

**A STUDY ON THE ADSORPTION AND MICELLIZATION
BEHAVIOURS OF MIXED SURFACTANT SYSTEMS**

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ABSTRACT

The thesis entitled, "A Study on the Adsorption and Micellization Behaviours of Mixed Surfactant Systems" consists of six chapters.

In chapter 1, a general introduction to the present study along with the scope and objective of the work done has been given.

In chapter 2, the experimental techniques used in this study have been described.

In chapter 3, critical micelle concentration (cmc) of AOT + SDS mixed systems in water medium is presented. The cmc was determined from surface tension, conductance, emf and fluorescence emission measurements at 25 °C. Mixture of AOT and SDS shows synergism when mole fraction of AOT in the bulk (α_1) is ≤ 0.7 and ideality above 0.7. Composition of individual surfactants in the mixed micelle has been determined by using the Rubingh's and the Rodenas-Valiente-Villafraula (RVV) methods. Analysis of the dependence of the mole fraction of AOT in the mixed micelle (x_1) on the total surfactant concentration (c) revealed that x_1 becomes equal to α_1 , when $c \geq 0.1 \text{ mol kg}^{-1}$. The counter ion binding of the mixed system is controlled by that of AOT indicating that in the Stern layer of the mixed micelle heads of AOT are more exposed. The influence of dodecylsulfate ion on the aggregation number of AOT is less than that of dioctylsulfosuccinate ion on the aggregation number of SDS. Both adsorption layer and micellar phase are enriched with AOT. In the composition region where $0.1 \lesssim \alpha_1 \lesssim 0.7$, the free energy for micellization has almost constant values.

In chapter 4, cmc of AOT + SDS mixed systems in aqueous NaCl medium is presented, which was determined from surface tension measurements at 25 °C. In aqueous NaCl medium, the AOT + SDS system shows synergism in cmc. The synergism is however relatively much less in the region where $\alpha_{\text{AOT}} \geq 0.7$. Mole fractions of individual surfactants in the mixed micelle were determined by using the Rubingh's and RVV methods. The micellar composition calculated from both the methods has a complex type of dependence on the added NaCl concentration. The calculated interaction parameter indicates attractive interaction between the two components of the mixed micelle. Added NaCl is found to enhance the attractive interaction between AOT and SDS in the micellar phase. The mixed systems with $\alpha_{\text{AOT}} \geq 0.245$ show two counter ion binding constant values similar to that of AOT. The counter ion binding of the mixed system is controlled by that of AOT indicating that in the Stern layer of the mixed micelle heads of AOT are more exposed. The surface excess of the mixture (Γ_{cmc}) is found to be predominantly due to adsorption of AOT. Thus, in AOT + SDS mixed system, micellar phase and adsorbed layer are enriched with AOT and the counter ion binding behaviour is also controlled by AOT. The shape of AOT + SDS mixed micelle is expected to change from prolate to rod-type near 0.015 mol kg⁻¹ of NaCl similar to the case with pure AOT.

In chapter 5, cmc values of AOT + TX-100 mixed systems in water and aqueous NaCl media are presented. The cmc was determined from surface tension measurements at 25 °C. In water medium, emf and fluorescence emission (pyrene probe) measurements have also been used to determine the cmc. In both these

media AOT + TX-100 system exhibits synergism in cmc. In the mixed micelle, the mutual interaction between the two surfactants became less attractive in the presence of NaCl. In water, in the composition range of $0.3 \leq \alpha_{\text{AOT}} < 1$, the micellar phase is enriched with TX-100. Added NaCl increases the composition of AOT in the mixed micelle and also makes the interaction parameter less negative. The counter ion binding of AOT is suppressed to a great extent by the presence of nonionic TX-100 even at high mole fraction of the anionic AOT. It was observed that in the composition range $0.15 \leq \alpha_{\text{AOT}} \leq 0.936$, counter ion binding constant has value equal to 0.1 ± 0.04 . Only when $\alpha_{\text{AOT}} > 0.94$, the mixed system shows counter ion binding value (about 0.3) which is comparable to the lower value of pure AOT. The modified Corrin – Harkins equation is not strictly applicable to this mixed system. In water, the mixed adsorbed monolayer contains predominantly TX-100 and added NaCl is found to push more AOT to the air – water interface when $\alpha_{\text{AOT}} > 0.5$. Surface excess of the mixtures has negligible dependence on NaCl concentration. The interaction between the surfactants in the adsorbed layer is more repulsive than that in the micellar phase. On adding AOT to TX-100, the aggregation number of the mixed micelle does not seem to change till the mole fraction of AOT becomes 0.8. On the other hand, when TX-100 is added to AOT the aggregation number of the mixed micelle increases sharply and attains a maximum value at $\alpha_{\text{AOT}} \approx 0.9$. Surfactant concentration is found to have influence on aggregation number only in the region of $0.8 < \alpha_{\text{AOT}} < 1$.

In chapter 6, cmc of AOT + CTAB mixed systems in water + formamide (FA) medium is presented, which was determined from surface tension measurements. In 10% FA (w/w), fluorescence method (using pyrene probe) was also used to determine the cmc of the mixed systems. In addition, to ascertain the cmc values of pure CTAB in water + FA media conductance measurements were made. The cmc values of AOT + CTAB mixed systems in water + FA media are much less than the ideal cmc value indicating synergism to a large extent. Both β_m (interaction parameter in the mixed micellar phase) and β_a (interaction parameter in the adsorbed layer of mixed surfactants) have very large negative values showing strong attractive interaction in the mixed micelle and the adsorbed layer. The interactions between AOT and CTAB are of similar type both at air – water interface and micellar phase. The values of β_m and β_a become less negative with increasing weight % of FA in the medium indicating a decrease in the attractive interaction between AOT and CTAB and this is attributable to the increase in the dielectric constant of the solvent medium (with addition of FA dielectric constant of the medium increases). The solvophobicity of AOT and CTAB towards the water + FA solvent is dependent on the relative amounts of the two surfactants in the bulk medium thereby indicating that competitive solvophobicity operates in this mixed surfactant + mixed solvent system. Aggregation number of the mixture increases on adding AOT to CTAB and also by the addition of CTAB to AOT, which is similar to the trend reported for this system in water at 50 °C.

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SURFACTANT SYSTEMS**

By

OINAM GOBIN SINGH, M.Sc.

DEPARTMENT OF CHEMISTRY

SCHOOL OF PHYSICAL SCIENCES

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FOR THE DEGREE OF

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OF

NORTH-EASTERN HILL UNIVERSITY

SHILLONG-793022,

INDIA

2010

DEDICATED TO MY FAMILY



The North Eastern Hill University

Declaration

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I, Oinam Gobin Singh, hereby declare that the subject matter of the thesis is the record of work done by me, that the contents of this thesis did not form basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and that the thesis has not been submitted by me for any research degree in any other University / Institute.

This is being submitted to the North-Eastern Hill University for the award of degree of Doctor of Philosophy in Chemistry.



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OINAM GOBIN SINGH

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CHAPTER 1

General Introduction

1.1 Surfactants

Surface-active agents are in short known as surfactants. A surfactant molecule has two distinct parts, (i) non-polar portion which is a hydrophobic part and (ii) polar portion which is a hydrophilic part. The hydrophilic part is simply called head group and the hydrophobic part the tail. The presence of both hydrophobic and hydrophilic parts in a molecule renders a surfactant its amphiphilic behaviour. Surfactant molecules have strong tendency to accumulate or adsorb at the interface thereby changing the interfacial properties drastically. In addition to this, at a particular critical concentration known as the critical micelle concentration (cmc), surfactant molecules have tendency to self-aggregate or associate in solution. This is generally known as micellization process. These two properties, adsorption and aggregation, of surfactants enable them to be used in detergency, emulsion stabilization, drug-delivery, etc.

1.1.1 Classification

Surfactants can be either natural or synthetic. Naturally occurring surfactants are known as biosurfactants as they are found in biological systems. Phospholipids, fatty acids and bile salts are examples of biosurfactants. Synthetic surfactants are synthesized for specific application in domestic or industrial uses. They are main components in soaps and detergents. Depending on the nature of the charge on the head group, both natural and synthetic surfactants are further classified as:

i) Anionic surfactants- These surfactants when dissolved in polar solvents dissociate to give negatively charged head group and on micellization form

anionic micelles with positive counter ions. Some examples of anionic surfactants are $\text{CH}_3(\text{CH}_2)_{11}\text{SO}_4\text{Na}^+$ (sodium dodecyl sulfate; SDS) and $\text{RC}_6\text{H}_4\text{SO}_3\text{Na}^+$ (sodium alkyl benzene sulfonate).

ii) Cationic surfactants- In polar solvents cationic surfactants dissociate to give positively charged head group and negatively charged counter ions. They form cationic micelles on micellization. Some examples of cationic surfactants are $\text{CH}_3(\text{CH}_2)_{15}\text{N}^+(\text{CH}_3)_3\text{Br}^-$ (cetyltrimethylammonium bromide; CTAB) and $\text{C}_{16}\text{H}_{33}\text{C}_5\text{H}_4\text{N}^+\text{Cl}^-$ (cetylpyridinium chloride; CPC).

iii) Nonionic surfactants- Nonionic surfactants do not carry any electrical charge on the hydrophilic head group and their aggregates do not have surface charge and form nonionic micelles. Some examples of nonionic surfactants are polyoxyethylene (23) dodecanol (brij 35), polyoxyethylene (9-10) octyl phenol (Triton X-100) and polyoxyethylene (20) sorbitanmonooleate (Tween 80). The hydrophilic part in the nonionic surfactants is the oxyethylene portion of the molecule.

iv) Zwitterionic surfactants- Zwitterionic surfactants possess both anionic and cationic head groups and depending on the pH of the solution these surfactants can behave as anionic or cationic or neutral species. Some common zwitterionic¹ surfactants are N-alkyl and C-alkyl betaines, phosphatidyl amino alcohols and acids.

There are surfactant molecules containing two hydrophobic tails attached to one head group. Examples are sodium salt of dioctylsulfosuccinic acid (anionic surfactant) commonly known as Aerosol OT or AOT and

dioctadecyldimethylammonium chloride (cationic surfactant). Ionic surfactants with three hydrophobic chains are also known.²

Surfactant molecules with two head groups and two hydrocarbon chains have also been synthesized. Such surfactants are called gemini (or dimeric) surfactants if the spacer is present between the two head groups and bolaforms if the spacer present is between the hydrocarbon chains.³ Newer surfactants with special properties are being synthesized, for e.g., photo-sensitive surfactants.⁴⁻⁶

1.2 Gibbs Adsorption Isotherm

Equilibrium exists between surfactant molecules at the interface and those in the bulk solution. The change in surface Gibbs function, dG_s at constant temperature and pressure is given as

$$dG_s = \gamma d\sigma + \sum_i \mu_i dn_{i\sigma} \quad (1.1)$$

where γ is the surface tension, $d\sigma$ is the change in the area of the surface, μ_i is the chemical potential of the i^{th} component and $dn_{i\sigma}$ is the change in the amount of the i^{th} component at the interface. In the light of the thermodynamic principles and by using the same approach that is used for deriving Gibbs – Duhem equation, we obtain the relation

$$d\gamma = - \sum_i \Gamma_i d\mu_i \quad (1.2)$$

where $d\gamma$ is the change in the surface or interfacial tension of the solvent and $d\mu_i$ is the change in chemical potential of the i^{th} component. Γ_i is the surface excess of the i^{th} component and is defined as

$$\Gamma_i = \frac{n_{i\sigma}}{\sigma} \quad (1.3)$$

$n_{i\sigma}$ and Γ_i can be positive or negative. Equation (1.2) is known as the Gibbs adsorption isotherm. For a two- component system at constant temperature and pressure equation (1.2) reduces to

$$d\gamma = -\Gamma_1 d\mu_1 - \Gamma_2 d\mu_2 \quad (1.4)$$

Subscripts 1 and 2 refer to solvent and solute, respectively. The location of the dividing surface of the two bulk phases is arbitrarily chosen such that the surface excess concentration of the solvent, Γ_1 , becomes zero. This is, in fact, the most realistic position since we are considering a surface layer of adsorbed solute. Equation (1.4) now becomes

$$d\gamma = -\Gamma_2 d\mu_2 = -RT\Gamma_2 d\ln a_2 \quad (1.5)$$

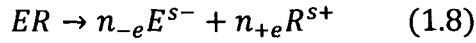
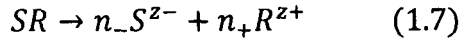
Where a_2 is the activity of solute, R is the gas constant and T is the temperature. For dilute solutions Γ_2 can be written as

$$\Gamma_2 = -\left(\frac{1}{RT}\right)\left(\frac{d\gamma}{d\ln c_2}\right) \quad (1.6)$$

where a_2 has been replaced by the concentration, c_2 . Equation (1.6) is the modified form of Gibbs adsorption isotherm for solute by presuming the solution to be ideal. Since Γ_2 is positive for surfactants, $d\gamma/d\ln c_2$ must be negative. Therefore, accumulation of surfactants on the surface or interface lowers the surface tension. In surfactant solutions the surface tension initially decreases with increasing surfactant concentration and then attains generally a constant value above a critical concentration. Due to the ability the surfactants to lower interfacial tension, they are used as emulsifiers, foaming agents, etc.

1.2.1 Gibbs Adsorption Isotherm for Ionic Surfactants

Gibbs adsorption isotherm given by equation (1.2) has been looked into in more detail in the case of ionic surfactants.⁷ We consider here an anionic surfactant SR in aqueous medium in the presence of an added electrolyte ER . The dissociations of SR and ER in the bulk solution are given by



S^{z-} is the surfactant anion having charge $z-$ and R^{z+} is the counter ion having charge $z+$. E^{s-} is an indifferent non-adsorbing co-ion and R^{s+} is the counter ion contributed by the added electrolyte, which is considered to be the same as the surfactant counter ion. n_- and n_+ are the number of moles of surfactant ion and counter ion produced by the dissociation of one mole of surfactant, respectively. Similarly, n_{-e} and n_{+e} are the number of moles of E^{s-} and R^{s+} produced by the dissociation of one mole of electrolyte, respectively. Since the counter ion R^{z+} is the same, the charges $z+ = s+$ and $n_- = n_{-e}$. Let c_R , c_S and c_E be the concentrations of the ionic species R^{z+} , S^{z-} and E^{s-} in the solution, respectively. The Gibbs adsorption isotherm given by equation (1.2) can now be written in the expanded form for the solution containing SR and ER as

$$d\gamma = -RT [\Gamma_R d\ln c_R + \Gamma_S d\ln c_S + \Gamma_E d\ln c_E] \quad (1.9)$$

where Γ_R , Γ_S and Γ_E are the surface excess of ionic species R^{z+} , S^{z-} and E^{s-} , respectively. If c and c_e are the bulk concentrations of surfactant and electrolyte, respectively, then the ion concentrations are related to the known bulk concentrations as

$$c = \frac{c_S}{n_-} \quad , \quad c_e = \frac{c_E}{n_{-e}} \quad (1.10)$$

If Γ and Γ_e are the surface excess of the surfactant and the electrolyte, then

$$\Gamma = \frac{\Gamma_S}{n_-} \quad , \quad \Gamma_e = \frac{\Gamma_E}{n_{-e}} \quad (1.11)$$

Electro-neutrality condition gives the following relations:

$$z_+ = \frac{n_- z_-}{n_+} \quad , \quad s_+ = z_+ = \frac{n_{-e} s_-}{n_{+e}} \quad (1.12)$$

$$c_R = n_+ c + n_{+e} c_e \quad (1.13)$$

$$z_+ c_R = s_- c_E + z_- c_S = s_- n_{-e} c_e + z_- n_- c = n_{+e} z_+ c_e + n_+ z_+ c \quad (1.14)$$

$$z_+ \Gamma_R = z_- \Gamma_S + s_- \Gamma_E \quad (1.15)$$

Substituting equations (1.10) - (1.15) into equation (1.9) and by considering the surface excess of co-ion, Γ_E , to be zero, we get after rearrangement

$$d\gamma = -RT\Gamma \, d\ln[c_S^{n_-} (n_+ c + n_{+e} c_e)^{n_+}] \quad (1.16)$$

For a symmetric univalent surfactant and added electrolyte, equation (1.16) takes the form

$$d\gamma = -RT\Gamma [d\ln(c + c_e) + d\ln c] \quad (1.17)$$

In the absence of an electrolyte, for surface excess of a symmetric univalent surfactant one gets from equation (1.17) an expression of the type

$$\Gamma = -\left(\frac{1}{2RT}\right) \left(\frac{d\gamma}{d\ln c}\right) \quad (1.18)$$

Equation (1.16) on differentiation and further rearrangement yields an expression for the surface excess of a surfactant in the presence of a particular concentration of an electrolyte, which is of the form

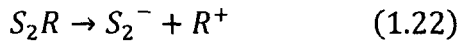
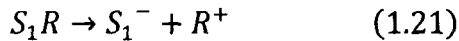
$$\Gamma = -\left(\frac{1}{RT}\right) \left(\frac{1}{n_- + \frac{n_+^2 c}{n_+ c + n_{+e} c_e}}\right) \left(\frac{d\gamma}{d\ln c}\right)_{c_e} \quad (1.19)$$

Thus, from the above expressions the amount of an ionic surfactant adsorbed at the air–water or air–solution interface can be quantitatively estimated. If both the ionic surfactant and the added electrolyte are 1:1 type, then $n_- = n_+ = n_{+e} = 1$ and equation (1.19) becomes

$$\Gamma = -\left(\frac{1}{RT}\right)\left(\frac{1}{1 + \frac{c}{c+c_e}}\right)\left(\frac{d\gamma}{d\ln c}\right)_{c_e} \quad (1.20)$$

1.2.2 Gibbs Adsorption Isotherm for Binary Mixture of Anionic Surfactants

We consider here two uni-univalent anionic surfactants S_1R and S_2R with same counter ion R^+ in presence of added electrolyte ER contributing the same counter ion. The dissociations of S_1R , S_2R and ER in the bulk solution can be expressed as



Let c_R , c_{S_1} , c_{S_2} and c_E be the concentrations of the ionic species R^+ , S_1^- , S_2^- and E^- in the solution, respectively. The Gibbs adsorption isotherm given by equation (1.2) can now be written in the expanded form for the solution containing S_1R , S_2R and ER as

$$d\gamma = -RT [\Gamma_R d\ln c_R + \Gamma_{S_1} d\ln c_{S_1} + \Gamma_{S_2} d\ln c_{S_2} + \Gamma_E d\ln c_E] \quad (1.24)$$

where Γ_R , Γ_{S_1} , Γ_{S_2} and Γ_E are the surface excess of ionic species R^+ , S_1^- , S_2^- and E^- , respectively. If c and c_e are the bulk concentrations of surfactant mixture and electrolyte, respectively, then the ion concentrations are related to the known bulk concentrations as

$$c_{S1} = \alpha_1 c \quad , \quad c_{S2} = \alpha_2 c \quad , \quad c_e = c_E \quad (1.25)$$

where α_1 and α_2 are the mole fractions of S_1R and S_2R in the bulk solution. If Γ is the surface excess of the mixed surfactant, then

$$\Gamma_{S1} = x_{1a}\Gamma \quad , \quad \Gamma_{S2} = x_{2a}\Gamma \quad (1.26)$$

where x_{1a} and x_{2a} are the compositions of S_1^- and S_2^- at the air-water interface

Electro-neutrality condition gives the following relations:

$$c_R = c_{S1} + c_{S2} + c_E = \alpha_1 c + \alpha_2 c + c_e = c + c_e \quad (1.27)$$

$$\Gamma_R = \Gamma_{S1} + \Gamma_{S2} + \Gamma_E \quad (1.28)$$

If we consider the surface excess of co-ion, Γ_E , to be zero, we get

$$\Gamma_R = \Gamma_{S1} + \Gamma_{S2} = x_{1a}\Gamma + x_{2a}\Gamma = \Gamma \quad (1.29)$$

Substituting equations (1.25) - (1.29) into equation (1.24), we get after rearrangement

$$d\gamma = -RT\Gamma [x_{1a}d\ln\alpha_1 + x_{2a}d\ln\alpha_2 + d\ln c + d\ln(c + c_e)] \quad (1.30)$$

For a mixed system of a particular composition (constants α_i), equation (1.30) takes the form

$$d\gamma = -RT\Gamma [d\ln(c + c_e) + d\ln c] \quad (1.31)$$

In the absence of an electrolyte, for surface excess one gets from equation (1.31) an expression of the type

$$\Gamma = -\left(\frac{1}{2RT}\right)\left(\frac{d\gamma}{d\ln c}\right) \quad (1.32)$$

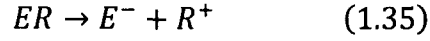
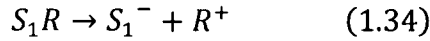
Equation (1.31) on differentiation and further rearrangement yields an expression, which is of the form

$$\Gamma = -\left(\frac{1}{RT}\right)\left(\frac{1}{1 + \frac{c}{c+c_e}}\right)\left(\frac{d\gamma}{d\ln c}\right)_{c_e} \quad (1.33)$$

Thus the expressions for surface excess of mixed ionic surfactants in the absence and presence of electrolyte (containing same counter ion) are the same as those for single ionic surfactants.

1.2.3 Gibbs Adsorption Isotherm for Binary Mixture of Anionic - Nonionic Surfactants

We consider here a uni-univalent anionic surfactant S_1R and a nonionic surfactant S_2 in presence of added electrolyte ER contributing the same counter ion R^+ . The dissociations of S_1R and ER in the bulk solution can be expressed as



But the nonionic surfactant S_2 remains as such in the bulk solution. Let c_R , c_{S_1} , c_{S_2} and c_E be the concentrations of the ionic species R^+ , S_1^- , S_2 and E^- in the solution, respectively. The Gibbs adsorption isotherm given by equation (1.2) can now be written in the expanded form for the solution containing S_1R , S_2 and ER as

$$d\gamma = -RT [\Gamma_R d\ln c_R + \Gamma_{S_1} d\ln c_{S_1} + \Gamma_{S_2} d\ln c_{S_2} + \Gamma_E d\ln c_E] \quad (1.36)$$

where Γ_R , Γ_{S_1} , Γ_{S_2} and Γ_E are the surface excess of species R^+ , S_1^- , S_2 and E^- , respectively. If c and c_e are the bulk concentrations of surfactant mixture and electrolyte, respectively, then

$$c_{S_1} = \alpha_1 c, \quad c_{S_2} = \alpha_2 c, \quad c_e = c_E \quad (1.37)$$

where α_1 and α_2 are the mole fractions of S_1R and S_2 in the bulk solution. If Γ is the surface excess of the mixed surfactant, then

$$\Gamma_{S1} = x_{1a}\Gamma \quad , \quad \Gamma_{S2} = x_{2a}\Gamma \quad (1.38)$$

where x_{1a} and x_{2a} are the compositions of S_1^- , and S_2 in the air-water interface

Electro-neutrality condition gives the following relations:

$$c_R = c_{S1} + c_E = \alpha_1 c + c_e \quad (1.39)$$

$$\Gamma_R = \Gamma_{S1} + \Gamma_E \quad (1.40)$$

If we consider the surface excess of co-ion, Γ_E , to be zero, we get

$$\Gamma_R = \Gamma_{S1} = x_{1a}\Gamma \quad (1.41)$$

Substituting equations (1.37) - (1.41) into equation (1.36), we get after rearrangement

$$d\gamma = -RT\Gamma[x_{1a}d\ln\alpha_1 + x_{2a}d\ln\alpha_2 + d\ln c + x_{1a}d\ln(\alpha_1 c + c_e)] \quad (1.42)$$

In the absence of an electrolyte, equation (1.42) becomes

$$d\gamma = -RT\Gamma[x_{1a}d\ln\alpha_1 + x_{2a}d\ln\alpha_2 + d\ln c + x_{1a}d\ln\alpha_1 + x_{1a}d\ln c] \quad (1.43)$$

For a mixed system of a particular composition (constants α_i) equation (1.43) takes the form

$$d\gamma = -RT\Gamma [1 + x_{1a}]d\ln c \quad (1.44)$$

And the surface excess expression is of the type

$$\Gamma = - \left[\frac{1}{(1 + x_{1a})RT} \right] \left(\frac{d\gamma}{d\ln c} \right) \quad (1.45)$$

Equation (1.42) on further rearrangement yields an expression, which is of the form

$$d\gamma = -RT\Gamma[x_{1a}d\ln\alpha_1 + x_{2a}d\ln\alpha_2 + d\ln\{c(\alpha_1 c + c_e)^{x_{1a}}\}] \quad (1.46)$$

On differentiation of equation (1.46) and then rearranging, equation (1.46) takes the form

$$d\gamma = -RT\Gamma \left[x_{1a} d\ln\alpha_1 + x_{2a} d\ln\alpha_2 + \left\{ 1 + \frac{\alpha_1 x_{1a} c}{\alpha_1 c + c_e} \right\} d\ln c \right] \quad (1.47)$$

For a mixed system of a particular composition (constants α_i) we get

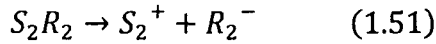
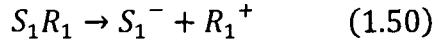
$$d\gamma = -RT\Gamma \left[1 + \frac{\alpha_1 x_{1a} c}{\alpha_1 c + c_e} \right] d\ln c \quad (1.48)$$

The expression for surface excess therefore becomes

$$\Gamma = - \left(\frac{1}{RT} \right) \left(\frac{1}{1 + \frac{\alpha_1 x_{1a} c}{\alpha_1 c + c_e}} \right) \left(\frac{d\gamma}{d\ln c} \right)_{c_e} \quad (1.49)$$

1.2.4 Gibbs Adsorption Isotherm for Binary Mixture of Anionic - Cationic Surfactants

We consider here a uni-univalent anionic surfactant S_1R_1 and a uni-univalent cationic surfactant S_2R_2 with counter ions R_1^+ and R_2^- respectively in the absence of added electrolyte. The dissociations of S_1R_1 and S_2R_2 in the bulk solution can be expressed as



Let c_{R_1} , c_{R_2} , c_{S_1} and c_{S_2} be the concentrations of the ionic species R_1^+ , R_2^- , S_1^- and S_2^+ in the solution, respectively. The Gibbs adsorption isotherm given by equation (1.2) can now be written in the expanded form for the solution containing S_1R_1 and S_2R_2 as

$$d\gamma = -RT[\Gamma_{R_1} d\ln c_{R_1} + \Gamma_{S_1} d\ln c_{S_1} + \Gamma_{S_2} d\ln c_{S_2} + \Gamma_{R_2} d\ln c_{R_2}] \quad (1.52)$$

where Γ_{R_1} , Γ_{R_2} , Γ_{S_1} , Γ_{S_2} are the surface excess of ionic species R_1^+ , R_2^- , S_1^- and S_2^+ , respectively. If c is the total or bulk concentration of surfactant mixture, then the ion concentrations are related to the known bulk concentration as

$$c_{S1} = \alpha_1 c \quad , \quad c_{S2} = \alpha_2 c \quad (1.53)$$

where α_1 and α_2 are the mole fractions of S_1R_1 and S_2R_2 in the bulk solution

If Γ is the surface excess of the mixed surfactant, then

$$\Gamma_{S1} = x_{1a}\Gamma \quad , \quad \Gamma_{S2} = x_{2a}\Gamma \quad (1.54)$$

where x_{1a} and x_{2a} are the compositions of S_1^- and S_2^+ in the air-water interface

Electro-neutrality condition gives the following relations:

$$c_{R1} + c_{S2} = c_{S1} + c_{R2} = \alpha_1 c + \alpha_2 c = c \quad (1.55)$$

$$\Gamma_{R1} = \Gamma_{S1} \quad , \quad \Gamma_{R2} = \Gamma_{S2} \quad , \quad \Gamma_{R1} + \Gamma_{R2} = \Gamma_{S1} + \Gamma_{S2} \quad (1.56)$$

Substituting equations (1.53) - (1.56) into equation (1.52), we get after rearrangement

$$d\gamma = -RT [2\Gamma d\ln c + \Gamma_{S1} d\ln \alpha_1 + \Gamma_{S2} d\ln \alpha_2 + \Gamma_{R1} d\ln \alpha_1 + \Gamma_{R2} d\ln \alpha_2] \quad (1.57)$$

For a mixed system of a particular composition, constants α_i , the surface excess equation becomes

$$\Gamma = - \left(\frac{1}{2RT} \right) \left(\frac{d\gamma}{d\ln c} \right) \quad (1.58)$$

1.3 Micelle Formation

The second important property of a surfactant is its ability to undergo aggregation. Aggregation of a surfactant in solution is commonly known as micellization and the aggregates are called micelles.⁸ Hydrophobic interaction is considered to be responsible for micellization of a surfactant. Water molecules become more ordered around the hydrocarbon tail of a surfactant. Transfer of hydrophobic tails of a surfactant from bulk water into micellar phase results in positive entropy change due to disordering of the ordered water molecules around the hydrocarbon tail. The entropy generated thus in the solvent medium drives the

micellization process. Micelles formed in polar solvents are called normal micelles, whereas those formed in non-polar solvents are called reverse micelles.

1.3.1 Thermodynamics of Micelle Formation

The two main approaches that are employed to understand the thermodynamics of the micellization process are (i) Phase - Separation Model and (ii) Mass - Action Model. In the phase - separation approach the micelles are considered to form a separate phase at the cmc in equilibrium with the solution phase, while in the mass - action approach micelles and unassociated monomers are considered to be in association - dissociation equilibrium. The two models merge asymptotically with increasing aggregation number. Besides these two approaches thermodynamics of small systems developed by Hill⁹ has also been applied to the aggregation of solutes. Application of mass-action law to small thermodynamic systems has been assessed by Blumenfeld et al.¹⁰ and by Sokirko.¹¹ The phase - separation and the mass - action models are briefly discussed below.

1.3.2 Phase – Separation Model

According to this model the micelle along with the bound counter ion is treated as a separate phase, although there are problems associated with the application of the phase rule to micellar phase. In order to calculate the thermodynamic parameters of micellization, appropriate standard states are to be defined first. The hypothetical standard state for the surfactant in the aqueous phase is taken to be the solvated monomer at unit mole fraction with the

properties of the infinitely dilute solution. For the surfactant in the micellar state, the micellar state itself is considered to be the standard state.^{12,13}

If μ_s and μ_m are the chemical potential of the unassociated surfactant in the aqueous phase and of the associated surfactant in the micellar phase, respectively, and since the two phases are in equilibrium at and above the cmc

$$\mu_s = \mu_m \quad (1.59)$$

For a non-ionized surfactant

$$\mu_s = \mu_s^o + RT \ln a_s \quad (1.60)$$

μ_s^o corresponds to the chemical potential at the standard state. It is assumed that the concentration of free monomers is low and this permits one to replace the activity, a_s , of surfactant monomers by its mole fraction, x_s . The above equation (1.60) is therefore written as

$$\mu_s = \mu_s^o + RT \ln x_s \quad (1.61)$$

Since micellar phase is treated as a separate hydrocarbon phase the mole fraction of the associated surfactant in this phase is equal to one and therefore

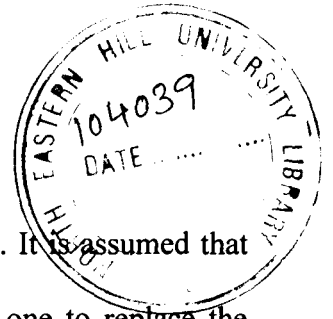
$$\mu_m = \mu_m^o \quad (1.62)$$

If ΔG_m^o is the standard free energy change for transfer of one mole of surfactant from solution to micellar phase, then

$$\Delta G_m^o = \mu_m^o - \mu_s^o = \mu_m - \mu_s + RT \ln x_s = RT \ln x_s \quad (1.63)$$

Assuming that the concentration of free surfactant in the presence of micelle is constant and equal to the critical micelle concentration, we get $x_s = x_{cmc}$. Equation (1.63) therefore becomes

$$\Delta G_m^o = RT \ln x_{cmc} \quad (1.64)$$



In the case of ionic surfactants, ΔG_m^o must also include the free energy change for the transfer of β moles of counter ion from its standard state in the solution phase to the micellar phase. β is the number of moles of counter ion per mole of the associated monomer in the micellar phase and is known as the counter ion binding constant. If one mole of micelle consist of n mole of surfactant and m moles of counter ion, $\beta = m/n$. n is generally know as aggregation number. It is also considered that the free counter ions present in the solution phase are in equilibrium with the counter ions bound to the micelle. For ionic surfactants we have,

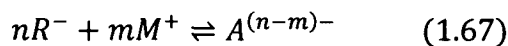
$$\Delta G_m^o = RT \ln x_{cmc} + \beta RT \ln x_M \quad (1.65)$$

where x_M is the mole fraction of counter ion in the solution. At the cmc when the micellar phase is just formed, in the absence of added electrolyte it can be approximated that $x_M = x_{cmc}$ and equation (1.65) becomes

$$\Delta G_m^o = (1 + \beta)RT \ln x_{cmc} \quad (1.66)$$

1.3.3 Mass – Action Model

According to this model, in the case of ionic surfactants, micelles are assumed to be in equilibrium with the surfactant monomer ions and counter ions. Further it is assumed that micelles are effectively monodispersed. The equilibrium is represented as



In the above equilibrium R^- , M^+ and $A^{(n-m)-}$ represent single detergent ion, counter ion and anionic micelle, respectively. Applying the mass-action law to the above equilibrium, the corresponding equilibrium constant, K , can be written as

$$K = \frac{a_A}{a_R^n a_M^m} \quad (1.68)$$

a_A , a_R and a_M are activities of the surfactant monomer, counter ion and micelle, respectively. The standard free energy of micellization per mole of surfactant monomer is given by

$$\Delta G_m^o = -\frac{RT}{n} \ln K \quad (1.69)$$

Substituting the value of K from equation (1.68), we get

$$\frac{\Delta G_m^o}{RT} = -\left(\frac{1}{n}\right) \ln a_A + \ln a_R + \left(\frac{m}{n}\right) \ln a_M \quad (1.70)$$

Equation (1.70) can be rearranged to the form

$$\ln a_R = \left[\frac{\Delta G_m^o}{RT} + \left(\frac{1}{n}\right) \ln a_A \right] - \left(\frac{m}{n}\right) \ln a_M \quad (1.71)$$

Near the cmc, which generally falls in the low concentration region for most of the ionic surfactants activity terms can be approximated to concentration terms and equation (1.71) becomes

$$\ln c_R = \left[\frac{\Delta G_m^o}{RT} + \left(\frac{1}{n}\right) \ln c_A \right] - \left(\frac{m}{n}\right) \ln c_M \quad (1.72)$$

Just above the cmc, we can approximate

$$c_R \approx c_o \text{ and } \frac{\Delta G_m^o}{RT} + \left(\frac{1}{n}\right) \ln c_A \approx \frac{\Delta G_m^o}{RT} \quad (1.73)$$

We have denoted above cmc by c_o . Equation (1.72) now becomes

$$\ln c_o = \frac{\Delta G_m^o}{RT} - \beta \ln c_M \quad (1.74)$$

In mole fraction units equation (1.74) can be written as

$$\ln x_{cmc} = A - \beta \ln x_M \quad (1.75)$$

where $\Delta G_m^o/RT$ is represented by A . Equation (1.75) is similar to equation (1.65). Equations (1.65), (1.74) and (1.75) are the different forms of the Corrin – Harkins equation.¹⁴

1.4 Mixed Micelle Formation

Solubilizes can incorporate into micelle of pure surfactant resulting in the formation of mixed micelle. Solubilization is closely related to mixed micelle formation and mixed micellization is, therefore, a special case of micellar solubilization. When surfactants are mixed, they form mixed micelles.

1.4.1 Clint Model

Mixed micelles can be either ideal or non-ideal. The Clint's equation¹⁵ for ideal mixed micelle is of the form,

$$\frac{1}{c_{0m}} = \sum_i \frac{\alpha_i}{c_{0i}} \quad (1.76)$$

For non-ideal mixed micelle the equation is,

$$\frac{1}{c_{0m}} = \sum_i \frac{\alpha_i}{f_i c_{0i}} \quad (1.77)$$

where, α_i and f_i denote the bulk mole fraction of the component 'i' and its activity coefficient in mixed micelle, respectively. c_{0i} and c_{0m} are the critical micelle concentrations of the component 'i' and the mixture, respectively.

1.4.2 Rubingh Model

In this model,^{16,17} the regular solution approximation is employed to describe the non-ideality of the mixed micelle. According to this approximation, the relation between the interaction parameter (β_m) responsible for non-ideality and the activity coefficient is given by

$$\beta_m = \frac{\ln f_1}{(1 - x_1)^2} = \frac{\ln f_2}{x_1^2} \quad (1.78)$$

$$f_i = \frac{\alpha_i c_{0m}}{x_i c_{0i}} \quad (1.79)$$

At c_{0m} , after substituting for the activity coefficients in Eq. (1.78), we get the expression,

$$x_1^2 \ln \frac{\alpha_1 c_{0m}}{x_1 c_{01}} = (1 - x_1)^2 \ln \frac{(1 - \alpha_1) c_{0m}}{(1 - x_1) c_{02}} \quad (1.80)$$

Values of x_1 can be computed from Eq. (1.80) by using an iterative method and the interaction parameter β_m can be determined using Eq. (1.78). Negative value of β_m indicates attractive interaction, positive value indicates repulsion and zero value indicates ideal micellization between the surfactants.

1.4.3 RVV Model

Rodenas¹⁸ proposed an approach to determine x_1 by using the Gibbs-Duhem relation and without resorting to the regular solution approximation. According to this model the equation for x_1 is of the form

$$x_1 = \alpha_1 - \alpha_1(1 - \alpha_1) d \ln c_{0m} / d\alpha_1 \quad (1.81)$$

The values of x_1 can be computed from Eq. (1.81) using the value of the slope, $d \ln c_{0m} / d\alpha_1$, determined by least-squares fitting the c_{0m} versus α_1 data.

Different other models have also been proposed for determining micellar composition and energetics of micellization of mixed surfactants.¹⁹⁻²¹

1.5 Micellization Parameters

Micellization of surfactants in solution always begins at a particular critical concentration known as the critical micelle concentration (cmc). When micelle is formed a sudden change in several physical properties of surfactant

solutions takes place enabling us to determine experimentally values of cmc of surfactants. Normally, changes in physical properties like surface tension, conductivity, viscosity, solubilization, osmotic pressure, etc, take place over a narrow concentration range. Therefore, a precise determination of the cmc is difficult and moreover values of cmc estimated from different experimental methods may also differ to a certain extent. Thus, numerous methods are available for determining the value of cmc.²² Tensiometry, conductometry and fluorimetry are the widely used methods. Although calorimetry is also one of the best methods to estimate cmc and energetics of micellization, the cost of the instrument is relatively much higher. Critical micelle concentration is one of the important properties of a surfactant by which its micellization behaviour is characterized. Cmc depends on the structure of surfactant and on the concentration of added electrolytes. More about the factors affecting cmc are discussed in a latter section.

Aggregation number is another important fundamental parameter concerning a micelle. It gives an idea about the size of a micelle. Similar to cmc, aggregation number also shows dependence on the structure of a surfactant and on the amount of added electrolyte.²³⁻³⁰ Marked changes in the aggregation number of surfactants indicate about changes in the micellar shape. Unlike cmc, aggregation number has dependence on the surfactant concentration.³¹⁻³⁴ In a particular surfactant solution micelles of different aggregation number can exist.³⁵ Such polydispersity is generally ignored for calculation purpose and only monodispersed micelles with single aggregation number are taken into account.

Aggregation number is determined using experimental techniques like quasi-elastic light scattering, small-angle neutron scattering, steady-state fluorescence quenching and time-resolved fluorescence quenching.^{23-25,29,30,32,36,37}

Other related micellization parameters are thermodynamic functions (Gibbs function, enthalpy and entropy) of micellization, counter ion binding constant of ionic surfactants and surface potential of ionic surfactants. Some other parameters/properties of surfactants that are related to their micellization are Kraft temperature, cloud point and solubilization.

1.6 Factors Affecting the CMC

As mentioned above cmc is an important property of a surfactant, which reflects on its micellization behaviour. As we have seen above cmc is related to different other micellization parameters like Gibbs function and counter ion binding. Cmc of a surfactant is affected by several factors. Cmc is dependent on the number of carbon atoms in the hydrocarbon chain of the surfactant. As the number of carbon atoms increases cmc decreases. The dependence of cmc on the number of carbon atoms beyond 16 is not very significant. Branching of the hydrocarbon chain also affects the cmc. Nature of hydrophilic group is another factor on which cmc shows strong dependence. There is a pronounced difference between the cmc's of ionic and nonionic surfactants with identical hydrophobic moieties indicating the influence of hydrophilic group on cmc. The lower cmc's of the nonionic surfactants are a consequence of the lack of electrical work necessary in forming the micelles. Nature of counter ion, its radius and valence, also largely affects the value of cmc of ionic surfactants.³⁸⁻⁴⁴ Cmc has interesting

temperature dependence.⁴⁵⁻⁵¹ Most of the ionic surfactants exhibit at some temperature a minimum in the cmc.^{45,46,52} This property of ionic surfactants is used in the differential scanning calorimetry technique for studying the micellization behaviour of ionic surfactants.⁵³ With increase in pressure cmc of ionic surfactants in water show a maximum.⁵⁴⁻⁶¹ Added electrolytes have significant effect on the cmc of both ionic and nonionic surfactants.^{38-44,62,63} The addition of electrolytes also affects other properties of surfactants like cloud point,⁶⁴⁻⁶⁶ free energy of micellization,⁶² aggregation number,²³⁻³⁰ etc. Non-electrolytes like urea, amides, alcohols, etc on addition produce both increase and decrease of cmc of surfactants.⁶⁷⁻⁶⁹

1.7 Structure and Shape of Micelles

Micelles are aggregates in dynamic equilibrium with the surfactant monomers in solution. Therefore considering them to be rigid with precise structures and shapes may be unrealistic. Hartley⁷⁰ conceived a spherical shape to micelles. Small-angle neutron scattering (SANS) experiments on micellar solutions,^{24,32,36,71,72} dynamic light scattering (DLS) experiments and phase diagram studies support the concept of micelles having regular shapes.^{23-25,32,73,74} It is assumed that micelles at concentrations closed to the critical micelle concentration are roughly spherical. The radius of a micelle cannot be greater than the stretched-out length of the surfactant molecule. Typically micelles may have average radii of 1.2 – 3 nm and can contain 20 – 100 monomers. Other proposed structures include the rod-like micelle of Debye,⁷⁵ the lamellar model of Philippoff⁷⁶ and the disk or cylindrical model of Harkins.⁷⁷ Added electrolyte has

great influence on the shape of ionic micelles. As the counter ion concentration is increased, the shape of ionic micelles changes in the sequence spherical – cylindrical – hexagonal – lamellar.^{23,24,74,78-80} Some of the shapes of micelles are shown in Fig. 1.1. Geometrical parameters like surface area of the head group, alkyl chain length, molecular volume of the hydrocarbon chain, etc. control the shapes adopted by micelles.²⁷

A general structure of a regular ionic micelle formed in polar solvents⁸¹ is shown in Fig. 1.2. An ionic micelle consists of a liquid core or interior, which is oil like, formed by the associated hydrocarbon chains. The charged head groups project out into the water phase. Similar structure of micelles exists in polar non-aqueous solvents also. In non-polar solvents the structure of micelle gets reversed. The region immediately surrounding the core is the Stern layer which contains the ionic head groups and a part of counter ions (bound counter ions). The Stern layer constitutes the inner part of the electrical double layer surrounding the micelle. The outer layer, which is a diffuse layer contains the remaining counter ions (free counter ions) and is known as Gouy-Chapman layer. The shear layer lies between the Stern and the diffuse layers. Appreciable amount of water has been reported^{82,83} to penetrate into the liquid-like hydrocarbon core.

1.8 Scope and Objective of the Present Work

In most practical applications, well-chosen mixtures of surfactants are found to perform better than single surfactants. For example, in household detergents, formulations containing mixtures of ionic and non-ionic surfactants have superior properties than those containing only ionic or only non-ionic

surfactants. Better performance by mixtures of surfactants in the various applied fields has emphasized the importance of undertaking physicochemical investigations on mixed surfactant systems. Mixed surfactants can exhibit either synergism or antagonism and it is important from both theoretical and practical points of view to investigate the adsorption and micellization behaviours of mixed surfactant systems. Binary mixed systems of cationic-cationic, anionic-anionic, cationic-anionic, cationic-nonionic, anionic-nonionic surfactants have been studied.^{1,84-88} However, limited study has been done on binary surfactant systems containing double-chained surfactant as one of the components.

Aggregation behaviour of mixed surfactant systems can be quantified by estimating parameters such as cmc, aggregation number, interaction parameter, counter ion binding constant at the micellar surface, surface potential at the micellar surface and thermodynamic functions (free energy, enthalpy and entropy) of micellization. Similarly, adsorption behaviour of mixed surfactant systems can be quantified by estimating parameters such as surface excess, surface area per adsorbed molecule, free energy of adsorption, adsorption coefficient, interaction parameter in the adsorbed layer, counter ion binding constant at air – water interface, surface potential at the air – water interface, etc. Both micellization and adsorption parameters of an ionic surfactant are known to be affected by the added electrolyte. Normally, the changes that occur in the values of micellization and adsorption parameters of an ionic surfactant due to the addition of electrolytes are attributed entirely to counter ion effect. Scattered works,⁸⁹⁻⁹³ however, indicate that co-ions of added electrolytes can also have influence on the

micellization and adsorption parameters of ionic surfactants depending on the nature and structure of co-ion and the surfactant. Studies on mixed surfactant systems have been carried out by many researchers.⁹⁴⁻¹⁰² But most of the works have been done in absence of added electrolyte and reported works on counter ion binding of mixed surfactant systems is scanty. Moreover, sodium dioctylsulfosuccinate (AOT) is a double-chained anionic surfactant having special properties¹⁰³⁻¹⁰⁹ and therefore binary mixtures of surfactants containing AOT as one of the components are also expected to have special properties. In view of these considerations, it is therefore, thought worthwhile to study the micellization and adsorption behaviours of AOT in mixed state in absence and presence of added NaCl. The second surfactant components taken up for investigation in this thesis are: sodium dodecylsulfate (SDS), Triton X-100 and cetyltrimethylammonium bromide (CTAB). Mixed system of AOT with CTAB is studied in mixed solvent of water + formamide. Surface tension, conductance, EMF and steady-state fluorescence quenching methods are used for determining some of the micellization and adsorption parameters. The experimental results are presented in chapters 3 - 6.

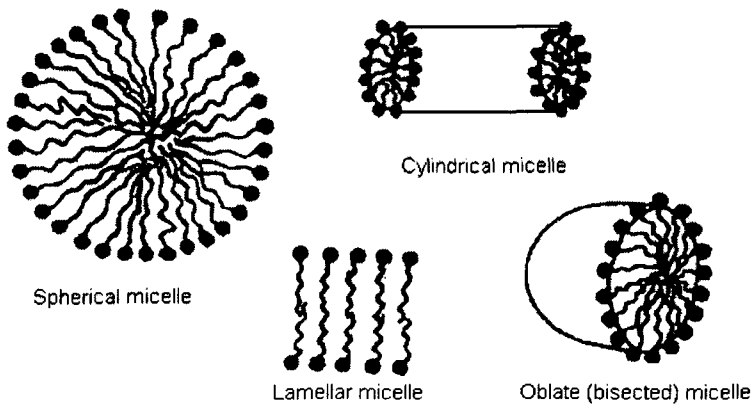


Figure 1.1 - Schematic representation of different shapes of micelles

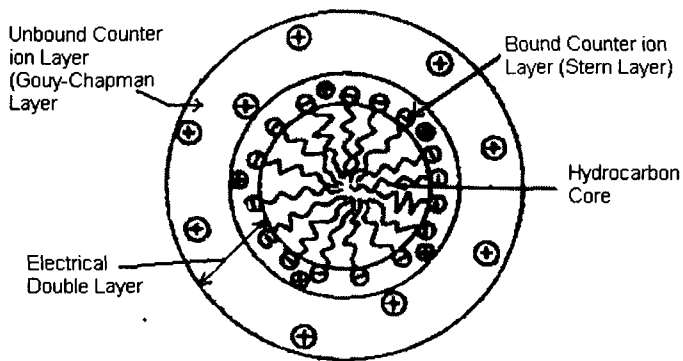


Figure 1.2 – The generalized micellar microstructure of spherical anionic micelle showing bound positive counter ions and the electrical double layer.

1.9 References

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CHAPTER 2

Experimental Techniques

2.1 Surface Tension Measurement

Surface tension of the experimental surfactant solutions was measured using a K11 Krüss Tensiometer. The surface tension of the test solution is determined with the help of an optimally wettable probe suspended from a precision balance. The probe is either a ring or a plate. We used here a plate known as Wilhelmy plate method. Using a height-adjustable sample carrier, the liquid or solution in the sample vessel is brought into contact with the plate. A force acts on the balance as soon as the plate touches the liquid surface. If the length of the plate is known, the force measured can be used to calculate the surface tension using the following relation

$$\gamma = \frac{F}{L \cos\theta} \quad (2.1)$$

where γ is the surface tension, F is the force acting on the balance, L is the wetted length of the plate and θ is the contact angle. The plate is made of roughened platinum and is optimally wetted so that the contact angle is virtually 0° such that $\cos\theta$ has a value of approximately 1. The K11 tensiometer is first calibrated using the prescribed method described in the instrument's manual. By calibrating the tensiometer actually the force measuring balance is calibrated. For calibration the supplied 1g weight is used which gives an equivalent surface tension of 243.95 mN m^{-1} according to equation (2.1) since the length of the plate, $L = 0.0402 \text{ m}$.

Before every use the plate is first rinsed with acetone to remove any organic material sticking to the plate and thereafter washed with double-distilled

water. Finally, the plate was heated to red hot with a Bunsen burner and then cooled.

The recommended sample vessel made up of Corning glass was used for holding the liquid or solution. This sample vessel is also cleaned thoroughly with acetone and water. The dry sample vessel is also flamed off with a Bunsen burner to make it free from any surface-active substance. The solution is taken in the cooled sample vessel up to the recommended height. The sample vessel containing the solution is then placed in the steel jacket of the tensiometer. The steel jacket is maintained at the required temperature using Haake DC 10 circulation bath. The supplied temperature sensor senses the temperature of the solution. The recommended immersion speed, search speed and immersion depth were selected. The entire operation of the tensiometer is controlled by the microprocessor. The instrument is attached to a PC and the surface tension values are displayed on the monitor screen. Ten surface tension values taken at an interval of 1 second and an average of these values were displayed on the screen. This particular tensiometer has a resolution of 0.01mN m^{-1} . The reproducibility of the measured surface tension values of the solutions was found to be within $\pm 1\text{ mN m}^{-1}$.

2.2 EMF Measurement

EMF of the test surfactant solutions were measured using Jenway 3345 Ion Meter and Jenway 924-329 combined ion-selective electrode reversible to sodium ion concentration in the solution. The principle of the Ion Meter is the same as that of a potentiometer. Before use, the Ion Meter was calibrated with a

standard solution of sodium chloride. This Ion Meter has a resolution of 0.1 mV and accuracy of ± 0.2 mV.

2.3 Electrical Conductance Measurement

All conductance measurements were made at 1 kHz using Wayne Kerr B905 Automatic Precision Bridge. This LCR meter has 0.01 nS resolution and measures conductance with an accuracy of 0.05%. It has an averaging facility and averages 2 ('Average' 1) to 128 ('Average' 9) measurements in a time span of about 670 ms to 36 s, respectively. We have used throughout the 'Average' 9 option. The bridge works basically on the principle of Ohm's law. Matching currents are passed through the standard resistor and the solution under test. The corresponding two voltages produced, whose values depend upon the impedances at the standard resistor and the test solution, are measured, resolved and computed to give the desired information on the display. All functions of the instrument are under the direct control of a microprocessor. A dip-type conductivity cell having platinized platinum electrodes was used. The cell constant was determined using standard KCl solution.

2.4 Fluorescence Quenching Method for Aggregation Number Measurement

Pyrene has been used as a fluorescence probe and cetylpyridinium chloride as a quencher. In a homogeneous solution the Stern – Volmer equation relates the fluorescence emission intensity to the quencher concentration. Stern – Volmer equation is written as

$$\frac{I_0}{I_q} = 1 + K_{sv}[Q] \quad (2.2)$$

I_0 and I_q are the intensities of fluorescence emission of pyrene in the absence and presence of the quencher, respectively. $[Q]$ is the quencher concentration and K_{sv} is called Stern – Volmer constant.

In a micellar solution, pyrene and the quencher reside in the micellar phase. For quenching to take place quencher molecule and the probe molecule must reside in the same micelle. Selecting Poisson statistics to describe the distribution of probe and quencher among the micelles and assuming that intramicellar quenching rate is much faster than the rate of intramicellar fluorescence decay of the probe, in a micellar solution equation (2.2) takes the form

$$\frac{I_0}{I_q} = \exp\left\{\frac{[Q]}{[Micelle]}\right\} \quad (2.3)$$

From equation (2.3) micelle concentration can be obtained. After obtaining micelle concentration, aggregation number, N_0 , is calculated using the relation

$$N_0 = \frac{C - C_0}{[micelle]} \quad (2.4)$$

Here, steady-state fluorescence quenching is considered. The instrument used for recording fluorescence emission spectra is Hitachi F4500 FL spectrophotometer. The temperature of the sample was controlled by circulating water of required temperature from the circulation bath.

2.5 Density Measurement

Density of solutions whenever required to convert molal to molar concentration was measured using Anton Paar DMA 5000 Density Meter. Mettler Toledo AG245 Electronic Balance was used for weighing.

CHAPTER 3

Micellization and adsorption behaviours of mixtures of sodium dioctylsulfosuccinate with sodium dodecylsulfate in water

3.1 Introduction

Compared to single surfactants, mixtures of surfactants perform better and hence formulations that are developed for different applications in various fields consist of mixed surfactants. Investigation of micellization properties of mixed surfactants has therefore got fundamental as well as industrial importance. For forming mixtures of surfactants different combinations of single surfactants are possible. Mixtures of dissimilar type of surfactants ordinarily exhibit considerable synergism. Mixtures of similar type of surfactants are also known to exhibit synergism and among them combinations of same type of ionic surfactants are studied relatively less than the mixtures of nonionic - nonionic surfactants.¹⁻⁹ Particularly, mixed systems containing double-chained and single-chained ionic surfactants have not been explored much.^{3,7-9} Sodium dioctylsulfosuccinate (AOT) is a widely used double-chained anionic surfactant, because it forms microemulsions without any cosurfactant. To the best of our knowledge, no report is available on the behaviour of mixtures of AOT with other anionic surfactants, although one report was found on mixtures of AOT with a cationic surfactant, cetyltrimethylammonium bromide.¹⁰ The objective of this work is therefore to study the micellization and adsorption properties of mixtures of AOT and sodium dodecylsulfate (SDS) in water by using the surface tension, emf, conductance and fluorescence emission methods.

3.2 Experimental Section

AOT (Sigma, 99% assay), SDS (Aldrich, 99% assay), pyrene (Fluka, 99% assay) and cetylpyridinium chloride (CPC; Fluka, 98% assay) were used as

received. All solutions were prepared in Millipore water and measurements were made under thermostated condition at 25 °C. Aqueous solution containing a mixture of AOT (surfactant 1) and SDS (surfactant 2) of a particular composition was prepared by mixing required amounts of the solutions of pure surfactants.

Surface tension measurements were made by the Wilhelmy plate method using Krüss K11 tensiometer. Conductance measurements were made using Wayne Kerr B905 Automatic Precision Bridge. EMF measurements were made using Jenway 3345 model Ionmeter and Jenway 924-329 combined ion-selective electrode reversible to sodium ion concentration in the solution. The fluorescence emission measurements of pyrene probe were made using Hitachi F4500 model Fluorescence Spectrophotometer. The excitation of pyrene was done at 335 nm and the fluorescence emission was recorded in the range of 360 – 420 nm. CPC was used for fluorescence quenching.

3.3 Results and Discussion

Experimental values of surface tension (γ) of AOT + SDS mixed systems are given in Table 3.1. Representative plots of surface tension versus mixed surfactant concentration are shown in Fig. 3.1. The SDS sample used in this study exhibited surface tension minimum and the depth of the minimum decreased with the addition of AOT. Occurrence of such a surface tension minimum for SDS and its disappearance on adding more of sodium ion have been discussed in a recent paper.¹¹ Experimental values of emf and I_3/I_1 as a function of mixed surfactant concentration are given in Tables 3.2 and 3.3, respectively. I_1 and I_3 denote the intensities of fluorescence emission of pyrene in the mixed surfactant system

corresponding to 373 and 384 nm, respectively. Representative plots of measured emf as a function of surfactant concentration are presented in Fig. 3.2. A few representative plots of I_3/I_1 ratio versus surfactant concentration are shown in Fig. 3.3.

It has generally been considered that cmc of AOT cannot be determined correctly from the plot of specific conductance versus concentration¹² unlike the case with other ionic surfactants. Molal conductance (Λ) of the surfactant solutions was therefore calculated from the specific conductance values. Molal conductance data are given in Table 3.4. A few representative plots of Λ versus square root of concentration are shown in Fig. 3.4. Surprisingly, such a plot for AOT exhibits a minimum followed by a maximum and the concentration at the minimum is found to correspond to the cmc of AOT. Thus, it is possible to determine accurately cmc of AOT from molal conductance data rather than from specific conductance data. By the addition of SDS to AOT the Λ minimum gradually disappears and no minimum occurs in the region where mole fraction of $\text{AOT} \leq 0.8$ (Fig. 3.4). This type of variation of Λ with concentration is generally not observed for ionic surfactants. Bile salts are the only other example where a similar trend has been reported.¹³⁻¹⁵ Although in bile salts occurrence of conductance minimum and maximum is ascribed to the presence of a dynamical equilibrium between transient structures like dimers and trimers,¹³⁻¹⁵ the species responsible for the type of molal conductance behaviour shown by AOT are not known at the moment.

3.3.1 Cmc of mixed surfactants

The values of cmc of the mixed surfactants (c_{0m}) determined from the various methods are shown in Fig. 3.5 (Table 3.5) as a plot of c_{0m} versus mole fraction of AOT in the bulk solution (α_1). Relation between c_{0m} and the cmc's of AOT (c_{01}) and SDS (c_{02}) is of the form^{16,17}

$$1/c_{0m} = \sum_i [\alpha_i / (f_i c_{0i})] \quad (3.1)$$

$$f_i = \alpha_i c_{0m} / (x_i c_{0i}) \quad (3.2)$$

In Eqs. (3.1) and (3.2) x_i and f_i refer to mole fraction and activity coefficient of AOT ($i = 1$) or SDS ($i = 2$) in the mixed micelle, respectively. When the mixed micelle is assumed to behave ideally ($f_i = 1$), Eq. (3.1) reduces to the Clint's equation.¹⁸ From Fig. 3.5 it is apparent that the experimental values of c_{0m} are less than the ideal values thereby indicating synergism for compositions less than 0.7 mole fraction of AOT. In the region of $0.7 \leq \alpha_1 \leq 1$, c_{0m} takes up ideal values.

3.3.2 Mixed micelle composition from Rubingh's method

In this method,^{16,17} the regular solution approximation is employed to describe the non-ideality of the mixed micelle. According to this approximation, the relation between the interaction parameter (β_m) responsible for non-ideality and the activity coefficient is given by

$$\beta_m = \ln f_1 / (1-x_1)^2 = \ln f_2 / x_1^2 \quad (3.3)$$

At c_{0m} , after substituting for the activity coefficients in Eq. (3.3), we get the expression

$$x_1^2 \ln[\alpha_1 c_{0m} / (x_1 c_{01})] = (1-x_1)^2 \ln[(1-\alpha_1) c_{0m} / \{(1-x_1) c_{02}\}] \quad (3.4)$$

Values of x_1 as a function of α_1 were computed from Eq. (3.4) by using an iterative method, which are shown in Fig. 3.6 (Table 3.6) as x_1^{Rb} . It is evident

from Eq. (3.2) that the value of x_i is controlled by the ratio c_{0m}/c_{0i} and therefore $x_1 > \alpha_1$ and $x_2 < \alpha_2$. An expression for x_1 was also derived from Eq. (3.2) under the condition of ideality and it is of the form

$$x_1 = \alpha_1 c_{02} / (\alpha_1 c_{02} + \alpha_2 c_{01}) \quad (3.5)$$

The values of x_1 calculated from Eq. (3.5) are also shown in Fig. 3.6 as x_1^{id} . From Fig. 3.6, it may be observed that (i) $x_1^{Rb} > x_1^{id}$ in the region where $\alpha_1 < 0.25$, (ii) $x_1^{Rb} < x_1^{id}$ in the region where $0.38 < \alpha_1 < 0.73$ and (iii) $x_1^{Rb} = x_1^{id}$ in the region where $\alpha_1 \geq 0.73$. To explain this type of trend in the values of x_1^{Rb} and x_1^{id} , the values of f_i 's were first calculated from Eq. (3.2) after substituting the values of x_1^{Rb} for x_1 . The values of f_i 's calculated in this way are presented in Fig. 3.6. Eq. (3.2) can now be written as $x_1^{Rb} = x_1^{id}/f_1$, which reveals that $x_1^{Rb} > x_1^{id}$ since $f_1 < 1$. This condition must be applicable in the region where $\alpha_1 < 0.25$. On the other hand, Eq. (3.2) can also be written as $x_1^{Rb} = 1 - \alpha_2 c_{0m}/(f_2 c_{02})$ and $x_1^{id} = 1 - \alpha_2 c_{0m}/c_{02}$, which reveals that $x_1^{Rb} < x_1^{id}$ since $f_2 < 1$. This condition must be applicable in the region where $0.38 < \alpha_1 < 0.73$. In the region where $\alpha_1 \geq 0.73$, $f_1 = f_2 = 1$ and hence $x_1^{Rb} = x_1^{id}$. Thus, the value of x_1^{Rb} is controlled by f_1 in the region where $\alpha_1 < 0.25$ and by f_2 in the region where $0.38 < \alpha_1 < 0.73$.

The values of the interaction parameter β_m were determined using Eq. (3.3) and are presented in Fig. 3.7. Negative values of β_m are indicative of attractive interaction between the two anionic surfactants. The magnitude of β_m becomes less negative with increasing mole fraction of AOT and finally reaches zero above 0.7 mole fraction of AOT (Fig. 3.7). Initial addition of a small amount

of AOT to SDS causes a sharp change in the interaction parameter and further addition of AOT weakens the interaction (Fig. 3.7).

It is worthwhile to compare the micellization behaviour of the AOT + SDS mixed system with that of other anionic – anionic mixed surfactant systems having SDS as one of the components and sodium as the only counter ion. In the case of STSa (sodium tetradecylsarcosinate) + SDS system¹⁹ the mixing was reported to be ideal. On the other hand, SDBS (sodium dodecyl benzene sulfonate) + SDS system was reported¹⁹ to show marginal antagonistic behaviour with cmc of the mixture having values slightly higher (maximum deviation = 3.5 %) than the ideal values (average $\beta_m = 0.66$). In STS (sodium tetradecylsulfate) + SDS system² synergism was found with cmc of the mixture having a maximum deviation of 8.5 % from the ideal value (average $\beta_m = -0.40$). In the AOT + SDS system, as mentioned above, synergism occurs only in the region where $\alpha_1 < 0.7$ with maximum deviation of 22.2 % from the ideal value.

3.3.3 Mixed micelle composition from RVV method

Rodenas et al.²⁰ proposed an alternative approach to determine x_1 by using the Gibbs-Duhem relation and without resorting to the regular solution approximation. According to this method the equation for x_1 is of the form

$$x_1 = \alpha_1 - \alpha_1(1 - \alpha_1)d\ln c_{0m}/d\alpha_1 \quad (3.6)$$

For computing the values of x_1 from Eq. (3.6), the value of the slope, $d\ln c_{0m}/d\alpha_1$, was determined first by least-squares fitting the c_{0m} versus α_1 data to an empirical relation of the form

$$\ln c_{0m} = \sum_j a_j \alpha_1^j, \quad j = 0 \text{ to } 5 \quad (3.7)$$

The least – squares fitted values of the empirical coefficients of Eq. (3.7) are $a_0 = -4.820$, $a_1 = -5.732$, $a_2 = 18.859$, $a_3 = -33.805$, $a_4 = 29.782$ and $a_5 = -10.231$. The values of x_1 calculated from Eq. (3.6) are presented in Fig. 3.6 as x_1^{Rd} . Deviation of x_1^{Rd} from x_1^{id} is found to be more than that of x_1^{Rb} (Fig. 3.6).

3.3.4 Dependence of mixed micelle composition on concentration of the mixed surfactants

It may be noted that the values of x_1 evaluated from Rubingh's and RVV methods are valid only at c_{0m} . The composition of the mixed micelle may be expected to vary with the total surfactant concentration (c). To obtain information about the dependence of x_1 on c , x_1 is written on the basis of its definition as²⁰

$$x_1 = (\alpha_1 c - c_1)/(c - c_1 - c_2) \quad (3.8)$$

In the region where $c \geq c_{0m}$ if we presume that the concentrations of the surfactants 1 (c_1) and 2 (c_2) in the bulk solution remain constant and are given by $c_i = \alpha_i c_{0m}$, then Eq. (3.8) reduces to the form $x_1 = \alpha_1$. However, since x_1 is found to be greater than α_1 (Fig. 3.6), it is implied that c_1 and c_2 do not remain constant above cmc and vary with c . Since above cmc also equilibrium exists between a surfactant in the free and mixed micellar forms, we get from the expressions for the chemical potential terms that $c_1 = x_1 f_1 c_{01}$ and $c_2 = x_2 f_2 c_{02}$. By substituting these values for c_1 and c_2 in Eq. (3.8), we obtain a quadratic equation²⁰ of the form

$$x_1^2 (c_{01} f_1 - c_{02} f_2) - x_1 (c + c_{01} f_1 - c_{02} f_2) + \alpha_1 c = 0 \quad (3.9)$$

Eq. (3.9) was solved for different values of c after substituting the values of f_1 and f_2 . While solving Eq. (3.9) for a chosen value of α_1 , f_1 and f_2 were presumed to be independent of c . The values of x_1 so obtained from Eq. (3.9) are shown as a

function of c in Fig. 3.8. From Fig. 3.8 it is apparent that x_1 approaches the value of α_1 at $c \geq 0.1 \text{ mol kg}^{-1}$. This can be explained on the basis of Eq. (3.9) itself because on rearrangement it takes the form

$$x_1 x_2 (c_0 f_2 - c_0 f_1) + \alpha_1 c - x_1 c = 0 \quad (3.10)$$

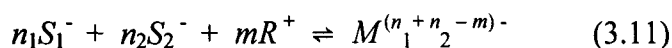
At high values of c , in the present case above 0.1 mol kg^{-1} , the first term of Eq. (3.10) becomes negligible making $x_1 = \alpha_1$.

3.3.5 Counter ion binding to mixed micelle

From the emf (E) data counter ion binding constant β_c was determined as described elsewhere²¹ and the calculated values of β_c (Table 3.5) are presented in Fig. 3.7. In the mixed micelle, it is interesting to note that β_c has a value that is characteristic of AOT²¹ even if the proportion of SDS is more in the mixed micelle (Fig. 3.7). This envisages that counter ion binding of the mixed micelle is controlled entirely by the AOT thereby indicating that in the Stern layer of the mixed micelle probably heads of AOT are more exposed than those of SDS.

3.3.6 Free energy of mixed micelle formation

For calculating the free energy of mixed micelle formation the same expression as that applicable in the case of single surfactant solution is commonly used.^{5,22,23} The expressions for the free energy of micelle formation in the cases of mixed and pure surfactants can be different. To show this, the following equilibrium is considered for a mixture of two anionic surfactants containing same counter ion (R^+):



In this equilibrium M refers to mixed ionic micelle and m is the number of counter ions that binds to a mixed micelle. n_1 and n_2 indicate the number of molecules of surfactants RS_1 and RS_2 , respectively that aggregate to form the mixed micelle. In the present system, the charges of S_1 , S_2 and R are equal to one. Based on thermodynamics, an expression for the standard free energy change (ΔG°) for the above equilibrium process can be written and rearranged to the form

$$x_1 \ln[S_1^-] + x_2 \ln[S_2^-] \approx [\Delta G^\circ / (N_o RT)] - \beta_c \ln[R^+] \quad (3.12)$$

where $N_o = n_1 + n_2$ is the aggregation number of the mixed surfactant system and $x_1 = n_1 / (n_1 + n_2)$. In writing Eq. (3.12), the value of $\ln[M]$ has been neglected in comparison to $\Delta G^\circ / (RT)$, which is an approximation made in the case of single surfactant solutions also. At the cmc of the mixed surfactant solution of a particular composition (α_1) and in the absence of added electrolyte, Eq. (3.12) can be written as

$$\Delta G_m^\circ = RT[(1 + \beta_c) \ln c_{0m} + x_1 \ln \alpha_1 + x_2 \ln \alpha_2] \quad (3.13)$$

Where ΔG_m° is the standard free energy of micellization of the mixed surfactants per monomer and is defined as $\Delta G_m^\circ = \Delta G^\circ / N_o$. Values of ΔG_m° calculated (Table 3.7) by using Eq. (3.13) are presented in Fig. 3.8. In the composition region where $0.1 \leq \alpha_1 \leq 0.7$, ΔG_m° is found to be almost constant, which implies that in this region β_c controls the value of ΔG_m° , because β_c is constant in this region.

3.3.7 Adsorption parameters

Using the Gibbs adsorption isotherm,²⁴ it can be shown for a mixture of 1:1 ionic surfactants having same counter ion that

$$d\gamma = - RTT(2d \ln c + x_{1a} d \ln \alpha_1 + x_{2a} d \ln \alpha_2) \quad (3.14)$$

where Γ is the surface excess of the mixed surfactant system. $x_{ia} = \Gamma_i / \Gamma$ is the mole fraction of AOT ($i = 1$) or SDS ($i = 2$) in the adsorbed layer. In the case of a mixed ionic surfactant system having a particular composition (constant α_1), Eq. (3.14) becomes $dy = -2RTT d \ln c$, which is the same equation used for calculating the surface excess of single surfactant.²⁴ Accordingly, surface excess at the cmc (Γ_{cmc}) and the minimum surface area per mole of the surfactant mixture (A_{min}) were calculated²⁴ (Table 3.8) and are shown in Fig. 3.9. By applying the Rubingh's approach to adsorption at a reference point of constant surface tension, Rosen and Hua²⁵ reported expressions for activity coefficient (f_{ia}), interaction parameter (β_a) and composition of the adsorbed layer (x_{ia}), which are of the form

$$f_{ia} = \alpha_{ia} c_{\gamma m} / (x_{ia} c_{i\gamma}) \quad (3.15)$$

$$\beta_a = \ln f_{1a} / (1 - x_{1a})^2 = \ln f_{2a} / x_{1a}^2 \quad (3.16)$$

$$x_{1a}^2 \ln [\alpha_1 c_{\gamma m} / (x_{1a} c_{1\gamma})] = (1 - x_{1a})^2 \ln \{ (1 - \alpha_1) c_{\gamma m} / [(1 - x_{1a}) c_{2\gamma}] \} \quad (3.17)$$

In Eq. (3.15) – (3.17), the subscript 'a' indicates that the activity coefficient (f), interaction parameter (β) and mole fraction (x) of a surfactant correspond to the adsorbed layer. $c_{\gamma m}$, $c_{1\gamma}$ and $c_{2\gamma}$ indicate the concentrations of surfactant mixture, surfactant 1 (AOT) and surfactant 2 (SDS) in the solution corresponding to the chosen value of constant surface tension (chosen below c_{0m} in the linear region of the plot of surface tension versus $\ln c$). Using Eqs. (3.15) – (3.17), values of f_{1a} , f_{2a} and x_{1a} were calculated (Table 3.8) and are shown in Fig. 3.9, while the calculated values of β_a are shown in Fig. 3.7. The ideal values of A_{min} calculated from the expression $A_{min}^{id} = x_{1a} A_{1min} + x_{2a} A_{2min}$ are also presented in Fig. 3.9. A_{1min} and A_{2min} represent the A_{min} values for surfactants 1 and 2, respectively. The values of

A_{min} are found to be almost equal to those of A_{min}^{id} . The values of β_a are negative (Fig. 3.7), which indicate an attractive interaction between the surfactant molecules adsorbed at the interface. The mole fraction of AOT at the adsorbed layer (x_{1a}) is more than the bulk mole fraction (α_1) indicating that the mixed adsorption layer is enriched with AOT and it is due to higher surface activity of AOT.

3.3.8 Aggregation number

Aggregation number (N_0) of the mixed surfactant system was determined by measuring fluorescence emission of pyrene in the absence and presence of the quencher CPC (Fig. 3.10) and using the reported²⁶ expressions,

$$\ln\left(\frac{I_0}{I_q}\right) = \frac{[q]}{[micelle]} \quad (3.18)$$

$$N_0 = \frac{(c - c_0)}{[micelle]} \quad (3.19)$$

Where I_0 and I_q are the intensities of fluorescence emission at 374 nm of pyrene in the absence and presence of the quencher (CPC) of concentration $[q]$, respectively. The experimental values of I_0/I_q are given in Table 3.9. The N_0 values determined thus are presented in Table 3.10 and Fig. 3.11. The number of molecules of AOT (n_{AOT}) and SDS (n_{SDS}) in the mixed micelle were estimated from the values of N_0 by using mole fraction values of the individual surfactants in the mixed micelle. N_0 increases by the initial addition of AOT to SDS and has a maximum at $\alpha_1 \approx 0.12$ (Fig. 3.11). In the mixed micelle, n_{SDS} decreases by adding AOT, while the change in n_{AOT} by the addition of SDS is not much (Fig. 3.11). Since we measured N_0 of mixed micelle by keeping the value of $c - c_{0m}$ constant

at $0.005 \pm 0.001 \text{ mol kg}^{-1}$, the observed trends in the variation of n_{AOT} and n_{SDS} with α_1 seem to indicate that the influence of dodecylsulfate ion on n_{AOT} is much less than that of dioctylsulfosuccinate ion on n_{SDS} .

3.4 Conclusions

Mixture of AOT and SDS shows synergism when mole fraction of AOT in the bulk (α_1) is ≤ 0.7 and ideality above 0.7. Cmc of AOT can be accurately determined from the molal conductance data instead of specific conductance data. Molal conductance versus concentration behaviour of AOT is different from that of other ionic surfactants, but is similar to that of bile salts. Composition of individual surfactants in the mixed micelle has been determined by using the Rubingh's and the Rodenas-Valiente-Villafruela (RVV) methods. Analysis of the dependence of the mole fraction of AOT in the mixed micelle (x_1) on the total surfactant concentration (c) reveals that x_1 becomes equal to α_1 , when $c \geq 0.1 \text{ mol kg}^{-1}$. The counter ion binding of the mixed system is controlled by that of AOT indicating that in the Stern layer of the mixed micelle heads of AOT are more exposed. The influence of dodecylsulfate ion on the aggregation number of AOT is less than that of dioctylsulfosuccinate ion on the aggregation number of SDS. Both adsorption layer and micellar phase are enriched with AOT. In the composition region where $0.1 \lesssim \alpha_1 \lesssim 0.7$, the free energy has almost constant values.

