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THERMODYNAMICS OF NON-IONIC SURFACTANT (TRITON X-114) IN PRESENCE OF MYO-INOSITOL USING CLOUDING PHENOMENON

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ABSTRACT

The Phenomenon of micellization of non-ionic surfactant Triton X-114 has been studied by measuring cloud point (CP) of the pure surfactant and with myo-inositol. The CP of pure surfactant found to be increased with increased surfactant concentration .The CP of mixed system also shows same trend with increased myo-inositol concentration. The influence of myo-inositol on cloud point of Triton X-114 is clear indication that the phenomenon of clouding is associated with different micellization coalescing. The phase separation is due to the micelle-micelle interactions. Considering the CP as the threshold limit of solubility, the thermodynamic parameters of clouding process (ΔG^o_{cl} , ΔH^o_{cl} and ΔS^o_{cl}) have been evaluated using "Phase separation model." From the present study it is found that the overall clouding process is exothermic indicating that process of clouding is guided by both enthalpy and entropy. Present work would be supportive evidence for additive-surfactant interactions in aqueous medium in the future use of non-ionic surfactant with different additives.

Key words: Micellization, Cloud (CP), Triton X-114, Phase separation model.

INTRODUCTION

The physico-chemical studies of additive surfactant solution have been created much interest regarding their pharmaceutical and industrial importance [1-2]. Non-ionic surfactant belonging to polyethylene oxide family, typically abbreviated as CiEj is widely used as detergents, solubilizer, emulsifier and pharmaceutical preparations, their practical importance has triggered a significant effort to gain the fundamental understanding of their micellization characteristics as well as their phase behavior in both aqueous and non-aqueous media [3]. The cloud point is important phenomenon of non-ionic surfactant, below CP a single phase of molecular solution exist, above CP water solubility of water surfactant is reduced and it results in to cloudy dispersion [4-6], by formation of giant molecular aggregates in the state of separate phase [7-8]. The unique structures of surfactant offer a convenient way to study influence of additive like myo-inositol on micellization behavior through the clouding phenomenon supported by thermodynamic characterization using phase separation model.

Inositol is well studied organic compound with specific stereochemistry, its high reactivity control many cellular processes in living organism [9-10]. 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 [12-13]. 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.

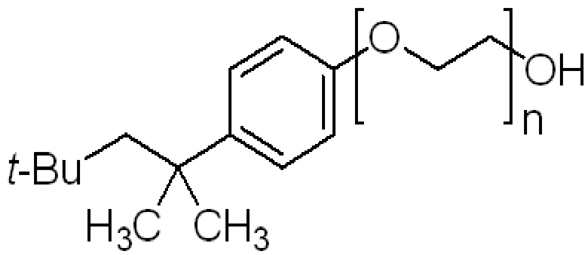
In this paper the results of our study on clouding phenomenon of pure Triton X-114 in presence of myo-inositol have been reported. Considering cloud point as threshold temperature of solubility in aqueous medium, the thermodynamic parameters of clouding process ΔG^0_{cl}, ΔH^0_{cl}, ΔS^0_{cl} have been evaluated using phase separation model.

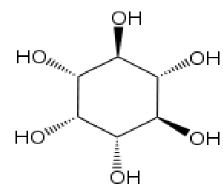
EXPERIMENTAL

Material and Method

The non-ionic surfactant Triton X-114 (M.W. 537) and Myo-inositol (M.W. 180.16) both are the product of E-Merck, Germany 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.

The cloud point (CP) of surfactant solution were determined by controlled heating in well stirred surfactant solution in a glass tube immersed in beaker containing water, until it clouded or get turbid. The turbid solution was then allowed to cool slowly under stirring condition; the temperature of disappearance of turbidity was also noted. The average of two was taken as the cloud point of system. The heating and cooling were regulated by less than $1^{o}C$/min. around the cloud point. The reproducibility of the measurements was found to be within ± 0.2 ^{0}C.





Clouding species:-Triton X-114 (Tx-114)   Additive: - Myo-inositol

RESULTS AND DISCUSSION

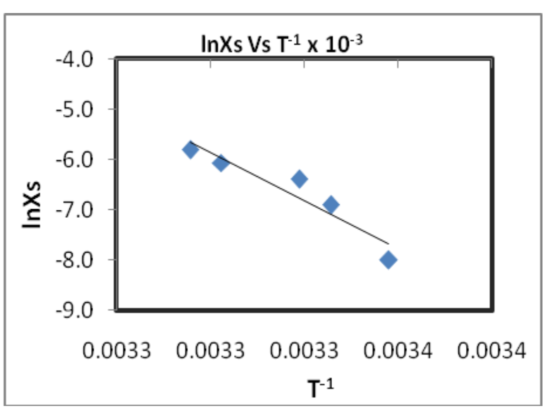
The cloud point of pure surfactant Triton X-114 at various concentrations in wt. % is given in Table-1. It was observed that cloud point increases with increased surfactant concentration, since at higher concentration well structured water-surfactant system is present. Rakshit et al [14] pointed out that higher temperature is to be required to break the water-surfactant self assembly. It was found that below 1% there is very mild variation in cloud point of pure surfactant, this might be due to fact that to form cluster agglomerates of surfactant moiety are not sufficient at lower concentration. Table-1 shows the increase in Cp value with increased surfactant concentrations. Higher temperature is required to remove the water molecules which are barrier for the micellar interaction. Once they move at higher temperature the micelle-micelle interaction become easier. That is why cloud point is seen at higher temperature. The variation of cloud point as a function of surfactant concentrations are shown in fig.1

