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Study of Physiochemical Properties of Cetyltrimethylammonium Bromide (CTAB) Surfactant: its Micellization, Almond Oil Water Emulsification and Industrial Applications

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Abstract:- **This The present study was devoted to investigate the effect of addition of cetyltrimethylammonium bromide (CTAB) and lauryl alcohol (LA) on the formation of o/w microemulsions from almond- water system. Two techniques were used in this study, namely electrical conductivity and hydrodynamic viscosity, which revealed the enhanced micellization and solubilization of almond oil in water. This was indicated by the variations of critical micelle concentration, degree of micelle ionization, and thermodynamic parameters as a function of oil addition and temperature.**

Keywords:- *Surfactant; Microemulsions;Almond Oil; Lauryl Alcohol; Emulsification; CMC; CTAB; Electrical Conductivity.*

I. INTRODUCTION

Surfactants (surface active agents) are present in a large number of commercial products that are widely used in everyday life, for example, in detergents, cosmetics as well as in some types of antibiotics and herbicides. Furthermore, it has been well established that the presence of surfactants in the systems under study changes the physicochemical properties of the compounds with biological relevance. [1-2-7]

Surface active agents (usually referred to as surfactants) are Amphipathic molecule that consist of a non-polar hydrophobic portion, usually a straight or branched hydrocarbon or fluorocarbon chain containing 8–18 carbon atoms, which is attached to a polar or ionic portion (hydrophilic).[8-9] The hydrophilic portion can, therefore, be nonionic, ionic or zwitterionic, and accompanied by counter ions in the last two cases. The hydrocarbon chain interacts weakly with the water molecules in an aqueous environment, whereas the polar or ionic head group interacts strongly with water molecules via dipole or ion–dipole interactions. This strong interaction with the water molecules renders the surfactant soluble in water. However, the cooperative action of dispersion and hydrogen bonding between the water molecules tends to squeeze the hydrocarbon chain out of the water and hence these chains are referred to as hydrophobic. As we will see later, the balance between hydrophobic and hydrophilic parts of the molecule gives these systems their special properties, e.g. accumulation at various interfaces and association in solution (to form micelles). Surfactants find application in almost every chemical industry, including detergents, paints, dyestuffs, cosmetics, pharmaceuticals, agrochemicals, fibers, plastics. Moreover, surfactants play a major role in the oil industry, for example in enhanced and tertiary oil recovery. They are also occasionally used for environmental protection, e.g. in oil slick dispersants. Therefore, a fundamental understanding of the physical chemistry of surface-active agents, their unusual properties and their phase behavior is essential for most industrial chemists. [3-4-6]. In view of its amphiphilic nature and distinctive capability of lowering the interfacial tension, surfactant finds applications in almost every aspect of our daily life directly or otherwise in household detergents and personal care products, in industrial process as in pharmaceuticals, food processing, oil recovery and in nanotechnologies, etc. [5]. The CMC decreases sharply with the increase of the water hydrophobic part of the surface tension and is faster in the case of non-ion substances than in the ion surface [10]. The micellization Gibb's free energy of micellization, ΔG_m is computed by:

$$\Delta G_m = RT \ln CMC \qquad (1)$$

$\Delta \mathring{S}_m$ is equal to the slope obtained from the plot of ΔG_m vs T. ΔH_m is calculated using the relation: cation.[9]

$$\Delta Gm = \Delta H_m - T\,\Delta S_m \qquad (2)$$

II. INSTRUMENTS AND METHODS

A. The Required Instruments

- *Mixer, which used to mixing and blending the components*
- *Balance- Pipet-Stopwatch - Hot bath*

B. Method Of Experiment

Cetyltrimethylammonium bromide (CTAB) was purchased with a purity of 99.5 w/w%. Lauryl alcohol (LA) was obtained by Desulphonating of (CTAB). Almond oil was obtained from local market with a high purity.

A series of aqueous (CTAB) surfactant solutions (series A) in concentration range of $0.1x10^{-3}$,$0.5x10^{-3,}$ $1x10^{-3}$,$2x10^{-3}$,$5x10^{-3}$,$6x10^{-3}$,$8x10^{-3}$**,** $9x10^{-3}$,$10x10^{-3}$ was prepared by diluting 0.1 M (CTAB) stock solution with accurate portion of distilled water. A 0.2 - ml cosurfactant (LA) was added into each as-prepared CTAB surfactant solution of series A. The resulting mixtures were subjected to instant shaking for 15 minutes to attain equilibrium stabilization, followed by addition of different amounts of Almond oil (oil) at a varying weight percent ranging from 0.1672 - 1.672 %, with a instant shaking for 15 minutes, constituting a series B. The specific conductivity (K) of each solution of series A and B was measured using conductivity bridge (METRIC model) in temperature range of 22 – 60 oC. Values od CMC was obtained by plotting of K vs. surfactant concentration, where CMC corresponds to the point at which two lines intersect. However, the estimated value of degree of the micelle ionization (α) is obtained from the absolute ratio of two-line slopes and thermodynamic parameters of the micellization was calculated using equations (1) and (2). The relative viscosities (ɳr) at CMC of all solutions were measured using Ostwald viscometer. Origin Pro. version 6.1 was used for data presentation and line- regression fitting.

