



International Journal of PharmTech Research

CODEN (USA): IJPRIF, ISSN: 0974-4304 Vol.8, No.6, pp 192-197, 2015

Miceller Behavior of Non-ionic surfactant Triton-X-100 in Presence of Myo-Inositol at Different Temperatures by Surface Tension

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Abstract: Studies on surface tension of Triton-X-100 in presence and in absence of myoinositol at 298, 303, 308 and 312 K. are reported. The values of critical micelle concentration, maximum surface excess concentration (Γ_{max}) and minimum area per molecule (A_{min}) at CMC are evaluated. It has been found that CMC value of additive surfactant system are higher than that of pure surfactant system. Thermodynamic parameters of micellization and those of adsorption have been also evaluated. The negative values of standard (ΔG_m^0) and positive values of enthalpy (ΔH_m^0), entropy (ΔS_m^0) and increase with increase in temperature favours the process of micellization.

Key words: critical micelle concentration (cmc), Triton-X-100 (Tx-100), maximum surface excess concentration (Γ_{max}), maximum area per molecule (Λ_{min}).

Introduction:-

Inositol is well studied organic compound with specific stereochemistry. Its high reactivity control many cellular processes in living organism [1-2]. Inositol is water soluble cyclic hexahydric alcohols. It has nine isomeric forms out of which myo-inositol is the only isomer which shows biological activity [3-4]. Myo-inositol is crystalline compound with sweet test. It plays important role in animal and human metabolism. Myo-inositol is widely used for analytical as well as in pharmaceuticals, plant growing, food industry and variety of biotechnological processes. Myo-inositol is key function in maintaining normal brain function [5]. Therefore, studies on the interaction between non-ionic surfactant and inositol in water are valuable for interpreting the influence of surfactant on physiological behavior, and also helpful in understanding the essence of some biological phenomena. Myo- Inositol often referred as *Vitamin B-8*. Non-ionic surfactant contains both hydrophobic group (hydrocarbon chain) and hydrophilic group (polar head) in the same surfactant molecule [6-8]. Non-ionic surfactant belonging to polyethylene oxide family, typically abbreviated as CiEj is widely used as detergents, solubilizer, emulsifier and pharmaceutical preparations [9-10], their practical importance has triggered a significant effort to gain the fundamental understanding of their micellization characteristics as well as their phase behaviour in both aqueous and non-aqueous medium [11].

In the present investigation, the data of surface parameter such as surface excess concentration (Γ_{max}), minimum area per molecule (A_{min}) have been reported. Thermodynamic parameters for micellization as standard free energy (ΔG^0_m) and positive values of enthalpy (ΔH^0_m), entropy (ΔS^0_m) values for Triton X-100 with and without additive myo-inositol at 298, 303, 308 and 312 K. are have been evaluated.

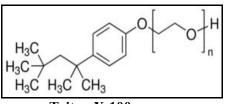
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Experimental

Material and Method:-

The non-ionic surfactant Triton X-100 (M.W. 646) and Myo-inositol (M.W. 180.16) both are the product of Merck and used as received. Doubly distilled water with specific conductance 2-4 μs cm⁻¹ at 303.15 K was used in preparation of all solutions of different concentrations.

Surface tension of liquid can be determined by using modified stlagmometer by drop number methods. Stlagmometer consisting of a pipette with capillary outflow tube, the end of which was flattened out and polished in order to give a large dropping surface. The necessary drop corrections were applied. It was calibrated using standard liquids such as tolune and double distilled water. Reproducibility of measured surface tension was within $\pm 0.2~\text{mNm}^{-1}$ of the literature values. The temperature control of thermostatic bath was within $\pm 0.1^{0}\text{C}$



HO OH OH OH OH

Triton X-100

Results and Discussion:-

The results obtained during the present investigation are given in Table (1-3). The critical micelle concentration (CMC) values for TX-100 pure and with additive are obtain from the break point of surface tension versus log C [surfactant] plot. The CMC values are found to be well agreement with published data [12,13]

From the present study, it reveals that the CMC values for pure surfactants Triton X-100, decreased with increased temperature of selected range in present investigation.

This behaviour may be taken as typical characteristics of non-ionic surfactants ^[14]. It is well known fact that, London dispersion forces are the main attraction forces in the formation of micelle, similarly in addition to above fact, the micelle formation is supposed to be result of hydrophobic interaction ^[15-16]. Increase in temperature causes reduction in hydrophobic interaction. The lowering of CMC with increase in temperature may causes reduction in hydration of oxyethylene group which favours the process of micellization.