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Table 3.1 - Surface Tension (γ) Values of AOT + SDS Systems in Water at 298K

$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
$\alpha_{\text{AOT}} = 0$					
2.0375	55.4	5.5615	38.1	8.4799	37.6
2.2988	53.6	5.8024	37.4	8.5925	37.8
2.5586	51.6	6.0421	36.7	8.8168	38.2
2.8169	49.8	6.2806	35.9	9.0398	38.6
3.0736	48.2	6.5175	35.4	9.2617	38.5
3.3289	47.0	6.7532	34.9	9.4824	38.5
3.5827	45.9	6.9876	34.5	9.7017	38.5
3.8350	45.2	7.2207	34.1	9.9202	38.6
4.0859	43.9	7.4525	33.9	10.137	38.6
4.3354	42.7	7.6830	33.5	10.353	38.6
4.5834	41.5	7.9122	33.4	10.568	38.6
4.8300	40.5	8.1403	35.0	10.782	38.5
5.0752	39.7	8.2537	35.9	10.994	38.6
5.3190	38.7	8.3670	36.5		
$\alpha_{\text{AOT}} = 0.091$					
0.2051	59.7	3.7279	35.7	9.7600	34.5
0.3738	56.6	4.3449	33.6	10.412	34.6
0.5404	54.0	4.9289	32.9	11.014	34.5
0.8671	50.3	5.4825	32.8	11.572	34.5
1.2639	47.0	6.5074	33.3	12.336	34.6
1.6485	44.6	7.4357	33.5	13.024	34.5
2.3831	40.9	8.2802	34.1	13.646	34.5
3.0751	37.9	9.0521	34.3	14.213	34.5
$\alpha_{\text{AOT}} = 0.117$					
0.0043	70.8	0.6762	52.8	6.5098	33.0
0.0087	70.2	0.8398	50.3	7.4401	33.4
0.0130	69.7	1.2397	47.0	8.2859	33.7
0.0173	69.8	1.6271	44.5	9.0582	33.9
0.0433	67.8	2.3668	40.6	9.7663	34.1
0.0865	65.7	3.0630	37.2	10.418	34.0
0.1295	63.5	3.7195	34.8	11.019	34.1

Table 3.1 - Continued

$c \times 10^3 /$ mol kg^{-1}	$\gamma /$ mN m^{-1}	$c \times 10^3 /$ mol kg^{-1}	$\gamma /$ mN m^{-1}	$c \times 10^3 /$ mol kg^{-1}	$\gamma /$ mN m^{-1}
$\alpha_{\text{AOT}} = 0.117$					
0.1724	62.1	4.3395	33.3	11.839	34.0
0.2578	59.2	4.9261	32.8	12.574	34.1
0.3425	57.8	5.4818	33.1		
0.5104	55.1	6.0090	33.2		
$\alpha_{\text{AOT}} = 0.245$					
0.0040	66.8	0.2396	52.8	2.8478	34.2
0.0081	66.2	0.3184	51.2	3.4583	32.2
0.0121	65.0	0.4745	49.0	4.0349	31.8
0.0161	63.9	0.6286	46.9	4.5803	32.1
0.0403	61.0	0.7807	45.6	5.0971	31.9
0.0804	57.7	1.1525	42.4	6.0533	31.9
0.1204	56.3	1.5127	41.0	6.9186	32.0
0.1603	54.8	2.2005	36.9	7.7053	32.0
$\alpha_{\text{AOT}} = 0.389$					
0.0038	71.3	0.3009	54.3	3.8134	31.8
0.0076	70.8	0.4484	50.7	4.3289	31.4
0.0114	70.0	0.5940	48.6	4.8175	31.2
0.0152	69.1	0.7378	46.5	5.2809	31.4
0.0381	66.9	1.0892	43.0	6.1403	31.4
0.0760	63.7	1.4296	40.5	6.9199	31.3
0.1138	61.3	2.0796	36.7	7.6303	31.4
0.1515	59.3	2.6914	34.0		
0.2264	56.3	3.2684	32.2		
$\alpha_{\text{AOT}} = 0.494$					
0.0036	70.6	0.1448	57.1	2.5736	33.4
0.0073	69.4	0.2165	54.5	3.1253	31.8
0.0109	68.4	0.2878	52.0	3.6464	30.9
0.0146	67.9	0.4288	49.3	4.1394	31.1
0.0182	67.0	0.7055	45.5	4.6065	31.0
0.0218	66.5	1.0415	41.9	5.4708	31.0
0.0364	64.5	1.3670	39.5	6.2530	31.1

Table 3.1 - Continued

$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
$\alpha_{AOT} = 0.494$					
0.0727	60.8	1.6825	37.2	6.9642	31.0
0.1088	59.1	1.9885	35.6		
$\alpha_{AOT} = 0.564$					
0.0003	71.6	0.0311	62.2	1.9164	35.8
0.0007	71.3	0.0621	59.2	2.4727	32.9
0.0021	70.6	0.0966	56.6	2.9977	31.7
0.0035	70.1	0.1651	52.9	3.4938	31.2
0.007	68.1	0.3007	49.5	3.9634	31.0
0.0104	66.9	0.4346	47.2	4.8310	30.7
0.0139	65.5	0.6973	43.7	5.6149	30.6
0.0208	63.7	1.0164	40.7	6.6582	30.7
0.0276	62.2	1.3257	39.1	7.5694	30.4
$\alpha_{AOT} = 0.652$					
0.0034	65.4	0.3315	46.3	3.3723	30.9
0.0067	63.5	0.4610	45.0	3.8283	30.5
0.0101	62.2	0.5889	43.0	4.2605	30.5
0.0135	61.5	0.7152	41.8	4.6707	30.3
0.0336	58.3	0.8399	40.7	5.0603	30.5
0.0672	55.3	0.9629	39.6	5.4311	30.5
0.1006	53.3	1.2640	38.1	6.1210	30.4
0.1339	52.2	1.8387	34.5	6.7498	30.5
0.2002	49.6	2.3799	32.3		
0.2660	48.3	2.8901	31.1		
$\alpha_{AOT} = 0.730$					
0.0033	69.4	0.2616	50.4	2.8409	31.1
0.0066	67.7	0.3898	47.7	3.3146	30.6
0.0099	66.5	0.5163	45.7	3.7628	30.6
0.0132	66.2	0.6413	44.1	4.1875	30.5
0.0331	61.9	0.9467	41.0	4.5904	30.3
0.0660	59.3	1.2426	38.3	4.9732	30.2
0.0989	56.6	1.5294	36.5	5.6843	30.0

Table 3.1 - Continued

$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
$\alpha_{AOT} = 0.730$					
0.1316	55.5	1.8075	34.8	6.3310	30.0
0.1968	52.2	2.3394	32.4	6.9215	29.7
$\alpha_{AOT} = 0.888$					
0.0003	70.7	0.0275	59.5	1.6897	34.0
0.0006	70.0	0.0305	58.2	2.1803	31.5
0.0009	69.8	0.0549	55.9	2.6431	30.7
0.0012	69.3	0.0852	54.2	3.0805	30.4
0.0031	67.0	0.1456	50.7	3.4945	29.9
0.0062	65.1	0.2652	47.2	3.8870	30.1
0.0092	63.9	0.4998	43.2	4.6136	29.7
0.0123	62.6	0.6149	42.0	5.2717	29.6
0.0184	61.0	0.8962	39.2	5.8704	29.3
0.0244	59.9	1.1689	36.9		
$\alpha_{AOT} = 1$					
0.2916	46.6	1.8590	33.0	3.1693	30.0
0.5739	42.0	2.0934	32.0	3.3671	30.0
0.8472	39.3	2.3211	31.1	3.5597	29.9
1.1120	37.5	2.5422	30.7	3.7471	29.8
1.3686	35.8	2.7571	30.5	4.1076	29.7
1.6176	34.4	2.9661	30.0	4.4502	29.6

Table 3.2 - EMF Values of AOT+ SDS Systems in Water at 298 K

$c \times 10^3 /$ mol kg^{-1}	EMF / mV	$c \times 10^3 /$ mol kg^{-1}	EMF / mV	$c \times 10^3 /$ mol kg^{-1}	EMF / mV
$\alpha_{\text{AOT}} = 0$					
0.5528	-44.0	5.0837	1.10	11.001	12.3
1.0843	-30.0	5.8173	3.80	11.801	12.7
1.5957	-22.5	6.5058	5.60	12.702	13.1
2.0882	-17.1	7.1530	7.60	13.509	13.6
2.5629	-13.1	7.7628	8.90	14.235	14.0
3.2432	-8.30	8.6141	10.8	14.894	14.4
3.8885	-4.60	9.3972	11.5		
4.5012	-1.80	10.120	11.9		
$\alpha_{\text{AOT}} = 0.117$					
0.5216	-44.6	4.0582	-0.20	7.3255	10.3
1.0232	-30.3	4.4338	1.90	7.8686	11.3
1.5058	-22.0	4.7973	3.30	8.6282	12.4
1.9706	-16.1	5.1491	5.30	9.3285	12.9
2.4185	-11.5	5.4896	6.40	9.9763	14.0
2.8504	-8.00	5.8194	7.20	10.954	14.8
3.2671	-5.00	6.1392	8.10	11.818	15.5
3.6694	-2.60	6.7501	9.20	12.601	16.3
$\alpha_{\text{AOT}} = 0.253$					
0.4894	-54.9	4.1595	-1.90	8.3190	8.60
0.9599	-38.3	4.5004	-0.20	9.1614	9.60
1.4127	-28.5	4.8304	1.10	9.9227	10.3
1.8487	-21.9	5.1498	2.50	10.777	11.1
2.2688	-15.9	5.4593	3.40	11.539	12.0
2.6739	-12.3	5.7593	4.40	12.224	12.8
3.0649	-8.60	6.3323	5.50	12.842	13.2
3.4423	-6.20	6.8723	6.80	13.403	13.6
3.8070	-3.80	7.6257	7.90		
$\alpha_{\text{AOT}} = 0.397$					
0.4594	-58.4	3.5741	-4.30	6.4519	4.80
0.9012	-40.8	3.9051	-2.10	6.9301	5.50
1.3263	-30.8	4.2252	-0.80	7.3823	6.60
1.7356	-23.8	4.5349	0.40	7.8102	7.80

Table 3.2 - Continued

$c \times 10^3 /$ mol kg ⁻¹	EMF / mV	$cx 10^3 /$ mol kg ⁻¹	EMF / mV	$c \times 10^3 /$ mol kg ⁻¹	EMF / mV
$\alpha_{AOT} = 0.397$					
2.1301	-17.9	4.8349	1.50	8.4110	8.50
2.5104	-13.4	5.1254	2.10	8.9673	8.90
2.8775	-10.3	5.4070	2.80	9.6478	9.80
3.2318	-7.70	5.9451	3.90		
$\alpha_{AOT} = 0.486$					
0.4426	-55.4	3.7622	-4.10	7.5244	5.80
0.8682	-39.0	4.0706	-2.90	8.2865	6.60
1.2777	-29.4	4.3691	-1.30	8.9749	7.50
1.6721	-23.4	4.6580	-0.40	9.7477	8.30
2.0521	-18.4	4.9379	0.70	10.437	8.80
2.4186	-14.3	5.2092	1.50	11.056	9.10
2.7722	-10.9	5.7276	2.60	11.615	9.50
3.1136	-8.20	6.2158	3.90		
3.4434	-6.10	6.8975	5.30		
$\alpha_{AOT} = 0.611$					
0.4212	-60.5	3.2764	-6.90	5.9144	2.80
0.8261	-42.8	3.5797	-4.90	6.5630	4.10
1.2158	-32.8	3.8732	-3.10	7.1595	4.80
1.5910	-25.9	4.1571	-2.00	7.8846	5.80
1.9526	-20.1	4.4321	-0.90	8.5396	6.40
2.3013	-15.9	4.6984	-0.10	9.2749	7.20
2.6377	-12.2	4.9566	0.80	9.9309	7.80
2.9626	-9.50	5.4498	1.80	10.520	8.40
$\alpha_{AOT} = 0.690$					
0.4085	-57.9	3.4722	-6.70	6.9443	3.90
0.8013	-41.6	3.7567	-5.00	7.6475	4.80
1.1792	-31.7	4.0322	-3.80	8.2830	5.40
1.5432	-25.4	4.2988	-2.80	8.9960	6.30
1.8939	-20.8	4.5572	-1.60	9.6325	6.90
2.2321	-16.6	4.8076	-0.60	10.204	7.30
2.5584	-13.1	5.2859	0.60	10.720	7.80

Table 3.2 - Continued

$c \times 10^3 /$ mol kg ⁻¹	EMF / mV	$c \times 10^3 /$ mol kg ⁻¹	EMF / mV	$c \times 10^3 /$ mol kg ⁻¹	EMF / mV
$\alpha_{AOT} = 0.690$					
2.8735	-10.6	5.7367	1.70		
3.1779	-7.90	6.3656	2.60		
$\alpha_{AOT} = 0.767$					
0.3970	-57.8	3.3740	-5.90	6.7481	4.10
0.7786	-41.1	3.6506	-4.90	7.4316	5.40
1.1459	-32.2	3.9183	-3.20	8.0490	5.90
1.4996	-26.0	4.1774	-2.30	8.7420	6.90
1.8404	-20.4	4.4284	-1.10	9.3603	7.50
2.1691	-16.4	4.6718	-0.40	9.9156	7.90
2.4862	-12.9	5.1367	0.80	10.417	8.40
2.7924	-10.1	5.5746	1.80	10.872	9.10
3.0882	-7.90	6.1859	3.10		
$\alpha_{AOT} = 0.862$					
0.3836	-69.0	3.2604	-10.2	6.5208	2.40
0.7524	-50.0	3.5276	-8.60	7.1811	3.60
1.1073	-38.9	3.7863	-7.30	7.7779	4.80
1.4491	-30.9	4.0366	-5.80	8.4473	5.80
1.7784	-24.7	4.2793	-4.60	9.0450	6.50
2.0959	-20.9	4.5144	-3.30	9.5814	7.10
2.4024	-16.9	4.9635	-1.50	10.066	7.60
2.6982	-14.0	5.3867	-0.30		
2.9841	-12.3	5.9774	0.90		
$\alpha_{AOT} = 1$					
0.2756	-74.5	2.6411	-16.3	5.6980	-3.30
0.5431	-56.4	2.8446	-14.6	6.2160	-2.00
0.8030	-46.5	3.1080	-13.1	6.8454	-0.80
1.0556	-39.9	3.3627	-11.6	7.4143	0.60
1.3010	-34.4	3.6093	-10.2	8.0525	1.30

Table 3.2 - Continued

$c \times 10^3 /$ mol kg^{-1}	EMF / mV	$c \times 10^3 /$ mol kg^{-1}	EMF / mV	$c \times 10^3 /$ mol kg^{-1}	EMF / mV
$\alpha_{\text{AOT}} = 1$					
1.5397	-30.0	3.8480	-9.00	8.6222	1.90
1.7720	-26.4	4.0792	-7.90	9.1338	2.70
1.9980	-23.4	4.3034	-7.10	9.5956	3.50
2.2180	-20.4	4.7315	-5.80		
2.4323	-17.9	5.1350	-4.30		

Table 3.3 - Ratio of the intensities of Fluorescence Emission of Pyrene at 373 nm and at 384 nm in AOT + SDS + Water Solution at 298 K

$c \times 10^3 /$ mol kg^{-1}	I_3 / I_1	$c \times 10^3 /$ mol kg^{-1}	I_3 / I_1	$c \times 10^3 /$ mol kg^{-1}	I_3 / I_1
$\alpha_{\text{AOT}} = 0$					
4.1220	0.6411	7.5150	0.7058	10.784	0.8135
4.8925	0.6410	8.8124	0.7734	12.448	0.8077
5.8583	0.6526	9.1640	0.7848		
6.5380	0.6593	9.8371	0.8055		
$\alpha_{\text{AOT}} = 0.078$					
2.5152	0.6110	6.3642	0.8289	8.9038	0.8586
4.1104	0.6563	6.9555	0.8374		
5.7434	0.7786	7.6193	0.8577		
$\alpha_{\text{AOT}} = 0.190$					
1.5359	0.6490	4.5601	0.7503	7.8759	0.8428
2.4595	0.6503	5.1636	0.7779	9.0880	0.8398
3.6307	0.6795	5.5266	0.7991		
4.2398	0.7077	6.6373	0.8232		
$\alpha_{\text{AOT}} = 0.275$					
0.8764	0.6409	4.0779	0.7224	7.0159	0.8425
1.7576	0.6445	4.6854	0.7719	8.7215	0.8486
2.9077	0.6491	5.2507	0.7948		
3.4886	0.6621	5.8106	0.8269		
$\alpha_{\text{AOT}} = 0.407$					
1.3492	0.5988	3.5003	0.7103	6.7585	0.8869
1.8901	0.6264	4.0585	0.7956	8.1145	0.8957
2.1379	0.6421	4.8822	0.8447		
3.2501	0.6660	5.3901	0.8703		
$\alpha_{\text{AOT}} = 0.494$					
1.0573	0.6002	3.2036	0.6519	5.3821	0.8930
1.6192	0.6182	3.7975	0.7628	6.4977	0.9098
2.1165	0.6210	4.2899	0.8290	7.5536	0.9005
2.6912	0.6412	4.8866	0.8621		

Table 3.3 - Continued

$c \times 10^3 /$ mol kg^{-1}	I_3 / I_1	$c \times 10^3 /$ mol kg^{-1}	I_3 / I_1	$c \times 10^3 /$ mol kg^{-1}	I_3 / I_1
$\alpha_{\text{AOT}} = 0.671$					
0.5121	0.6375	4.0722	0.8172	5.6197	0.8892
2.0200	0.6366	4.5730	0.8576	6.6490	0.8992
2.5329	0.6595	5.0654	0.8710	7.6629	0.9168
$\alpha_{\text{AOT}} = 0.793$					
0.4916	0.6388	2.9068	0.7334	5.8664	0.8936
1.2266	0.6435	3.4443	0.7924	7.2793	0.9089
1.9532	0.6672	4.3883	0.8500		
2.4379	0.6901	4.8645	0.8588		
$\alpha_{\text{AOT}} = 1$					
0.9031	0.6642	2.7073	0.7458	4.5317	0.9046
1.3617	0.6696	3.1635	0.7797	5.7204	0.9386
1.8119	0.6895	3.6046	0.8446		
2.2561	0.7069	4.0699	0.8771		

Table 3.4 - Molal Conductance (Λ) Values of AOT+ SDS Systems in Water at 298 K

$c \times 10^3 /$ mol kg ⁻¹	$\Lambda /$ S cm ² mol ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\Lambda /$ S cm ² mol ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\Lambda /$ S cm ² mol ⁻¹
$\alpha_{\text{AOT}} = 0$					
1.0614	70.145	6.0407	67.753	9.4512	61.919
2.0445	68.971	6.6950	67.626	10.361	58.728
2.9576	68.782	7.3109	67.389	11.378	55.648
3.8078	68.511	7.8917	66.972	12.283	53.339
4.6016	68.380	8.4404	65.596		
5.3443	68.055	8.9594	63.694		
$\alpha_{\text{AOT}} = 0.065$					
0.9767	69.498	5.8653	67.295	7.7693	62.853
1.8813	69.116	6.4499	66.337	8.2473	61.496
2.7216	68.835	6.7293	65.664	9.3368	58.485
3.5042	68.380	7.0006	64.979	10.297	56.818
4.2349	68.097	7.2641	64.242		
$\alpha_{\text{AOT}} = 0.117$					
1.9222	69.813	5.3579	67.884	7.4214	62.241
2.7807	69.196	5.6802	67.168	8.1849	60.098
3.5803	68.965	5.9926	66.412	8.8884	58.246
4.3267	68.732	6.2956	65.586	9.7446	56.139
5.0252	68.360	6.8750	63.840		
$\alpha_{\text{AOT}} = 0.158$					
0.9280	69.936	4.6743	68.030	6.1300	64.894
1.7876	69.729	4.9838	67.693	6.6535	63.305
2.5861	69.140	5.2837	67.168	7.1476	61.890
3.3299	68.634	5.5744	66.424	8.2696	58.848
4.0244	68.374	5.8564	65.648	9.2536	56.466
$\alpha_{\text{AOT}} = 0.245$					
1.8090	69.924	4.7286	67.065	6.2003	62.915
2.6169	69.000	5.0416	66.350	6.4687	62.208
3.3692	68.406	5.3448	65.454	6.9825	60.783
4.0715	67.956	5.6387	64.583	7.4679	59.458
4.4055	67.667	5.9237	63.764	7.9272	58.290

Table 3.4 - Continued

$c \times 10^3 /$ mol kg^{-1}	$\Lambda /$ $\text{S cm}^2 \text{ mol}^{-1}$	$c \times 10^3 /$ mol kg^{-1}	$\Lambda /$ $\text{S cm}^2 \text{ mol}^{-1}$	$c \times 10^3 /$ mol kg^{-1}	$\Lambda /$ $\text{S cm}^2 \text{ mol}^{-1}$
$\alpha_{\text{AOT}} = 0.386$					
0.8975	68.439	4.9793	64.603	8.8952	55.626
2.3100	68.022	6.1671	61.367	9.6032	54.438
2.9743	67.744	6.6396	58.972	10.237	53.472
3.5947	67.624	8.0990	57.072		
$\alpha_{\text{AOT}} = 0.494$					
0.4290	70.356	3.0183	68.607	4.7878	65.283
0.8414	70.270	3.3382	68.474	5.3062	63.775
1.2384	69.921	3.6474	67.999	6.2545	61.468
1.9891	69.474	3.9465	67.401	7.2977	59.145
2.6873	68.723	4.2359	66.683		
$\alpha_{\text{AOT}} = 0.559$					
2.1350	68.169	3.3226	67.721	4.6029	65.566
2.4474	67.796	3.5954	67.583	5.0618	64.472
2.7491	67.926	3.8594	67.078	6.0982	61.943
3.0407	67.859	4.1150	66.651	7.0007	61.083
$\alpha_{\text{AOT}} = 0.730$					
1.4693	68.480	4.0962	66.302	6.6218	62.272
2.1257	67.635	4.3427	65.908	7.4513	61.132
2.7370	67.128	4.5816	65.564	8.1835	60.399
3.3077	67.107	4.8133	65.203	8.8346	59.341
3.5791	66.832	5.2564	64.399		
3.8418	66.474	5.6743	63.795		
$\alpha_{\text{AOT}} = 0.759$					
1.6706	68.266	3.3157	67.799	5.7978	64.137
1.9692	68.105	3.5591	67.546	6.6075	62.867
2.2573	67.813	3.7947	67.291	7.3200	61.765
2.5355	67.769	4.0231	66.995	7.9518	60.895
2.8043	67.818	4.4591	66.278		
3.0642	67.872	4.8696	65.671		

Table 3.4 - Continued

$c \times 10^3 /$ mol kg ⁻¹	$\Lambda /$ S cm ² mol ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\Lambda /$ S cm ² mol ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\Lambda /$ S cm ² mol ⁻¹
$\alpha_{AOT} = 0.864$					
0.3692	68.784	3.1417	65.874	5.3907	64.925
0.7243	67.733	3.3996	65.871	6.2915	63.938
1.3953	65.952	3.6492	66.015	7.0801	63.040
2.0188	65.794	3.8910	65.988	8.3957	61.667
2.3142	65.520	4.1252	66.015	9.4492	60.638
2.5995	65.420	4.5724	65.595		
2.8752	65.640	4.9935	65.253		
$\alpha_{AOT} = 1$					
0.7044	70.741	2.3883	67.373	4.0044	67.414
1.0362	69.209	2.5251	67.297	4.4382	66.741
1.3564	68.452	2.6605	67.288	5.2302	66.596
1.6646	67.929	2.7931	67.659	6.1027	66.064
1.9616	67.763	2.9236	67.865	6.8658	65.599
2.1059	67.418	3.3017	67.841	7.5377	65.145
2.2487	67.343	3.5438	67.945		

Table 3.5 - Values of Cmc and Counter Ion Binding Constant (β_c) for AOT+ SDS Systems in Water at 298 K

Surface tension			EMF		Fluorescence			Conductance	
α_{AOT}	Cmc / mmol kg ⁻¹	α_{AOT}	Cmc / mmol kg ⁻¹	β_c	α_{AOT}	Cmc / mmol kg ⁻¹	α_{AOT}	Cmc / mmol kg ⁻¹	
0	8.10	0	8.13	0.71	0	8.00	0	8.10	
0.091	5.37	0.117	5.25	0.48	0.078	5.50	0.065	6.00	
0.117	5.07	0.253	4.17	0.43	0.190	4.50	0.117	5.26	
0.245	4.21	0.397	3.71	0.42	0.275	4.10	0.158	4.90	
0.389	3.76	0.486	3.47	0.43	0.407	3.60	0.245	4.36	
0.494	3.43	0.611	3.31	0.42	0.494	3.50	0.386	3.72	
0.564	3.31	0.690	3.27	0.42	0.671	3.30	0.494	3.48	
0.652	3.27	0.767	3.12	0.42	0.793	3.02	0.559	3.36	
0.730	3.22	0.862	2.90	0.44	1	2.60	0.730	3.18	
0.888	2.84	1	2.63	0.42			0.759	3.11	
1	2.63			0.42			0.864	2.86	
							1	2.60	

Table 3.6 - Values of x_1 , β_m , f_1 and f_2 for AOT+SDS Systems in Water at 298 K from Surface Tension Measurements

α_{AOT}	$x_1^{\text{id}} / x_1^{\text{Rb}} / x_1^{\text{Rd}}$	β_m	f_1	f_2
0	0/0/0	0.0	-	1.000
0.091	0.235/0.320/0.342	-1.18	0.580	0.886
0.117	0.290/0.359/0.377	-1.14	0.627	0.863
0.245	0.499/0.500/0.432	-0.97	0.784	0.784
0.389	0.662/0.620/0.524	-0.76	0.896	0.747
0.494	0.750/0.692/0.627	-0.76	0.931	0.696
0.564	0.799/0.742/0.692	-0.67	0.956	0.691
0.652	0.852/0.820/0.760	-0.37	0.988	0.782
0.730	0.893/0.893/0.814	0.0	1.0	1.0
0.888	0.960/0.960/0.948	0.0	1.0	1.0
1	1.0/1.0/1.0	0.0	1.0	-

Table 3.7 - Values of x_1 and ΔG_m° for AOT + SDS Systems in Water at 298 K from EMF Measurements

α_{AOT}	x_1^{Rb}	$\Delta G_m^\circ / \text{kJ mol}^{-1}$
0	0.0	-37.41
0.117	0.354	-36.06
0.253	0.508	-35.73
0.397	0.625	-35.72
0.486	0.689	-36.04
0.611	0.786	-35.68
0.690	0.860	-35.46
0.767	0.910	-35.36
0.862	0.950	-35.77
1	1.000	-35.03

Table 3.8 - Values of Γ_{cmc} , A_{min} , $A_{\text{min}}^{\text{id}}$, x_{1a} , β_a , f_{1a} and f_{2a} for AOT+SDS Systems in Water at 298 K from Surface Tension Measurements

α_{AOT}	$10^6 \times \Gamma_{\text{cmc}} /$ mol m^{-2}	$A_{\text{min}} /$ nm^2	$A_{\text{min}}^{\text{id}} /$ nm^2	x_{1a}	β_a	f_{1a}	f_{2a}
0	3.42	0.485	0.485	0.0	-	-	1.0
0.091	2.50	0.664	0.679	0.369	-1.11	0.643	0.860
0.117	2.45	0.678	0.701	0.411	-1.07	0.689	0.833
0.245	2.15	0.772	0.777	0.555	-1.12	0.802	0.708
0.389	2.00	0.830	0.843	0.683	-0.70	0.932	0.722
0.494	1.93	0.860	0.879	0.750	-0.70	0.957	0.676
0.564	1.88	0.883	0.895	0.781	-0.81	0.962	0.610
0.652	1.85	0.897	0.914	0.816	-0.96	0.968	0.526
0.730	1.81	0.917	0.943	0.873	-0.72	0.988	0.575
0.888	1.74	0.954	0.981	0.944	-0.80	0.997	0.488
1	1.65	1.006	1.006	1.0	-	1.0	-

Table 3.9 - Ratio of the intensities (I_0 / I_q) of Fluorescence Emission of Pyrene in the absence (I_0) and presence (I_q) of the quencher (CPC) at 373 nm in AOT+ SDS + Water Solution at 298K

α_{AOT}	$c / \text{mol kg}^{-1}$	[CPC] x $10^5 / \text{mol kg}^{-1}$	I_0 / I_q
0	0.0103	0.0000	1.0000
		1.4109	1.2836
		2.8218	1.7363
		4.2327	2.3444
		5.6436	2.7681
0.098	0.0115	0.0000	1.0000
		1.8750	1.2349
		2.5000	1.2849
		3.5000	1.4195
0.117	0.0097	0.0000	1.0000
		1.4109	1.2831
		2.8218	1.4543
		4.2327	1.7972
		5.6436	1.9700
0.140	0.0081	0.0000	1.0000
		1.8750	1.4240
		2.5000	1.5995
		3.5000	2.0762
0.248	0.0091	0.0000	1.0000
		1.4109	1.1342
		2.8218	1.2823
		4.2327	1.4741
		5.6436	1.6913
0.393	0.0086	7.0546	1.8446
		0.0000	1.0000
		1.4109	1.1540
		2.8218	1.2853
		4.2327	1.4886
		5.6436	1.5220
		7.0546	1.8386

Table 3.9 - Continued

α_{AOT}	$c/\text{mol kg}^{-1}$	$[\text{CPC}] \times 10^5 / \text{mol kg}^{-1}$	I_o / I_d
0.492	0.0082	0.0000	1.0000
		1.4109	1.1359
		2.8218	1.2694
		4.2327	1.3939
		5.6436	1.4896
0.564	0.0078	0.0000	1.0000
		9.4060	1.1562
		1.8812	1.2144
		2.8218	1.3081
		3.7624	1.4741
0.652	0.0076	4.7030	1.5536
		0.0000	1.0000
		9.4060	1.1262
		1.8812	1.1943
		2.8218	1.2580
0.730	0.0075	0.0000	1.0000
		1.4109	1.1917
		2.8218	1.2585
		4.2327	1.3794
		5.6436	1.4804
0.885	0.0069	0.0000	1.0000
		1.4109	1.0885
		2.8218	1.1709
		4.2327	1.3083
1	0.0066	0.0000	1.0000
		9.4060	1.0369
		1.8812	1.0959
		2.8218	1.1605
		3.7624	1.2163
		4.7030	1.2924

Table 3.10 - Values of aggregation number (N_θ) for AOT + SDS Systems in Water at 298 K

α_{AOT}	x_1^{Rb}	$c - c_0$ / mol kg ⁻¹	N_θ	n_{AOT}	n_{SDS}
0.0	0.0	0.0022	44	0	44
0.098	0.320	0.0062	62	20	42
0.117	0.359	0.0046	63	23	40
0.140	0.390 ^{a)}	0.0032	60	23	37
0.248	0.500	0.0049	45	23	22
0.393	0.620	0.0049	45	28	17
0.492	0.692	0.0048	41	28	13
0.564	0.742	0.0045	44	33	11
0.652	0.820	0.0043	34	28	6
0.730	0.893	0.0043	33	29	4
0.885	0.960	0.0041	26	25	1
1.0	1.0	0.0040	22	22	0

^{a)} Obtained by interpolation

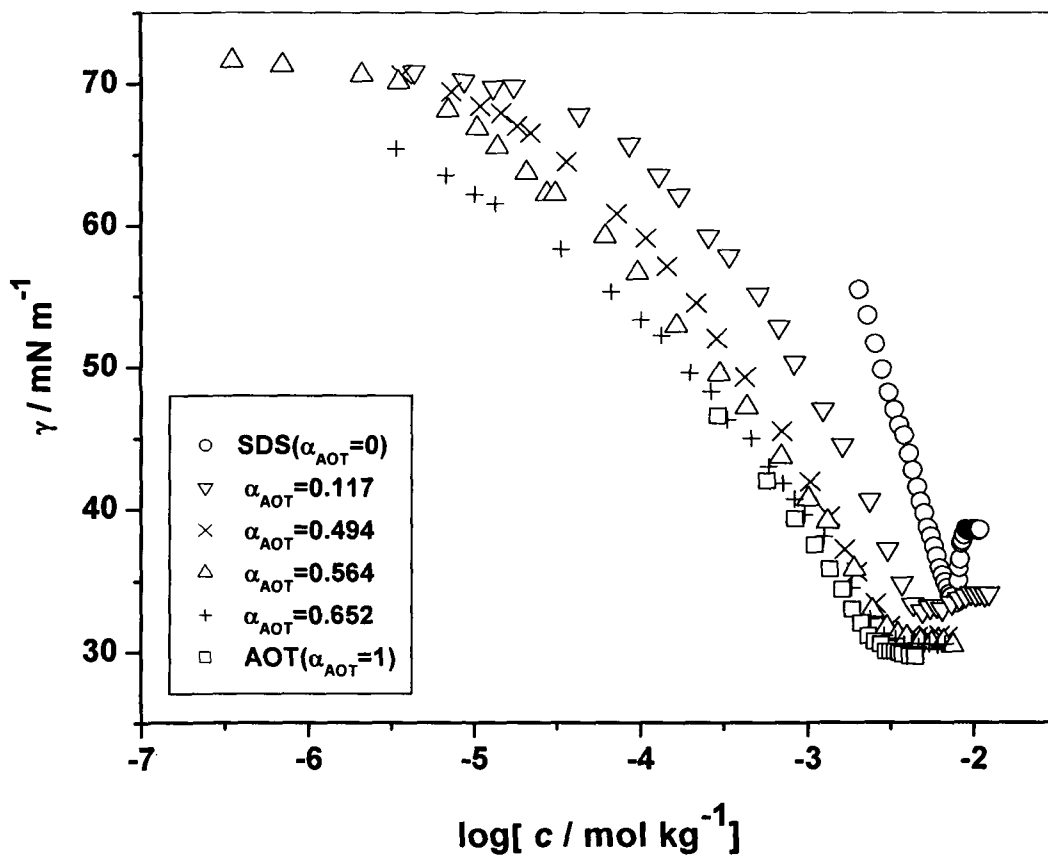


Figure 3.1 - Representative plots of surface tension of AOT + SDS system against logarithm of total surfactant concentration.

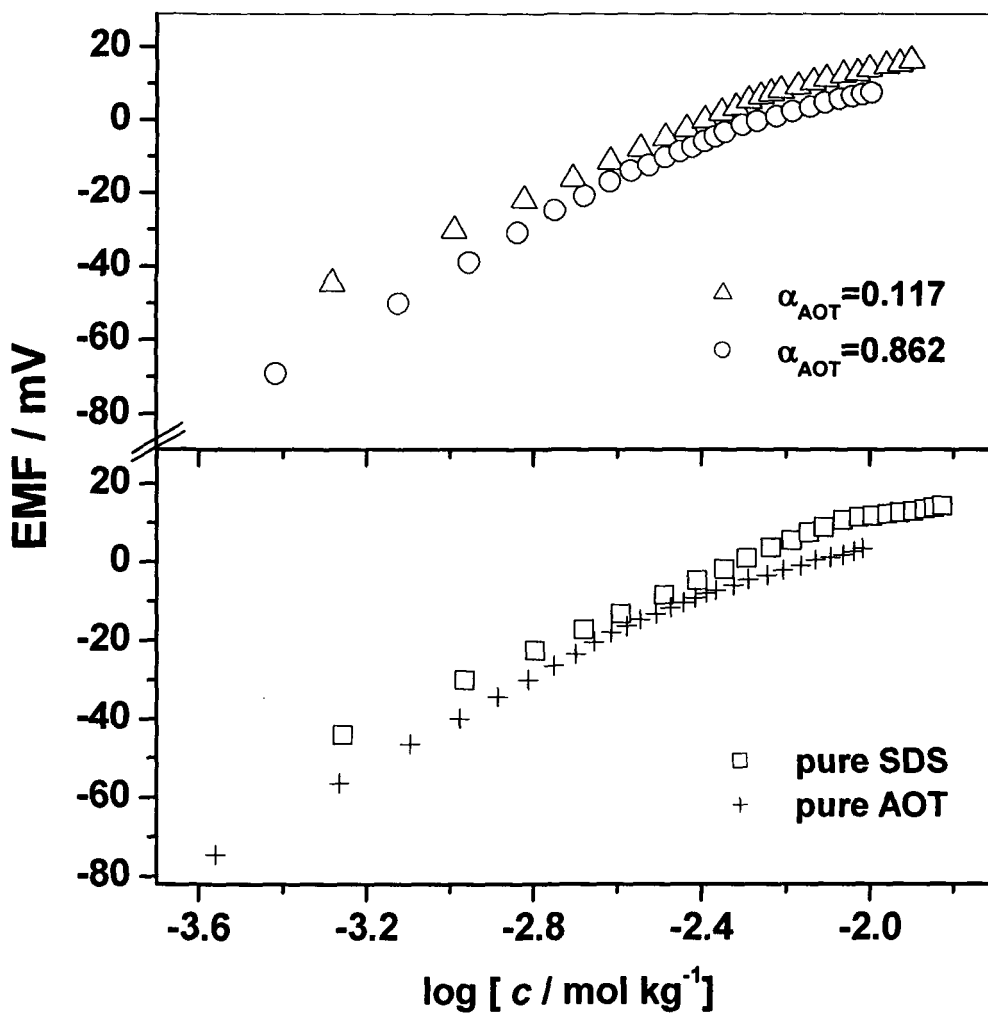


Figure 3.2 - Representative plots of emf of AOT + SDS system against logarithm of total surfactant concentration.

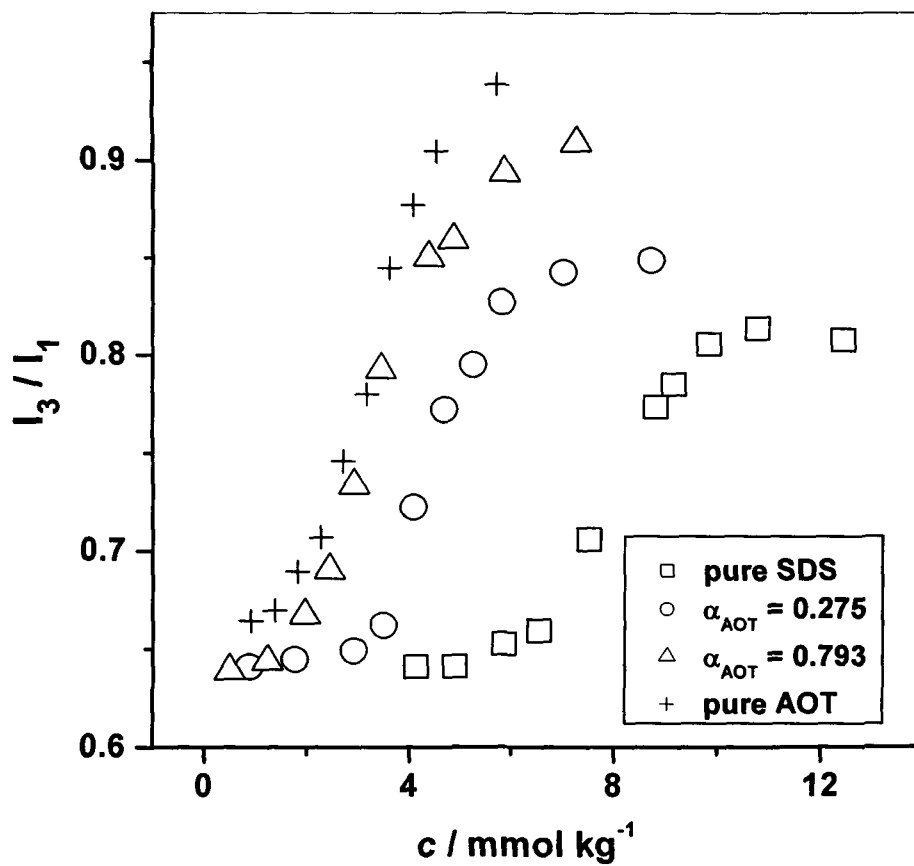


Figure 3.3 - Representative plots of I_3/I_1 values of pyrene in AOT + SDS system against total surfactant concentration.

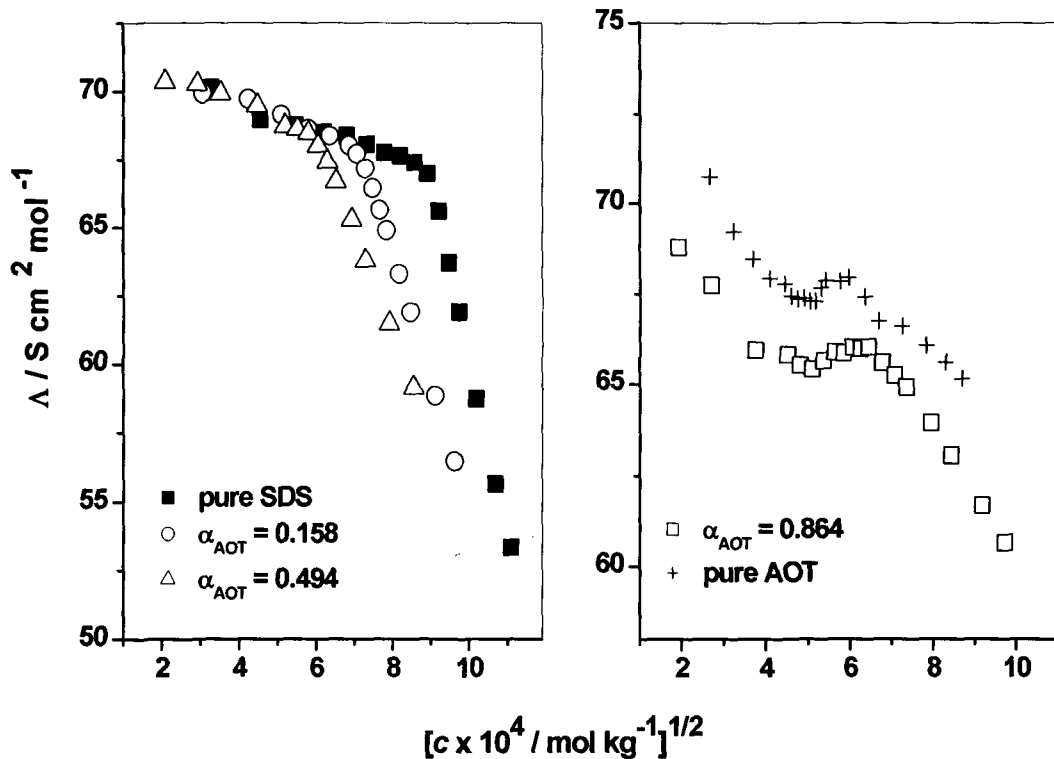


Figure 3.4 – Representative plots of molal conductance of AOT + SDS system versus square root of total surfactant concentration.

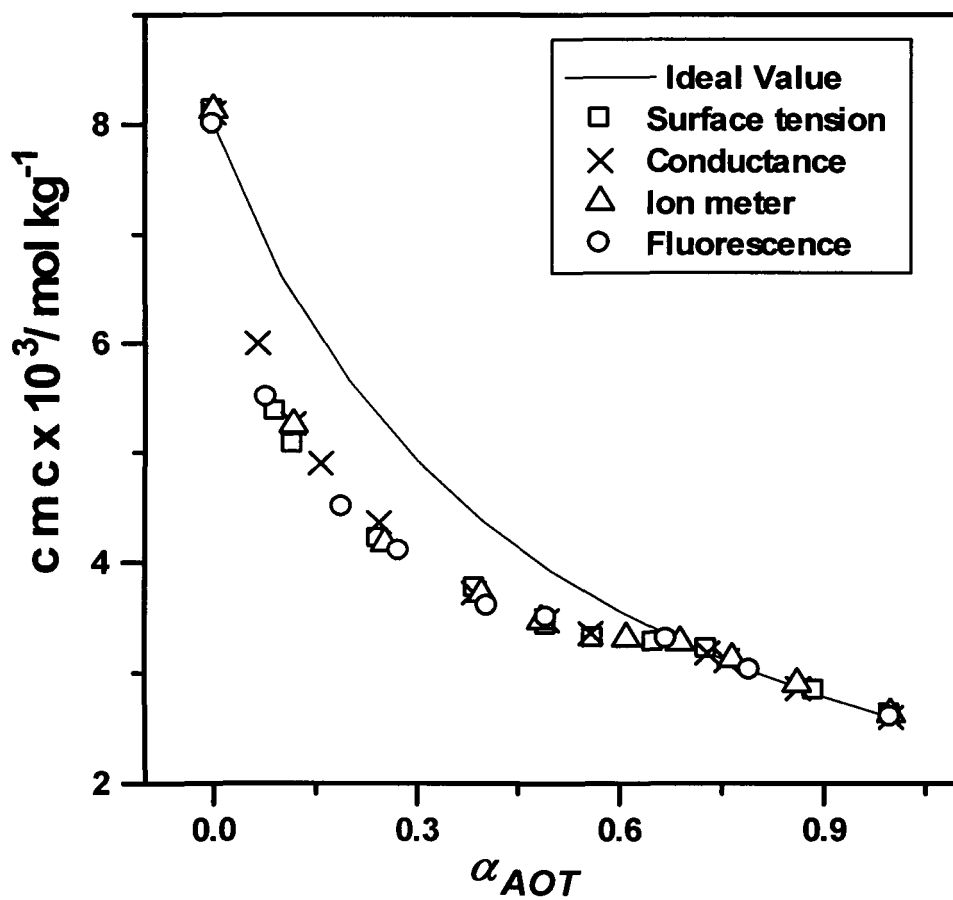


Figure 3.5 - Values of cmc of AOT + SDS system obtained from surface tension, conductance, emf and fluorescence methods as a function of mole fraction of AOT in the bulk solution. Ideal value of cmc is calculated from Clint's equation.

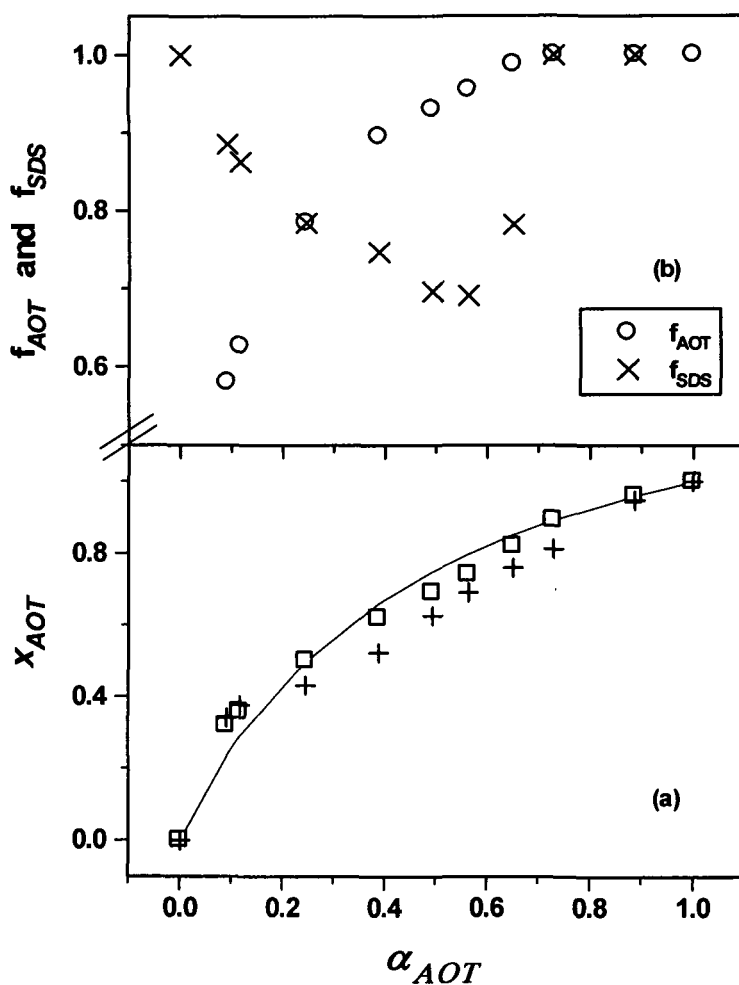


Figure 3.6 - Plots of (a) mole fraction of AOT (x_{AOT}) and (b) activity coefficients of AOT (f_{AOT}) and SDS (f_{SDS}) in the mixed micelle against mole fraction of AOT in the bulk solution. Values of x_{AOT} were calculated from (i) Rubingh's method [Eq. (3.4), x_{AOT}^{Rb} (\square)], (ii) RVV method [Eq. (3.6), x_{AOT}^{Rd} ($+$)] and (iii) by considering ideal condition [Eq. (3.5), x_{AOT}^{id} ($-$)].

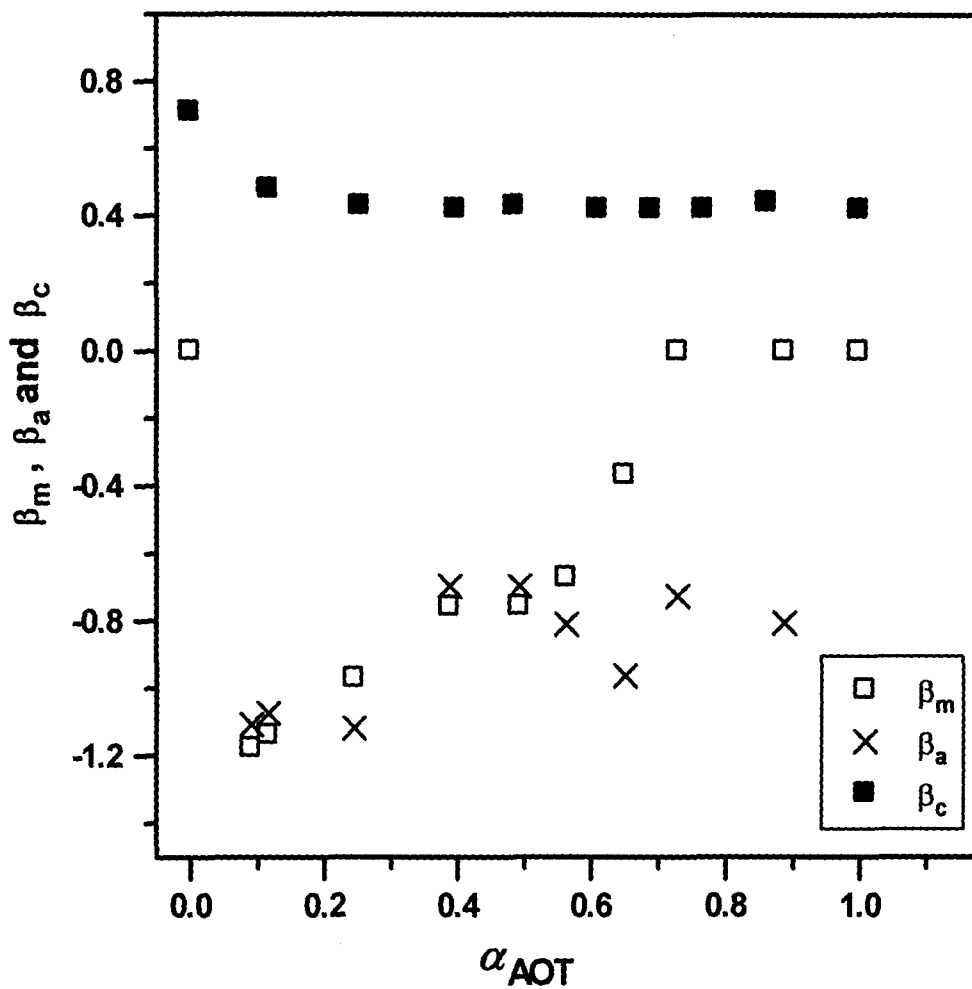


Figure 3.7 - Values of interaction parameter in the mixed micelle (β_m), interaction parameter in the adsorbed layer (β_a) and counter ion binding constant (β_c) as a function of mole fraction of AOT in the bulk solution.

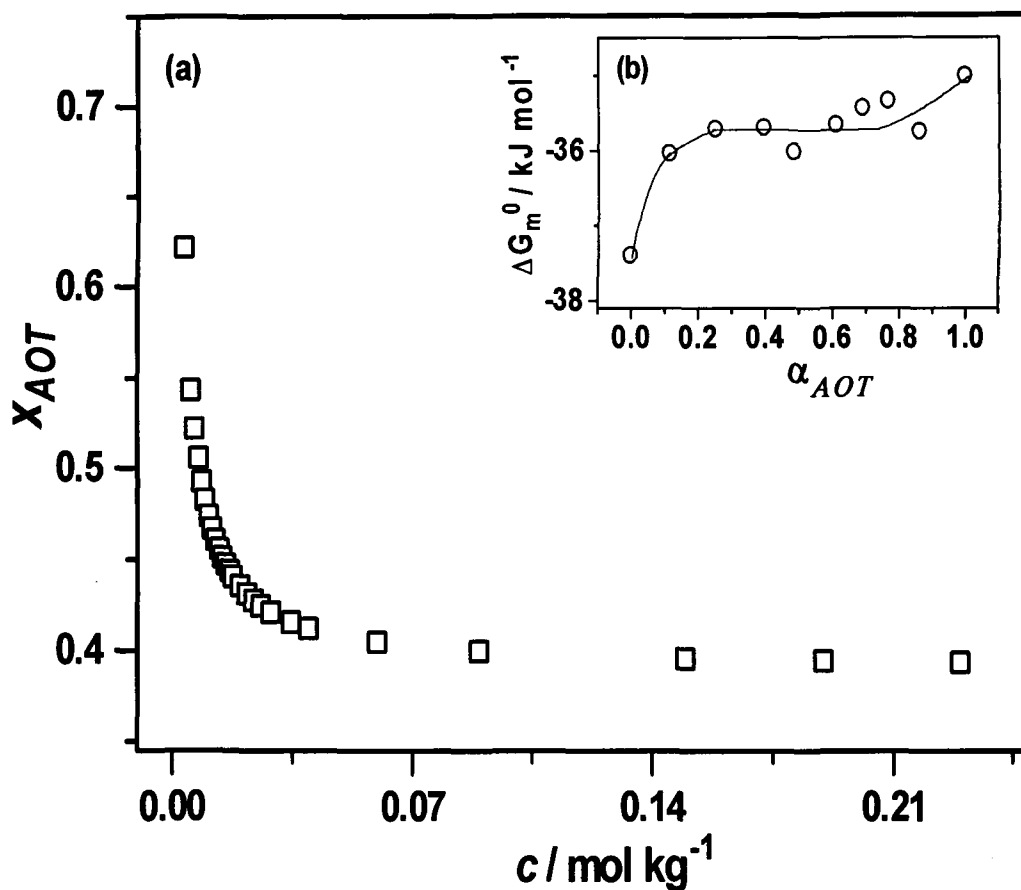


Figure 3.8 - Plots of (a) mole fraction of AOT in the mixed micelle against total surfactant concentration above cmc and corresponding to $\alpha_{AOT} = 0.389$ and (b) standard free energy for mixed micelle formation against mole fraction of AOT in the bulk solution.

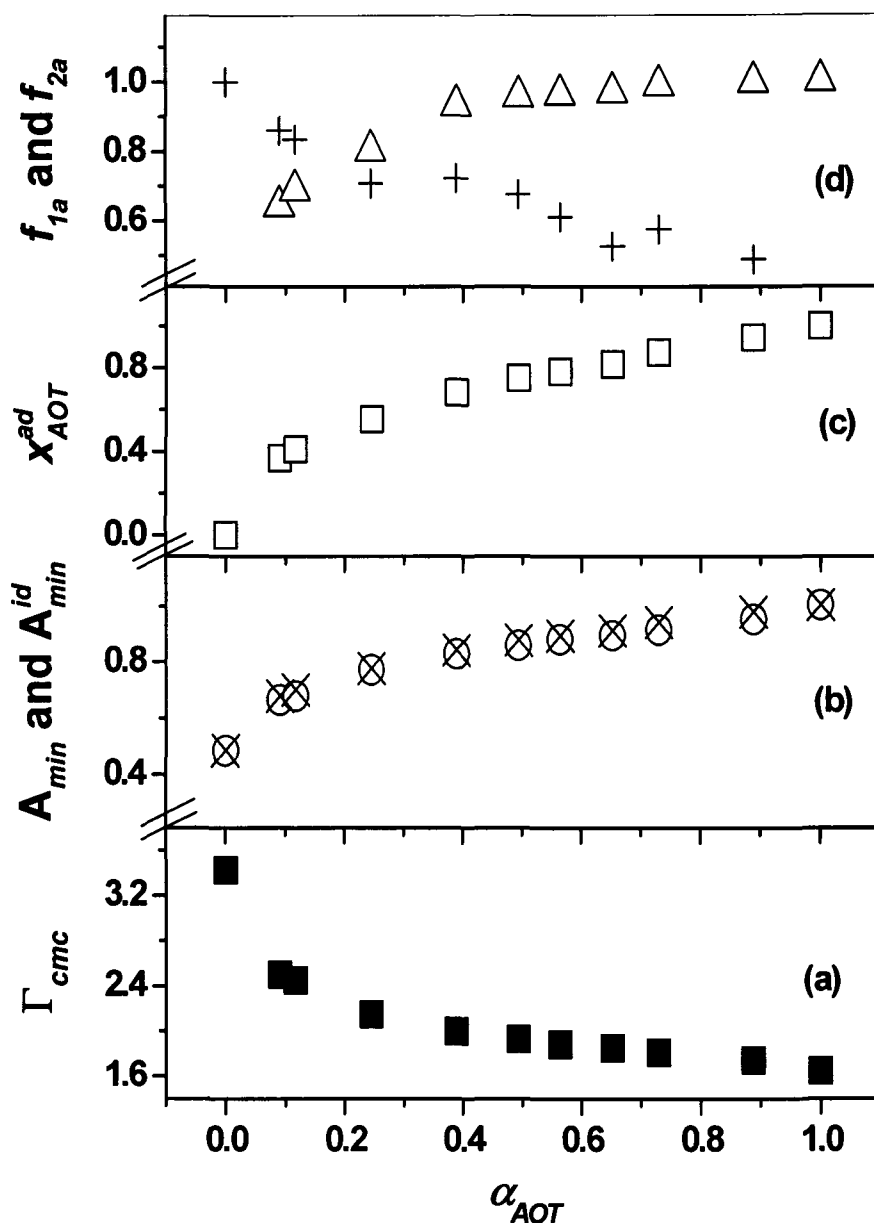


Figure 3.9 - Plots of (a) surface excess ($10^{-6} \text{ mol m}^{-2}$) at the cmc, Γ_{cmc} , (b) area (nm^2) per molecule in the adsorbed layer, A_{min} (\circ) and A_{min}^{id} (\times), (c) mole fraction of AOT in the adsorbed layer (x_{AOT}^{ad}), and (d) activity coefficients of AOT [f_{1a} , Δ] and SDS [f_{2a} , $+$] versus mole fraction of AOT in the bulk solution.

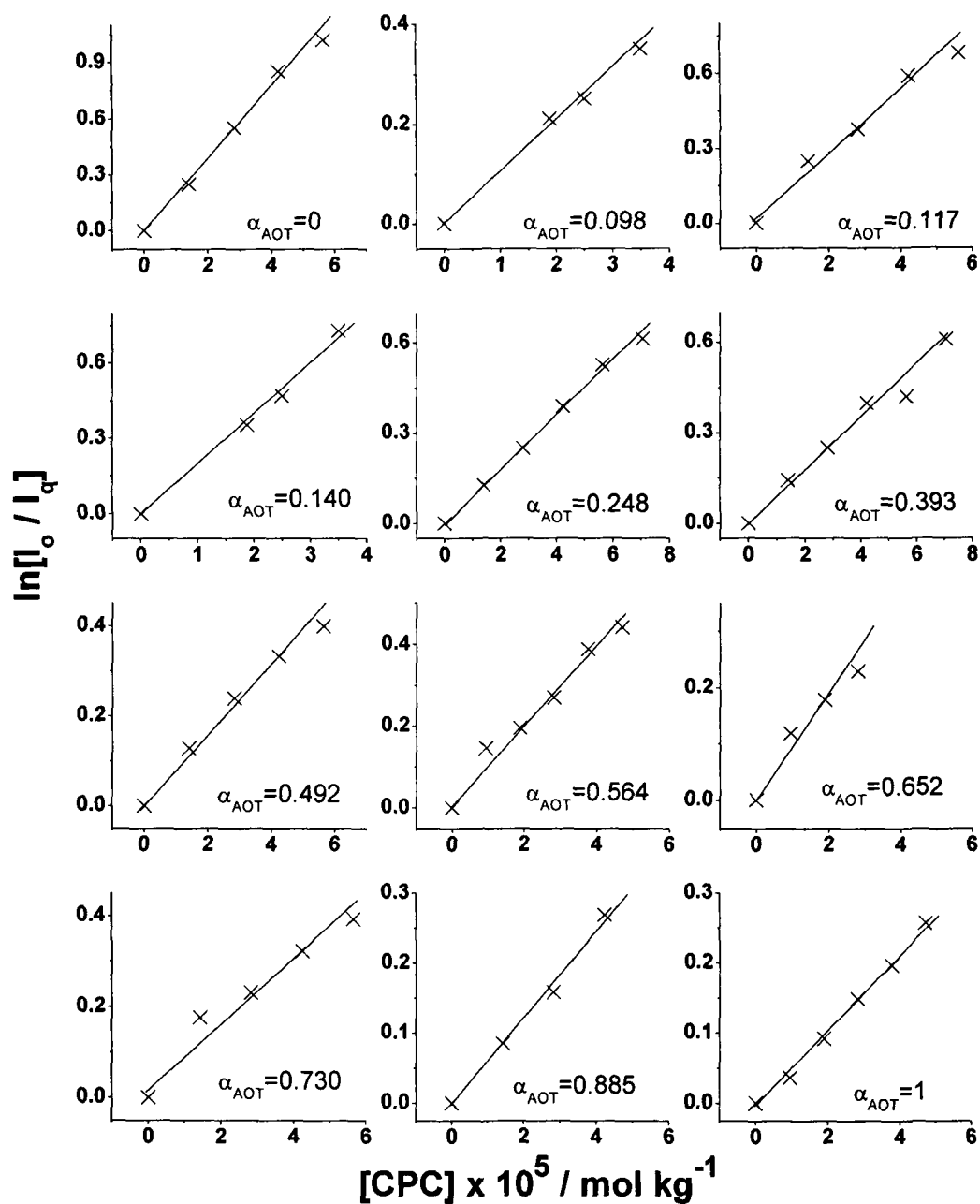


Figure 3.10 - Variation of $\ln[I_0/I_q]$ of pyrene at 373 nm with the concentration of the quencher in AOT + SDS systems in water. Composition of AOT in the bulk solution is given in the inset.

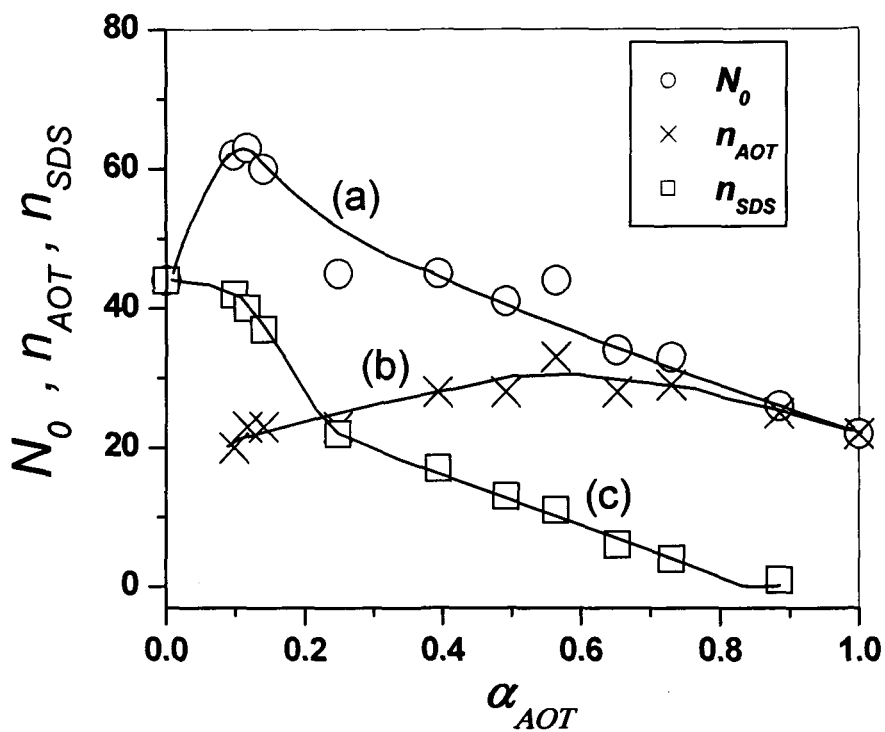


Figure 3.11 - Plots of (a) aggregation number (N_0 , ○) of AOT + SDS mixed system, (b) number of molecules of AOT in the mixed micelle (n_{AOT} , ×), and (c) number of molecules of SDS in the mixed micelle (n_{SDS} , □) against mole fraction of AOT in the bulk solution.

CHAPTER 4

Micellization and adsorption behaviours of mixtures of sodium dioctylsulfosuccinate and sodium dodecylsulfate in aqueous NaCl medium

4.1 Introduction

Micellization behaviours of ionic surfactants are greatly influenced by added electrolytes and it is attributed to the counter ion effect. The amount of counter ion bound to an ionic micelle is expressed in terms of counter ion binding constant (β_c) and its value depends on the nature of both ionic surfactant and counter ion. It has been reported¹ that sodium dioctylsulfosuccinate (AOT) shows two counter ion binding regions in aqueous sodium chloride medium. Below a critical concentration (c^*) of NaCl equal to about 0.02 mol kg⁻¹ β_c of AOT is nearly equal to 0.4 and it becomes about 0.8 above c^* . This sudden two-fold increase in the value of β_c is attributed to the shape change of AOT micelles.² Our objective in this chapter is to investigate how the special counter ion binding behaviour of AOT is affected when AOT is mixed with another ionic surfactant having same counter ion. In order to carry out this investigation we chose once again the same AOT + SDS mixed surfactant system (*ca.* chapter 3) and studied its micellization, adsorption and counter ion binding behaviours in aqueous NaCl medium.

4.2 Experimental Section

AOT (Sigma, 99% assay), SDS (Aldrich, 99% assay) and NaCl (Merck, 99.5% assay) were used as received. All solutions were prepared in Millipore water and measurements were made under thermostated condition at 298K. A stock aqueous solution of NaCl was prepared and diluted to get the required concentrations. Solution containing a mixture of AOT and SDS of a particular composition was prepared by mixing required amounts of the surfactants in the

diluted NaCl solutions. Surface tension measurements were made as described in the preceding chapter.

4.3 Results and Discussion

4.3.1 Cmc of mixed surfactants

Measured surface tension (γ) values of AOT + SDS systems in aqueous electrolyte solutions containing varying amounts of NaCl are listed in Table 4.1. Plots of γ versus logarithm of surfactant concentration (c) for AOT + SDS systems of different α_{SDS} (mole fraction of SDS in the bulk) in aqueous NaCl media are shown in Figs. 4.1 – 4.10. The cmc values of the pure (c_{01} and c_{02}) and mixtures of surfactants (c_{0m}) at different NaCl concentrations determined from the surface tension isotherms are shown in Table 4.2 and Fig. 4.11. Similar to single surfactant systems, mixed surfactant system of a particular composition show a decrease in the critical micelle concentration with added NaCl concentration. The reduction in the cmc with added salt is due to the screening of the electrostatic repulsion between the head groups of the surfactants in the micelle. For determining the composition of the mixed micelle from the different models, we require cmc values of AOT + SDS systems of different compositions (from $\alpha_{\text{AOT}} = 0$ to 1) at fixed NaCl concentrations. At a particular NaCl concentration, cmc values of the AOT + SDS mixed system corresponding to all the compositions were estimated from the experimental cmc values (Table 4.2 and Fig. 4.11) by interpolation. Cmc values thus estimated at different fixed NaCl concentrations are given in Table 4.3 and these interpolated cmc values were used for further calculations.

The ideal values of cmc of the mixtures were calculated from the Clint's equation,³

$$1/c_{0m} = \sum_i [\alpha_i / c_{0i}] \quad (4.1)$$

where (α_i) is the mole fraction of component i ($i = 1$ for AOT and $i = 2$ for SDS) in the bulk solution. As discussed in chapter 3, in water medium the experimentally determined cmc values of the mixed systems are less than the ideal values thereby indicating synergism for compositions less than 0.7 mole fraction of AOT and takes up ideal values in the region of $0.7 \leq \alpha_1 \leq 1$. In the aqueous NaCl medium the mixtures exhibit synergism throughout the whole composition range (Fig. 4.12), the synergism in the region of $0.7 \leq \alpha_1 \leq 1$ is, however, much less.

4.3.2 Mixed micelle composition

Rubingh's method: As described in chapter 3, in Rubingh's approach,^{4,5} composition of the mixed micelle is estimated from the expression

$$x_1^2 \ln[\alpha_1 c_{0m} / (x_1 c_{01})] = (1-x_1)^2 \ln[(1-\alpha_1) c_{0m} / \{(1-x_1) c_{02}\}] \quad (4.2)$$

From Eq. (4.2) x_1 ($= x_{\text{AOT}}$) as a function of α_1 was computed by an iterative method and these values are given in Table 4.4 and also presented in Fig. 4.13. From Fig. 4.13 it appears that x_{AOT} has a complex dependence on NaCl concentration. In mixtures of $\alpha_{\text{AOT}} = 0.163$ and 0.245 , x_{AOT} keeps on increasing by increasing the amount of added NaCl. In mixtures of $\alpha_{\text{AOT}} \geq 0.393$, initial addition of NaCl decreases x_{AOT} and further addition of NaCl increases x_{AOT} if $\alpha_{\text{AOT}} < 0.745$ and does not change x_{AOT} much if $\alpha_{\text{AOT}} \geq 0.745$. The mixed micelle is

always enriched with AOT and if the mixed system has $\alpha_{\text{AOT}} > 0.5$, then added NaCl is not effective in further enrichment of AOT in the mixed micelle.

Once the value of x_1 was obtained, the corresponding values of f_1 , f_2 , and β_m were determined in the manner explained in chapter 3 (Eqs. 3.2 and 3.3). The variation of β_m with NaCl concentration for AOT + SDS systems is shown in Fig. 4.14. Negative values of β_m are indicative of attractive interaction between the two anionic surfactants in the mixed micelle. From Fig. 4.14, it is apparent that an initial increase in the attractive interaction between AOT and SDS on adding NaCl is a general pattern. With the continued addition of NaCl, the attractive interaction between the components after the initial increase (i) starts decreasing for mixtures of $\alpha_{\text{AOT}} \leq 0.648$ and (ii) remains almost constant for mixtures of $\alpha_{\text{AOT}} > 0.648$. Greater negative value of interaction parameter was reported⁶ for the cationic-cationic mixture of hexadecyltrimethylammoniumbromide and hexadecylbenzyltrimethylammonium chloride at 25°C in 30 mM aqueous NaCl solution. For the mixture of like-charged ionic surfactants (anionic – anionic or cationic – cationic), the contributions to the interaction between the surfactants are from the van der Waals interaction between the tails of the surfactants and the repulsive interaction between the head groups. The interaction between the tails is negative and that between the heads is positive. With the addition of NaCl, the repulsive interaction between the like charged head groups decreases because of high ionic strength in the solution, which in turn makes β_m more negative.

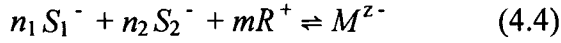
RVV method: We determined the mixed micelle composition from the RVV⁷ method by using the procedure described in chapter 3 (ca. Eq. 3.6 of chapter 3). The values of x_{AOT} calculated from this method are presented in Table 4.5 and Fig. 4.15. Although methods of data analysis adopted in the Rubingh's and RVV approaches are different, x_{AOT} calculated from the two approaches is found to have, depending upon the composition (value of α_{AOT}) of the mixed surfactant system, similar or different types of dependence on NaCl concentration. For e.g., for the mixture of $\alpha_{\text{AOT}} = 0.745$, x_{AOT} determined from the two methods has different types of dependence on NaCl concentration, while for the mixture of $\alpha_{\text{AOT}} = 0.5$, x_{AOT} obtained from the two methods has similar dependence on NaCl concentration.

4.3.3 Counter ion binding to mixed micelle

The dependence of cmc of single ionic surfactant solutions on the concentration of added NaCl (c_e) is described by the Corrin – Harkins (CH)⁸ equation of the form

$$\ln c_{0i} = A_1 - \beta_c \ln(c_{0i} + c_e) \quad i = \text{SDS or AOT} \quad (4.3)$$

where A_1 is a constant related to the standard free energy of micellization and β_c is the binding constant of sodium counter ion. The plots of $\ln c_{0i}$ versus $\ln(c_{0i} + c_e)$ for SDS and AOT are shown in Fig. 4.16. For a mixed surfactant system the form of CH equation is different from Eq. (4.3). To show this, we consider the equilibrium for the micellization of a mixture of two anionic surfactants (RS_1 and RS_2) containing the same counter ion (R^+). This equilibrium is the same as that considered in chapter 3 (ca. Eq. 3.11)



In the above equilibrium, n_1 and n_2 are the aggregation numbers of surfactants RS_1 and RS_2 in the mixed micelle, respectively, m is the number of counter ions that binds to the mixed micelle, M refers to the mixed micelle and the charge on the micelle $z = n_1 + n_2 - m$. In the mixture, let α_1 and α_2 be the mole fractions of RS_1 and RS_2 in the bulk, respectively. Writing the expression for the equilibrium constant of the equilibrium (4.4) and then relating it to standard free energy of micellization (ΔG^0), we get the relation just above the cmc as

$$x_1 \ln[S_1^-] + x_2 \ln[S_2^-] \approx (\Delta G^0/N_0 RT) - \beta_c \ln[R^+] \quad (4.5)$$

In Eq. (4.5), $N_0 = n_1 + n_2$, which gives the total aggregation number of the mixed micelle and $x_i = n_i/n$ ($i = 1$ or 2) is the mole fraction of surfactant in the mixed micelle. In writing Eq. (4.5), near the cmc the value of $\ln[M]/N_0$ has been neglected in comparison to $\Delta G^0/N_0$, which is an approximation made while deriving CH equation for single surfactants also. Applying Eq. (4.5) to the present mixed surfactant system of a particular composition, we get in the presence of an added electrolyte having same counter ion an expression of the form

$$\ln(\alpha_{SDS} c_{0m}) + x_{AOT} \ln(\alpha_{AOT}/\alpha_{SDS}) = A - \beta_c \ln(c_{0m} + c_e) \quad (4.6)$$

In Eq. (4.6), the term A is given by the expression

$$A = \frac{\Delta G^0}{N_0 RT} = \frac{\Delta G_m^0}{RT} = (1 + \beta_c) \ln c_{0m} + x_{SDS} \ln \alpha_{SDS} + x_{AOT} \ln \alpha_{AOT} \quad (4.7)$$

Eq. (4.6) is a modified form of CH equation for a mixture of two ionic surfactants containing a common counter ion. In Eq. (4.7), c_{0m} refers to cmc in the absence of electrolyte (at $c_e = 0$) and ΔG_m^0 is the standard free energy of micellization per

mole of monomer. β_c of mixed surfactants corresponding to different values of α_{SDS} was determined by plotting the terms in the left hand side of Eq. (4.6) against $\ln(c_{0m} + c_e)$. These plots are shown in Fig. 4.16 and the values of β_c obtained from the slopes of these plots are shown in Table 4.6. AOT has been reported¹⁻⁵ to exhibit a special type of counter ion binding behaviour, viz., $\beta_c \approx 0.4$ when $[\text{NaCl}] \leq 0.015 \text{ mol kg}^{-1}$ and $\beta_c \approx 0.8$ when $[\text{NaCl}] > 0.015 \text{ mol kg}^{-1}$. SDS, on the other hand, has only one value of β_c in aqueous NaCl solution. It is interesting to note that AOT + SDS mixture also exhibits counter ion binding behaviour similar to that of AOT. The mixture of $\alpha_{AOT} = 0.163$ has only one value for β_c as in the case of SDS, the value of β_c in this mixture is, however, lower than that in neat SDS (Table 4.6). All mixtures of $\alpha_{AOT} \geq 0.245$ have two values for β_c as in the case of neat AOT. The values of β_c and the NaCl concentration (c^*) at which the value of β_c changes over from lower to higher value are almost same in AOT + SDS mixture and in AOT. Thus, in AOT + SDS mixture some minimum amount of AOT is required for exhibiting the special counter ion binding behaviour and SDS does not affect the value of β_c or c^* . This envisages that counter ion binding of the mixed micelle is controlled entirely by the AOT, which leads one to visualize that in the Stern layer of the mixed micelle heads of AOT are more exposed than those of SDS. In the case of neat AOT, the shift in the β_c value is reported² to be due to change of shape of AOT micelle from prolate ellipsoidal to rod-type. Therefore, in AOT + SDS mixtures also the shape of the mixed micelle is expected to change from prolate to rod-type near c^* .

4.3.4 Adsorption parameters

For a mixture of 1:1 ionic surfactants having same counter ion the Gibbs adsorption isotherm can be written as (*ca.* chapter 3)

$$d\gamma = -RT\Gamma(2d \ln c + x_{1a} d \ln \alpha_1 + x_{2a} d \ln \alpha_2) \quad (4.8)$$

where Γ is the surface excess of the mixed surfactant system. $x_{ia} = \Gamma_i / \Gamma$ is the mole fraction of surfactant 1 ($i = 1$) or 2 ($i = 2$) in the adsorbed layer. In the case of a mixed ionic surfactant system having a particular composition (constant α_i), Eq. (4.8) however reduces to the same equation that is used for calculating the surface excess of single ionic surfactant. Accordingly, in water medium surface excess of the mixed surfactant at the cmc (Γ_{cmc}) was calculated from the expression,

$$\Gamma_{cmc} = - \left(\frac{1}{4.606RT} \right) \lim_{c \rightarrow c_{om}} \left(\frac{d\gamma}{d \log c_{om}} \right) \quad (4.9)$$

In aqueous NaCl medium, Γ_{cmc} was calculated from the expression,⁹

$$\Gamma_{cmc} = - \left(\frac{1}{2.303RT} \right) \left[\frac{1}{1 + \left(\frac{c_{om}}{c_{om} + c_e} \right)} \right] \lim_{c \rightarrow c_{om}} \left(\frac{d\gamma}{d \log c_{om}} \right) \quad (4.10)$$

In the absence of electrolyte, Eq. 4.10 reduces to Eq. 4.9. Choosing a reference point of constant surface tension and applying the Rubingh's approach to adsorption as employed to micellization, Rosen and Hua¹⁰ reported expressions for activity coefficient (f_{ia}), interaction parameter (β_a) and mole fraction (x_{ia}) of a surfactant corresponding to the adsorbed layer, which are given in chapter 3 (*ca.* Eqs. 3.15 – 3.17). These expressions are reproduced below:

$$f_{ia} = \alpha_{ia} c_{\gamma m} / (x_{ia} c_{i\gamma}) \quad (4.11)$$

$$\beta_a = \ln f_{1a} / (1 - x_{1a})^2 = \ln f_{2a} / x_{1a}^2 \quad (21) \quad (4.12)$$

$$x_{1a}^2 \ln [\alpha_1 c_{\gamma m} / (x_{1a} c_{1\gamma})] = (1 - x_{1a})^2 \ln \{ (1 - \alpha_1) c_{\gamma m} / [(1 - x_{1a}) c_{2\gamma}] \} \quad (4.13)$$

$c_{\gamma m}$, $c_{1\gamma}$ and $c_{2\gamma}$ indicate the concentrations of surfactant mixture, surfactant 1 (AOT) and surfactant 2 (SDS) in the solution corresponding to the chosen value of surface tension of 34 mN m^{-1} . The calculated values of the parameters Γ_{cmc} , x_{ia} , β_a and f_{ia} are given in Table 4.7. Dependence of Γ_{cmc} , x_{1a} and β_a on NaCl concentration are shown in Figs. 4.17, 4.18 and 4.19, respectively. In Fig. 4.18, we have represented x_{1a} as x_{AOT}^{ad} . From Fig. 4.17 it can be seen that Γ_{cmc} increases with the addition of NaCl, which is a general trend observed in single surfactant solutions also and is attributed to the salting-out effect of the added electrolyte. It is evident from Fig. 4.18 that the mole fraction of AOT in the adsorbed layer is more than that in the bulk solution. The variation trends of x_{AOT}^{ad} (Fig. 4.18) and β_a (Fig. 4.19) with NaCl concentration are complex and depend upon the values of α_{AOT} and the concentration of added NaCl. In Fig. 4.17 we have also shown the surface excess values of AOT (Γ_{AOT}) and SDS (Γ_{SDS}) in the mixed systems, which were calculated using the values of Γ_{cmc} and x_{1a} . It is observed that surface excess of the mixture and that of AOT in the mixture increases with added NaCl concentration, but the surface excess of SDS in the mixture either decreases slowly or remains almost invariant with the electrolyte concentration. Thus, the surface excess of the mixed system is controlled by the AOT component and this is considered to be due to the higher surface activity of AOT.

4.4 Conclusions

In aqueous NaCl medium, the AOT + SDS system shows synergism in cmc. The synergism is however is relatively much less in the region where $\alpha_{AOT} \geq 0.7$. Mole fractions of individual surfactants in the mixed micelle were determined

by using the Rubingh's and RVV methods. The micellar composition calculated from both the methods has a complex type of dependence on the added NaCl concentration. The calculated interaction parameter indicates attractive interaction between the two components of the mixed micelle. Added NaCl is found to enhance the attractive interaction between AOT and SDS in the micellar phase. The mixed systems with $\alpha_{\text{AOT}} \geq 0.245$ show two counter ion binding constant values similar to that of AOT. The counter ion binding of the mixed system is controlled by that of AOT indicating that in the Stern layer of the mixed micelle heads of AOT are more exposed. The surface excess of the mixture (Γ_{cmc}) is found to be predominantly due to adsorption of AOT. Thus, in AOT + SDS mixed system, micellar phase and adsorbed layer are enriched with AOT and the counter ion binding behaviour is also controlled by AOT. In AOT + SDS mixtures also the shape of the mixed micelle is expected to change from prolate to rod-type near $0.015 \text{ mol kg}^{-1}$ of NaCl.

4.5 References

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Table 4.1 - Surface Tension (γ) Values of AOT + SDS Systems in Aqueous Sodium Chloride Medium at 298K.