III. RESULTS AND DISCUSSION

Table (1) It gives the values of the critical micelle concentration of the surfactant (CTAB) at different temperatures and the myelin values before and after the change point, as well as the calculated values for the micelle ionization degree (**α**). As it becomes clear that the value of the (CMC) decreases with increasing the temperature, while the values of (**α**)change in a non-constant line with the increase in temperature. The decrease in the (CMC) with an increase in the temperature indicates that the increase in temperature leads to a decrease in the number of aggregation (N) which is the number of Surfactant molecules (CTAB) for each micelle aggregated in a state of dynamic equilibrium in the solution. Table (2) gives the values of the thermodynamic parameters for the mycelial formation of the surfactant (CTAB). Entropy of the standard micelle configuration for a surfactant L (CTAB) is equal to the enthalpy of the standard mushy form of a surfactant (CTAB) is $\Delta S^{\circ}_m = 251.51\ JK - 1$5426.44 J= ΔH°_m For every mole of servant The (CTAB) This indicates that the mycelial formation process in the surfactant (CTAB) Automatic thermodynamic operation. In this paper, the ability of surfactant. was studied (CTAB) in the solubility of bitter almond oil in the hydrophobic cavity of micelles formed in the absence and presence of a neutral auxiliary surfactant, lauryl alcohol (LA) at room temperature.

The results of the solubility of almond oil can be summarized by the action of the surfactant (CTAB) in Figure (1) and Table (3), which show the change in the values of (CMC) and (**α**) and the relative viscosity at the value of (CMC) η_r (cmc), when adding different percentages of bitter almond oil and the stability of the amount of auxiliary surfactant (LA) A continuous increase in the (CMC) of the (CTAB) surfactant can be observed with the added weight percentage of almond oil. This indicates without a doubt that the (CTAB) micelles surfactant formed in the solution works to dissolve and emulsify small oil droplets in its hydrophobic cavity.

This phenomenon is offset by an increase in the degree of micelleionization (**α**) with the added percentage of the oil with the appearance of a maximum value of (**α**) at about 2.44% of the oil. A decrease in the relative viscosity corresponding to the mycelial formation η_r (cmc) is observed, except at about 2.44% of the added oil, where there is a maximum value. Regardless of this maximum value in viscosity, this is consistent with the decrease in the (CMC) with the amount of oil added.

Table 1 Estimate Values of CMC and the Degree of Micelles I Onization (**A**) of the (CTAB) Surfactant at Different Temperatures with Other Statistical Parameters.

$T_C{}^{\circ}$	$CMC_K(M)$	R^2	SD	P	α
22	7.76 x10-3	0.922	0.0112	0.0001	1.5003
34	6.23 x10-3	0.924	0.0179	0.0090	2.0766
39	5.98 x10-3	0.917	0.0185	0.0103	1.8682
45	5.91 x10-3	0.918	0.0183	0.0101	1.9568
50	5.89 x10-3	0.915	0.0188	0.0106	1.9840
55	5.76 x10-3	0.921	0.0187	0.0096	2.1597
60	5.59 x10-3	0.923	0.0188	0.0091	1.9808

Table 2 Values of Critical Micelle Concentration (CMC) and Thermodynamic Functions of the (CTAB) Surfactant at Different Temperatures with Other Statistical Parameters in the Absence of LA and Sesame Oil.

T(K)	CMC_K	$lnCMC_K$	ΔG°m (J)	ΔS°m JK^-1	R2	SD	ΔH°m (J)
295	7.76x10-3	-4.858	- 11914.87	251.51	0.390	3045.2	5426.44
307	6.23x10-3	-5.078	-12961.077				
312	5.98x10-3	-5.119	-13278.522				
318	5.91x10-3	-5.131	-13565.604				
323	5.89x10-3	-5.134	-13786,956				
328	5.76x10-3	-5.156	-5879.394				
333	5.59x10-3	-5.186	-14357.762				

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Table 3- values of the critical micelle concentration (cmc), the degree of micelle ionization (α) and the relative viscosity of the (CTAB)

V_{oil}	**% Almond Oil**	**CMC_K**	**α**	**η_r(CMC)**
1ml	1.22	2.038x10-3	2.991	0.969
1.5ml	1.83	5.452x10-3	2.379	0.925
2ml	2.44	6.433x10-3	12.969	0.985
2.5ml	3.05	6.875x10-3	4.075	0.939
3ml	3.66	7.598x10-3	6.723	0.949

