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Short Communication

Impact of Alkaline Earth Metal salts on the Thermodynamics of Clouding Behavior of Tween 80

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Abstract

The cloud point (CP) determination of non ionic surfactant in presence of additives is useful in the study of interaction between surfactant and additive. Polyoxyethylene (20) sorbitan mono-oleate (Tween 80) was used as surfactant and chlorides of some alkaline earth metals like magnesium, calcium, strontium and barium were used as additives. The addition of these additives in Tween 80 solution caused decrease in cloud point of the surfactant. The influence of alkaline earth metal salts on the cloud point of Tween 80 indicates that the clouding phenomenon results in merging of different micelle. The thermodynamic parameters of clouding process (ΔG^0_{cl}, ΔH^0_{cl} and ΔS^0_{cl}) were calculated using phase separation model. The overall clouding process is exothermic which shows that clouding phenomenon is guided by enthalpy and entropy. The present work is useful for the study of surfactant-additive interaction in aqueous phase.

Keywords: Tween 80, Cloud point, alkaline earth metal salts, phase separation model.

Introduction

Non ionic surfactants exhibit a characteristic feature, cloud point. The micelle grows larger and larger with increase in temperature. The micelle becomes so large at a certain temperature called cloud point that, turbidity of the solution becomes perceptible even to the naked eye. Further growth causes the separation into surfactant rich phase and water phase having slight amount of surfactant[1,2]. The cloud point determination is useful in the study of the quality and characteristics of surfactant alone or in a mixture[3].

The present study deals with the cloud point determination of pure Tween 80 in absence and in the presence of alkaline earth metal salts at various concentrations. The phase separation model was used to calculate thermodynamic parameters of clouding phenomenon.

Materials and Methods

The nonionic surfactant Polyoxyethylene (20) sorbitan monooleate [Tween 80 (Mol wt 1310)] was the product of SISCO Research Laboratories, India and used as received. Chlorides of alkaline earth metals like magnesium, calcium, strontium and barium of AnalaR grade supplied by BDH, EMercK and Loba Cheme were used as such. The solutions of various concentrations were prepared using double distilled water. The sample solution taken in a glass tube was placed in a beaker containing water and heated carefully. Cloud point was determined by noting the temperature at which a solution heated above the clouding temperature lost its turbidity on cooling.

Results and Discussion

The cloud point is a characteristic feature of every nonionic surfactant. The cloud point of polyoxyethylene based surfactant solution exhibits liquid-liquid phase separation by increasing the temperature. The temperature increase results in partial dehydration and finally causes separation of the surfactant rich phase.

The effect of alkaline earth metal salts on cloud point of Tween 80(1%) is shown in Figure-1.

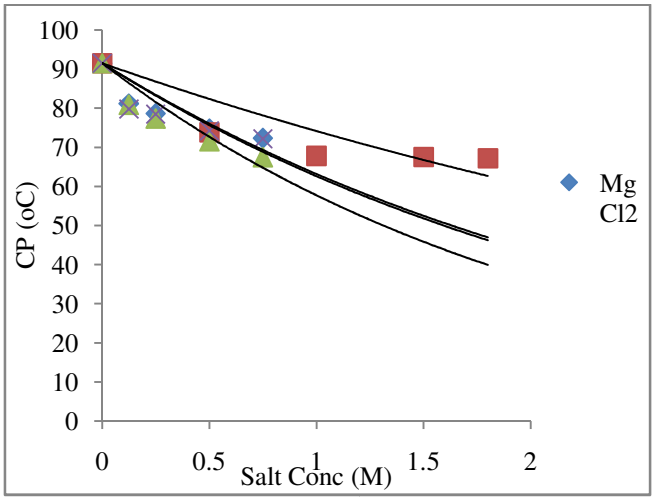

Figure-1
Effect of alkaline earth metal salts on CP of TW-80 (1%)

The cloud point of Tween 80(1%) was found to be 91.5^0C. Additive increase or decrease the cloud point of a nonionic surfactant. Generally electrolytes lower the cloud point[4-6] but iodide, thiocyanates and some nitrates increase it. This may be due to opposite effects on the heat of solution[7]. The decrease in cloud point is due to increase in aggregation number; hence the temperature of maximum solubilization is changed in the presence of electrolytes.