$\alpha_{\text{AOT}} = 0$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
$[\text{NaCl}] = 0 \text{ mol kg}^{-1}$					
0.1642	70.7	4.3354	42.7	8.1403	35.0
0.4367	69.1	4.5834	41.5	8.2537	35.9
0.7075	66.2	4.8300	40.5	8.3670	36.5
0.9767	63.6	5.0752	39.7	8.4799	37.6
1.2442	61.4	5.3190	38.7	8.5925	37.8
1.5102	59.4	5.5615	38.1	8.8169	38.2
1.7746	57.5	5.8024	37.4	9.0398	38.6
2.0375	55.4	6.0421	36.7	9.2617	38.5
2.2988	53.6	6.2806	35.9	9.4824	38.5
2.5586	51.6	6.5175	35.4	9.7017	38.5
2.8169	49.8	6.7532	34.9	9.9202	38.6
3.0736	48.2	6.9876	34.5	10.137	38.6
3.3289	47.0	7.2207	34.1	10.353	38.6
3.5827	45.9	7.4525	33.9	10.568	38.6
3.8350	45.2	7.6830	33.5	10.782	38.5
4.0859	43.9	7.9122	33.4	10.994	38.6
$[\text{NaCl}] = 0.0043 \text{ mol kg}^{-1}$					
0.0037	71.7	1.0691	56.6	5.3793	34.6
0.0074	71.7	1.4074	53.9	5.8511	34.1
0.0148	71.5	1.7372	51.0	6.3035	36.1
0.0222	71.0	2.0589	48.7	6.7375	37.3
0.0370	70.8	2.3728	46.9	7.1543	38.3
0.0739	70.4	2.6790	45.2	7.5549	38.2
0.1475	69.1	3.2699	42.3	8.3113	38.4
0.2206	67.5	3.8337	39.6	9.0130	38.3
0.3657	65.0	4.3721	37.5	10.275	38.4
0.7220	60.4	4.8867	35.7		
$[\text{NaCl}] = 0.0063 \text{ mol kg}^{-1}$					
0.0039	71.5	0.9128	54.7	5.1486	33.5
0.0079	71.3	1.1319	52.5	5.4092	34.8

Table 4.1- Continued

$\alpha_{\text{AOT}} = 0$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0063 mol kg ⁻¹					
0.0157	71.0	1.4895	49.6	5.6640	36.0
0.0236	70.4	1.8378	46.6	6.1570	37.2
0.0392	70.0	2.1772	44.8	6.6290	37.6
0.0784	69.8	2.5080	43.1	7.0816	38.2
0.1563	67.2	2.8306	42.3	7.9325	38.2
0.2338	65.1	3.4523	38.8	8.7183	38.1
0.3876	61.4	4.0445	36.8	10.122	38.0
0.5397	59.0	4.6093	34.8		
0.6901	57.2	4.8820	33.9		
[NaCl] = 0.0085 mol kg ⁻¹					
0.0355	70.7	1.3557	50.9	5.0015	34.8
0.0709	68.8	1.6751	48.6	5.2425	36.1
0.1415	66.8	1.9871	47.0	5.7103	37.2
0.2118	65.3	2.2921	45.3	6.1600	37.9
0.3513	62.2	2.5904	42.9	6.5925	38.0
0.4894	60.2	3.1672	39.6	7.0091	38.1
0.6262	57.9	3.7193	37.6	7.7972	38.1
0.8290	56.0	4.2483	35.5	8.5308	38.2
1.0288	53.7	4.7556	34.3	9.2153	38.2
[NaCl] = 0.0152 mol kg ⁻¹					
0.0707	62.2	2.8290	37.2	5.8348	36.9
0.2353	56.6	3.2714	35.9	6.2463	36.8
0.5482	52.1	3.7096	34.8	6.6563	36.9
1.0147	47.6	4.1431	34.1	6.9154	36.8
1.4755	44.5	4.5722	35.6	7.1832	37.1
1.9312	41.6	4.9972	36.3	7.5931	36.8
2.3825	39.3	5.3117	37.2	7.9849	36.9
[NaCl] = 0.0302 mol kg ⁻¹					
0.0359	64.0	1.2385	42.8	3.7458	36.1
0.0718	63.2	1.4345	41.2	4.2758	36.2
0.1432	60.2	1.6276	40.0	4.7833	36.4

Table 4.1- Continued

$\alpha_{AOT} = 0$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0302 mol kg ⁻¹					
0.2142	57.0	2.0057	37.4	5.7368	36.2
0.3553	53.7	2.3732	35.6	6.6158	36.1
0.4949	51.2	2.7305	34.6	7.8130	36.2
0.6331	49.1	2.9055	34.9	8.8850	36.3
0.8379	46.8	3.0781	35.7		
1.0397	44.5	3.4165	36.2		
[NaCl] = 0.0408 mol kg ⁻¹					
0.0119	70.1	0.5843	48.2	2.5493	35.2
0.0238	68.5	0.7548	45.8	2.7934	35.3
0.0358	67.3	0.9233	43.5	3.0329	35.9
0.0595	65.1	1.1447	41.0	3.4986	35.6
0.1188	61.3	1.3624	38.6	3.9471	35.5
0.1779	58.7	1.5767	37.1	4.7967	35.6
0.2367	56.7	1.7876	35.3	5.5883	35.7
0.3535	53.3	2.0465	33.8	6.3278	35.4
0.4694	50.3	2.3004	34.0		
[NaCl] = 0.0603 mol kg ⁻¹					
0.0114	68.1	0.5586	43.8	2.1106	33.9
0.0228	65.3	0.6677	42.2	2.3527	34.3
0.0341	63.2	0.7760	40.8	2.5904	34.5
0.0569	60.7	0.9368	38.6	3.0530	34.4
0.1135	56.6	1.0958	37.3	3.4995	34.4
0.1699	54.4	1.2530	36.0	3.9306	34.3
0.2261	52.1	1.4083	34.2	4.7497	34.5
0.2821	50.2	1.5620	33.3	6.2348	34.3
0.3370	48.7	1.7138	32.8		
0.4487	46.2	1.8640	33.5		

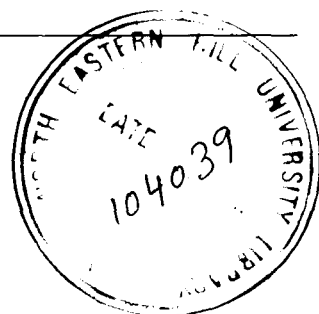


Table 4.1- Continued

$\alpha_{AOT} = 0$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
$[\text{NaCl}] = 0.0797 \text{ mol kg}^{-1}$					
0.0798	53.9	1.1842	35.0	2.2622	34.1
0.2398	48.1	1.3401	34.2	2.4140	34.3
0.3982	44.9	1.4950	34.1	2.5652	34.2
0.5566	42.6	1.6494	34.0	2.7160	34.6
0.7142	40.5	1.8036	33.7	2.8663	34.4
0.8716	38.0	1.9567	34.1		
1.0281	37.2	2.1097	34.2		

Table 4.1- Continued

$\alpha_{AOT} = 0.163$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0 mol kg ⁻¹					
0.0043	71.4	0.2542	60.3	4.3271	33.2
0.0085	71.0	0.3379	57.8	4.9198	33.0
0.0128	70.9	0.5038	55.1	5.4830	32.8
0.0171	70.5	0.6676	52.2	6.0191	33.1
0.0256	70.2	0.8295	50.2	7.0166	33.1
0.0342	69.8	1.2259	46.6	7.9261	33.1
0.0427	69.2	1.6107	43.8	8.7587	33.1
0.0853	66.7	2.3476	40.0	9.8832	33.3
0.1277	65.0	3.0438	37.3	10.881	33.4
0.1700	63.0	3.7027	35.0	11.773	33.4
[NaCl] = 0.0007 mol kg ⁻¹					
0.0043	70.4	0.2556	55.2	4.3490	32.7
0.0086	69.3	0.3397	53.4	4.9445	32.6
0.0129	68.6	0.5064	50.6	5.5102	32.8
0.0172	68.0	0.6712	48.8	6.0487	32.9
0.0258	66.5	0.8339	47.3	7.0507	33.0
0.0343	65.2	1.2323	44.1	7.9642	33.1
0.0429	64.1	1.6191	41.7	8.8001	33.2
0.0857	61.1	2.3597	38.2	9.9293	33.2
0.1284	59.0	3.0594	35.7	10.931	33.4
0.1709	57.6	3.7215	34.0	11.826	33.4
[NaCl] = 0.0010 mol kg ⁻¹					
0.0043	67.8	0.3395	50.6	4.9425	32.2
0.0086	65.7	0.5062	48.7	5.5082	32.4
0.0129	64.6	0.6709	46.7	6.0466	32.7
0.0172	63.6	0.8335	45.5	7.0484	33.0
0.0215	62.8	1.2318	42.5	7.9616	33.0
0.0300	61.5	1.6184	40.4	9.1895	32.9
0.0429	60.4	1.9939	38.6	10.273	33.3

Table 4.1- Continued

$\alpha_{AOT} = 0.163$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0010 mol kg ⁻¹					
0.0857	57.6	2.3587	37.2	11.238	33.4
0.1283	55.8	3.0582	34.9	12.369	33.4
0.1708	54.4	3.7201	33.1		
0.2554	52.1	4.3473	32.3		
[NaCl] = 0.0014 mol kg ⁻¹					
0.0043	69.9	0.3387	51.4	4.9326	32.5
0.0086	68.4	0.5050	49.4	5.4974	32.6
0.0128	67.2	0.6693	47.5	6.0349	32.5
0.0171	65.8	0.8316	45.9	6.5470	32.5
0.0257	64.4	1.2289	43.1	7.5017	32.7
0.0342	63.2	1.6147	40.6	8.3741	32.9
0.0428	62.4	1.9894	39.0	9.5499	33.1
0.0855	59.1	2.3535	37.5	10.591	33.4
0.1280	57.1	3.0515	34.9	11.519	33.4
0.1704	55.6	3.7122	33.2		
0.2548	53.4	4.3383	32.4		
[NaCl] = 0.0018 mol kg ⁻¹					
0.0043	69.4	0.1703	54.4	3.7097	32.6
0.0086	68.2	0.2547	52.1	4.3353	32.1
0.0128	66.6	0.3386	50.0	4.9291	32.1
0.0171	65.5	0.5048	48.0	5.4934	32.5
0.0214	64.6	0.6689	46.1	6.0302	32.4
0.0257	63.8	0.8312	44.7	7.0296	32.5
0.0300	63.2	1.2283	41.7	7.9407	32.8
0.0342	62.7	1.6138	39.6	9.1656	32.8
0.0428	61.6	1.9882	37.8	10.247	32.9
0.0854	58.4	2.3521	36.7	11.209	33.2
0.1279	56.0	3.0496	34.6	12.071	33.2
[NaCl] = 0.0021 mol kg ⁻¹					
0.0043	62.1	0.3377	49.1	4.9195	32.2
0.0085	62.0	0.5035	47.0	5.4830	32.2

Table 4.1- Continued

$\alpha_{AOT} = 0.163$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0021 mol kg ⁻¹					
0.0128	61.9	0.6673	45.4	6.0194	32.4
0.0171	61.3	0.8291	43.8	7.0179	32.7
0.0213	60.7	1.2253	41.3	7.9283	33.1
0.0299	60.0	1.6099	39.3	8.7619	33.1
0.0427	58.6	1.9836	37.7	9.8885	33.1
0.0852	56.0	2.3467	36.2	10.888	33.2
0.1276	54.3	3.0429	34.1	11.781	33.1
0.1699	52.8	3.7019	32.3		
0.2541	50.8	4.3265	32.2		
[NaCl] = 0.0041 mol kg ⁻¹					
0.0043	68.3	0.3398	47.8	4.3504	32.0
0.0086	66.0	0.5065	45.6	4.9461	32.1
0.0129	64.7	0.6713	43.8	5.5123	32.4
0.0172	63.5	0.8341	42.3	6.0510	32.5
0.0215	62.6	1.2326	39.9	7.0536	32.6
0.0258	61.7	1.6195	38.2	7.9676	32.9
0.0344	60.5	1.9952	36.2	9.1967	33.1
0.0429	59.3	2.3603	34.9	10.282	33.2
0.0857	55.6	2.7152	33.7	11.247	33.2
0.1284	53.3	3.0603	32.6	12.379	33.2
0.1709	52.1	3.3959	32.0		
0.2556	49.8	3.7226	32.0		
[NaCl] = 0.0063 mol kg ⁻¹					
0.0043	67.7	0.1699	50.5	3.0418	31.8
0.0085	65.2	0.2541	48.1	3.7002	31.8
0.0128	63.6	0.3377	47.0	4.3241	31.8
0.0171	62.1	0.5035	44.3	4.9163	31.9
0.0213	61.0	0.6672	42.1	5.4791	32.0
0.0256	60.2	0.8290	40.5	6.5247	32.1
0.0299	59.8	1.2251	38.0	7.4757	32.2
0.0341	59.0	1.6097	36.2	8.3447	32.3

Table 4.1- Continued

$\alpha_{AOT} = 0.163$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0063 mol kg ⁻¹					
0.0427	57.9	1.9832	34.3	9.5155	32.4
0.0852	54.2	2.3461	33.2	10.552	32.4
0.1276	51.9	2.6988	32.3		
[NaCl] = 0.0083 mol kg ⁻¹					
0.0043	67.2	0.1707	48.9	3.0549	31.1
0.0086	64.2	0.2552	46.8	3.7159	31.5
0.0129	62.1	0.3392	44.9	4.3424	31.6
0.0172	60.7	0.5057	42.4	4.9370	31.7
0.0214	59.8	0.6702	40.9	5.5019	31.8
0.0257	58.8	0.8327	39.5	6.5515	32.0
0.0300	58.3	1.2305	36.9	7.5060	32.3
0.0343	57.6	1.6168	34.9	8.3780	32.4
0.0429	56.4	1.9918	33.5	9.5530	32.5
0.0856	52.7	2.3562	32.4	10.593	32.5
0.1282	50.3	2.7104	31.2	11.807	32.6
[NaCl] = 0.0128 mol kg ⁻¹					
0.0042	66.3	0.2524	45.4	3.3541	31.1
0.0085	62.9	0.3355	43.6	3.6769	31.1
0.0127	61.1	0.5002	41.4	4.2971	31.1
0.0170	59.6	0.6629	39.5	4.8857	31.4
0.0212	58.9	0.8237	38.0	5.4451	31.7
0.0254	57.7	1.2172	35.6	6.4847	32.0
0.0339	56.3	1.5994	33.8	7.4305	32.2
0.0424	55.1	1.9705	31.9	8.6992	32.3
0.0847	51.5	2.3311	31.1	9.8166	32.3
0.1268	49.2	2.6816	30.8	11.409	32.3
0.1688	48.0	3.0225	30.9		
[NaCl] = 0.0169 mol kg ⁻¹					
0.0043	65.4	0.2534	44.0	3.0345	30.6
0.0085	62.4	0.3369	42.4	3.6914	30.9

Table 4.1- Continued

$\alpha_{AOT} = 0.163$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0169 mol kg ⁻¹					
0.0128	60.5	0.5023	39.7	4.3140	31.2
0.0170	59.1	0.6656	38.2	4.9048	31.4
0.0213	57.9	0.8270	36.6	6.0005	31.6
0.0256	56.9	1.1441	34.3	6.9950	31.7
0.0341	55.4	1.4537	32.7	8.3257	31.9
0.0426	54.4	1.7561	31.5	9.4942	32.0
0.0850	50.3	2.0516	30.5	10.529	32.0
0.1273	48.4	2.3404	30.4		
0.1695	46.5	2.6923	30.6		
[NaCl] = 0.0306 mol kg ⁻¹					
0.0030	65.7	0.1762	42.7	1.9329	29.9
0.0059	62.8	0.2342	40.9	2.2204	30.1
0.0089	60.3	0.3494	38.1	2.6806	30.3
0.0118	58.8	0.4632	36.4	3.1183	30.5
0.0177	56.7	0.5758	35.2	3.5352	30.6
0.0237	55.1	0.7972	32.9	4.3125	30.8
0.0296	53.4	1.0138	31.3	5.0223	31.0
0.0591	50.0	1.2258	30.1	5.9786	31.1
0.0885	47.5	1.4332	29.6	6.8248	31.2
0.1178	45.0	1.6362	29.6		
[NaCl] = 0.0403 mol kg ⁻¹					
0.0027	66.0	0.1583	42.6	1.7524	29.3
0.0053	63.3	0.2105	40.5	2.0160	29.4
0.0080	61.0	0.3142	38.0	2.4396	29.8
0.0106	59.2	0.4168	36.1	2.8444	30.1
0.0159	57.3	0.5184	34.6	3.2317	30.2
0.0212	55.4	0.7186	32.6	3.9580	30.4
0.0265	54.0	0.9148	30.6	4.6265	30.6
0.0530	49.6	1.1073	29.4	5.5350	30.8
0.0794	47.0	1.2960	29.1	6.3464	30.8
0.1058	44.8	1.4812	29.3		

Table 4.1- Continued

$\alpha_{AOT} = 0.163$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0515 mol kg ⁻¹					
0.0028	65.0	0.1674	41.1	1.8445	29.5
0.0056	62.0	0.2226	38.8	2.1204	29.6
0.0084	60.3	0.3320	36.3	2.5628	29.6
0.0112	58.5	0.4404	34.3	2.9846	29.7
0.0169	56.3	0.5476	32.9	3.3873	29.8
0.0225	54.2	0.7586	30.6	4.1401	30.0
0.0281	53.0	0.9652	29.0	4.8302	30.1
0.0561	48.4	1.1676	28.9	5.4652	30.2
0.0840	45.9	1.3659	28.8	6.3279	30.3
0.1119	43.3	1.5602	29.3		

Table 4.1- Continued

$\alpha_{AOT} = 0.245$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0 mol kg ⁻¹					
0.0038	71.4	0.3011	55.1	4.3835	32.5
0.0076	70.6	0.4489	52.5	4.8852	32.4
0.0114	69.5	0.5949	50.1	5.3627	32.3
0.0152	69.1	0.7392	48.5	5.8174	32.6
0.0228	68.0	1.0924	45.2	6.6655	31.9
0.0304	67.3	1.4353	42.9	7.4401	32.4
0.0380	66.5	1.7682	40.8	8.1504	32.4
0.0760	63.5	2.0918	39.3	9.1121	32.5
0.1138	61.3	2.7121	36.5	9.9674	32.5
0.1515	59.6	3.2991	34.6	10.733	32.4
0.2265	57.0	3.8555	32.8		
[NaCl] = 0.0008 mol kg ⁻¹					
0.0038	67.0	0.2278	51.6	3.3152	33.0
0.0077	65.0	0.3028	50.0	3.8738	32.0
0.0115	64.0	0.4514	48.1	4.4038	32.0
0.0153	62.8	0.5982	46.2	4.9074	32.0
0.0191	62.2	0.7432	44.9	5.3864	32.0
0.0268	61.1	1.0982	42.3	6.2778	32.2
0.0383	59.5	1.4428	40.3	7.0901	32.2
0.0764	57.1	1.7774	38.1	7.8334	32.1
0.1144	55.1	2.1025	37.4	8.8371	32.2
0.1523	53.7	2.7256	35.1		
[NaCl] = 0.0011 mol kg ⁻¹					
0.0038	68.6	0.2269	51.8	3.8616	32.0
0.0076	66.2	0.3016	50.4	4.3904	31.9
0.0114	64.8	0.4497	48.1	4.8928	32.0
0.0153	63.7	0.5960	46.2	5.3709	32.0
0.0191	62.7	0.7405	44.9	5.8263	32.0
0.0267	61.6	1.0943	42.4	6.6753	32.0
0.0381	60.1	1.4377	40.3	7.4509	32.0
0.0761	57.3	2.0953	37.2	8.4959	32.1

Table 4.1- Continued

$\alpha_{AOT} = 0.245$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0011 mol kg ⁻¹					
0.1140	55.1	2.7166	35.0		
0.1518	54.0	3.3045	33.0		
[NaCl] = 0.0014 mol kg ⁻¹					
0.0038	66.2	0.2251	50.5	3.2797	32.4
0.0076	64.0	0.2993	49.0	3.8328	31.7
0.0114	62.8	0.4462	47.1	4.3578	31.9
0.0151	62.1	0.5913	45.3	4.8568	31.8
0.0189	61.2	0.7347	44.0	5.3316	31.9
0.0265	60.1	1.0858	41.5	5.7840	32.0
0.0378	58.7	1.4266	39.4	6.6274	32.0
0.0755	55.8	1.7576	37.7	7.3979	32.1
0.1131	54.2	2.0793	36.4	8.4366	32.0
0.1506	52.7	2.6960	34.3		
[NaCl] = 0.0019 mol kg ⁻¹					
0.0038	68.3	0.2275	51.0	3.3121	32.3
0.0077	65.7	0.3024	49.4	3.8703	31.7
0.0115	64.6	0.4508	47.5	4.4000	31.9
0.0153	63.4	0.5975	45.7	4.9033	32.0
0.0191	62.3	0.7424	44.1	5.3822	31.9
0.0268	61.0	1.0970	41.4	5.8383	31.9
0.0382	59.3	1.4412	39.4	6.6887	32.0
0.0763	56.4	1.7755	37.8	7.4652	32.0
0.1143	54.7	2.1003	37.0	8.5116	32.0
0.1521	53.3	2.723	34.4	3.3121	32.3
[NaCl] = 0.0021 mol kg ⁻¹					
0.0038	64.2	0.2264	48.8	3.2983	31.9
0.0076	62.0	0.3010	47.2	3.8545	31.7
0.0114	61.2	0.4488	45.2	4.3825	31.7
0.0152	59.9	0.5947	43.4	4.8842	31.8
0.0190	59.4	0.7389	42.2	5.3615	32.0
0.0266	58.1	1.0920	39.6	6.2501	32.0

Table 4.1- Continued

$\alpha_{AOT} = 0.245$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0021 mol kg ⁻¹					
0.0380	56.9	1.4348	37.8	7.0602	32.0
0.0759	54.4	1.7677	36.7	7.8019	32.0
0.1137	52.4	2.0912	35.1		
0.1514	50.8	2.7114	33.4		
[NaCl] = 0.0042 mol kg ⁻¹					
0.0038	67.6	0.2273	48.4	2.7201	32.2
0.0076	65.1	0.3021	47.0	3.0184	31.5
0.0115	63.0	0.4504	44.9	3.3086	31.4
0.0153	61.6	0.5969	43.0	3.8662	31.3
0.0191	60.6	0.7416	41.6	4.3952	31.4
0.0267	59.2	1.0959	39.1	4.8979	31.6
0.0382	57.5	1.4397	36.9	5.8318	31.7
0.0762	54.1	1.7737	35.7	6.6810	32.0
0.1142	52.2	2.0981	34.2	7.8197	32.1
0.1520	50.7	2.4135	33.4	8.8221	32.1
[NaCl] = 0.0064 mol kg ⁻¹					
0.0038	65.1	0.1516	48.6	2.4074	31.8
0.0076	62.1	0.2267	46.2	2.7133	31.0
0.0114	60.6	0.3013	45.0	3.0109	31.0
0.0152	59.0	0.4492	42.5	3.3004	31.1
0.0191	58.2	0.5953	41.1	3.8567	31.1
0.0229	57.3	0.7396	39.8	4.3847	31.0
0.0267	56.6	1.0930	37.3	4.8864	31.2
0.0381	54.8	1.4360	35.4	5.8185	31.3
0.0760	51.9	1.7691	33.9	7.0617	31.5
0.1139	50.2	2.0928	33.1	8.1502	31.5
[NaCl] = 0.0085 mol kg ⁻¹					
0.0038	63.7	0.1513	47.5	2.7096	30.7
0.0076	61.0	0.2263	45.3	3.0068	30.6
0.0114	59.3	0.3008	43.5	3.2961	30.6
0.0152	58.0	0.4485	41.7	3.8519	30.6

Table 4.1- Continued

$\alpha_{AOT} = 0.245$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0085 mol kg ⁻¹					
0.0190	57.2	0.5944	40.0	4.3796	30.9
0.0228	56.5	0.7385	38.6	4.8808	31.0
0.0266	55.8	1.0914	36.2	5.8123	31.2
0.0304	55.1	1.4339	34.3	6.6596	31.0
0.0380	54.0	1.7666	33.0	7.4336	31.1
0.0759	50.9	2.0899	31.6	8.4768	31.1
0.1137	49.0	2.4041	30.6		
[NaCl] = 0.0143 mol kg ⁻¹					
0.0025	64.2	0.1953	43.7	2.1120	29.9
0.0049	61.4	0.2918	41.3	2.3955	29.8
0.0074	59.5	0.3875	39.6	2.7881	30.1
0.0098	58.6	0.4824	38.4	3.1669	30.0
0.0148	57.0	0.6701	36.5	3.5325	30.2
0.0197	55.4	0.8548	34.9	4.2270	30.5
0.0246	54.3	1.0366	33.4	4.8764	30.6
0.0491	51.0	1.2157	32.3	5.7752	30.7
0.0736	49.3	1.3919	31.5	6.5945	30.7
0.0980	48.0	1.6086	30.6	7.5800	30.8
0.1468	45.2	1.8211	30.0	8.4614	31.2
[NaCl] = 0.0211 mol kg ⁻¹					
0.0025	66.3	0.1517	44.3	1.8353	29.4
0.0051	63.2	0.2017	42.2	2.2382	29.7
0.0076	61.6	0.3009	40.4	2.6218	29.9
0.0102	60.1	0.3990	38.5	2.9876	30.0
0.0153	58.0	0.4961	36.9	3.3368	30.1
0.0204	55.7	0.7342	34.6	3.9895	30.1
0.0255	54.3	0.9660	32.8	4.8687	30.0
0.0508	50.3	1.1918	31.0	5.6464	30.3
0.0762	48.0	1.4118	29.9	6.5536	30.7
0.1014	46.8	1.6263	29.7		

Table 4.1- Continued

$\alpha_{AOT} = 0.245$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0308 mol kg ⁻¹					
0.0025	65.3	0.1481	42.9	1.7150	29.2
0.0050	62.5	0.1970	40.9	2.0361	29.3
0.0075	60.3	0.2939	38.5	2.4205	29.5
0.0099	58.1	0.3897	37.0	2.7872	29.5
0.0149	56.0	0.4846	35.3	3.2732	29.6
0.0199	53.6	0.6714	33.2	3.9171	29.8
0.0249	52.4	0.8543	31.6	4.7865	30.1
0.0496	48.6	1.0335	30.3	5.5573	30.3
0.0744	46.5	1.2090	29.2	6.4588	30.5
0.0990	44.9	1.3811	29.1		
[NaCl] = 0.0397 mol kg ⁻¹					
0.0024	64.8	0.1449	42.0	1.6809	28.8
0.0049	61.6	0.1927	40.0	1.9963	28.8
0.0073	59.6	0.2876	37.5	2.3741	28.9
0.0097	57.8	0.3814	35.6	2.7350	29.0
0.0146	56.0	0.4743	33.9	3.0799	29.1
0.0195	53.6	0.6572	31.9	3.7260	29.2
0.0243	52.2	0.8365	30.1	4.3197	29.4
0.0486	47.7	1.0121	28.7	5.3734	29.6
0.0727	46.1	1.1843	28.7	6.4874	29.8
0.0969	43.8	1.3531	28.7		
[NaCl] = 0.0505 mol kg ⁻¹					
0.0025	63.0	0.1972	38.3	1.7985	28.5
0.0050	60.3	0.2943	35.6	2.1945	28.7
0.0075	58.8	0.3903	34.1	2.5719	28.9
0.0100	56.7	0.4853	32.6	2.9321	29.1
0.0149	54.2	0.6259	30.8	3.6055	29.5

Table 4.1- Continued

$\alpha_{AOT} = 0.245$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
$[\text{NaCl}] = 0.0505 \text{ mol kg}^{-1}$					
0.0199	52.1	0.7643	29.4	4.2225	29.4
0.0249	50.6	0.9006	28.4	5.0570	29.3
0.0497	46.5	1.0348	28.2	5.7986	29.6
0.0745	44.4	1.1669	28.4	6.4619	29.8
0.0991	42.5	1.3827	28.7		
0.1483	40.2	1.5932	28.4		

Table 4.1- Continued

$\alpha_{AOT} = 0.393$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0 mol kg ⁻¹					
0.0030	71.3	0.2340	56.5	3.4050	32.4
0.0059	71.0	0.3489	53.5	3.7946	32.2
0.0089	70.8	0.4623	51.1	4.1652	31.9
0.0118	70.2	0.5744	49.1	4.5183	31.8
0.0177	69.5	0.8488	45.9	5.1765	31.6
0.0237	68.9	1.1152	43.7	5.7776	31.4
0.0296	68.2	1.3739	41.3	6.3289	31.3
0.0590	65.4	1.6253	39.9	7.0749	31.4
0.0884	63.5	2.1071	37.3	7.7384	31.3
0.1177	61.1	2.5631	35.6	8.3322	31.2
0.1760	58.4	2.9951	33.8		
[NaCl] = 0.0006 mol kg ⁻¹					
0.0030	68.5	0.1762	51.5	2.5658	33.4
0.0059	66.0	0.2342	50.3	2.9983	32.5
0.0089	64.5	0.3492	47.9	3.4087	31.4
0.0118	64.0	0.4628	46.3	3.7987	31.4
0.0148	62.7	0.5750	45.0	4.1697	31.4
0.0207	61.5	0.8497	42.3	4.8603	31.5
0.0296	60.2	1.1164	40.4	5.4896	31.4
0.0591	57.0	1.3754	38.6	6.0657	31.5
0.0885	55.2	1.6270	37.3	6.8435	31.4
0.1178	53.9	2.1094	35.0		
[NaCl] = 0.0008 mol kg ⁻¹					
0.0030	68.0	0.1770	51.1	2.5758	33.5
0.0059	65.6	0.2352	49.5	3.0097	32.1
0.0089	64.2	0.3507	47.3	3.4215	31.4
0.0119	63.0	0.4648	46.0	3.8128	31.1
0.0149	62.3	0.5774	44.2	4.1849	31.0
0.0208	60.9	0.8533	42.1	4.8774	31.1
0.0297	59.6	1.1210	40.0	5.5086	31.0
0.0594	56.3	1.3810	38.1	6.0860	31.1

Table 4.1- Continued

$\alpha_{AOT} = 0.393$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0008 mol kg ⁻¹					
0.0889	54.8	1.6336	37.0		
0.1183	53.2	2.1177	35.1		
[NaCl] = 0.0010 mol kg ⁻¹					
0.0030	67.1	0.1771	50.4	2.1189	34.3
0.0060	64.7	0.2353	48.6	2.5773	32.9
0.0089	63.3	0.3509	46.5	3.0115	31.7
0.0119	62.4	0.4650	44.9	3.4237	31.2
0.0149	61.5	0.5777	43.5	3.8152	31.2
0.0208	59.9	0.8537	41.1	4.1877	30.9
0.0297	58.5	1.1215	39.1	4.8809	31.1
0.0594	55.3	1.3817	37.6	5.5126	31.0
0.0889	53.9	1.6344	36.5	6.0907	30.9
0.1184	52.4	1.8800	35.5		
[NaCl] = 0.0014 mol kg ⁻¹					
0.0030	68.8	0.1775	49.7	2.1237	33.9
0.0060	65.4	0.2359	48.0	2.5830	32.2
0.0089	63.7	0.3517	46.1	3.0182	31.5
0.0119	62.7	0.4661	44.1	3.4311	31.1
0.0149	61.5	0.5791	43.3	3.8235	31.0
0.0209	60.2	0.8557	40.6	4.5522	31.1
0.0298	58.7	1.1242	38.8	5.2148	31.0
0.0595	55.7	1.3849	37.2	5.8200	31.1
0.0891	53.6	1.6382	35.8		
0.1187	52.0	1.8843	34.5		
[NaCl] = 0.0018 mol kg ⁻¹					
0.0030	67.2	0.1777	49.3	2.1262	33.8
0.0060	64.3	0.2362	47.9	2.5859	32.2
0.0090	63.1	0.3521	45.6	3.0216	31.1
0.0119	61.9	0.4666	44.0	3.4349	31.1
0.0149	61.1	0.5798	42.4	3.8276	30.9
0.0209	59.8	0.8567	40.3	4.2012	31.1

Table 4.1- Continued

$\alpha_{\text{AOT}} = 0.393$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0018 mol kg ⁻¹					
0.0298	57.9	1.1255	38.3	4.5570	31.0
0.0596	54.9	1.3865	36.8	5.2201	31.0
0.0893	53.0	1.6401	35.6	5.8256	31.1
0.1188	51.5	1.8866	34.7		
[NaCl] = 0.0021 mol kg ⁻¹					
0.0030	66.4	0.1767	48.6	2.1145	33.5
0.0059	63.7	0.2348	47.1	2.5719	31.8
0.0089	62.2	0.3501	44.9	3.0054	30.9
0.0119	60.9	0.4640	43.2	3.4167	31.0
0.0148	59.8	0.5765	41.8	3.8076	30.8
0.0208	58.7	0.8518	40.0	4.5337	30.7
0.0297	57.4	1.1191	37.8	5.1939	30.9
0.0592	54.2	1.3788	36.7	6.0792	30.8
0.0887	52.1	1.6309	35.2		
0.1181	50.8	1.8761	34.2		
[NaCl] = 0.0042 mol kg ⁻¹					
0.0030	66.1	0.1185	48.9	1.6360	33.4
0.0060	63.1	0.1772	46.9	1.8818	32.4
0.0089	61.6	0.2356	45.1	2.1208	31.5
0.0119	59.7	0.3512	43	2.3533	30.7
0.0149	58.9	0.4655	41.3	2.5795	30.6
0.0208	57.2	0.5783	40.1	3.0140	30.5
0.0298	55.7	0.8546	38.0	3.4263	30.1
0.0594	52.8	1.1227	36.0	4.1906	30.2
0.0890	50.5	1.3831	34.6	4.8839	30.1
[NaCl] = 0.0063 mol kg ⁻¹					
0.0030	65.5	0.0889	49.1	1.6347	32.5
0.0060	62.5	0.1184	47.6	1.8804	31.4
0.0089	60.4	0.1771	45.6	2.1192	30.7
0.0119	59.1	0.2354	43.9	2.3516	30.1
0.0149	58.0	0.3509	41.7	2.5777	30.2

Table 4.1- Continued

$\alpha_{AOT} = 0.393$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0063 mol kg ⁻¹					
0.0179	57.3	0.4651	40.1	3.0121	30.2
0.0208	56.3	0.5778	38.8	3.4243	30.1
0.0238	55.7	0.8538	36.4	4.1884	30.0
0.0297	54.7	1.1218	34.6	4.8817	30.1
0.0594	51.1	1.3819	33.5		
[NaCl] = 0.0085 mol kg ⁻¹					
0.0030	62.6	0.0888	47.8	1.6325	31.4
0.0059	59.9	0.1183	46.2	1.8778	30.5
0.0089	58.6	0.1768	44.2	2.1164	29.8
0.0119	56.8	0.2351	42.8	2.3484	29.8
0.0149	56.0	0.3504	40.5	2.5742	29.8
0.0178	55.0	0.4644	38.7	3.0081	29.8
0.0208	54.5	0.5770	37.6	3.4197	29.9
0.0238	53.9	0.8527	35.3	4.1829	29.8
0.0297	52.6	1.1202	33.7		
0.0593	49.5	1.3801	32.5		
[NaCl] = 0.0206 mol kg ⁻¹					
0.0020	62.4	0.0779	45.4	1.0852	30.2
0.0039	59.6	0.1165	43.5	1.4110	28.9
0.0059	57.7	0.1550	41.6	1.7210	28.6
0.0078	56.6	0.2312	39.6	2.0163	28.8
0.0117	54.7	0.3066	37.7	2.5669	28.6
0.0156	53.3	0.3812	36.6	3.0699	28.7
0.0196	52.2	0.5642	34.3	3.7477	28.8
0.0391	49.2	0.7424	32.6	4.3476	28.7
0.0585	47.0	0.9160	31.3	4.8824	28.9
[NaCl] = 0.0319 mol kg ⁻¹					
0.0020	63.5	0.1216	41.5	1.4014	28.0
0.0041	60.6	0.1617	39.5	1.6621	28.2
0.0061	58.4	0.2412	37.2	1.9126	28.1
0.0082	56.9	0.3198	35.6	2.2120	28.2

Table 4.1- Continued

$\alpha_{AOT} = 0.393$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0319 mol kg ⁻¹					
0.0122	54.5	0.3975	34.2	2.4973	28.2
0.0163	52.6	0.5503	32.3	2.7695	28.3
0.0204	51.5	0.6999	30.4	3.2779	28.4
0.0408	47.6	0.8462	29.4	3.7433	28.5
0.0611	45.4	0.9895	28.4		
0.0813	43.8	1.1297	28.0		
[NaCl] = 0.0405 mol kg ⁻¹					
0.0020	63.0	0.1218	40.0	1.4051	27.6
0.0041	59.8	0.1619	38.0	1.6670	27.6
0.0061	58.1	0.2416	35.8	1.9185	27.7
0.0082	56.1	0.3203	34.1	2.2195	27.7
0.0123	54.0	0.3982	32.9	2.5063	27.7
0.0164	52.4	0.5514	30.7	2.7802	27.8
0.0204	51.0	0.7014	28.8	3.2918	27.9
0.0408	46.8	0.8481	28.3	3.7608	28.3
0.0612	44.5	0.9917	27.9		
0.0814	42.4	1.1324	27.7		
[NaCl] = 0.0503 mol kg ⁻¹					
0.0019	63.7	0.1158	39.5	1.3350	27.5
0.0039	60.8	0.1540	37.6	1.5835	27.4
0.0058	59.0	0.2297	34.7	1.8221	27.7
0.0078	56.5	0.3046	33.5	2.1075	27.6
0.0117	54.2	0.3786	31.9	2.3794	27.5
0.0156	51.8	0.5242	30.0	2.6388	27.6
0.0194	50.2	0.6667	28.6	3.1234	27.7
0.0388	46.2	0.8061	27.6	3.5671	27.7
0.0582	43.6	0.9425	27.3		
0.0774	41.3	1.0761	27.3		

Table 4.1- Continued

$\alpha_{AOT} = 0.500$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0 mol kg ⁻¹					
0.0034	71.1	0.2042	56.1	2.9745	32.8
0.0069	70.8	0.2714	53.8	3.4762	31.9
0.0103	70.3	0.4047	51.3	3.9525	31.6
0.0137	69.3	0.5363	48.7	4.4050	31.3
0.0206	68.4	0.6663	46.9	4.8357	31.3
0.0274	67.7	0.9847	43.2	5.2461	31.2
0.0343	67.0	1.2938	40.6	6.0112	31.0
0.0685	63.9	1.5941	38.3	6.7101	30.9
0.1026	61.7	1.8858	37.1	7.3512	30.8
0.1365	59.5	2.4452	34.9	8.2192	30.7
[NaCl] = 0.0005 mol kg ⁻¹					
0.0035	68.2	0.1376	51.6	1.9000	35.0
0.0069	65.3	0.2058	49.2	2.1857	34.1
0.0104	63.7	0.2735	47.8	2.4635	33.2
0.0138	62.4	0.4078	45.6	2.9967	31.2
0.0173	61.3	0.5404	44.2	3.5020	31.0
0.0242	59.8	0.6714	42.8	3.9816	30.7
0.0346	58.6	0.9922	40.1	4.8710	30.6
0.0690	55.0	1.3036	38.0	5.6782	30.7
0.1034	53.3	1.6061	36.4	6.758	30.6
[NaCl] = 0.0008 mol kg ⁻¹					
0.0035	67.8	0.2057	49.4	2.4625	32.7
0.0069	65.5	0.2735	48.0	2.7326	31.5
0.0104	63.9	0.4077	45.7	2.9954	31.2
0.0138	62.5	0.5403	44.1	3.5003	30.6
0.0173	61.5	0.6713	42.8	3.9796	30.6
0.0242	59.8	0.9920	40.1	4.4350	30.7
0.0346	58.4	1.3033	37.9	5.2809	30.4
0.0690	55.3	1.6056	36.2	6.0503	30.4
0.1033	53.1	1.8994	35.0	7.0822	30.4
0.1376	51.8	2.1849	33.5	7.9906	30.3

Table 4.1- Continued

$\alpha_{\text{AOT}} = 0.500$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0010 mol kg ⁻¹					
0.0035	66.2	0.1380	51.1	1.9046	34.9
0.0069	64.1	0.2063	49.6	2.1908	33.4
0.0104	62.3	0.2743	48.0	2.4691	32.3
0.0139	61.7	0.4089	46.0	2.7397	31.4
0.0173	60.2	0.5419	44.1	3.0030	31.1
0.0243	59.4	0.6733	42.7	3.5090	30.7
0.0347	57.6	0.9949	40.3	3.9891	30.7
0.0692	54.6	1.3070	37.9	4.4451	30.6
0.1037	52.7	1.6101	36.0	5.2922	30.6
[NaCl] = 0.0014 mol kg ⁻¹					
0.0035	61.8	0.1375	48.8	1.8988	33.3
0.0069	59.9	0.2057	46.9	2.1841	32.2
0.0104	58.7	0.2734	45.5	2.4616	31.2
0.0138	57.7	0.4076	43.2	2.7315	30.6
0.0173	57.1	0.5402	41.8	2.9941	30.5
0.0242	55.9	0.6711	40.4	3.4986	30.7
0.0345	54.6	0.9917	38.1	3.9774	30.5
0.0690	52.1	1.3029	36.2	4.8651	30.7
0.1033	50.3	1.6052	34.9	5.6705	30.6
[NaCl] = 0.0018 mol kg ⁻¹					
0.0035	65.5	0.1375	49.7	1.8981	33.4
0.0069	62.6	0.2056	47.4	2.1834	32.3
0.0104	60.9	0.2733	46.0	2.4608	31.2
0.0138	59.8	0.4075	43.9	2.7307	30.5
0.0173	58.7	0.5400	42.2	2.9932	30.6
0.0242	57.5	0.6709	41.1	3.4977	30.5
0.0345	56.0	0.9914	38.4	3.9764	30.6
0.0690	52.9	1.3025	36.4	4.8640	30.4
0.1033	51.0	1.6046	34.8	5.6693	30.5

Table 4.1- Continued

$\alpha_{AOT} = 0.500$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0021 mol kg ⁻¹					
0.0034	64.9	0.1371	49.7	1.8929	33.3
0.0069	62.1	0.2050	47.6	2.1774	32.3
0.0103	60.6	0.2725	45.9	2.4540	31.2
0.0138	59.2	0.4063	43.8	2.9850	30.6
0.0172	58.5	0.5385	42.1	3.4881	30.6
0.0241	57.1	0.6690	40.7	4.4192	30.2
0.0344	55.8	0.9886	38.3	5.2620	30.1
0.0688	53.0	1.2989	36.3	6.3862	30.0
0.1030	50.8	1.6001	35.0		
[NaCl] = 0.0042 mol kg ⁻¹					
0.0035	64.2	0.1379	47.5	1.9038	31.5
0.0069	61.3	0.2063	45.0	2.1898	30.6
0.0104	59.0	0.2742	43.6	2.4680	29.9
0.0139	57.8	0.4087	41.6	3.0017	29.8
0.0173	57.1	0.5417	39.8	3.9872	29.8
0.0243	55.4	0.6730	38.6	4.8767	29.6
0.0346	53.9	0.9944	35.9	6.0595	29.6
0.0692	50.8	1.3064	34.1		
0.1036	49.0	1.6094	32.5		
[NaCl] = 0.0064 mol kg ⁻¹					
0.0035	62.6	0.1030	47.0	1.8938	30.0
0.0069	59.4	0.1372	45.6	2.1784	29.4
0.0103	57.5	0.2051	43.4	2.4552	29.5
0.0138	56.2	0.2727	42.2	2.7245	29.3
0.0172	55.4	0.4065	39.7	2.9864	29.4
0.0207	54.4	0.5387	38.1	3.4898	29.1
0.0241	53.6	0.6693	36.8	3.9675	29.4
0.0276	53.1	0.9891	34.4	4.8532	29.4
0.0345	52.0	1.2995	32.1		
0.0688	49.0	1.6009	31.2		

Table 4.1- Continued

$\alpha_{AOT} = 0.500$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0084 mol kg ⁻¹					
0.0035	61.0	0.0691	48.2	1.3057	31.4
0.0069	57.8	0.1036	45.7	1.6086	30.1
0.0104	56.2	0.1379	44.5	1.9027	29.1
0.0139	54.7	0.2061	42.4	2.1887	29.0
0.0173	53.9	0.2740	41.0	2.4667	28.8
0.0208	53.1	0.4085	38.6	3.0001	29.0
0.0242	52.3	0.5414	36.8	3.5056	28.9
0.0277	51.9	0.6726	35.6	4.4408	29.0
0.0346	50.8	0.9939	33.2		
[NaCl] = 0.0141 mol kg ⁻¹					
0.0015	64.3	0.0911	45.0	1.5686	28.8
0.0031	61.7	0.1211	43.7	1.7864	28.8
0.0046	59.5	0.1807	41.6	1.9940	28.7
0.0061	58.4	0.2396	40.1	2.1922	28.7
0.0092	56.3	0.2978	38.7	2.5627	28.6
0.0122	54.8	0.4406	36.4	2.9022	28.6
0.0153	53.7	0.5795	34.6	3.3616	28.7
0.0305	50.4	0.8463	32.8	3.7698	28.8
0.0458	48.7	1.0995	30.8	4.8539	29.0
0.0609	47.0	1.3399	29.6		
[NaCl] = 0.0204 mol kg ⁻¹					
0.0015	65.3	0.0920	43.4	1.5820	27.9
0.0031	62.5	0.1223	42.1	1.8013	28.2
0.0046	59.9	0.1824	40.1	2.0104	27.7
0.0062	58.4	0.2419	38.0	2.2099	28.0
0.0093	56.2	0.3006	37.0	2.5827	28.1
0.0124	54.5	0.4447	34.6	2.9242	28.0
0.0154	53.1	0.5849	32.5	3.3858	27.9
0.0308	49.7	0.8540	30.7	3.7959	28.0
0.0462	47.4	1.1092	28.9	4.3861	28.2
0.0615	45.8	1.3515	28.1		

Table 4.1- Continued

$\alpha_{AOT} = 0.500$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0249 mol kg ⁻¹					
0.0015	65.5	0.1225	41.0	1.5858	27.9
0.0031	62.6	0.1828	39.0	1.8058	27.5
0.0046	60.1	0.2423	37.6	2.0156	28.0
0.0062	58.1	0.3012	36.4	2.4071	27.8
0.0093	55.7	0.4456	33.8	2.7651	27.9
0.0124	54.0	0.5860	32.3	3.2482	27.8
0.0155	52.9	0.7227	30.8	3.9358	28.0
0.0309	49.2	0.8558	29.8	4.5085	28.1
0.0463	47.2	0.9854	28.8	5.4078	28.0
0.0616	45.2	1.1117	28.4		
0.0922	42.9	1.3547	28.0		
[NaCl] = 0.0333 mol kg ⁻¹					
0.0035	60.8	0.1035	40.6	1.6071	26.9
0.0069	56.6	0.1377	39.1	1.9010	27.2
0.0104	54.0	0.2060	36.8	2.4643	27.2
0.0139	52.2	0.2738	34.7	2.9972	27.1
0.0173	50.6	0.4082	32.4	3.5020	27.1
0.0208	49.6	0.5409	30.6	4.4361	27.0
0.0277	47.9	0.6720	29.5	5.2812	27.0
0.0346	46.7	0.9930	27.4	6.0495	27.1
0.0691	42.9	1.3046	27.2	7.0796	27.2
[NaCl] = 0.0514 mol kg ⁻¹					
0.0013	63.5	0.0800	40.4	0.9754	26.5
0.0027	60.4	0.1064	38.9	1.1918	26.5
0.0040	58.7	0.1588	36.3	1.3986	26.4
0.0054	56.6	0.2106	35.1	1.5965	26.5
0.0081	54.3	0.2620	33.8	1.9677	26.4
0.0107	52.2	0.3882	31.0	2.3094	26.5
0.0134	50.9	0.5113	29.3	2.7738	26.4
0.0268	46.8	0.6315	27.9	3.1888	26.5
0.0401	44.6	0.7489	27.1		
0.0535	42.5	0.8635	26.7		

Table 4.1- Continued

$\alpha_{AOT} = 0.648$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0 mol kg ⁻¹					
0.0030	71.1	0.1812	55.6	3.0840	31.8
0.0061	70.2	0.2408	53.5	3.5064	31.3
0.0091	69.8	0.3590	50.6	3.9079	31.1
0.0122	68.5	0.4758	48.5	4.2898	31.1
0.0183	68.0	0.5912	46.2	4.6538	31.1
0.0244	67.0	0.8737	43.0	5.3324	30.8
0.0304	66.2	1.1479	40.7	5.9522	30.5
0.0608	63.0	1.6731	37.2	6.7878	30.4
0.0910	60.5	2.1694	34.7	7.5275	30.4
0.1212	58.9	2.6389	33.0		
[NaCl] = 0.0008 mol kg ⁻¹					
0.0031	67.6	0.1820	49.6	2.6497	31.7
0.0061	65.0	0.2419	47.8	3.0964	30.8
0.0092	63.1	0.3606	45.7	3.5205	30.8
0.0122	62.6	0.4779	43.6	3.9234	30.5
0.0153	61.2	0.5937	42.2	4.3067	30.4
0.0214	59.8	0.8774	39.9	4.6719	30.4
0.0306	58.2	1.1528	37.8	5.3528	30.3
0.0610	55.2	1.4202	36.4	5.9748	30.1
0.0914	53.1	1.6801	35.1	6.8129	29.9
0.1217	51.9	2.1783	33.1		
[NaCl] = 0.0010 mol kg ⁻¹					
0.0031	65.4	0.1814	48.3	2.6417	31.3
0.0061	63.2	0.2411	46.8	3.0872	30.9
0.0091	61.3	0.3594	44.2	3.5101	30.6
0.0122	60.1	0.4763	42.9	3.9119	30.5
0.0152	59.5	0.5918	41.5	4.2944	30.3
0.0213	58.2	0.8746	39.5	4.6586	30.2
0.0305	56.7	1.1492	37.3	5.3379	30.1
0.0608	53.6	1.4158	36.0	5.9584	29.9

Table 4.1- Continued

$\alpha_{AOT} = 0.648$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0010 mol kg ⁻¹					
0.0911	51.8	1.6749	34.7	6.7947	29.7
0.1213	50.2	2.1717	32.6		
[NaCl] = 0.0014 mol kg ⁻¹					
0.0030	61.4	0.1812	46.8	2.6401	31.1
0.0061	60.2	0.2409	45.2	3.0855	30.6
0.0091	58.7	0.3591	43.4	3.5083	30.4
0.0122	57.9	0.4759	42.2	3.9102	30.3
0.0152	57.2	0.5913	40.7	4.2926	30.2
0.0213	56.1	0.8739	38.4	5.0045	30.1
0.0304	54.8	1.1483	36.4	5.6535	30.0
0.0608	51.8	1.4148	34.8	6.5265	29.8
0.0910	49.9	1.6737	33.9	2.6401	31.1
0.1212	48.6	2.1702	31.9	3.0855	30.6
[NaCl] = 0.0018 mol kg ⁻¹					
0.0031	64.7	0.1217	49.4	2.1789	31.7
0.0061	62.0	0.1820	47.4	2.6505	30.8
0.0092	60.2	0.2419	46.0	3.0974	30.5
0.0122	59.2	0.3606	43.7	3.5216	30.4
0.0153	58.2	0.4779	42.2	3.9247	30.2
0.0184	57.6	0.5938	40.7	4.6738	29.7
0.0245	56.5	0.8776	38.1	5.3551	29.7
0.0306	55.7	1.1530	36.2	6.2690	29.6
0.0610	52.9	1.4205	35.0	7.0738	29.5
0.0914	50.7	1.6805	33.7		
[NaCl] = 0.0021 mol kg ⁻¹					
0.0030	65.4	0.1209	48.9	2.1652	31.3
0.0061	62.6	0.1808	46.6	2.6338	30.3
0.0091	61.0	0.2404	45.5	3.0780	30.2
0.0122	59.7	0.3584	43.1	3.4995	30.0
0.0152	58.4	0.4749	41.6	3.9001	30.0
0.0182	57.8	0.5901	40.1	4.6445	29.8

Table 4.1- Continued

$\alpha_{\text{AOT}} = 0.648$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0021 mol kg ⁻¹					
0.0243	56.3	0.8720	37.9	5.3216	29.7
0.0304	55.2	1.1458	36.0	6.2297	29.5
0.0607	52.4	1.4116	34.5	7.0296	29.5
0.0908	50.5	1.6699	33.2		
[NaCl] = 0.0041 mol kg ⁻¹					
0.0031	63.3	0.1215	46.5	1.9292	30.6
0.0061	60.2	0.1816	45.0	2.1744	30.0
0.0092	58.3	0.2414	44.0	2.6450	29.7
0.0122	57.5	0.3599	41.0	3.0909	29.4
0.0153	56.1	0.4770	39.6	3.5141	29.3
0.0183	55.2	0.5927	37.9	3.9163	29.3
0.0244	54.4	0.8758	35.9	4.6636	29.2
0.0305	53.1	1.1507	34.2	5.3433	29.2
0.0609	50.1	1.4177	32.7	6.2549	29.1
0.0912	47.9	1.6771	31.6		
[NaCl] = 0.0063 mol kg ⁻¹					
0.0031	61.0	0.0912	47.0	1.6769	30.4
0.0061	58.5	0.1214	45.5	1.9291	29.5
0.0092	56.6	0.1816	43.5	2.1743	29.4
0.0122	55.4	0.2414	41.9	2.6448	29.0
0.0153	54.5	0.3599	39.5	3.0909	28.9
0.0183	53.5	0.4769	38.0	3.5141	28.8
0.0214	53.0	0.5926	36.6	4.2991	28.7
0.0244	52.5	0.8757	34.3	5.0116	28.7
0.0305	51.5	1.1506	32.8	5.9647	28.6
0.0609	48.2	1.4176	31.2		
[NaCl] = 0.0083 mol kg ⁻¹					
0.0031	61.5	0.1218	44.4	1.9346	28.8
0.0061	58.2	0.1821	41.9	2.1804	28.4
0.0092	56.3	0.2421	40.6	2.6522	28.5
0.0122	54.8	0.3610	38.4	3.0993	28.6

Table 4.1- Continued

$\alpha_{AOT} = 0.648$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0083 mol kg ⁻¹					
0.0153	53.9	0.4784	36.7	3.5236	28.4
0.0184	52.9	0.5944	35.4	4.3104	28.3
0.0214	52.1	0.8783	33.4	5.0245	28.2
0.0306	50.9	1.1540	31.5	5.9794	28.2
0.0611	47.5	1.4216	30.0	6.818	28.1
0.0915	45.5	1.6817	29.1		
[NaCl] = 0.0144 mol kg ⁻¹					
0.0011	65.4	0.0870	43.8	1.4395	27.9
0.0022	62.6	0.1298	41.7	1.7212	27.9
0.0033	61.1	0.1721	40.3	1.9794	27.8
0.0044	59.4	0.2140	39.0	2.4362	27.5
0.0066	57.0	0.3167	37.1	2.8278	27.7
0.0088	55.5	0.4167	35.2	3.2450	27.7
0.0110	54.5	0.6090	32.6	3.5992	27.6
0.0219	50.7	0.7917	31.2	3.959	27.6
0.0329	48.9	0.9655	30.1	4.2636	27.5
0.0437	47.2	1.1310	29.1		
0.0654	45.3	1.2889	28.2		
[NaCl] = 0.0203 mol kg ⁻¹					
0.0011	65.4	0.0909	42.0	1.4943	27.1
0.0023	62.8	0.1355	40.1	1.7845	27.0
0.0034	60.2	0.1797	38.5	2.0498	27.0
0.0046	58.3	0.2233	36.9	2.5177	26.9
0.0069	55.7	0.3304	34.9	2.9174	27.2
0.0092	53.8	0.4345	33.2	3.3417	27.0
0.0115	52.7	0.6345	31.0	3.7005	26.8
0.0229	49.5	0.8242	29.2	4.0642	27.0
0.0343	47.2	1.0044	28.0	4.3710	27.1
0.0457	45.3	1.1757	27.4		
0.0683	43.5	1.3388	27.3		

Table 4.1- Continued

$\alpha_{AOT} = 0.648$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0246 mol kg ⁻¹					
0.0011	64.5	0.0676	43.2	1.1633	27.1
0.0023	61.2	0.0898	41.6	1.3249	27.0
0.0034	58.5	0.1340	39.4	1.6260	26.9
0.0045	56.8	0.1776	37.9	1.9009	26.9
0.0068	55.2	0.2208	36.5	2.3847	27.0
0.0091	53.3	0.3267	34.0	2.7969	26.8
0.0113	52.1	0.4297	32.7	3.2336	27.0
0.0226	49.2	0.6276	30.6	3.6019	27.0
0.0339	46.7	0.8153	28.5	4.1893	26.9
0.0452	45.5	0.9937	27.5		
[NaCl] = 0.0313 mol kg ⁻¹					
0.0010	62.3	0.0592	42.1	0.8825	26.9
0.0020	59.7	0.0788	40.1	1.0356	26.5
0.0030	58.1	0.1176	38.4	1.1821	26.7
0.0040	56.7	0.1560	36.5	1.3225	26.4
0.0060	54.8	0.1940	35.6	1.5861	26.2
0.0079	53.2	0.2874	33.3	1.8292	26.3
0.0099	52.0	0.3786	31.5	2.1602	26.4
0.0198	49.0	0.4676	30.5	2.4566	26.2
0.0297	46.6	0.5545	29.4	2.8067	26.2
0.0396	44.6	0.7223	27.7		
[NaCl] = 0.0412 mol kg ⁻¹					
0.0010	61.8	0.0568	41.4	0.6955	26.9
0.0019	59.0	0.0756	39.5	0.8505	26.2
0.0029	57.1	0.1128	37.4	0.9990	25.9
0.0038	55.7	0.1497	35.9	1.1413	26.0
0.0057	54.3	0.1863	34.5	1.4088	25.8
0.0076	53.0	0.2761	32.2	1.6558	25.8
0.0095	51.6	0.3639	30.9	1.9928	25.8
0.0190	48.1	0.4496	29.4	2.2950	26.0

Table 4.1- Continued

$\alpha_{AOT} = 0.648$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
		[NaCl] = 0.0412 mol kg ⁻¹			
0.0285	46.1	0.5334	28.4	2.7348	25.7
0.0380	44.1	0.6154	27.4		
		[NaCl] = 0.0532 mol kg ⁻¹			
0.0009	64.5	0.0560	40.6	0.6862	26.0
0.0019	61.7	0.0745	38.6	0.8395	25.7
0.0028	59.6	0.1112	36.6	0.9863	25.5
0.0038	57.3	0.1475	34.5	1.1272	25.4
0.0056	55.3	0.1836	33.7	1.2624	25.5
0.0075	53.5	0.2722	31.2	1.5172	25.4
0.0094	52.0	0.3587	29.7	1.7530	25.4
0.0187	47.7	0.4434	28.2	2.0757	25.4
0.0281	45.2	0.5261	27.5	2.3661	25.4
0.0374	43.1	0.6071	26.4	2.7904	25.2

Table 4.1- Continued

$\alpha_{\text{AOT}} = 0.745$					
$c \times 10^3 /$ mol kg^{-1}	$\gamma /$ mN m^{-1}	$c \times 10^3 /$ mol kg^{-1}	$\gamma /$ mN m^{-1}	$c \times 10^3 /$ mol kg^{-1}	$\gamma /$ mN m^{-1}
$[\text{NaCl}] = 0 \text{ mol kg}^{-1}$					
0.0028	71.3	0.2227	55.4	3.2418	31.7
0.0056	70.8	0.3321	51.7	3.6128	31.2
0.0084	70.7	0.4401	49.3	3.9657	31.0
0.0113	70.2	0.5468	47.3	4.3020	30.8
0.0169	69.6	0.8080	43.8	4.6226	30.6
0.0225	69.3	1.0616	41.3	5.2214	30.4
0.0281	68.5	1.3079	38.7	5.7695	30.2
0.0562	65.7	1.5472	37.7	6.5097	30.1
0.0842	62.8	2.0059	34.9	7.1664	30.0
0.1121	61.1	2.4401	33.3	7.9349	30.0
0.1676	57.8	2.8514	32.5		
$[\text{NaCl}] = 0.0008 \text{ mol kg}^{-1}$					
0.0028	61.5	0.1676	48.0	2.8526	30.7
0.0056	61.1	0.2228	46.8	3.2433	30.6
0.0084	60.4	0.3321	44.6	3.6146	30.5
0.0113	59.3	0.4401	42.9	4.3046	30.2
0.0141	58.4	0.5469	41.7	4.9321	30.0
0.0197	57.1	0.8082	39.6	5.5054	29.8
0.0281	55.9	1.0618	37.6	6.2781	29.6
0.0562	53.0	1.5476	34.8	6.9623	29.4
0.0842	51.1	2.0066	32.9		
0.1121	50.0	2.4410	31.3		
$[\text{NaCl}] = 0.0011 \text{ mol kg}^{-1}$					
0.0028	65.8	0.1681	48.6	2.4481	31.4
0.0056	63.5	0.2234	47.2	2.8609	30.5
0.0085	61.9	0.3331	45.4	3.2527	30.3
0.0113	60.6	0.4415	43.7	3.6251	30.2
0.0141	59.8	0.5485	42.4	4.3169	30.0
0.0198	58.4	0.8106	39.9	4.9462	29.6
0.0282	56.9	1.0650	37.6	5.5210	29.5
0.0564	54.1	1.3121	36.2	6.2958	29.4

Table 4.1- Continued

$\alpha_{AOT} = 0.745$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0011 mol kg ⁻¹					
0.0844	52.3	1.5522	35.0		
0.1124	50.7	2.0125	33.0		
[NaCl] = 0.0014 mol kg ⁻¹					
0.0028	58.1	0.1678	46.8	2.4447	30.9
0.0056	57.4	0.2231	45.5	2.8570	30.3
0.0085	56.8	0.3326	43.3	3.2483	30.1
0.0113	56.5	0.4408	42.2	3.6202	29.9
0.0141	56.3	0.5477	40.9	4.3112	29.6
0.0197	55.5	0.8094	38.2	4.9398	29.5
0.0282	54.4	1.0634	36.8	5.5142	29.4
0.0563	51.8	1.3102	35.3	6.2882	29.3
0.0843	50.1	1.5500	34.3	7.1847	29.2
0.1122	48.9	2.0096	32.2	7.9559	29.1
[NaCl] = 0.0019 mol kg ⁻¹					
0.0028	64.8	0.1113	48.9	1.9936	31.4
0.0056	62.1	0.1664	46.7	2.4254	30.4
0.0084	60.4	0.2212	45.5	2.8347	30.3
0.0112	59.3	0.3298	43.2	3.2233	30.0
0.0140	58.2	0.4371	41.6	3.5927	29.8
0.0168	57.4	0.5431	40.3	4.2792	29.5
0.0224	56.3	0.8027	38.1	4.9040	29.4
0.0279	55.4	1.0547	36.3	5.7422	29.3
0.0558	52.0	1.2994	34.7	6.4808	29.3
0.0836	50.6	1.5373	33.6		
[NaCl] = 0.0021 mol kg ⁻¹					
0.0028	64.9	0.1112	48.8	1.9920	32.3
0.0056	62.0	0.1663	47.0	2.4233	30.5
0.0084	60.4	0.2211	45.6	2.8322	29.9
0.0112	58.9	0.3296	43.3	3.2203	29.8
0.0140	58.2	0.4368	41.5	3.5893	29.5
0.0168	57.7	0.5427	40.3	3.9403	29.4

Table 4.1- Continued

$\alpha_{AOT} = 0.745$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0021 mol kg ⁻¹					
0.0223	56.3	0.8021	38.0	4.2748	29.3
0.0279	55.4	1.0539	36.2	4.8987	29.2
0.0558	52.0	1.2985	34.7	5.4686	29.1
0.0835	50.2	1.5362	33.1		
[NaCl] = 0.0042 mol kg ⁻¹					
0.0028	61.5	0.1677	44.2	2.0081	29.7
0.0056	58.8	0.2230	42.8	2.2284	29.2
0.0085	57.4	0.3324	40.3	2.4427	29.2
0.0113	56.0	0.4405	38.9	2.6514	29.1
0.0141	55.2	0.5474	37.7	2.8546	29.0
0.0197	53.8	0.8089	35.5	3.2453	28.8
0.0282	52.4	1.0627	33.5	3.6168	28.6
0.0563	49.3	1.3093	32.3	3.9702	28.6
0.0843	47.5	1.5488	31.2	4.6279	28.6
0.1122	46.1	1.7817	30.4		
[NaCl] = 0.0064 mol kg ⁻¹					
0.0028	62.7	0.1125	44.8	1.7867	29.3
0.0057	59.2	0.1682	42.7	2.0138	28.7
0.0085	57.2	0.2236	41.2	2.2347	28.7
0.0113	55.7	0.3334	39.5	2.4496	28.4
0.0141	54.4	0.4418	37.5	2.8627	28.3
0.0170	53.5	0.5489	36.2	3.2546	28.3
0.0198	52.9	0.8112	33.8	3.6271	28.3
0.0282	51.5	1.0657	32.2	4.3192	28.2
0.0564	48.0	1.3130	31.2	4.9486	28.2
0.0845	46.4	1.5532	29.9		
[NaCl] = 0.0085 mol kg ⁻¹					
0.0028	57.8	0.1129	44.0	1.5590	28.8
0.0057	55.1	0.1410	42.6	1.7934	28.4
0.0085	53.3	0.1689	41.8	2.0212	28.2
0.0114	52.6	0.2245	40.3	2.2427	28.1

Table 4.1- Continued

$\alpha_{AOT} = 0.745$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0085 mol kg ⁻¹					
0.0142	51.4	0.3347	37.8	2.4583	28.1
0.0170	50.8	0.4436	36.3	2.8725	28.1
0.0227	49.7	0.5511	35.4	3.2655	28.0
0.0284	48.6	0.8143	32.8	3.9941	27.8
0.0566	46.8	1.0699	31.1	4.6550	27.8
0.0848	44.8	1.3180	29.7		
[NaCl] = 0.0145 mol kg ⁻¹					
0.0011	65.3	0.0875	43.4	1.4243	27.9
0.0022	62.6	0.1304	41.4	1.6974	27.5
0.0033	61.3	0.1728	39.7	1.9462	27.3
0.0044	59.9	0.2148	38.4	2.3827	27.1
0.0066	57.7	0.3175	36.3	2.7533	27.0
0.0088	56.2	0.4172	34.6	3.1445	27.1
0.0110	54.6	0.6084	32.4	3.4735	27.1
0.0221	50.8	0.7893	30.7	3.7541	27.0
0.0330	48.8	0.9606	29.5	4.0840	27.1
0.0440	47.5	1.1231	28.5		
0.0658	45.0	1.2775	27.8		
[NaCl] = 0.0208 mol kg ⁻¹					
0.0011	66.5	0.0651	43.7	1.0165	27.3
0.0022	63.8	0.0866	41.7	1.3239	27.0
0.0033	61.6	0.1079	40.8	1.6024	26.7
0.0044	59.7	0.1501	38.6	1.8557	26.6
0.0066	56.8	0.1919	37.3	2.2996	26.5
0.0087	54.7	0.2942	35.0	2.6757	26.7
0.0109	53.2	0.3935	33.2	3.0721	26.6
0.0218	49.6	0.4901	31.6	3.4049	26.7
0.0327	47.5	0.6752	30.2	3.9327	26.4
0.0435	45.8	0.8504	28.6		

Table 4.1- Continued

$\alpha_{AOT} = 0.745$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0243 mol kg ⁻¹					
0.0011	65.8	0.0654	42.7	0.9549	27.1
0.0022	62.4	0.0870	41.3	1.1164	26.8
0.0033	59.9	0.1297	39.1	1.4156	26.3
0.0044	57.9	0.1719	37.2	1.6868	26.5
0.0066	55.7	0.2136	36.0	1.9338	26.2
0.0088	53.8	0.3157	33.5	2.3671	26.0
0.0110	52.6	0.4149	32.0	2.7347	26.2
0.0219	48.5	0.5113	30.8	3.1227	26.1
0.0329	46.2	0.6050	29.6	3.4489	26.2
0.0437	44.6	0.7847	27.9	3.7270	26.0
[NaCl] = 0.0287 mol kg ⁻¹					
0.0011	65.2	0.0637	41.7	0.9322	26.3
0.0021	61.9	0.0847	39.8	1.0902	26.3
0.0032	60.1	0.1263	37.8	1.2405	26.1
0.0043	58.0	0.1674	36.0	1.5197	25.8
0.0064	55.3	0.2081	34.7	1.7739	25.9
0.0086	53.7	0.3077	32.7	2.1149	26.0
0.0107	52.3	0.4044	31.0	2.4153	25.9
0.0214	48.3	0.4985	30.0	2.8439	25.8
0.0320	46.0	0.5900	28.9	3.2015	25.9
0.0426	44.1	0.7656	27.5		
[NaCl] = 0.0310 mol kg ⁻¹					
0.0011	64.7	0.0665	41.3	0.9676	26.4
0.0022	61.1	0.0884	39.5	1.1306	26.3
0.0033	58.9	0.1317	37.3	1.2853	26.1
0.0045	56.8	0.1746	36.0	1.5721	25.9
0.0067	54.9	0.2169	34.4	1.8324	25.9
0.0089	53.0	0.3205	32.4	2.1804	25.8
0.0112	51.7	0.4211	30.8	2.4859	25.9
0.0223	47.8	0.5187	29.6	2.9198	25.8

Table 4.1- Continued

$\alpha_{AOT} = 0.745$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0310 mol kg ⁻¹					
0.0334	45.6	0.6136	28.4	3.2802	25.9
0.0444	44.0	0.7955	26.9		
[NaCl] = 0.0345 mol kg ⁻¹					
0.0009	64.5	0.0555	41.9	0.8078	26.4
0.0019	62.2	0.0738	40.0	0.9439	26.3
0.0028	60.2	0.1100	37.7	1.0730	26.1
0.0037	58.3	0.1458	36.1	1.3124	25.6
0.0056	55.9	0.1811	35.0	1.5296	25.7
0.0075	53.9	0.2676	32.4	1.8199	25.7
0.0093	52.4	0.3516	31.1	2.0749	25.7
0.0186	48.4	0.4331	29.9	2.4368	25.5
0.0279	45.8	0.5123	28.8	2.7375	25.4
0.0371	44.6	0.6642	27.6	3.2083	25.4
[NaCl] = 0.0406 mol kg ⁻¹					
0.0009	61.0	0.0550	41.4	0.8187	26.0
0.0018	57.7	0.0731	39.8	0.9606	25.9
0.0028	55.9	0.1091	37.7	1.0964	25.8
0.0037	54.4	0.1448	36.0	1.3511	25.6
0.0055	53.0	0.1801	34.7	1.5854	25.5
0.0074	51.7	0.2668	32.3	1.9038	25.5
0.0092	50.7	0.3514	30.9	2.1882	25.4
0.0184	47.4	0.4339	29.8	2.6001	25.4
0.0276	45.1	0.5145	28.6	2.9497	25.4
0.0367	43.9	0.6701	26.8	3.2501	25.4
[NaCl] = 0.0519 mol kg ⁻¹					
0.0008	64.2	0.0450	41.7	0.6643	26.3
0.0015	61.6	0.0598	40.0	0.7782	25.8
0.0023	59.7	0.0893	37.8	0.8868	25.6
0.0030	57.9	0.1184	36.3	1.0897	25.5

Table 4.1- Continued

$\alpha_{\text{AOT}} = 0.745$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0519 mol kg ⁻¹					
0.0045	55.8	0.1472	35.0	1.2753	25.4
0.0060	54.0	0.2178	32.5	1.5259	25.5
0.0075	52.8	0.2866	30.9	1.7483	25.4
0.0151	48.5	0.3536	29.9	2.0678	25.6
0.0226	46.2	0.4189	28.8	2.3367	25.3
0.0301	44.3	0.5447	27.0	2.5661	25.2

Table 4.1- Continued

$\alpha_{AOT} = 0.865$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0 mol kg ⁻¹					
0.0024	71.3	0.1911	55.2	2.7818	31.6
0.0048	70.8	0.2849	51.7	3.1002	31.0
0.0072	69.8	0.3776	49.5	3.4031	30.9
0.0097	69.2	0.4691	47.5	3.6917	30.6
0.0145	69.2	0.6933	44.3	4.2298	30.2
0.0193	67.5	0.9109	41.7	4.7213	30.1
0.0241	67.2	1.1222	39.3	5.3837	29.9
0.0482	64.5	1.3275	38.5	5.9699	29.8
0.0722	62.1	1.7212	35.9	6.4926	29.8
0.0961	60.2	2.0937	34.0		
0.1438	57.3	2.4467	32.7		
[NaCl] = 0.0005 mol kg ⁻¹					
0.0024	69.2	0.1448	51.4	2.1080	32.7
0.0049	66.9	0.1925	49.4	2.4633	31.2
0.0073	65.6	0.2870	47.4	2.8004	30.7
0.0097	64.2	0.3803	45.8	3.1207	30.2
0.0122	63.1	0.4725	44.1	3.7156	29.9
0.0170	61.5	0.6983	41.8	4.2566	29.7
0.0243	59.9	0.9174	39.7	4.7506	29.5
0.0486	57.1	1.1302	37.7	5.4163	29.2
0.0727	55.0	1.3369	36.7		
0.0968	53.7	1.7332	34.4		
[NaCl] = 0.0008 mol kg ⁻¹					
0.0024	65.0	0.0967	50.9	1.3353	35.4
0.0049	63.4	0.1447	49.0	1.7310	33.2
0.0073	61.7	0.1923	47.4	2.1054	31.7
0.0097	60.6	0.2867	45.7	2.4600	30.4
0.0122	60.0	0.3799	43.9	2.7965	29.9
0.0170	58.8	0.4720	42.6	3.4203	29.6
0.0243	57.4	0.6975	40.4	3.9862	29.4

Table 4.1- Continued

$\alpha_{AOT} = 0.865$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0008 mol kg ⁻¹					
0.0485	54.2	0.9163	38.3	4.7429	29.2
0.0727	52.2	1.1289	36.7		
[NaCl] = 0.0013 mol kg ⁻¹					
0.0025	64.7	0.1482	46.8	1.7697	32.1
0.0050	61.7	0.1970	45.5	1.9632	31.1
0.0075	60.2	0.2937	43.3	2.1514	30.9
0.0100	59.2	0.3891	41.3	2.5126	29.9
0.0125	58.0	0.4834	40.5	2.8550	29.7
0.0174	56.6	0.7141	38.3	3.4889	29.4
0.0249	55.2	0.9379	36.3	4.0630	29.5
0.0497	52.0	1.1551	35.2	4.8292	29.0
0.0745	50.5	1.3659	33.9		
0.0991	48.6	1.5707	32.8		
[NaCl] = 0.0017 mol kg ⁻¹					
0.0024	62.2	0.0968	49.1	1.3359	33.9
0.0049	60.7	0.1447	47.3	1.7318	32.1
0.0073	58.9	0.1924	46.1	2.1063	30.9
0.0097	58.1	0.2868	43.7	2.4611	29.9
0.0122	57.4	0.3801	42.2	2.7978	29.7
0.0170	56.2	0.4723	41.0	3.4218	29.3
0.0243	54.8	0.6979	38.5	3.9878	29.1
0.0485	52.0	0.9168	36.5	4.7445	29.2
0.0727	50.4	1.1294	35.3	5.4087	29.1
[NaCl] = 0.0021 mol kg ⁻¹					
0.0024	64.6	0.0967	49.2	1.3347	33.9
0.0049	61.7	0.1446	47.2	1.7304	32.2
0.0073	60.4	0.1922	46.0	2.1047	30.2
0.0097	59.2	0.2865	43.7	2.4594	29.6
0.0121	58.4	0.3797	42.2	2.7959	29.3
0.0170	57.2	0.4718	40.9	3.1157	29.3
0.0243	55.6	0.6971	38.6	3.7097	29.1

Table 4.1- Continued

$\alpha_{AOT} = 0.865$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0021 mol kg ⁻¹					
0.0485	52.3	0.9159	36.6	4.5019	29.0
0.0726	50.6	1.1283	35.1	5.1955	28.9
[NaCl] = 0.0024 mol kg ⁻¹					
0.0024	63.3	0.0966	47.1	1.3339	32.6
0.0049	60.3	0.1445	44.9	1.5345	31.5
0.0073	58.6	0.1920	43.4	1.7295	30.8
0.0097	57.5	0.2863	41.3	1.9191	30.1
0.0121	56.5	0.3794	40.1	2.1037	29.7
0.0170	54.8	0.4714	38.9	2.4584	29.3
0.0243	53.7	0.6967	36.5	2.7949	29.1
0.0485	50.3	0.9153	34.9	3.4190	28.9
0.0726	48.5	1.1276	33.8	3.9854	28.7
[NaCl] = 0.0033 mol kg ⁻¹					
0.0024	61.3	0.0968	47.0	1.3362	32.2
0.0049	59.6	0.1447	45.2	1.7322	30.5
0.0073	58.1	0.1924	43.9	2.1069	29.1
0.0097	57.1	0.2868	41.8	2.4620	28.9
0.0122	56.4	0.3801	40.1	3.1190	28.4
0.0170	55.0	0.4723	38.8	3.7136	28.4
0.0243	53.6	0.6979	36.4	4.5067	28.4
0.0485	50.7	0.9169	35.0	5.2009	28.3
0.0727	48.6	1.1296	33.5		
[NaCl] = 0.0050 mol kg ⁻¹					
0.0024	64.9	0.0965	45.7	1.3325	30.7
0.0048	61.2	0.1443	43.7	1.5327	29.9
0.0073	59.3	0.1919	42.1	1.7275	29.2
0.0097	57.9	0.2860	40.0	2.1012	28.7
0.0121	56.5	0.3791	38.6	2.4553	28.4
0.0170	54.7	0.4710	37.0	3.1106	28.0
0.0242	53.3	0.6959	35.0	3.9796	28.0

Table 4.1- Continued

$\alpha_{\text{AOT}} = 0.865$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0050 mol kg ⁻¹					
0.0484	49.4	0.9143	33.5	4.7355	27.9
0.0725	47.6	1.1264	31.8	5.3992	27.8
[NaCl] = 0.0064 mol kg ⁻¹					
0.0121	54.6	0.2848	39.2	1.7209	28.5
0.0169	53.0	0.3775	37.4	2.0934	28.0
0.0241	51.5	0.4690	36.4	2.4464	28.0
0.0482	48.0	0.6931	34.0	3.0998	27.7
0.0722	46.2	0.9107	32.2	3.9667	27.5
0.0961	44.9	1.1220	31.1	4.7211	27.4
0.1437	42.6	1.3273	30.0		
0.1911	40.9	1.5269	28.9		
[NaCl] = 0.0075 mol kg ⁻¹					
0.0024	63.0	0.0969	44.1	1.3376	29.3
0.0049	59.3	0.1449	42.4	1.5386	28.4
0.0073	57.0	0.1927	40.7	1.7339	28.1
0.0097	55.5	0.2872	38.4	2.1088	27.7
0.0122	54.7	0.3806	36.9	2.4640	27.5
0.0170	53.1	0.4729	35.5	3.1210	27.4
0.0243	51.3	0.6988	33.2	3.9919	26.9
0.0486	47.8	0.9180	31.7	4.7492	26.6
0.0728	45.8	1.1308	30.3		
[NaCl] = 0.0085 mol kg ⁻¹					
0.0024	59.7	0.0969	43.8	1.3372	29.2
0.0049	57.4	0.1448	41.7	1.7336	27.9
0.0073	55.6	0.1925	40.4	2.1086	27.3
0.0097	54.3	0.2870	38.0	2.4639	27.3
0.0122	53.3	0.3804	36.6	3.1215	27.2
0.0170	51.7	0.4726	35.2	3.9936	26.9
0.0243	50.4	0.6984	33.1	4.7520	26.9
0.0486	47.1	0.9176	31.2		
0.0728	45.4	1.1304	30.0		

Table 4.1- Continued

$\alpha_{\text{AOT}} = 0.865$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0106 mol kg ⁻¹					
0.0097	53.7	0.1922	39.0	1.5351	27.3
0.0121	52.8	0.2865	37.0	1.7301	27.3
0.0170	50.9	0.3797	35.5	2.1043	27.2
0.0243	49.4	0.4717	34.0	2.7953	26.8
0.0485	46.4	0.6971	32.0	3.4593	26.8
0.0726	44.4	0.9158	30.2	4.5004	26.7
0.0967	42.6	1.1282	29.0		
0.1446	41.0	1.3346	28.1		
[NaCl] = 0.0162 mol kg ⁻¹					
0.0018	64.2	0.1080	41.3	0.9974	28.0
0.0036	60.6	0.1436	39.6	1.1473	27.2
0.0054	58.2	0.1790	38.3	1.2931	27.0
0.0073	56.2	0.2141	37.4	1.5729	26.5
0.0109	54.0	0.2837	35.6	1.8379	26.6
0.0145	52.3	0.3525	34.4	2.0895	26.4
0.0181	50.5	0.4542	32.7	2.3286	26.3
0.0362	47.0	0.5540	31.4	3.3649	26.1
0.0543	45.1	0.6521	30.6	4.1947	26.1
0.0722	43.6	0.7485	29.8	4.8739	26.2
0.0902	42.3	0.8432	29.2		
[NaCl] = 0.0179 mol kg ⁻¹					
0.0018	61.3	0.0539	44.5	1.1387	27.0
0.0036	58.4	0.0717	42.9	1.2833	27.0
0.0054	56.7	0.1072	40.7	1.5608	26.5
0.0072	54.9	0.1426	39.2	1.8238	26.3
0.0090	53.9	0.2125	36.8	2.0732	26.1
0.0108	52.9	0.2816	35.3	2.5358	26.3
0.0144	51.3	0.3499	33.8	2.9553	26.2
0.0180	50.3	0.5171	31.7	3.5163	25.9
0.0216	49.3	0.6793	29.8	4.0087	26.0

Table 4.1- Continued

$\alpha_{\text{AOT}} = 0.865$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0179 mol kg ⁻¹					
0.0288	47.8	0.8369	28.9	4.7079	25.8
0.0360	46.5	0.9899	27.4	5.2887	25.6
[NaCl] = 0.0195 mol kg ⁻¹					
0.0012	64.6	0.0723	42.2	1.2292	26.7
0.0024	61.0	0.0961	40.7	1.3973	26.7
0.0036	58.6	0.1433	38.2	1.7089	26.2
0.0049	56.7	0.1899	36.7	1.9916	26.2
0.0073	54.3	0.2359	35.5	2.2492	25.9
0.0097	53.2	0.3486	33.3	2.8028	26.2
0.0121	51.7	0.4579	31.6	3.2560	25.9
0.0242	47.9	0.6673	29.3	3.6335	25.8
0.0363	46.0	0.8650	27.9	3.9531	25.6
0.0483	44.2	1.0520	26.8		
[NaCl] = 0.0214 mol kg ⁻¹					
0.0011	64.5	0.0668	42.2	1.1364	26.3
0.0022	61.0	0.0888	40.5	1.2920	26.7
0.0034	58.9	0.1324	38.4	1.5804	25.9
0.0045	57.2	0.1754	36.8	1.8422	25.9
0.0067	54.8	0.2179	35.6	2.1923	25.8
0.0090	53.2	0.3221	33.4	2.4997	26.0
0.0112	51.9	0.4231	31.6	2.9364	25.9
0.0224	48.2	0.6166	29.4	3.2993	25.7
0.0335	45.9	0.7995	27.9	3.8678	25.6
0.0447	44.4	0.9725	27.3		
[NaCl] = 0.0249 mol kg ⁻¹					
0.0012	64.3	0.0481	43.3	0.6645	28.8
0.0024	61.0	0.0720	41.2	0.8614	26.9
0.0036	58.5	0.0957	39.5	1.0478	26.4
0.0048	56.7	0.1192	38.4	1.2244	26.3
0.0073	54.2	0.1426	37.2	1.3920	26.2

Table 4.1- Continued

$\alpha_{AOT} = 0.865$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0249 mol kg ⁻¹					
0.0097	52.7	0.1890	35.5	1.7027	26.0
0.0121	51.1	0.2349	34.4	1.9847	25.7
0.0241	47.2	0.3470	32.3	2.4768	26.0
0.0362	45.0	0.4559	30.5		
[NaCl] = 0.0287 mol kg ⁻¹					
0.0007	64.9	0.0418	43.1	0.7117	27.5
0.0014	61.5	0.0556	41.7	0.8091	26.5
0.0021	59.5	0.0829	39.5	0.9016	26.2
0.0028	57.7	0.1099	37.9	1.0736	25.8
0.0042	56.0	0.1365	36.6	1.2299	25.6
0.0056	54.3	0.2017	34.5	1.4396	25.6
0.0070	53.1	0.2650	33.1	1.6242	25.2
0.0140	49.7	0.3862	31.0	1.8872	25.7
0.0210	47.4	0.5007	29.2	2.1065	25.2
0.0280	45.8	0.6090	28.2	2.4514	25.5
[NaCl] = 0.0310 mol kg ⁻¹					
0.0007	64.7	0.0419	42.9	0.7126	26.7
0.0014	61.8	0.0557	41.4	0.8101	26.2
0.0021	60.1	0.0830	39.0	0.9910	25.7
0.0028	58.8	0.1100	37.4	1.1550	25.4
0.0042	56.4	0.1367	36.4	1.3745	25.3
0.0056	54.8	0.2020	34.3	1.5671	25.1
0.0070	53.2	0.2654	32.4	1.8408	25.3
0.0140	49.7	0.3867	30.5	2.0682	25.2
0.0210	47.3	0.5014	28.8	2.4243	25.3
0.0280	45.4	0.6098	27.7		
[NaCl] = 0.0407 mol kg ⁻¹					
0.0006	63.6	0.0384	42.5	0.5674	26.7
0.0013	60.9	0.0510	40.7	0.6649	26.1
0.0019	58.6	0.0761	38.4	0.7580	25.8
0.0026	57.8	0.1009	37.0	0.8470	25.5

Table 4.1- Continued

$\alpha_{\text{AOT}} = 0.865$					
$c \times 10^3 /$ mol kg^{-1}	$\gamma /$ mN m^{-1}	$c \times 10^3 /$ mol kg^{-1}	$\gamma /$ mN m^{-1}	$c \times 10^3 /$ mol kg^{-1}	$\gamma /$ mN m^{-1}
$[\text{NaCl}] = 0.0407 \text{ mol kg}^{-1}$					
0.0039	55.4	0.1255	35.8	1.0134	25.3
0.0051	54.1	0.1858	33.6	1.1662	25.4
0.0064	52.5	0.2445	32.1	1.3732	25.2
0.0129	49.1	0.3018	31.0	1.5575	25.3
0.0193	46.8	0.3576	29.7	1.8236	25.4
0.0256	45.0	0.4651	28.3	2.0486	25.2
$[\text{NaCl}] = 0.0523 \text{ mol kg}^{-1}$					
0.0007	64.7	0.0395	41.2	0.5825	26.4
0.0013	62.9	0.0526	39.6	0.6821	25.6
0.0020	60.0	0.0784	37.6	0.7771	25.2
0.0027	57.9	0.1040	35.7	0.8676	25.6
0.0040	55.5	0.1293	34.5	1.0367	25.4
0.0053	53.7	0.1913	32.4	1.1916	25.3
0.0066	52.2	0.2517	31.0	1.4008	25.3
0.0133	48.1	0.3105	29.8	1.5865	25.2
0.0199	45.6	0.3677	28.6	1.8537	25.2
0.0264	44.1	0.4778	27.0	0.5825	26.4

Table 4.1- Continued

$\alpha_{AOT} = 0.931$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0 mol kg ⁻¹					
0.0047	70.1	0.2780	49.3	3.3338	30.4
0.0093	67.0	0.3695	47.1	4.0570	29.9
0.0140	65.8	0.5510	44.2	4.7430	29.4
0.0187	64.5	0.7302	41.8	5.3945	29.3
0.0280	63.0	0.9074	40.0	6.6039	28.8
0.0374	62.0	1.3413	37.0	7.7030	28.5
0.0467	60.6	1.7627	34.2	9.1753	28.2
0.0932	57.3	2.1721	32.6	11.250	27.7
0.1396	54.3	2.5702	31.3		
0.1859	52.9	2.9573	30.6		
[NaCl] = 0.0005 mol kg ⁻¹					
0.0047	64.5	0.2813	46.9	3.3679	29.9
0.0095	62.1	0.3739	44.7	4.0970	29.4
0.0142	60.5	0.5574	42.2	4.7881	29.3
0.0189	59.5	0.7387	40.3	5.4439	29.0
0.0284	58.1	0.9178	38.4	6.0672	28.8
0.0378	56.5	1.3564	35.6	7.2254	28.7
0.0472	56.0	1.7822	33.1	8.2790	28.6
0.0943	52.8	2.1957	31.3	9.6924	28.2
0.1413	50.9	2.5975	30.5	10.937	27.9
0.1881	49.7	2.9881	30.1		
[NaCl] = 0.0008 mol kg ⁻¹					
0.0046	66.3	0.2749	45.9	3.2998	29.8
0.0092	62.9	0.3654	43.9	4.0164	29.3
0.0139	60.9	0.5449	41.5	4.6964	28.9
0.0185	59.7	0.7223	39.6	5.9572	28.6
0.0277	58.1	0.8975	38.0	7.1008	28.3
0.0369	56.6	1.3268	35.2	8.6302	28.2
0.0462	55.6	1.7439	32.9	9.9726	28.1
0.0922	52.2	2.1493	31.2	11.879	27.3

Table 4.1- Continued

$\alpha_{AOT} = 0.931$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0008 mol kg ⁻¹					
0.1381	50.1	2.5434	30.3		
0.1838	48.5	2.9268	30.0		
[NaCl] = 0.0015 mol kg ⁻¹					
0.0047	63.5	0.2811	43.6	3.3682	29.5
0.0095	60.5	0.3737	41.6	4.0979	28.7
0.0142	58.4	0.5571	39.5	4.7897	28.6
0.0189	57.4	0.7384	37.2	5.4465	28.7
0.0283	55.3	0.9175	36.1	6.6650	28.3
0.0378	54.2	1.3560	33.6	7.7714	28.0
0.0472	53.1	1.7818	31.6	9.7047	27.8
0.0943	49.6	2.1954	30.1	11.338	27.6
0.1412	47.8	2.5973	29.8		
0.1880	46.3	2.9881	29.5		
[NaCl] = 0.0019 mol kg ⁻¹					
0.0040	65.2	0.2398	44.5	2.8732	29.3
0.0081	61.8	0.3187	42.8	3.4958	29.3
0.0121	59.6	0.4752	40.4	4.0861	29.1
0.0161	58.5	0.6298	38.7	4.6465	28.8
0.0242	56.5	0.7826	37.3	5.6864	28.3
0.0322	55.2	1.1566	34.7	6.6309	27.9
0.0403	54.2	1.5198	32.5	8.2811	27.9
0.0804	50.6	1.8726	31.0	9.9908	27.8
0.1204	48.9	2.2155	29.8		
0.1603	47.0	2.5489	29.6		
[NaCl] = 0.0040 mol kg ⁻¹					
0.0040	61.0	0.1606	44.0	2.2195	28.6
0.0081	58.0	0.2402	41.5	2.5535	28.6
0.0121	55.6	0.3193	40.0	2.8783	28.2
0.0161	54.8	0.4761	37.8	3.5019	28.0
0.0242	52.8	0.6310	35.9	4.0932	28.2
0.0323	51.6	0.7840	34.6	5.1880	27.7

Table 4.1- Continued

$\alpha_{\text{AOT}} = 0.931$					
$c \times 10^3 /$ mol kg^{-1}	$\gamma /$ mN m^{-1}	$c \times 10^3 /$ mol kg^{-1}	$\gamma /$ mN m^{-1}	$c \times 10^3 /$ mol kg^{-1}	$\gamma /$ mN m^{-1}
[NaCl] = 0.0040 mol kg ⁻¹					
0.0403	50.2	1.1587	31.9	6.1799	27.6
0.0806	47.5	1.5225	30.0	7.5041	27.4
0.1207	45.1	1.8760	28.8		
[NaCl] = 0.0059 mol kg ⁻¹					
0.0031	63.0	0.1856	41.3	2.1258	28.1
0.0062	59.2	0.2468	39.9	2.5181	27.9
0.0094	56.5	0.3679	37.7	2.9853	27.9
0.0125	54.9	0.4876	35.8	3.4288	27.5
0.0187	53.1	0.6059	34.7	3.8503	27.4
0.0249	51.8	0.8384	32.6	4.6333	27.3
0.0312	50.9	1.0654	31.3	5.3456	27.3
0.0623	47.4	1.2872	29.9	6.8732	26.8
0.0932	45.5	1.5040	29.2		
0.1241	43.8	1.7159	28.7		
[NaCl] = 0.0110 mol kg ⁻¹					
0.0024	61.9	0.1416	40.0	0.9899	28.6
0.0048	57.3	0.1883	38.4	1.1584	27.8
0.0071	54.9	0.2348	37.1	1.3237	27.4
0.0095	53.7	0.2811	35.9	1.5258	27.3
0.0143	51.1	0.3728	34.6	1.7232	27.2
0.0190	50.0	0.4637	33.2	2.1042	27.0
0.0238	48.9	0.5536	32.2	2.4680	26.8
0.0474	45.6	0.6426	31.2	3.1485	26.7
0.0711	43.9	0.7307	30.5	3.7727	26.6
0.0947	42.4	0.8180	29.8	4.8778	26.2
[NaCl] = 0.0154 mol kg ⁻¹					
0.0019	63.2	0.1107	40.4	0.9734	27.4
0.0037	60.7	0.1472	38.7	1.1341	27.0
0.0056	58.2	0.1836	37.3	1.2911	26.7
0.0074	56.2	0.2198	35.8	1.5948	26.4
0.0111	53.9	0.2916	34.6	1.8854	26.1

Table 4.1- Continued

$\alpha_{AOT} = 0.931$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
$[\text{NaCl}] = 0.0154 \text{ mol kg}^{-1}$					
0.0148	52.5	0.3627	33.4	2.1636	26.0
0.0186	50.8	0.4332	32.2	2.4303	25.9
0.0371	46.8	0.5376	31.1	2.9318	25.8
0.0555	44.5	0.6406	30.2		
0.0740	42.8	0.8089	28.5		
$[\text{NaCl}] = 0.0207 \text{ mol kg}^{-1}$					
0.0011	65.7	0.0868	40.8	0.6985	28.8
0.0022	62.5	0.1082	39.8	0.7880	27.7
0.0033	59.9	0.1295	38.5	0.9605	26.7
0.0044	58.1	0.1716	37.1	1.1245	26.5
0.0066	55.6	0.2134	35.5	1.2808	26.1
0.0088	53.7	0.2546	34.6	1.4298	26.0
0.0110	52.1	0.2954	33.8	1.7080	25.8
0.0219	48.4	0.3558	32.6	1.9626	25.6
0.0328	46.0	0.4152	31.7	2.3065	25.3
0.0436	44.8	0.5121	30.7	2.6114	25.3
0.0653	42.4	0.6065	29.7	2.8838	25.2
$[\text{NaCl}] = 0.0251 \text{ mol kg}^{-1}$					
0.0011	64.1	0.0859	40.1	0.7279	27.4
0.0022	60.6	0.1071	38.6	0.8159	26.8
0.0033	58.8	0.1491	36.8	0.9854	26.0
0.0043	56.8	0.1906	35.5	1.1468	25.5
0.0065	54.1	0.2317	34.2	1.3007	25.5
0.0087	52.3	0.2724	33.3	1.5878	25.8
0.0108	50.9	0.3325	32.1	1.8504	25.6
0.0217	47.5	0.3917	31.2	2.2047	25.5
0.0324	45.3	0.4500	30.5	2.7090	25.4
0.0432	43.5	0.5450	28.9	3.1290	25.6
0.0646	41.2	0.6377	28.2		

Table 4.1- Continued

$\alpha_{AOT} = 0.931$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0299 mol kg ⁻¹					
0.0007	65.3	0.0569	41.6	0.5161	28.4
0.0014	62.8	0.0709	40.1	0.6290	27.6
0.0022	60.4	0.0987	38.2	0.7364	26.5
0.0029	58.4	0.1262	37.1	0.8386	25.6
0.0043	56.1	0.1534	36.1	1.0292	25.5
0.0057	54.1	0.1936	34.5	1.2031	25.6
0.0072	52.9	0.2331	33.3	1.3626	25.5
0.0143	49.7	0.2720	32.4	1.7084	25.4
0.0215	46.8	0.3355	31.3	1.9946	25.6
0.0286	45.5	0.3973	30.5	2.2354	25.4
0.0428	43.1	0.4575	29.1	2.4407	25.5
[NaCl] = 0.0398 mol kg ⁻¹					
0.0005	65.3	0.0319	43.4	0.4542	28.2
0.0011	62.2	0.0424	41.7	0.5358	26.8
0.0016	59.8	0.0632	39.4	0.6136	26.3
0.0021	58.4	0.0839	37.7	0.6879	25.6
0.0032	55.9	0.1043	36.8	0.8267	25.4
0.0043	55.0	0.1444	34.7	0.9540	25.4
0.0053	53.0	0.1838	33.3	1.1263	25.3
0.0107	49.6	0.2223	32.3	1.3724	25.5
0.0160	47.8	0.2969	30.5	1.5782	25.4
0.0213	45.9	0.3686	29.4		