Table-1: CMC, surface excess concentration (Γ_{max}), minimum surface area per molecule (A_{min}) and Thermodynamics parameters of Pure TritonX-100

Temp. (K)	CMC mM	$\frac{\Gamma_{\text{max}} \times 10^{10}}{(\text{molcm}^{-2})}$	A _{min} x 10 ² (nm ²)	-ΔG ⁰ _m	$\Delta H^0_{\ m}$	$\Delta S^0_{\ m}$	
298	0.238	1.94	0.85	30.62	3.69	115.15	
303	0.230	1.92	0.86	31.22	3.82	115.65	
308	0.223	1.90	0.87	31.82	3.94	116.11	
313	0.220	1.88	0.88	32.37	4.07	116.43	

The maximum surface excess concentration Γ_{max} describe adsorption tendency of surfactant molecule at air-liquid interface. The maximum surface excess concentration Γ_{max} at air liquid interface have been calculated [17]

$$\Gamma_{\text{max}} = 1/\text{nRT} \left(\frac{\text{d}\gamma}{\text{dlnC}} \right)_{\text{T}} \qquad ------ (1)$$

Where n is the number of particles per molecule of surfactant whose surface concentration varies with change in surfactant concentration(C) in bulk phase. For non-ionic surfactant n=1, R is gas constant (0.008314 KJ mo1⁻¹) and ($d\gamma$ /dlnC) is slope of surface tension (γ) versus log C plot at temperature T.

The present study revealed that, Γ_{max} value for Pure TritonX-100, decreased with increase in temperature which may be due to the enhanced thermal agitation at higher temperature.

The results of present work reveals that addition of additive (Myo-Inositol) all four surfactant results in the lowering of maximum surface excess concentration values. The decrease in Γ_{max} value becomes more significant at higher concentration of additive. This attributed to stronger affinity of surfactant molecules with additive in comparison to water [18]. This leads to shifting of surfactant molecule from liquid air interface to the bulk of the solution. Hence decrease in Γ_{max} value is observed.

Table- 2: CMC, surface excess concentration (Γ_{max}), minimum surface area per molecule (A_{min}) for TritonX-100 + Myo-Inositol mixed system

[Myo- Inositol] mM	CMC mM				$\Gamma_{\rm max} \times 10^{10} \ ({ m molcm}^{-2})$				A _{min} x 10 ² (nm ²)			
	298K	303K	308K	313K	298K	303K	308K	313K	298K	303K	308K	313K
1	0.255	0.262	0.268	0.273	1.95	1.90	1.87	1.82	0.85	0.87	0.89	0.91
3	0.258	0.265	0.271	0.277	1.93	1.88	1.85	1.80	0.86	0.88	0.90	0.92
5	0.262	0.268	0.275	0.280	1.90	1.86	1.81	1.78	0.87	0.89	0.92	0.93
7	0.265	0.270	0.275	0.278	1.87	1.83	1.79	1.75	0.89	0.91	0.93	0.95

The minimum area per molecule (A_{min}) at liquid-air interface was calculated using following equation.

$$A_{min} = 10^{14} / N \Gamma_{max}$$
 (2)

Where N is Avogadro's number.

Form the data it reveals that, Γ_{max} value decreased with increased temperature as well as with increased concentration of additive Myo-Inositol. Addition of Myo-Inositol results in the lowering of surface excess concentration values. The decrease in Γ_{max} values becomes more significant at higher concentration of additive. This is attributed to stronger affinity of surfactant molecule with Myo-Inositol in comparison to water. This leads to the shifting of surfactant molecules from liquid air interface to bulk of the solution and hence decrease in Γ_{max} value is observed.

An examination of these values revealed that, A_{min} increases both with the increase in temperature as well as concentration of Myo-Inositol. This behaviour can be explained in terms of the enhanced compatibility of surfactant with solvent in presence of additive thereby causing shift of surfactant molecule from air-liquid interface to the bulk phase.

