different temperatures.

[Met]	Temp.	ΔH˚	ΔG˚	ΔS˚	-TΔS˚
	K˚	KJ/mol.	KJ/mol.	J/mol.K.	KJ/mol.
0	293.15	-8.4081	-46.692	130.596	-38.284
	298.15	-8.4155	-47.420	130.822	-39.005
	303.15	-8.3353	-47.661	129.724	-39.326
	308.15	-8.3171	-48.107	129.126	-39.790
1×10^{-5}	293.15	-8.4174	-46.838	131.062	-38.421
	298.15	-8.3944	-47.384	130.771	-38.989
	303.15	-8.2922	-47.497	129.325	-39.205
	308.15	-8.2897	-48.047	129.020	-39.758
5×10^{-5}	293.15	-8.5301	-46.934	131.004	-38.404
	298.15	-8.3982	-46.876	129.056	-38.478
	303.15	-8.3365	-47.215	128.250	-38.879
	308.15	-8.3428	-47.809	128.074	-39.466
1×10^{-4}	293.15	-8.4394	-46.436	129.616	-37.997
	298.15	-8.5119	-47.501	130.769	-38.989
	303.15	-8.4168	-47.637	129.376	-39.220
	308.15	-8.3486	-47.852	128.195	-39.503
5×10^{-4}	293.15	-8.4413	-46.553	130.008	-38.112
	298.15	-8.3970	-46.955	129.323	-38.558
	303.15	-8.3575	-47.401	128.793	-39.044
	308.15	-8.3493	-47.966	128.562	-39.616

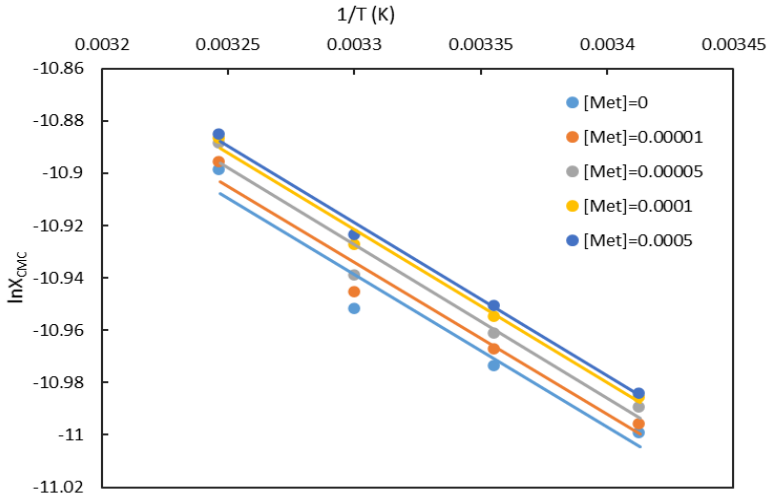


Fig. 6: The relationship between $\ln X_{CMC}$ of CTAB micellization with 1/T (K) at different concentrations of Met.

CONCLUSIONS

The presence of Met drug in its pure form in the aqueous solutions of anionic SDS and cationic CTAB surfactants remarkably affect their CMC in different moods. Met causes a positive effect to the CMC of SDS and a negative effect to that of CTAB. Such an achievement could suggest that the SDS is more suitable for external use of Met preparations in contrast to that of CTAB as the solution of SDS is more stable and dissolves Met in less quantity of surfactants.

REFERENCES

Abo Gabal, R.; Osama, S.; Hanafy, N.; Oraby, A. (2023), Micellization thermodynamics a function of the temperature of a cationic zwitterionic dodecyl phosphocholine and anionic sodium dodecyl sulfate mixed micelles with fluorometry, *App. Phy. A*, **129**, 201, DOI: 10.1007/s00339-023-06482-8

Al-Sultan, S.A.; Al-Jubouri, S.H. (2005), Sensitivity test and choosing anti helicobacter pylori therapy, *Raf. J. Sci.*, **16**(6A), 111-120.

Aramaki, K.; Olsson, U.; Yamaguchi, Y.; Kunieda, H. (1999). Effect of water-soluble alcohols on surfactant aggregation in the $C_{12}EO_8$ system, *Lang.*, **15**(19), 6226-6232, DOI: 10.1021/la9900573

Bawazir, W.A.; Al-Mahmood, M.A.; Almalki, R.S.; Alofi, G.F.; Alharbi, R.S.; Zaheer, Z. (2024), Surfactants interaction with sulfathiazole: spectroscopic, conductometric, and thermodynamic approach, *Arab. J. Chem.*, **17**(1), DOI: 10.1016/j.arabjc.2023.105436

Berezin, I.V.; Martinek, K.; Yatsimirskii, A.K. (1973). Physicochemical foundations of micellar catalysis, *Rus. Chem. Rev.*, **42**(10), 787-802, DOI: 10.1070/rc1973v042n10abeh002744

Bhattacharjee, J.; Verma, G.; Aswal, V.K.; Patravale, V.; Hassan, P.A. (2013). Microstructure, drug binding and cytotoxicity of pluronic P123-aerosol OT mixed micelles, *RSC Adv.*, **3**, 23080-23089, DOI: 10.1039/C3RA44983A

British Pharmacopeia. (2022), The Stationary Office, London, Vol. II, 302p.

Bunton, C.A. (1977), Micellar catalysis and inhibition, *Pure App. Chem.*, **49**, 969-979.