Table 4.1- Continued

$\alpha_{AOT} = 1$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0 mol kg ⁻¹					
0.2916	46.6	1.8590	33.0	3.1693	30.0
0.5739	42.0	2.0934	32.0	3.3671	30.0
0.8472	39.3	2.3211	31.1	3.5597	29.9
1.1120	37.5	2.5422	30.7	3.7471	29.8
1.3686	35.8	2.7571	30.5	4.1076	29.7
1.6176	34.4	2.9661	30.0	4.4502	29.6
[NaCl] = 0.0012 mol kg ⁻¹					
0.0500	53.5	1.1482	35.6	3.2887	29.4
0.1163	48.9	1.4485	34.3	3.5223	29.1
0.2483	46.3	1.7359	32.5	3.7491	29.4
0.3627	43.1	2.0148	31.3	3.9703	29.3
0.5246	40.7	2.2852	30.4	4.1853	29.2
0.6829	39.1	2.8433	29.7		
0.9031	37.4	3.0488	29.7		
[NaCl] = 0.0021 mol kg ⁻¹					
0.0683	50.1	1.2343	33.9	2.6196	29.7
0.2042	44.3	1.4751	33.0	2.8283	29.4
0.3718	41.0	1.7093	32.2	3.0327	30.1
0.5363	39.0	1.9383	31.1	3.2317	29.7
0.7314	37.6	2.1614	30.2	3.4366	29.3
0.9873	35.7	2.4051	29.8	3.6168	29.5
[NaCl] = 0.0079 mol kg ⁻¹					
0.0348	48.5	1.0659	31.0	2.2409	27.5
0.1043	43.2	1.3147	28.8	2.4051	27.4
0.2425	38.9	1.5572	28.3	2.5664	27.5
0.3784	36.5	1.7295	28.8	2.7248	27.2
0.5788	34.0	1.9034	28.2		
0.8088	32.2	2.0736	27.5		
[NaCl] = 0.0139 mol kg ⁻¹					
0.0650	43.2	0.7235	30.4	1.5088	26.8
0.1619	38.0	0.9037	29.5	1.5920	26.4

Table 4.1- Continued

$\alpha_{AOT} = 1$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0139 mol kg ⁻¹					
0.2577	35.8	0.9925	29.1	1.7641	26.3
0.3526	34.3	1.0805	28.0	1.8375	26.3
0.4467	33.1	1.1677	27.5	1.9179	26.2
0.5398	32.2	1.3398	26.8		
0.6320	31.2	1.4247	26.2		
[NaCl] = 0.0197 mol kg ⁻¹					
0.0691	41.1	0.6385	28.7	1.2985	26.2
0.1549	36.6	0.8359	27.4	1.3891	26.1
0.2441	34.7	0.9269	26.8	1.4785	26.2
0.3412	32.3	1.0213	26.7	1.5676	26.1
0.4413	31.1	1.1144	26.3		
0.5404	30.0	1.2068	26.3		
[NaCl] = 0.0292 mol kg ⁻¹					
0.0530	41.1	0.5352	28.6	1.0283	25.6
0.1234	36.8	0.6710	27.3	1.0920	25.8
0.1933	34.3	0.7373	26.7	1.1554	25.6
0.2626	32.5	0.7690	26.4	1.2182	25.4
0.3303	31.6	0.8345	25.9		
0.4694	29.4	0.9641	25.7		
[NaCl] = 0.0480 mol kg ⁻¹					
0.0501	39.0	0.5059	26.6	0.8803	25.6
0.1165	35.0	0.5693	26.1	0.9411	25.9
0.1824	32.5	0.6322	25.9	1.0017	25.8
0.2480	30.6	0.6948	25.7	1.0302	26.1
0.3131	29.3	0.7571	25.7		
0.4434	27.3	0.8187	25.8		
[NaCl] = 0.0612 mol kg ⁻¹					
0.0241	41.9	0.3092	28.3	0.6165	26.0
0.0561	37.7	0.3714	26.9	0.6978	25.6
0.1200	33.6	0.4332	25.3	0.7597	25.5

Table 4.1- Continued

$\alpha_{AOT} = 1$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
		[NaCl] = 0.0612 mol kg ⁻¹			
0.1835	31.3	0.4947	26.2	0.8223	25.8
0.2465	29.4	0.5558	25.5	0.8807	25.3
		[NaCl] = 0.0668 mol kg ⁻¹			
0.0320	41.6	0.2851	28.3	0.5005	25.9
0.0640	38.0	0.3158	27.7	0.5311	25.6
0.0958	35.4	0.3468	27.1	0.5615	25.5
0.1275	33.3	0.3778	27.3	0.5917	26.1
0.1592	32.1	0.4086	26.5	0.6219	25.5
0.1910	31.0	0.4446	26.1	0.7141	25.7
0.2221	30.1	0.4700	26.2		
		[NaCl] = 0.0788 mol kg ⁻¹			
0.0158	43.9	0.1960	29.9	0.5019	25.9
0.0401	38.8	0.2584	28.4	0.5081	25.7
0.0710	35.6	0.3201	27.1	0.5620	25.7
0.1024	33.5	0.3813	25.6	0.5916	25.6
0.1337	32.9	0.4422	25.8		
0.1649	30.9	0.4718	25.7		

Table 4.2 - Values of cmc and $c_{\gamma m}$ (or $c_{i\gamma}$) of AOT + SDS Systems at Different NaCl Concentrations at 298K [$c_{\gamma m}$ is the concentration of the mixture and $c_{i\gamma}$ is the concentration of AOT ($i=1$) or SDS ($i=2$) when $\gamma = 34 \text{ mN m}^{-1}$]

α_{AOT}	[NaCl] / mol kg ⁻¹	Cmc x 10 ³ / mol kg ⁻¹	$c_{\gamma m}$ (or $c_{i\gamma}$) x 10 ³ / mol kg ⁻¹
0.0	0.0000	8.10	7.28
	0.0043	6.31	5.46
	0.0063	5.46	4.87
	0.0085	5.01	4.59
	0.0152	4.10	3.98
	0.0302	2.82	2.74
	0.0408	2.24	2.24
	0.0603	1.78	1.58
	0.0797	1.58	1.37
0.163	0.0000	4.73	3.98
	0.0007	4.47	3.76
	0.0010	4.47	3.38
	0.0014	4.22	3.38
	0.0018	4.22	3.20
	0.0021	3.98	3.07
	0.0041	3.55	2.66
	0.0063	3.16	2.11
	0.0083	2.82	1.88
	0.0128	2.37	1.51
	0.0169	2.05	1.22
	0.0306	1.41	0.67
	0.0403	1.19	0.56
	0.0515	1.00	0.47
	0.245	0.0000	4.21
0.0008		3.76	3.07
0.0011		3.76	3.02
0.0014		3.55	2.77
0.0019		3.45	2.68
0.0021		3.35	2.47
0.0042		2.99	2.11
0.0064		2.66	1.78
0.0085		2.51	1.50

Table 4.2 - Continued

α_{AOT}	[NaCl] / mol kg ⁻¹	Cmc x 10 ³ / mol kg ⁻¹	c_{ym} (or c_{iy}) x 10 ³ / mol kg ⁻¹
0.245	0.0143	1.94	0.97
	0.0211	1.58	0.79
	0.0308	1.30	0.59
	0.0397	1.06	0.47
	0.0505	0.94	0.40
0.393	0.0000	3.66	2.98
	0.0006	3.35	2.42
	0.0008	3.25	2.37
	0.0010	3.16	2.31
	0.0014	2.99	2.10
	0.0018	2.99	2.09
	0.0021	2.90	1.99
	0.0042	2.51	1.50
	0.0063	2.24	1.26
	0.0085	2.09	1.06
	0.0206	1.37	0.59
	0.0319	1.06	0.42
	0.0405	0.89	0.32
	0.0503	0.79	0.28
	0.500	0.0000	3.35
0.0005		3.16	2.21
0.0008		3.07	2.05
0.0010		3.07	2.05
0.0014		2.90	1.69
0.0018		2.90	1.69
0.0021		2.82	1.78
0.0042		2.44	1.33
0.0064		2.18	1.00
0.0084		1.99	0.84
0.0141		1.58	0.67
0.0204		1.33	0.49
0.0249		1.15	0.45
0.0333		0.94	0.32
0.0514		0.73	0.24

Table 4.2 - Continued

α_{AOT}	[NaCl] / mol kg ⁻¹	Cmc x 10 ³ / mol kg ⁻¹	c_{ym} (or c_{iy}) x 10 ³ / mol kg ⁻¹
0.648	0.0000	3.25	2.37
	0.0008	2.99	1.88
	0.0010	2.99	1.81
	0.0014	2.90	1.60
	0.0018	2.74	1.59
	0.0021	2.74	1.50
	0.0041	2.37	1.15
	0.0063	2.11	0.92
	0.0083	1.94	0.75
	0.0144	1.58	0.50
	0.0203	1.26	0.37
	0.0246	1.09	0.33
	0.0313	0.94	0.25
	0.0412	0.79	0.20
	0.0532	0.67	0.17
0.745	0.0000	3.18	2.37
	0.0008	2.90	1.78
	0.0011	2.90	1.74
	0.0014	2.82	1.59
	0.0019	2.66	1.45
	0.0021	2.66	1.45
	0.0042	2.24	1.02
	0.0064	1.99	0.78
	0.0085	1.88	0.67
	0.0145	1.49	0.47
	0.0208	1.19	0.34
	0.0243	1.06	0.29
	0.0287	0.97	0.24
	0.0310	0.89	0.24
	0.0345	0.84	0.21
0.0406	0.75	0.21	
0.0519	0.67	0.17	

Table 4.2 - Continued

α_{AOT}	[NaCl] / mol kg ⁻¹	Cmc x 10 ³ / mol kg ⁻¹	c_{ym} (or c_{iy}) x 10 ³ / mol kg ⁻¹
0.865	0.0000	2.89	2.11
	0.0005	2.82	1.78
	0.0008	2.74	1.58
	0.0013	2.66	1.33
	0.0017	2.59	1.34
	0.0021	2.51	1.34
	0.0024	2.37	1.07
	0.0033	2.30	1.06
	0.0050	1.99	0.79
	0.0064	1.94	0.70
	0.0075	1.83	0.59
	0.0085	1.73	0.58
	0.0106	1.58	0.48
	0.0162	1.33	0.37
	0.0179	1.22	0.35
	0.0195	1.15	0.30
	0.0214	1.09	0.28
	0.0249	1.00	0.25
	0.0287	0.92	0.22
	0.0310	0.87	0.21
0.0407	0.67	0.17	
0.0523	0.63	0.14	
0.931	0.0000	2.76	1.83
	0.0005	2.66	1.64
	0.0008	2.59	1.50
	0.0015	2.37	1.26
	0.0019	2.30	1.26
	0.0040	2.05	0.84
	0.0059	1.88	0.67
	0.0110	1.45	0.41
	0.0154	1.22	0.33
	0.0207	1.09	0.29
	0.0251	0.94	0.24

Table 4.2 - Continued

α_{AOT}	[NaCl] / mol kg ⁻¹	Cmc x 10 ³ / mol kg ⁻¹	$c_{\gamma m}$ (or c_{iy}) x 10 ³ / mol kg ⁻¹
0.931	0.0299	0.82	0.20
	0.0398	0.67	0.16
1.0	0.0000	2.63	1.68
	0.0012	2.51	1.45
	0.0021	2.29	1.26
	0.0079	1.86	0.59
	0.0139	1.38	0.39
	0.0197	1.07	0.27
	0.0292	0.85	0.20
	0.0480	0.60	0.14
	0.0612	0.47	0.11
	0.0668	0.43	0.11
	0.0788	0.41	0.10

Table 4.3 - Interpolated Cmc Values of AOT + SDS Systems at Fixed NaCl Concentrations at 298K

[NaCl] / mol kg ⁻¹	$\alpha_{\text{AOT}}=0$ Cmc x 10 ³ / mol kg ⁻¹	$\alpha_{\text{AOT}}=0.163$ Cmc x 10 ³ / mol kg ⁻¹	$\alpha_{\text{AOT}}=0.245$ Cmc x 10 ³ / mol kg ⁻¹	$\alpha_{\text{AOT}}=0.393$ Cmc x 10 ³ / mol kg ⁻¹	$\alpha_{\text{AOT}}=0.500$ Cmc x 10 ³ / mol kg ⁻¹
0.000	8.10	4.73 / 6.05 ^{id}	4.21 / 5.36 ^{id}	3.66 / 4.46 ^{id}	3.35 / 3.97 ^{id}
0.003	7.00	3.70 / 5.21	3.22 / 4.61	2.75 / 3.82	2.70 / 3.40
0.006	6.20	3.15 / 4.57	2.78 / 4.04	2.30 / 3.34	2.30 / 2.97
0.009	5.50	2.70 / 4.03	2.50 / 3.55	2.10 / 2.93	2.00 / 2.60
0.012	5.00	2.40 / 3.62	2.30 / 3.18	1.85 / 2.61	1.77 / 2.31
0.015	4.50	2.20 / 3.23	2.00 / 2.83	1.65 / 2.31	1.60 / 2.04
0.018	3.95	1.92 / 2.85	1.90 / 2.50	1.50 / 2.04	1.40 / 1.80
0.021	3.65	1.83 / 2.61	1.65 / 2.28	1.40 / 1.86	1.30 / 1.64
0.024	3.45	1.70 / 2.43	1.50 / 2.12	1.30 / 1.72	1.20 / 1.51
0.027	3.20	1.52 / 2.23	1.42 / 1.93	1.20 / 1.56	1.10 / 1.37
0.030	3.00	1.45 / 2.09	1.33 / 1.82	1.10 / 1.47	1.00 / 1.29
0.033	2.85	1.40 / 1.98	1.25 / 1.71	1.05 / 1.38	0.94 / 1.21
0.036	2.70	1.33 / 1.86	1.20 / 1.61	1.00 / 1.30	0.89 / 1.14
0.039	2.55	1.27 / 1.77	1.10 / 1.53	0.90 / 1.24	0.85 / 1.09
0.042	2.45	1.20 / 1.69	1.05 / 1.46	0.87 / 1.17	0.80 / 1.03
0.045	2.30	1.15 / 1.58	1.00 / 1.37	0.83 / 1.10	0.77 / 0.96
0.048	2.20	1.10 / 1.50	0.95 / 1.29	0.80 / 1.03	0.74 / 0.90

^{id} Cmc value from Clint's Equation.

Table 4.3 - Continued

[NaCl] / mol kg ⁻¹	$\alpha_{AOT}=0.648$	$\alpha_{AOT}=0.745$	$\alpha_{AOT}=0.865$	$\alpha_{AOT}=0.931$	$\alpha_{AOT}=1$
	Cmc x 10 ³ / mol kg ⁻¹	Cmc x 10 ³ / mol kg ⁻¹	Cmc x 10 ³ / mol kg ⁻¹	Cmc x 10 ³ / mol kg ⁻¹	Cmc x 10 ³ / mol kg ⁻¹
0.000	3.25 / 3.45 ^{id}	3.18 / 3.18 ^{id}	2.89 / 2.89 ^{id}	2.76 / 2.76 ^{id}	2.63
0.003	2.60 / 2.96	2.55 / 2.72	2.35 / 2.48	2.25 / 2.36	2.25
0.006	2.20 / 2.57	2.18 / 2.36	2.00 / 2.15	1.95 / 2.05	1.95
0.009	1.95 / 2.25	1.95 / 2.06	1.78 / 1.87	1.70 / 1.78	1.70
0.012	1.75 / 1.99	1.75 / 1.82	1.58 / 1.66	1.50 / 1.58	1.50
0.015	1.60 / 1.76	1.52 / 1.61	1.40 / 1.46	1.34 / 1.39	1.32
0.018	1.40 / 1.55	1.35 / 1.42	1.22 / 1.29	1.17 / 1.23	1.17
0.021	1.30 / 1.41	1.20 / 1.29	1.10 / 1.17	1.06 / 1.11	1.06
0.024	1.20 / 1.30	1.10 / 1.19	1.00 / 1.07	0.97 / 1.02	0.97
0.027	1.10 / 1.17	1.00 / 1.07	0.92 / 0.96	0.87 / 0.92	0.87
0.030	1.00 / 1.10	0.92 / 1.01	0.87 / 0.91	0.82 / 0.86	0.82
0.033	0.92 / 1.04	0.86 / 0.95	0.81 / 0.85	0.77 / 0.81	0.77
0.036	0.85 / 0.97	0.81 / 0.88	0.76 / 0.80	0.72 / 0.76	0.72
0.039	0.82 / 0.93	0.76 / 0.85	0.71 / 0.76	0.69 / 0.73	0.69
0.042	0.77 / 0.88	0.72 / 0.80	0.67 / 0.72		0.65
0.045	0.75 / 0.82	0.70 / 0.75	0.64 / 0.68		0.61
0.048	0.70 / 0.77	0.65 / 0.70	0.61 / 0.63		0.57

^{id} Cmc value from Clint's Equation.

Table 4.4 - Values of x_1 , β_m , f_1 and f_2 at fixed [NaCl] for AOT + SDS Systems at 298K from Rubingh's Approach

[NaCl] / mol kg ⁻¹	x_1	β_m	f_1	f_2	x_1	β_m	f_1	f_2
	$\alpha_{AOT}=0.163$				$\alpha_{AOT}=0.245$			
0.000	0.416	-1.03	0.704	0.837	0.499	-0.97	0.784	0.785
0.003	0.427	-1.42	0.628	0.772	0.501	-1.44	0.699	0.696
0.006	0.432	-1.54	0.609	0.749	0.504	-1.50	0.692	0.683
0.009	0.437	-1.65	0.592	0.730	0.507	-1.41	0.710	0.696
0.012	0.441	-1.69	0.591	0.719	0.512	-1.30	0.734	0.711
0.015	0.442	-1.58	0.612	0.734	0.514	-1.40	0.719	0.691
0.018	0.441	-1.62	0.603	0.729	0.514	-1.10	0.771	0.747
0.021	0.442	-1.45	0.636	0.752	0.517	-1.30	0.738	0.706
0.024	0.446	-1.47	0.636	0.745	0.520	-1.40	0.724	0.684
0.027	0.452	-1.56	0.626	0.726	0.526	-1.25	0.755	0.707
0.030	0.451	-1.50	0.635	0.737	0.525	-1.26	0.752	0.705
0.033	0.451	-1.42	0.652	0.749	0.527	-1.28	0.750	0.700
0.036	0.452	-1.38	0.661	0.753	0.529	-1.20	0.766	0.713
0.039	0.451	-1.34	0.667	0.760	0.528	-1.33	0.743	0.690
0.042	0.454	-1.38	0.662	0.751	0.530	-1.32	0.746	0.689
0.045	0.453	-1.31	0.676	0.765	0.530	-1.27	0.754	0.699
0.048	0.455	-1.27	0.685	0.768	0.533	-1.26	0.759	0.698
	$\alpha_{AOT}=0.393$				$\alpha_{AOT}=0.500$			
0.000	0.619	-0.85	0.883	0.720	0.690	-0.84	0.922	0.668
0.003	0.601	-1.42	0.798	0.598	0.676	-1.13	0.888	0.595
0.006	0.599	-1.60	0.773	0.562	0.673	-1.25	0.876	0.568
0.009	0.606	-1.44	0.800	0.589	0.674	-1.28	0.872	0.558
0.012	0.609	-1.49	0.796	0.574	0.677	-1.31	0.872	0.548
0.015	0.612	-1.48	0.800	0.573	0.683	-1.23	0.883	0.561
0.018	0.614	-1.36	0.816	0.598	0.679	-1.28	0.877	0.553
0.021	0.621	-1.26	0.835	0.615	0.688	-1.18	0.891	0.571
0.024	0.625	-1.26	0.838	0.611	0.691	-1.21	0.891	0.562
0.027	0.633	-1.19	0.851	0.620	0.698	-1.15	0.900	0.569

Table 4.4 - Continued

[NaCl] / mol kg ⁻¹	x_1	β_m	f_1	f_2	x_1	β_m	f_1	f_2		
		$\alpha_{AOT}=0.393$					$\alpha_{AOT}=0.500$			
0.030	0.628	-1.30	0.835	0.598	0.688	-1.32	0.880	0.535		
0.033	0.631	-1.25	0.843	0.607	0.689	-1.33	0.879	0.531		
0.036	0.635	-1.20	0.853	0.617	0.692	-1.31	0.883	0.534		
0.039	0.627	-1.41	0.821	0.574	0.695	-1.25	0.890	0.546		
0.042	0.631	-1.34	0.833	0.585	0.694	-1.30	0.886	0.534		
0.045	0.633	-1.29	0.841	0.597	0.701	-1.16	0.902	0.564		
0.048	0.639	-1.20	0.855	0.612	0.707	-1.11	0.910	0.575		
		$\alpha_{AOT}=0.648$					$\alpha_{AOT}=0.745$			
0.000	0.813	-0.43	0.985	0.754	0.899	0.00	1.000	1.000		
0.003	0.780	-0.85	0.960	0.595	0.855	-0.61	0.987	0.641		
0.006	0.771	-1.02	0.948	0.546	0.847	-0.74	0.983	0.587		
0.009	0.778	-0.94	0.955	0.564	0.863	-0.55	0.990	0.662		
0.012	0.787	-0.88	0.961	0.578	0.875	-0.44	0.993	0.715		
0.015	0.804	-0.70	0.973	0.638	0.864	-0.61	0.989	0.635		
0.018	0.797	-0.77	0.969	0.614	0.865	-0.58	0.989	0.646		
0.021	0.812	-0.61	0.978	0.667	0.856	-0.73	0.985	0.583		
0.024	0.815	-0.62	0.979	0.661	0.855	-0.79	0.983	0.560		
0.027	0.827	-0.52	0.985	0.701	0.863	-0.73	0.986	0.582		
0.030	0.808	-0.76	0.972	0.610	0.848	-0.92	0.979	0.516		
0.033	0.800	-0.87	0.966	0.573	0.846	-0.97	0.977	0.499		
0.036	0.793	-0.99	0.958	0.535	0.850	-0.93	0.979	0.510		
0.039	0.804	-0.84	0.968	0.580	0.844	-1.00	0.976	0.488		
0.042	0.801	-0.91	0.965	0.559	0.845	-1.01	0.976	0.485		
0.045	0.814	-0.73	0.975	0.616	0.863	-0.76	0.986	0.569		
0.048	0.811	-0.79	0.972	0.594	0.857	-0.87	0.982	0.528		

Table 4.4 - Continued

[NaCl] / mol kg ⁻¹	x_1	β_m	f_1	f_2	x_1	β_m	f_1	f_2
	$\alpha_{AOT}=0.865$				$\alpha_{AOT}=0.931$			
0.000	0.952	0.00	1.000	1.000	0.977	0.00	1.000	1.000
0.003	0.909	-0.83	0.993	0.501	0.935	-1.21	0.995	0.345
0.006	0.897	-1.07	0.989	0.424	0.936	-1.24	0.995	0.338
0.009	0.912	-0.85	0.993	0.495	0.936	-1.26	0.995	0.332
0.012	0.916	-0.80	0.994	0.509	0.936	-1.29	0.995	0.323
0.015	0.919	-0.78	0.995	0.517	0.945	-1.11	0.997	0.372
0.018	0.906	-0.99	0.991	0.444	0.936	-1.30	0.995	0.320
0.021	0.906	-1.02	0.991	0.432	0.936	-1.32	0.995	0.313
0.024	0.898	-1.18	0.988	0.384	0.936	-1.35	0.994	0.305
0.027	0.915	-0.93	0.993	0.459	0.936	-1.39	0.994	0.296
0.030	0.917	-0.88	0.994	0.475	0.936	-1.38	0.994	0.298
0.033	0.913	-0.98	0.993	0.442	0.936	-1.39	0.994	0.294
0.036	0.915	-0.95	0.993	0.450	0.936	-1.41	0.994	0.291
0.039	0.905	-1.12	0.990	0.399	0.936	-1.40	0.994	0.292
0.042	0.902	-1.20	0.988	0.376				
0.045	0.911	-1.03	0.992	0.423				
0.048	0.922	-0.86	0.995	0.482				

Table 4.5 - Micellar Composition (x_1) at fixed [NaCl] for AOT + SDS Systems at 298K from Rodenas's approach

[NaCl]/ mol kg ⁻¹	x_1							
	$\alpha_{AOT} =$ 0.163	$\alpha_{AOT} =$ 0.245	$\alpha_{AOT} =$ 0.393	$\alpha_{AOT} =$ 0.500	$\alpha_{AOT} =$ 0.648	$\alpha_{AOT} =$ 0.745	$\alpha_{AOT} =$ 0.865	$\alpha_{AOT} =$ 0.931
0.000	0.453	0.501	0.540	0.598	0.733	0.835	0.943	0.982
0.003	0.511	0.531	0.495	0.537	0.715	0.843	0.935	0.957
0.006	0.527	0.543	0.499	0.536	0.709	0.834	0.926	0.951
0.009	0.501	0.507	0.498	0.559	0.720	0.827	0.923	0.961
0.012	0.514	0.524	0.503	0.554	0.714	0.829	0.931	0.966
0.015	0.528	0.536	0.492	0.539	0.721	0.849	0.941	0.962
0.018	0.497	0.514	0.523	0.589	0.743	0.840	0.925	0.959
0.021	0.511	0.522	0.508	0.576	0.760	0.872	0.940	0.956
0.024	0.519	0.522	0.501	0.574	0.770	0.882	0.939	0.950
0.027	0.501	0.497	0.507	0.599	0.784	0.879	0.937	0.958
0.030	0.513	0.529	0.542	0.612	0.760	0.847	0.922	0.956
0.033	0.515	0.537	0.557	0.626	0.767	0.848	0.918	0.952
0.036	0.501	0.528	0.580	0.659	0.776	0.837	0.908	0.953
0.039	0.546	0.573	0.548	0.594	0.758	0.867	0.934	0.949
0.042	0.534	0.557	0.557	0.616	0.768	0.859	0.926	0.951
0.045	0.533	0.557	0.545	0.600	0.766	0.873	0.943	0.960
0.048	0.516	0.540	0.565	0.637	0.777	0.856	0.924	0.956

Table 4.6 - Values of Counter Ion Binding Constant (β_c) for AOT + SDS Systems at 298 K (c^* is the Counter Ion Concentration Where β_c Value Changes)

α_{AOT}	β_c	c^* (mol kg ⁻¹)	c^* (mol kg ⁻¹)
0 (SDS)	0.72	-	-
0.163	0.64	-	-
0.245	0.44	0.75	0.0157
0.393	0.43	0.74	0.0164
0.500	0.43	0.75	0.0157
0.648	0.44	0.77	0.0165
0.745	0.43	0.80	0.0149
0.865	0.44	0.76	0.0149
0.931	0.44	0.79	0.0149
1 (AOT)	0.39	0.81	0.0149

Table 4.7- Values of Γ_{cmc} , Γ_{AOT} , Γ_{SDS} , x_{1a} , β_a , f_{1a} and f_{2a} for AOT + SDS Systems at Different NaCl Concentrations at 298K

α_{AOT}	[NaCl] / mol kg ⁻¹	$\Gamma_{cmc} \times 10^6$ / mol m ⁻²	$\Gamma_{AOT} \times 10^6$ / mol m ⁻²	$\Gamma_{SDS} \times 10^6$ / mol m ⁻²	x_{1a}	β_a	f_{1a}	f_{2a}
0	0.0			3.46				
	0.0043			3.56				
	0.0063			3.62				
	0.0085			3.74				
	0.0152			3.70				
	0.0302			3.94				
	0.0408			4.13				
	0.0603			4.16				
	0.0797			4.25				
0.163	0.0	1.93	0.90	1.03	0.468	-0.68	0.824	0.861
	0.0007	1.95	0.91	1.04	0.468	-0.57	0.850	0.882
	0.0010	1.83	0.87	0.96	0.474	-0.88	0.784	0.821
	0.0014	1.95	0.93	1.02	0.479	-0.73	0.820	0.845
	0.0018	1.86	0.90	0.96	0.486	-0.78	0.813	0.832
	0.0021	1.89	0.92	0.97	0.488	-0.82	0.807	0.822
	0.0041	1.97	1.01	0.96	0.515	-0.69	0.850	0.833
	0.0063	2.14	1.16	0.98	0.540	-0.90	0.826	0.768
	0.0083	2.22	1.25	0.97	0.562	-0.83	0.852	0.769
	0.0128	2.35	1.45	0.90	0.619	-0.53	0.925	0.814
	0.0169	2.43	1.60	0.83	0.657	-0.48	0.945	0.812
	0.0306	2.51	1.62	0.89	0.643	-1.29	0.849	0.587
	0.0403	2.64	1.73	0.91	0.655	-1.16	0.871	0.609
	0.0515	2.71	1.80	0.91	0.663	-1.04	0.888	0.632
	0.245	0.0	1.87	1.05	0.82	0.562	-0.73	0.869
0.0008		1.82	1.03	0.79	0.565	-0.70	0.876	0.801
0.0011		1.82	1.04	0.78	0.571	-0.61	0.894	0.820
0.0014		1.77	1.01	0.76	0.569	-0.87	0.851	0.755
0.0019		1.85	1.07	0.78	0.579	-0.77	0.872	0.772
0.0021		1.75	1.00	0.75	0.573	-1.02	0.831	0.715
0.0042		2.03	1.23	0.80	0.606	-0.82	0.880	0.740
0.0064		2.00	1.27	0.73	0.635	-0.76	0.904	0.736
0.0085		2.16	1.41	0.75	0.654	-0.81	0.907	0.706

Table 4.7 - Continued

α_{AOT}	[NaCl] / mol kg ⁻¹	$\Gamma_{cmc} \times 10^6$ / mol m ⁻²	$\Gamma_{AOT} \times 10^6$ / mol m ⁻²	$\Gamma_{SDS} \times 10^6$ / mol m ⁻²	x_{1a}	β_a	f_{1a}	f_{2a}
0.245	0.0143	2.35	1.62	0.73	0.691	-1.05	0.905	0.605
	0.0211	2.43	1.91	0.52	0.785	-0.29	0.987	0.837
	0.0308	2.52	1.90	0.62	0.753	-0.69	0.959	0.677
	0.0397	2.57	1.94	0.63	0.754	-0.77	0.954	0.644
	0.0505	2.59	2.01	0.58	0.775	-0.56	0.972	0.715
0.393	0.0	1.78	1.27	0.51	0.713	-0.28	0.977	0.867
	0.0006	1.69	1.14	0.55	0.672	-0.90	0.907	0.665
	0.0008	1.66	1.12	0.54	0.674	-0.90	0.909	0.664
	0.0010	1.66	1.12	0.54	0.675	-0.91	0.908	0.659
	0.0014	1.70	1.14	0.56	0.669	-1.15	0.881	0.598
	0.0018	1.71	1.17	0.54	0.684	-0.95	0.910	0.641
	0.0021	1.70	1.16	0.54	0.682	-1.02	0.902	0.622
	0.0042	1.82	1.25	0.57	0.689	-1.31	0.881	0.537
	0.0063	1.96	1.40	0.56	0.712	-1.24	0.902	0.532
	0.0085	1.98	1.45	0.53	0.733	-1.22	0.917	0.520
	0.0206	2.28	2.11	0.17	0.925	0.41	1.002	1.427
	0.0319	2.41	2.11	0.30	0.873	-0.33	0.995	0.774
	0.0405	2.44	1.99	0.45	0.816	-1.11	0.963	0.476
	0.0503	2.41	2.07	0.34	0.857	-0.63	0.987	0.630
	0.500	0.0	1.81	1.44	0.37	0.797	-0.16	0.993
0.0005		1.72	1.27	0.45	0.740	-0.85	0.944	0.627
0.0008		1.82	1.32	0.50	0.729	-1.06	0.925	0.569
0.0010		1.83	1.35	0.48	0.739	-0.94	0.938	0.598
0.0014		1.84	1.29	0.55	0.701	-1.67	0.861	0.439
0.0018		1.90	1.36	0.54	0.718	-1.43	0.892	0.478
0.0021		1.88	1.40	0.48	0.747	-0.99	0.938	0.575
0.0042		1.97	1.47	0.50	0.746	-1.32	0.919	0.480
0.0064		2.03	1.50	0.53	0.740	-1.74	0.889	0.385
0.0084		2.08	1.56	0.52	0.749	-1.83	0.890	0.358
0.0141		2.16	1.88	0.28	0.868	-0.58	0.990	0.645
0.0204		2.23	2.19	0.04	0.979	1.32	1.000	3.539
0.0249	2.29	2.24	0.05	0.978	1.25	1.000	3.311	

Table 4.7 - Continued

α_{AOT}	[NaCl] / mol kg ⁻¹	$\Gamma_{cmc} \times 10^6$ / mol m ⁻²	$\Gamma_{AOT} \times 10^6$ / mol m ⁻²	$\Gamma_{SDS} \times 10^6$ / mol m ⁻²	x_{1a}	β_a	f_{1a}	f_{2a}
0.500	0.0333	2.34	2.01	0.33	0.860	-1.07	0.979	0.452
	0.0514	2.36	2.18	0.18	0.924	-0.19	0.999	0.850
0.648	0.0	1.67	1.52	0.15	0.912	0.32	1.002	1.301
	0.0008	1.56	1.28	0.28	0.823	-0.85	0.974	0.562
	0.0010	1.62	1.33	0.29	0.818	-0.94	0.969	0.533
	0.0014	1.63	1.28	0.35	0.789	-1.41	0.939	0.415
	0.0018	1.69	1.37	0.32	0.812	-1.12	0.961	0.476
	0.0021	1.69	1.36	0.33	0.804	-1.27	0.952	0.440
	0.0041	1.83	1.47	0.36	0.801	-1.56	0.940	0.369
	0.0063	1.91	1.56	0.35	0.816	-1.56	0.948	0.352
	0.0083	1.98	1.60	0.38	0.811	-1.84	0.936	0.299
	0.0144	2.15	1.87	0.28	0.872	-1.37	0.978	0.352
	0.0203	2.21	2.12	0.09	0.959	-0.06	1.000	0.943
	0.0246	2.26	2.11	0.15	0.932	-0.66	0.997	0.563
	0.0313	2.28	2.00	0.28	0.875	-1.71	0.974	0.269
	0.0412	2.35	2.00	0.35	0.850	-2.13	0.953	0.215
	0.0532	2.45	2.26	0.19	0.923	-0.98	0.994	0.433
0.745	0.0	1.69	-	-	-	-	-	-
	0.0008	1.68	1.48	0.20	0.881	-0.71	0.990	0.575
	0.0011	1.74	1.56	0.18	0.898	-0.49	0.995	0.675
	0.0014	1.73	1.49	0.24	0.863	-1.04	0.980	0.460
	0.0019	1.73	1.48	0.25	0.853	-1.24	0.974	0.405
	0.0021	1.66	1.44	0.22	0.867	-1.05	0.981	0.454
	0.0042	1.78	1.48	0.30	0.832	-1.80	0.950	0.287
	0.0064	1.89	1.55	0.34	0.821	-2.23	0.931	0.222
	0.0085	2.03	1.71	0.32	0.845	-2.01	0.953	0.238
	0.0145	2.20	2.08	0.12	0.948	-0.59	0.998	0.589
	0.0208	2.23	-	-	-	-	-	-
	0.0243	2.24	2.11	0.13	0.942	-0.98	0.997	0.417
	0.0287	2.30	2.03	0.27	0.879	-2.20	0.968	0.182
	0.0310	2.39	2.26	0.13	0.944	-0.99	0.997	0.414
	0.0345	2.35	2.09	0.26	0.891	-2.03	0.976	0.199

- Iteration did not converge

Table 4.7- Continued

α_{AOT}	[NaCl] / mol kg ⁻¹	$\Gamma_{cmc} \times 10^6$ / mol m ⁻²	$\Gamma_{AOT} \times 10^6$ / mol m ⁻²	$\Gamma_{SDS} \times 10^6$ / mol m ⁻²	x_{1a}	β_a	f_{1a}	f_{2a}
0.745	0.0406	2.36	2.31	0.05	0.978	0.08	1.000	1.085
	0.0519	2.44	2.38	0.06	0.974	-0.09	1.000	0.916
0.865	0.0	1.77	-	-	-	-	-	-
	0.0005	1.83	1.78	0.05	0.974	0.34	1.000	1.376
	0.0008	1.81	1.65	0.16	0.909	-1.27	0.989	0.351
	0.0013	1.68	1.43	0.25	0.852	-2.30	0.951	0.188
	0.0017	1.68	1.48	0.20	0.881	-1.83	0.974	0.240
	0.0021	1.74	1.59	0.15	0.914	-1.28	0.991	0.343
	0.0024	1.70	1.40	0.30	0.824	-2.94	0.913	0.136
	0.0033	1.77	1.54	0.23	0.872	-2.16	0.965	0.194
	0.0050	1.86	1.56	0.30	0.839	-2.96	0.926	0.125
	0.0064	1.98	1.68	0.30	0.850	-2.87	0.937	0.126
	0.0075	1.99	1.64	0.35	0.824	-3.48	0.898	0.094
	0.0085	1.97	1.69	0.28	0.858	-2.89	0.943	0.119
	0.0106	2.05	1.75	0.30	0.854	-3.13	0.935	0.102
	0.0162	2.23	2.17	0.06	0.970	-0.83	0.999	0.456
	0.0179	2.24	-	-	-	-	-	-
	0.0195	2.22	2.21	0.01	0.998	1.81	1.000	6.100
	0.0214	2.30	2.23	0.07	0.970	-1.03	0.999	0.380
	0.0249	2.21	2.09	0.12	0.945	-1.78	0.995	0.203
	0.0287	2.29	2.11	0.18	0.920	-2.38	0.985	0.134
	0.0310	2.31	2.21	0.10	0.958	-1.47	0.997	0.259
0.0407	2.43	2.26	0.17	0.929	-2.22	0.989	0.147	
0.0523	2.39	2.25	0.14	0.939	-2.02	0.992	0.169	
0.931	0.0	1.70	-	-	-	-	-	-
	0.0005	1.72	1.66	0.06	0.967	-0.73	0.999	0.507
	0.0008	1.71	1.58	0.13	0.927	-1.79	0.991	0.214
	0.0015	1.68	1.49	0.19	0.886	-2.69	0.966	0.121
	0.0019	1.77	1.62	0.15	0.916	-2.14	0.985	0.166
	0.0040	1.90	1.60	0.30	0.843	-3.82	0.910	0.066
	0.0059	1.91	1.62	0.29	0.846	-3.96	0.910	0.059
	0.0110	2.11	1.79	0.32	0.846	-4.39	0.902	0.043

- Iteration did not converge

Table 4.7 - Continued

α_{AOT}	[NaCl] / mol kg ⁻¹	$\Gamma_{cmc} \times 10^6$ / mol m ⁻²	$\Gamma_{AOT} \times 10^6$ / mol m ⁻²	$\Gamma_{SDS} \times 10^6$ / mol m ⁻²	x_{1a}	β_a	f_{1a}	f_{2a}
0.931	0.0154	2.22	2.01	0.21	0.905	-3.38	0.970	0.063
	0.0207	2.25	-	-	-	-	-	-
	0.0251	2.32	-	-	-	-	-	-
	0.0299	2.31	2.17	0.14	0.940	-2.79	0.990	0.085
	0.0398	2.40	2.26	0.14	0.940	-2.82	0.990	0.083
1.0	0.0		1.63					
	0.0012		1.93					
	0.0021		1.80					
	0.0079		1.85					
	0.0139		2.06					
	0.0197		2.15					
	0.0292		2.38					
	0.0480		2.40					
	0.0612		2.52					
	0.0668		2.49					
	0.0788		2.52					

- Iteration did not converge

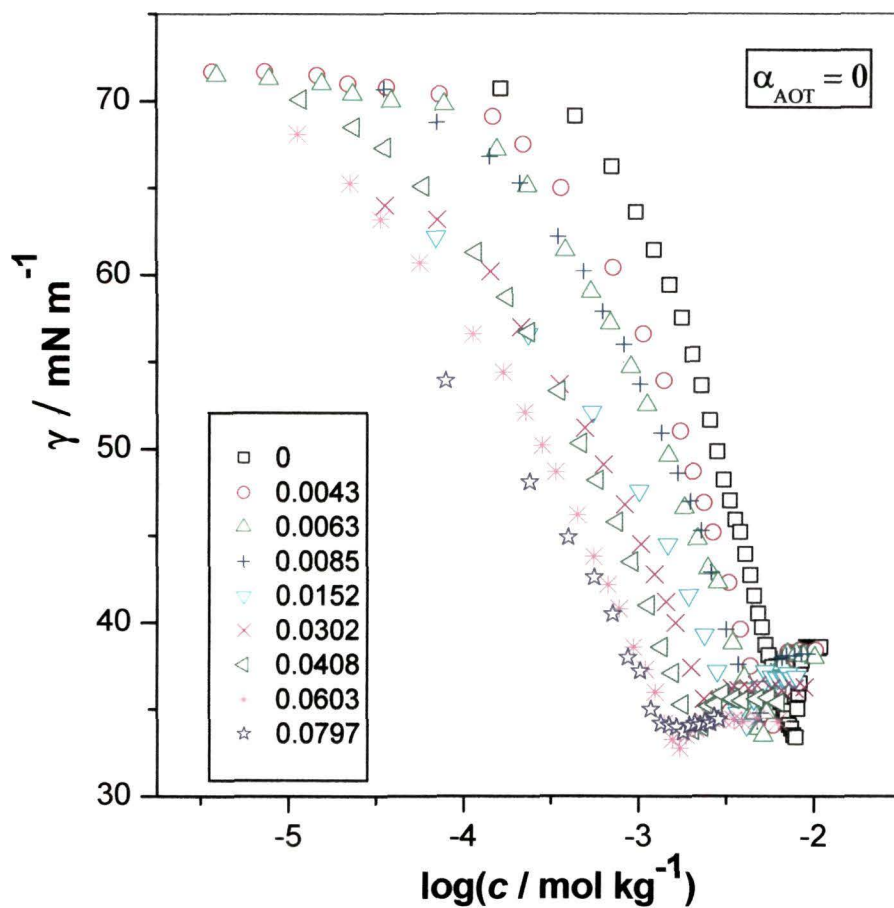


Figure 4.1 - Variation of surface tension with logarithm of total surfactant concentration for AOT + SDS system with $\alpha_{AOT} = 0$ in aqueous sodium chloride solutions. Sodium chloride concentrations in mol kg⁻¹ are given in the inset.

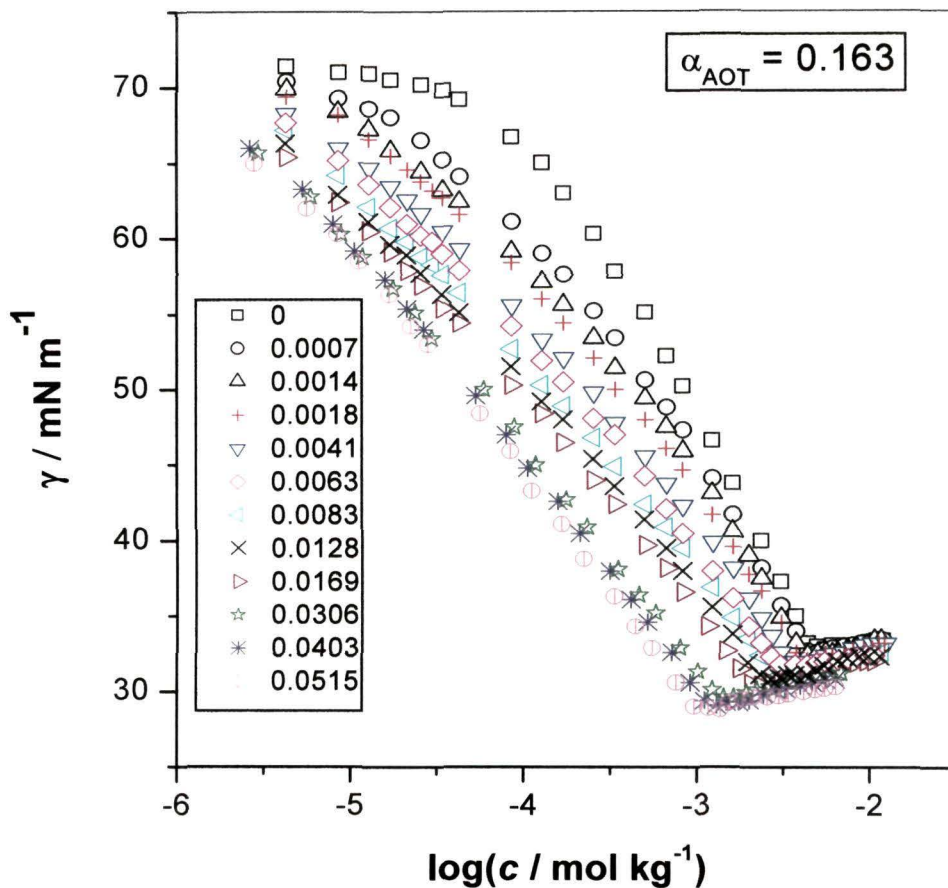


Figure 4.2 - Variation of surface tension with logarithm of total surfactant concentration for AOT + SDS system with $\alpha_{\text{AOT}} = 0.163$ in aqueous sodium chloride solutions. Sodium chloride concentrations in mol kg^{-1} are given in the inset.

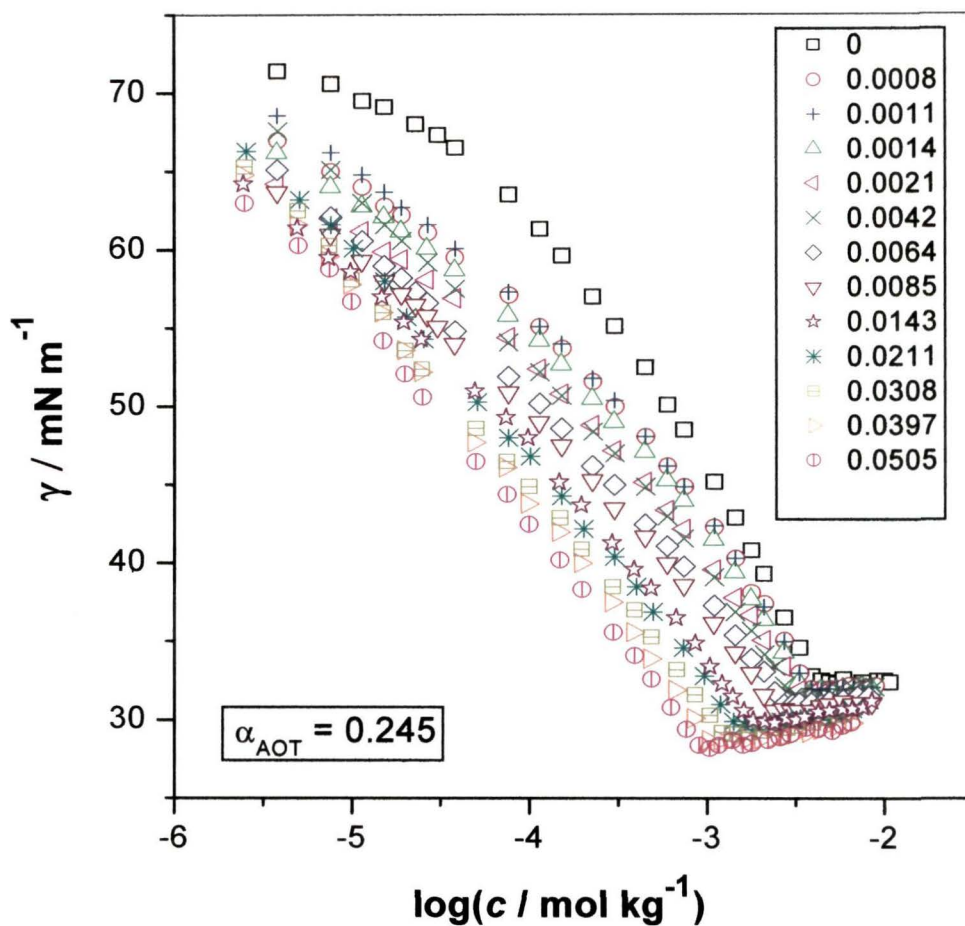


Figure 4.3 - Variation of surface tension with logarithm of total surfactant concentration for AOT + SDS system with $\alpha_{\text{AOT}} = 0.245$ in aqueous sodium chloride solutions. Sodium chloride concentrations in mol kg^{-1} are given in the inset.

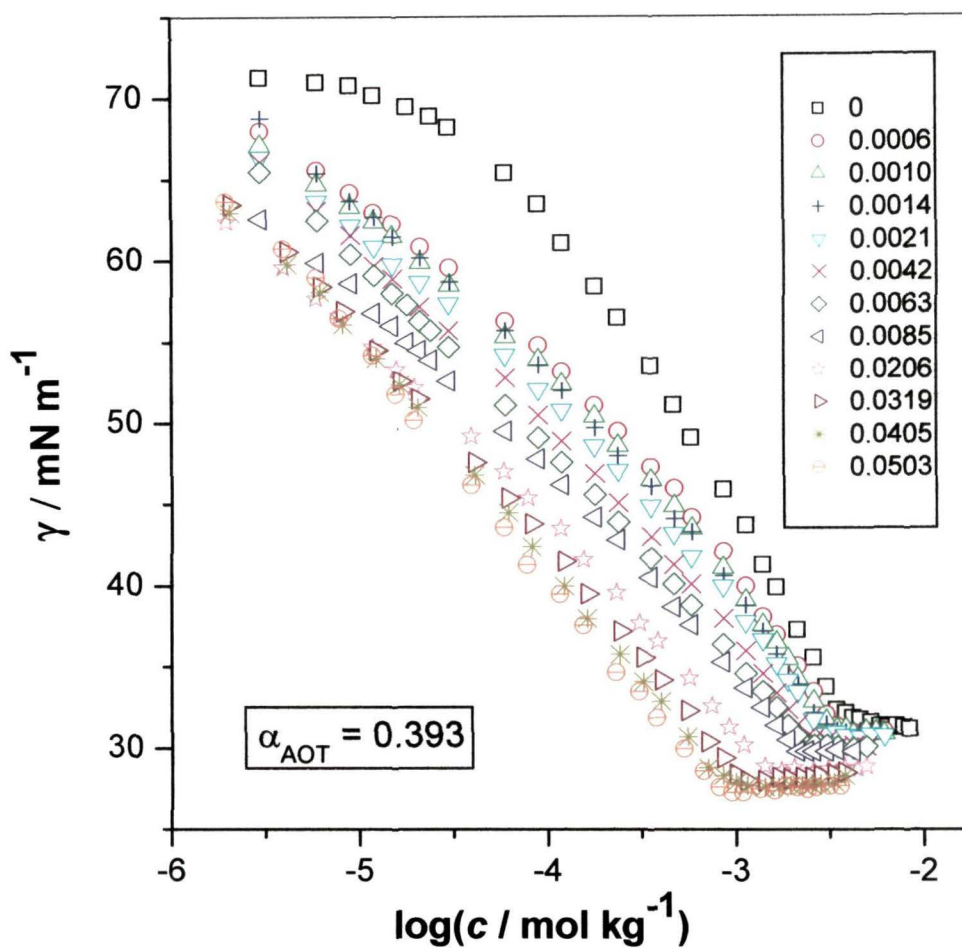


Figure 4.4 - Variation of surface tension with logarithm of total surfactant concentration for AOT + SDS system with $\alpha_{\text{AOT}} = 0.393$ in aqueous sodium chloride solutions. Sodium chloride concentrations in mol kg^{-1} are given in the inset.

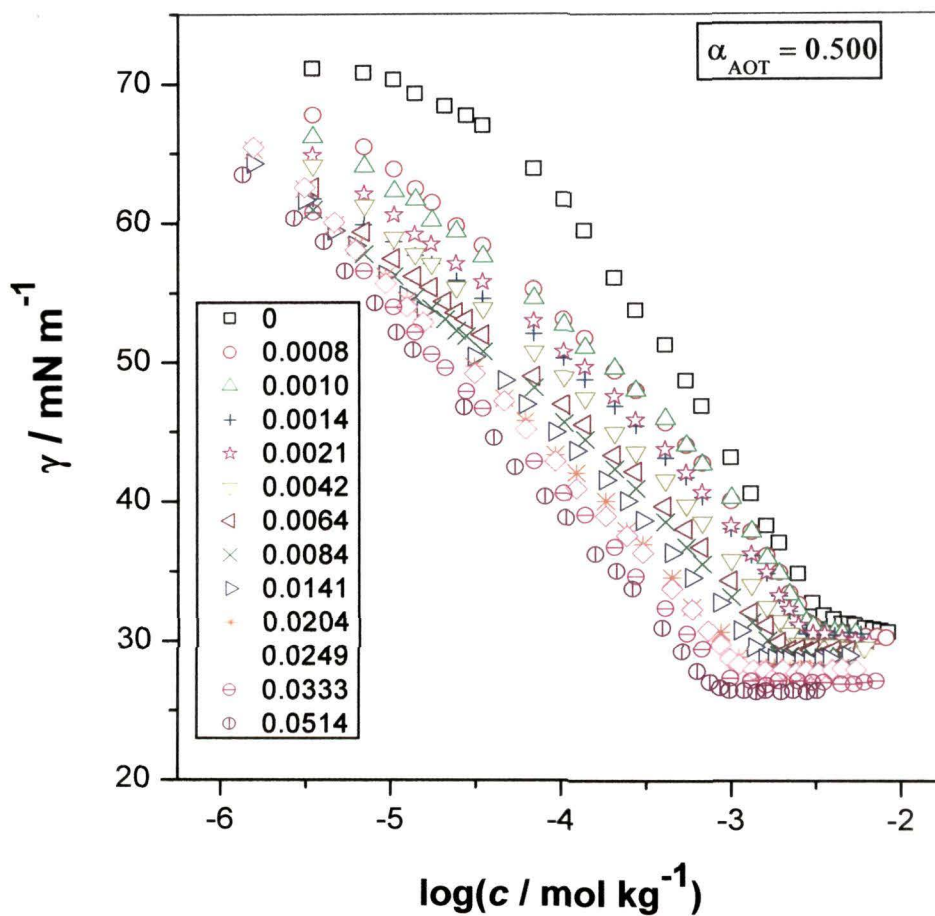


Figure 4.5 - Variation of surface tension with logarithm of total surfactant concentration for AOT + SDS system with $\alpha_{\text{AOT}} = 0.500$ in aqueous sodium chloride solutions. Sodium chloride concentrations in mol kg⁻¹ are given in the inset.

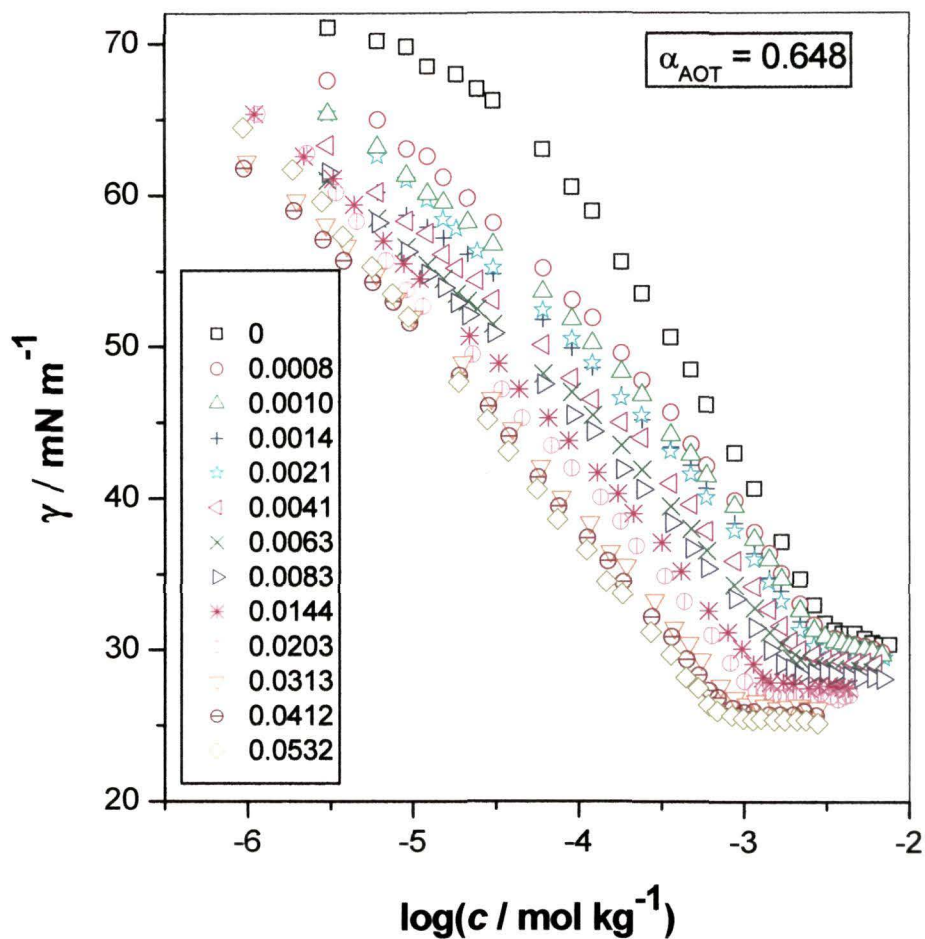


Figure 4.6 - Variation of surface tension with logarithm of total surfactant concentration for AOT + SDS system with $\alpha_{\text{AOT}} = 0.648$ in aqueous sodium chloride solutions. Sodium chloride concentrations in mol kg^{-1} are given in the inset.

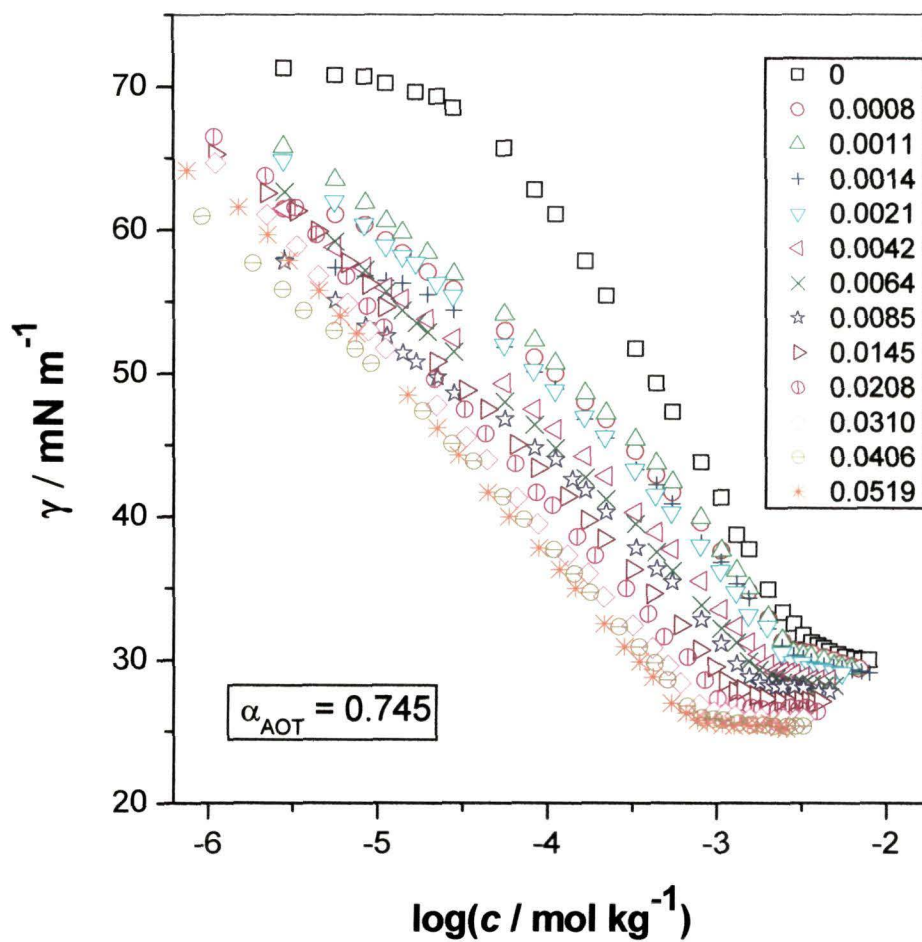


Figure 4.7 - Variation of surface tension with logarithm of total surfactant concentration for AOT + SDS system with $\alpha_{\text{AOT}} = 0.745$ in aqueous sodium chloride solutions. Sodium chloride concentrations in mol kg^{-1} are given in the inset.

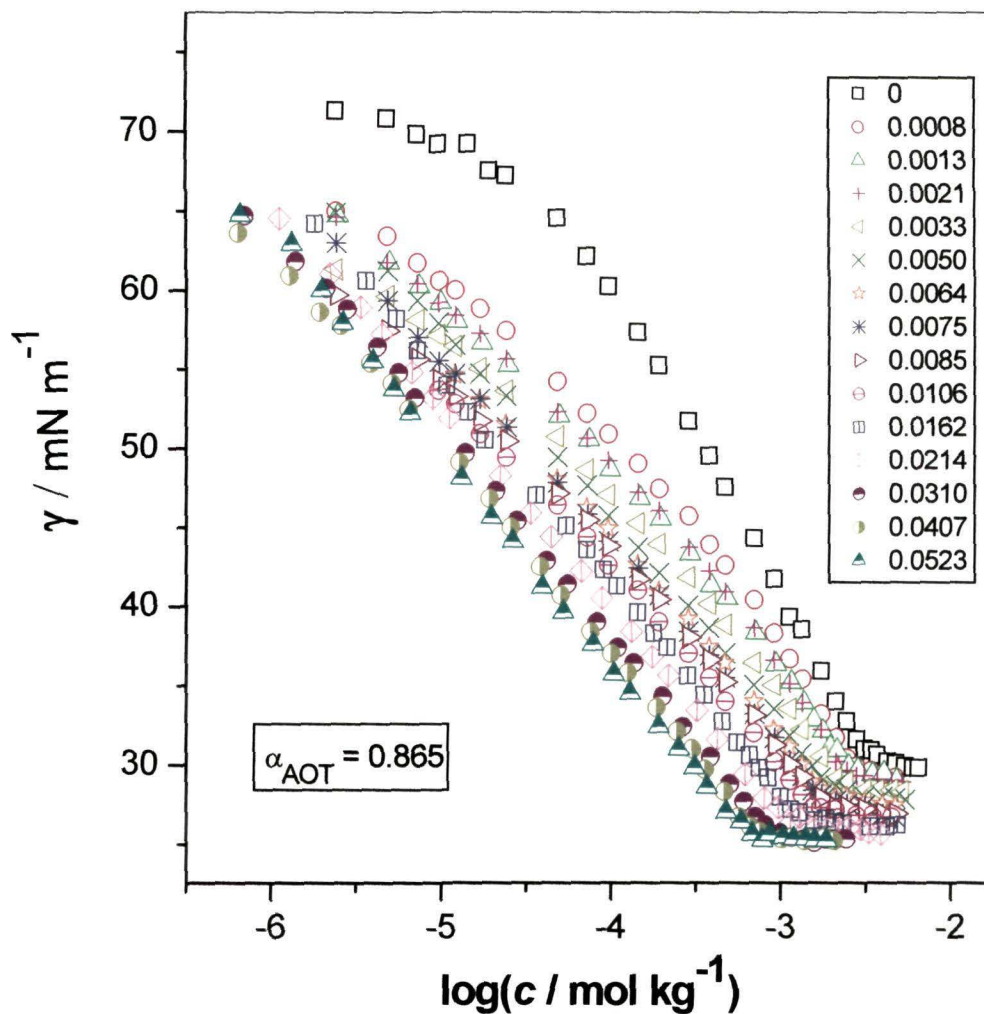


Figure 4.8 - Variation of surface tension with logarithm of total surfactant concentration for AOT + SDS system with $\alpha_{\text{AOT}} = 0.865$ in aqueous sodium chloride solutions. Sodium chloride concentrations in mol kg^{-1} are given in the inset.

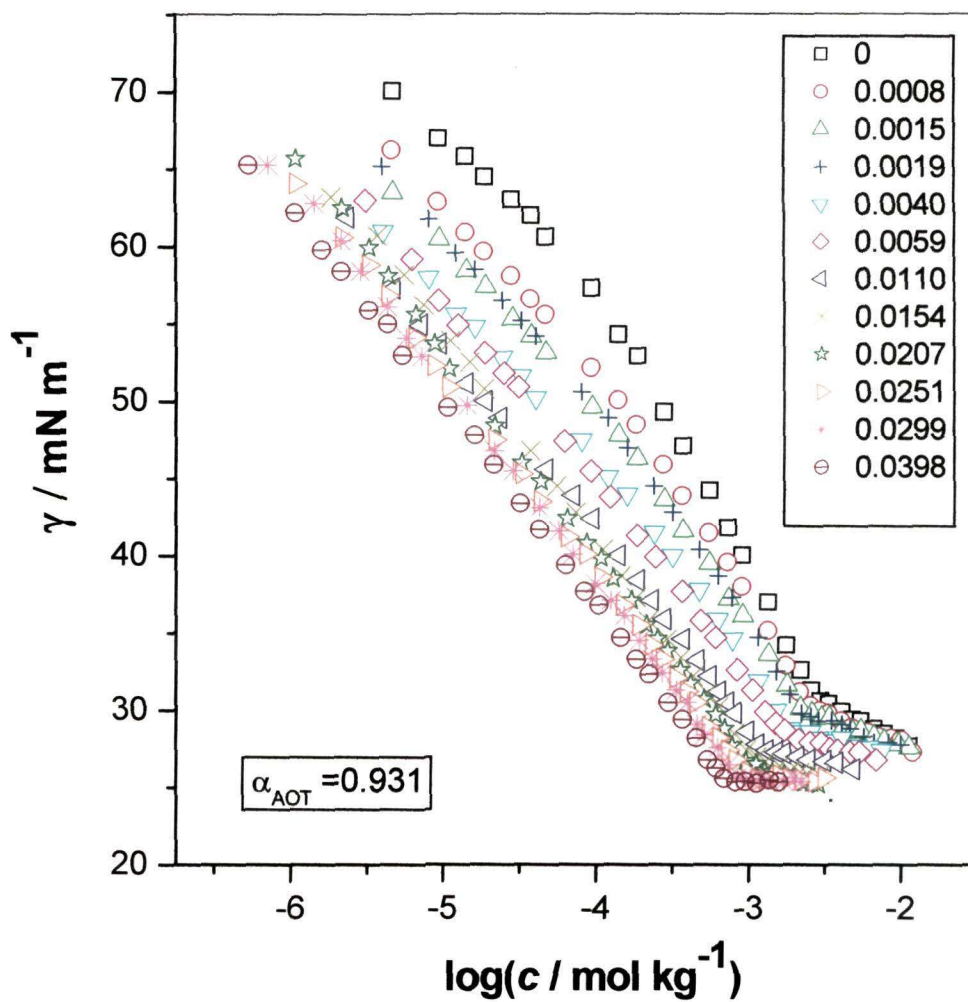


Figure 4.9 - Variation of surface tension with logarithm of total surfactant concentration for AOT + SDS system with $\alpha_{\text{AOT}} = 0.931$ in aqueous sodium chloride solutions. Sodium chloride concentrations in mol kg^{-1} are given in the inset.

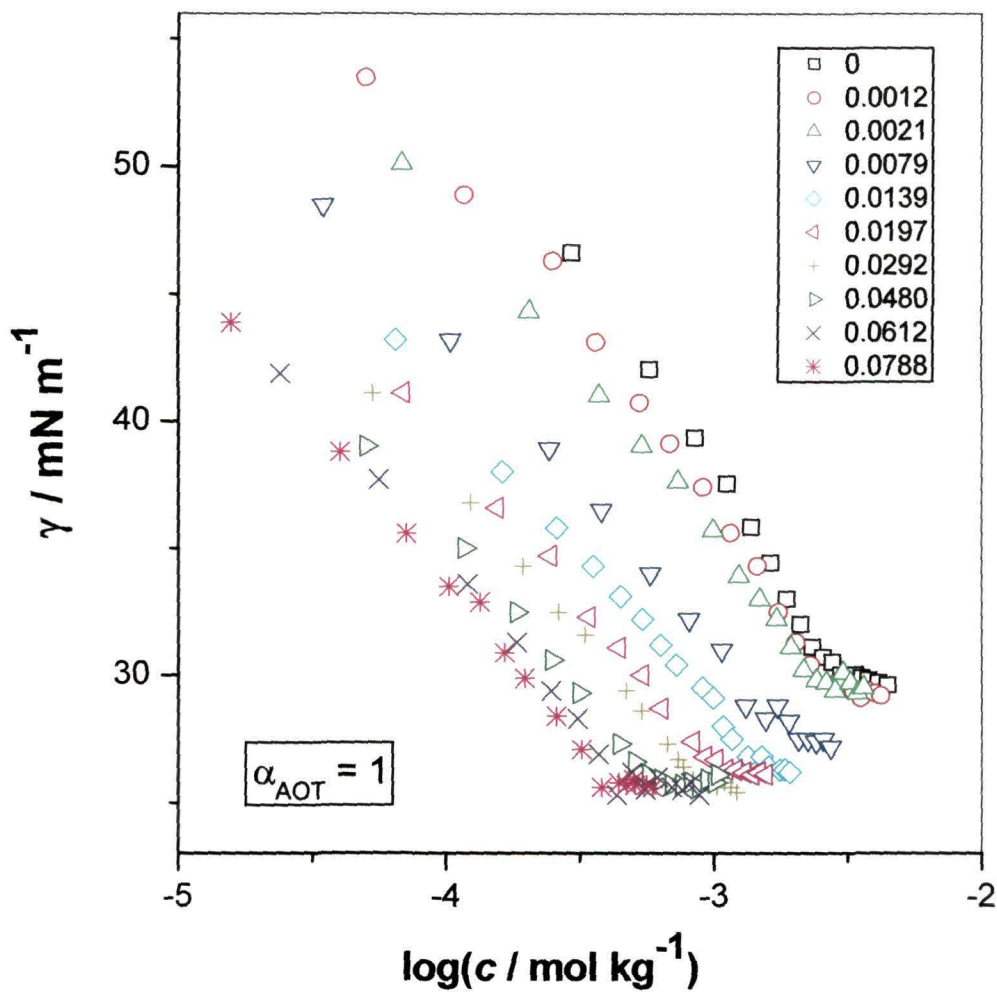


Figure 4.10 - Variation of surface tension with logarithm of total surfactant concentration for AOT + SDS system with $\alpha_{\text{AOT}} = 1$ in aqueous sodium chloride solutions. Sodium chloride concentrations in mol kg^{-1} are given in the inset.

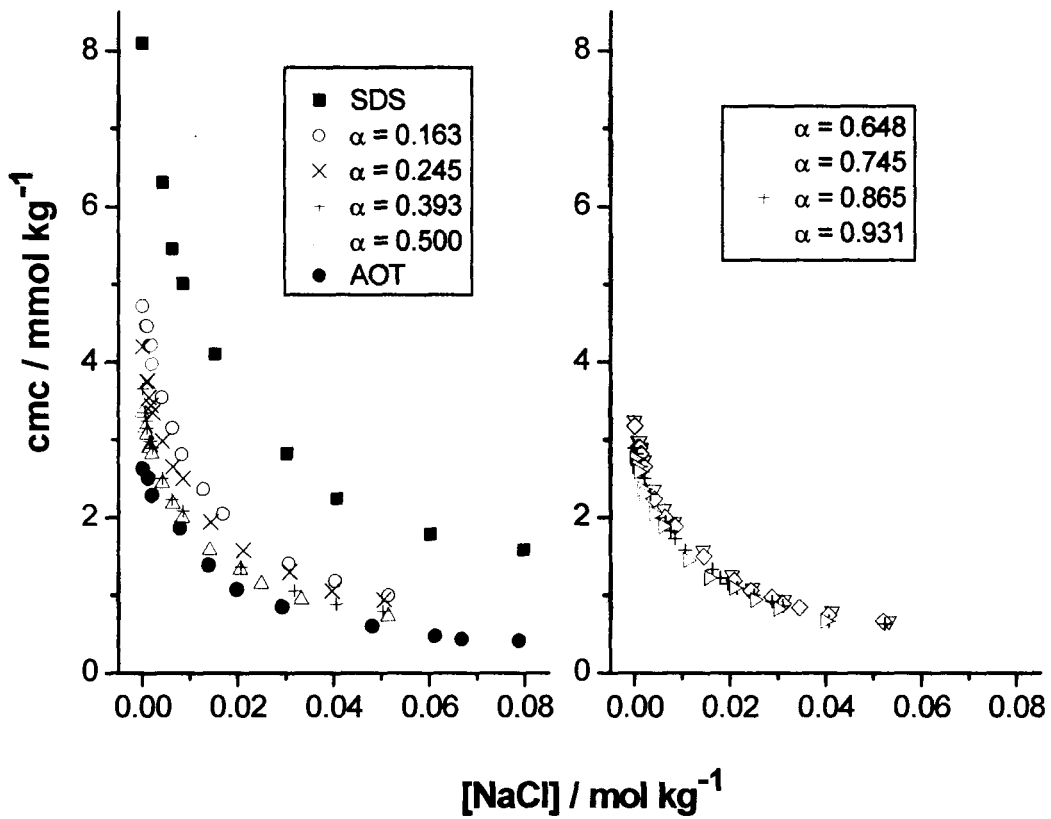


Figure 4.11 - Variation of cmc of AOT + SDS systems as a function of sodium chloride concentration.

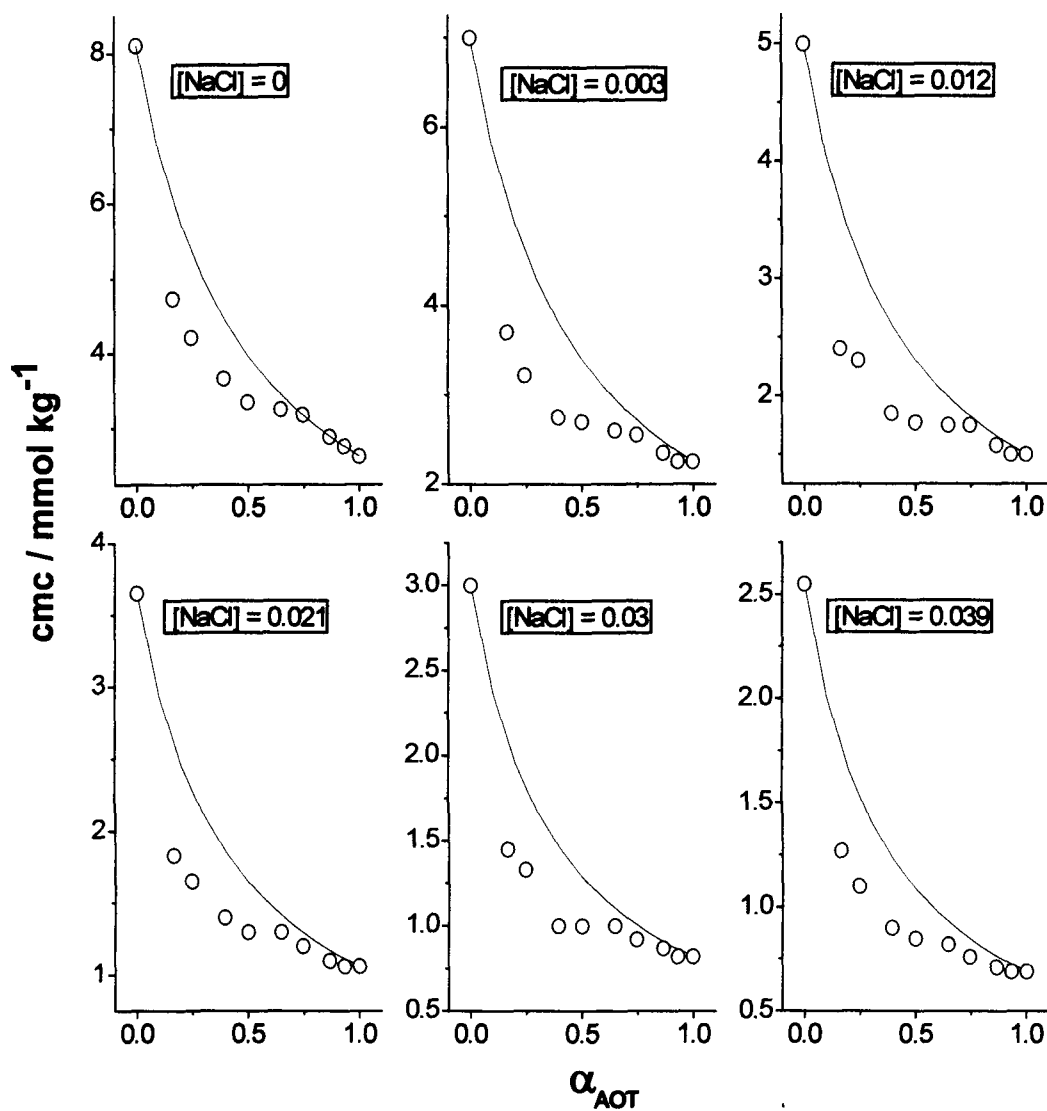


Figure 4.12 - Values of cmc of AOT + SDS system as a function of mole fraction of AOT in the bulk solution at different concentrations of added NaCl (shown in the insets). Solid lines indicate ideal values of cmc calculated from the Clint's equation.

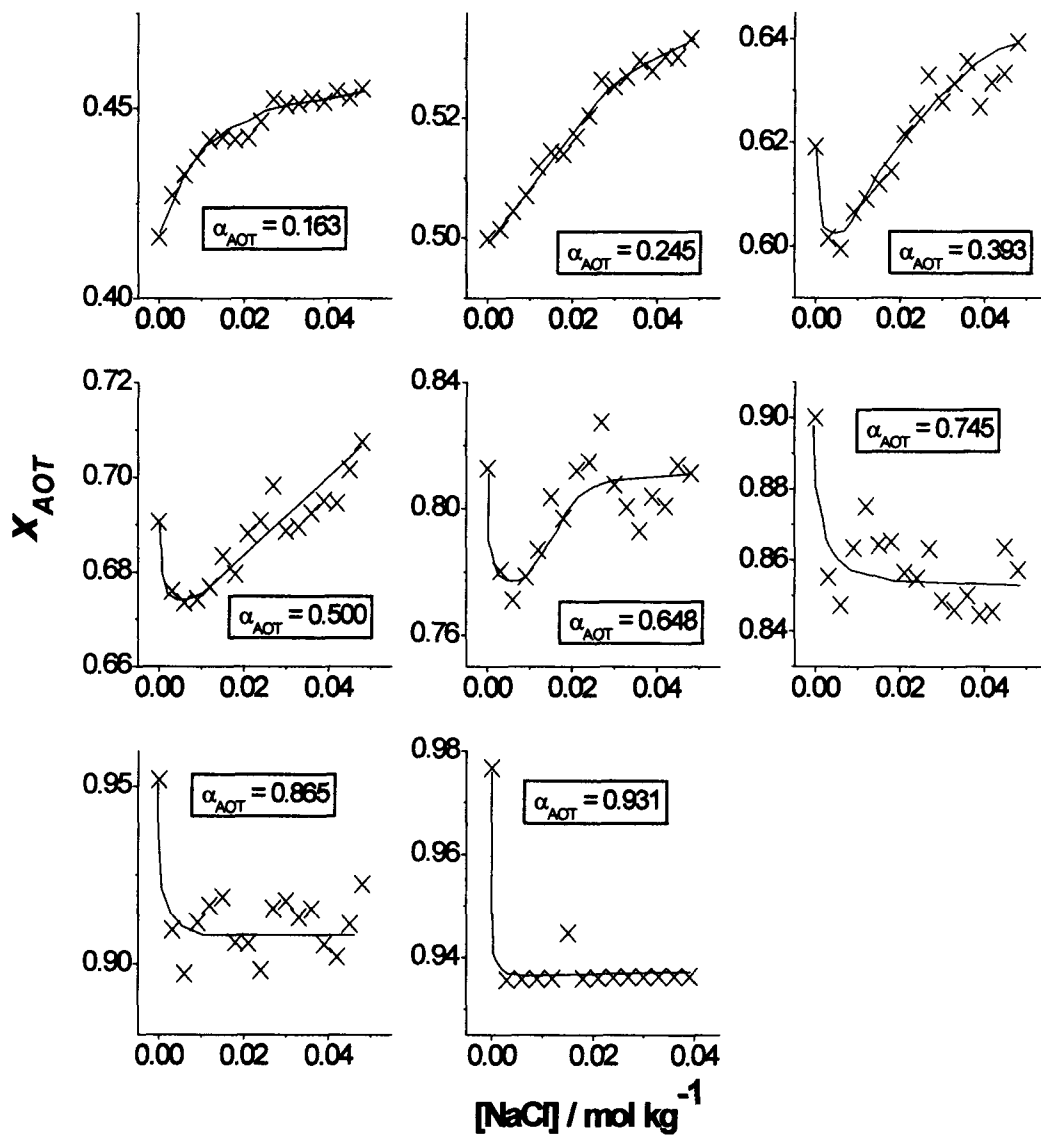


Figure 4.13 – Variation of composition of AOT in the mixed micelle from Rubingh’s Model for AOT + SDS systems as a function of sodium chloride concentration.

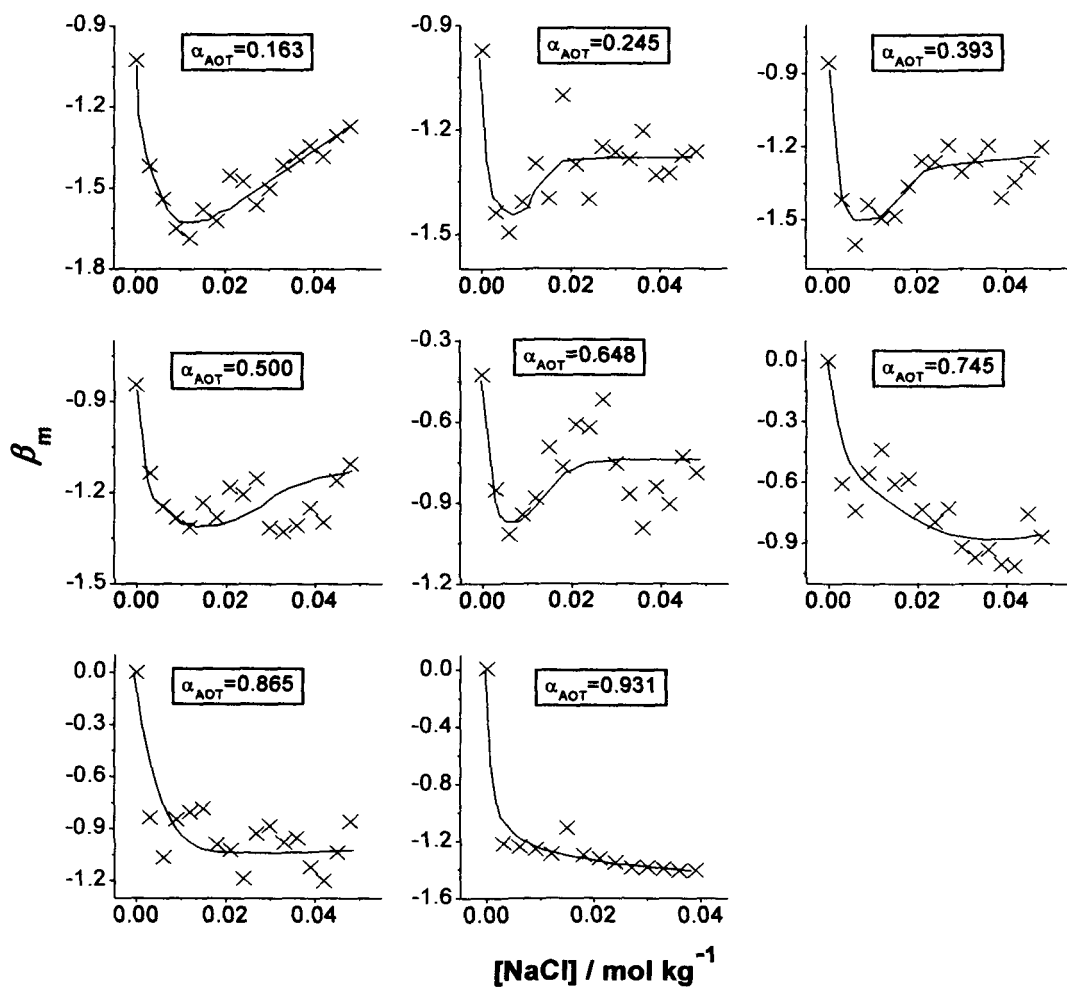


Figure 4.14 - Variation of interaction parameter in the mixed micelle of AOT + SDS systems with sodium chloride concentration.