The standard Gibb's free energy of micellization (ΔG^0_m) standard enthalpy of micellization (ΔH^0_m) and standard entropy of micellization (ΔS^0_m) for the present work is evaluated using equations ^[19,20].

$$\Delta G_{m}^{0} = RT ln X_{cmc} \qquad ----- (1)$$

$$\Delta H_{m}^{0} = -RT^{2}/(dlnX_{cmc}/dT)_{p}$$
 ----- (2)

$$\Delta S_{m}^{0} = (\Delta H_{m}^{0} - \Delta G_{m}^{0}) / T \qquad (3)$$

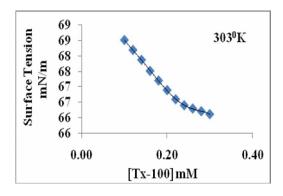
Where X_{cmc} is the CMC expressed in terms of mole fractions of surfactant at the CMC. The data obtained for thermodynamic properties viz ΔG^0_m , ΔH^0_m and ΔS^0_m , TritonX-100, with and without additive are presented in Table 3. The ΔG^0_m values are found to be negative for present system. In absence of additive, the free energy of micellization becomes more negative with increased temperature indicating that formation of micelles becomes more spontaneous with increasing temperature. The negative value of ΔG^0_m also increased with increase in temperature and also with additive concentration, even though CMC value increased with temperature. This indicates that change in magnitude of logarithm of CMC in terms is more than compensated by the change in value of the RT terms.

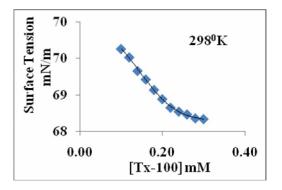
Table-3: CMC and Thermodynamics parameters of the micellization forTritonX-100 + Myo- Inositol mixed system.

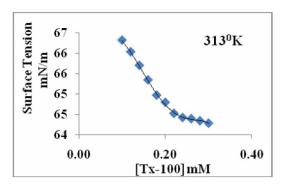
[Myo- Inositol] mM	CMC mM				-ΔG ⁰ _m (KJmol ⁻¹)				ΔH ⁰	ΔS ⁰ _m	
	298K	303K	308K	313K	298K	303K	308K	313K	(KJ mol ⁻¹)	(Jmol ⁻¹ K ⁻¹)	
1	0.255	0.262	0.268	0.273	30.45	30.90	31.35	31.81	3.10	112.04	
3	0.258	0.265	0.271	0.277	30.42	30.87	31.32	31.77	3.10	111.95	
5	0.262	0.268	0.275	0.280	30.39	30.84	31.28	31.74	3.10	111.84	
7	0.265	0.270	0.275	0.278	30.36	30.82	31.28	31.76	2.33	109.28	

The ΔS_m^0 values are positive for the studied system, it may be due to breaking of water structure when the surfactant hydrophobic chain transfers from bulk water to micellar core. The standard entropy of micellization (ΔS_m^0) values are positive for all present studied system suggesting that the process of micellization is favored by entropy gain [21]. Rosen et.al. [22] predicted that, steric factor is also responsible for this positive value of ΔH_m^0 suggest that like entropy effect enthalpy change also favors the process of micellization.

The CMC obtained from plot of Surface tension Vs. [Non-ionic Surfactants] in mM for pure non-ionic surfactants TX-100, is represented in Fig. 1. The representative plot of Surface tension Vs. [Non-ionic Surfactants] in mM and 1 mM Myo-Inositol mixed system are depicted in Fig. 2.







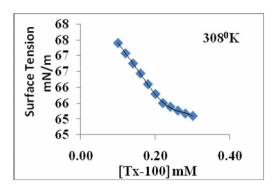
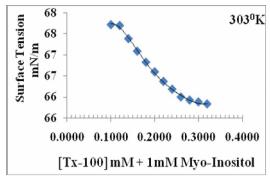
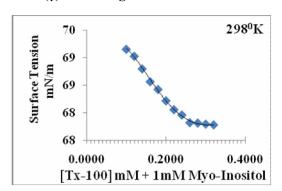
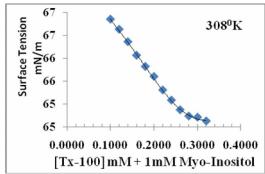


Fig.1 Graphical Representation of surface tension (γ) versus log C







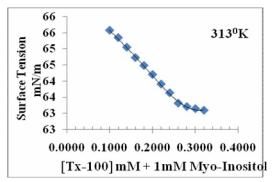


Fig.-2 Graphical Representation of surface tension (γ) versus log C +1 mM myo-inositol

Acknowledgement

The author (Chautmal R. C.) thankful to Hon'ble Principal Dr. P. N. Patil, GET's Arts, Commerce and Science College, Nagaon, Dist., Dhule. Hon'ble Principal, Z. B. Patil College, Dhule. Head, Department of Chemistry, Z. B. Patil College, Dhule and Head, Department of Chemistry, GET's Arts, Commerce and Science College, Nagaon, Dist., Dhule for providing laboratory facilities.

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