Dingsdag, S.A.; Hunter, N. (2018), Metronidazole: an update on metabolism, structure-cytotoxicity and resistance mechanisms, *J. Antimicro. Chemoth.*, **73**, 265-279, DOI: 10.1093/jac/dkx351

Hammad, F.J.; Khalil, R.A. (2024), The effect of adding sodium hypochlorite on the critical micelle concentrations for anionic and cationic surfactants, *Samarra J. Pure App. Sci.*, **6**(1), 38-50, DOI: 10.54153/sjpas.2024.v6i1.582

Jiang, B.; Du, J.; Cheng, S.; Wang, Q.; Zeng, X. (2003), Effects of amine additives on critical micelle concentration of ionic surfactants, *J. Disp. Sci. Tech.*, **24**(6), 755-760, DOI: 10.1081/DIS-120025542

Khalil, R.A.; Al-Khayat, R.Z. (2008). Micellar catalysis in reactions of some β-lactam antibiotics with p-dimethylaminobenzaldehyde. *Phy. Chem. Liq.*, **46**(1), 34-46. DOI:10.1080/00319100601084993

Khalil, R.A.; Hussain, S.A. (2010a), Surfactant enhanced reaction between benzocaine and p-dimethylaminobenzaldehyde: Kinetic study and its analytical application. *Arab. J. Sci. Eng.*, **35**(2A), 55-66.

Khalil, R.A.; Al-khiro, B.Z. (2006) Surfactant effect on kinetic of reaction of some sulphonamides with p-dimethylaminobenzaldehyde: Surfactant-modified determination of sulphonamides in aqueous solution, *JCCS*, **53**(3), 637-642, DOI: 10.1002/jccs.200600084

Khalil, R.A.; Hassan, M.Q. (2010b), Exploration for micelles driving force from determination of critical micelle concentration of ionic surfactants in presence of hydrocortisone acetate, *J. Disp. Sci. Tech.*, **31**(9), 1195-1201, DOI: 10.1080/01932690903224078

Khalil, R.A; Hashim, A.M. (2011), The role of organic additives in changing the sign of standard enthalpy of micellization, *PCAIJ*, **6**(3), 105-112.

Löfmark, S.; Edlund, C.; Nord, C. (2010), Metronidazole is still the drug of choice for treatment of anaerobic infections, *Clin. Infect. Dis.*, **50**(Suppl. 1), S16-S23, DOI: 10.1086/647939

Mosa, A.A.; Qadir, R.M. (2008), Spectrophotometric assay of pyridoxine hydrochloride (Vitamin B6) in pharmaceutical preparations and serum via arsenazo III- cerium (III) reaction, *Raf. J. Sci.*, **19**(2E), 28-41.

Zana, R. (1996), Critical micellization concentration of surfactants in aqueous solution and free energy of micellization, *Lang.*, **12**, 1208-1211.

دراسة تأثير وجود عقار الميترونيدازول على قابلية تكوين المذيلات للعوامل الفعالة سطحيا الأيونية

بشار زهير عبد الحميد

قسم تقنيات الصيدلة/ المعهد التقني الطبي/ الموصل/ الجامعة التقنية الشمالية/ موصل/ عراق

رباح علي خليل

قسم الكيمياء/ كلية العلوم/ جامعة الموصل/ العراق

ميسر محمد القوطجي

كلية الصيدلة/ جامعة نينوى/ العراق

الملخص

يعنى هذا البحث بدراسة العوامل التي تدفع جزيئات المواد الفعالة سطحيا للتجمع على شكل المذيلات. لدعم الدراسات السابقة التي اهتمت بهذا الموضوع، تم اختيار دواء الميترونيدازول (metronidazole, Met) قليل الذوبان في الماء وكذلك احتوائه على ثلاث مجاميع فعالة في تركيبه، كمادة عضوية مضافة بعدة تراكيز ودرجات حرارية لقياس تركيز المذيلات الحرج (critical micelle concentration, CMC) لكل من المادتين الأيونيتين الفعالتين سطحيا كبريتات دوديسيل الصوديوم (sodium dodecyl sulfate, SDS) وسيتيل ثلاثي مثيل أمونيوم بروميد (cetyltrimethylammonium bromide, CTAB) باستخدام طريقة التوصيل الكهربائي للسوائل. من خلال القياسات وجد ان تركيز CMC لمادة SDS يقل بازدياد تركيز Met مما يؤدي الى نقصان في درجة التأين للمادة الفعالة سطحيا. على خلاف ذلك، نجد ان تركيز CTAB الحرج يرتفع مع زيادة تركيز الدواء في المحلول. تم إيجاد المتغيرات الثرموديناميكية الثلاثة لعملية تكوين المذيلات لكلا المادتين الفعالتين سطحيا، وتشمل: الانثالبي القياسي (ΔH°)، الانتروبي القياسي (ΔS°) والطاقة الحرة القياسية (ΔG°) بوجود وعدم وجود الدواء. لوحظ بان إشارة الانثالبي والطاقة الحرة كانتا سالبة وهذا يدل على أن عملية تكوين المذيلات لكلا المادتين الفعالة سطحيا هي عملية باعثة للحرارة وتلقائية. من جانب اخر، وجد ان إشارة الانتروبي موجبة دليل على زيادة العشوائية نتيجة نقصان الترابطات البينية لجزيئات الماء لوجود السلاسل الهيدروكربونية للمواد الفعالة سطحيا في الوسط وكذلك تحرر جزء من الايونات المرافقة لهذه المواد في الطبقة المحيطة بكرية المذيل.

الكلمات الدالة: تركيز المذيلات الحرج، ميترونيدازول، كبريتات دوديسيل الصوديوم، سيتيل ثلاثي مثيل أمونيوم بروميد.