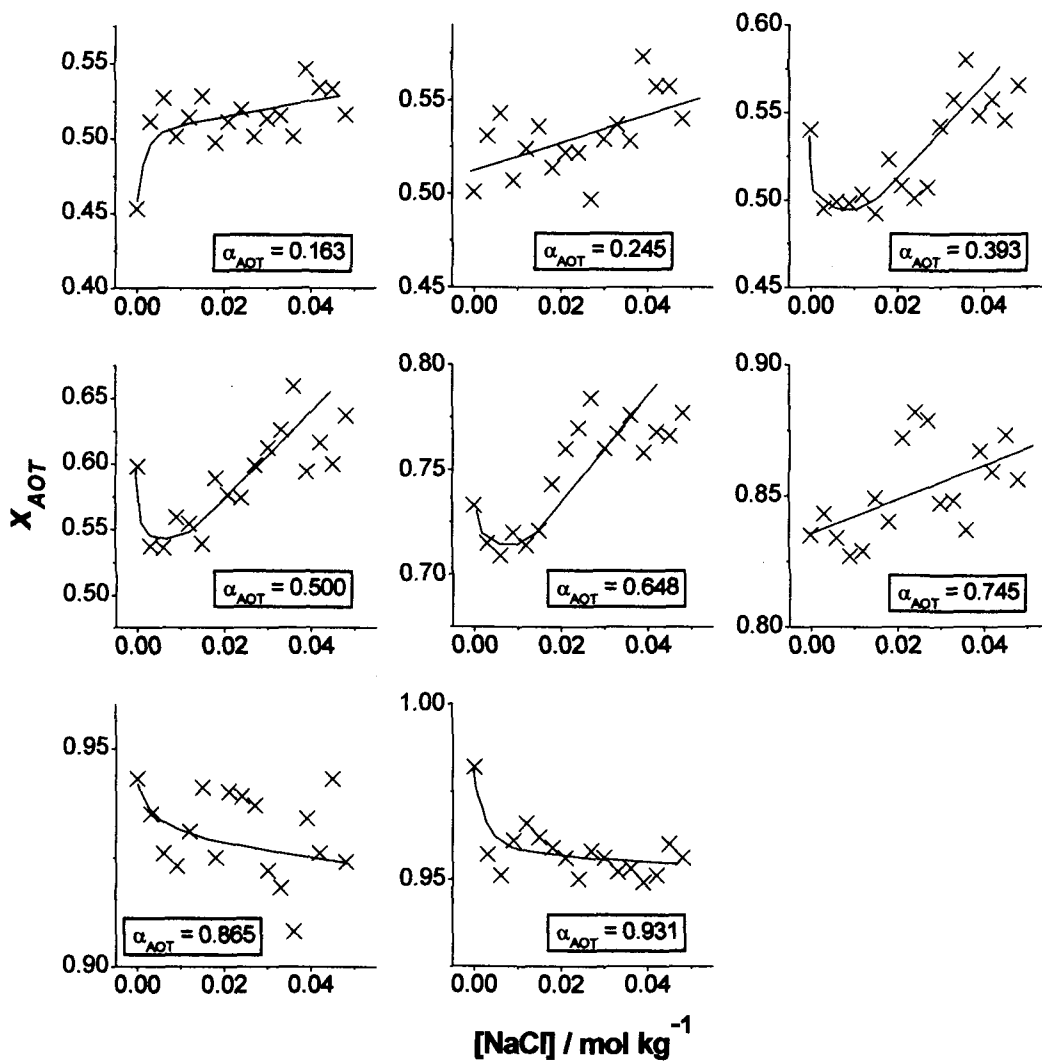


Figure 4.15 - Variation of composition of AOT in the mixed micelle from Rodena's Model for AOT + SDS systems as a function of sodium chloride concentration.

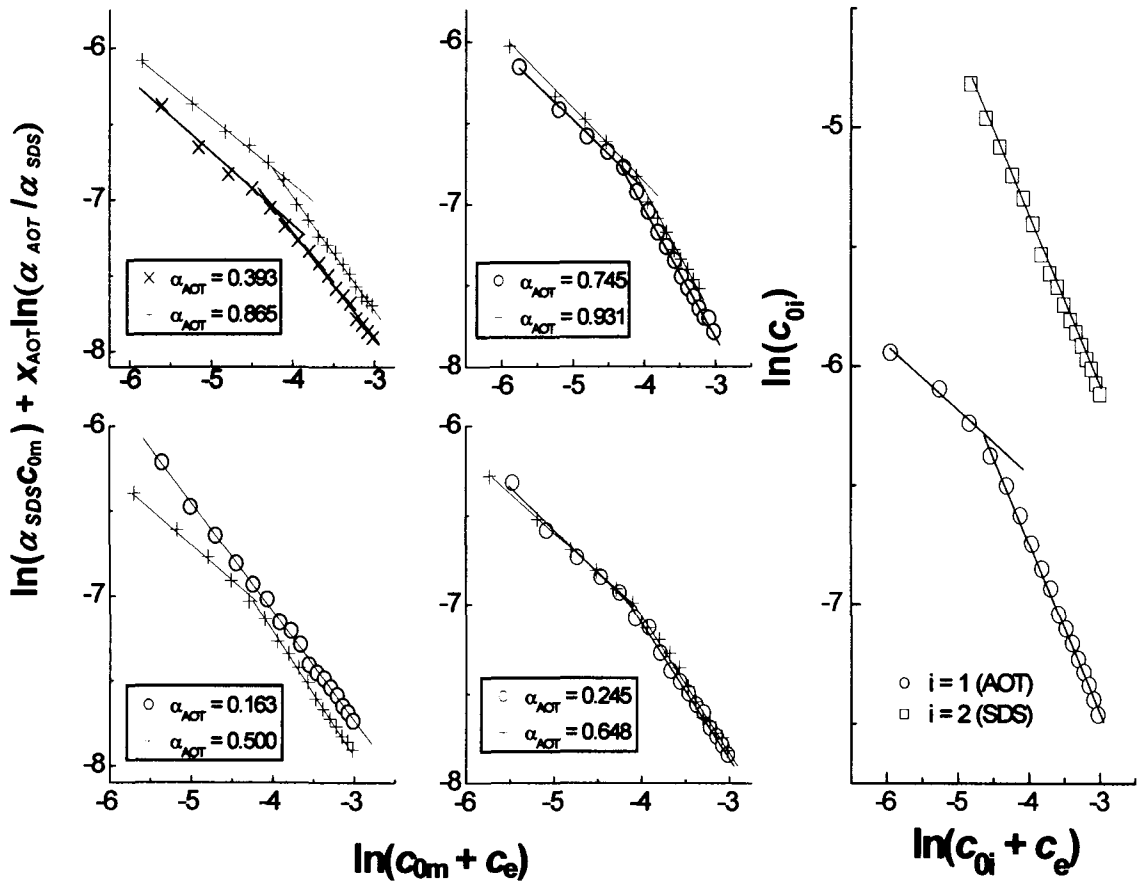


Figure 4.16 – CH plots for AOT + SDS mixed systems and for AOT and SDS single surfactant systems

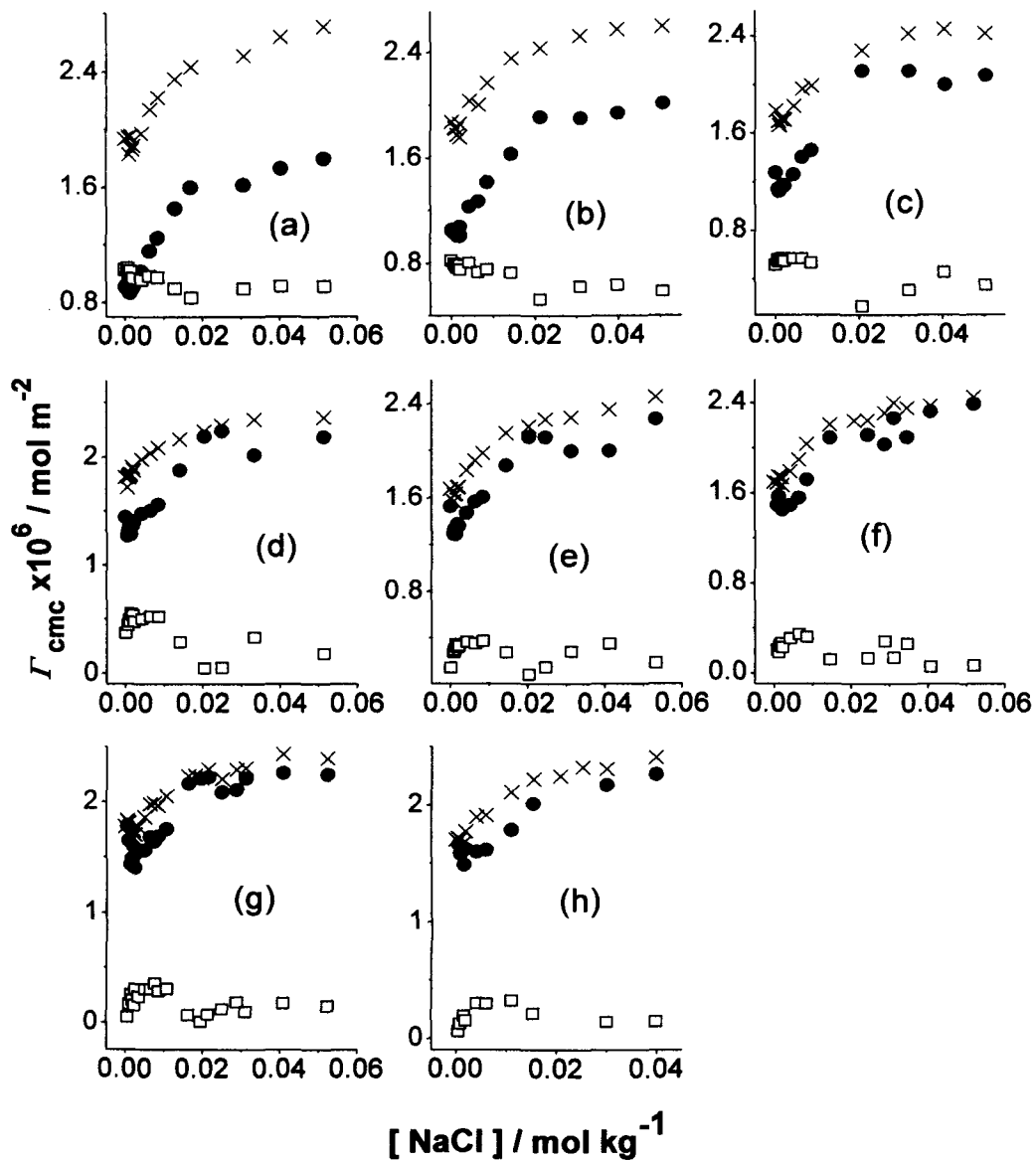


Figure 4.17 - Variation of surface excess of the mixture (cross symbols) and that of the components AOT (solid circles) and SDS (open squares) in the mixed state of AOT + SDS systems with sodium chloride concentration. (a) $\alpha_{\text{AOT}} = 0.163$ (b) $\alpha_{\text{AOT}} = 0.245$ (c) $\alpha_{\text{AOT}} = 0.393$ (d) $\alpha_{\text{AOT}} = 0.500$ (e) $\alpha_{\text{AOT}} = 0.648$ (f) $\alpha_{\text{AOT}} = 0.745$ (g) $\alpha_{\text{AOT}} = 0.865$ (h) $\alpha_{\text{AOT}} = 0.931$

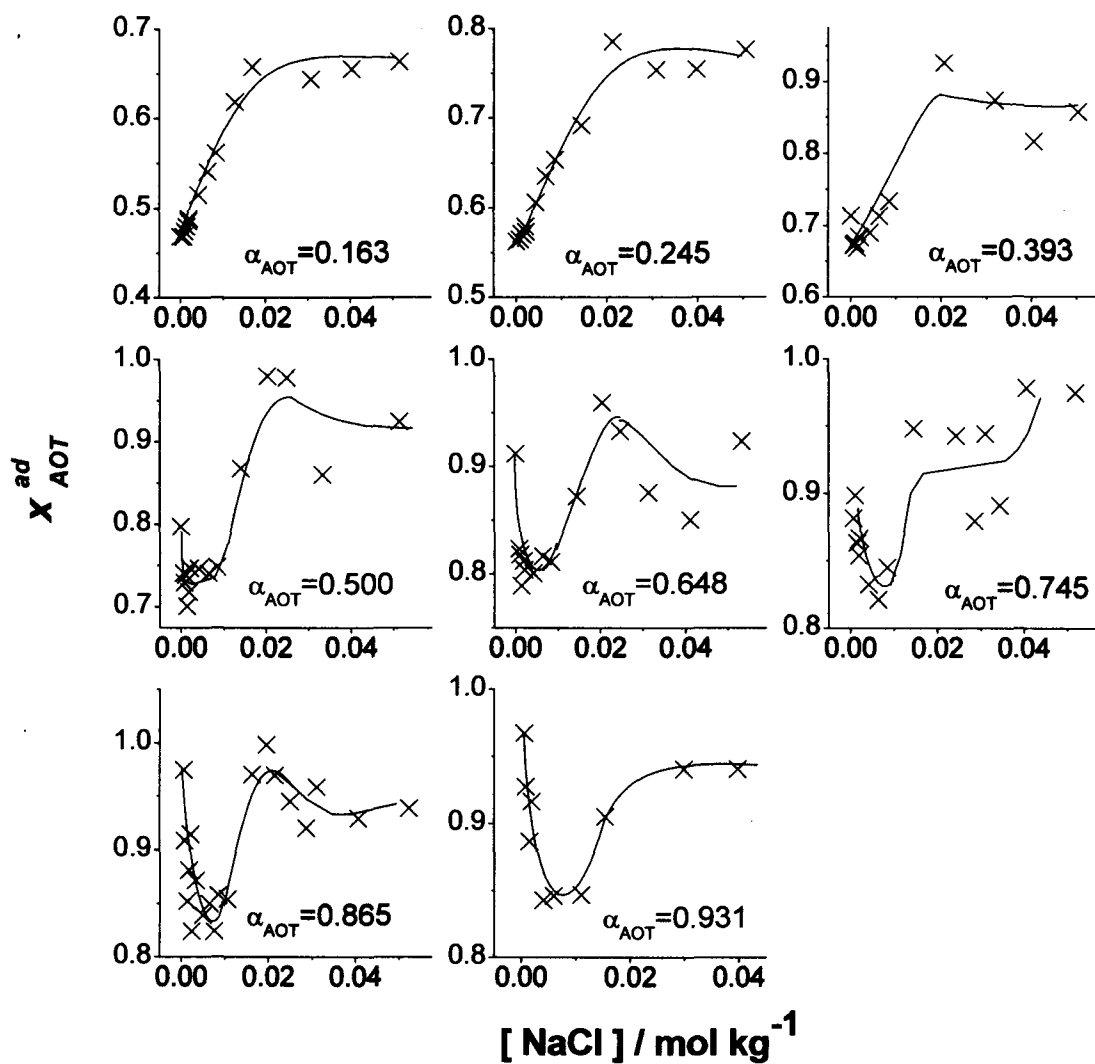


Figure 4.18 - Variation of composition of AOT in the adsorbed layer from Rosen's model for AOT + SDS systems with sodium chloride concentration.

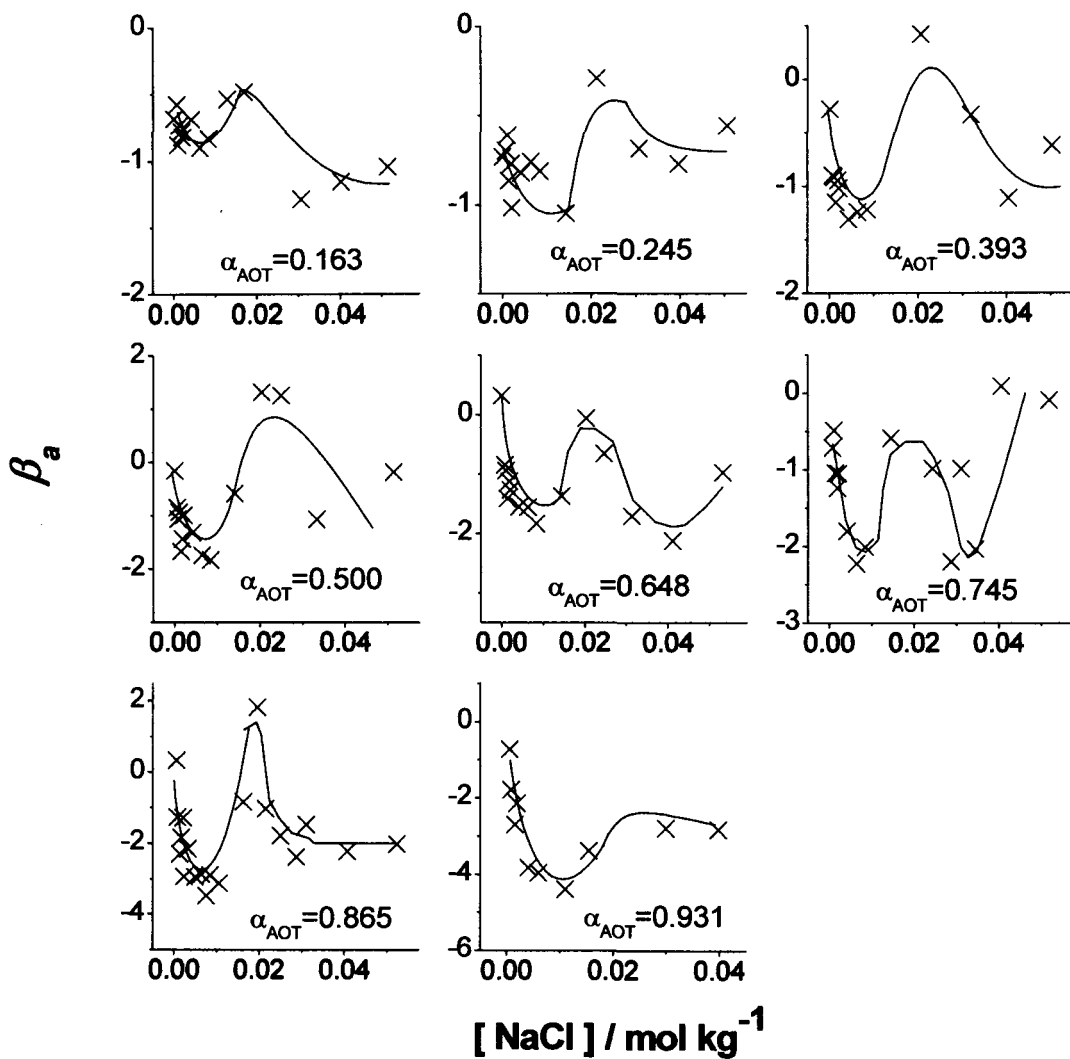


Figure 4.19 - Variation of interaction parameter in the adsorbed layer of AOT + SDS systems with sodium chloride concentration.

CHAPTER 5

Micellization and adsorption behaviours of mixtures of sodium dioctylsulfosuccinate with Triton X-100 in aqueous NaCl medium

5.1 Introduction

As mentioned in the preceding chapters, our main objective is to study the aggregation and adsorption behaviours of mixed surfactant systems containing AOT, a double chained anionic surfactant, as one of the components with emphasis on the effect of second surfactant component on the special counter ion binding property of AOT. In chapter 4 we chose the mixture of AOT with SDS (a single-chain anionic surfactant) and studied its micellization, adsorption and counter ion binding characteristics. In this chapter, we have chosen for study the mixture of AOT with Triton X-100 (TX-100), a nonionic surfactant. There are already three reports¹⁻³ on AOT + TX-100 mixed system. Varade et al.¹ studied the micellar composition and cloud point of this mixture in water. Zhai et al.² studied the vesicle formation ability of this mixed system in aqueous medium under the influence of NaCl. Jan et al.³ studied the effect of several salts on the clouding behaviour of this mixed system. As mentioned already, our emphasis is mainly to investigate the influence of TX-100 on the special counter ion binding property of AOT.

5.2 Experimental Section

AOT (Sigma), TX-100 (Sigma), pyrene (Fluka), NaCl (E. Merck) and cetylpyridinium chloride (CPC; Fluka) were used as received. All solutions were prepared in Millipore water and measurements were made under thermostated condition at 25 °C temperature. A stock aqueous solution of NaCl was prepared and diluted to get the required concentrations. Solution containing a mixture of

AOT and TX-100 of a particular composition was prepared by mixing required amounts of the surfactants in the diluted NaCl solutions.

Surface tension measurements were made by the Wilhelmy plate method using Krüss K11 tensiometer. EMF measurements were made using Jenway 3345 model Ionmeter and Jenway 924-329 combined ion-selective electrode reversible to sodium ion concentration in the solution. The Fluorescence emission measurements of pyrene probe were made using Hitachi F4500 model Fluorescence Spectrophotometer. The excitation of pyrene was done at 335 nm and the fluorescence emission was recorded in the range of 350 – 420 nm. CPC was used for fluorescence quenching.

5.3 Results and Discussion

5.3.1 Critical micelle concentration of mixed surfactants

Experimental values of surface tension (γ) of AOT + TX-100 mixed systems are given in Table 5.1. Representative plots of surface tension versus mixed surfactant concentration are shown in Fig. 5.1. Experimental values of I_1/I_3 and EMF as a function of mixed surfactant concentration are given in Tables 5.2 and 5.3, respectively. I_1 and I_3 denote the intensities of fluorescence emission of pyrene in the mixed surfactant system corresponding to 373 and 384 nm, respectively. Plots of I_1/I_3 ratio versus surfactant concentration are shown in Fig. 5.2. Representative plots of measured EMF as a function of surfactant concentration are presented in Fig. 5.3.

Critical micelle concentration (cmc) values of AOT (c_{01}), TX-100 (c_{02}) and the mixed systems (c_{0m}) in water determined from the surface tension,

fluorescence emission and EMF data are listed in Table 5.4. From the plots (Fig. 5.2) of I_1/I_3 versus total surfactant concentration (c), cmc was chosen as c corresponding to the first inflexion point. Plots of EMF versus logarithm of Na^+ concentration (Fig. 5.3) showed breaks for mixtures with mole fraction of AOT ($\alpha_{\text{AOT}} \geq 0.944$) and hence cmc could be determined from the EMF data in this composition range only. Similar plots of EMF for mixtures having $\alpha_{\text{AOT}} < 0.944$ did not show any break (Fig. 5.3) indicating a greater extent of suppression of the counter ion binding to the mixed micelle by the nonionic surfactant TX-100. The cmc values obtained from the surface tension method are utilized for determining micellar compositions. The variation of cmc with α_{AOT} is shown in Fig. 5.4. It is interesting to note that the cmc of TX-100 decreases when it is initially mixed with AOT.

5.3.2 *Composition of the mixed micelle in water*

The ideal cmc values for the mixed systems are calculated theoretically using the Clint's equation⁴ (*ca.* chapter 4, Eq. 4.1) and are plotted along with the experimental values in Fig. 5.4. It is seen that the experimental values of cmc are lower than the ideal values indicating synergism.

The mole fraction of AOT (x_1) in the mixed micellar phase was calculated from the Rubingh's model^{5,6} by using the equation in the preceding chapters (*ca.* chapter 3, Eq. 3.4 and chapter 4, Eq. 4.2). These values of x_1 (x_{AOT}) are listed in Table 5.5 as x_1^{Rb} . The values of activity coefficients (f_i) and interaction parameter (β_m) were calculated using Eqs. (3.2) and (3.3) of chapter 3 (Table 5.5). The variation of x_1^{Rb} , f_{AOT} , and f_{TX100} with α_{AOT} are shown in Figs. 5.5 and 5.6,

respectively. The reported¹ values of x_1 are in good agreement with x_1^{Rb} . In the composition range of $0.3 \leq \alpha_{AOT} < 1$, the micellar phase is enriched with TX-100, which is due to ten times lower cmc value of TX-100. Enrichment of micellar phase by nonionic component in the case of ionic + nonionic mixed surfactant systems is a general trend.⁷⁻⁹ In the composition range of $0 < \alpha_{AOT} < 0.9$, x_1^{Rb} has values higher than the ideal values. The interaction parameter has negative values (Fig. 5.7) in the entire composition range of mixed surfactant indicating thereby attractive interactions between AOT and TX-100. However, the value of β_m becomes less negative with increase in the amount of AOT (Fig. 5.7) in the mixture which is due to increasing repulsive interaction between the head groups of AOT.

The values of x_1 were also estimated by using the Rodenas, Valiente and Villafruela (RVV)¹⁰ model (*ca.* chapter 3, Eq. 3.6). For calculating x_1 from Eq. (3.6) given in chapter 3, we first determined the slope $dlnc_{0m}/d\alpha_1$ ($\alpha_1 = \alpha_{AOT}$) by least-squares fitting the lnc_{0m} versus α_1 data of the mixed system to a polynomial (Fig. 5.8)

$$lnc_{0m} = \sum_j a_j \alpha_1^j, \quad j = 0 \text{ to } 6 \quad (5.1)$$

The fitted values of the empirical coefficients a_j are -8.222 ($j = 0$), -7.920 ($j = 1$), 64.742 ($j = 2$), -255.253 ($j = 3$), 523.845 ($j = 4$), -513.612 ($j = 5$) and 190.502 ($j = 6$). The x_1 values calculated thus are denoted by x_1^{RVV} given in Table 5.5 and also shown in Fig. 5.5. Values of x_1^{RVV} are much scattered and differ from x_1^{Rb} .

5.3.3 Composition of the mixed micelle in aqueous NaCl medium

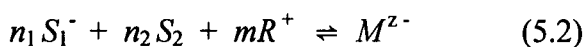
In order to assess the counter ion binding behaviour of AOT + TX-100 system using Corrin – Harkins approach¹¹ we require cmc values of the mixed system as a function of NaCl concentration. For this purpose, we measured surface tension of AOT + TX-100 system as a function of mixed surfactant concentration (c) at different values of α_{AOT} and NaCl concentration. The surface tension data are given in Table 5.6 and the surface tension isotherms are shown in Fig. 5.9a-h. The cmc values of the mixed system at different NaCl concentrations determined from the surface tension data are listed in Table 5.7 and also plotted in Fig. 5.10. As in water medium, in aqueous NaCl medium also cmc of TX-100 initially decreases by mixing with AOT.

In aqueous NaCl medium also we determined the micellar composition using Rubingh's model. In order to apply the Rubingh's model in aqueous NaCl medium, we first calculated the cmc values of the mixed system at fixed NaCl concentrations by interpolation of the cmc data given in Table 5.7. These interpolated cmc values are listed in Table 5.8. The composition of AOT (x_1) in the mixed micelle increases with increase of NaCl concentration (Fig. 5.11). By adding NaCl the repulsive interaction between the head groups of AOT can decrease due to the presence of increased counter ions in the Stern layer of the mixed micelle and this would cause β_m to become more negative. But, from Fig. 5.11 it can be seen that β_m becomes more negative only in the mixtures of $\alpha_{\text{AOT}} = 0.850$ and 0.936 up to only 0.01 mol kg^{-1} addition of NaCl and the general trend otherwise is that β_m becomes less negative by increasing the concentration of added NaCl. It is therefore appears that increase in the added electrolyte

concentration pushes more and more ionic component (AOT) into the mixed micelle leading to more repulsion and hence decrease in the negative value of β_m . Consequently, repulsive interaction between the head groups of AOT is not controlling the enrichment of mixed micelle by AOT (because if repulsive interaction is the controlling factor, then enrichment of mixed micelle by AOT would not have been favoured) due to addition of NaCl. Similar observations were made in SDS + TX-100, TTAB + TX-100, C₁₆Br + Brij 58 and C₁₆BzCl + Brij58 mixed systems.^{12,13}

5.3.4 Counter ion binding to mixed micelle

From the EMF (E) data counter ion binding constant β_c for AOT + TX-100 mixed system in water was determined by applying the method for data analysis that was described elsewhere¹⁴ and the calculated values of β_c are given in Table 5.4. In the mixed micelle, it is interesting to note that β_c has values equal to zero except for the mixtures with composition of AOT, $\alpha_{AOT} \geq 0.944$. Suppression of counter ion binding by addition of nonionic to ionic surfactants has been reported earlier by many researchers.^{7,13,15,16} From the cmc values of the mixed AOT + TX-100 systems in electrolyte solutions we made an attempt to determine the counter ion binding constant. As discussed in the preceding chapters, considering an equilibrium of the form



we can derive a modified Corrin-Harkins equation (ca. chapter 4, Eq. 4.6) for AOT + TX-100 mixture, which can be written as

$$\ln(\alpha_{TX100} c_{0m}) + x_{AOT} \ln(\alpha_{AOT}/\alpha_{TX100}) = A - \beta_c \ln(\alpha_{AOT} c_{0m} + c_e) \quad (5.3)$$

In the equilibrium (5.2), S_1^- refers to AOT, S_2 to TX-100 and R^+ to the sodium counter ion. Surprisingly, when we plotted (Fig. 5.12) the left hand side terms of Eq. (5.3) versus $\ln(\alpha_{AOT}c_{0m} + c_e)$, it appeared that Eq. (5.3) is not applicable to AOT + TX-100 mixed system in the entire region of NaCl concentration (from 0 to 0.07 mol kg⁻¹). We, however, made an attempt to find the values of β_c from the plots given in Fig. 5.12 by choosing limited data points lying in the linear region with highest slope. By the least-squares fit of such data points we evaluated the value of β_c and its value is found to be 0.1 ± 0.04 in the composition range $0.15 \leq \alpha_{AOT} \leq 0.936$. From this analysis, it is amply clear that TX-100 suppresses the counter ion binding to the mixed micelle significantly, which is also in accordance with the observation made above from the EMF data.

5.3.5 Interfacial property at air-water interface

The surface excess (Γ_{cmc}) in mol m⁻² at cmc for the nonionic TX-100 in absence and presence of NaCl is calculated from the surface tension data lying below the cmc using the equation,

$$\Gamma_{cmc} = -\frac{1}{2.303RT} \left[\frac{\partial \gamma}{\partial \log c} \right] \quad (5.4)$$

For the anionic AOT in the presence of NaCl of concentration c_e the surface excess is calculated using the equation (*ca.* chapter 1, Eq. 1.20)

$$\Gamma_{cmc} = -\frac{1}{2.303RT} \left[\frac{1}{1 + \frac{c}{c+c_e}} \right] \left[\frac{\partial \gamma}{\partial \log c} \right] \quad (5.5)$$

For AOT in the absence of NaCl, we get from Eq. (5.5) expression for Γ_{cmc} as (*ca.* chapter 1, Eq. 1.18)

$$\Gamma_{cmc} = -\frac{1}{4.606RT} \left[\frac{\partial \gamma}{\partial \log c} \right] \quad (5.6)$$

The slope of the surface tension (γ) versus logarithm of the total surfactant concentration (c) plot in the linear part close to the cmc gives the value of $\partial\gamma/\partial\log c$. The surface excess values so obtained are given in Table 5.9 and shown in Fig. 5.13 as a function of NaCl concentration. The surface excess of the mixture of a particular composition (constant α_1) is given in the absence of NaCl by the expression (ca. chapter 1, Eq. 1.45)

$$\Gamma_{cmc} = -\left[\frac{1}{(1 + x_{1a})RT} \right] \left(\frac{d\gamma}{d\ln c} \right) \quad (5.7)$$

and in the presence of NaCl by the expression (ca. chapter 1, Eq. 1.49)

$$\Gamma_{cmc} = -\left(\frac{1}{RT} \right) \left(\frac{1}{1 + \frac{\alpha_1 x_{1a} c}{\alpha_1 c + c_e}} \right) \left(\frac{d\gamma}{d\ln c} \right)_{c_e} \quad (5.8)$$

To calculate Γ_{cmc} of mixed system we therefore require the composition of the surfactant in the adsorbed layer (x_{1a}). The values of x_{1a} were calculated by choosing a reference point of constant surface tension (35 mN m⁻¹ was selected here) and by using the approach of Rosen and Hua.¹⁷ The relevant expressions used for calculation are given in chapter 4 (Eqs. 4.11 – 4.13) and the estimated concentrations of surfactant mixture (c_{ym}) corresponding to the chosen value of surface tension (35 mN m⁻¹) are given in Table 5.7. The compositions of the mixed adsorbed monolayer were computed by iterative method as explained in chapter 4. The calculated values of x_{1a} (composition of AOT in the mixed adsorbed layer), interaction parameter (β_a) and activity coefficients (f_{1a} and f_{2a})

corresponding to the adsorbed layer are given in Table 5.10. Unfortunately, for the mixtures with composition, $\alpha_{AOT} < 0.5$, the x_{1a} values could not be computed since the iteration did not converge. The variation of x_{1a} both with α_{AOT} and NaCl concentration is shown in Figs. 5.14. Using the computed values of x_{1a} , surface excess (Γ_{cmc}) of the mixed systems was evaluated from Eqs. 5.7 and 5.8 (Table 5.9 and Fig. 5.13). Although Γ_{cmc} of TX-100 and AOT increase with NaCl concentration, that of the mixtures show negligible dependence on the NaCl concentration. In water medium the mixed adsorbed monolayer has very small mole fraction of AOT (x_{1a}) even up to 0.95 of α_{AOT} . This is attributed to the higher surface activity of the nonionic TX-100 compared to that of the anionic AOT. The present observation is similar to that reported for the cationic-Brij surfactant systems.^{7,17} In aqueous NaCl medium, the composition of AOT in the mixed adsorbed monolayer (x_{1a}) increases with NaCl concentration in the mixtures with $\alpha_{AOT} \geq 0.8$, while in the mixture with $\alpha_{AOT} = 0.5$, x_{1a} does not show increase with the electrolyte concentration. Knowing x_{1a} , we could calculate the surface excess of AOT and TX-100 separately in the adsorbed layer from the values of Γ_{cmc} in the mixture (Fig. 5.15). From Fig. 5.15 it is apparent that the negligible dependence of surface excess of the mixtures with NaCl concentration in mixtures of $\alpha_{AOT} \geq 0.8$ is because surface excesses of TX-100 (decreases with [NaCl]) and AOT (increases with [NaCl]) have opposite trends with respect to their dependence on NaCl concentration. The interaction parameter between the two surfactants in the adsorbed layer (β_a) has negligible dependence on NaCl concentration (Fig. 5.14) and the overall values of β_a are positive in contrary to

β_m . This may be because in the adsorbed layer the inter-surfactant interaction is controlled by that between the head groups and since the tails may be hanging in the air phase the contribution to β_a from the van der Waals interaction between the tails may be negligible.

5.3.6 Aggregation number

Aggregation number (N_o) of the mixed surfactant system was determined by measuring fluorescence emission of pyrene in the absence and presence of the quencher CPC and using the relations¹⁸

$$I_o / I_q = \exp ([q] / [\text{micelle}]) \quad (5.9)$$

$$N_o = (c - \text{cmc}) / [\text{micelle}] \quad (5.10)$$

where I_o and I_q are the intensities of fluorescence emission at 373 nm of pyrene in the absence and presence of CPC of concentration $[q]$, respectively. We determined N_o at two different surfactant concentrations, one by keeping $c \approx 2\text{cmc}$ and the other by keeping $c - \text{cmc}$ constant at $0.0004 \text{ mol kg}^{-1}$. The values of I_o/I_q are listed in Table 5.11 and the plots of $\ln(I_o/I_q)$ versus $[q]$ are shown in Figs. 5.16 and 5.17. Values of N_o are given in Table 5.12 and its variation with α_{AOT} is shown in Fig.5.18. On adding AOT to TX-100, the aggregation number of the mixed micelle does not seem to change till the mole fraction of AOT becomes 0.8. On the other hand, when TX-100 is added to AOT the aggregation number of the mixed micelle increases sharply and attains a maximum value at $\alpha_{\text{AOT}} \approx 0.9$. Therefore, it appears that when TX-100 is added to AOT, the electrostatic self-repulsion of the head group in anionic AOT are weakened thereby enabling more monomers into the mixed micellar phase. However, addition of AOT to TX-100

does not seem to change much the interaction between the TX-100 monomers within the micellar phase. From the two set of N_o values determined at two different surfactant concentrations it is observed that the surfactant concentration has influence on N_o only in the region of $0.8 < \alpha_{AOT} < 1$. Using the values of x_1^{Rb} from Table 5.5, we also evaluated the aggregation numbers of AOT and TX-100 separately in the mixed micelle which are given in Table 5.12.

5.4 Conclusions

Mixed systems of AOT and TX-100 have been studied in water and aqueous NaCl media. In both these media AOT + TX-100 system exhibits synergism in cmc. In the mixed micelle, the mutual interaction between the two surfactants became less attractive in the presence of NaCl. In water, in the composition range of $0.3 \leq \alpha_{AOT} < 1$, the micellar phase is enriched with TX-100. Added NaCl increases the composition of AOT in the mixed micelle and also makes the interaction parameter less negative. The counter ion binding of AOT is suppressed to a great extent by the presence of nonionic TX-100 even at high mole fraction of the anionic AOT. It was observed that in the composition range $0.15 \leq \alpha_{AOT} \leq 0.936$, counter ion binding constant has value equal to 0.1 ± 0.04 . Only when $\alpha_{AOT} > 0.94$, the mixed system shows counter ion binding value (about 0.3) which is comparable to the lower value of pure AOT. The modified Corrin – Harkins equation is not strictly applicable to this mixed system. In water, the mixed adsorbed monolayer contains predominantly TX-100 and added NaCl is found to push more AOT to the air – water interface when $\alpha_{AOT} > 0.5$. Surface excess of the mixtures has negligible dependence on NaCl concentration. The

interaction between the surfactants in the adsorbed layer is more repulsive than that in the micellar phase. On adding AOT to TX-100, the aggregation number of the mixed micelle does not seem to change till the mole fraction of AOT becomes 0.8. On the other hand, when TX-100 is added to AOT the aggregation number of the mixed micelle increases sharply and attains a maximum value at $\alpha_{\text{AOT}} \approx 0.9$. Surfactant concentration is found to have influence on aggregation number only in the region of $0.8 < \alpha_{\text{AOT}} < 1$.

5.5 References

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Table 5.1 - Surface Tension (γ) Values of AOT+TX-100 Systems in Water at 298K

$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
$\alpha_{\text{AOT}} = 0$					
0.0011	57.4	0.0266	37.0	0.2776	30.2
0.0022	53.8	0.0310	36.1	0.3185	30.2
0.0033	51.7	0.0354	35.0	0.3588	30.4
0.0044	50.8	0.0398	35.2	0.3986	30.5
0.0055	48.6	0.0442	34.4	0.4380	30.4
0.0067	48.4	0.0551	33.9	0.5345	30.5
0.0089	47.2	0.0660	33.3	0.6282	30.6
0.0111	45.3	0.0878	32.9	0.7194	30.8
0.0133	42.2	0.1094	31.9	0.8942	30.8
0.0155	40.9	0.1309	31.6	1.0597	30.8
0.0177	39.4	0.1522	31.3	1.2167	30.9
0.0199	38.1	0.1945	30.7	1.3658	31.1
0.0221	38.2	0.2363	30.7		
$\alpha_{\text{AOT}} = 0.106$					
0.0011	63.0	0.0217	40.9	0.2154	30.4
0.0022	59.1	0.0260	38.9	0.2562	30.5
0.0033	56.7	0.0368	36.3	0.2966	31.0
0.0043	54.6	0.0475	35.4	0.3957	30.7
0.0054	52.9	0.0582	34.4	0.4920	30.8
0.0065	50.8	0.0689	33.2	0.5859	31.0
0.0087	49.1	0.0902	32.3	0.6773	31.3
0.0108	47.7	0.1114	31.6	0.8532	31.3
0.0130	45.4	0.1324	31.3	1.0205	31.4
0.0173	43.0	0.1741	30.7		
$\alpha_{\text{AOT}} = 0.170$					
0.0011	63.3	0.0316	37.1	0.2964	30.8
0.0023	59.9	0.0360	36.2	0.3381	30.8
0.0034	57.6	0.0472	34.9	0.4405	31.0
0.0045	55.3	0.0584	34.7	0.5402	31.3
0.0056	53.5	0.0696	34.0	0.6372	31.2
0.0068	52.0	0.0807	33.4	0.8240	31.6
0.0090	49.9	0.1028	32.5	1.0014	31.8

Table 5.1- Continued

$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
$\alpha_{AOT} = 0.170$					
0.0113	47.4	0.1248	31.9	1.1703	31.7
0.0136	44.2	0.1466	31.6	1.3311	31.8
0.0181	41.2	0.1684	31.3	1.4846	31.9
0.0226	39.0	0.2115	30.6		
0.0271	38.2	0.2542	30.7		
$\alpha_{AOT} = 0.290$					
0.0012	62.6	0.0393	36.8	0.2401	31.1
0.0025	58.7	0.0442	36.0	0.2866	31.1
0.0037	56.2	0.0491	35.6	0.3325	31.2
0.0049	54.3	0.0564	34.9	0.4452	31.4
0.0062	52.8	0.0637	34.9	0.5549	31.5
0.0074	51.6	0.0710	34.3	0.6617	31.7
0.0099	49.6	0.0783	34.2	0.8672	31.8
0.0123	48.6	0.0856	33.4	1.0624	31.9
0.0148	46.7	0.0977	33.0	1.2481	32.0
0.0172	44.9	0.1097	32.9	1.4250	31.9
0.0197	43.2	0.1217	32.5	1.5937	32.0
0.0246	41.6	0.1457	31.7	1.9087	31.9
0.0295	39.2	0.1695	31.3		
0.0344	37.3	0.1932	31.0		
$\alpha_{AOT} = 0.420$					
0.0014	62.4	0.0383	37.9	0.2953	30.8
0.0027	59.0	0.0464	36.0	0.3720	31.0
0.0041	56.9	0.0546	34.3	0.4475	31.2
0.0055	54.8	0.0627	33.9	0.5218	31.4
0.0069	54.6	0.0708	33.1	0.6429	31.7
0.0082	53.0	0.0843	33.0	0.7609	31.9
0.0110	50.8	0.0978	32.6	0.8759	32.0
0.0137	49.6	0.1112	32.5	0.9879	32.1
0.0164	47.7	0.1379	32.2	1.2036	32.0

Table 5.1 - Continued

$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
$\alpha_{AOT} = 0.420$					
0.0219	45.1	0.1645	31.7	1.4088	31.9
0.0274	42.6	0.1910	31.0	1.6043	32.0
0.0328	40.1	0.2434	30.8	1.9689	32.2
$\alpha_{AOT} = 0.550$					
0.0015	63.0	0.0457	38.3	0.3553	30.9
0.0031	60.1	0.0609	36.9	0.4123	31.4
0.0046	57.9	0.0760	35.2	0.4686	31.3
0.0061	56.0	0.0911	34.9	0.6068	31.8
0.0092	53.5	0.1211	33.3	0.7413	32.0
0.0122	51.9	0.1509	32.8	0.8724	31.9
0.0153	49.7	0.1806	32.4	1.0001	32.0
0.0183	48.0	0.2101	31.8	1.2458	32.1
0.0244	45.3	0.2395	31.6	1.4795	32.1
0.0305	42.7	0.2687	31.2	1.7020	32.0
0.0366	40.3	0.2977	31.4	1.9141	32.1
$\alpha_{AOT} = 0.711$					
0.0018	64.0	0.0712	38.3	0.4821	31.3
0.0036	60.2	0.0889	37.1	0.5480	31.6
0.0054	58.4	0.1065	35.9	0.6131	31.8
0.0072	56.8	0.1416	34.5	0.6776	32.0
0.0107	54.6	0.1765	33.9	0.8358	31.9
0.0143	52.7	0.2112	33.0	0.9898	32.2
0.0179	51.1	0.2457	32.5	1.2861	32.1
0.0214	49.7	0.2801	32.0	1.5677	32.2
0.0286	47.7	0.3142	31.6	1.8356	32.1
0.0357	45.1	0.3481	31.5	2.0909	32.2
0.0428	42.6	0.3819	31.2	2.3343	32.2
0.0535	40.5	0.4155	31.4		
$\alpha_{AOT} = 0.810$					
0.0020	65.3	0.0631	44.2	0.6102	31.9
0.0040	62.3	0.0827	41.8	0.7890	32.0
0.0059	60.5	0.1023	39.4	0.9631	32.3

Table 5.1- Continued

$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
$\alpha_{AOT} = 0.810$					
0.0079	59.2	0.1218	37.5	1.1327	32.2
0.0099	58.0	0.1606	36.0	1.2979	32.1
0.0119	57.0	0.1992	35.2	1.6159	32.1
0.0158	55.2	0.2376	34.4	1.9184	32.3
0.0198	54.1	0.3138	33.2	2.2064	32.1
0.0277	51.9	0.3891	32.3	2.4810	32.2
0.0356	50.0	0.4636	31.9	2.7431	32.0
0.0435	48.1	0.5373	31.6		
$\alpha_{AOT} = 0.902$					
0.0022	66.4	0.0936	47.6	1.2814	32.5
0.0045	65.0	0.1157	46.0	1.4682	32.3
0.0067	62.9	0.1378	44.3	1.8279	32.0
0.0090	62.3	0.1817	42.1	2.1699	32.0
0.0134	60.0	0.2254	39.9	2.4957	32.0
0.0179	58.5	0.3121	37.5	2.8062	31.7
0.0224	57.8	0.3978	35.9	3.1025	31.3
0.0313	55.5	0.4825	34.2	3.6564	31.0
0.0402	53.9	0.6904	32.4	4.1640	30.8
0.0492	52.4	0.8926	32.2		
0.0714	49.4	1.0896	32.4		
$\alpha_{AOT} = 0.944$					
0.0024	64.3	0.1175	48.1	1.5072	32.2
0.0047	62.3	0.1408	47.1	1.7005	32.3
0.0071	61.7	0.1872	44.8	2.0727	31.8
0.0095	60.9	0.2334	43.0	2.4269	31.7
0.0142	59.3	0.2793	42.1	2.7643	31.4
0.0189	58.1	0.3703	39.6	3.3933	30.7
0.0284	56.2	0.4603	37.5	3.9678	30.5
0.0378	54.2	0.6811	34.3	4.4946	30.3
0.0472	53.5	0.8960	32.9	5.2077	29.6
0.0707	51.1	1.1051	32.3		
0.0941	49.7	1.3088	32.2		

Table 5.1 - Continued

$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
$\alpha_{AOT} = 0.980$					
0.0025	67.8	0.0988	52.8	1.5819	32.3
0.0050	65.3	0.1477	50.0	1.7849	31.8
0.0074	63.9	0.1964	48.4	2.1760	31.9
0.0099	63.0	0.2930	45.8	2.5481	31.2
0.0149	62.1	0.3885	43.0	2.9027	30.9
0.0198	60.9	0.4830	41.6	3.2411	30.4
0.0297	59.0	0.7147	39.1	3.8729	30.1
0.0396	57.7	0.9402	36.6	4.4515	29.8
0.0495	56.6	1.1597	35.2	4.9833	29.5
0.0742	54.3	1.3735	33.6	5.4738	29.2
$\alpha_{AOT} = 1.0$					
0.2916	46.6	1.8590	33.0	3.3671	30.0
0.5739	42.0	2.0934	32.0	3.5597	29.9
0.8472	39.3	2.3211	31.1	3.7471	29.8
1.1120	37.5	2.5422	30.7	4.1076	29.7
1.3686	35.8	2.9661	30.0	4.4502	29.6
1.6176	34.4	3.1693	30.0		

Table 5.2 - Ratio of the intensities of Fluorescence Emission of Pyrene at 373 nm and at 384 nm for AOT+TX-100 Systems in Water at 298K

$c \times 10^3 /$ mol kg^{-1}	I_1 / I_3	$c \times 10^3 /$ mol kg^{-1}	I_1 / I_3	$c \times 10^3 /$ mol kg^{-1}	I_1 / I_3
$\alpha_{\text{AOT}} = 0$					
0.0000	1.8187	0.1438	1.5480	0.7727	1.4384
0.0090	1.7607	0.3145	1.4497	0.8985	1.4353
0.0180	1.7828	0.3684	1.4465	1.1680	1.4385
0.0359	1.7502	0.4403	1.4431	1.7071	1.4226
0.0719	1.7368	0.5481	1.4428	2.3360	1.4077
0.1078	1.6345	0.6739	1.4400		
$\alpha_{\text{AOT}} = 0.106$					
0.0000	1.7840	0.0768	1.6666	0.3458	1.4033
0.0048	1.7826	0.1249	1.6076	0.4515	1.3973
0.0058	1.7907	0.1537	1.5438	0.5475	1.3981
0.0067	1.8077	0.1729	1.5031	0.6532	1.3890
0.0096	1.7821	0.1921	1.4703	0.9606	1.3923
0.0192	1.7584	0.2305	1.4650	1.2584	1.3843
0.0384	1.7412	0.2690	1.4349	1.9212	1.3807
$\alpha_{\text{AOT}} = 0.170$					
0.0062	1.8114	0.1753	1.5463	0.4023	1.4093
0.0072	1.8471	0.2063	1.5168	0.5054	1.3868
0.0103	1.8173	0.2269	1.4932	0.6085	1.3833
0.0516	1.7575	0.2475	1.4443	0.7117	1.3795
0.0928	1.7046	0.2785	1.4357	1.0108	1.3787
0.1341	1.6047	0.3197	1.4182	1.3408	1.3755
$\alpha_{\text{AOT}} = 0.290$					
0.0056	1.8257	0.1678	1.5637	0.2908	1.4371
0.0447	1.7763	0.1902	1.5229	0.3356	1.4080
0.0895	1.6875	0.2125	1.5060	0.4139	1.3898
0.1119	1.6450	0.2237	1.4805	0.5146	1.3785
0.1454	1.5966	0.2461	1.4635	0.6264	1.3690
$\alpha_{\text{AOT}} = 0.420$					
0.0000	1.8528	0.1854	1.6120	0.5687	1.3885
0.0062	1.8170	0.2102	1.5537	1.1126	1.3457
0.0074	1.8487	0.2225	1.5564	1.6071	1.3313

Table 5.2 - Continued

$c \times 10^3 /$ mol kg^{-1}	I_1 / I_3	$c \times 10^3 /$ mol kg^{-1}	I_1 / I_3	$c \times 10^3 /$ mol kg^{-1}	I_1 / I_3
$\alpha_{\text{AOT}} = 0.420$					
0.0087	1.8427	0.2472	1.5268	2.7196	1.3190
0.0124	1.8489	0.3090	1.4839	3.7086	1.3156
0.0494	1.6785	0.3585	1.4145		
0.1483	1.6164	0.4698	1.4043		
$\alpha_{\text{AOT}} = 0.550$					
0.0413	1.8097	0.2614	1.5508	0.6879	1.3692
0.0826	1.7623	0.2889	1.5029	0.7980	1.3553
0.1376	1.6735	0.3302	1.4873	0.9081	1.3556
0.1513	1.6579	0.3853	1.4317	1.1007	1.3377
0.2201	1.6133	0.4403	1.4056	1.3071	1.3315
0.2477	1.5636	0.5641	1.3751		
$\alpha_{\text{AOT}} = 0.711$					
0.0000	1.5027	0.3620	1.3784	2.6327	1.3053
0.0329	1.4767	0.9050	1.3302	3.2908	1.2969
0.1645	1.4260	1.2341	1.3273	4.1135	1.2932
0.2962	1.3589	1.3986	1.3308		
$\alpha_{\text{AOT}} = 0.810$					
0.0000	1.7856	0.4918	1.5454	0.7025	1.4081
0.0176	1.7911	0.5093	1.4978	0.7903	1.3899
0.0703	1.7681	0.5269	1.5107	1.2821	1.3365
0.1405	1.7473	0.5444	1.5068	1.7563	1.3170
0.4039	1.6176	0.5796	1.4658	2.8100	1.2741
0.4566	1.5669	0.6147	1.4463	3.8638	1.2545
$\alpha_{\text{AOT}} = 0.902$					
0.0000	1.8047	0.5755	1.6386	0.8931	1.4616
0.0198	1.8146	0.6152	1.6069	1.3892	1.3353
0.0595	1.8018	0.6351	1.6187	1.9846	1.2977
0.0992	1.7728	0.6549	1.5653	2.9768	1.2456
0.1588	1.7681	0.6946	1.5632	3.9691	1.1998
0.3969	1.7108	0.7343	1.5454	5.9537	1.1479
0.5557	1.6422	0.8137	1.5155		

Table 5.2 - Continued

$c \times 10^3 /$ mol kg ⁻¹	I_1 / I_3	$c \times 10^3 /$ mol kg ⁻¹	I_1 / I_3	$c \times 10^3 /$ mol kg ⁻¹	I_1 / I_3
$\alpha_{AOT} = 0.944$					
0.0000	1.8231	0.7932	1.6504	1.3150	1.4372
0.0209	1.8259	0.8558	1.6280	1.5028	1.3820
0.1044	1.8192	0.8975	1.6292	1.7116	1.3636
0.2087	1.7777	0.9393	1.6029	2.7134	1.2813
0.3131	1.7654	0.9810	1.5792	3.7153	1.2179
0.5009	1.7304	1.0228	1.5671	4.7172	1.1656
0.6053	1.6981	1.1062	1.5186	6.0113	1.1328
$\alpha_{AOT} = 0.980$					
0.0000	1.7476	1.2106	1.5840	3.1915	1.2500
0.0440	1.7358	1.6948	1.4937	4.9303	1.1297
0.2201	1.7504	1.8929	1.4384	6.0528	1.0881
0.4402	1.6507	2.2010	1.4027	7.0212	1.0777
0.8144	1.6367	2.6412	1.3059	8.0117	1.0468
$\alpha_{AOT} = 1.0$					
0.9031	1.5055	3.1635	1.2825		
1.3617	1.4934	3.6046	1.1840		
1.8119	1.4504	4.0699	1.1401		
2.2561	1.4146	4.5317	1.1055		
2.7073	1.3409	5.7204	1.0654		

Table 5.3 - EMF Values of AOT+TX-100 Systems in Water at 298K

[Na ⁺] x 10 ³ / mol kg ⁻¹	EMF / mV	[Na ⁺] x 10 ³ / mol kg ⁻¹	EMF / mV	[Na ⁺] x 10 ³ / mol kg ⁻¹	EMF / mV
$\alpha_{\text{AOT}} = 0.170$					
0.0183	-99.8	0.0449	-85.8	0.1189	-68.0
0.0228	-96.8	0.0536	-82.6	0.1343	-65.6
0.0273	-93.6	0.0621	-80.2	0.1639	-61.8
0.0318	-91.2	0.0705	-78.6	0.1991	-58.0
0.0362	-89.3	0.0871	-74.1	0.2636	-53.1
0.0406	-87.4	0.1032	-70.7	0.3216	-49.3
$\alpha_{\text{AOT}} = 0.290$					
0.0440	-83.5	0.1031	-72.8	0.2579	-57.8
0.0526	-81.8	0.1195	-70.6	0.3145	-54.6
0.0612	-79.1	0.1357	-68.1	0.3815	-52.1
0.0697	-79.2	0.1674	-65.0	0.4447	-49.6
0.0781	-77.0	0.1984	-62.3	0.5044	-47.2
0.0865	-75.7	0.2285	-60.1	0.5608	-45.7
$\alpha_{\text{AOT}} = 0.420$					
0.0705	-83.5	0.1915	-68.4	0.6106	-50.0
0.0843	-80.9	0.2174	-66.4	0.7116	-46.0
0.0980	-79.1	0.2682	-62.7	0.8970	-42.9
0.1117	-76.4	0.3177	-59.4	1.0631	-40.9
0.1252	-75.5	0.3659	-57.3	1.2128	-39.6
0.1386	-73.1	0.4129	-55.2		
0.1652	-71.6	0.5035	-51.3		
$\alpha_{\text{AOT}} = 0.550$					
0.0632	-98.6	0.1857	-78.2	0.4707	-59.6
0.0840	-93.8	0.2056	-75.9	0.5420	-55.4
0.1046	-89.6	0.2450	-72.4	0.6115	-54.1
0.1251	-85.9	0.2839	-69.1	0.7452	-50.0
0.1454	-83.3	0.3223	-66.3	0.9034	-47.2
0.1656	-80.6	0.3975	-62.5	1.0522	-44.1
$\alpha_{\text{AOT}} = 0.711$					
0.0352	-94.8	0.1449	-69.0	0.4477	-47.6
0.0469	-90.4	0.1733	-65.7	0.5528	-44.2
0.0585	-88.9	0.2015	-62.8	0.6553	-41.5

Table 5.3 - Continued

$[\text{Na}^+] \times 10^3 /$ mol kg^{-1}	EMF / mV	$[\text{Na}^+] \times 10^3 /$ mol kg^{-1}	EMF / mV	$[\text{Na}^+] \times 10^3 /$ mol kg^{-1}	EMF / mV
$\alpha_{\text{AOT}} = 0.711$					
0.0701	-83.1	0.2296	-61.4	0.7554	-38.9
0.0817	-79.9	0.2851	-56.1	0.9953	-34.8
0.0933	-77.1	0.3400	-52.9	1.2217	-32.1
0.1163	-75.0	0.3942	-50.3		
$\alpha_{\text{AOT}} = 0.810$					
0.0624	-85.4	0.3052	-59.1	0.8680	-40.7
0.0779	-78.8	0.3421	-57.0	1.1280	-36.9
0.1164	-75.7	0.3789	-55.4	1.3752	-33.8
0.1547	-71.1	0.4516	-51.2	1.6676	-31.4
0.1927	-66.7	0.5233	-49.3	1.9429	-29.3
0.2304	-65.0	0.5941	-47.6		
0.2679	-61.5	0.7328	-43.8		
$\alpha_{\text{AOT}} = 0.902$					
0.0831	-77.9	0.4059	-49.1	1.1513	-30.7
0.1037	-74.0	0.4550	-47.0	1.3252	-28.7
0.1550	-66.6	0.5037	-45.1	1.4944	-26.4
0.2059	-62.6	0.6002	-41.8	1.6592	-24.6
0.2564	-58.1	0.6952	-39.3	1.8198	-23.4
0.3066	-54.7	0.7890	-37.5		
0.3564	-52.1	0.9727	-33.6		
$\alpha_{\text{AOT}} = 0.944$					
0.1021	-83.9	0.4975	-54.5	1.4028	-35.8
0.1274	-78.6	0.5574	-51.6	1.6124	-34.0
0.1904	-72.9	0.6169	-49.6	1.8159	-32.6
0.2528	-68.2	0.7345	-46.9	2.2056	-30.3
0.3147	-63.4	0.8502	-43.5	2.6627	-28.1
0.3761	-60.3	0.9641	-42.2		
0.4370	-56.9	1.1868	-38.4		
$\alpha_{\text{AOT}} = 0.980$					
0.1000	-79.5	0.5476	-46.7	1.7990	-27.0
0.1248	-74.7	0.6062	-44.4	1.9975	-25.6
0.1865	-68.2	0.7223	-41.6	2.1909	-24.3

Table 5.3 - Continued

$[\text{Na}^+] \times 10^3 /$ mol kg^{-1}	EMF / mV	$[\text{Na}^+] \times 10^3 /$ mol kg^{-1}	EMF / mV	$[\text{Na}^+] \times 10^3 /$ mol kg^{-1}	EMF / mV
$\alpha_{\text{AOT}} = 0.980$					
0.2478	-62.4	0.8368	-38.9	2.6533	-21.8
0.3086	-58.2	0.9497	-36.2	3.0877	-20.0
0.3690	-54.7	1.1708	-33.5	3.8823	-17.4
0.4289	-51.7	1.3859	-30.6	4.5911	-15.7
0.4885	-49.2	1.5952	-28.6		
$\alpha_{\text{AOT}} = 1.0$					
0.2756	-74.5	2.6411	-16.3	5.6980	-3.3
0.5431	-56.4	2.8446	-14.6	6.2160	-2.0
0.8030	-46.5	3.1080	-13.1	6.8454	-0.8
1.0556	-39.9	3.3627	-11.6	7.4143	0.6
1.3010	-34.4	3.6093	-10.2	8.0525	1.3
1.5397	-30.0	3.8480	-9.0	8.6222	1.9
1.7720	-26.4	4.0792	-7.9	9.1338	2.7
1.9980	-23.4	4.3034	-7.1	9.5956	3.5
2.2180	-20.4	4.7315	-5.8		
2.4323	-17.9	5.1350	-4.3		

Table 5.4 - Values of cmc from surface tension (S.T.), fluorescence (FL) and EMF methods and counter ion binding constant (β_c) from EMF data for AOT + TX-100 mixed systems in water at 298 K

α_{AOT}	Cmc / mmol kg ⁻¹			β_c
	S.T.	FL	EMF	
0	0.27	0.20	-	-
0.106	0.18	0.21	-	-
0.170	0.20	0.26	-	-
0.290	0.19	0.22	-	-
0.420	0.22	0.35	-	-
0.550	0.32	0.37	-	-
0.711	0.41	0.44	-	-
0.810	0.55	0.59	-	-
0.902	0.63	0.61	-	-
0.944	0.94	0.89	0.94	0.33
0.980	1.78	1.66	1.63	0.35
1	2.63	2.27	2.63	0.42

Table 5.5 - Values of x_1 , β_m , f_1 and f_2 for AOT + TX-100 mixed systems in water at 298 K

α_{AOT}	$x_1^{\text{id}} / x_1^{\text{Rb}} / x_1^{\text{RVV}}$	f_1 / f_2	β_m
0	0 / 0 / 0	- / 1	-
0.106	0.012 / 0.219 / 0.164	0.033 / 0.764	-5.60
0.170	0.020 / 0.223 / 0.131	0.058 / 0.791	-4.71
0.290	0.040 / 0.275 / 0.184	0.076 / 0.689	-4.90
0.420	0.069 / 0.300 / 0.017	0.117 / 0.675	-4.37
0.550	0.111 / 0.300 / 0.0	0.224 / 0.761	-3.05
0.711	0.202 / 0.361 / 0.386	0.307 / 0.686	-2.89
0.810	0.304 / 0.409 / 0.626	0.414 / 0.655	-2.53
0.902	0.486 / 0.494 / 0.360	0.437 / 0.452	-3.24
0.944	0.634 / 0.559 / 0.303	0.603 / 0.442	-2.60
0.980	0.834 / 0.731 / 0.584	0.908 / 0.490	-1.34
1	1 / 1 / 1	1 / -	-

Table 5.6 - Surface Tension (γ) Values of AOT + TX-100 Systems in Aqueous Sodium Chloride Medium at 298K

$\alpha_{AOT} = 0$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0 mol kg ⁻¹					
0.0011	57.4	0.0266	37.0	0.2776	30.2
0.0022	53.8	0.0310	36.1	0.3185	30.2
0.0033	51.7	0.0354	35.0	0.3588	30.4
0.0044	50.8	0.0398	35.2	0.3986	30.5
0.0056	48.6	0.0442	34.4	0.4380	30.4
0.0067	48.4	0.0551	33.9	0.5345	30.5
0.0089	47.2	0.0660	33.3	0.6282	30.6
0.0111	45.3	0.0878	32.9	0.7194	30.8
0.0133	42.2	0.1094	31.9	0.8942	30.8
0.0155	40.9	0.1309	31.6	1.0597	30.8
0.0177	39.4	0.1522	31.3	1.2167	30.9
0.0199	38.1	0.1945	30.7	1.3658	31.1
0.0222	38.2	0.2363	30.7		
[NaCl] = 0.0100 mol kg ⁻¹					
0.0006	64.0	0.0313	34.9	0.2630	30.6
0.0013	60.9	0.0376	34.4	0.3079	30.6
0.0019	58.5	0.0438	33.6	0.3519	30.7
0.0025	56.3	0.0500	33.2	0.4375	30.5
0.0038	52.9	0.0623	32.5	0.5201	30.6
0.0050	50.1	0.0746	32.4	0.6192	30.7
0.0063	47.4	0.0989	31.9	0.7138	30.9
0.0126	42.9	0.1231	31.5	0.8046	30.8
0.0189	38.8	0.1706	31.0		
0.0251	36.7	0.2173	30.7		
[NaCl] = 0.0205 mol kg ⁻¹					
0.0007	63.8	0.0354	33.8	0.2720	30.5
0.0014	60.7	0.0424	33.5	0.3235	30.1
0.0021	57.6	0.0494	33.3	0.3991	30.6
0.0028	53.2	0.0564	33.0	0.4727	30.7
0.0043	50.9	0.0704	32.4	0.5445	30.7

Table 5.6 - Continued

$\alpha_{\text{AOT}} = 0$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0205 mol kg ⁻¹					
0.0057	47.8	0.0842	32.0	0.6601	30.8
0.0071	43.7	0.1118	31.4	0.7709	30.7
0.0142	39.0	0.1391	31.2	0.9290	30.8
0.0213	36.7	0.1661	31.2		
0.0283	35.7	0.2195	30.6		
[NaCl] = 0.0305 mol kg ⁻¹					
0.0007	63.2	0.0359	33.5	0.1413	31.4
0.0014	60.4	0.0431	32.9	0.1688	30.8
0.0022	57.1	0.0502	32.7	0.1961	30.9
0.0029	54.3	0.0573	32.4	0.2499	30.7
0.0043	49.9	0.0644	32.4	0.3027	30.3
0.0058	47.0	0.0715	32.2	0.3546	30.5
0.0072	44.6	0.0856	31.7	0.4308	30.7
0.0144	38.9	0.0996	31.5	0.5050	30.6
0.0216	35.9	0.1136	31.3	0.6246	30.7
0.0288	34.4	0.1275	31.2	0.7394	30.7
[NaCl] = 0.0510 mol kg ⁻¹					
0.0007	62.6	0.0288	34.3	0.1688	30.7
0.0014	59.7	0.0359	33.8	0.1961	30.7
0.0022	56.5	0.0431	33.3	0.2499	30.4
0.0029	53.6	0.0502	32.6	0.3027	30.1
0.0043	49.4	0.0573	32.4	0.3547	30.4
0.0058	46.1	0.0715	31.8	0.4433	30.6
0.0087	43.4	0.0856	31.8	0.5294	30.6
0.0115	40.6	0.0996	31.5	0.6482	30.7
0.0144	38.4	0.1136	31.3	0.7619	30.8
0.0216	36.0	0.1413	30.9	0.8714	30.7
[NaCl] = 0.0708 mol kg ⁻¹					
0.0007	61.5	0.0303	33.9	0.1879	30.7
0.0014	57.1	0.0358	33.7	0.2395	30.4
0.0021	54.2	0.0440	33.1	0.2902	30.3

Table 5.6 - Continued

$\alpha_{\text{AOT}} = 0$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
$[\text{NaCl}] = 0.0708 \text{ mol kg}^{-1}$					
0.0028	51.5	0.0521	32.5	0.3401	30.2
0.0041	48.1	0.0603	32.4	0.4133	30.5
0.0055	45.5	0.0684	32.1	0.4847	30.7
0.0083	40.8	0.0819	32.0	0.6001	30.9
0.0111	38.8	0.0954	31.6	0.7107	30.8
0.0138	37.7	0.1088	30.9	0.8171	30.9
0.0193	35.9	0.1354	30.9		
0.0248	35.0	0.1617	30.6		
$[\text{NaCl}] = 0.1012 \text{ mol kg}^{-1}$					
0.0006	63.2	0.0230	40.8	0.1470	30.7
0.0012	60.3	0.0290	38.4	0.1930	29.7
0.0018	57.7	0.0410	35.7	0.2383	29.4
0.0024	56.8	0.0530	34.5	0.3160	29.6
0.0036	53.8	0.0649	33.4	0.3918	30.0
0.0061	50.5	0.0768	32.1	0.4968	30.2
0.0085	48.6	0.0886	32.0	0.5981	30.4
0.0109	46.6	0.1004	31.9	0.6960	30.6
0.0169	42.9	0.1238	31.4	0.7906	30.6

Table 5.6 - Continued

$\alpha_{AOT} = 0.150$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0 mol kg ⁻¹					
0.0010	61.7	0.0595	35.5	0.4751	31.2
0.0020	58.8	0.0792	32.8	0.5647	31.3
0.0030	56.9	0.0988	32.2	0.7390	31.5
0.0040	55.1	0.1183	31.7	0.9069	31.7
0.0060	53.0	0.1571	30.8	1.0688	31.4
0.0100	50.1	0.1956	30.6	1.2250	31.7
0.0199	45.1	0.2339	30.2	1.3758	31.8
0.0298	42.0	0.3094	30.8		
0.0398	39.3	0.3838	30.9		
[NaCl] = 0.0031 mol kg ⁻¹					
0.0010	60.9	0.0297	40.1	0.2330	29.7
0.0020	57.8	0.0396	38.4	0.3083	30.1
0.0030	55.7	0.0495	36.9	0.3824	30.5
0.0040	54.0	0.0593	35.4	0.4734	30.7
0.0060	51.6	0.0789	33.5	0.5627	30.6
0.0099	48.2	0.0984	31.9	0.7364	30.8
0.0139	45.7	0.1179	31.1	0.9037	31.0
0.0179	43.1	0.1566	30.2	1.0651	30.9
0.0238	41.6	0.1949	30.0	1.2208	30.7
[NaCl] = 0.0061 mol kg ⁻¹					
0.0010	60.9	0.0399	36.8	0.3852	30.2
0.0020	57.5	0.0498	35.4	0.4768	30.4
0.0030	54.7	0.0597	34.7	0.5667	30.1
0.0040	52.9	0.0795	32.7	0.7415	30.3
0.0060	50.7	0.0992	31.9	0.9099	30.5
0.0100	47.3	0.1188	31.1	1.0722	30.7
0.0140	44.2	0.1577	30.1	1.2288	30.6
0.0180	42.5	0.1964	29.8	1.3799	30.7
0.0240	39.8	0.2347	29.8		
0.0300	39.0	0.3105	30.2		

Table 5.6 - Continued

$\alpha_{\text{AOT}} = 0.150$					
$c \times 10^3 /$ mol kg^{-1}	$\gamma /$ mN m^{-1}	$c \times 10^3 /$ mol kg^{-1}	$\gamma /$ mN m^{-1}	$c \times 10^3 /$ mol kg^{-1}	$\gamma /$ mN m^{-1}
$[\text{NaCl}] = 0.0097 \text{ mol kg}^{-1}$					
0.0010	60.3	0.0236	42.1	0.1930	29.4
0.0020	55.3	0.0294	40.9	0.2307	29.9
0.0030	53.5	0.0392	38.3	0.2681	30.0
0.0039	52.1	0.0490	36.4	0.3052	30.1
0.0059	50.4	0.0587	35.5	0.3786	29.9
0.0079	48.8	0.0781	34.0	0.4688	30.1
0.0098	47.6	0.0975	32.1	0.5573	30.4
0.0138	45.3	0.1167	31.5	0.7293	30.4
0.0177	43.7	0.1550	30.4	1.0551	30.5
$[\text{NaCl}] = 0.0203 \text{ mol kg}^{-1}$					
0.0010	60.7	0.0298	38.6	0.2338	29.3
0.0020	57.1	0.0397	36.6	0.2717	29.4
0.0030	54.6	0.0496	35.4	0.3093	29.6
0.0040	52.7	0.0595	33.8	0.3836	29.4
0.0060	50.2	0.0792	32.2	0.4748	30.0
0.0080	48.6	0.0988	31.2	0.5644	30.1
0.0100	47.1	0.1183	30.5	0.7384	30.0
0.0139	44.7	0.1377	30.0	0.9061	30.1
0.0179	42.4	0.1571	29.7	1.0678	30.3
0.0239	40.6	0.1956	29.1		
$[\text{NaCl}] = 0.0288 \text{ mol kg}^{-1}$					
0.0011	60.2	0.0317	37.4	0.2076	28.9
0.0021	56.6	0.0422	36.2	0.2481	29.5
0.0032	54.1	0.0527	34.5	0.2883	29.4
0.0042	51.9	0.0632	32.3	0.3281	29.8
0.0064	49.1	0.0841	30.9	0.4067	29.4
0.0085	47.4	0.1049	30.6	0.5032	29.7
0.0106	46.1	0.1256	30.1	0.5978	29.8
0.0148	43.2	0.1463	29.4	0.7812	29.8
0.0191	41.3	0.1668	29.1	0.9576	29.9
0.0254	39.2	0.1873	29.0		

Table 5.6 - Continued

$\alpha_{AOT} = 0.150$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
$[\text{NaCl}] = 0.0488 \text{ mol kg}^{-1}$					
0.0010	59.6	0.0221	39.2	0.1587	29.0
0.0020	55.9	0.0302	36.5	0.1782	29.2
0.0030	53.1	0.0402	33.8	0.1976	29.0
0.0040	51.1	0.0502	33.0	0.2362	28.9
0.0060	48.4	0.0601	32.9	0.2745	29.1
0.0081	46.6	0.0800	31.6	0.3125	29.2
0.0101	45.2	0.0998	30.4	0.3876	29.2
0.0141	42.5	0.1195	30.1	0.5702	29.3
0.0181	40.7	0.1392	29.2	0.9152	29.7
$[\text{NaCl}] = 0.0702 \text{ mol kg}^{-1}$					
0.0010	58.4	0.0245	39.2	0.1611	29.1
0.0020	55.6	0.0306	38.0	0.1809	28.7
0.0031	53.5	0.0408	35.8	0.2006	28.6
0.0041	51.2	0.0509	34.9	0.2397	28.8
0.0061	48.9	0.0610	32.8	0.2786	28.7
0.0082	47.2	0.0812	31.1	0.3171	29.0
0.0102	45.8	0.1013	30.3	0.3933	29.0
0.0143	43.1	0.1213	29.6	0.5785	28.9
0.0184	41.4	0.1413	29.2	0.9283	29.2

Table 5.6 - Continued

$\alpha_{AOT} = 0.300$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0 mol kg ⁻¹					
0.0010	61.8	0.0384	39.5	0.2995	30.8
0.0019	59.3	0.0576	36.2	0.3716	31.4
0.0029	57.3	0.0766	34.6	0.4603	31.4
0.0039	55.8	0.0956	33.6	0.5473	31.7
0.0077	52.0	0.1145	32.2	0.7167	31.6
0.0116	49.5	0.1520	30.9	0.8802	31.7
0.0154	47.2	0.1893	30.3	1.0381	31.8
0.0193	45.8	0.2263	30.3	1.1905	32.0
0.0289	42.2	0.2631	30.6		
[NaCl] = 0.0032 mol kg ⁻¹					
0.0010	60.5	0.0612	35.6	0.3179	30.1
0.0021	57.4	0.0814	33.8	0.3943	30.8
0.0031	55.6	0.1016	32.3	0.4880	30.5
0.0041	54.2	0.1216	31.6	0.5800	30.8
0.0082	50.3	0.1416	30.8	0.7587	30.7
0.0123	47.2	0.1615	30.6	0.9307	30.8
0.0164	45.0	0.1813	30.0	1.0965	31.0
0.0205	43.6	0.2011	29.7	1.2563	31.1
0.0307	41.4	0.2403	29.8		
0.0409	38.5	0.2793	29.9		
[NaCl] = 0.0062 mol kg ⁻¹					
0.0010	60.7	0.0408	38.4	0.2402	29.7
0.0021	57.2	0.0611	35.6	0.2791	30.0
0.0031	54.8	0.0814	33.8	0.3177	30.1
0.0041	53.1	0.1015	32.4	0.3940	30.4
0.0082	49.8	0.1216	31.6	0.4877	30.4
0.0123	47.8	0.1415	30.4	0.5796	30.3
0.0164	43.6	0.1614	29.8	0.7582	30.5
0.0205	42.2	0.1812	29.7	0.9301	30.5
0.0307	40.6	0.2010	29.5		

Table 5.6- Continued

$\alpha_{AOT} = 0.300$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0102 mol kg ⁻¹					
0.0010	61.0	0.0414	37.4	0.2037	29.5
0.0021	57.4	0.0517	33.7	0.2434	29.6
0.0031	55.5	0.0620	33.1	0.2828	29.8
0.0042	53.4	0.0722	33.4	0.3219	29.7
0.0062	50.3	0.0825	32.2	0.3992	30.1
0.0083	48.8	0.1029	31.7	0.4940	30.0
0.0104	47.5	0.1232	30.9	0.5869	30.1
0.0207	42.9	0.1434	30.4	0.7675	30.1
0.0311	39.6	0.1636	29.9		
[NaCl] = 0.0210 mol kg ⁻¹					
0.0009	60.5	0.0446	36.5	0.2448	29.1
0.0018	56.8	0.0535	35.6	0.2788	29.4
0.0027	54.7	0.0624	34.6	0.3461	29.2
0.0036	53.2	0.0712	33.8	0.4289	29.3
0.0054	50.9	0.0888	32.3	0.5102	29.3
0.0072	48.8	0.1064	31.5	0.6689	29.4
0.0090	47.8	0.1239	30.2	0.8223	29.3
0.0179	43.5	0.1414	29.8	1.1144	29.5
0.0268	40.1	0.1761	29.2	1.3884	29.5
0.0357	38.3	0.2106	29.0	1.6458	29.4
[NaCl] = 0.0301 mol kg ⁻¹					
0.0011	60.5	0.0320	38.8	0.2505	29.2
0.0021	56.8	0.0426	36.8	0.2910	29.3
0.0032	54.5	0.0533	35.5	0.3312	29.4
0.0043	52.4	0.0638	32.9	0.4106	29.2
0.0064	49.9	0.0744	32.1	0.5080	29.5
0.0086	48.3	0.0849	31.3	0.6034	29.5
0.0107	46.6	0.1059	30.3	0.7886	29.4
0.0150	44.4	0.1269	30.0	0.9665	29.3
0.0192	42.7	0.1684	29.2	1.1377	29.4
0.0256	40.6	0.2096	28.7		

Table 5.6 - Continued

$\alpha_{AOT} = 0.300$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
$[\text{NaCl}] = 0.0506 \text{ mol kg}^{-1}$					
0.0010	60.2	0.0291	39.4	0.1908	28.8
0.0019	56.4	0.0388	37.4	0.2281	28.6
0.0029	53.9	0.0484	35.9	0.2651	28.7
0.0039	52.1	0.0580	34.5	0.3018	28.8
0.0058	49.7	0.0676	33.5	0.3744	28.7
0.0078	48.2	0.0772	32.6	0.5512	28.7
0.0097	46.4	0.0963	31.2	0.8860	28.9
0.0136	44.5	0.1154	30.3	1.4886	28.8
0.0175	42.6	0.1343	29.5		
0.0233	40.6	0.1532	29.0		
$[\text{NaCl}] = 0.0720 \text{ mol kg}^{-1}$					
0.0011	58.6	0.0320	38.7	0.2095	28.4
0.0021	55.3	0.0426	35.6	0.2503	28.5
0.0032	52.9	0.0532	34.3	0.2908	28.5
0.0043	51.2	0.0638	33.0	0.3310	28.7
0.0064	49.2	0.0743	32.3	0.4104	28.5
0.0086	47.6	0.0849	31.9	0.6031	28.6
0.0107	46.0	0.1059	31.0	0.9661	28.3
0.0150	43.7	0.1268	29.6	1.6137	28.6
0.0192	42.3	0.1476	29.2		
0.0256	40.3	0.1683	28.9		

Table 5.6 - Continued

$\alpha_{AOT} = 0.500$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0 mol kg ⁻¹					
0.0010	64.7	0.0481	40.7	0.2266	31.5
0.0019	62.0	0.0577	38.7	0.2633	31.5
0.0029	59.9	0.0672	37.1	0.2997	31.0
0.0039	58.3	0.0767	35.2	0.3717	31.3
0.0048	57.4	0.0862	34.9	0.4601	31.4
0.0058	56.2	0.0957	34.2	0.5468	31.8
0.0097	53.5	0.1146	33.3	0.7154	32.0
0.0135	51.2	0.1335	32.9	0.8777	32.1
0.0193	48.7	0.1522	32.6	1.0341	32.1
0.0289	44.4	0.1709	32.1	1.3305	32.2
0.0385	41.9	0.1896	31.9		
[NaCl] = 0.0030 mol kg ⁻¹					
0.0010	63.5	0.0483	37.1	0.2275	30.9
0.0019	59.7	0.0579	34.3	0.2644	30.9
0.0029	58.1	0.0675	34.2	0.3009	30.7
0.0039	55.8	0.0771	33.8	0.3732	30.7
0.0049	54.4	0.0866	33.3	0.4620	31.0
0.0058	53.1	0.0961	33.2	0.5490	31.1
0.0097	49.9	0.1151	32.4	0.7182	31.4
0.0136	47.2	0.1340	31.8	0.8810	31.2
0.0194	44.5	0.1529	31.7	1.1893	31.3
0.0290	41.1	0.1716	31.6	1.4763	31.2
0.0387	38.9	0.1903	31.2		
[NaCl] = 0.0060 mol kg ⁻¹					
0.0010	63.2	0.0479	37.1	0.2258	30.7
0.0019	59.5	0.0575	35.1	0.2624	30.5
0.0029	57.2	0.0670	34.2	0.2988	30.3
0.0038	55.6	0.0765	33.7	0.3705	30.6
0.0048	53.6	0.0860	33.3	0.4587	30.7
0.0058	52.3	0.0954	32.8	0.5451	30.7
0.0096	49.0	0.1143	32.4	0.7132	30.7

Table 5.6 - Continued

$\alpha_{AOT} = 0.500$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0060 mol kg ⁻¹					
0.0135	45.9	0.1331	31.6	0.8751	30.5
0.0192	43.6	0.1518	31.3	1.1815	30.6
0.0288	40.5	0.1704	31.4		
0.0384	38.3	0.1890	30.8		
[NaCl] = 0.0102 mol kg ⁻¹					
0.0017	60.7	0.0406	38.7	0.2663	30.1
0.0034	56.5	0.0541	37.2	0.2988	30.1
0.0051	53.6	0.0675	34.7	0.3313	30.2
0.0068	51.5	0.0843	33.8	0.3957	30.1
0.0102	49.0	0.1010	32.8	0.4595	30.1
0.0136	47.0	0.1177	32.5	0.5227	30.2
0.0169	45.0	0.1344	31.8	0.6474	30.0
0.0203	43.7	0.1676	30.9	0.8002	30.1
0.0271	41.0	0.2006	30.4	0.9495	30.2
0.0338	40.0	0.2335	30.3		
[NaCl] = 0.0205 mol kg ⁻¹					
0.0018	54.4	0.0351	39.5	0.1739	30.5
0.0035	53.3	0.0421	38.0	0.2082	30.0
0.0053	51.7	0.0491	36.8	0.2423	29.7
0.0070	50.2	0.0561	35.8	0.2762	29.5
0.0106	47.8	0.0701	34.5	0.3436	29.5
0.0141	44.5	0.0875	33.0	0.4103	29.4
0.0176	43.7	0.1049	32.3	0.4764	29.6
0.0211	42.2	0.1222	31.9	0.6066	29.6
0.0246	41.4	0.1395	31.4	0.9217	29.4
0.0281	40.5	0.1567	31.0	1.2223	29.5
[NaCl] = 0.0311 mol kg ⁻¹					
0.0010	59.8	0.0161	44.5	0.1312	31.6
0.0020	56.6	0.0201	43.0	0.1507	30.7
0.0030	54.9	0.0241	42.4	0.1702	30.5
0.0040	53.2	0.0321	40.1	0.1896	29.7

Table 5.6 - Continued

$\alpha_{AOT} = 0.500$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0311 mol kg ⁻¹					
0.0050	51.9	0.0401	38.7	0.2281	29.4
0.0060	50.4	0.0521	36.0	0.2664	29.2
0.0070	50.0	0.0640	35.2	0.3606	29.4
0.0080	48.5	0.0760	34.0	0.4529	29.2
0.0101	47.3	0.0878	33.1	0.5433	29.2
0.0121	46.7	0.0997	32.6	0.6320	29.4
0.0141	45.3	0.1115	32.1	0.7189	29.2
[NaCl] = 0.0502 mol kg ⁻¹					
0.0010	60.3	0.0160	43.8	0.1380	30.1
0.0020	58.3	0.0200	42.1	0.1574	29.8
0.0030	55.9	0.0240	40.6	0.1768	29.3
0.0040	53.4	0.0319	39.2	0.2152	29.2
0.0050	51.9	0.0399	37.5	0.2532	28.7
0.0060	50.3	0.0498	36.8	0.2910	29.0
0.0070	49.1	0.0597	35.5	0.3841	28.9
0.0080	48.1	0.0695	34.1	0.4753	28.7
0.0100	47.0	0.0794	33.1	0.5647	28.5
0.0120	45.7	0.0990	31.6	0.6523	28.7
0.0140	44.2	0.1186	30.6	0.7383	28.5
[NaCl] = 0.0702 mol kg ⁻¹					
0.0010	61.2	0.0156	43.3	0.1345	30.4
0.0019	57.8	0.0195	41.8	0.1534	29.7
0.0029	54.8	0.0233	40.7	0.1723	29.3
0.0039	52.9	0.0311	39.4	0.2097	28.7
0.0049	51.0	0.0388	37.7	0.2468	28.6
0.0058	50.0	0.0485	36.5	0.2837	28.4
0.0068	48.9	0.0581	35.2	0.3745	28.2
0.0078	47.8	0.0677	34.1	0.4636	28.1
0.0097	46.7	0.0773	33.4	0.5509	28.0
0.0117	45.2	0.0965	32.1	0.6366	27.8
0.0136	44.0	0.1155	31.3	1.1179	27.7