The variation of cloud point of Tween-80 (1%) at different alkaline earth metal salt concentrations has been shown in Table 1-4(A). It decreases in the presence of given alkaline earth metal salts. The effect of alkaline earth metal salts on the thermodynamic parameters of TW-80 has been indicated in Table 1-4 (B).

Table-1
A) Variation of cloud point of TW-80(1%) in presence of $MgCl_2$ and B) Effect of $MgCl_2$ on thermodynamic parameter of TW-80(1%)

(A)			(B)		
Salt conc.(M)	Mole Fraction x 10^{-3}	CP ^{0}C	$-\Delta H^0_{cl}$	ΔG^0_{cl}	$-\Delta S^0_{cl}$
0.125	2.245	81.2		17.96	296.5
0.250	4.479	78.6	87.1	15.81	292.6
0.500	8.919	74.8		13.65	289.5
0.750	13.320	72.3		12.40	288.0

Table-2
A) Variation of cloud point of TW-80(1%) in presence of $CaCl_2$ and B) Effect of $CaCl_2$ on thermodynamic parameter of TW-80(1%)

(A)			(B)		
Salt Conc.(M)	Mole Fraction x 10^{-3}	CP ^{0}C	$-\Delta H^0_{cl}$	ΔG^0_{cl}	$-\Delta S^0_{cl}$
0.500	8.919	73.8		13.61	241.8
1.000	17.682	67.8	70.3	11.43	239.7
1.500	26.290	67.5		10.30	236.6
1.800	31.383	67.2		9.79	235.3

Table-3
A) Variation of cloud point of TW-80(1%) in presence of $SrCl_2$ and B) Effect of $SrCl_2$ on thermodynamic parameter of TW-80(1%)

(A)			(B)		
Salt Conc.(M)	Mole Fraction x 10^{-3}	CP ^{0}C	$-\Delta H^0_{cl}$	ΔG^0_{cl}	$-\Delta S^0_{cl}$
0.125	2.245	80.8		17.94	210.4
0.250	4.479	77.3	56.5	15.75	206.2
0.500	8.919	71.5		13.52	203.2
0.750	13.320	67.4		12.22	201.9

Table-4
A) Variation of cloud point of TW-80(1%) in presence of $BaCl_2$ and B) Effect of $BaCl_2$ on thermodynamic parameter of TW-80(1%)

(A)			(B)		
Salt Conc.(M)	Mole Fraction x 10^{-3}	CP ^{0}C	- Δ H $^0_{cl}$	Δ G $^0_{cl}$	-Δ S $^0_{cl}$
0.125	2.245	79.8		17.89	317.7
0.250	4.479	78.5	94.2	15.80	312.9
0.500	8.919	74.2		13.62	310.5
0.750	13.320	72.2		12.39	308.7

(*ΔG^0_{cl}, ΔH^0_{cl} in KJ mole^{-1} and ΔS^0_{cl} in J mole^{-1}K^{-1})

The cloud point decrease depends on the solvation capacity of micelles by the aqueous medium in presence of additive. The cloud point becomes low at less solvation of Tween micelles. The cloud point decreases due to decrease in the hydration of Tween micelles[8]. Thermodynamics of non ionic surfactants is energetically controlled process. The cloud point is entropy dominated process[9]. Water molecule gets separated from micelle at the cloud point[10]. Cloud point is considered as phase separation point and the thermodynamic parameter such as standard free energy (ΔG^0cl), enthalpy (ΔH^0cl), and entropy (ΔS^0cl) for clouding process have been determined using phase separation model[11,12]. $\Delta H\ ^0$cl < ΔG^0cl indicating the process of clouding is exothermic and $\Delta H\ ^0$cl < ΔS^0cl shows that the process of clouding is guided by both enthalpy and entropy[12].

Conclusion

The cloud point of Tween 80 decreases with increase in molar concentration of chlorides of alkaline earth metal salts such as magnesium, calcium, strontium and barium indicating surfactant – additive interaction. Phase separation results at elevated temperature. The clouding phenomenon is guided by enthalpy and entropy.

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