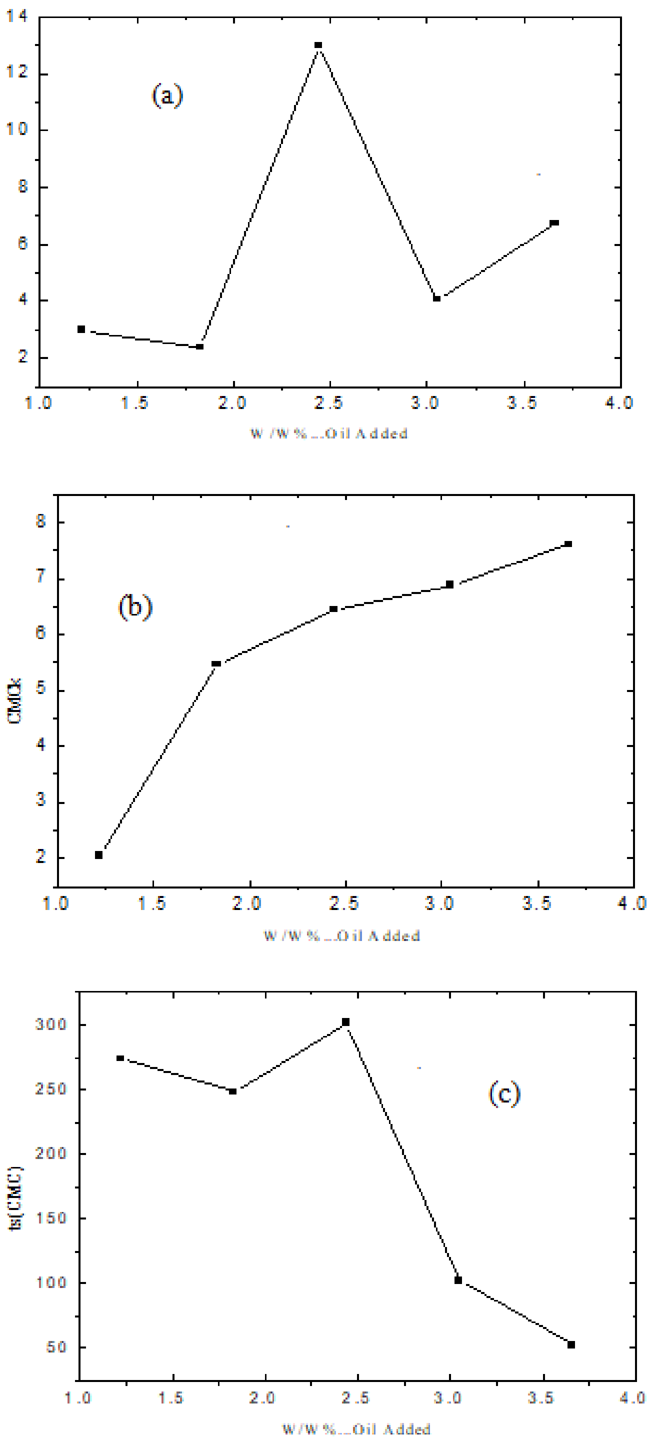

Fig 1 The critical micelles concentration (a), the degree of micelles ionization(**b**), and the relative viscosity η_r (c) as a function of the amount of oil added

IV. CONCLUSION

Surfactant is one of the molecules with wide applications in the field of industry, because it has two double parts in its structures: a hydrophilic (polar) part and a hydrophobic (non-polar) part.

They are used in the manufacture of detergents, cosmetics, food, etc., and this is possible due to the ability of this surfactant to dissolve and emulsify the oil phases in the aqueous medium. There are several thermodynamic and kinetic factors that affect the emulsification process depending on the type of application in which this surfactant is involved.

In this research project, a quantitative study was conducted to estimate the efficiency of the cationic surfactant cetyltrimethylammonium ammonium bromide (CTAB) in the dissolution and emulsification of bitter almond oil in the aqueous media in the presence of lauryl alcohol (LA) as a non-ionic auxiliary (neutral) as a solvent. In this study, two measurement techniques, electrical conductivity and relative viscosity, were used to track the critical micelle concentration. (CMC), degree of micelle ionization (**α**) and relative viscosity at critical micelle concentration(cmc) η_r by changing the temperature with respect to the pure surfactant as well as at different weight ratios for each of the oil and the auxiliary surfactant at room temperature. This research has found that the surfactant the cationic (CTAB) showed an acceptable efficiency in dissolving and emulsifying bitter almond oil in aqueous media in the presence of a reasonable amount of lauryl alcohol (LA).

Therefore, it is recommended to use this surfactant in the emulsification of oils that are used in the manufacture of cosmetics and skin care.

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