Table 5.6 - Continued

$\alpha_{AOT} = 0.800$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0 mol kg ⁻¹					
0.0014	67.1	0.0847	46.3	0.5983	32.5
0.0028	64.8	0.1127	43.6	0.7016	32.6
0.0043	63.2	0.1684	40.7	0.8033	32.4
0.0057	62.2	0.2236	37.6	0.9283	32.5
0.0113	58.7	0.2784	35.7	1.0510	32.8
0.0170	57.6	0.3328	34.9	1.2895	32.3
0.0227	55.6	0.3867	33.5	1.5194	32.4
0.0283	54.3	0.4402	32.9	1.7411	32.5
0.0425	51.4	0.4933	32.6	1.9551	32.6
0.0566	49.4	0.5460	32.6		
[NaCl] = 0.0030 mol kg ⁻¹					
0.0013	63.2	0.0769	43.5	0.4006	32.1
0.0026	60.2	0.1024	41.8	0.4972	31.6
0.0039	58.8	0.1277	39.6	0.6160	31.7
0.0051	57.5	0.1530	38.4	0.7328	31.7
0.0077	55.7	0.1781	37.3	0.8475	31.5
0.0129	53.3	0.2032	36.4	0.9603	31.8
0.0180	51.4	0.2282	35.7	1.1800	31.5
0.0257	49.9	0.2531	34.9	1.3925	31.2
0.0386	47.6	0.3026	33.7	1.5980	31.3
0.0514	46.0	0.3518	32.2		
[NaCl] = 0.0060 mol kg ⁻¹					
0.0014	63.8	0.0810	41.7	0.3700	32.3
0.0027	60.7	0.1077	40.5	0.4213	31.3
0.0041	58.6	0.1344	38.5	0.5226	31.2
0.0054	57.0	0.1610	36.7	0.6472	31.2
0.0068	56.1	0.1875	35.4	0.7696	31.3
0.0081	54.6	0.2138	35.0	1.0076	31.0
0.0136	52.5	0.2401	34.2	1.2372	30.4
0.0271	48.5	0.2663	33.9	1.4588	30.2

Table 5.6 - Continued

$\alpha_{\text{AOT}} = 0.800$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0060 mol kg ⁻¹					
0.0406	46.2	0.2924	33.7	1.6728	30.0
0.0541	44.1	0.3183	33.2		
[NaCl] = 0.0106 mol kg ⁻¹					
0.0015	61.5	0.0581	42.8	0.4518	30.5
0.0029	59.2	0.0726	41.3	0.5603	30.6
0.0044	57.3	0.0870	39.8	0.6935	30.3
0.0058	56.0	0.1157	38.4	0.8240	30.0
0.0087	53.7	0.1444	36.9	1.0776	29.3
0.0117	52.3	0.1729	35.9	1.3217	29.3
0.0146	50.6	0.2296	33.5	1.5567	29.4
0.0204	48.9	0.2858	32.2	2.0017	28.8
0.0291	47.1	0.3416	31.0	2.4160	28.7
0.0436	44.5	0.3970	30.8		
[NaCl] = 0.0208 mol kg ⁻¹					
0.0014	62.1	0.0579	41.4	0.3957	29.7
0.0029	59.3	0.0723	39.8	0.4504	29.6
0.0044	57.2	0.0867	38.5	0.5585	29.4
0.0058	55.5	0.1154	36.6	0.6913	29.1
0.0087	53.1	0.1439	35.0	0.8215	28.6
0.0116	50.9	0.1723	33.9	0.9491	28.3
0.0145	49.2	0.2007	33.2	1.0744	28.0
0.0203	47.8	0.2289	32.3	1.3178	28.0
0.0290	45.4	0.2849	31.2	1.5522	27.8
0.0435	43.0	0.3405	30.3	2.2065	27.5
[NaCl] = 0.0307 mol kg ⁻¹					
0.0009	62.8	0.0375	42.5	0.3096	29.6
0.0019	60.2	0.0469	41.3	0.3622	29.0
0.0028	58.0	0.0562	39.9	0.4483	28.7
0.0038	55.9	0.0747	38.6	0.5329	28.3
0.0056	53.4	0.0932	36.9	0.6159	28.4
0.0075	51.7	0.1117	35.9	0.7772	27.9

Table 5.6 - Continued

$\alpha_{AOT} = 0.800$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0307 mol kg ⁻¹					
0.0094	50.3	0.1483	33.7	0.9326	27.5
0.0132	48.5	0.1847	32.5	1.0825	27.2
0.0188	46.4	0.2207	31.2	1.5018	27.0
0.0282	44.3	0.2565	30.7		
[NaCl] = 0.0511 mol kg ⁻¹					
0.0009	63.7	0.0374	41.2	0.2557	28.9
0.0019	60.3	0.0467	39.6	0.2910	28.6
0.0028	57.5	0.0560	38.5	0.3262	28.3
0.0037	55.8	0.0745	37.0	0.3610	27.8
0.0056	53.0	0.0929	35.3	0.4469	27.4
0.0075	51.0	0.1113	34.3	0.5312	27.5
0.0094	49.5	0.1296	33.6	0.6139	27.1
0.0131	47.6	0.1478	32.4	0.6951	27.0
0.0187	45.4	0.1841	30.8	0.8530	26.6
0.0281	43.0	0.2200	29.9	1.2939	26.1
[NaCl] = 0.0721 mol kg ⁻¹					
0.0006	63.5	0.0227	43.0	0.3223	27.4
0.0011	61.3	0.0340	40.7	0.3724	27.1
0.0017	59.5	0.0452	39.0	0.4216	26.8
0.0023	56.9	0.0676	36.3	0.5173	26.8
0.0034	54.4	0.0897	34.4	0.6095	26.7
0.0046	52.7	0.1117	33.4	0.6984	26.4
0.0057	51.2	0.1335	31.9	0.7842	26.5
0.0080	49.1	0.1766	30.4	1.0245	26.3
0.0114	47.0	0.2190	29.0	1.2420	26.0
0.0170	44.5	0.2712	28.2		

Table 5.6 - Continued

$\alpha_{AOT} = 0.850$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0 mol kg ⁻¹					
0.0006	66.0	0.0453	50.5	0.7029	31.9
0.0011	65.2	0.0677	47.7	0.7897	31.8
0.0017	64.3	0.0899	45.6	0.9549	32.1
0.0023	63.5	0.1119	43.7	1.1097	32.2
0.0034	62.1	0.1663	40.9	1.2550	32.3
0.0057	60.6	0.2197	38.6	1.4570	32.4
0.0114	57.6	0.3234	35.3	1.6420	32.1
0.0171	55.5	0.4234	33.8	1.8120	31.9
0.0227	53.9	0.5199	32.0	2.1140	31.7
0.0340	52.2	0.6130	31.8		
[NaCl] = 0.0030 mol kg ⁻¹					
0.0006	64.1	0.0347	47.5	0.5294	30.9
0.0012	61.8	0.0462	45.7	0.6240	30.7
0.0017	60.5	0.0690	43.1	0.7153	31.0
0.0023	59.7	0.0917	41.3	0.8886	31.0
0.0035	58.2	0.1141	39.8	1.0506	30.8
0.0058	56.1	0.1695	37.2	1.2025	30.9
0.0116	53.2	0.2239	35.7	1.3449	30.5
0.0174	51.2	0.3296	32.4	1.4790	30.2
0.0232	49.5	0.4313	31.2	1.7244	30.1
[NaCl] = 0.0059 mol kg ⁻¹					
0.0005	60.9	0.0428	44.1	0.5822	30.0
0.0011	59.2	0.0639	41.8	0.6682	30.5
0.0016	57.3	0.0849	40.0	0.7514	30.3
0.0021	56.9	0.1058	38.8	0.8320	30.2
0.0032	55.2	0.1572	36.5	0.9101	30.0
0.0054	53.7	0.2078	34.9	1.0593	29.9
0.0107	50.8	0.2575	33.4	1.1998	29.7
0.0161	49.3	0.3063	32.2	1.3323	29.6
0.0215	47.8	0.4014	30.8	1.5759	29.5
0.0321	45.9	0.4933	30.3		

Table 5.6 - Continued

$\alpha_{AOT} = 0.850$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0107 mol kg ⁻¹					
0.0006	62.4	0.0457	44.0	0.6177	29.6
0.0011	60.3	0.0683	41.7	0.7082	29.4
0.0017	58.3	0.0907	39.7	0.8801	29.2
0.0023	57.0	0.1129	38.4	1.0408	29.0
0.0034	55.1	0.1677	35.7	1.1915	28.8
0.0057	53.5	0.2215	34.1	1.3331	28.6
0.0115	50.7	0.2743	32.5	1.4663	28.7
0.0172	49.0	0.3261	30.2	1.7104	28.2
0.0229	47.3	0.4268	29.8		
0.0343	45.7	0.5240	29.8		
[NaCl] = 0.0211 mol kg ⁻¹					
0.0005	63.3	0.0429	42.8	0.5773	28.4
0.0011	60.7	0.0640	40.2	0.6614	28.1
0.0016	58.5	0.0850	38.2	0.7426	28.0
0.0022	57.2	0.1059	36.7	0.8967	27.8
0.0032	55.2	0.1572	34.2	1.0406	27.5
0.0054	53.3	0.2076	32.5	1.1753	27.3
0.0108	49.9	0.2570	31.4	1.3017	27.1
0.0162	47.7	0.3054	30.1	1.4773	27.0
0.0215	46.2	0.3995	29.1	1.6381	27.0
0.0322	44.2	0.4900	28.7		
[NaCl] = 0.0309 mol kg ⁻¹					
0.0005	62.1	0.0414	41.6	0.4752	28.3
0.0010	59.8	0.0619	39.0	0.5601	28.0
0.0016	57.5	0.0823	37.7	0.6421	27.6
0.0021	56.1	0.1024	35.8	0.7212	27.4
0.0031	54.1	0.1522	34.1	0.7977	27.1
0.0052	51.9	0.2009	32.0	0.9433	26.9
0.0104	48.8	0.2488	30.9	1.0796	26.7
0.0156	46.6	0.2958	30.0	1.2076	26.6

Table 5.6 - Continued

$\alpha_{AOT} = 0.850$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
		[NaCl] = 0.0309 mol kg ⁻¹			
0.0208	45.3	0.3419	28.8	1.3281	26.5
0.0311	43.1	0.3871	28.5		
		[NaCl] = 0.0506 mol kg ⁻¹			
0.0003	65.0	0.0279	41.5	0.3193	27.5
0.0007	60.5	0.0416	39.1	0.3763	27.0
0.0010	59.1	0.0553	38.0	0.4313	26.9
0.0014	56.9	0.0689	35.8	0.5357	26.6
0.0021	54.8	0.1023	33.7	0.6333	26.2
0.0035	52.6	0.1351	32.4	0.7246	25.8
0.0070	49.6	0.1672	30.9	0.8910	26.0
0.0105	47.4	0.1988	29.9	1.0386	25.8
0.0140	45.6	0.2298	29.0		
0.0209	42.9	0.2601	28.3		
		[NaCl] = 0.0720 mol kg ⁻¹			
0.0003	60.8	0.0210	42.2	0.2306	28.1
0.0007	58.0	0.0280	40.9	0.2611	27.6
0.0011	56.3	0.0418	38.4	0.3204	26.8
0.0014	55.3	0.0555	36.7	0.3776	26.5
0.0021	54.5	0.0691	35.9	0.4328	26.5
0.0035	52.1	0.1027	32.6	0.5375	26.1
0.0070	48.2	0.1356	31.0	0.6354	26.0
0.0105	46.1	0.1678	30.1	0.7270	25.9
0.0140	44.5	0.1995	28.9	0.8939	25.9

Table 5.6 - Continued

$\alpha_{AOT} = 0.936$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0 mol kg ⁻¹					
0.0009	69.3	0.0715	53.0	0.9708	32.4
0.0018	67.2	0.1068	49.9	1.1138	32.4
0.0027	66.6	0.1419	48.0	1.2521	32.4
0.0036	66.5	0.1767	46.1	1.5156	31.8
0.0054	66.3	0.2627	43.2	1.7629	31.7
0.0090	63.6	0.3471	40.7	1.9955	31.7
0.0180	60.9	0.4299	38.3	2.2147	31.5
0.0269	58.7	0.5113	37.0	2.4215	31.3
0.0359	57.4	0.6698	35.2	2.7109	31.0
0.0537	55.1	0.8229	34.0		
[NaCl] = 0.0031 mol kg ⁻¹					
0.0009	67.1	0.0719	47.0	0.6735	32.9
0.0018	65.6	0.0897	45.8	0.8273	32.0
0.0027	63.0	0.1074	44.8	0.9759	31.8
0.0036	62.2	0.1427	42.6	1.1195	31.5
0.0054	60.2	0.1777	41.3	1.3928	31.0
0.0090	58.0	0.2125	39.8	1.6489	30.6
0.0181	54.3	0.2813	38.0	1.8895	30.5
0.0271	52.5	0.3490	36.8	2.1159	30.4
0.0361	50.6	0.4323	35.5	2.4315	29.8
0.0540	48.6	0.5141	34.4		
[NaCl] = 0.0062 mol kg ⁻¹					
0.0009	66.5	0.0732	44.9	0.4401	33.9
0.0018	63.6	0.0914	44.1	0.5233	33.1
0.0028	62.2	0.1094	42.8	0.6852	31.4
0.0037	60.8	0.1274	41.9	0.8414	30.6
0.0055	58.4	0.1454	40.9	0.9923	30.3
0.0092	56.0	0.1810	39.8	1.1380	30.4
0.0184	52.6	0.2164	38.0	1.4150	30.0
0.0276	50.4	0.2515	37.5	1.6744	29.4

Table 5.6 - Continued

$\alpha_{AOT} = 0.936$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0062 mol kg ⁻¹					
0.0368	48.6	0.2864	36.5	2.0339	28.9
0.0550	46.5	0.3553	35.2		
[NaCl] = 0.0104 mol kg ⁻¹					
0.0007	66.9	0.0666	44.1	0.6680	30.4
0.0013	64.2	0.0798	43.2	0.7756	29.8
0.0020	62.3	0.1060	41.5	0.8796	29.6
0.0027	60.9	0.1320	39.9	0.9801	29.5
0.0040	59.1	0.1578	38.8	1.0772	29.2
0.0067	56.2	0.2088	37.1	1.2621	28.8
0.0134	52.6	0.2590	35.5	1.5183	28.4
0.0201	50.4	0.3451	33.8	1.7519	28.2
0.0268	49.6	0.4289	32.3	1.9658	28.0
0.0401	47.1	0.5106	31.4		
0.0534	45.1	0.5903	30.6		
[NaCl] = 0.0210 mol kg ⁻¹					
0.0005	67.1	0.0475	43.6	0.4751	29.5
0.0010	64.6	0.0569	42.5	0.5515	29.0
0.0014	62.9	0.0755	40.7	0.6253	28.7
0.0019	61.3	0.0940	39.5	0.6965	28.5
0.0029	59.0	0.1124	38.3	0.7654	28.1
0.0048	56.1	0.1487	37.1	0.8963	27.5
0.0096	52.2	0.1844	35.2	1.0190	27.4
0.0143	50.2	0.2456	33.7	1.1892	27.2
0.0191	48.6	0.3053	32.4	1.3447	27.0
0.0286	46.4	0.3633	31.1		
0.0380	45.0	0.4199	30.6		
[NaCl] = 0.0311 mol kg ⁻¹					
0.0005	65.4	0.0473	42.8	0.4342	29.3
0.0009	64.1	0.0566	41.9	0.5118	28.3
0.0014	61.9	0.0752	40.0	0.5867	27.9
0.0019	60.6	0.0936	38.8	0.6590	27.6

Table 5.6 - Continued

$\alpha_{AOT} = 0.936$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0311 mol kg ⁻¹					
0.0029	58.4	0.1119	37.4	0.7289	27.3
0.0048	55.6	0.1481	35.8	0.8618	27.0
0.0095	51.4	0.1837	34.2	1.0457	26.6
0.0143	49.5	0.2361	32.9	1.2131	26.3
0.0190	47.6	0.2873	31.8	1.3663	26.0
0.0285	45.6	0.3374	30.6		
0.0379	44.1	0.3863	30.0		
[NaCl] = 0.0490 mol kg ⁻¹					
0.0004	66.6	0.0291	42.7	0.3932	27.7
0.0007	64.4	0.0435	40.8	0.4507	27.2
0.0011	63.0	0.0577	39.2	0.5063	26.9
0.0015	61.8	0.0719	37.7	0.6119	26.4
0.0022	59.0	0.1068	35.3	0.7107	26.3
0.0037	56.0	0.1411	33.7	0.8034	26.2
0.0073	51.2	0.1746	32.4	0.9322	26.0
0.0110	48.7	0.2076	31.1	1.0499	25.8
0.0146	47.0	0.2717	29.6	1.2254	25.7
0.0219	44.4	0.3335	28.7		
[NaCl] = 0.0695 mol kg ⁻¹					
0.0004	66.6	0.0218	43.4	0.2715	28.6
0.0007	63.5	0.0291	41.9	0.3332	27.4
0.0011	61.7	0.0363	40.8	0.3928	26.7
0.0015	60.4	0.0434	39.8	0.4503	26.4
0.0022	58.0	0.0577	37.6	0.5058	26.1
0.0037	54.8	0.0718	36.7	0.6114	26.0
0.0073	50.2	0.1067	34.2	0.7103	25.9
0.0109	47.3	0.1409	32.6	0.8030	25.8
0.0146	45.8	0.1744	31.3	0.9722	25.6
0.0182	44.3	0.2074	29.9	1.1227	25.5

Table 5.6 - Continued

$\alpha_{AOT} = 1.0$					
$c \times 10^3 /$ mol kg^{-1}	$\gamma /$ mN m^{-1}	$c \times 10^3 /$ mol kg^{-1}	$\gamma /$ mN m^{-1}	$c \times 10^3 /$ mol kg^{-1}	$\gamma /$ mN m^{-1}
[NaCl] = 0 mol kg ⁻¹					
0.29163	46.6	1.85905	33.0	3.16935	30.0
0.57388	42.0	2.09344	32.0	3.36713	30.0
0.84719	39.3	2.32108	31.1	3.55967	29.9
1.11196	37.5	2.5422	30.7	3.74714	29.8
1.36864	35.8	2.75715	30.5	4.10762	29.7
1.61756	34.4	2.96613	30.0	4.4502	29.6
[NaCl] = 0.0012 mol kg ⁻¹					
0.0500	53.5	1.1482	35.6	3.2887	29.4
0.1163	48.9	1.4485	34.3	3.5223	29.1
0.2483	46.3	1.7359	32.5	3.7491	29.4
0.3627	43.1	2.0148	31.3	3.9703	29.3
0.5246	40.7	2.2852	30.4	4.1853	29.2
0.6829	39.1	2.8433	29.7		
0.9031	37.4	3.0488	29.7		
[NaCl] = 0.0021 mol kg ⁻¹					
0.0683	50.1	1.2343	33.9	2.6196	29.7
0.2042	44.3	1.4751	33.0	2.8283	29.4
0.3718	41.0	1.7093	32.2	3.0327	30.1
0.5363	39.0	1.9383	31.1	3.2317	29.7
0.7314	37.6	2.1614	30.2	3.4366	29.3
0.9873	35.7	2.4051	29.8	3.6168	29.5
[NaCl] = 0.0079 mol kg ⁻¹					
0.0348	48.5	1.0659	31.0	2.2409	27.5
0.1043	43.2	1.3147	28.8	2.4051	27.4
0.2425	38.9	1.5572	28.3	2.5664	27.5
0.3784	36.5	1.7295	28.8	2.7248	27.2
0.5788	34.0	1.9034	28.2		
0.8088	32.2	2.0736	27.5		
[NaCl] = 0.0139 mol kg ⁻¹					
0.0650	43.2	0.7235	30.4	1.5088	26.8
0.1619	38.0	0.9037	29.5	1.5920	26.4

Table 5.6 - Continued

$\alpha_{AOT} = 1.0$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
[NaCl] = 0.0139 mol kg ⁻¹					
0.2577	35.8	0.9925	29.1	1.7641	26.3
0.3526	34.3	1.0805	28.0	1.8375	26.3
0.4467	33.1	1.1677	27.5	1.9179	26.2
0.5398	32.2	1.3398	26.8		
0.6320	31.2	1.4247	26.2		
[NaCl] = 0.0197 mol kg ⁻¹					
0.0691	41.1	0.6385	28.7	1.2985	26.2
0.1549	36.6	0.8359	27.4	1.3891	26.1
0.2441	34.7	0.9269	26.8	1.4785	26.2
0.3412	32.3	1.0213	26.7	1.5676	26.1
0.4413	31.1	1.1144	26.3		
0.5404	30.0	1.2068	26.3		
[NaCl] = 0.0292 mol kg ⁻¹					
0.0530	41.1	0.5352	28.6	1.0283	25.6
0.1234	36.8	0.6710	27.3	1.0920	25.8
0.1933	34.3	0.7373	26.7	1.1554	25.6
0.2626	32.5	0.7690	26.4	1.2182	25.4
0.3303	31.6	0.8345	25.9		
0.4694	29.4	0.9641	25.7		
[NaCl] = 0.0480 mol kg ⁻¹					
0.0501	39.0	0.5059	26.6	0.8803	25.6
0.1165	35.0	0.5693	26.1	0.9411	25.9
0.1824	32.5	0.6322	25.9	1.0017	25.8
0.2480	30.6	0.6948	25.7	1.0302	26.1
0.3131	29.3	0.7571	25.7		
0.4434	27.3	0.8187	25.8		
[NaCl] = 0.0612 mol kg ⁻¹					
0.0241	41.9	0.3092	28.3	0.6165	26.0
0.0561	37.7	0.3714	26.9	0.6978	25.6
0.1200	33.6	0.4332	25.3	0.7597	25.5

Table 5.6 - Continued

$\alpha_{AOT} = 1.0$					
$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
		[NaCl] = 0.0612 mol kg ⁻¹			
0.1835	31.3	0.4947	26.2	0.8223	25.8
0.2465	29.4	0.5558	25.5	0.8807	25.3
		[NaCl] = 0.0668 mol kg ⁻¹			
0.0320	41.6	0.2851	28.3	0.5005	25.9
0.0640	38.0	0.3158	27.7	0.5311	25.6
0.0958	35.4	0.3468	27.1	0.5615	25.5
0.1275	33.3	0.3778	27.3	0.5917	26.1
0.1592	32.1	0.4086	26.5	0.6219	25.5
0.1910	31.0	0.4446	26.1	0.7141	25.7
0.2221	30.1	0.4700	26.2		
		[NaCl] = 0.0788 mol kg ⁻¹			
0.0158	43.9	0.1960	29.9	0.5019	25.9
0.0401	38.8	0.2584	28.4	0.5081	25.7
0.0710	35.6	0.3201	27.1	0.5620	25.7
0.1024	33.5	0.3813	25.6	0.5916	25.6
0.1337	32.9	0.4422	25.8		
0.1649	30.9	0.4718	25.7		

Table 5.7 - Values of cmc and $c_{\gamma m}$ (or c_{γ}) of AOT + TX-100 Mixed Systems at Different NaCl Concentrations at 298K

α_{AOT}	[NaCl] / mol kg ⁻¹	Cmc x 10 ³ / mol kg ⁻¹	$c_{\gamma m}$ (or c_{γ}) x 10 ³ / mol kg ⁻¹
0.0	0	0.266	0.0398
	0.0100	0.263	0.0316
	0.0205	0.261	0.0313
	0.0305	0.258	0.0282
	0.0510	0.256	0.0266
	0.0708	0.251	0.0251
	0.1012	0.244	0.0500
0.150	0	0.199	0.0631
	0.0031	0.199	0.0612
	0.0061	0.197	0.0577
	0.0097	0.194	0.0596
	0.0203	0.188	0.0521
	0.0288	0.183	0.0487
	0.0488	0.178	0.0446
0.300	0	0.211	0.0718
	0.0032	0.208	0.0687
	0.0062	0.205	0.0687
	0.0102	0.199	0.0583
	0.0210	0.194	0.0583
	0.0301	0.190	0.0540
	0.0506	0.186	0.0540
0.500	0	0.251	0.0851
	0.0030	0.248	0.0648
	0.0060	0.244	0.0610
	0.0102	0.240	0.0610
	0.0205	0.230	0.0560
	0.0311	0.217	0.0550
	0.0502	0.199	0.0530
0.800	0	0.460	0.3237

Table 5.7- Continued

α_{AOT}	[NaCl] / mol kg ⁻¹	Cmc x 10 ³ / mol kg ⁻¹	c_{ym} (or c_{iy}) x 10 ³ / mol kg ⁻¹
0.800	0.0030	0.398	0.2458
	0.0060	0.387	0.2112
	0.0106	0.365	0.1883
	0.0208	0.335	0.1497
	0.0307	0.316	0.1246
	0.0511	0.282	0.0990
	0.0721	0.266	0.0843
	0.850	0	0.546
0.0030		0.447	0.2400
0.0059		0.410	0.2016
0.0107		0.387	0.1817
0.0211		0.360	0.1424
0.0309		0.335	0.1210
0.0506		0.298	0.0856
0.0720		0.274	0.0728
0.936	0	0.944	0.6789
	0.0031	0.794	0.4710
	0.0062	0.729	0.3815
	0.0104	0.668	0.2879
	0.0210	0.531	0.1971
	0.0311	0.473	0.1696
	0.0490	0.410	0.1139
	0.0695	0.335	0.0931
1.0	0	2.630	1.4711
	0.0012	2.510	1.2510
	0.0021	2.290	1.0590
	0.0079	1.860	0.5050
	0.0139	1.380	0.3225
	0.0197	1.070	0.2238
	0.0292	0.850	0.1763
	0.0480	0.600	0.1188
	0.0612	0.470	0.0944
	0.0668	0.430	0.1016
	0.0788	0.410	0.0819

Table 5.8 – Interpolated cmc values at 298K for AOT + TX-100 mixed systems at fixed NaCl concentrations

[NaCl] / mol kg ⁻¹	$\alpha_{\text{AOT}} = 0$ Cmc / mmol kg ⁻¹	$\alpha_{\text{AOT}} = 0.150$ Cmc / mmol kg ⁻¹	$\alpha_{\text{AOT}} = 0.300$ Cmc / mmol kg ⁻¹	$\alpha_{\text{AOT}} = 0.500$ Cmc / mmol kg ⁻¹
0	0.266	0.199	0.211	0.251
0.003	0.266	0.199	0.207	0.248
0.006	0.264	0.196	0.204	0.244
0.010	0.264	0.194	0.201	0.238
0.020	0.262	0.188	0.195	0.227
0.030	0.260	0.184	0.191	0.218
0.040	0.257	0.180	0.187	0.209
0.050	0.256	0.177	0.185	0.201
0.060	0.253	0.175	0.182	0.196
0.070	0.251	0.173	0.180	0.190

Table 5.8 – Continued

[NaCl] /	$\alpha_{\text{AOT}} = 0.800$	$\alpha_{\text{AOT}} = 0.850$	$\alpha_{\text{AOT}} = 0.936$	$\alpha_{\text{AOT}} = 1$
mol kg ⁻¹	Cmc / mmol kg ⁻¹	Cmc / mmol kg ⁻¹	Cmc / mmol kg ⁻¹	Cmc / mmol kg ⁻¹
0	0.459	0.546	0.944	2.630
0.003	0.404	0.447	0.808	2.189
0.006	0.386	0.416	0.740	1.877
0.010	0.370	0.392	0.660	1.625
0.020	0.337	0.360	0.540	1.100
0.030	0.315	0.337	0.470	0.850
0.040	0.297	0.320	0.430	0.700
0.050	0.285	0.302	0.400	0.600
0.060	0.275	0.290	0.370	0.500
0.070	0.267	0.277	0.340	0.425

Table 5.9 - Values of Γ_{cmc} , Γ_{AOT} , Γ_{TX100} , x_{1a} , β_a , f_{1a} and f_{2a} for AOT + TX-100 mixed systems at different NaCl concentrations at 298K

α_{AOT}	[NaCl] / mol kg ⁻¹	$\Gamma_{cmc} \times 10^6$ / mol m ⁻²	$\Gamma_{AOT} \times 10^6$ / mol m ⁻²	$\Gamma_{TX100} \times 10^6$ / mol m ⁻²	x_{1a}	β_a	f_{1a}	f_{2a}
0	0			2.82				
	0.0100			3.20				
	0.0205			3.16				
	0.0305			3.32				
	0.0510			3.37				
	0.0708			3.45				
	0.1012			3.31				
0.150	0	*			-	-	-	-
	0.0031				-	-	-	-
	0.0061				-	-	-	-
	0.0097				-	-	-	-
	0.0203				-	-	-	-
	0.0288				-	-	-	-
	0.0488				-	-	-	-
0.300	0	*			-	-	-	-
	0.0032				-	-	-	-
	0.0062				-	-	-	-
	0.0102				-	-	-	-
	0.0210				-	-	-	-
	0.0301				-	-	-	-
	0.0506				-	-	-	-
0.500	0	-	-	-	-	-	-	-
	0.0030	2.71	0.29	2.42	0.108	-1.43	0.321	0.983
	0.0060	2.54	0.30	2.24	0.118	-1.21	0.391	0.983
	0.0102	2.51	0.20	2.31	0.080	-0.14	0.900	0.999
	0.0205	2.43	0.18	2.25	0.076	0.61	1.685	1.003
	0.0311	2.61	0.08	2.53	0.031	1.73	5.085	1.002
	0.0502	-	-	-	-	-	-	-
0.0702	-	-	-	-	-	-	-	

- Iteration did not converge; * Since x_{1a} could not be determined, Γ_{cmc} also could not be evaluated.

Table 5.9 - Continued

α_{AOT}	[NaCl] / mol kg ⁻¹	$\Gamma_{cmc} \times 10^6$ / mol m ⁻²	$\Gamma_{AOT} \times 10^6$ / mol m ⁻²	$\Gamma_{TX100} \times 10^6$ / mol m ⁻²	x_{1a}	β_a	f_{1a}	f_{2a}
0.800	0	-	-	-	-	-	-	-
	0.0030	-	-	-	-	-	-	-
	0.0060	-	-	-	-	-	-	-
	0.0106	-	-	-	-	-	-	-
	0.0208	2.55	0.02	2.53	0.007	4.41	77.03	1.000
	0.0307	2.54	0.41	2.13	0.163	1.78	3.497	1.049
	0.0511	2.54	0.97	1.57	0.382	1.36	1.681	1.219
	0.0721	2.46	1.45	1.01	0.590	1.42	1.270	1.642
0.850	0	-	-	-	-	-	-	-
	0.0030	2.67	0.07	2.60	0.027	2.20	7.992	1.002
	0.0059	2.39	0.37	2.02	0.156	0.69	1.631	1.017
	0.0107	2.55	0.54	2.01	0.210	0.96	1.826	1.043
	0.0211	2.55	0.99	1.56	0.389	0.99	1.449	1.162
	0.0309	2.35	1.09	1.26	0.466	0.83	1.268	1.199
	0.0506	2.36	1.30	1.06	0.552	0.28	1.058	1.089
	0.0720	2.41	1.56	0.85	0.646	0.50	1.064	1.230
0.936	0	-	-	-	-	-	-	-
	0.0031	2.47	0.59	1.88	0.237	1.20	2.010	1.070
	0.0062	2.42	0.97	1.45	0.401	0.94	1.404	1.164
	0.0104	2.48	1.39	1.09	0.560	0.74	1.155	1.263
	0.0210	2.39	1.96	0.43	0.820	1.26	1.042	2.327
	0.0311	2.43	2.20	0.23	0.905	1.71	1.015	4.056
	0.0490	2.37	1.95	0.42	0.823	0.65	1.021	1.556
	0.0695	2.37	2.17	0.20	0.917	1.25	1.009	2.866

- Iteration did not converge

Table 5.9 - Continued

α_{AOT}	[NaCl] / mol kg ⁻¹	$\Gamma_{cmc} \times 10^6$ / mol m ⁻²	$\Gamma_{AOT} \times 10^6$ / mol m ⁻²	$\Gamma_{TX100} \times 10^6$ / mol m ⁻²	x_{1a}	β_a	f_{1a}	f_{2a}
1	0		1.63					
	0.0012		1.93					
	0.0021		1.80					
	0.0079		1.85					
	0.0139		2.06					
	0.0197		2.15					
	0.0292		2.38					
	0.0480		2.40					
	0.0612		2.52					
	0.0668		2.49					
	0.0788		2.52					

Table 5.10 - Values of x_1 , β_m , f_1 and f_2 at fixed [NaCl] for AOT + TX-100 systems at 298K from Rubingh's Model

[NaCl] / mol kg ⁻¹	x_1	β_m	f_1	f_2	x_1	β_m	f_1	f_2
		$\alpha_{\text{AOT}} = 0.150$				$\alpha_{\text{AOT}} = 0.300$		
0	0.212	-4.71	0.054	0.809	0.259	-4.32	0.093	0.749
0.003	0.216	-4.49	0.063	0.811	0.267	-4.17	0.106	0.743
0.006	0.220	-4.35	0.071	0.809	0.272	-4.00	0.120	0.743
0.010	0.225	-4.22	0.079	0.806	0.279	-3.88	0.133	0.739
0.020	0.239	-3.84	0.108	0.803	0.295	-3.45	0.180	0.739
0.030	0.248	-3.59	0.131	0.802	0.307	-3.16	0.219	0.742
0.040	0.255	-3.40	0.152	0.801	0.316	-2.93	0.254	0.747
0.050	0.262	-3.26	0.169	0.799	0.324	-2.75	0.285	0.749
0.060	0.268	-3.04	0.196	0.803	0.333	-2.50	0.328	0.757
0.070	0.274	-2.85	0.223	0.807	0.342	-2.28	0.372	0.765
	$\alpha_{\text{AOT}} = 0.500$				$\alpha_{\text{AOT}} = 0.800$			
0	0.310	-3.94	0.154	0.684	0.412	-3.13	0.339	0.587
0.003	0.319	-3.73	0.177	0.684	0.432	-3.34	0.341	0.535
0.006	0.326	-3.55	0.199	0.685	0.445	-3.23	0.370	0.527
0.010	0.335	-3.45	0.218	0.678	0.458	-3.14	0.398	0.517
0.020	0.359	-3.04	0.287	0.676	0.495	-2.75	0.495	0.509
0.030	0.377	-2.78	0.340	0.673	0.522	-2.48	0.567	0.507
0.040	0.392	-2.61	0.381	0.669	0.545	-2.28	0.623	0.508
0.050	0.406	-2.51	0.412	0.661	0.565	-2.10	0.672	0.512
0.060	0.421	-2.27	0.466	0.668	0.592	-1.79	0.743	0.533
0.070	0.436	-2.10	0.513	0.671	0.622	-1.49	0.808	0.562

Table 5.10 - Continued

[NaCl] / mol kg ⁻¹	x_1	β_m	f_1	f_2	x_1	β_m	f_1	f_2
	$\alpha_{AOT} = 0.850$				$\alpha_{AOT} = 0.936$			
0	0.444	-2.99	0.397	0.554	0.545	-2.34	0.616	0.499
0.003	0.466	-3.46	0.372	0.472	0.563	-2.55	0.614	0.445
0.006	0.479	-3.44	0.393	0.454	0.579	-2.54	0.637	0.426
0.010	0.492	-3.39	0.417	0.439	0.592	-2.67	0.642	0.392
0.020	0.530	-2.93	0.524	0.439	0.637	-2.49	0.721	0.364
0.030	0.559	-2.61	0.602	0.441	0.669	-2.35	0.773	0.350
0.040	0.584	-2.35	0.665	0.449	0.698	-2.13	0.824	0.355
0.050	0.604	-2.20	0.709	0.448	0.724	-1.94	0.862	0.362
0.060	0.634	-1.88	0.777	0.470	0.760	-1.62	0.911	0.391
0.070	0.664	-1.60	0.835	0.494	0.794	-1.37	0.943	0.420

Table 5.11 - Ratio of the intensities (I_o / I_q) of Fluorescence Emission of Pyrene in the absence (I_o) and presence (I_q) of the quencher (CPC) at 373 nm of AOT+ TX-100 Systems in Water at 298K

α_{AOT}	$c \approx 2cmc$			α_{AOT}	$c - cmc \approx 0.0004 \text{ mol kg}^{-1}$				
	$c \times 10^3 / \text{mol kg}^{-1}$	$[\text{CPC}] \times 10^6 / \text{mol kg}^{-1}$	I_o / I_q		$c \times 10^3 / \text{mol kg}^{-1}$	$[\text{CPC}] \times 10^6 / \text{mol kg}^{-1}$	I_o / I_q		
0	0.5031	0.0000	1.0000	0	0.6505	0.0000	1.0000		
			1.2349			1.2053		1.2988	1.0720
			2.4699			1.3917		2.5976	1.2738
			3.7048			1.5346		3.8965	1.4043
			4.9398			1.7735		5.1954	1.4928
			6.1747			1.8953		6.4942	1.8281
			7.4097			2.3131	0.106	0.6024	0.0000
	8.6446	2.6037		1.2988	1.1570				
0.106	0.4991	0.0000	1.0000		2.5976	1.3257			
			1.2349	1.1178		3.8965			1.4383
			2.4699	1.2980		5.1954			1.6351
			3.7048	1.5238		6.4942			1.8214
			4.9398	1.7252		7.7930			2.1190
			6.1747	1.9854		9.0919	2.2933		
			7.4097	2.1371	0.170	0.6496	0.0000	1.0000	
0.170	0.5651	0.0000	1.0000				1.2988	1.2885	
			1.2349	1.2073				2.5976	1.3728
			2.4699	1.4060				3.8965	1.5495
			3.7048	1.6234				5.1954	1.7913
			4.9398	1.8293				6.4942	1.9075
			6.1747	2.0642				7.7930	2.4177
			7.4097	2.3131	0.290	0.6580	0.0000	1.0000	
0.290	0.6121	0.0000	1.0000				2.5976	1.3298	
			1.2349	1.2160				6.4942	2.0512
			2.4699	1.3674				7.7930	2.2994
			3.7048	1.6044				9.0919	2.5959
			4.9398	1.7404				10.391	2.8277
			6.1747	1.9722					
			7.4097	2.3131					

Table 5.11 - Continued

α_{AOT}	$c \approx 2cmc$			α_{AOT}	$c - cmc \approx 0.0004 \text{ mol kg}^{-1}$			
	$c \times 10^3 / \text{mol kg}^{-1}$	$[\text{CPC}] \times 10^6 / \text{mol kg}^{-1}$	I_o / I_q		$c \times 10^3 / \text{mol kg}^{-1}$	$[\text{CPC}] \times 10^6 / \text{mol kg}^{-1}$	I_o / I_q	
0.420	0.7010	0.0000	1.0000	0.420	0.7502	0.0000	1.0000	
			2.5976				2.5976	1.2643
			3.8965				3.8965	1.4697
			5.1954				5.1954	1.7249
			6.4942				6.4942	2.0050
			7.7930				7.7930	2.1496
			9.0919				9.0919	2.3919
			10.391				10.391	2.7856
0.550	0.8526	0.0000	1.0000	0.550	0.7102	0.0000	1.0000	
			1.2349				1.2988	1.2508
			2.4699				2.5976	1.3989
			3.7048				3.8965	1.6972
			4.9398				5.1954	2.0272
			6.1747				6.4942	2.3495
			7.4097				7.7930	2.6089
			8.6446				9.0919	2.8682
0.711	0.9495	0.0000	1.0000	0.711	0.7589	0.0000	1.0000	
			1.2349				3.8965	2.0564
			2.4699				5.1954	2.4165
			3.7048				6.4942	2.7153
			4.9398				7.7930	3.5927
			6.1747				9.0919	4.4701
			7.4097				10.391	5.3475
			8.6446				11.690	6.2249
0.810	1.1061	0.0000	1.0000	0.810	0.8561	0.0000	1.0000	
			1.2349				2.5976	1.5107
			2.4699				3.8965	1.9628
			3.7048				5.1954	2.4149
			4.9398				6.4942	2.8670
			6.1747				7.7930	3.3191
			7.4097				9.0919	3.7712
			8.6446				10.391	4.2233

Table 5.11 - Continued

$c \approx 2cmc$				$c - cmc \approx 0.0004 \text{ mol kg}^{-1}$			
α_{AOT}	$c \times 10^3 /$ mol kg^{-1}	$[\text{CPC}] \times 10^6$ $/\text{mol kg}^{-1}$	I_o / I_q	α_{AOT}	$c \times 10^3 /$ mol kg^{-1}	$[\text{CPC}] \times 10^6$ $/\text{mol kg}^{-1}$	I_o / I_q
0.810	1.1061	6.1747	2.0650	0.902	1.0186	0.0000	1.0000
		7.4097	2.3051			1.2988	1.4709
		8.6446	2.4595			2.5976	1.7608
0.848	1.0125	0.0000	1.0000	0.944	1.3433	3.8965	2.1438
		2.5976	1.8485			0.0000	1.0000
		3.8965	2.5021			1.2988	1.2220
0.902	1.2159	5.1954	3.0538	0.980	2.0416	2.5976	1.4968
		0.0000	1.0000			3.8965	1.9074
		1.2349	1.4538			5.1953	2.4706
0.944	1.9184	2.4699	1.7300	1.0	3.0385	0.0000	1.0000
		3.7048	2.1675			1.2988	1.2542
		4.9398	2.4159			2.5976	1.4074
0.980	3.4784	0.0000	1.0000	1.0	3.0385	3.8965	1.7715
		1.2349	1.1427			0.0000	1.0000
		2.4699	1.3608			1.2988	1.0531
1.0	6.6000	3.704	1.5331	1.0	3.0385	2.5976	1.0895
		4.9398	1.8422			3.8965	1.1691
		6.1747	2.0873			5.1954	1.2326
1.0	6.6000	0.0000	1.0000	1.0	6.6000	0.0000	1.0000
		9.4060	1.0369			9.4060	1.0369
		18.812	1.0959			18.812	1.0959
1.0	6.6000	28.218	1.1605	1.0	6.6000	28.218	1.1605
		37.624	1.2163			37.624	1.2163
		47.030	1.2924			47.030	1.2924

Table 5.12 – Values of total aggregation number (N_o) and aggregation numbers of the components (N_{AOT} and N_{TX}) in the AOT + TX-100 mixed micelles in water at 298 K and at two surfactant concentrations

α_{AOT}	$c - cmc \approx cmc$			$c - cmc \approx 0.4 \text{ mmol kg}^{-1}$		
	N_o	N_{AOT}	N_{TX}	N_o	N_{AOT}	N_{TX}
0	24	-	24	34	-	34
0.106	34	7	27	38	8	30
0.170	42	9	33	46	10	36
0.290	45	12	33	48	13	35
0.420	48	14	34	52	16	36
0.550	45	14	31	51	15	36
0.711	63	23	40	56	20	36
0.810	63	26	37	50	20	30
0.848	104	-	-	71	-	-
0.902	122	60	62	77	38	39
0.944	119	66	53	69	39	30
0.980	56	41	15	37	27	10
1	22	22	-	16	16	-

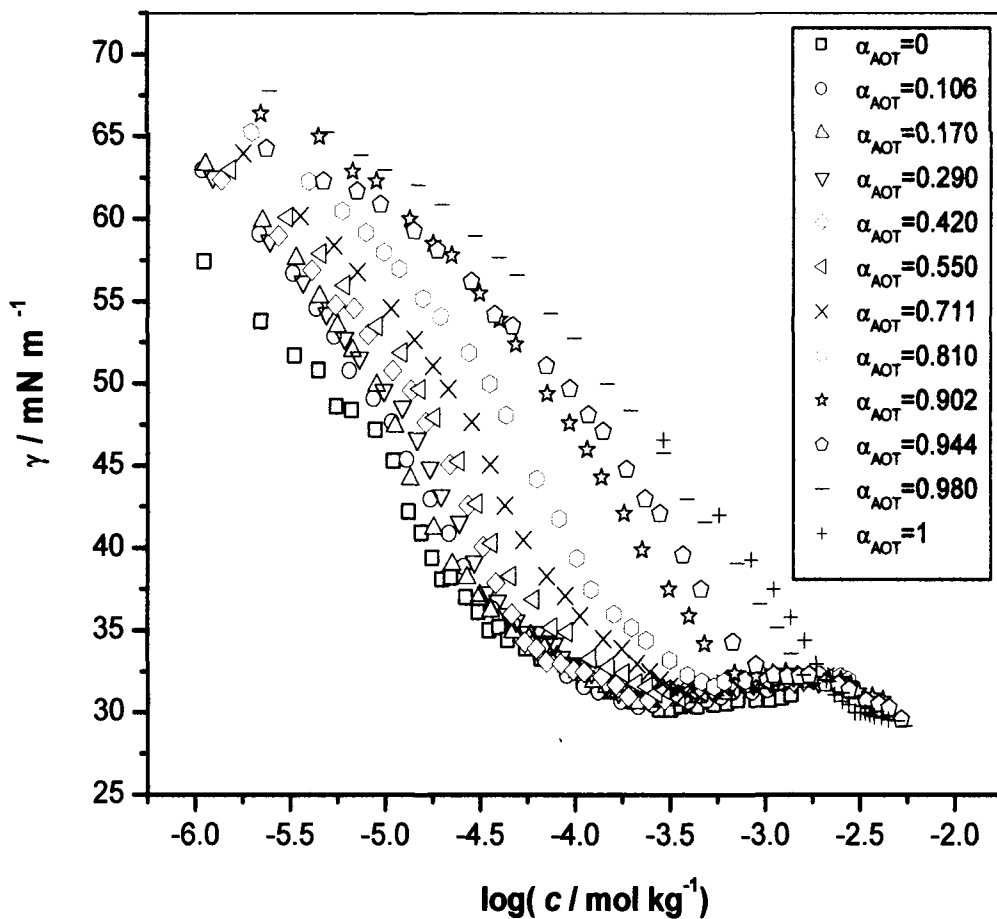


Figure 5.1 - Variation of surface tension with logarithm of total surfactant concentration for AOT + TX-100 systems in water.

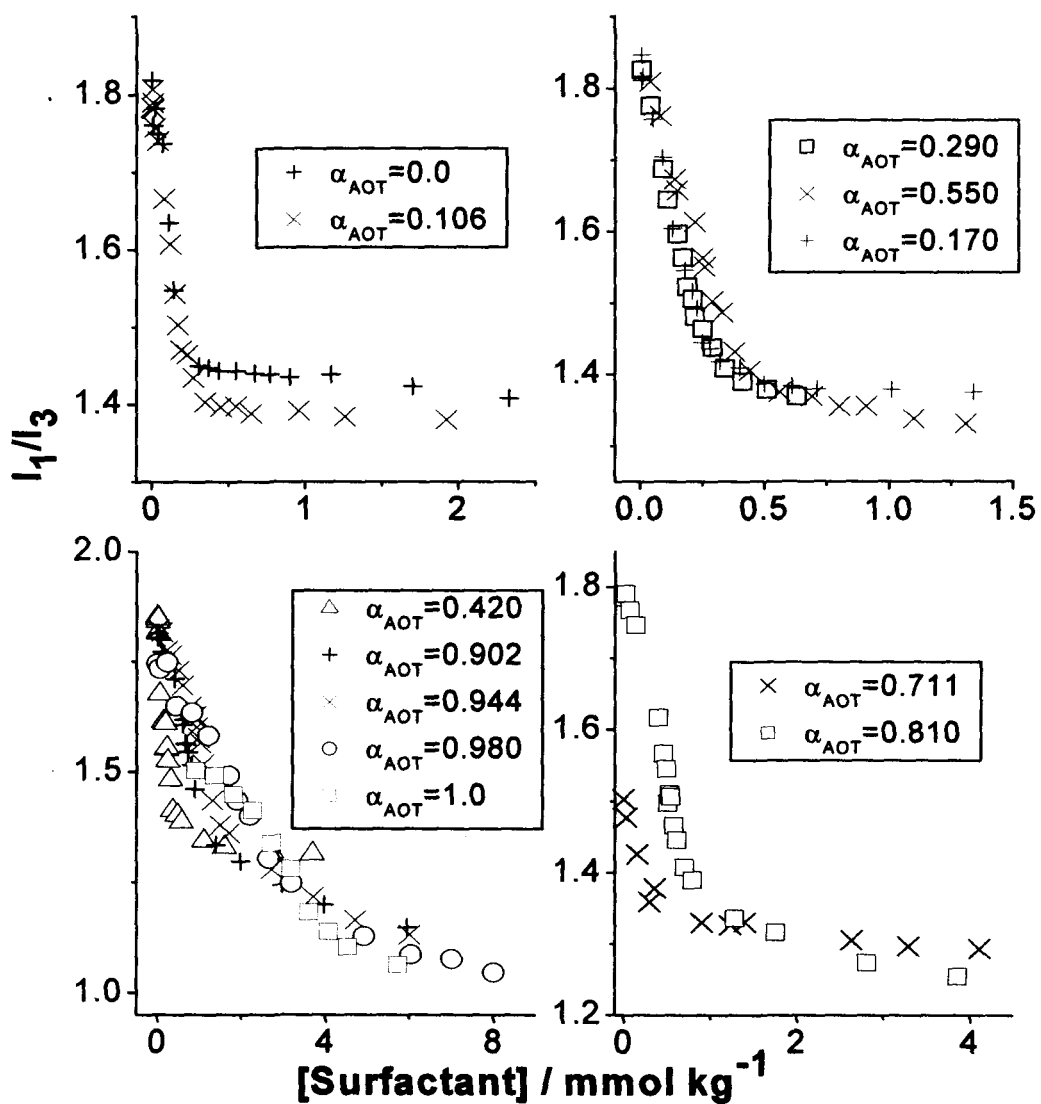


Figure 5.2 - Representative plots of I_1 / I_3 values of pyrene in AOT + TX-100 system against total surfactant concentration in water.

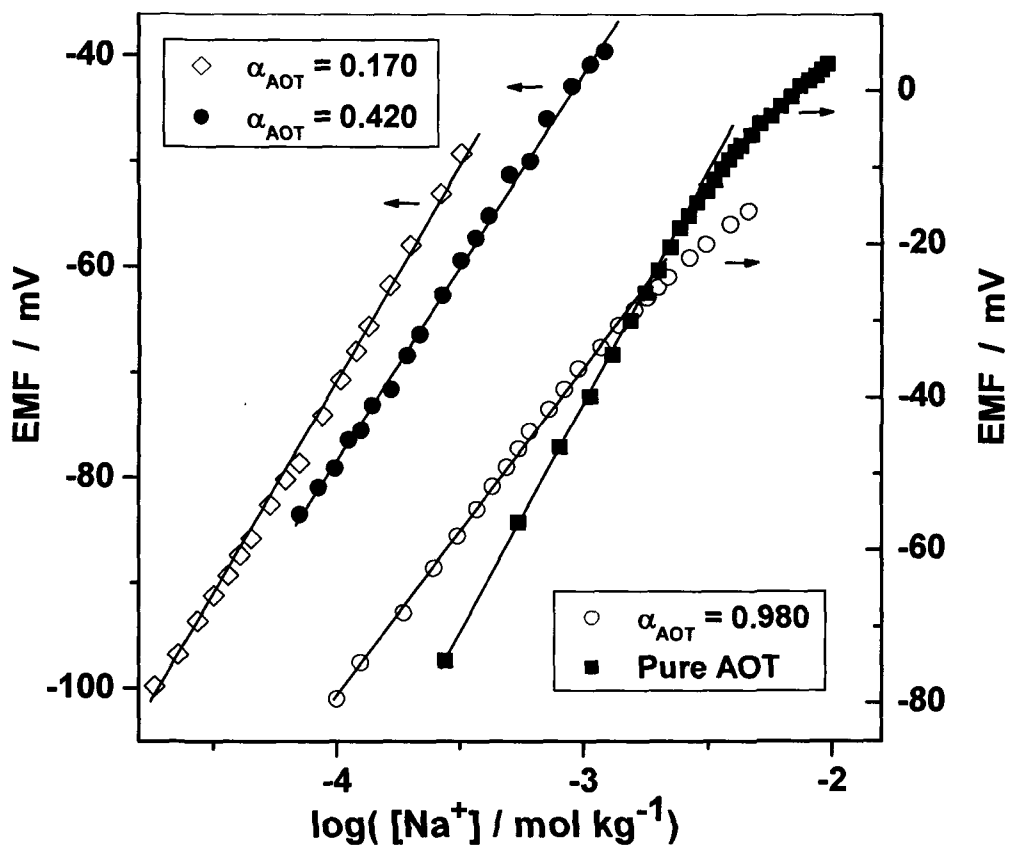


Figure 5.3 - Representative plots of emf of AOT + TX-100 system against logarithm of sodium ion concentration in water.

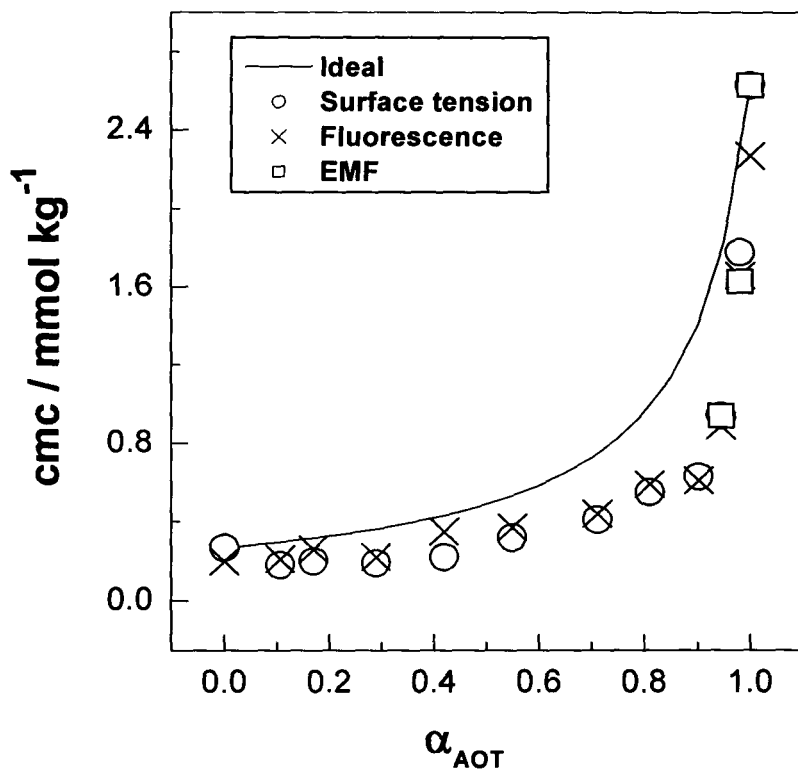


Figure 5.4 - Variation of cmc of AOT + TX-100 mixed system with mole fraction of AOT in water medium.

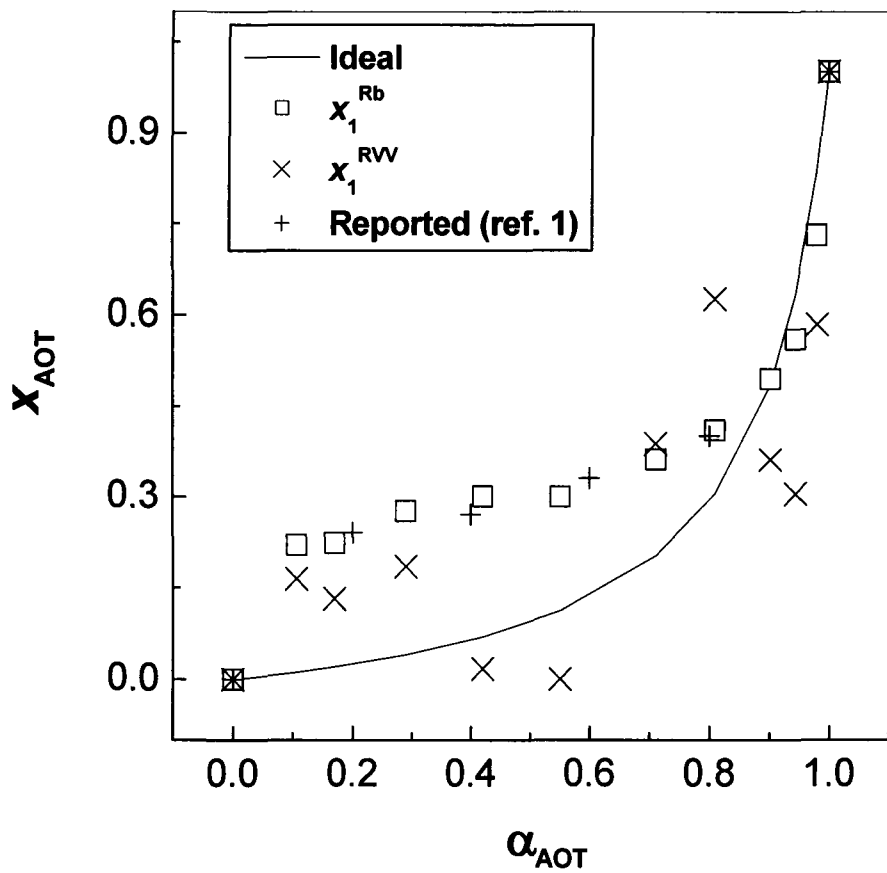


Figure 5.5 - Variation of mole fraction of AOT (x_1 or x_{AOT}) in the mixed micellar phase with its mole fraction in water medium (α_{AOT}).

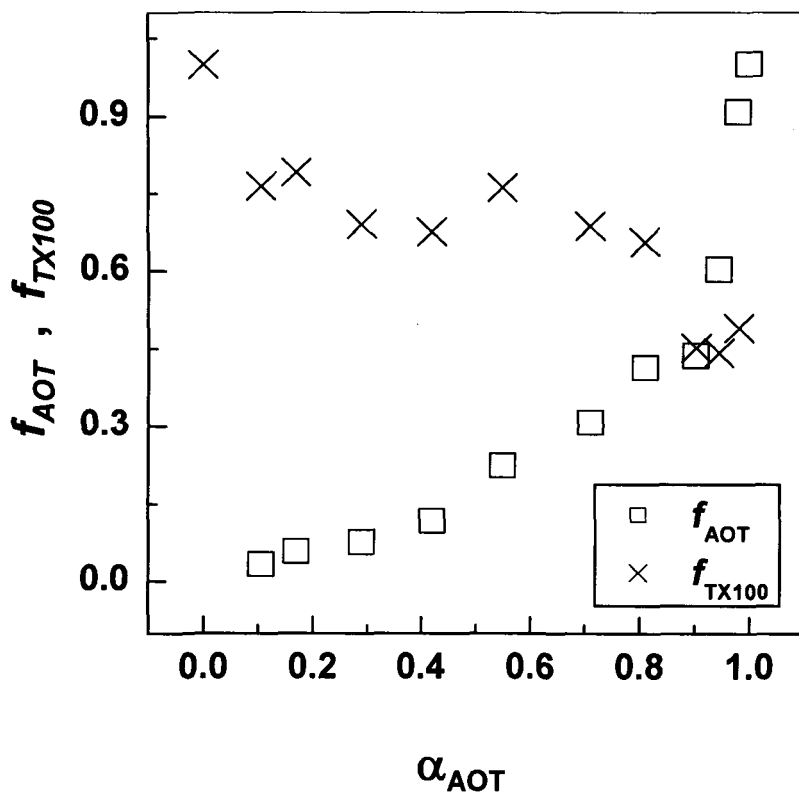


Figure 5.6 - Variation of the activity coefficients in the mixed micellar phase of AOT + TX-100 with mole fraction of AOT in water medium.

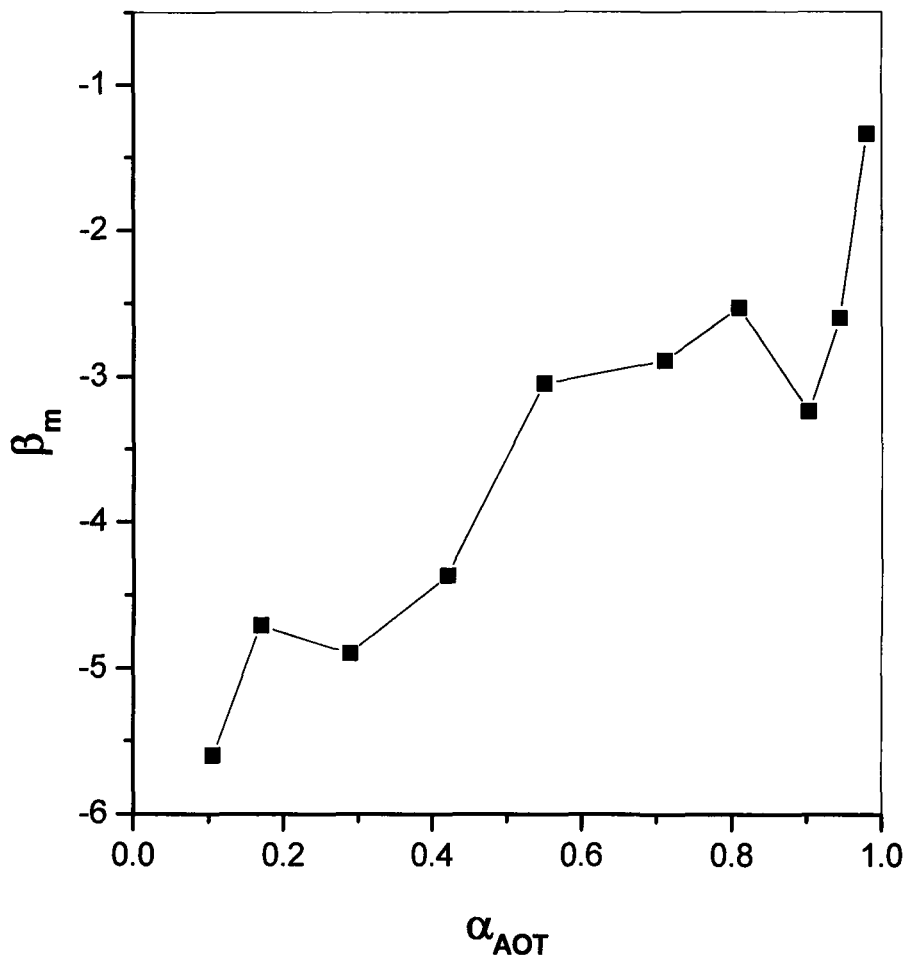


Figure 5.7 - Variation of interaction parameter in the mixed micellar phase of AOT + TX-100 with mole fraction of AOT in water medium.

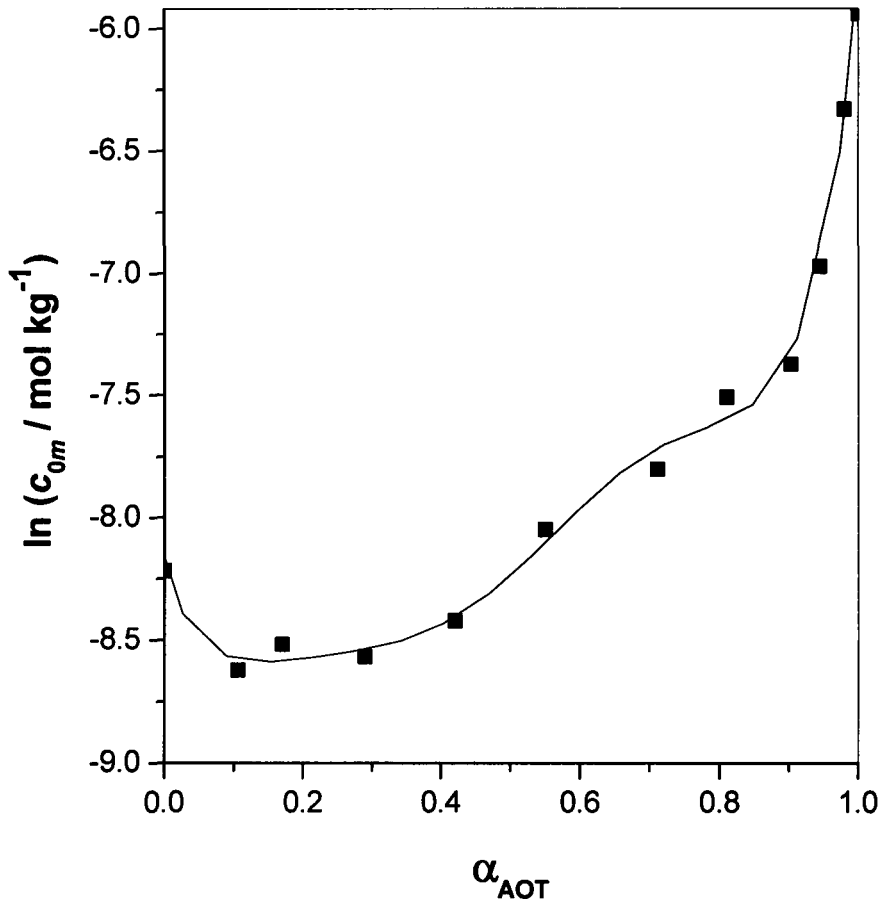


Figure 5.8 - Dependence of $\ln c_{om}$ of AOT + TX-100 system on the mole fraction of AOT in water medium. The solid line corresponds to the fitted value from Eq. (5.1).

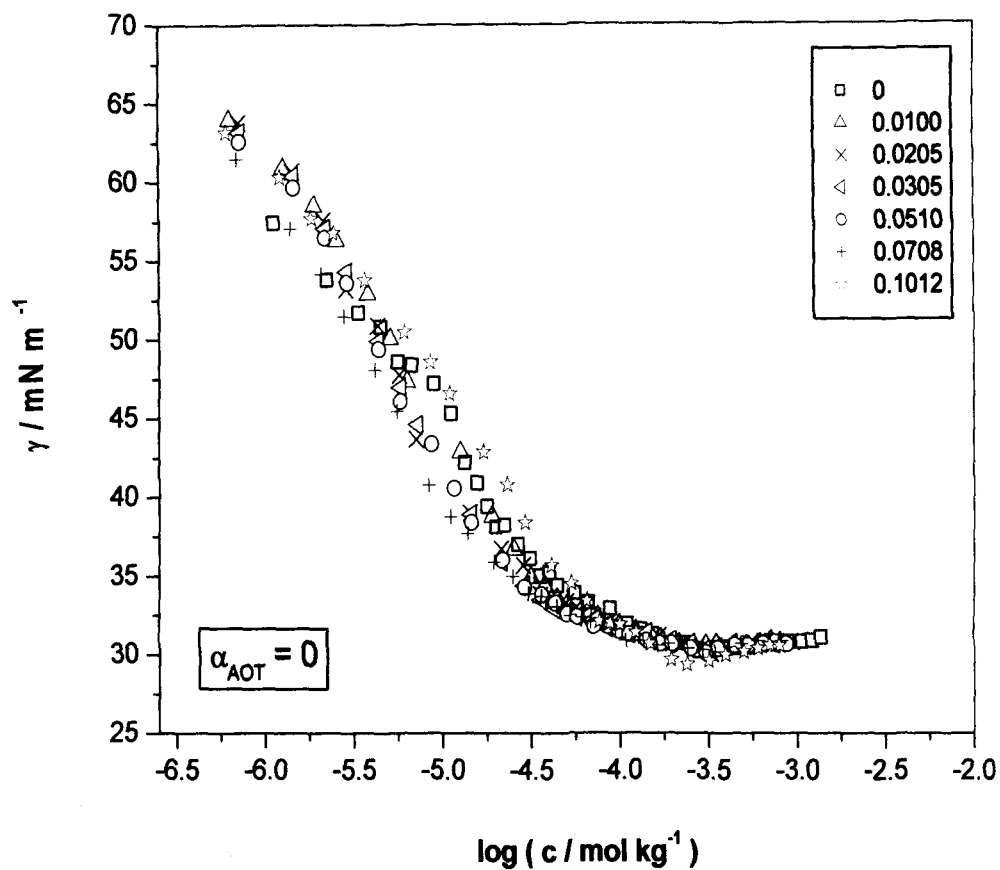


Figure 5.9a - Variation of surface tension with logarithm of total surfactant concentration for pure TX-100 in aqueous sodium chloride solutions. Sodium chloride concentrations in mol kg⁻¹ are given in the inset.

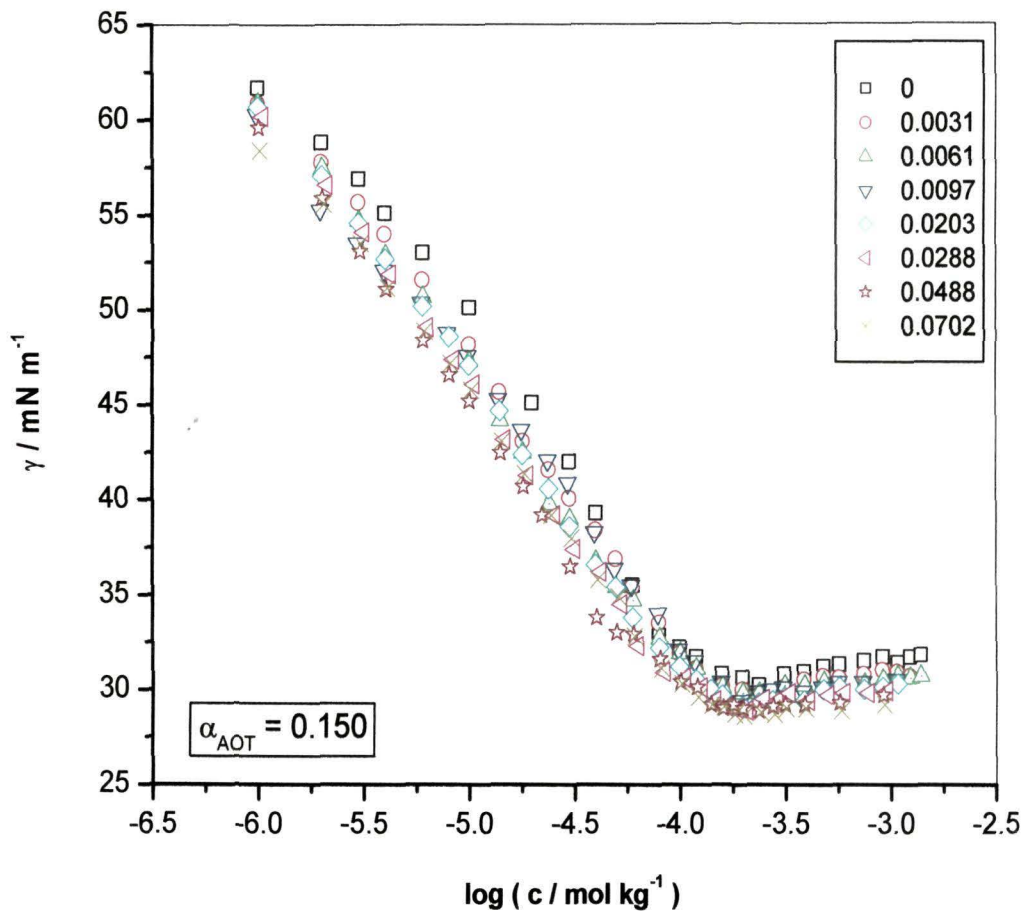


Figure 5.9b - Variation of surface tension with logarithm of total surfactant concentration for AOT + TX-100 system with $\alpha_{\text{AOT}} = 0.150$ in aqueous sodium chloride solutions. Sodium chloride concentrations in mol kg^{-1} are given in the inset.

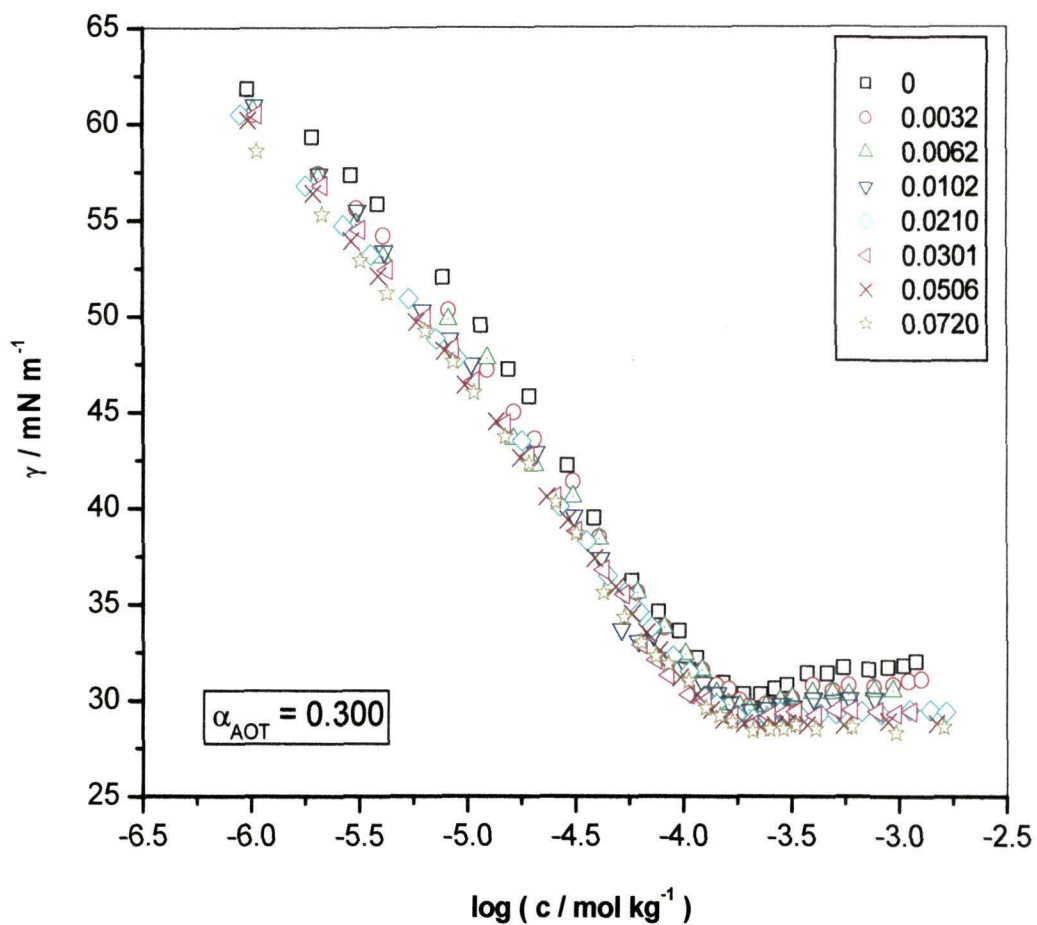


Figure 5.9c - Variation of surface tension with logarithm of total surfactant concentration for AOT + TX-100 system with $\alpha_{\text{AOT}} = 0.300$ in aqueous sodium chloride solutions. Sodium chloride concentrations in mol kg^{-1} are given in the inset.

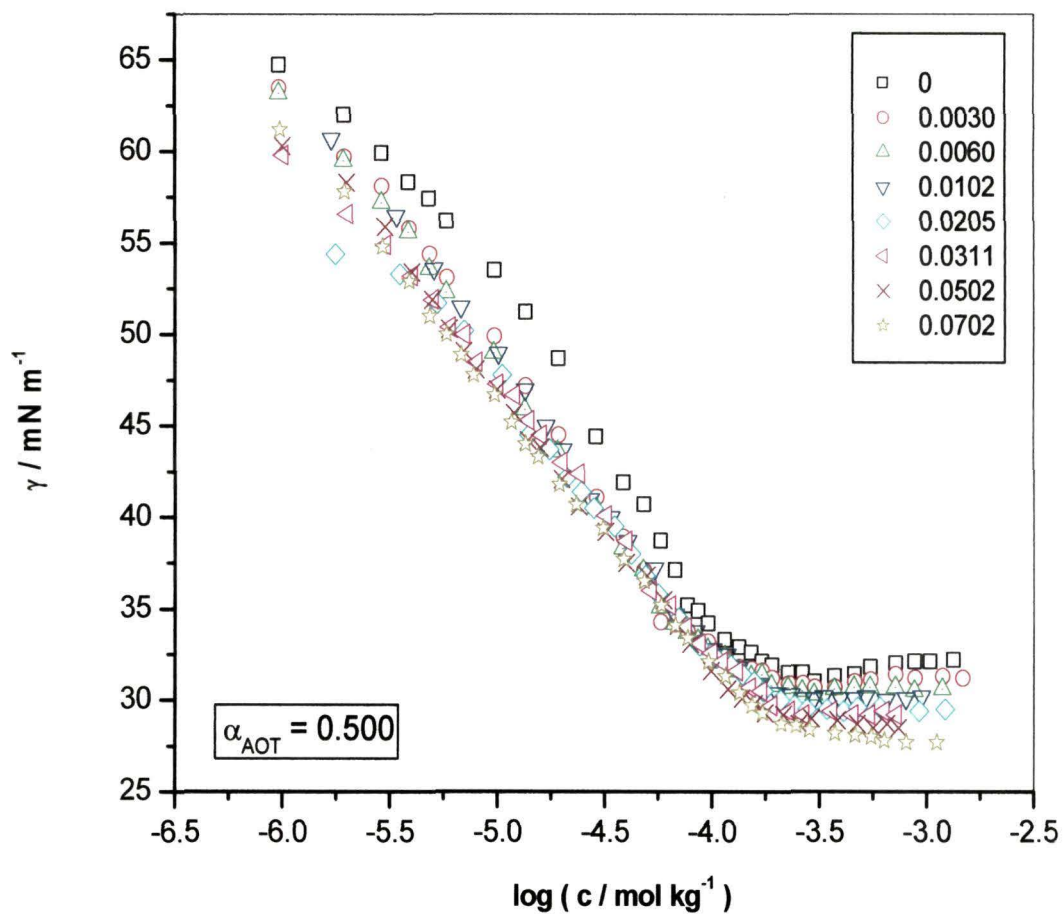


Figure 5.9d - Variation of surface tension with logarithm of total surfactant concentration for AOT + TX-100 system with $\alpha_{\text{AOT}} = 0.500$ in aqueous sodium chloride solutions. Sodium chloride concentrations in mol kg^{-1} are given in the inset.

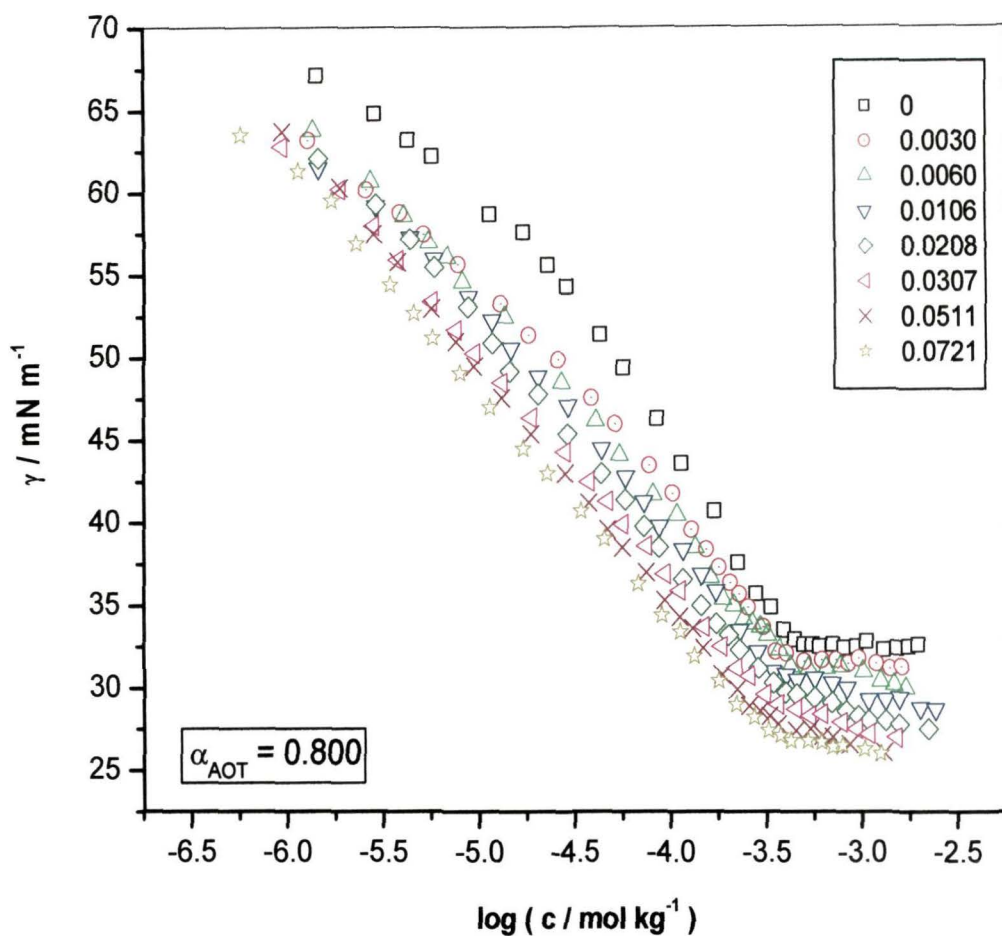


Figure 5.9e - Variation of surface tension with logarithm of total surfactant concentration for AOT + TX-100 system with $\alpha_{\text{AOT}} = 0.800$ in aqueous sodium chloride solutions. Sodium chloride concentrations in mol kg^{-1} are given in the inset.

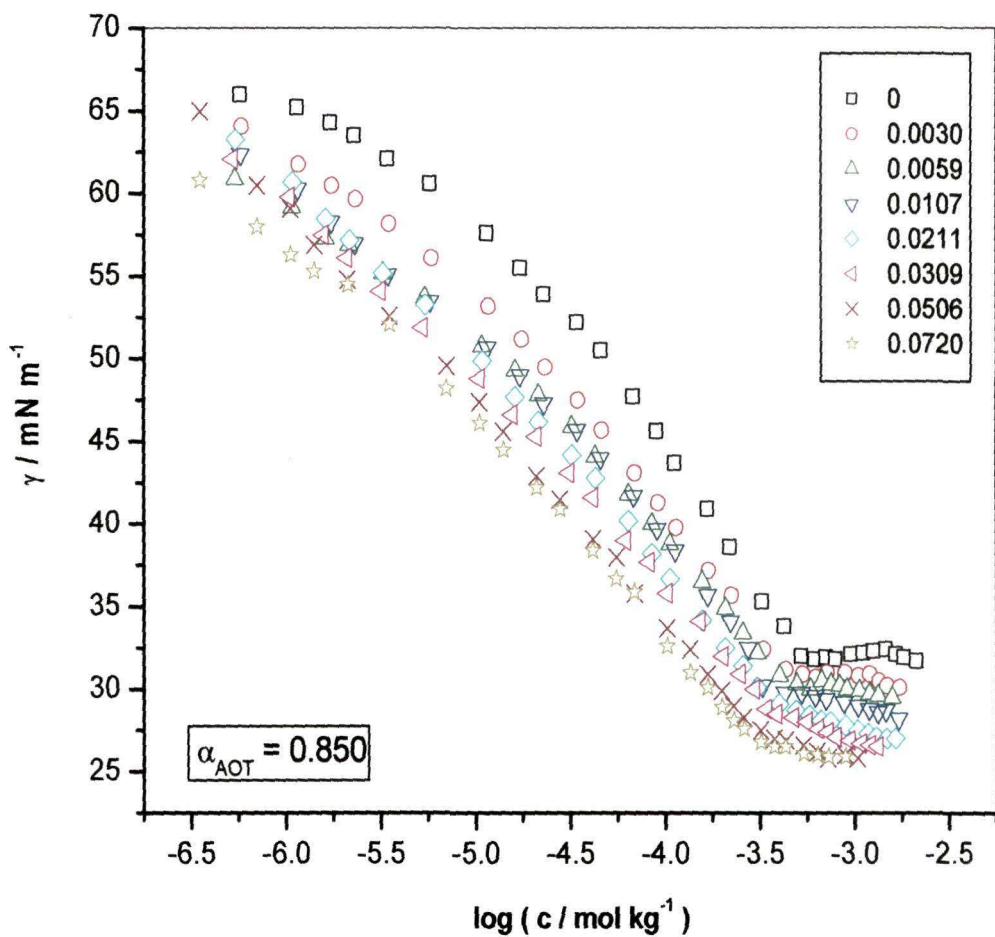


Figure 5.9f - Variation of surface tension with logarithm of total surfactant concentration for AOT + TX-100 system with $\alpha_{\text{AOT}} = 0.850$ in aqueous sodium chloride solutions. Sodium chloride concentrations in mol kg^{-1} are given in the inset.