Table-1: Cloud Points of Pure Triton X-114 at different concentrations

[TX-114] Wt%	Molarity x 10^{-3}	Mole Fraction x 10^{-4}	CP ^{0}C	CP K
1	18.622	3.351	24.8	297.8
3	55.866	10.046	25.9	298.9
5	93.110	16.732	26.5	299.5
7	130.354	23.409	28.0	301.0
9	167.598	30.077	28.6	301.6

Table-2: Thermodynamic parameters of Triton X-114

[Triton X-114] Weight (%)	$\Delta G°_{cl}$ (KJ mol^{-1})	$-\Delta H°_{cl}$ (KJ mol^{-1})	$-\Delta S°_{cl}$ (J $mol^{-1}K^{-1}$)
1	19.81	135.3	520.7
3	17.15		509.9
5	15.92		504.8
7	15.16		499.7
9	14.56		496.7



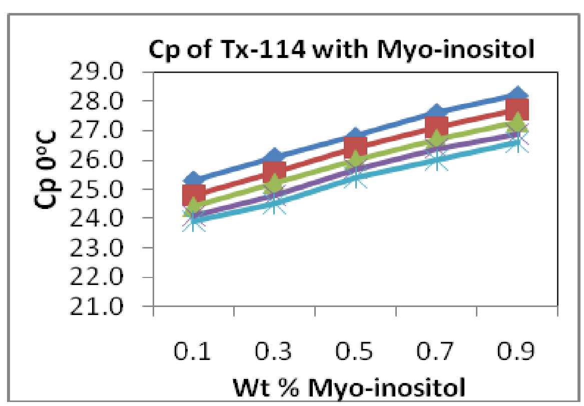


Fig.2 Variation of Cp as function of Tx-114

Fig.2 Influence of additive on CP of Tx-114

The influence of additive on CP of Tween-40 at varied concentration of myo-inositol has been given in Table-3. The results of mixed system are presented in Fig.-2. It was found that below 0.1 Wt % of myo-inositol did not show marked effect on CP of surfactant, since at lower concentration surfactant moiety do not agglomerate into visible micelle. The CP values declined with increased additive concentration effectively. This is mainly due to removal of water by the additive which helps the surfactant moiety to come closer to each other resulting in to phase separation by cloudy dispersion. Here additive compete for the water molecule with the micelles and the surfactant becomes less hydrated and resulting into lowering of cloud point.

Table-3: Thermodynamic parameters of Triton X-114 Myo-Inositol mixed system

[Myo-Inositol] Weight (%)	$\Delta G°_{cl}$ (KJ mol^{-1})	$-\Delta H°_{cl}$ (KJ mol^{-1})	$-\Delta S°_{cl}$ (J $mol^{-1}K^{-1}$)
0.1	22.84	44.5	225.9
0.3	20.10	44.2	215.8
0.5	18.82	43.5	209.2
0.7	17.98	40.9	197.9
0.9	17.34	38.6	188.1

TX-100/MYO-INOSITOL

The influence of Myo-inositol on cloud point of TritonX-114 at varied concentration has been given in Table-3. The results of influence of Myo-inositol on cloud point of TritonX-114 at varied concentration indicate that the cloud point of TritonX-114 increased considerably with increased concentration of Myo-inositol. This is due to break of structured water around additive-surfactant system. The removal of water molecule from surfactant by added Myo-inositol helps the surfactant micelli to come closer with each other resulting into increase of cloud point. The additive-surfactant complex is stronger due to solute-solvent interaction and hence higher temperature is required to break down this strong complex system. The dependence of cloud point on Myo-inositol is presented in Fig. 2

THERMODYNAMICS OF CLOUDING PHENOMENON

Cloud point is characteristics of non-ionic surfactants. The desolvation of hydrophilic group of surfactant leads to phase separation and visibility observed as cloudy dispersion. Kjellander et al[15] reported that phenomenon of clouding is entropy dominated. At the cloud point, the water molecule gets totally detached from micelles. Considering the cloud point as a separation point, the thermodynamic parameter such as standard free energy (ΔG^0_{cl}), enthalpy (ΔH^0_{cl}), and entropy (ΔS^0_{cl}) for clouding ›process have been evaluated using phase separation model[16]. Standard free energy (ΔG^0_{cl}) evaluated using relation-

$$\Delta G^o_{cl} = -RT \ln Xs \quad \text{……..(1)}$$

Where Xs is the mole fractional solubility of the solute

and "cl" stands for clouding process.

Standard entropy (ΔS^o_{cl}) for the clouding process have been calculated using following relationship-

$$\Delta S^o_{cl} = (\Delta H^o_{cl} - \Delta G^o_{cl}) / T \quad \text{…… (2)}$$

The standard enthalpy (ΔH^o_{cl}) for clouding process have been calculated from the solubilization curve is given by slop of the linear plot of ln Xs Vs 1/T in Fig-1 for pure non-ionic surfactant Tween-20.

$$- \Delta H^o_{cl} = RT^2 (d \ln Xs / dT)$$

$$LnXs = (\Delta H^o_{cl}/T)(1/T) + C \quad \text{…….. (3)}$$

The negative value of ΔH^o_{cl} indicates that process of clouding is exothermic in nature. The thermodynamic parameters of clouding for pure Tx-114 are given in Table-2 that for mixed system with Myo-Inositol in table number are given in Table-3. $\Delta H^0_{cl} < \Delta G^o_{cl}$, indicating the process of clouding is exothermic and also $\Delta H^0_{cl} > T\Delta S^0_{cl}$ indicating that the process of clouding is guided by both enthalpy and entropy.

The present work would be supportive evidence for the probable interaction between nonionic surfactant and biomolecule leading to phase separation at cloud point.

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