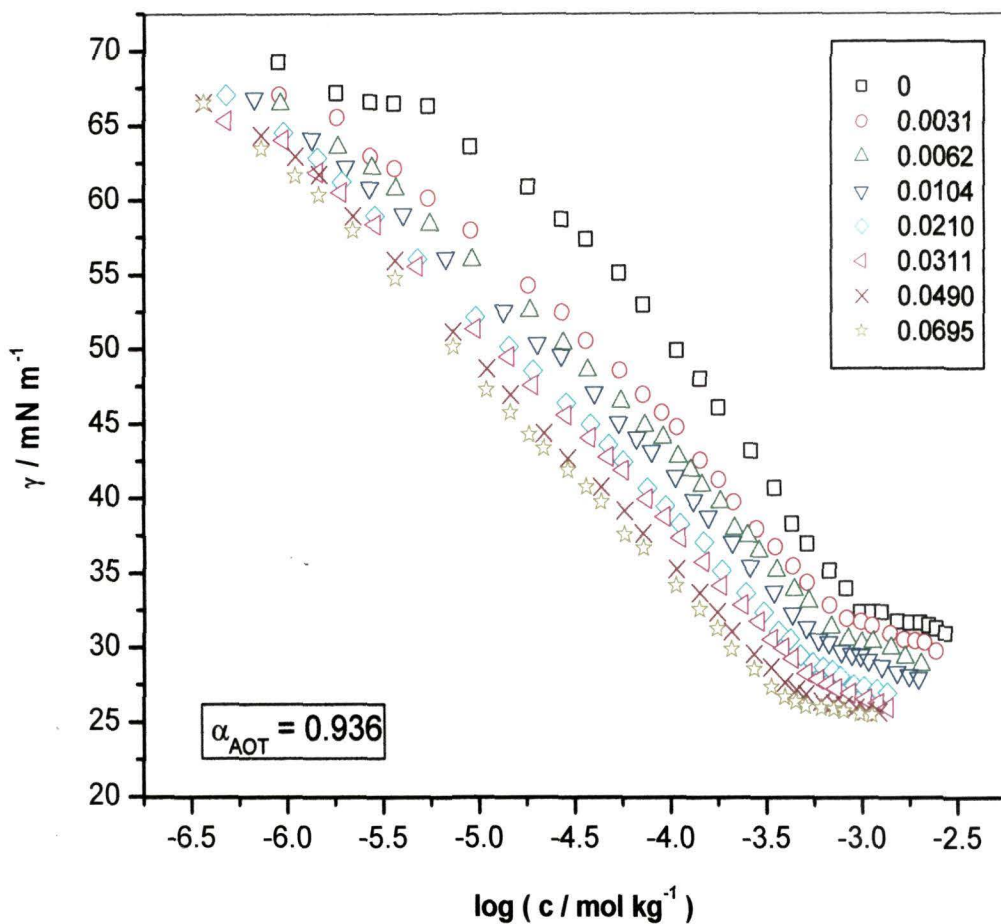


Figure 5.9g - Variation of surface tension with logarithm of total surfactant concentration for AOT + TX-100 system with $\alpha_{\text{AOT}} = 0.936$ in aqueous sodium chloride solutions. Sodium chloride concentrations in mol kg^{-1} are given in the inset.

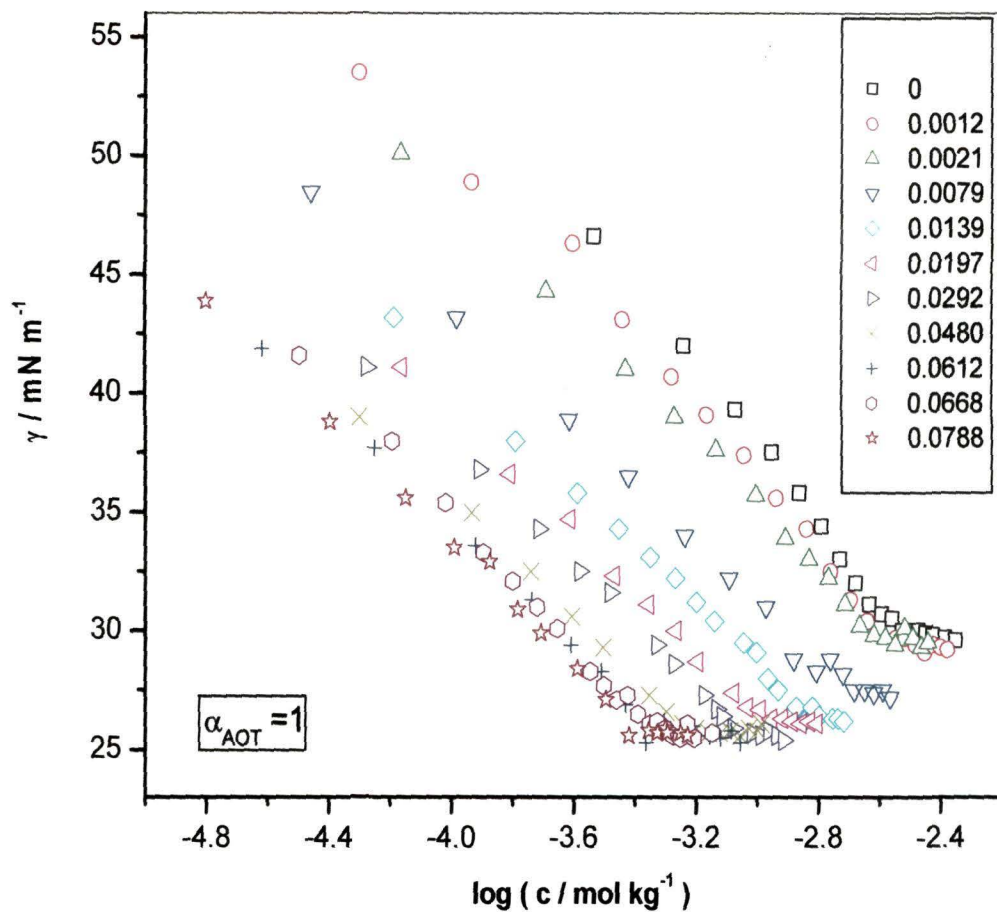


Figure 5.9h - Variation of surface tension with logarithm of total surfactant concentration for pure AOT in aqueous sodium chloride solutions. Sodium chloride concentrations in mol kg⁻¹ are given in the inset.

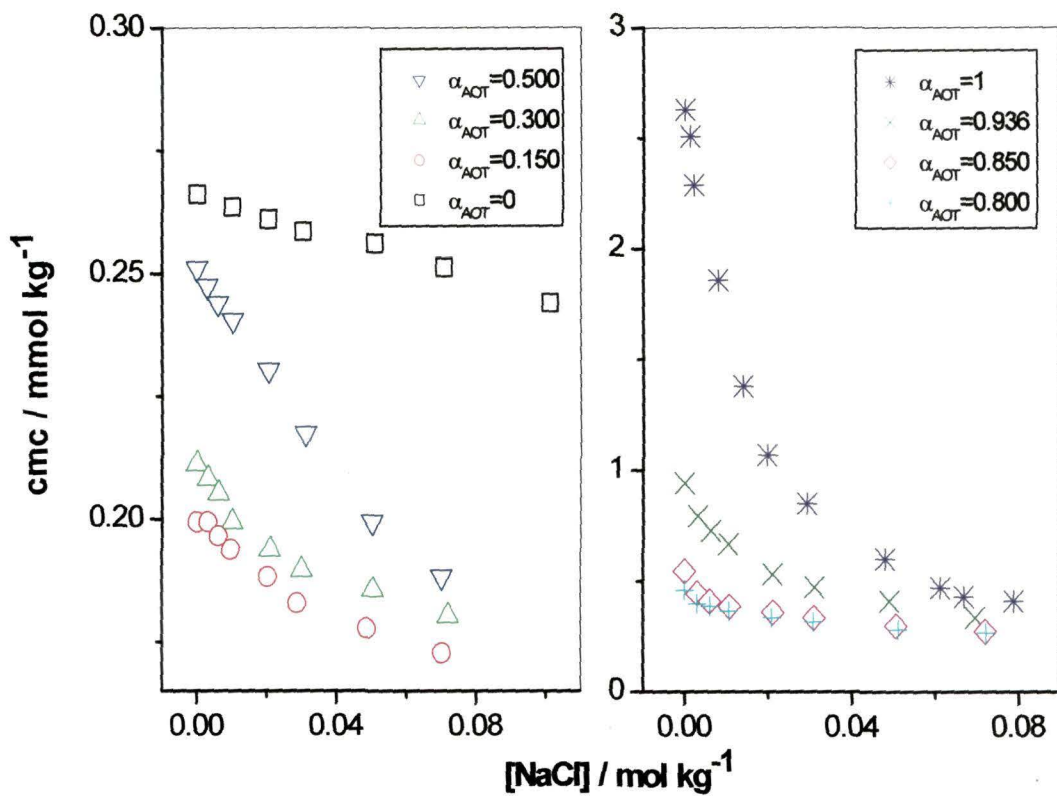


Figure 5.10 - Variation of critical micelle concentration of AOT + TX-100 mixed system with NaCl concentration.

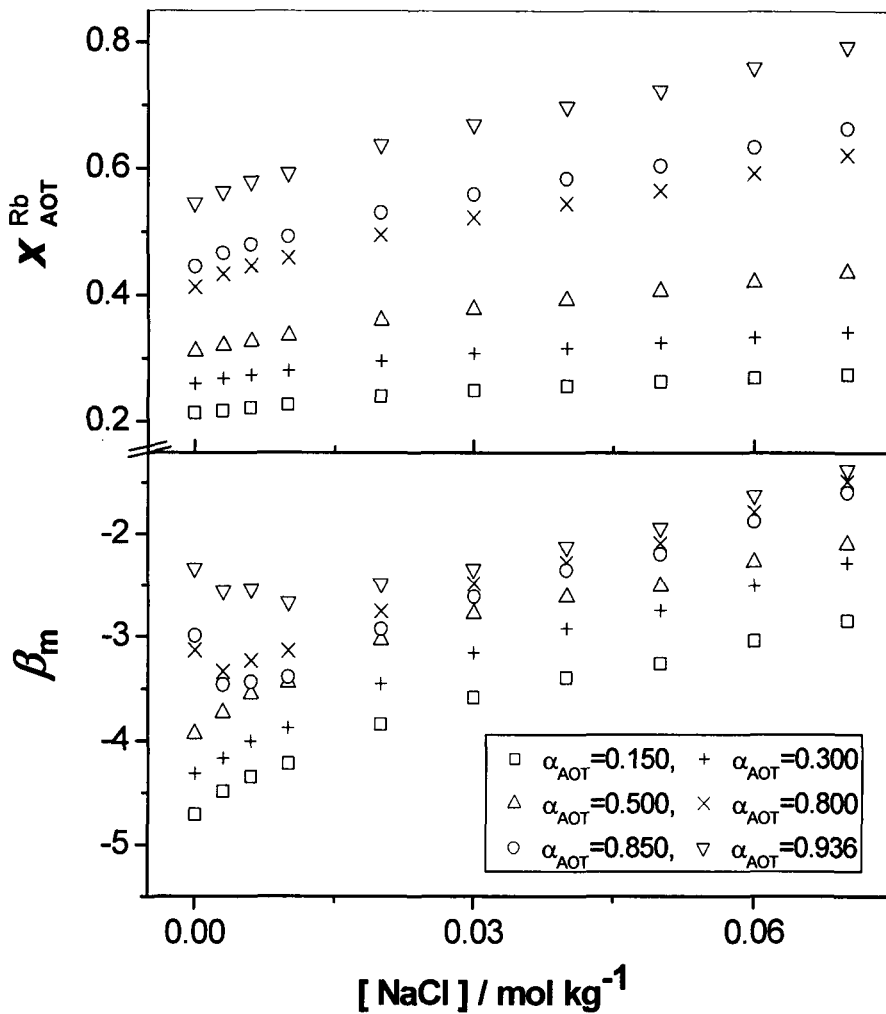


Figure 5.11 - Variation of composition of AOT (x_{AOT}) and interaction parameter (β_m) in the mixed micelle from Rubingh's Model for AOT + TX-100 systems as a function of sodium chloride concentration.

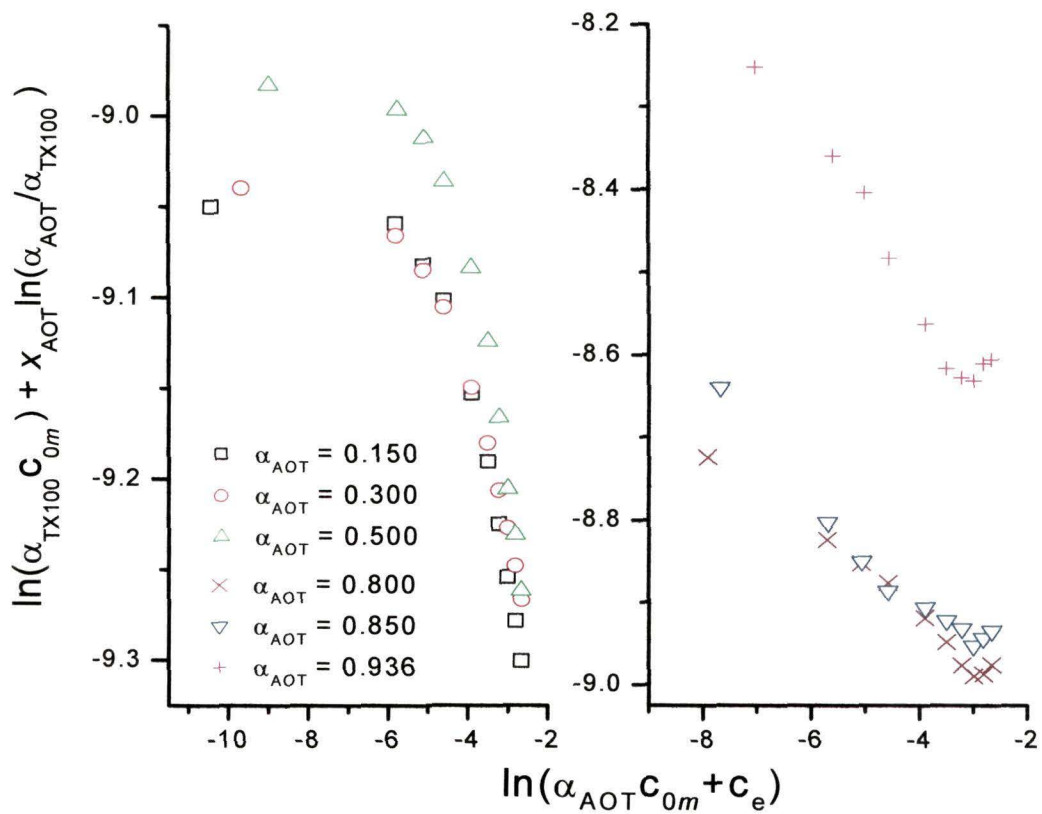


Figure 5.12 – Plots of modified Corrin – Harkins Eq. (5.3) for AOT + TX-100 mixed system.

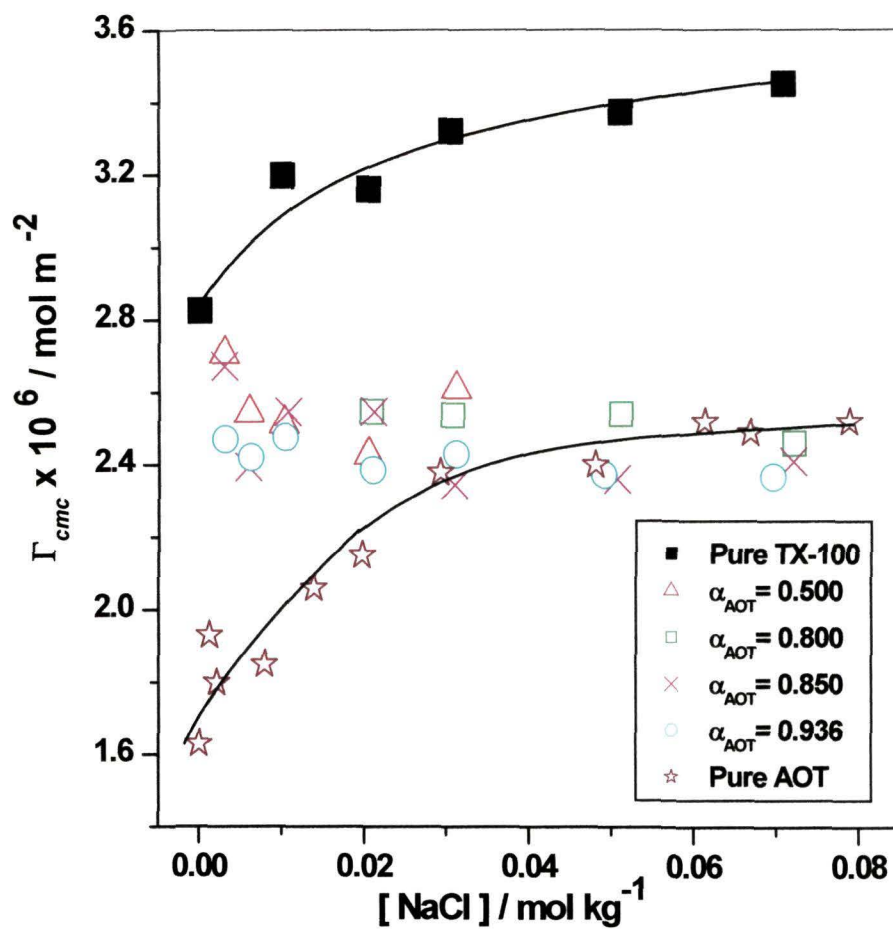


Figure 5.13 - Variation of surface excess for AOT + TX-100 systems as a function of sodium chloride concentration.

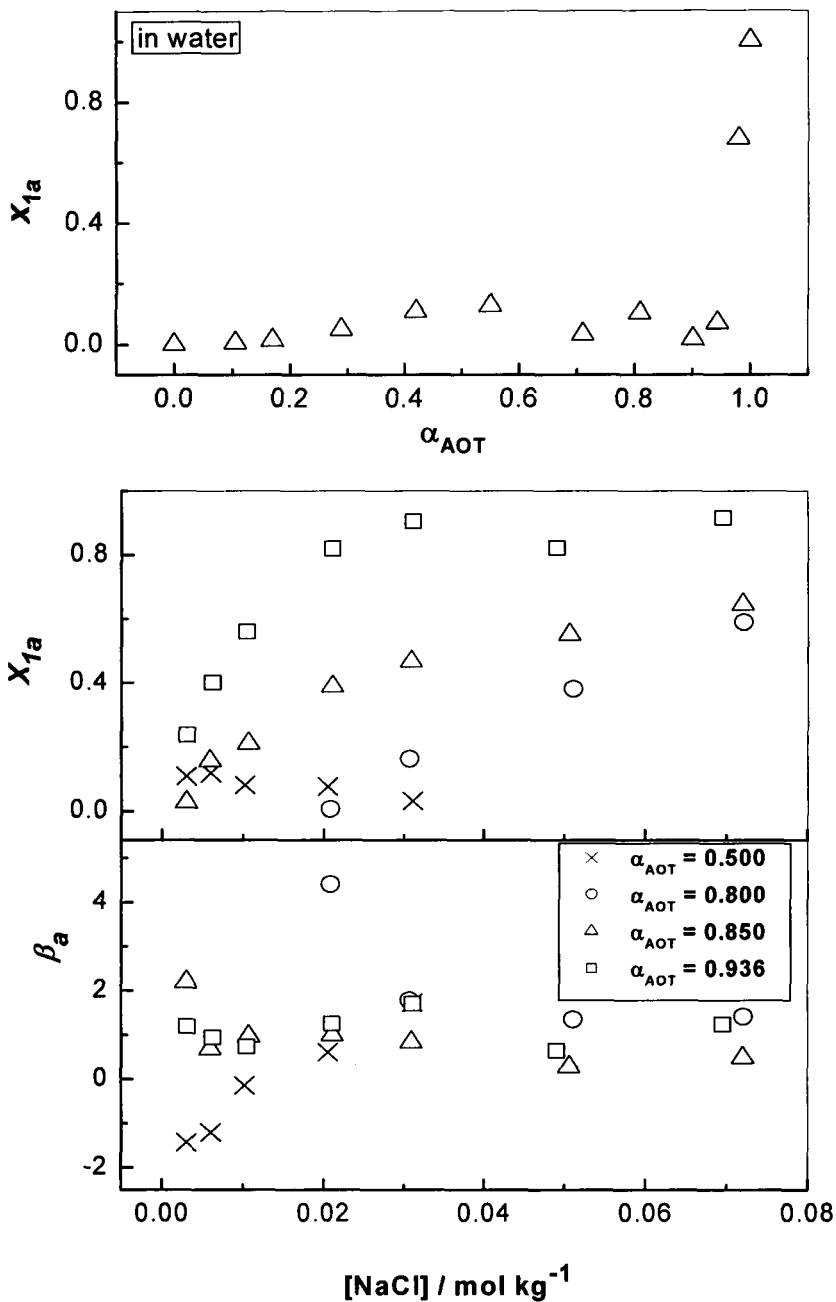


Figure 5.14 - Variation of mole fraction of AOT in the adsorbed layer with (i) α_{AOT} in water (upper layer), (ii) NaCl concentration at fixed α_{AOT} (values given in inset; middle layer) and (iii) variation of interaction parameter in the adsorbed layer with NaCl concentration at fixed α_{AOT} (values given in inset; bottom layer)

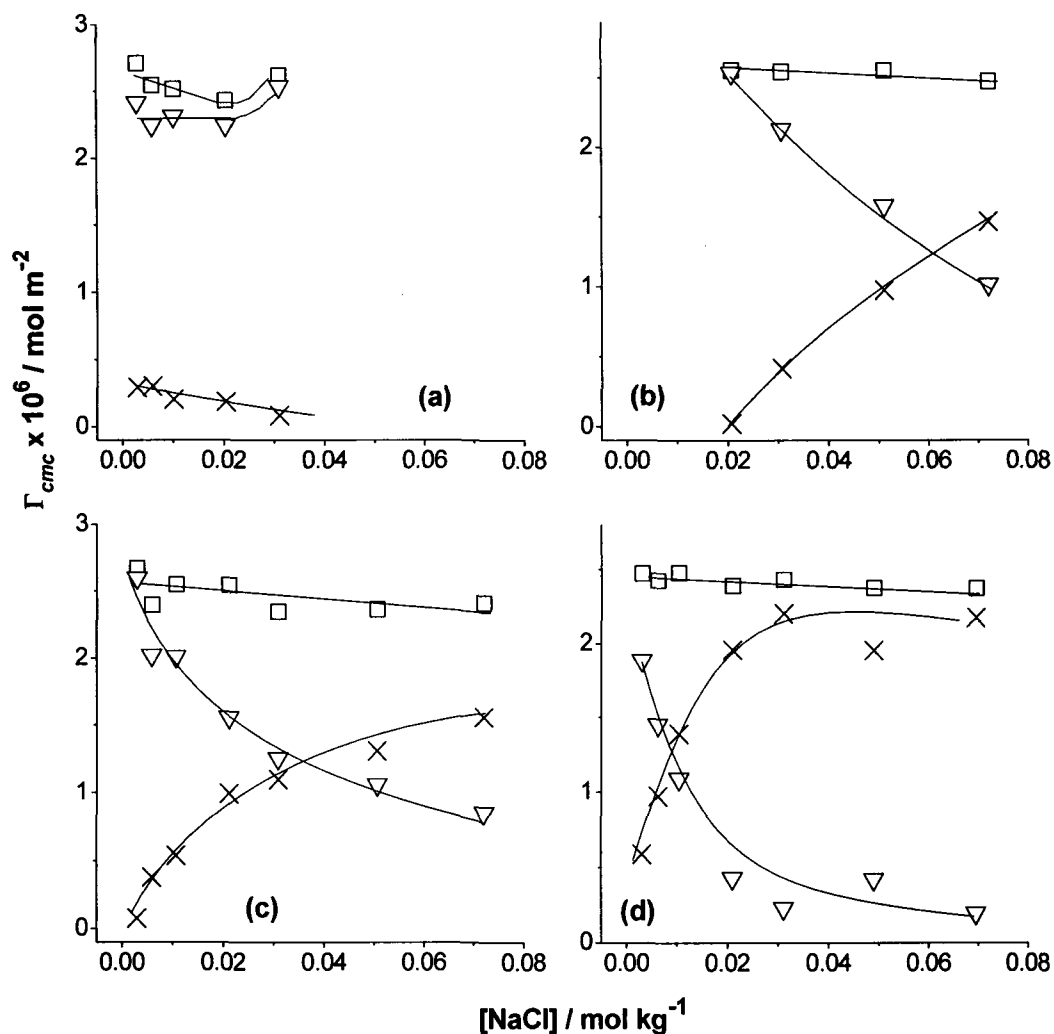


Figure 5.15 - Variation of surface excess of the AOT + TX-100 mixture (open square) and that of the components AOT (cross) and TX-100 (open inverted triangle) with NaCl concentration. (a) $\alpha_{\text{AOT}} = 0.500$ (b) $\alpha_{\text{AOT}} = 0.800$ (c) $\alpha_{\text{AOT}} = 0.850$ (d) $\alpha_{\text{AOT}} = 0.936$.

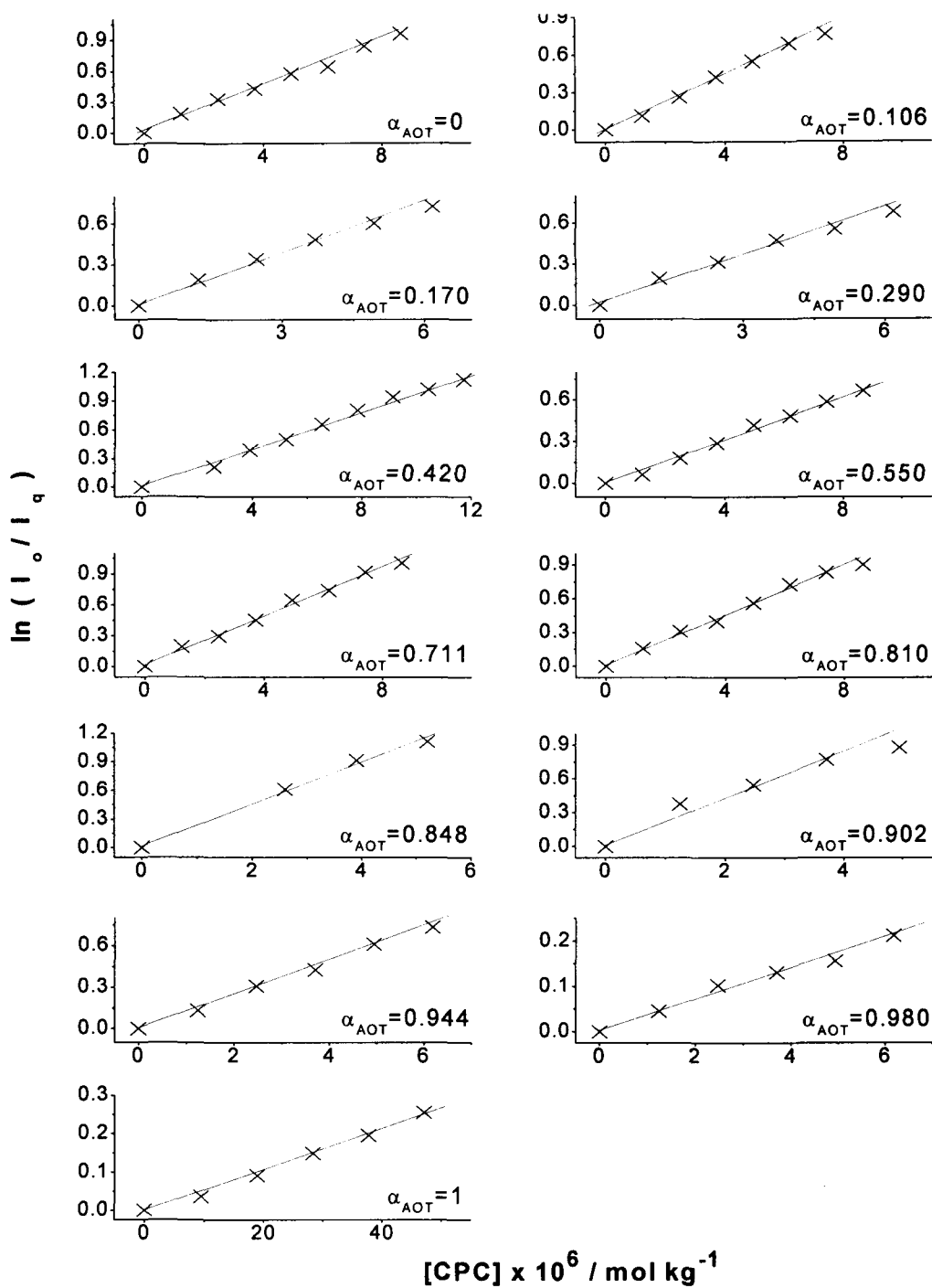


Figure 5.16 - Variation of $\ln[I_0/I_q]$ of pyrene at 373 nm with the concentration of the quencher in AOT + TX-100 systems in water. Composition of AOT in the bulk solution is given in the inset. $c \approx 2$ cmc.

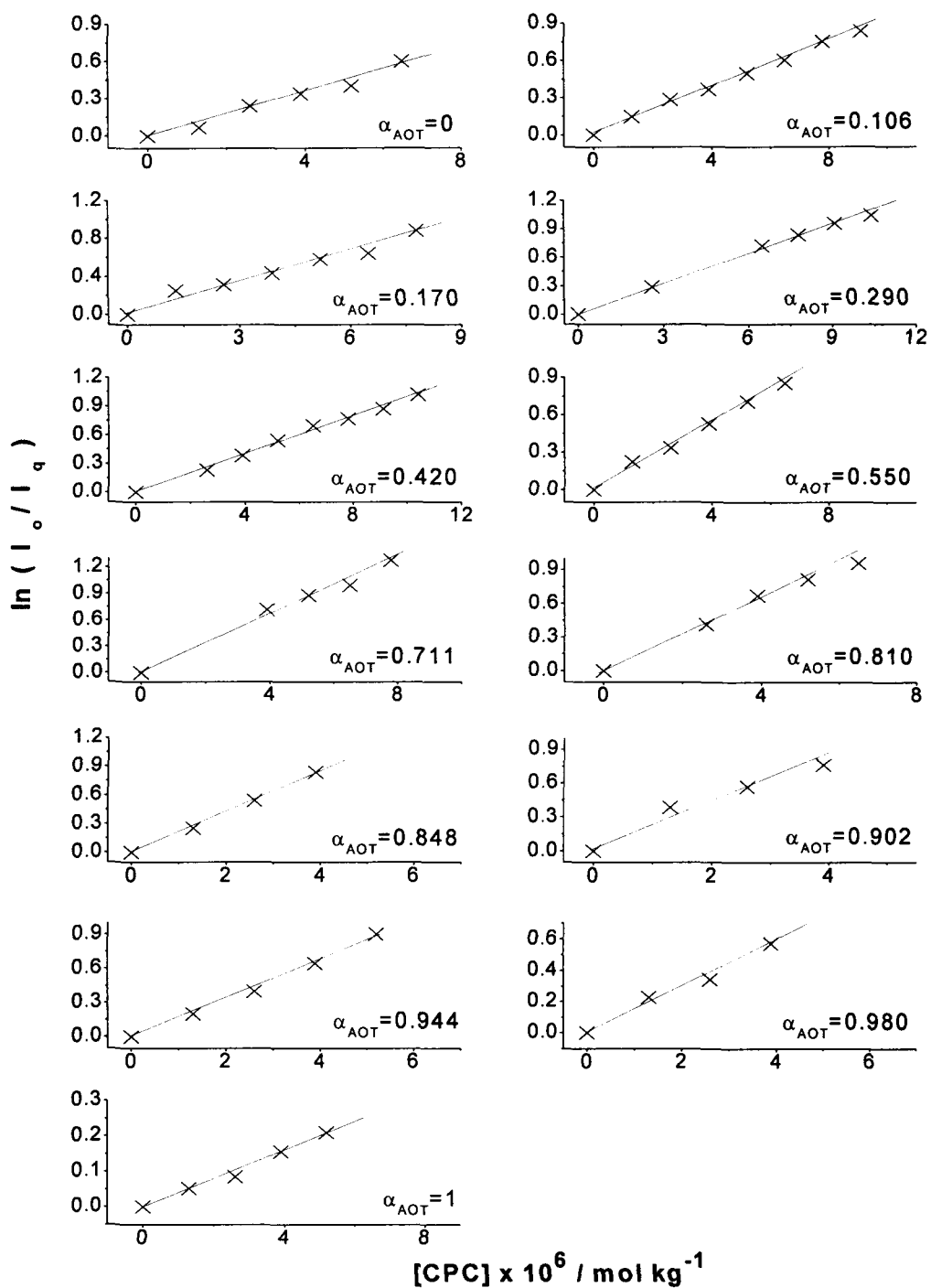


Figure 5.17 - Variation of $\ln[I_0/I_q]$ of pyrene at 373 nm with the concentration of the quencher in AOT + TX-100 systems in water. Composition of AOT in the bulk solution is given in the inset. $c - \text{cmc} \approx 0.0004 \text{ mol kg}^{-1}$.

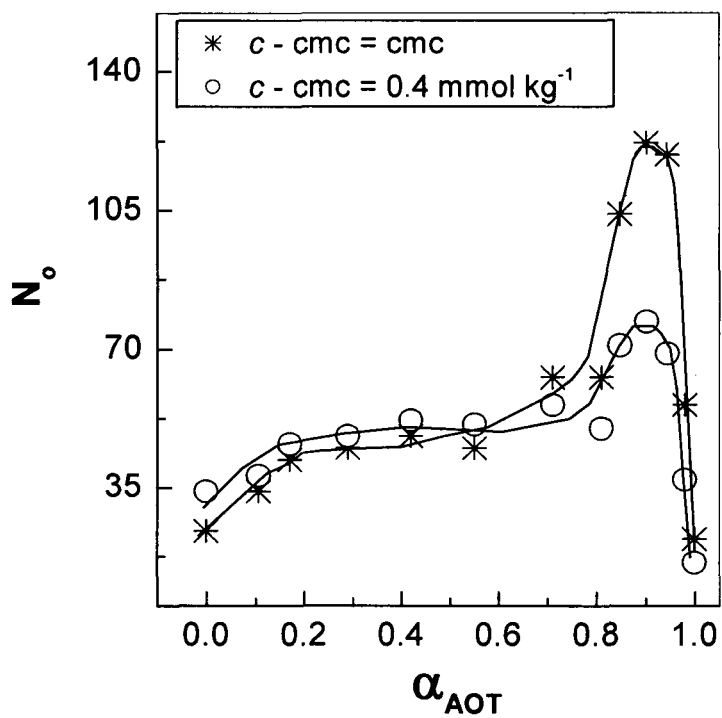


Figure 5.18 - Variation of aggregation number (N_0) of AOT + TX-100 mixed micelle with mole fraction of AOT (α_{AOT}) in water.

CHAPTER 6

Micellization and adsorption behaviours of mixtures of sodium dioctylsulfosuccinate and cetyltrimethylammonium bromide in water + formamide media

6.1 Introduction

In the preceding chapters, micellization and adsorption behaviours of AOT + SDS (AOT – anionic surfactant) and AOT + TX-100 (AOT – nonionic surfactant) mixed systems in aqueous medium in the absence and presence of NaCl have been studied. In this chapter our objective was to carry out a similar study with an AOT – cationic surfactant mixture and for this purpose we chose AOT + cetyltrimethylammonium bromide (CTAB) combination. In anionic – cationic surfactant mixture, unlike in anionic – anionic and anionic – nonionic surfactant mixtures, strong electrostatic attraction operates often leading to the formation of precipitate or coacervate. Some of the anionic – cationic surfactant mixtures studied in water medium by different authors are sodium cholate (NaC) + alkyltrimethylammonium bromide (C_n TAB; $n = 10, 12, 14, 16$ and 18),¹ NaC + cetyltrimethylammonium-*p*-toluene sulfonate (CTAT),² NaC + cetylpyridinium chloride (CPC),² sodium deoxycholate (NaDC) + CTAT,² NaDC + CPC,² sodium dioctylsulfosuccinate (AOT) + cetyltrimethylammonium bromide (CTAB),³ sodium oleate + CTAB,⁴ CTAB + different bile salts,⁵ sodium dodecylsulfate (SDS) + different bile salts,⁵ C_n TAB + sodium alkylsulfonate (C_n SO₃Na),⁶ SDS + dodecyltrimethylammonium bromide (DTAB),⁷ cetyltrimethylammonium halide + different bile salts⁸ and SDS + CPC.⁹ Formation of precipitate or coacervate posed difficulty in studying these mixtures of anionic and cationic surfactants. This problem is, however, reported^{1,6} to be absent in some of the combinations of surfactants; for e.g., mixtures of C_n TAB with bile salts and C_n SO₃Na. In view of these inherent problems of precipitation/coacervation, we thought of studying the

AOT + CTAB mixtures in a mixed solvent medium and here we chose water + formamide (FA) media. It may be mentioned that hardly any study on mixed surfactants in mixed solvent media has been reported and to the best of our knowledge only one report is available.¹⁰ Therefore in this chapter, we present the results of study made on AOT + CTAB mixed system in water + FA (10%, 20%, 30%, 40%, 60% and 80% FA) media at 25 °C. However, in this media also AOT + CTAB system formed precipitate in the region where mole fraction of AOT in the bulk solution (α_1) is between 0.45 and 0.774. In water we could not study this mixed system at 25 °C due to same precipitation or turbidity problem, although Zheng et al. studied this system at temperatures ≥ 50 °C. Even at 50 °C Zheng et al.³ reported precipitation in this system in the region of $0.3 < \alpha_1 < 0.7$.

6.2 Experimental Procedures

AOT (Sigma, 99% assay), CTAB (Sigma, 99% assay), formamide (Fluka, 99.5 assay), pyrene (Fluka, 99% assay) and cetylpyridinium chloride (CPC; Fluka, 98% assay) were used as received. All solutions were prepared in Millipore water and measurements were made under thermostated condition at 25 °C. Solution containing a mixture of AOT (surfactant 1) and CTAB (surfactant 2) of a particular composition was prepared by mixing required amounts of the solutions of pure surfactants in mixed solvent of water and FA of a particular weight % of FA.

Surface tension measurements were made by the Wilhelmy plate method using Krüss K11 tensiometer. Conductance measurements were made using Wayne Kerr B905 Automatic Precision Bridge. Fluorescence emission

measurements of pyrene probe were made using Hitachi F4500 model Fluorescence Spectrophotometer. The excitation of pyrene was done at 335 nm and the fluorescence emission was recorded in the range of 360 – 420 nm. CPC was used as quencher.

6.3 Results and Discussion

The measured surface tension (γ) values of AOT + CTAB mixed systems in water + FA mixed solvent media are tabulated in Tables 6.1 – 6.6 and the surface tension isotherms are shown in Figs. 6.1- 6.6. The surface tension plots of the mixed systems lie below those of the individual surfactants, which indicate much higher surface activity of the mixed systems. Pure CTAB has no surface tension minimum in 10 % FA, but starts exhibiting surface tension minimum when the amount of FA in the medium exceeds 20 %. Probably formation of pre-micellar aggregates is responsible for the occurrence of such surface tension minimum. Due to these minima it was difficult to locate the cmc of pure CTAB in media containing more than 20 % FA and therefore to ascertain the cmc values of pure CTAB in water + FA media we measured the conductance. Experimental values of conductance are listed in Table 6.7 and the plots of conductance of pure CTAB in water + FA media are shown in Fig. 6.7. In 10 % FA, we also measured the fluorescence emission of pyrene and the values of I_1/I_3 ratio are given in Table 6.8. I_1 and I_3 denote the intensities of fluorescence emission of pyrene corresponding to 373 and 384 nm, respectively. Plots of I_1/I_3 ratio versus total surfactant concentration in 10% FA are shown in Fig. 6.8.

6.3.1 Cmc of mixed surfactants

The values of cmc of the mixed surfactants (c_{0m}) in water + FA media determined from the different methods are given in Table 6.9. Relation between c_{0m} and the cmc's of AOT (c_{01}) and CTAB (c_{02}) is of the form^{11,12}

$$\frac{1}{c_{0m}} = \sum_i \frac{\alpha_i}{f_i c_{0i}} \quad (6.1)$$

$$f_i = \frac{\alpha_i c_{0m}}{x_i c_{0i}} \quad (6.2)$$

In Eqs. (6.1) and (6.2), x_i and f_i refer to mole fraction and activity coefficient of AOT ($i = 1$) or CTAB ($i = 2$) in the mixed micelle, respectively. When the mixed micelle is assumed to behave ideally ($f_i = 1$), Eq. (6.1) reduces to the Clint's equation.¹³ The ideal cmc values calculated from the Clint's equation are listed in Table 6.9. A representative plot of the experimental and ideal cmc values of the mixed system in 10 % FA medium is shown in Fig. 6.9. From Table 6.9 and Fig. 6.9 it is clear that the experimental values of cmc (c_{0m}) of AOT + CTAB mixed system are much less than the ideal cmc values thereby indicating synergism in cmc to a large extent.

6.3.2 Mixed micelle composition from Rubingh's method

In this method,^{11,12} the relation between the interaction parameter (β_m) responsible for non-ideality and the activity coefficient is given by

$$\beta_m = \frac{\ln f_1}{(1 - x_1)^2} = \ln \frac{f_2}{x_1^2} \quad (6.3)$$

At c_{0m} , after substituting for the activity coefficients in Eq. (6.3), we get the expression

$$x_1^2 \ln \frac{\alpha_1 c_{0m}}{x_1 c_{01}} = (1 - x_1)^2 \ln \frac{(1 - \alpha_1) c_{0m}}{(1 - x_1) c_{02}} \quad (6.4)$$

Values of x_1 as a function of α_1 were computed from Eq. (6.4) by using an iterative method, which are listed in Table 6.10 as x_1^{Rb} . An expression for x_1 was also derived from Eq. (6.2) under the condition of ideality and it is of the form

$$x_1 = \frac{\alpha_1 c_{02}}{\alpha_1 c_{02} + \alpha_2 c_{01}} \quad (6.5)$$

The values of x_1 calculated from Eq. (6.5) are given in Table 6.10 as x_1^{id} . The variation of x_1^{Rb} and x_1^{id} with α_1 ($=\alpha_{AOT}$) is shown in Fig. 6.10. It is observed (Fig. 6.10) that $x_1^{Rb} > x_1^{id}$ in the region where $\alpha_1 < \sim 0.7$ and $x_1^{Rb} < x_1^{id}$ in the region where $\alpha_1 > 0.7$ in water + FA media. From Fig. 6.11, it is interesting to see that as the FA content of the medium increases the amount of AOT in the mixed micelle shows a decreasing trend if $\alpha_{AOT} < 0.5$, but an increasing trend if $\alpha_{AOT} > 0.5$. This implies that the solvophobicity of AOT and CTAB towards the water + FA solvent is dependent on the relative amount of the two surfactants in the bulk medium thereby indicating that competitive solvophobicity operates in this mixed surfactant + mixed solvent system. Moreover, it is found that $x_{AOT} < \alpha_{AOT}$ when $\alpha_{AOT} > 0.5$ irrespective of the FA content of the medium.

The values of the interaction parameter β_m were determined using Eq. (6.3) and are presented in Table 6.10. Large negative values for β_m indicate strong attractive interaction between the two surfactants, which is a characteristic of anionic – cationic mixed systems and are due to the oppositely charged head groups. In a medium of fixed weight % of FA, β_m has negligible dependence on the bulk composition of the surfactants. On the other hand, the value of β_m becomes less negative with increasing weight % of FA in the medium indicating a

decrease in the attractive interaction between AOT and CTAB which must be due to the increase in the dielectric constant of the solvent medium (with addition of FA dielectric constant of the medium increases).

6.3.3 Mixed micelle composition from RVV method

According to this method¹⁴ the equation for x_1 is of the form

$$x_1 = \alpha_1 - \alpha_1(1 - \alpha_1) \left(\frac{d \ln c_{0m}}{d \alpha_1} \right) \quad (6.6)$$

For computing the values of x_1 from Eq. (6.6), we determined the value of the slope, $d \ln c_{0m} / d \alpha_1$, by least-squares fitting the $\ln c_{0m}$ versus α_1 data to a polynomial. The values of x_1 calculated from Eq. (6.6) are presented in Table 6.10 as x_1^{Rd} and in Fig. 6.13 as x_{AOT} . The trends in the variation of x_1^{Rd} with α_{AOT} and with weight % of FA are almost similar to those of x_1^{Rb} .

6.3.4 Adsorption parameters

Using the Gibbs adsorption isotherm,¹⁵ it can be shown for a mixture of 1:1 anionic and cationic surfactants in absence of added electrolyte that (ca. chapter 1)

$$d\gamma = -2RT\Gamma(d \ln c + x_{1a} d \ln \alpha_1 + x_{2a} d \ln \alpha_2) \quad (6.8)$$

where Γ is the surface excess of the mixed surfactant system. $x_{ia} = \Gamma_i / \Gamma$ is the mole fraction of surfactant 1 ($i = 1$) or 2 ($i = 2$) in the adsorbed layer. In the case of a mixed ionic surfactant system having a particular composition (constant α_i), Eq. (6.8) becomes $d\gamma = -2RT\Gamma d \ln c$. Accordingly, surface excess at the cmc for the mixture (Γ_{mix}) and the minimum surface area per mole of the surfactant mixture ($A_{min} = 1/[N_A \Gamma_{mix}]$, where N_A is the Avogadro number) were calculated.¹⁵ The values of Γ_{mix} and A_{min} are given Table 6.11. The values of surface excess of

the components, Γ_{AOT} and Γ_{CTAB} , were estimated from the values of Γ_{mix} by using mole fraction values (x_{ia}) of the individual surfactants in the adsorbed layer (evaluation of x_{ia} is discussed below). The trends in the variation of Γ_{mix} , Γ_{AOT} and Γ_{CTAB} with α_{AOT} are shown in Fig. 6.14. Both Γ_{mix} and Γ_{CTAB} values decrease with increase in α_{AOT} while Γ_{AOT} remain constant. This indicates that addition of AOT to CTAB lowers the surface excess of CTAB but addition of CTAB to AOT has no effect on the surface excess of AOT. By applying the approach of Rosen and Hua,¹⁶ values of activity coefficient (f_{ia}), interaction parameter (β_a) and mole fraction (x_{ia}) of a surfactant in the adsorbed layer of mixed surfactants were evaluated and are presented in Table 6.11 (for these calculation, solutions having constant surface tension equal to 40 mN m⁻¹ are taken as reference). The ideal values of A_{min} calculated from the expression $A_{min}^{id} = x_{1a}A_{1min} + x_{2a}A_{2min}$ are also presented in Table 6.11 (Fig. 6.15). A_{1min} and A_{2min} represent the A_{min} values for surfactants 1 (AOT) and 2 (CTAB), respectively. From the plots shown in Fig. 6.15 it is observed that $A_{min} < A_{min}^{id}$ when weight % of FA < 40 and $A_{min} > A_{min}^{id}$ when weight % of FA > 50. The variations of x_{1a} and β_a with weight fraction of FA are shown in Figs. 6.16 and 6.17, respectively. The value of x_{1a} decreases when the amount of FA in the medium increases up to 60 %, whereas β_a becomes less negative (weakening of attractive interaction) as the amount of FA in the medium increases. For both β_m and β_a , their values and the dependence on the amount of FA are almost same. Therefore, the interactions between AOT and CTAB are of similar type both at air – water interface and micellar phase.

6.3.5 Aggregation number

Aggregation number (N_0) of the mixed surfactant system in 10% FA was determined by measuring fluorescence emission of pyrene in the absence and presence of the quencher CPC and using the reported¹⁷ expressions (*ca.* chapter 5). The variation of $\ln(I_0/I_q)$ with quencher concentration (Table 6.12) is shown in Fig. 6.18. The measured values of N_0 are presented in Fig. 6.19. The number of molecules of AOT (n_{AOT}) and CTAB (n_{CTAB}) in the mixed micelle was estimated from the values of N_0 by using the mole fraction values of the individual surfactants in the mixed micelle (Table 6.13). It can be seen that N_0 increases on adding AOT to CTAB (the slight initial decrease up to $\alpha_{AOT} \approx 0.1$ is ignored) and also by the addition of CTAB to AOT. The increase in N_0 by the addition of CTAB to AOT is steeper. This trend is similar to the trend reported³ for this mixture in water at high temperatures (≥ 50 °C).

6.4 Conclusions

The cmc values of AOT + CTAB mixed systems in water + FA media are much less than the ideal cmc values indicating synergism to a large extent. Both β_m and β_a have very large negative values showing strong attractive interaction in the mixed micelle and the adsorbed layer. The interactions between AOT and CTAB are of similar type both at air – water interface and micellar phase. The values of β_m and β_a become less negative with increasing weight % of FA in the medium indicating a decrease in the attractive interaction between AOT and CTAB and this is attributable to the increase in the dielectric constant of the solvent medium (with addition of FA dielectric constant of the medium increases). The solvophobicity of AOT and CTAB towards the water + FA

solvent is dependent on the relative amounts of the two surfactants in the bulk medium thereby indicating that competitive solvophobicity operates in this mixed surfactant + mixed solvent system. Aggregation number of the mixture increases on adding AOT to CTAB and also by the addition of CTAB to AOT, which is similar to the trend reported for this system in water at 50 °C.

6.5 References

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Table 6.1 - Surface Tension (γ) Values of AOT + CTAB Systems in 10% FA at 298 K

$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
$\alpha_{\text{AOT}} = 0$					
0.0051	69.5	0.2518	55.8	1.3673	37.5
0.0101	68.1	0.3018	54.6	1.5544	37.6
0.0203	66.5	0.4012	51.6	1.9227	37.4
0.0304	64.6	0.5002	49.2	2.2835	37.6
0.0506	64.0	0.5986	47.2	2.6370	37.5
0.1011	61.2	0.7939	43.1	2.9833	37.6
0.1515	59.3	0.9870	40.1		
0.2017	58.0	1.1782	37.8		
$\alpha_{\text{AOT}} = 0.124$					
0.0007	63.7	0.0061	37.9	0.0121	32.0
0.0013	54.3	0.0067	36.9	0.0134	32.2
0.0020	49.8	0.0074	36.1	0.0148	32.0
0.0027	47.9	0.0081	34.6	0.0161	31.7
0.0034	44.8	0.0087	34.0	0.0175	31.7
0.0040	42.9	0.0094	32.7	0.0188	31.5
0.0047	41.1	0.0101	32.4		
0.0054	40.2	0.0108	31.8		
$\alpha_{\text{AOT}} = 0.270$					
0.0002	67.1	0.0022	46.9	0.0070	33.3
0.0004	62.3	0.0026	44.0	0.0078	33.5
0.0007	58.3	0.0031	42.5	0.0087	32.8
0.0009	56.1	0.0035	41.7	0.0096	32.5
0.0011	53.4	0.0039	40.2	0.0113	32.4
0.0013	52.1	0.0044	39.0	0.0130	32.0
0.0015	50.6	0.0052	37.1	0.0147	31.6
0.0017	49.5	0.0061	35.5	0.0181	31.3
$\alpha_{\text{AOT}} = 0.450$					
0.0003	67.3	0.0032	43.2	0.0094	31.0
0.0005	62.5	0.0037	41.3	0.0105	29.6
0.0008	58.9	0.0042	39.6	0.0126	28.8
0.0011	56.8	0.0047	39.0	0.0147	28.9

Table 6.1 - Continued

$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
$\alpha_{AOT} = 0.450$					
0.0013	54.2	0.0053	37.0	0.0167	28.7
0.0016	53.2	0.0063	35.1	0.0188	28.5
0.0021	49.2	0.0074	33.0	0.0240	28.7
0.0026	46.4	0.0084	31.9	0.0291	28.6
$\alpha_{AOT} = 0.774$					
0.0002	70.2	0.0026	44.9	0.0086	32.7
0.0004	65.0	0.0030	43.2	0.0094	32.6
0.0006	60.0	0.0034	41.3	0.0103	32.5
0.0009	56.4	0.0043	39.7	0.0111	32.4
0.0011	53.4	0.0051	36.5	0.0128	32.1
0.0013	51.5	0.0060	35.0	0.0145	31.6
0.0017	48.0	0.0069	33.9	0.0162	31.2
0.0021	46.5	0.0077	32.8		
$\alpha_{AOT} = 0.849$					
0.0002	69.8	0.0026	48.0	0.0144	32.3
0.0004	65.9	0.0033	45.5	0.0162	31.4
0.0006	61.6	0.0041	43.5	0.0180	31.4
0.0007	59.5	0.0048	41.2	0.0198	31.3
0.0009	56.8	0.0056	39.7	0.0216	31.2
0.0011	56.2	0.0067	37.9	0.0253	31.1
0.0013	53.7	0.0078	36.7	0.0289	31.0
0.0015	52.3	0.0089	35.8	0.0360	30.8
0.0019	50.7	0.0107	34.2		
0.0022	49.7	0.0125	33.1		
$\alpha_{AOT} = 0.928$					
0.0004	67.0	0.0049	45.3	0.0183	33.5
0.0007	62.9	0.0056	43.7	0.0211	33.8
0.0011	60.4	0.0071	42.0	0.0246	33.0
0.0014	56.7	0.0085	39.6	0.0280	32.7
0.0018	53.9	0.0099	37.9	0.0315	32.5
0.0021	52.5	0.0113	37.5	0.0350	32.2

Table 6.1 - Continued

$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
$\alpha_{AOT} = 0.928$					
0.0028	50.9	0.0127	35.8	0.0419	32.0
0.0035	47.9	0.0141	35.0		
0.0042	46.6	0.0155	34.2		
$\alpha_{AOT} = 1.0$					
0.0017	68.5	0.2332	48.4	2.5463	34.5
0.0041	66.5	0.2984	48.0	2.9812	33.8
0.0068	64.9	0.3950	45.6	3.5746	32.6
0.0102	63.5	0.5060	44.1	4.1069	32.2
0.0203	61.1	0.6307	43.2	4.5870	31.8
0.0338	58.8	0.7682	42.3	5.1586	31.6
0.0506	56.8	0.9176	41.3	5.7815	31.3
0.0708	55.3	1.0926	40.3	6.3216	31.1
0.0942	53.8	1.3186	38.6	6.8821	30.9
0.1209	52.5	1.5636	38.0	7.2121	30.8
0.1508	51.4	1.8249	37.0		
0.1839	50.1	2.1967	35.8		

Table 6.2 - Surface Tension (γ) Values of AOT + CTAB Systems in 20% FA at 298 K

$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
$\alpha_{\text{AOT}} = 0$					
0.0079	63.7	0.3157	49.3	2.5883	37.9
0.0159	60.0	0.3942	49.0	2.8792	38.0
0.0238	57.3	0.4724	47.8	3.3104	38.6
0.0317	56.7	0.6283	47.0	3.7356	38.4
0.0476	55.5	0.7835	46.0	4.1549	38.5
0.0634	54.6	0.9379	44.6	4.8411	39.2
0.0950	53.8	1.2445	43.2	5.5117	39.2
0.1267	52.4	1.5482	41.3	6.8086	38.8
0.1582	52.1	1.9982	38.0	8.0496	38.5
0.2371	50.6	2.2947	36.8	9.2382	38.6
$\alpha_{\text{AOT}} = 0.124$					
0.0005	65.2	0.0058	50.2	0.0381	31.9
0.0010	61.7	0.0077	47.9	0.0475	31.5
0.0014	59.4	0.0096	45.8	0.0568	31.0
0.0019	57.4	0.0115	43.7	0.0662	30.5
0.0024	55.7	0.0153	40.5	0.0755	30.0
0.0029	54.4	0.0191	37.9	0.0847	29.9
0.0038	53.2	0.0239	36.2	0.0939	29.8
0.0048	51.8	0.0286	33.8		
$\alpha_{\text{AOT}} = 0.270$					
0.0002	65.2	0.0046	50.5	0.0260	32.6
0.0003	62.4	0.0059	48.1	0.0292	31.6
0.0005	61.8	0.0072	45.3	0.0324	31.6
0.0007	62.1	0.0086	44.2	0.0387	30.4
0.0010	59.9	0.0099	42.5	0.0450	30.2
0.0013	59.0	0.0131	38.7	0.0512	30.0
0.0020	56.1	0.0164	36.2	0.0634	30.0
0.0026	54.3	0.0196	34.7	0.0755	29.8
0.0033	53.4	0.0228	33.5	0.0873	29.4
$\alpha_{\text{AOT}} = 0.450$					
0.0014	57.4	0.0111	35.6	0.0277	28.8
0.0028	50.2	0.0139	33.9	0.0332	28.5

Table 6.2 - Continued

$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
$\alpha_{AOT} = 0.450$					
0.0042	45.7	0.0166	32.4	0.0387	28.4
0.0055	43.0	0.0194	31.2	0.0524	28.3
0.0069	40.3	0.0222	29.0	0.0661	28.1
0.0083	38.4	0.0249	28.9	0.0798	28.0
$\alpha_{AOT} = 0.774$					
0.0002	68.5	0.0045	51.2	0.0313	31.1
0.0003	64.9	0.0057	48.7	0.0374	29.0
0.0005	63.4	0.0070	46.8	0.0434	29.0
0.0006	63.2	0.0083	45.1	0.0553	28.9
0.0010	61.2	0.0095	44.2	0.0671	28.8
0.0013	59.7	0.0127	40.3	0.0786	28.9
0.0019	57.5	0.0158	37.9	0.0899	28.9
0.0026	55.3	0.0189	35.9	0.1011	28.8
0.0032	53.7	0.0251	33.7		
$\alpha_{AOT} = 0.849$					
0.0000	70.4	0.0056	49.9	0.0435	30.3
0.0002	69.0	0.0074	48.1	0.0505	29.7
0.0004	64.6	0.0093	45.9	0.0575	29.3
0.0006	63.4	0.0111	44.0	0.0644	29.1
0.0007	62.6	0.0148	40.8	0.0712	28.9
0.0011	60.5	0.0184	38.5	0.0881	29.2
0.0015	58.8	0.0220	36.6	0.1046	29.0
0.0022	56.4	0.0256	34.8	0.1208	29.0
0.0030	54.6	0.0292	34.1	0.1522	29.1
0.0037	53.0	0.0364	32.3		
$\alpha_{AOT} = 0.928$					
0.0000	70.0	0.0083	49.1	0.0758	30.9
0.0003	64.9	0.0111	46.8	0.0863	30.1
0.0006	63.0	0.0139	45.3	0.1069	30.2
0.0008	61.0	0.0166	43.8	0.1322	30.1
0.0011	60.0	0.0221	40.9	0.1570	30.0
0.0017	57.4	0.0276	38.7	0.1813	30.0

Table 6.2 - Continued

$c \times 10^3 /$ mol kg^{-1}	$\gamma /$ mN m^{-1}	$c \times 10^3 /$ mol kg^{-1}	$\gamma /$ mN m^{-1}	$c \times 10^3 /$ mol kg^{-1}	$\gamma /$ mN m^{-1}
$\alpha_{\text{AOT}} = 0.928$					
0.0022	56.4	0.0331	36.6	0.2284	30.1
0.0033	54.6	0.0439	33.7	0.2737	30.2
0.0045	52.7	0.0546	31.9		
0.0056	51.7	0.0652	31.0		
$\alpha_{\text{AOT}} = 1.0$					
0.0044	65.9	0.6880	44.9	5.9574	32.4
0.0105	63.0	0.9395	43.0	6.5032	32.4
0.0175	61.3	1.2694	41.2	7.0878	32.3
0.0263	59.5	1.6734	39.5	8.1922	32.1
0.0525	56.8	2.1464	38.2	9.7042	31.9
0.0961	54.0	2.6825	37.0	11.901	31.3
0.1571	51.8	3.2024	35.8	13.057	31.0
0.2264	49.7	3.7776	34.5	14.112	31.3
0.3042	48.6	4.3336	33.6	15.079	31.2
0.3902	47.7	4.8714	33.1	15.967	31.1
0.5184	46.3	5.3918	32.7		

Table 6.3 - Surface Tension (γ) Values of AOT + CTAB Systems in 30% FA at 298 K

$c \times 10^3 /$ mol kg^{-1}	$\gamma /$ mN m^{-1}	$c \times 10^3 /$ mol kg^{-1}	$\gamma /$ mN m^{-1}	$c \times 10^3 /$ mol kg^{-1}	$\gamma /$ mN m^{-1}
$\alpha_{\text{AOT}} = 0$					
0.0083	64.7	0.4128	54.0	2.5713	33.8
0.0166	62.8	0.4949	52.8	2.7266	33.7
0.0249	62.2	0.6585	50.6	2.8813	33.8
0.0332	61.2	0.8215	47.6	3.1888	34.0
0.0498	60.2	0.9838	45.6	3.4939	34.1
0.0663	60.0	1.1454	39.9	3.7966	36.2
0.0829	59.6	1.3064	37.2	4.0969	38.0
0.0995	59.7	1.4668	37.8	4.6907	39.1
0.1326	58.9	1.6264	38.0	5.4201	39.7
0.1656	57.7	1.7855	38.2	6.1356	39.3
0.1987	56.9	1.9439	37.6	7.5268	39.7
0.2317	56.6	2.1017	36.2	8.8671	39.9
0.2647	56.2	2.2589	33.8	11.406	39.5
0.3306	55.1	2.4154	33.6	13.772	39.4
$\alpha_{\text{AOT}} = 0.124$					
0.0005	64.4	0.0141	47.7	0.0831	31.1
0.0009	63.0	0.0188	45.2	0.0921	30.7
0.0014	60.9	0.0234	42.6	0.1101	30.2
0.0019	60.4	0.0281	40.7	0.1279	29.7
0.0028	58.5	0.0373	37.2	0.1455	29.5
0.0038	57.1	0.0466	35.3	0.1804	29.8
0.0056	54.3	0.0558	33.1	0.2649	29.4
0.0075	52.8	0.0649	32.2	0.3460	29.3
0.0094	51.1	0.0740	31.6	0.4238	29.2
$\alpha_{\text{AOT}} = 0.270$					
0.0002	66.6	0.0089	48.7	0.0610	30.6
0.0004	65.4	0.0134	44.6	0.0695	30.1
0.0007	64.0	0.0178	41.8	0.0861	29.5
0.0009	63.0	0.0222	39.3	0.1025	29.2
0.0013	61.1	0.0266	37.7	0.1185	29.4
0.0018	60.0	0.0310	36.5	0.1576	28.8
0.0022	58.7	0.0353	35.1	0.1951	29.5

Table 6.3 - Continued

$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
$\alpha_{AOT} = 0.270$					
0.0045	54.4	0.0440	33.4	0.2312	29.3
0.0067	51.2	0.0525	31.9	0.2658	29.0
$\alpha_{AOT} = 0.450$					
0.0003	63.8	0.0080	46.2	0.0525	30.6
0.0005	61.9	0.0107	44.1	0.0628	29.6
0.0008	61.0	0.0133	41.9	0.0729	29.4
0.0011	59.2	0.0160	40.6	0.0830	29.2
0.0016	57.1	0.0213	37.9	0.1029	29.0
0.0021	55.1	0.0265	35.5	0.1273	29.1
0.0032	53.5	0.0318	33.9	0.1513	28.9
0.0043	51.7	0.0370	32.9	0.1978	28.7
0.0054	49.4	0.0422	31.7	0.2425	28.6
$\alpha_{AOT} = 0.774$					
0.0002	64.5	0.0127	45.0	0.0959	28.4
0.0003	64.0	0.0190	42.2	0.1070	28.5
0.0005	62.2	0.0252	39.4	0.1179	28.4
0.0006	61.1	0.0314	37.2	0.1444	28.1
0.0013	59.3	0.0375	35.9	0.1698	28.2
0.0019	57.9	0.0436	34.9	0.1943	28.4
0.0032	55.8	0.0496	33.5	0.2178	28.1
0.0048	53.3	0.0615	32.4	0.2404	27.9
0.0064	51.5	0.0731	31.1		
0.0096	48.3	0.0846	29.1		
$\alpha_{AOT} = 0.849$					
0.0002	62.3	0.0078	49.5	0.0532	32.5
0.0004	61.6	0.0097	47.8	0.0606	31.7
0.0006	60.6	0.0117	46.3	0.0751	30.0
0.0008	60.1	0.0155	44.0	0.0929	28.6
0.0012	58.7	0.0194	41.3	0.1103	28.2
0.0016	57.7	0.0232	39.5	0.1274	28.4
0.0023	55.9	0.0270	38.0	0.1442	28.4

Table 6.3 - Continued

$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
$\alpha_{AOT} = 0.849$					
0.0031	54.9	0.0308	36.8	0.1767	28.0
0.0039	54.0	0.0383	34.8	0.2381	28.1
0.0059	51.7	0.0458	33.6	0.2951	28.0
$\alpha_{AOT} = 0.928$					
0.0004	67.0	0.0118	51.1	0.0771	33.5
0.0008	65.3	0.0157	48.8	0.0921	32.3
0.0012	63.5	0.0196	47.0	0.1071	30.4
0.0016	62.8	0.0235	45.4	0.1219	28.9
0.0024	59.2	0.0312	42.3	0.1511	28.6
0.0031	58.3	0.0389	40.1	0.1799	28.7
0.0047	56.5	0.0466	38.0	0.2083	28.4
0.0063	54.8	0.0543	36.6	0.2499	28.3
0.0079	53.5	0.0619	35.6	0.2907	28.7
$\alpha_{AOT} = 1.0$					
0.0119	63.3	0.9388	45.1	11.452	32.6
0.0284	60.3	1.4013	42.9	13.242	32.2
0.0474	58.4	2.3125	40.8	14.955	32.1
0.0711	56.8	3.4267	38.5	16.598	31.8
0.1420	52.7	4.7285	36.6	19.687	31.5
0.2601	50.8	6.2008	35.1	23.884	31.4
0.4248	48.4	7.8251	34.0	27.633	31.0
0.6358	46.3	9.5823	33.2	32.051	30.7

Table 6.4 - Surface Tension (γ) Values of AOT + CTAB Systems in 40% FA at 298 K

$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
$\alpha_{\text{AOT}} = 0$					
0.0113	65.8	0.8978	42.8	3.2738	29.3
0.0227	64.6	1.0087	36.4	3.4834	29.0
0.0340	64.1	1.1193	35.0	3.8993	28.9
0.0453	63.5	1.2297	33.0	4.3111	29.5
0.0680	62.8	1.3397	31.2	5.3230	29.9
0.0906	62.0	1.5590	31.3	6.3105	31.6
0.1359	60.8	1.7772	33.0	7.2745	37.4
0.1810	59.9	1.9943	33.6	8.2157	39.1
0.2262	59.2	2.2102	34.0	9.1349	39.2
0.3388	57.6	2.4251	33.7	10.033	39.9
0.4512	54.8	2.6389	31.4	11.769	39.7
0.5633	53.2	2.8516	31.0	13.428	39.8
0.6751	50.7	3.0633	31.3	15.015	39.9
$\alpha_{\text{AOT}} = 0.124$					
0.0005	65.7	0.0207	50.3	0.2450	30.4
0.0010	65.5	0.0310	46.2	0.2906	29.8
0.0021	63.6	0.0412	43.6	0.3352	29.4
0.0031	62.7	0.0514	41.8	0.3787	29.8
0.0042	61.2	0.0615	39.8	0.4629	29.7
0.0062	59.3	0.0817	37.3	0.5435	29.5
0.0083	57.2	0.1016	35.9	0.6946	29.4
0.0104	55.6	0.1505	32.7	0.8337	29.5
0.0156	52.6	0.1983	31.1		
$\alpha_{\text{AOT}} = 0.270$					
0.0002	66.7	0.0242	45.9	0.1455	30.8
0.0005	66.5	0.0290	43.9	0.1623	30.5
0.0010	65.5	0.0337	42.6	0.1787	30.4
0.0020	64.1	0.0385	41.3	0.2028	29.8
0.0034	61.3	0.0479	39.4	0.2416	29.5
0.0049	59.4	0.0572	37.9	0.2788	29.4
0.0073	56.2	0.0755	35.1	0.3487	29.4
0.0098	53.6	0.0935	33.4	0.4131	29.4

Table 6.4 - Continued

$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
$\alpha_{AOT} = 0.270$					
0.0146	50.6	0.1112	32.8	0.5282	29.2
0.0194	48.0	0.1285	31.7		
$\alpha_{AOT} = 0.450$					
0.0007	66.5	0.0145	49.5	0.1135	32.4
0.0015	63.9	0.0217	47.4	0.1410	31.1
0.0022	62.5	0.0289	44.5	0.1683	30.0
0.0029	59.4	0.0360	41.2	0.2219	29.5
0.0044	59.2	0.0432	39.4	0.2743	29.6
0.0058	56.6	0.0574	38.2	0.3382	29.0
0.0072	54.8	0.0715	36.4	0.4003	29.0
0.0087	53.6	0.0856	34.7	0.5197	29.0
0.0116	51.7	0.0996	33.5	0.6331	29.0
$\alpha_{AOT} = 0.774$					
0.0002	62.9	0.0274	44.8	0.2107	29.5
0.0003	62.9	0.0341	43.2	0.2362	29.0
0.0007	62.4	0.0473	40.9	0.2843	28.3
0.0010	61.9	0.0603	38.5	0.3291	28.0
0.0017	60.5	0.0730	36.9	0.3707	28.5
0.0035	58.5	0.0918	34.8	0.4097	28.4
0.0052	56.1	0.1101	33.8	0.4802	28.3
0.0069	54.8	0.1279	32.6	0.5569	28.5
0.0104	52.2	0.1452	32.0	0.6233	28.2
0.0138	50.1	0.1622	31.2		
0.0206	47.2	0.1842	30.6		
$\alpha_{AOT} = 0.849$					
0.0002	66.6	0.0196	49.7	0.1787	32.3
0.0004	66.4	0.0235	48.7	0.2103	31.2
0.0008	65.1	0.0312	46.4	0.2406	30.1
0.0016	63.0	0.0388	44.4	0.2699	28.8
0.0024	61.9	0.0576	41.4	0.2980	28.5
0.0040	60.2	0.0760	39.0	0.3514	28.4

Table 6.4 - Continued

$c \times 10^3 /$ mol kg^{-1}	$\gamma /$ mN m^{-1}	$c \times 10^3 /$ mol kg^{-1}	$\gamma /$ mN m^{-1}	$c \times 10^3 /$ mol kg^{-1}	$\gamma /$ mN m^{-1}
$\alpha_{\text{AOT}} = 0.849$					
0.0059	58.1	0.0940	36.9	0.4011	28.3
0.0079	56.1	0.1116	35.7	0.4475	28.3
0.0118	54.2	0.1289	34.7	0.5317	28.1
0.0157	51.7	0.1458	33.5	0.6061	28.2
$\alpha_{\text{AOT}} = 0.928$					
0.0003	66.3	0.0400	47.3	0.3597	29.6
0.0007	66.2	0.0530	44.7	0.4120	28.7
0.0013	65.6	0.0660	43.1	0.4625	28.8
0.0034	63.1	0.0981	39.7	0.5112	28.9
0.0067	59.1	0.1295	37.2	0.6037	28.6
0.0134	55.2	0.1602	35.2	0.6902	28.8
0.0201	52.4	0.1904	33.7	0.7712	28.7
0.0267	50.3	0.2490	32.0	0.9187	28.9
0.0334	48.7	0.3054	30.9		
$\alpha_{\text{AOT}} = 1.0$					
0.0101	60.9	0.7664	46.4	13.073	33.6
0.0223	59.8	1.0069	45.7	14.775	33.3
0.0365	57.8	1.2867	45.0	16.769	33.2
0.0567	55.6	1.6053	44.1	19.030	33.1
0.0810	54.1	2.0018	43.2	21.225	32.8
0.1134	52.1	2.7892	41.9	23.654	32.6
0.1538	50.7	3.9562	40.2	26.292	32.4
0.2024	49.9	5.4868	38.1	29.112	32.1
0.2832	48.8	7.3600	36.6	34.425	31.7
0.4042	48.0	9.5512	35.1	41.670	31.4
0.5654	46.8	11.332	34.0	52.133	30.7

Table 6.5 - Surface Tension (γ) Values of AOT + CTAB Systems in 60% FA at 298 K

$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
$\alpha_{\text{AOT}} = 0$					
0.0087	64.0	0.9410	43.1	2.9999	28.9
0.0173	63.7	1.0254	40.6	3.3196	27.9
0.0346	62.5	1.1097	38.9	3.9509	26.6
0.0519	62.3	1.1938	37.8	4.5720	26.5
0.0692	61.4	1.2777	37.1	5.1832	26.2
0.1037	61.1	1.3614	37.2	6.3766	26.3
0.1382	60.2	1.5284	33.9	7.8161	25.6
0.1727	60.1	1.6116	33.6	10.534	25.6
0.2072	59.5	1.6946	32.3	13.057	26.7
0.2760	59.1	1.7775	33.0	15.404	27.0
0.3447	57.3	1.8602	31.4	17.593	27.9
0.4304	56.8	1.9427	30.9	19.641	32.0
0.5160	55.9	2.0251	31.2	21.559	37.9
0.6013	53.1	2.1893	29.7	25.056	39.5
0.6865	51.2	2.3527	29.1	27.418	40.1
0.7715	48.1	2.5155	29.3	28.612	40.0
0.8563	45.3	2.6777	28.9	38.254	40.1
$\alpha_{\text{AOT}} = 0.124$					
0.0005	64.5	0.1247	48.9	0.8339	33.3
0.0009	64.1	0.1590	47.3	0.9464	32.2
0.0028	64.0	0.1927	45.4	1.0513	31.2
0.0046	63.8	0.2257	44.6	1.1494	30.4
0.0092	63.3	0.2583	43.3	1.2414	30.4
0.0183	60.7	0.3139	41.5	1.3278	29.5
0.0274	58.8	0.3680	40.3	1.4480	29.9
0.0364	57.1	0.4425	38.5	1.6267	29.7
0.0544	54.5	0.5142	37.4	1.7826	29.8
0.0722	52.7	0.5831	36.5	1.9200	29.6
0.0899	50.9	0.7131	34.9		
$\alpha_{\text{AOT}} = 0.270$					
0.0003	64.7	0.1051	47.1	0.7638	31.6
0.0005	64.3	0.1301	45.6	0.8171	31.5

Table 6.5 - Continued

$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
$\alpha_{AOT} = 0.270$					
0.0016	64.2	0.1546	44.2	0.8674	31.1
0.0027	64.1	0.1881	42.9	0.9601	30.6
0.0055	63.3	0.2344	41.2	1.0434	30.0
0.0109	60.6	0.2789	39.9	1.1187	29.7
0.0163	58.5	0.3632	37.8	1.1871	29.5
0.0271	56.1	0.4416	35.8	1.2495	29.6
0.0378	54.2	0.5147	34.8	1.3068	29.5
0.0537	51.5	0.5831	33.7	1.3594	29.5
0.0693	49.4	0.6471	32.9		
0.0848	48.7	0.7072	32.2		
$\alpha_{AOT} = 0.450$					
0.0007	64.4	0.1272	45.1	0.7839	31.2
0.0020	64.1	0.1572	43.5	0.8817	30.7
0.0033	63.9	0.1865	42.2	0.9703	30.1
0.0066	62.7	0.2264	41.1	1.0510	30.0
0.0133	59.5	0.2652	39.9	1.1705	29.4
0.0199	57.1	0.3185	38.3	1.2745	28.9
0.0329	54.3	0.3697	37.1	1.3658	29.0
0.0459	51.9	0.4187	36.3	1.4466	28.9
0.0651	50.0	0.5110	34.3	1.5186	28.9
0.0840	48.4	0.5963	33.2		
0.1027	46.6	0.6754	32.3		
$\alpha_{AOT} = 0.774$					
0.0015	64.1	0.1785	43.4	1.0797	30.3
0.0031	63.7	0.2357	41.5	1.1803	30.0
0.0061	62.9	0.2917	39.5	1.2768	29.2
0.0153	59.6	0.3603	37.8	1.4587	28.8
0.0305	55.8	0.4271	36.7	1.6269	28.5
0.0457	52.9	0.4924	35.6	1.8568	28.3
0.0607	51.2	0.5562	34.6	2.0634	28.2
0.0757	49.5	0.6552	33.4	2.3651	28.3
0.0906	48.4	0.7506	32.4	2.6232	28.0

Table 6.5 - Continued

$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
$\alpha_{AOT} = 0.774$					
0.1202	46.4	0.8651	31.1	2.8467	28.3
0.1495	44.9	0.9747	30.7		
$\alpha_{AOT} = 0.849$					
0.0010	64.4	0.1518	46.8	1.0806	32.8
0.0021	64.1	0.1905	45.2	1.2494	31.5
0.0042	63.6	0.2285	43.9	1.4017	30.6
0.0105	61.9	0.2934	41.9	1.5397	30.4
0.0209	58.8	0.3563	40.9	1.6655	29.7
0.0312	56.8	0.4428	39.2	1.8167	29.2
0.0415	55.3	0.5256	38.0	1.9519	28.5
0.0518	54.3	0.6051	37.3	2.0734	28.9
0.0722	51.9	0.6813	36.1	2.1832	28.8
0.0924	49.6	0.8247	34.6	2.2830	28.9
0.1124	48.5	0.9575	33.4	2.3955	28.8
$\alpha_{AOT} = 0.928$					
0.0016	63.9	0.1669	47.4	1.1582	33.1
0.0031	63.9	0.2254	45.4	1.3580	32.1
0.0062	63.4	0.2828	43.6	1.6304	30.8
0.0155	61.9	0.3392	42.4	1.8744	30.0
0.0310	59.3	0.4217	40.9	2.0943	29.5
0.0464	56.8	0.5021	39.5	2.3557	29.3
0.0617	54.9	0.6058	38.1	2.5867	29.4
0.0770	53.3	0.7059	36.9	2.7923	29.3
0.1072	50.8	0.8263	35.7		
0.1372	49.3	0.9415	34.7		
$\alpha_{AOT} = 1.0$					
0.0319	60.7	0.7009	46.4	28.313	34.1
0.0766	56.1	0.9548	46.0	38.002	33.3
0.1277	52.2	1.3348	45.3	46.904	32.7
0.1596	50.6	1.8396	44.4	55.111	32.7

Table 6.5 - Continued

$c \times 10^3 /$ mol kg^{-1}	$\gamma /$ mN m^{-1}	$c \times 10^3 /$ mol kg^{-1}	$\gamma /$ mN m^{-1}	$c \times 10^3 /$ mol kg^{-1}	$\gamma /$ mN m^{-1}
$\alpha_{\text{AOT}} = 1.0$					
0.1915	49.2	2.4051	44.1	62.700	32.4
0.2234	48.9	3.6530	43.3	69.741	32.2
0.2681	48.0	6.1125	41.4	79.393	31.8
0.3191	47.7	9.7134	39.7	90.815	31.7
0.3828	47.4	14.357	37.9	100.85	31.6
0.5101	46.7	19.921	35.6		

Table 6.6 - Surface Tension (γ) Values of AOT + CTAB Systems in 80% FA at 298 K

$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
$\alpha_{\text{AOT}} = 0$					
0.0106	61.8	1.4598	57.1	10.490	25.9
0.0212	61.6	1.6645	56.6	11.147	25.2
0.0424	61.6	2.0711	55.4	12.112	24.7
0.0847	61.5	2.4739	53.5	13.054	24.3
0.1270	61.2	3.2687	49.4	14.574	24.1
0.2115	60.7	4.0492	44.7	17.441	23.6
0.3168	60.7	4.8158	40.8	20.099	23.9
0.4220	60.4	5.5689	36.9	24.872	23.7
0.5268	59.9	6.3088	34.3	29.038	23.7
0.6315	59.8	7.0359	33.7	35.954	24.2
0.7359	59.9	7.7505	31.2	39.536	23.6
0.8400	59.5	8.4530	29.3	46.682	27.0
1.0476	58.5	9.1437	28.4	53.532	34.0
1.2542	58.3	9.8227	26.6		
$\alpha_{\text{AOT}} = 0.124$					
0.0049	61.9	0.9371	45.5	5.2285	32.3
0.0098	61.5	1.1578	43.6	5.9915	31.4
0.0196	61.4	1.3735	42.6	6.6795	30.6
0.0490	60.5	1.7085	40.8	7.3031	30.0
0.0978	58.3	2.0316	39.6	7.8710	29.8
0.1464	57.2	2.3436	38.6	8.3902	29.6
0.1947	55.7	2.7186	37.5	8.8669	29.4
0.2907	53.2	3.0780	36.4	9.5798	29.2
0.3857	50.9	3.4227	35.5	10.207	29.0
0.4798	49.9	4.0718	33.8		
0.7112	47.4	4.6719	33.0		
$\alpha_{\text{AOT}} = 0.270$					
0.0038	61.8	0.5565	46.4	3.2248	33.9
0.0077	61.7	0.7332	44.6	3.6874	32.9
0.0192	60.7	0.9057	43.3	4.1161	31.9
0.0384	59.6	1.0742	41.6	4.7032	31.1
0.0766	57.3	1.3358	40.3	5.2321	30.6

Table 6.6 - Continued

$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
$\alpha_{AOT} = 0.270$					
0.1146	55.8	1.5879	39.4	5.7112	30.3
0.1525	54.4	1.8907	38.3	6.1470	30.0
0.2276	52.1	2.1804	37.3	6.5452	29.7
0.3019	50.6	2.4580	36.3	7.1377	29.4
0.3755	49.0	2.7242	35.3	7.6557	29.2
$\alpha_{AOT} = 0.450$					
0.0055	61.3	0.5349	46.1	5.025	30.4
0.0109	61.4	0.7936	43.2	5.6873	29.4
0.0273	60.7	1.0467	41.4	6.3053	28.9
0.0546	59.4	1.4404	39.2	7.1583	28.4
0.1089	55.8	1.8209	37.1	7.9335	28.2
0.1630	54.0	2.2789	35.7	8.6410	28.2
0.2169	52.4	2.7185	34.3	9.2893	28.1
0.3238	49.4	3.5468	32.6		
0.4299	47.6	4.3134	31.2		
$\alpha_{AOT} = 0.774$					
0.0095	61.4	1.3708	44.7	9.9003	30.1
0.0189	61.1	1.8066	43.5	10.419	29.5
0.0378	61.0	2.2325	42.5	10.919	29.2
0.0567	60.5	2.6487	40.8	11.403	28.9
0.0945	59.5	3.4536	39.4	11.870	28.8
0.1885	57.3	4.2237	38.5	12.758	28.7
0.2821	55.5	4.9612	37.5	13.590	28.6
0.3752	52.9	6.3464	36.6	14.371	28.5
0.5601	50.1	7.6235	34.4	15.106	28.3
0.9247	46.6	8.8046	32.1	15.798	28.1
$\alpha_{AOT} = 0.849$					
0.0082	60.7	1.1902	44.6	8.9397	34.5
0.0163	60.3	1.5717	43.8	9.9073	33.8
0.0327	58.1	2.3131	42.3	10.818	33.2
0.0490	57.0	3.0270	41.0	11.677	32.1

Table 6.6 - Continued

$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹	$c \times 10^3 /$ mol kg ⁻¹	$\gamma /$ mN m ⁻¹
$\alpha_{AOT} = 0.849$					
0.0816	56.4	3.7150	39.9	12.488	30.4
0.1628	52.5	4.3784	39.0	13.255	29.4
0.2437	50.6	5.0186	38.3	13.982	29.3
0.3243	47.5	5.6367	37.9	14.671	28.9
0.4046	47.3	6.2338	36.9	15.326	28.8
0.4845	47.1	6.8111	36.7	16.250	28.7
0.6435	46.3	7.3694	36.1	17.109	28.5
0.8013	45.5	7.9097	35.6	18.415	28.3
$\alpha_{AOT} = 0.928$					
0.0088	61.5	2.8314	39.2	13.070	29.7
0.0175	61.0	3.2011	38.4	13.785	29.2
0.0525	59.4	3.9172	37.4	14.460	29.0
0.0873	57.6	4.6038	36.7	15.402	28.3
0.1743	54.8	5.2626	35.8	16.270	28.1
0.2608	52.2	5.8954	35.0	17.071	28.4
0.4327	49.2	7.0887	33.7	17.813	28.3
0.8554	45.3	8.1945	33.1	18.721	28.4
1.2686	43.3	9.2220	32.3	19.935	28.2
1.6724	41.7	10.634	31.3	21.000	28.3
2.0673	40.9	11.499	31.0		
2.4535	39.8	12.309	30.2		
$\alpha_{AOT} = 1.0$					
0.0357	58.5	1.1379	46.2	28.687	38.1
0.0714	57.3	1.2795	45.9	33.700	37.4
0.1071	55.9	1.4209	45.8	39.028	36.6
0.1428	55.2	1.6327	45.6	44.118	36.3
0.1784	53.8	1.9147	45.3	58.658	34.8
0.2141	52.7	2.3364	45.0	65.776	34.3
0.2569	53.2	2.8967	44.7	72.769	33.8
0.3068	51.6	3.5241	44.3	81.000	33.6
0.3638	51.4	4.2178	43.9	90.388	33.1
0.4279	49.9	5.2516	43.6	100.84	33.0

Table 6.6 - Continued

$c \times 10^3 /$ mol kg^{-1}	$\gamma /$ mN m^{-1}	$c \times 10^3 /$ mol kg^{-1}	$\gamma /$ mN m^{-1}	$c \times 10^3 /$ mol kg^{-1}	$\gamma /$ mN m^{-1}
$\alpha_{\text{AOT}} = 1.0$					
0.4990	49.8	6.6172	43.3	112.27	32.7
0.5702	49.5	8.3044	42.6	124.58	32.4
0.6413	47.8	10.300	41.9	148.01	32.1
0.7123	47.8	12.914	41.1	180.49	31.6
0.7834	47.3	16.108	40.6	196.13	31.4
0.8544	47.1	19.835	39.6	217.83	31.2
0.9962	46.8	24.046	38.8		

Table 6.7 - Ratio of the intensities of Fluorescence Emission of Pyrene at 373 nm and at 384 nm in AOT + CTAB Systems in 10% FA at 298 K

$c \times 10^3 /$ mol kg^{-1}	I_1 / I_3	$c \times 10^3 /$ mol kg^{-1}	I_1 / I_3	$c \times 10^3 /$ mol kg^{-1}	I_1 / I_3
$\alpha_{\text{AOT}} = 0$					
0.0462	1.7425	1.3861	1.6118	3.6963	1.3728
0.1848	1.7473	1.6171	1.4431	4.3894	1.3736
0.4620	1.7333	1.8482	1.4032	5.7755	1.3610
0.6931	1.7287	2.0792	1.3961	9.2408	1.3540
0.9241	1.7081	2.5412	1.3771		
1.1551	1.7080	3.0033	1.3839		
$\alpha_{\text{AOT}} = 0.124$					
0.0000	1.7599	0.0541	1.6826	0.2166	1.4837
0.0027	1.7634	0.0812	1.6557	0.2707	1.4284
0.0081	1.7581	0.1083	1.6227	0.3790	1.3744
0.0108	1.7547	0.1354	1.5547	0.4873	1.3380
0.0217	1.7244	0.1624	1.5404		
$\alpha_{\text{AOT}} = 0.270$					
0.0011	1.7765	0.0109	1.7515	0.0874	1.5242
0.0022	1.7702	0.0131	1.7336	0.1747	1.4354
0.0044	1.7696	0.0175	1.7181	0.2621	1.3553
0.0066	1.7650	0.0480	1.6330		
$\alpha_{\text{AOT}} = 0.450$					
0.0000	1.7649	0.0081	1.7385	0.0346	1.6119
0.0023	1.7557	0.0092	1.7409	0.0923	1.4048
0.0035	1.7547	0.0161	1.7071	0.1845	1.2961
0.0069	1.7507	0.0231	1.6729	0.2768	1.2675
$\alpha_{\text{AOT}} = 0.774$					
0.0000	1.7895	0.0123	1.7730	0.0575	1.5742
0.0031	1.7884	0.0205	1.7351	0.1026	1.4450
0.0072	1.7830	0.0246	1.7274	0.2052	1.3260
0.0082	1.7812	0.0410	1.6198	0.3694	1.2411
0.0103	1.7783	0.0493	1.6126		
$\alpha_{\text{AOT}} = 0.849$					
0.0011	1.7870	0.0210	1.7713	0.0505	1.6922
0.0032	1.7864	0.0252	1.7682	0.1051	1.5738

Table 6.7 - Continued

$c \times 10^3 /$ mol kg^{-1}	I_1 / I_3	$c \times 10^3 /$ mol kg^{-1}	I_1 / I_3	$c \times 10^3 /$ mol kg^{-1}	I_1 / I_3
$\alpha_{\text{AOT}} = 0.849$					
0.0063	1.7902	0.0294	1.7587	0.1682	1.4493
0.0126	1.7887	0.0336	1.7373	0.4204	1.2850
$\alpha_{\text{AOT}} = 0.928$					
0.0019	1.7310	0.0343	1.7189	0.3048	1.4603
0.0038	1.7304	0.0419	1.7057	0.3810	1.4193
0.0076	1.7358	0.0533	1.6955	0.6857	1.3850
0.0152	1.7322	0.0648	1.6675		
0.0171	1.7259	0.1905	1.5451		
$\alpha_{\text{AOT}} = 1$					
0.0000	1.7376	1.2295	1.6822	6.7620	1.1279
0.0615	1.7334	1.8442	1.6873	8.6062	1.0961
0.1229	1.7268	2.4589	1.6367	10.450	1.0763
0.1844	1.7230	3.0736	1.4940	12.295	1.0648
0.3074	1.7320	3.6884	1.3335	15.368	1.0460
0.4918	1.7100	4.3031	1.2374	21.515	1.0235
0.6147	1.7124	5.5326	1.1716		

Table 6.8 - Conductance Values of CTAB Solution in Water + FA Media at 298K

$c \times 10^3 /$ mol kg^{-1}	Cond. / μS	$c \times 10^3 /$ mol kg^{-1}	Cond. / μS	$c \times 10^3 /$ mol kg^{-1}	Cond. / μS
Water					
0.0000	1.2460	0.5548	64.110	1.3351	105.14
0.0823	10.674	0.6301	72.480	1.4664	108.63
0.1636	20.230	0.7045	80.650	1.5946	111.88
0.2438	29.545	0.778	87.535	1.7200	115.14
0.3231	38.600	0.9223	93.805	1.8425	118.21
0.4013	47.230	1.0632	97.950	1.9624	121.18
0.4785	55.790	1.2008	101.68	2.0797	124.04
10% FA					
0.0000	112.60	0.5054	164.00	1.4758	241.40
0.0256	114.86	0.6296	176.53	1.5935	246.10
0.0512	117.44	0.7529	189.00	1.7104	250.40
0.0767	120.15	0.8755	201.80	1.9419	256.54
0.1022	122.58	0.9971	214.07	2.1704	263.50
0.1277	124.98	1.1180	225.70	2.3959	269.90
0.2544	137.92	1.2381	232.30		
0.3803	151.11	1.3573	237.25		
20% FA					
0.0000	221.58	1.3481	342.00	3.2428	445.90
0.2001	238.98	1.5311	357.76	3.5613	455.35
0.3976	257.30	1.7118	374.10	4.3261	477.35
0.5926	274.96	1.8903	389.78	5.0490	497.00
0.7851	292.34	2.2407	411.14	5.7334	516.80
0.9752	309.15	2.5828	424.50	6.3822	534.45
1.1628	325.74	2.9167	435.45		
30% FA					
0.0000	296.22	1.4942	423.00	4.2216	606.90
0.1953	311.98	1.6705	437.60	4.9270	631.30
0.3881	328.48	1.8447	451.66	5.5948	652.50
0.5783	344.10	2.1867	478.15	6.2278	671.75
0.7662	360.16	2.5205	504.10	6.8288	689.80
0.9517	376.56	2.8463	528.60	7.4000	706.75

Table 6.8 - Continued

$c \times 10^3 /$ mol kg ⁻¹	Cond. / μS	$c \times 10^3 /$ mol kg ⁻¹	Cond. / μS	$c \times 10^3 /$ mol kg ⁻¹	Cond. / μS
30% FA					
1.1348	392.44	3.1645	552.55	7.9437	722.30
1.3156	407.92	3.4753	573.80	8.4618	737.50
40% FA					
0.0000	367.30	2.1141	528.10	7.6736	857.70
0.2253	383.60	2.5027	555.90	8.2970	878.40
0.4473	401.02	2.8808	582.70	8.8877	896.70
0.6662	417.46	3.2491	608.25	9.4483	914.90
0.8819	434.36	3.6077	632.85	9.9810	932.40
1.0946	450.42	3.9572	656.75	10.488	948.10
1.3042	466.38	4.7928	713.25	10.971	962.85
1.5109	481.90	5.5781	764.95	11.431	975.90
1.7148	496.85	6.3174	803.50		
1.9158	512.80	7.0148	832.95		
60% FA					
0.0000	442.00	5.1597	751.80	17.477	1394.9
0.5456	476.50	6.1179	805.15	19.173	1460.2
1.0842	509.70	7.0535	856.45	20.785	1514.2
1.6161	542.50	7.9673	905.25	22.322	1562.4
2.1413	573.65	8.8601	952.10	23.787	1606.4
2.6600	604.10	9.7326	997.90	25.186	1646.5
3.1723	634.40	11.419	1088.6	26.523	1684.8
3.6783	665.00	13.033	1174.5	27.802	1721.5
4.1781	694.30	14.577	1255.6	29.026	1755.8
4.6719	723.40	16.058	1331.4		
80% FA					
0.0000	347.42	8.6642	751.75	31.038	1582.3
0.6694	382.18	9.7883	798.15	32.693	1643.9
1.3304	415.08	10.887	842.80	35.795	1751.9
1.9833	447.90	11.961	885.55	38.647	1846.3
2.6280	479.25	14.543	985.00	41.279	1933.7
3.2649	510.10	16.988	1075.3	43.714	2012.2

Table 6.8 - Continued

$c \times 10^3 /$ mol kg^{-1}	Cond. / μS	$c \times 10^3 /$ mol kg^{-1}	Cond. / μS	$c \times 10^3 /$ mol kg^{-1}	Cond. / μS
80% FA					
3.8941	539.70	19.307	1160.2	45.974	2083.6
4.5156	569.25	21.508	1239.5	48.078	2145.2
5.1296	597.95	23.602	1314.9	50.040	2189.5
5.7363	625.70	25.595	1384.3	53.595	2298.8
6.3358	653.10	27.494	1452.1	56.729	2377.2
7.5137	704.60	29.306	1518.2		

Table 6.9 - Cmc Values of AOT + CTAB Systems in Water + FA medium from Surface Tension measurements

α_{AOT}	Cmc x 10 ³ / mol kg ⁻¹					
	10% FA	20% FA	30% FA	40% FA	60% FA	80% FA
0	1.193 (1.207 ^a , 1.210 ^b)	2.261 (2.232 ^a)	3.587 (3.611 ^a)	6.179 (5.990 ^a)	15.313 (16.250 ^a)	40.695 (39.820 ^a)
0.124	0.010 (1.303 ^{id})	0.036 (2.440 ^{id})	0.115 (3.897 ^{id})	0.284 (6.623 ^{id})	1.313 (16.537 ^{id})	7.145 (43.237 ^{id})
0.270	0.007 (1.462 ^{id})	0.032 (2.691 ^{id})	0.081 (4.338 ^{id})	0.201 (7.236 ^{id})	1.128 (18.254 ^{id})	4.577 (46.669 ^{id})
0.450	0.009 (1.721 ^{id})	0.024 (3.081 ^{id})	0.069 (5.042 ^{id})	0.182 (8.168 ^{id})	1.240 (20.935 ^{id})	7.051 (51.731 ^{id})
0.774	0.008 (2.527 ^{id})	0.038 (4.170 ^{id})	0.100 (7.122 ^{id})	0.269 (10.631 ^{id})	1.673 (28.459 ^{id})	10.715 (64.283 ^{id})
0.849	0.016 (2.835 ^{id})	0.057 (4.542 ^{id})	0.110 (7.874 ^{id})	0.297 (11.429 ^{id})	1.929 (31.041 ^{id})	13.390 (68.109 ^{id})
0.928	0.017 (3.251 ^{id})	0.076 (5.012 ^{id})	0.131 (8.860 ^{id})	0.405 (12.411 ^{id})	2.119 (34.321 ^{id})	16.167 (72.664 ^{id})
1	3.753 (3.065 ^b)	5.535	10.000	13.464	37.979	77.380

^a from conductance, ^b from fluorescence and ^{id} cmc value from Clint's equation

Table 6.10 - Values of x_1 , β_m , f_1 and f_2 for AOT + CTAB Systems in Water + FA media at 298 K

Wt. % FA	α_{AOT}	$x_1^{Rb} / x_1^{Rd} / x_1^{id}$	β_m	f_1	f_2
10	0	0.00 / 0.00 / 0.00	-	-	1.000
	0.124	0.44 / 0.33 / 0.04	-22.7	0.001	0.013
	0.270	0.46 / 0.47 / 0.10	-23.1	0.001	0.008
	0.450	0.47 / 0.41 / 0.21	-21.8	0.002	0.008
	0.774	0.50 / 0.38 / 0.52	-23.0	0.003	0.003
	0.849	0.51 / 0.49 / 0.64	-20.8	0.007	0.004
	0.928	0.53 / 0.71 / 0.80	-21.8	0.008	0.002
	1	1.00 / 1.00 / 1.00	-	1.000	-
	20	0	0.00 / 0.00 / 0.00	-	-
0.124		0.43 / 0.43 / 0.05	-19.6	0.002	0.025
0.270		0.45 / 0.56 / 0.13	-19.1	0.003	0.019
0.450		0.47 / 0.42 / 0.25	-19.9	0.004	0.011
0.774		0.51 / 0.24 / 0.58	-18.8	0.010	0.008
0.849		0.52 / 0.37 / 0.70	-17.8	0.017	0.008
0.928		0.54 / 0.63 / 0.84	-17.9	0.023	0.005
1		1.00 / 1.00 / 1.00	-	1.000	-
30		0	0.00 / 0.00 / 0.00	-	-
	0.124	0.42 / 0.40 / 0.05	-17.0	0.003	0.048
	0.270	0.45 / 0.57 / 0.12	-17.5	0.005	0.030
	0.450	0.47 / 0.52 / 0.23	-17.8	0.007	0.020
	0.774	0.50 / 0.43 / 0.55	-17.1	0.015	0.013
	0.849	0.52 / 0.53 / 0.67	-17.3	0.018	0.010
	0.928	0.54 / 0.73 / 0.82	-17.8	0.022	0.006
	1	1.00 / 1.00 / 1.00	-	1.000	-

Table 6.10 - Continued

Wt. % FA	α_{AOT}	$x_1^{Rb} / x_1^{Rb} / x_1^{id}$	β_m	f_1	f_2
40	0	0.00 / 0.00 / 0.00	-	-	1.000
	0.124	0.42 / 0.40 / 0.06	-15.1	0.006	0.069
	0.270	0.45 / 0.56 / 0.14	-15.5	0.009	0.043
	0.450	0.47 / 0.48 / 0.27	-15.6	0.013	0.031
	0.774	0.51 / 0.37 / 0.61	-14.8	0.030	0.020
	0.849	0.53 / 0.48 / 0.72	-15.0	0.035	0.015
	0.928	0.55 / 0.70 / 0.85	-14.9	0.050	0.010
	1	1.00 / 1.00 / 1.00	-	1.000	-
60	0	0.00 / 0.00 / 0.00	-	-	1.000
	0.124	0.40 / 0.20 / 0.05	-12.7	0.011	0.126
	0.270	0.43 / 0.31 / 0.13	-12.5	0.018	0.095
	0.450	0.46 / 0.35 / 0.25	-11.8	0.032	0.082
	0.774	0.51 / 0.51 / 0.58	-11.4	0.066	0.051
	0.849	0.53 / 0.62 / 0.69	-11.4	0.081	0.040
	0.928	0.56 / 0.79 / 0.84	-12.2	0.092	0.022
	1	1.00 / 1.00 / 1.00	-	1.000	-
80	0	0.00 / 0.00 / 0.00	-	-	1.000
	0.124	0.38 / 0.23 / 0.07	-9.3	0.030	0.250
	0.270	0.43 / 0.31 / 0.16	-10.3	0.037	0.145
	0.450	0.46 / 0.25 / 0.30	-8.2	0.089	0.176
	0.774	0.53 / 0.32 / 0.64	-7.3	0.202	0.127
	0.849	0.56 / 0.47 / 0.75	-6.9	0.262	0.113
	0.928	0.60 / 0.70 / 0.87	-7.2	0.321	0.072
	1	1.00 / 1.00 / 1.00	-	1.000	-

Table 6.11 - Values of Γ_{mix} , A_{min} , A_{min}^{id} , x_{1a} , β_a , f_{1a} and f_{2a} for AOT + CTAB System in Water + FA media at 298K

Wt. % FA	α_{AOT}	$10^6 \times \Gamma_{mix}$ /mol m ⁻²	A_{min} / nm ²	A_{min}^{id} / nm ²	x_{1a}	β_a	f_{1a}	f_{2a}
10	0	2.63	0.63	0.63	0.00	-	-	1.000
	0.124	2.39	0.69	0.97	0.46	-22.9	0.001	0.008
	0.270	2.27	0.73	0.98	0.48	-22.7	0.002	0.005
	0.450	2.19	0.76	0.99	0.49	-22.3	0.003	0.004
	0.774	2.15	0.77	1.01	0.52	-23.0	0.005	0.002
	0.849	2.00	0.83	1.02	0.53	-21.9	0.008	0.002
	0.928	1.90	0.87	1.03	0.55	-21.9	0.012	0.001
	1	1.22	1.36	1.36	1.00	-	1.000	-
20	0	2.18	0.76	0.76	0.00	-	-	1.000
	0.124	2.07	0.80	1.03	0.46	-19.9	0.003	0.015
	0.270	2.07	0.80	1.05	0.48	-20.0	0.004	0.010
	0.450	2.03	0.82	1.06	0.50	-21.7	0.004	0.004
	0.774	2.06	0.81	1.08	0.53	-19.9	0.012	0.004
	0.849	1.99	0.83	1.09	0.54	-19.6	0.016	0.003
	0.928	1.87	0.89	1.10	0.56	-19.1	0.026	0.002
	1	1.22	1.36	1.36	1.00	-	1.000	-
30	0	3.26	0.51	0.51	0.00	-	-	1.000
	0.124	2.07	0.80	1.01	0.43	-17.3	0.003	0.041
	0.270	1.91	0.87	1.04	0.45	-17.9	0.005	0.024
	0.450	1.73	0.96	1.06	0.48	-18.6	0.006	0.014
	0.774	1.71	0.97	1.10	0.51	-17.8	0.014	0.009
	0.849	1.62	1.02	1.12	0.52	-18.9	0.013	0.006
	0.928	1.79	0.92	1.14	0.54	-17.6	0.026	0.005
	1	0.99	1.67	1.67	1.00	-	1.000	-

Table 6.11 - Continued

Wt. % FA	α_{AOT}	$10^6 \times \Gamma_{mix}$ /mol m ⁻²	A_{min} / nm ²	A_{min}^{id} / nm ²	x_{1a}	β_a	f_{1a}	f_{2a}
40	0	3.74	0.44	0.44	0.00	-	-	1.000
	0.124	1.78	0.93	0.92	0.40	-14.7	0.005	0.097
	0.270	1.80	0.92	0.95	0.43	-15.1	0.007	0.063
	0.450	1.64	1.01	0.98	0.45	-15.0	0.011	0.047
	0.774	1.60	1.04	1.03	0.49	-15.1	0.021	0.025
	0.849	1.58	1.05	1.05	0.51	-14.7	0.028	0.022
	0.928	1.57	1.06	1.08	0.53	-14.5	0.042	0.016
	1	1.02	1.63	1.63	1.00	-	1.000	-
60	0	3.84	0.43	0.43	0.00	-	-	1.000
	0.124	1.71	0.97	0.87	0.31	-8.7	0.016	0.436
	0.270	1.58	1.05	0.94	0.36	-9.2	0.023	0.302
	0.450	1.52	1.09	0.98	0.39	-9.2	0.034	0.240
	0.774	1.53	1.09	1.08	0.46	-10.3	0.050	0.111
	0.849	1.42	1.16	1.11	0.48	-9.5	0.077	0.111
	0.928	1.43	1.16	1.16	0.51	-10.1	0.093	0.068
	1	0.90	1.83	1.83	1.00	-	1.000	-
80	0	4.23	0.39	0.39	0.00	-	-	1.000
	0.124	1.54	1.08	0.88	0.31	-6.6	0.044	0.529
	0.270	1.43	1.16	0.98	0.37	-7.3	0.059	0.359
	0.450	1.42	1.17	1.05	0.42	-7.7	0.077	0.255
	0.774	1.38	1.20	1.16	0.49	-5.1	0.268	0.285
	0.849	1.31	1.26	1.22	0.53	-5.0	0.333	0.248
	0.928	1.20	1.38	1.27	0.56	-7.8	0.226	0.084
	1	0.85	1.96	1.96	1.00	-	1.000	-

Table 6.12 - Ratio of the intensities (I_o / I_q) of Fluorescence Emission of Pyrene in the absence (I_o) and presence (I_q) of the quencher (CPC) at 373 nm of AOT + CATB Systems in 10% FA at 298 K

α_{AOT}	$c \times 10^3 /$ mol kg^{-1}	[CPC] $\times 10^5 /$ mol kg^{-1}	I_o / I_q
0	2.4021	0.0000	1.0000
		0.0936	1.0203
		0.1871	1.0559
		0.2807	1.0911
		0.4679	1.1308
0.124	0.6768	0.0000	1.0000
		0.0936	1.0293
		0.1871	1.0576
		0.2807	1.1043
		0.4679	1.1756
0.270	0.6740	0.0000	1.0000
		0.1871	1.0924
		0.2807	1.1237
		0.4679	1.2390
0.450	0.6765	0.0000	1.0000
		0.0936	1.0925
		0.2807	1.2785
		0.3743	1.3738
		0.4679	1.5154
0.774	0.6753	0.0000	1.0000
		0.0936	1.1360
		0.1871	1.3160
		0.2807	1.4553

Table 6.12 - Continued

α_{AOT}	$c \times 10^3 /$ mol kg^{-1}	$[\text{CPC}] \times 10^5 /$ mol kg^{-1}	I_o / I_q
0.849	0.6832	0.0000	1.0000
		0.1871	1.2529
		0.2807	1.4535
		0.3743	1.6180
		0.4679	1.7090
0.928	0.6857	0.0000	1.0000
		0.0936	1.0686
		0.1871	1.1800
		0.2807	1.2673
		0.3743	1.4342
1	7.1851	0.4679	1.4175
		0.0000	1.0000
		0.1871	1.0069
		0.3743	1.0147
		0.5614	1.0234

Table 6.13 - Values of aggregation number (N_0) for AOT + CTAB Systems in 10% FA at 298 K

α_{AOT}	x_1	$(c - \text{cmc}) \times 10^3$ / mol kg ⁻¹	N_0	n_{AOT}	n_{CTAB}
0	0	1.2091	33	0	33
0.124	0.44	0.6668	23	10	13
0.270	0.46	0.6670	30	14	16
0.450	0.47	0.6675	58	27	31
0.774	0.50	0.6673	90	45	45
0.849	0.51	0.6672	79	40	39
0.928	0.53	0.6687	55	29	26
1	1	3.4321	14	14	0

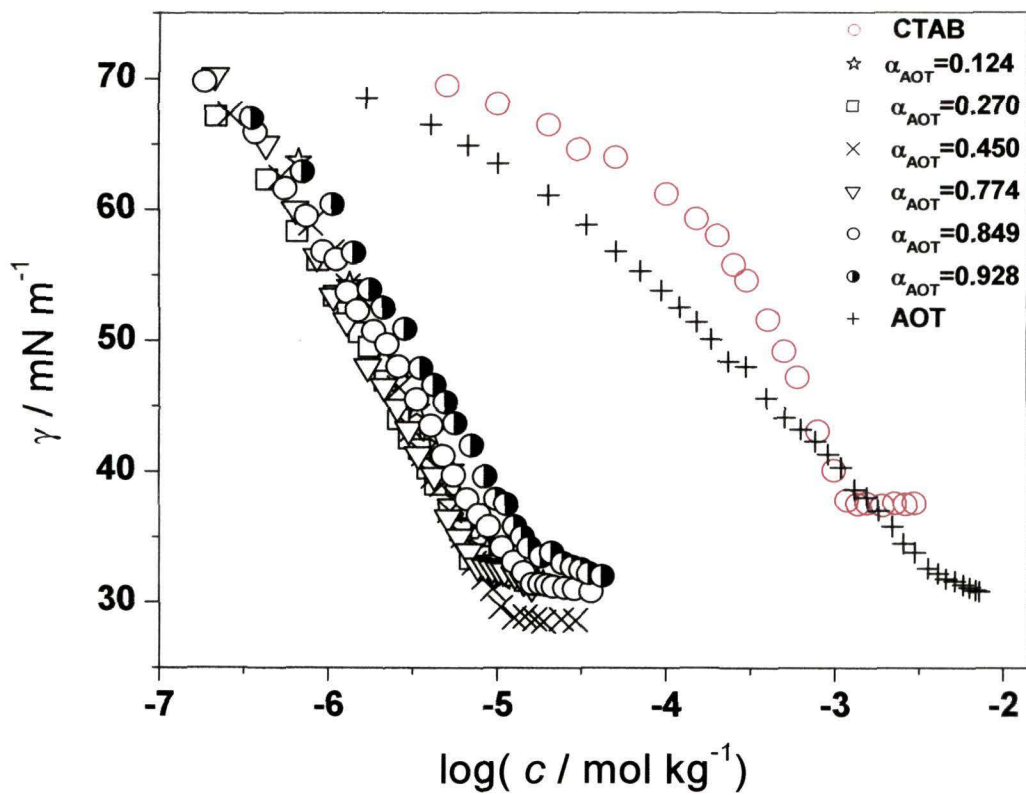


Figure 6.1 - Plots of surface tension of AOT + CTAB systems against logarithm of total surfactant concentration in 10% FA.

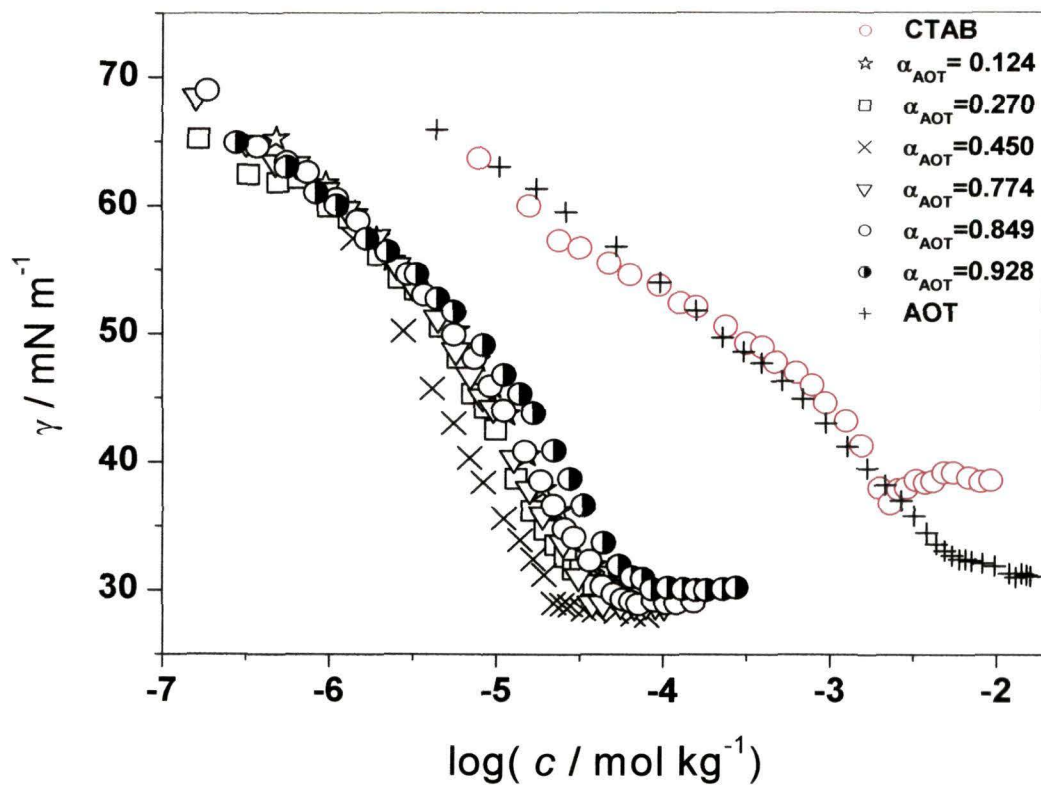


Figure 6.2 - Plots of surface tension of AOT + CTAB systems against logarithm of total surfactant concentration in 20% FA.

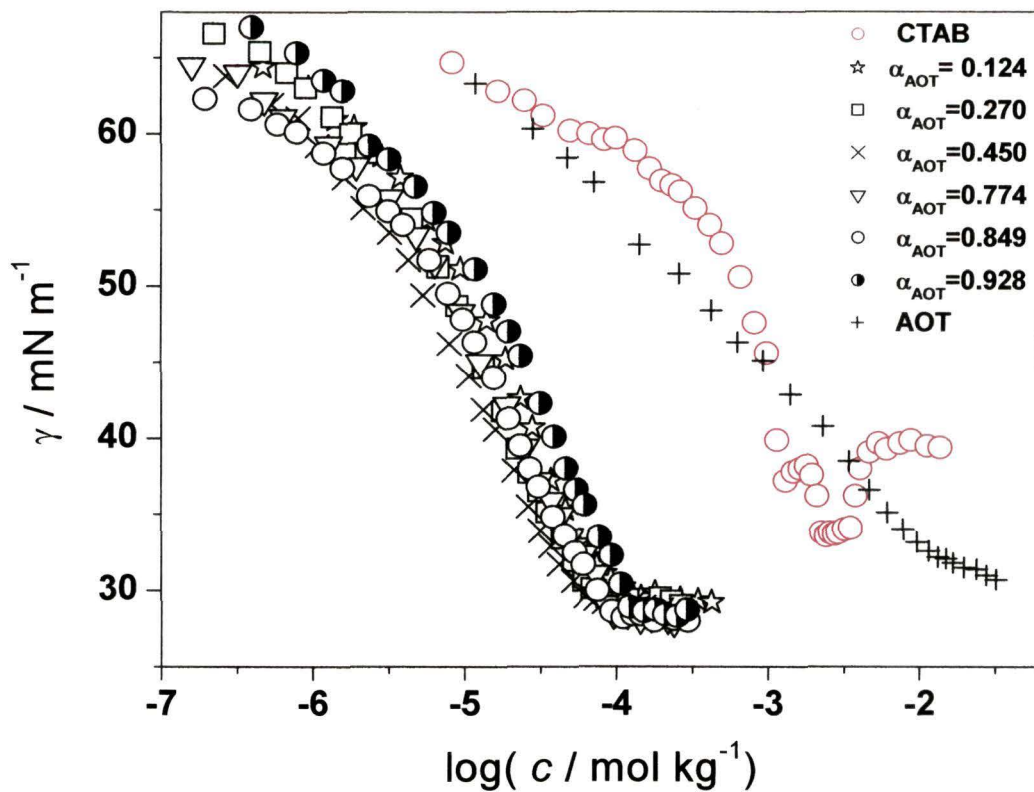


Figure 6.3 - Plots of surface tension of AOT + CTAB systems against logarithm of total surfactant concentration in 30% FA.

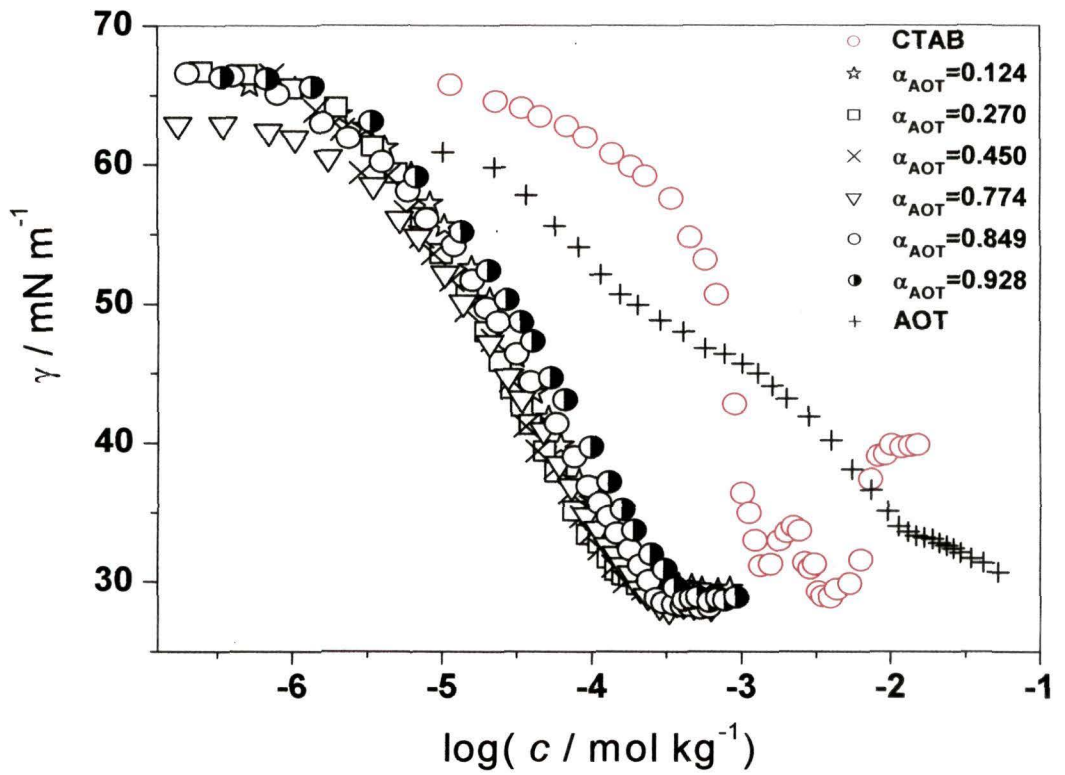


Figure 6.4 - Plots of surface tension of AOT + CTAB systems against logarithm of total surfactant concentration in 40% FA.

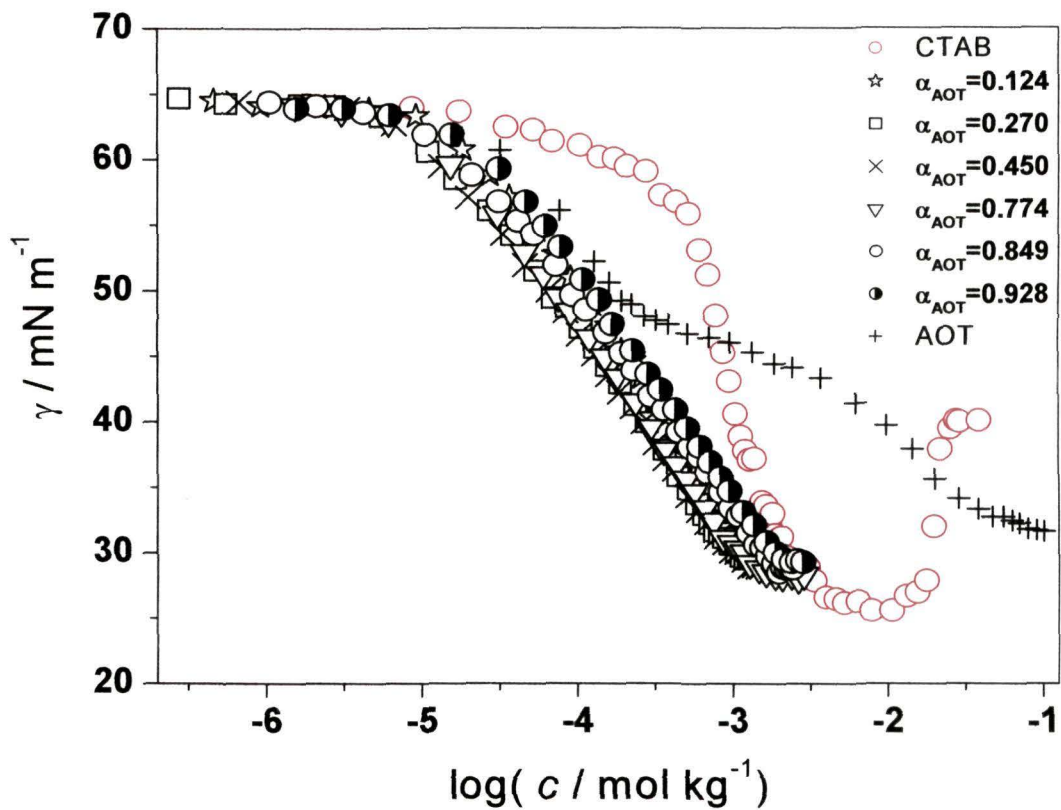


Figure 6.5 - Plots of surface tension of AOT + CTAB systems against logarithm of total surfactant concentration in 60% FA.

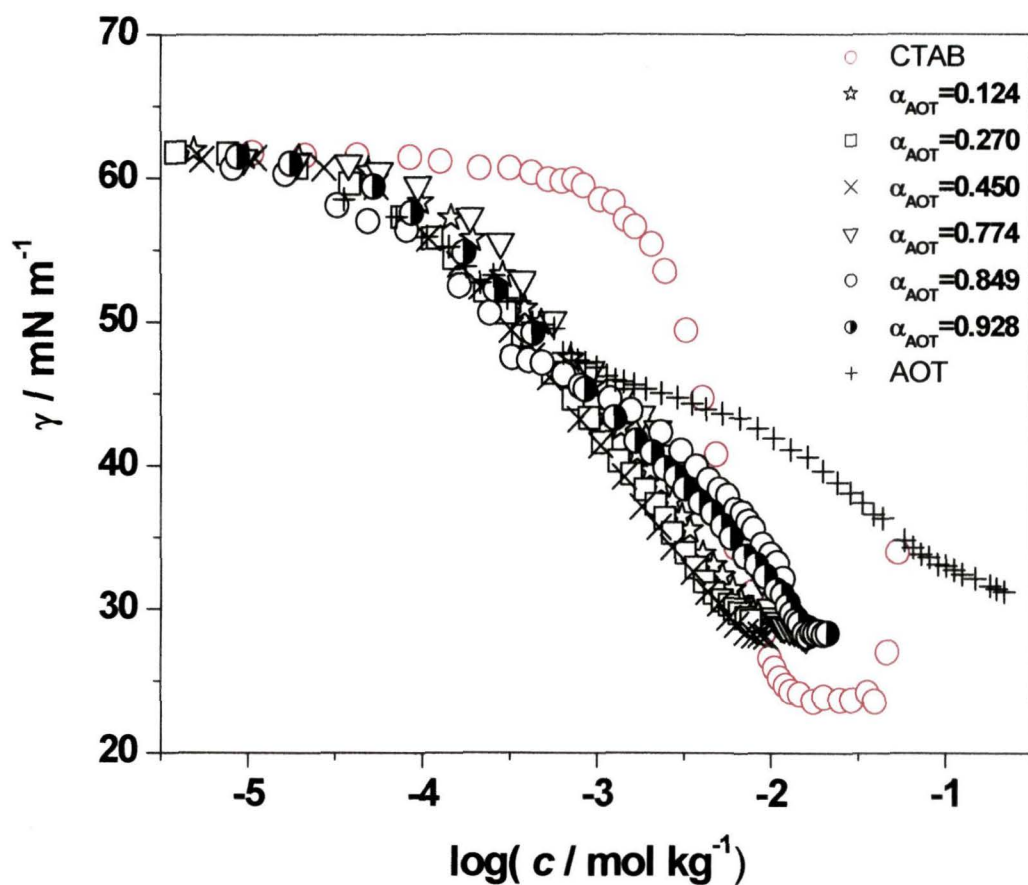


Figure 6.6 - Plots of surface tension of AOT + CTAB systems against logarithm of total surfactant concentration in 80% FA.

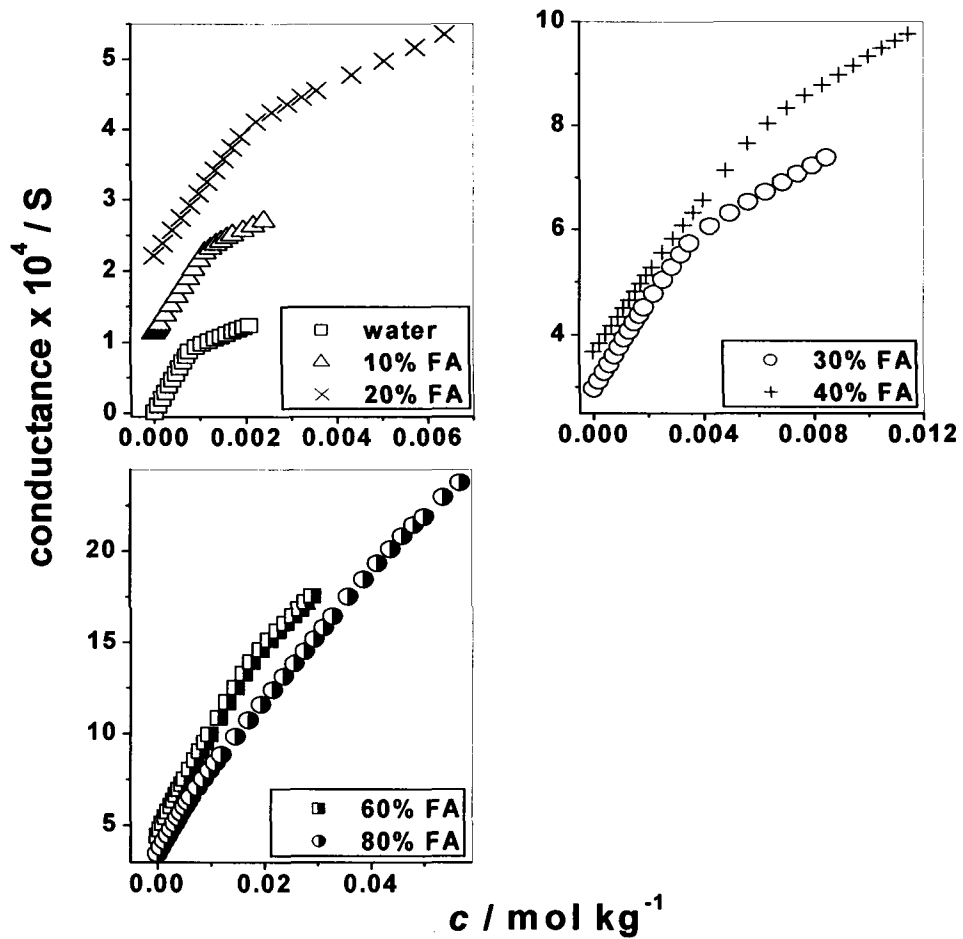


Figure 6.7 - Plots of conductance of CTAB against concentration in water + FA media

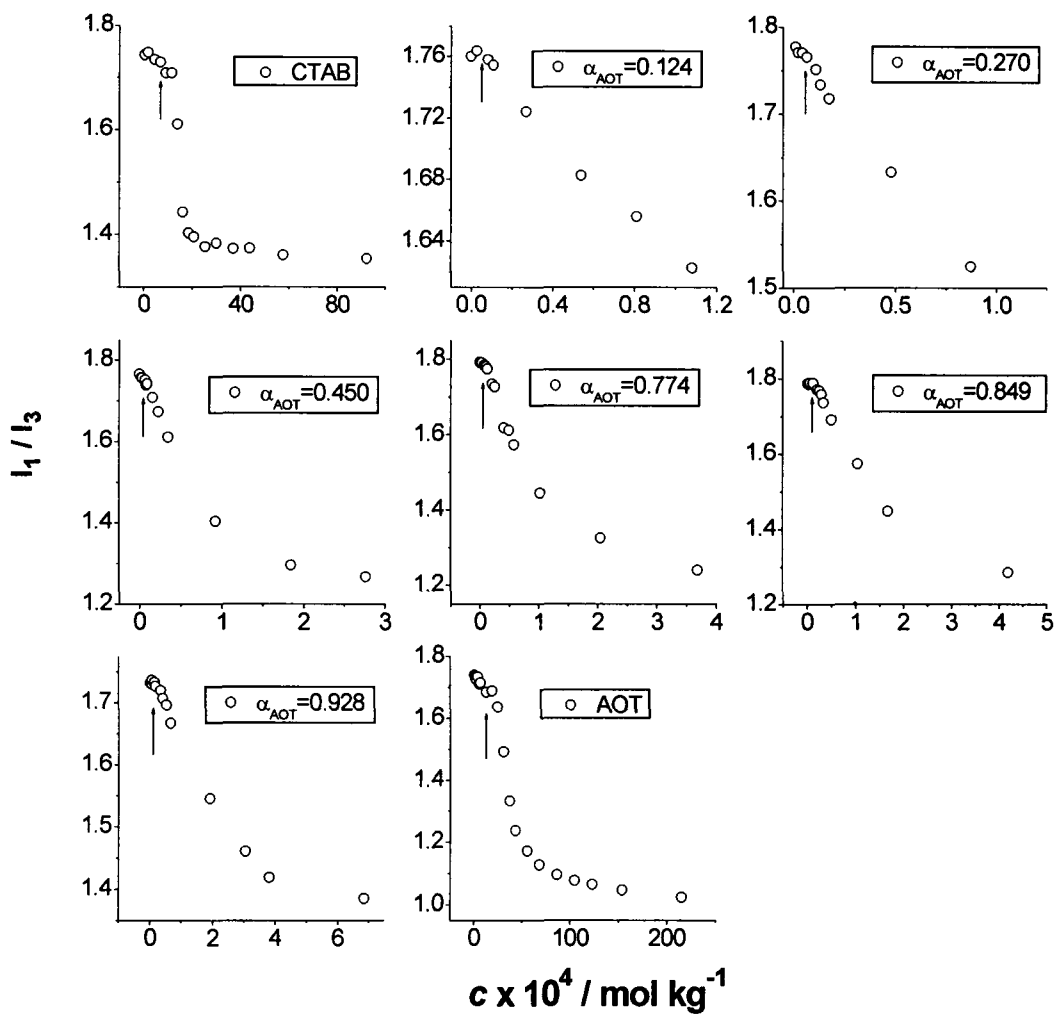


Figure 6.8 - Plots of I_1/I_3 values of pyrene in AOT + CTAB systems against total surfactant concentration in 10% FA. Arrows indicate the positions of cmc. Mole fractions of AOT in the bulk are shown in the insets.

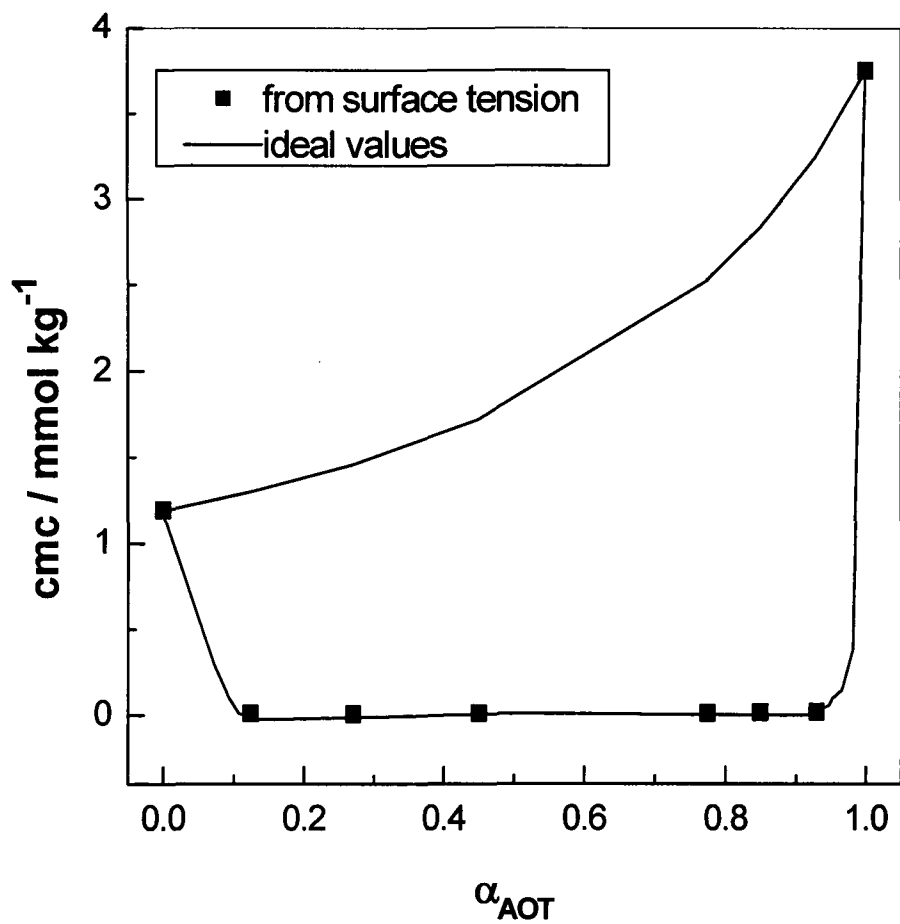


Figure 6.9 - Experimental and ideal (calculated from the Clint's equation) values of cmc of AOT + CTAB system at 25 °C as a function of mole fraction of AOT in the bulk medium (10 % FA).

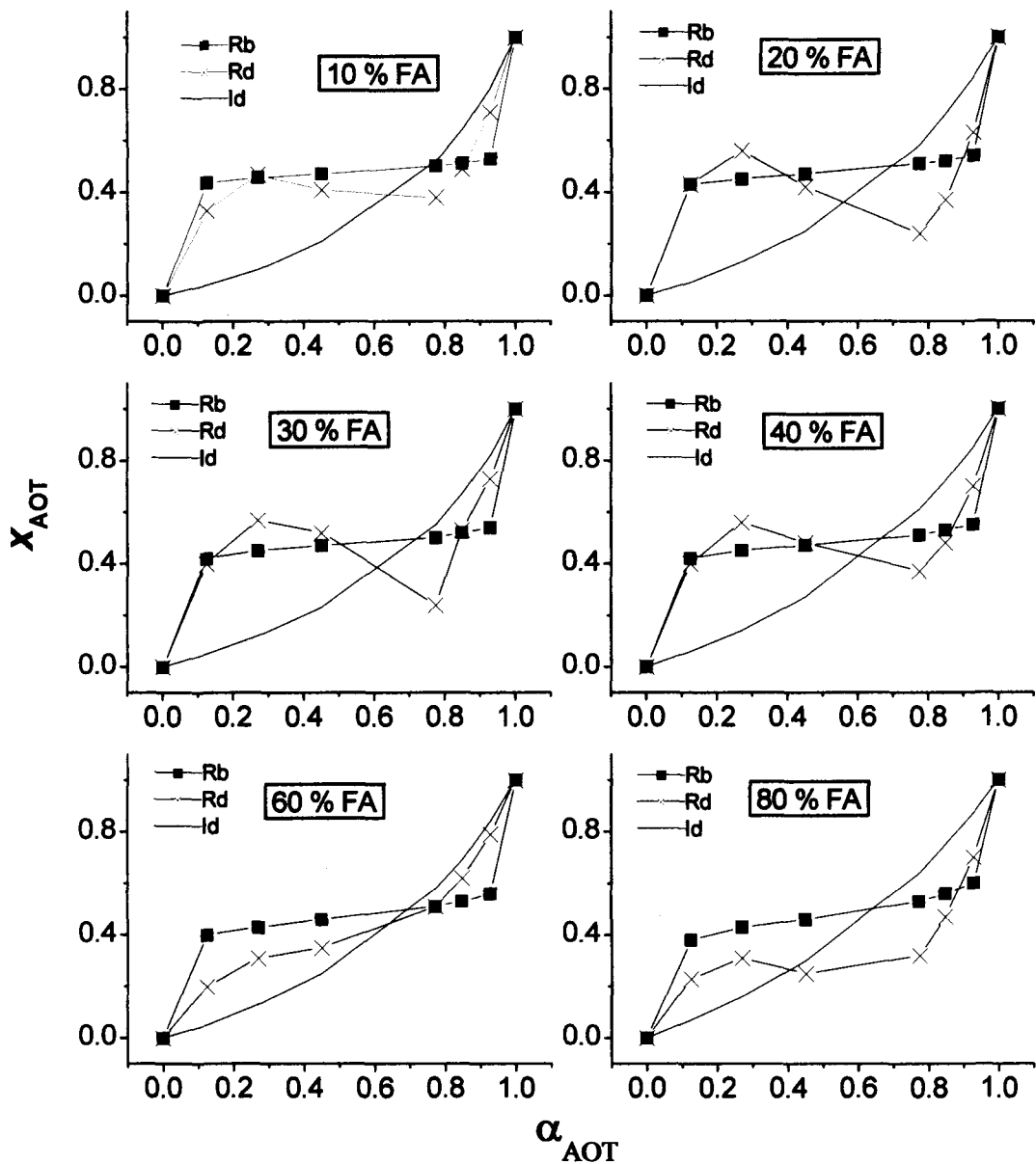


Figure 6.10 - Variation of mole fraction of AOT in the mixed micelle determined from the different methods with bulk composition of AOT.

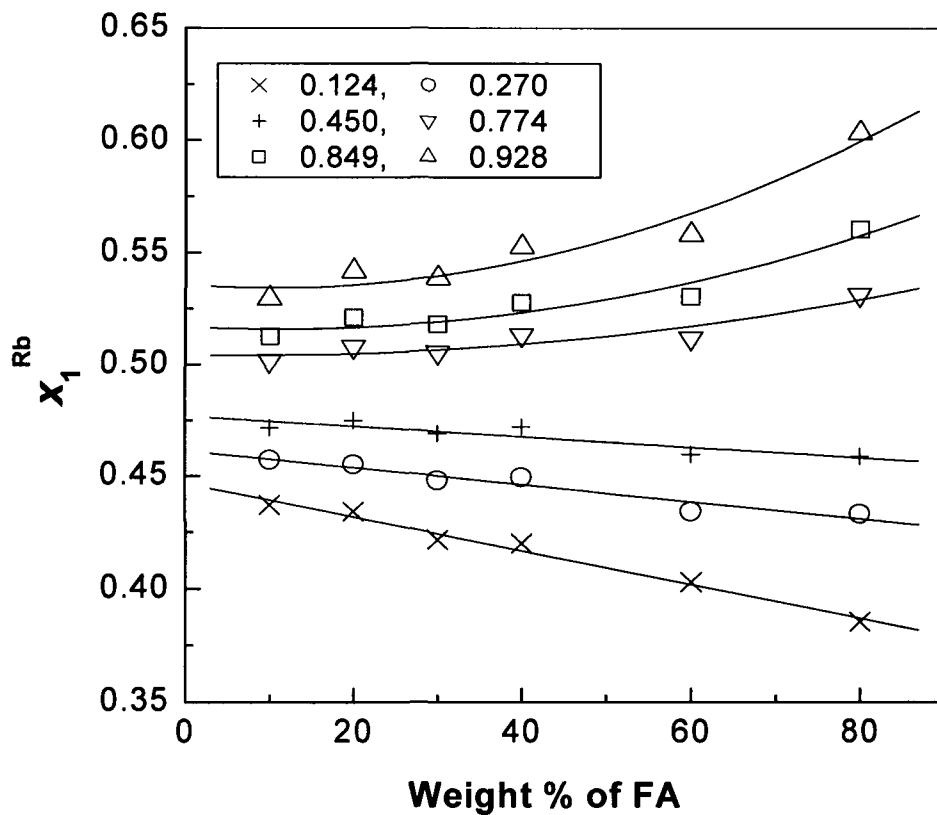


Figure 6.11 - Variation of mole fraction of AOT in the mixed micelle (determined from Rubingh's method) with weight % of FA. Values of the mole fraction of AOT in the bulk (α_{AOT}) are indicated in the inset.

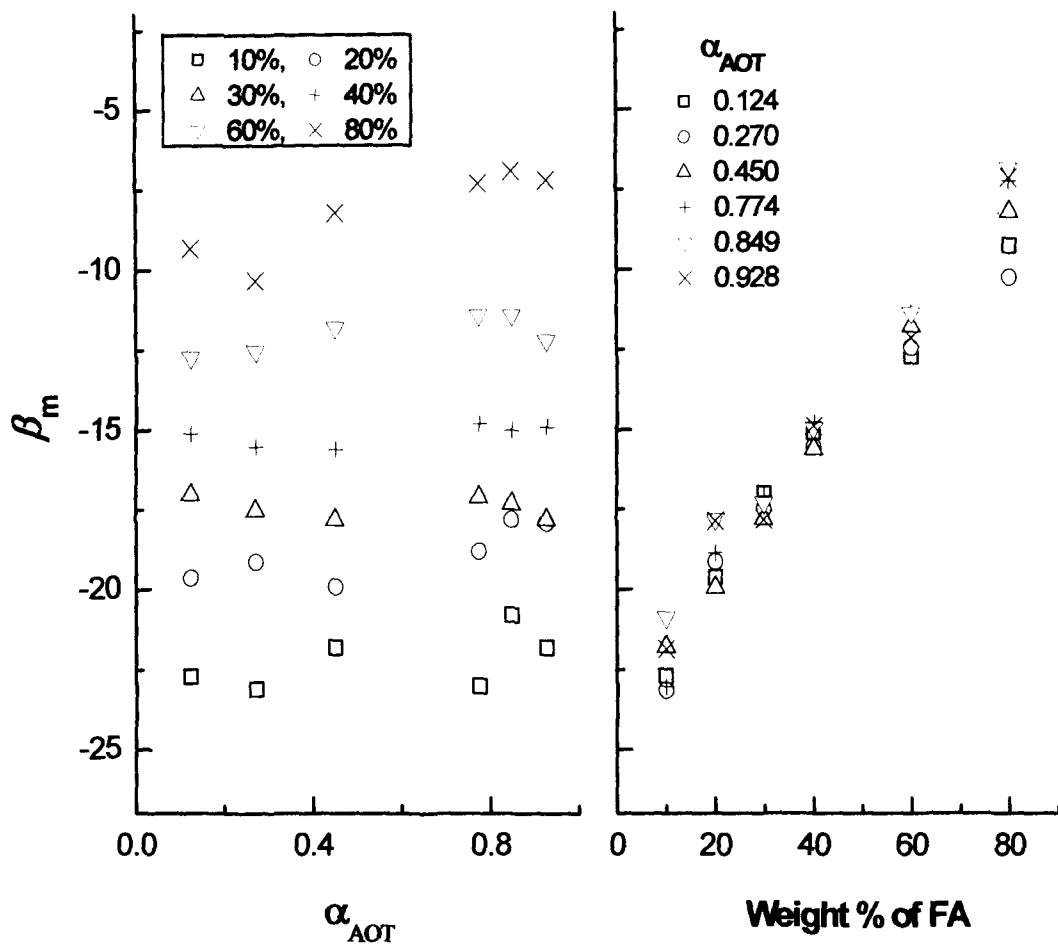


Figure 6.12 - Variation of interaction parameter in the mixed micelle (β_m) of AOT + CTAB systems with mole fraction of AOT in the bulk (α_{AOT}) and weight % of FA.

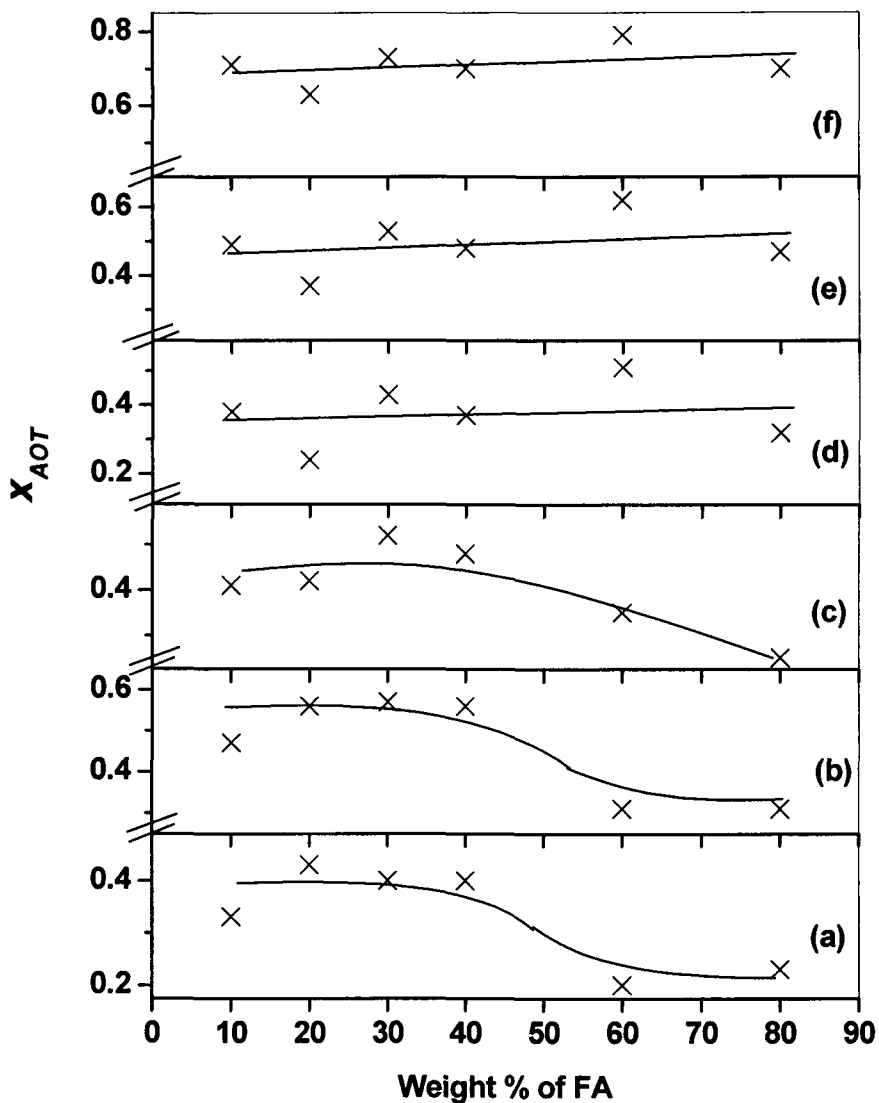


Figure 6.13 - Variation of mole fraction of AOT in the mixed micelle with weight % of FA determined from RVV method. Mole fractions of AOT in the bulk solution are (a) 0.124, (b) 0.270, (c) 0.450, (d) 0.774, (e) 0.849 and (f) 0.928.

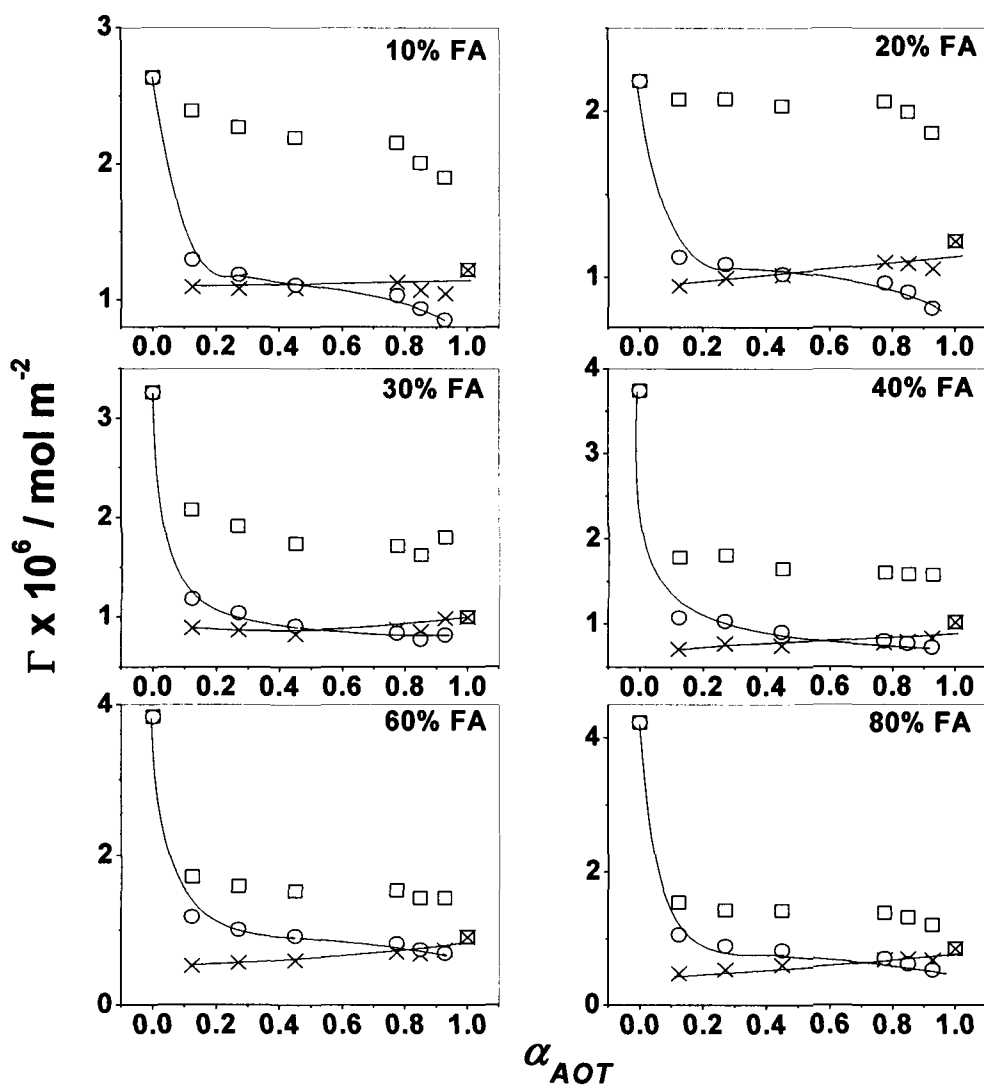


Figure 6.14 - Plots of surface excess at the cmc of the mixture (Γ_{mix} , \square), of the AOT component (Γ_{AOT} , \times) and of the CTAB component (Γ_{CTAB} , \circ) in the mixture against composition of AOT in the bulk solution.

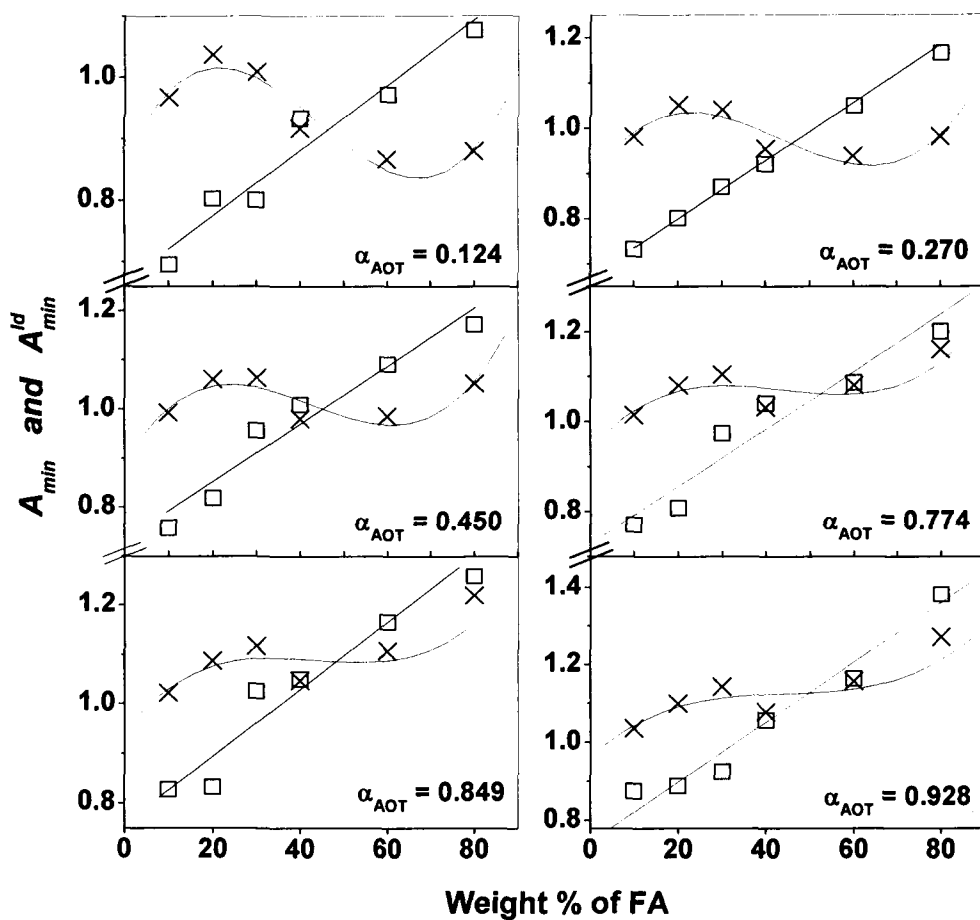


Figure 6.15 - Plots of area (nm^2) per molecule in the adsorbed layer, (A_{min} , \square) and (A_{min}^{id} , \times) versus weight % of FA.

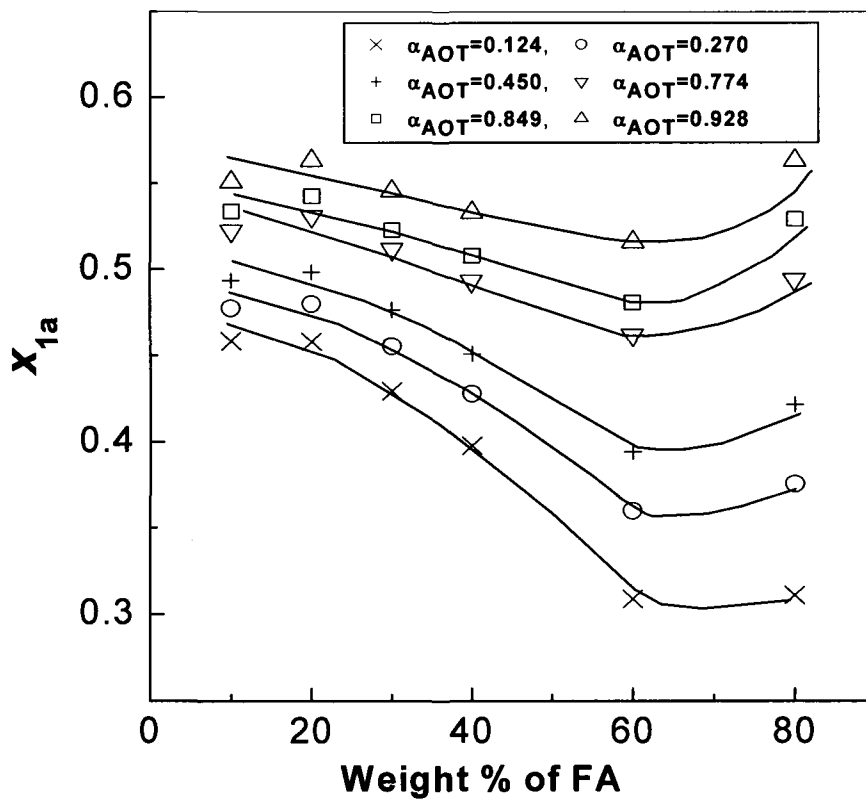


Figure 6.16 - Variation of mole fraction of AOT in the adsorbed layer with weight % of FA.

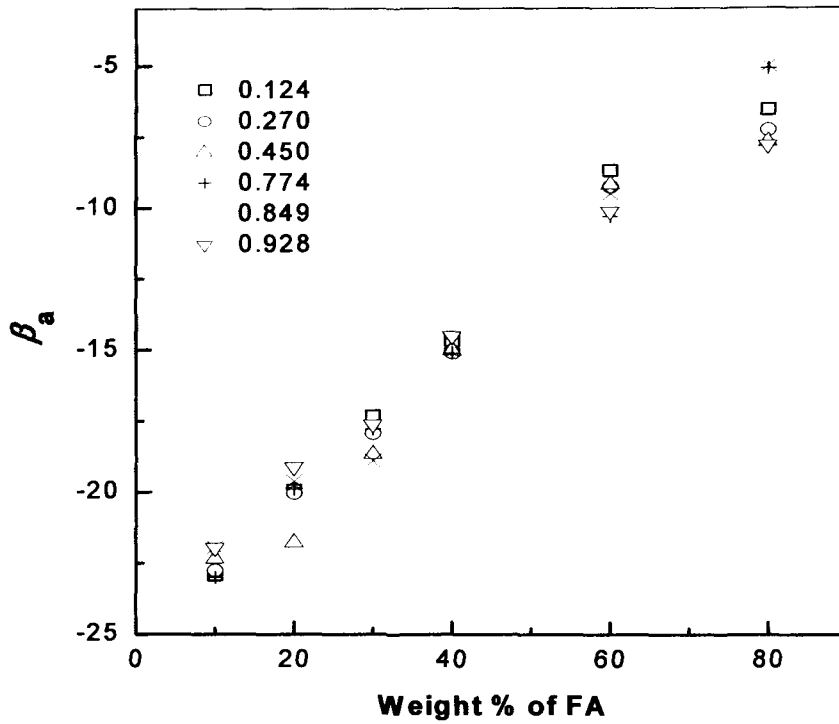


Figure 6.17 - Variation of interaction parameter in the adsorbed layer (β_a) of AOT + CTAB systems with weight % of FA.

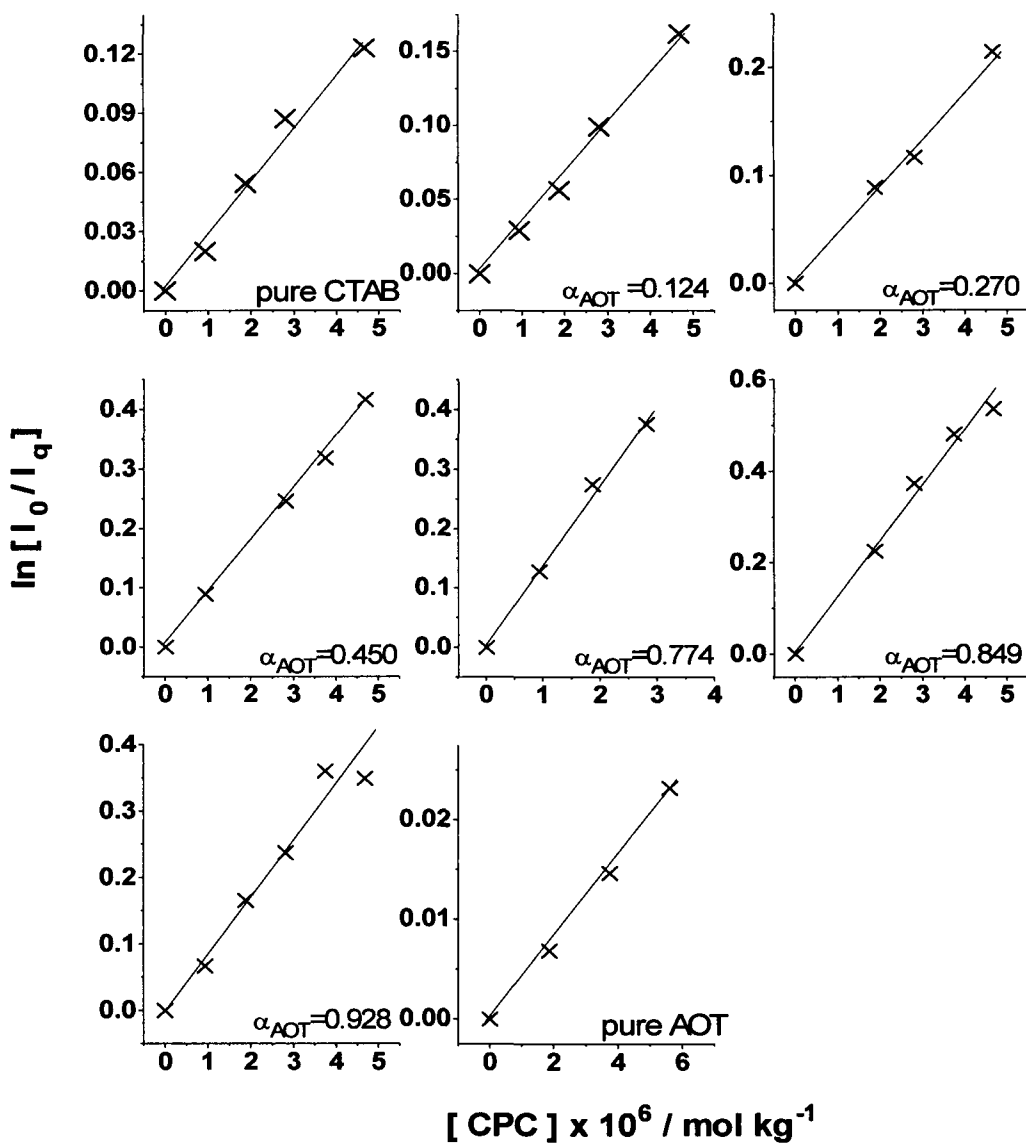


Figure 6.18 - Variation of $\ln[I_0/I_q]$ of pyrene at 373 nm with the concentration of the quencher in AOT + CTAB systems in 10% FA medium. Mole fractions of AOT in the bulk solution are given in the inset.

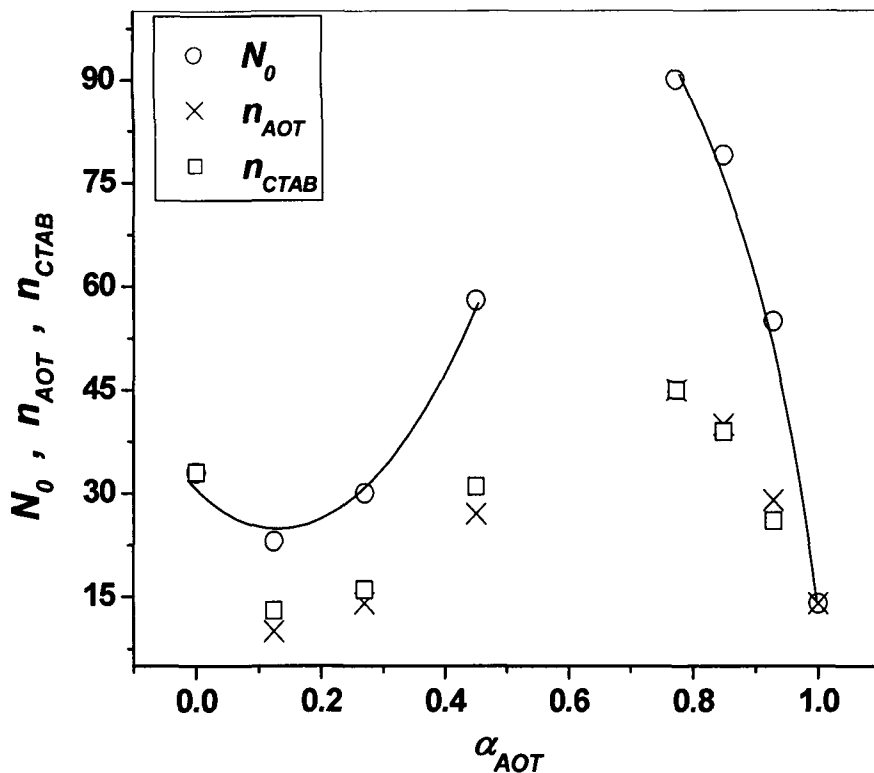


Figure 6.17 - Plots of aggregation number (N_0) of AOT + CTAB mixed system, number of molecules of AOT in the mixed micelle (n_{AOT}), and number of molecules of CTAB in the mixed micelle (n_{CTAB}) against mole fraction of AOT in the bulk solution in 10% FA.

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Research Publications

1. Micellization behavior of mixtures of sodium dioctylsulfosuccinate with sodium dodecylsulfate in water.

O. G. Singh and K. Ismail

J. Surf. Deterg. **2008**, 11, 89-96

2. Micellization characteristics of sodium dioctylsulfosuccinate. An overview, in “*Recent Trends in Surface and Colloid Science*”, Eds. B. K. Paul and S. P. Moulik, *World Scientific Pub., Singapore*, 2010, Ch. 9

S. Chanda, **O. G. Singh** and K. Ismail

Seminars / Symposia / Workshops / Conferences attended

1. XII- National Conference on Surfactants, Emulsions and Bio-colloids organized by Department of Chemistry, Manipur University in collaboration with Indian Society for Surface Science and Technology. (November 9th to 11th, 2005)
2. A One Day Workshop on Science and Technology for the better quality of life organized by Study Forum for Advanced Technology (N. E.) India and sponsored by Department of Atomic Energy, Govt. of India, held at North Eastern Hill University, Shillong (February 25th, 2006)
3. National Conference on Frontiers of Colloids, Surface and Nanostructured Systems organized by Department of Chemistry, Manipur University in collaboration with North East Chapter, Indian Society for Surface Science and Technology. (February 18th to 20th, 2009)
4. Two-day State Level Seminar on Assessment & Accreditation of Colleges under NAAC: Merits & Benefits organized by Moirang College, Manipur. (March 27th to 28th, 2009)
5. One day State Level Seminar cum Workshop on Semimicro Qualitative Analysis organized by Department of Chemistry, D. M. College of Science, Manipur. (August 14th, 2010)

Place: Shillong

Date: 27/10/2010

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Micellization Behavior of Mixtures of Sodium Dioctylsulfosuccinate with Sodium Dodecylsulfate in Water

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Abstract Mixtures of sodium dioctylsulfosuccinate (AOT) and sodium dodecylsulfate (SDS) that were studied in water at 25 °C by using surface tension, conductance, emf and fluorescence emission methods exhibit synergism in the region where the mole fraction of AOT in the bulk solution (α_1) is less than 0.7 and ideality in the region where $\alpha_1 \geq 0.7$. The molal conductance versus the concentration behavior of an aqueous solution of AOT is found to be different from that of other ionic surfactants with the exception of bile salts. Composition of the mixed micelle was evaluated and discussed using the Rubingh's and the Rodenas–Valiente–Villafruela (RVV) treatments. The values of the counter ion binding constant determined from the emf data show that the counter ion binding behavior of the mixed micelle is controlled entirely by AOT. The free energy for mixed micelle formation was calculated using a modified equation. The aggregation number determined by the fluorescence quenching method indicated that in the mixed micelle, as α_1 increases, the number of molecules of AOT remains constant and that of SDS decreases. Characteristics of the adsorption layer of the mixed surfactant system were also examined using the theoretical treatment of Rosen and Hua.

Keywords SDS · AOT · Mixed micelle · Critical micelle concentration · Counter ion binding constant · Surface excess · Free energy · Aggregation number

Introduction

Compared to single surfactants, mixtures of surfactants perform better and hence formulations developed for different applications in various fields consist of mixed surfactants. Investigation of the micellization properties of mixed surfactants has therefore become fundamental as well as of industrial importance. For forming mixtures of surfactants different combinations of single surfactants are possible. Mixtures of dissimilar types of surfactant ordinarily exhibit considerable synergism. Mixtures of similar type of surfactants are also known to exhibit synergism and among them combinations of same type of ionic surfactants have been studied relatively less frequently than the mixtures of nonionic–nonionic surfactants [1–9]. In particular, mixed systems containing double-chained and single-chained ionic surfactants have not been explored much [3,7–9]. Sodium dioctylsulfosuccinate (AOT) is a widely used double-chained anionic surfactant, because it forms microemulsions without any cosurfactant. To the best of our knowledge, no report is available on the behavior of mixtures of AOT with other anionic surfactants, although one report was found on mixtures of AOT with a cationic surfactant, cetyltrimethylammonium bromide [10]. Therefore, in the present article the micellization properties of mixtures of AOT and sodium dodecylsulfate (SDS) in water have been studied at 25 °C by using surface tension, emf, conductance and fluorescence emission methods.

Experimental Procedures

AOT (Sigma, 99% assay), SDS (Aldrich, 99% assay), pyrene (Fluka, 99% assay) and cetylpyridinium chloride (CPC; Fluka, 98% assay) were used as received. All

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CHAPTER 9

MICELLIZATION CHARACTERISTICS OF SODIUM
DIOCTYLSULFOSUCCINATE. AN OVERVIEW

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The counter ion binding constant of sodium dioctyl sulfosuccinate (AOT) abruptly increases by two fold at about $0.02 \text{ mol kg}^{-1} \text{ NaCl}$. However, such a sudden change in the counter ion binding constant of AOT does not take place in the presence of salicylate ion. The deviation from the Corrin-Harkins relation that takes place in AOT is not due to salting-out effect. It has been shown that at this particular concentration of NaCl the aggregation number of AOT and the polarity of the micellar interface change suddenly. Shift in the polarity of the interface occurring at about $0.02 \text{ mol kg}^{-1} \text{ NaCl}$ is found to be dependent on the probe used. An increase in the dielectric constant of the micellar interface is observed on the basis of the intensity ratio, I_3/I_1 , of pyrene and $E_T(30)$ value of Reichardt's dye, whereas λ_{max} value of pyrenecarboxylaldehyde indicate a decrease in the interfacial dielectric constant. Pyrene and Reichardt's dye are therefore considered to reside initially at the micellar interior and they move to the interface when the NaCl concentration reaches about 0.02 mol kg^{-1} . At this particular concentration of NaCl the shape of the AOT micelle is expected to change.

1. Introduction

Sodium dioctyl sulfosuccinate (AOT) is known to be a special surfactant owing to its ability to form microemulsions without the presence of any cosurfactant.¹⁻⁴ Recently we reported two more special properties of AOT, which are: (1) a different type of counter ion binding behaviour of AOT micelle^{5,6} and (2) a different type of electrical conductance behavior of AOT.⁷ In this paper we highlight the special counter ion binding behaviour of AOT.

Counter ion binding ability is one of the important characteristics of ionic micelles. Counter ions control not only the critical micelle concentration⁸ (cmc) and aggregation number⁹ (N) of ionic surfactants, but also the reactions¹⁰ that take place in the presence of ionic surfactants. Generally, the counter ion binding behaviour of ionic micelles is quantified in terms of counter ion binding constant, β . β is equal to $1 - \alpha$, where α is the degree of dissociation of AOT micelles. The definition of α is the same as that reported by Fletcher and coworkers¹¹ and is given by the relation

$$\alpha = (c_{\text{Na, aq}} - cmc - c_{\text{NaCl}}) / (c_{\text{AOT}} - cmc) \quad (1)$$

In Eq. (1) $c_{\text{Na, aq}}$, c_{AOT} and c_{NaCl} refer to the concentrations of total free counter ion, total AOT and of added NaCl solution, respectively. To estimate β Corrin-

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