PHYSICOCHEMICAL STUDY OF INTERACTIONS BETWEEN TRYPTOPHAN AND ANIONIC SURFACTANT (SODIUM DODECYL SULPHATE) IN AQUEOUS RICH MIXTURE OF DMSO

DISSERTATION-II

To the Lovely faculty of technology and sciences

Lovely Professional University (Phagwara)

In partial fulfillment of the requirement for the degree of Master of Science (Hons.)

In chemistry

Department of chemistry

Submitted by:

JASWAL

REG. NO: 11305638

Supervised By: RINKI

Dr. SANJAY KUMAR

Department of chemistry

Lovely Professional University

DECLARATION

I hereby declare that the dissertation entitled, **“PHYSICOCHEMICAL STUDY OF INTERACTIONS BETWEEN TRYPTOPHAN AND ANIONIC SURFACTANT (SODIUM DODECYL SULPHATE) IN AQUEOUS RICH MIXTURE OF DMSO**” submitted for M.Sc. Chemistry Degree is entirely original work and all ideas and references have been duly acknowledged. This dissertation has not been formed the basis for the award of any other degree.

SIGNATURE

DATE:

RINKI JASWAL

REG.NO: 11305638

CERTIFICATE

This is to certify that Rinki Jaswal has completed her M.Sc. Project work titled **"PHYSICOCHEMICAL STUDY OF INTERACTIONS BETWEEN TRYPTOPHAN AND ANIONIC SURFACTANT (SODIUM DODECYL SULPHATE) IN AQUEOUS RICH MIXTURE OF DMSO"** under my guidance and supervision. The report is fit for the submission and the partial fulfillment of the condition for the award of M.Sc. Chemistry.

Signature of supervisor

Dr. SANJAY K. PATHANIA Date:

Asstt. Prof. Department of chemistry

Lovely Professional University

ACKNOWLEDGEMENT

All praise in the name of almighty God, who give us in the darkness and help in difficulties. The dissertation is the result of full semester of work whereby I have been accompanied and supported by many people. It is a pleasant aspect to that I have the opportunity to express my gratitude for all of them.

I would like to express my gratitude and appreciation towards my supervisor Dr. Sanjay Kumar, Assistant Professor, Lovely Professional University, Phagwara, Punjab (India) under whose guidance, the present work has been completed. He not only provide skillful guidance balanced by the freedom to express myself thoroughly but also shares his experiences and gives valuable criticism which helped me out to overcome each and every obstacle during the course of his work and upcoming life.

I would like to acknowledge Dr. Ramesh Thakur (Dean) Lovely School of technology and Science for their support and co-operation. And to my Chemistry Department faculty Dr. Ramesh Thakur (HOD), Dr. Rekha, Dr. Harpreet kaur and Dr. Ajay Sharma.

I would like to thanks to Mr. Vivek Sharma (PhD Scholar) and my galaxy of friends of M.Sc. (Hons.) and M.Sc. (regular) for their support and co-operation.

I would like to express my heartfelt thanks to my beloved parents for their blessings, motivation and encouragement throughout this project and my life.

I also want to my special thanks to Lab assistant Mr. Manoj, Mr. Parveen Kumar, Mr. Varun Kumar, Mrs. Renki for providing their assistance while doing experiment work in laboratory.

RINKI JASWAL

CONTENTS

GLLOSERY OF ABBREVATIONS

NAME	ABBRIVATION
SDS	Sodium dodecyl sulphate
CMC	Critical micelle concentration
DMSO	Dimethyl sulphoxide

GLOSSERY OF SYMBOLS

Symbol	Meaning
C	Molar concentration
T	Temperature
R	Universal gas constant
κ	Specific conductance

LIST OF TABLES

LIST OF FIGURES:

9	Δ Vs. tryptophan concentration in aqueous rich mixtures of DMSO at 298.15 K	
10	[SDS] v/s absorbance of tryptophan at aqueous rich mixture of DMSO	

-

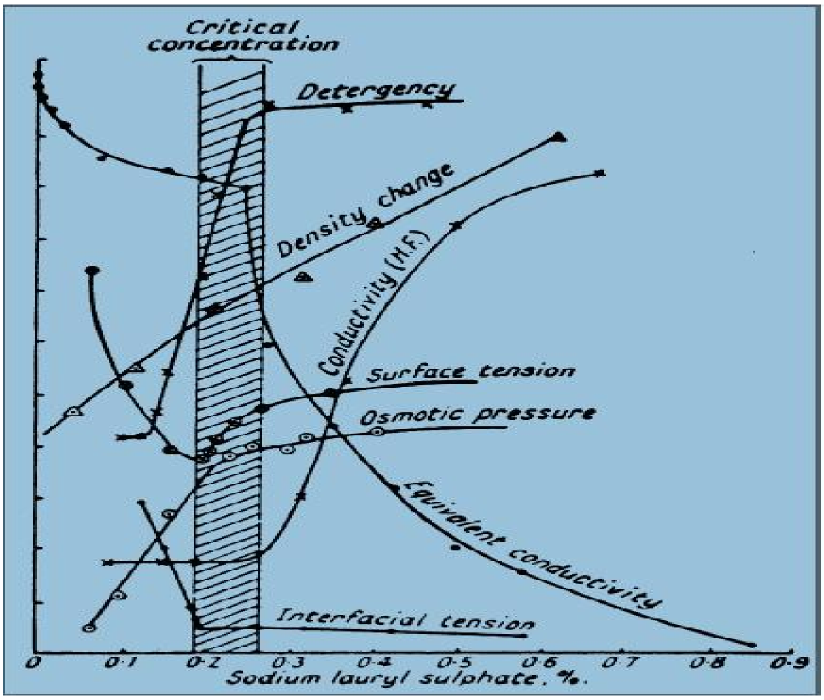
CHAPTER-1

INTRODUCTION

(Review of literature, Objectives of present study)

INTRODUCTION

The relevance studies on amino acid-surfactant interaction [1]comes from the manifold applications of amino acid-surfactant system for e.g. from the various industries like food pharmaceutical industry. At low amino acid concentration, the amino acid-surfactant interaction is the determination of binding isotherm, which yield the binding number i.e the number of surfactant molecule that bound per amino acid molecule as a function of surfactant concentration. Techniques used for the binding studies is include ultra filtration, potentiometry, ion selective electrode and surface tension. This thesis is an experimental study of amino acid- surfactant interaction.



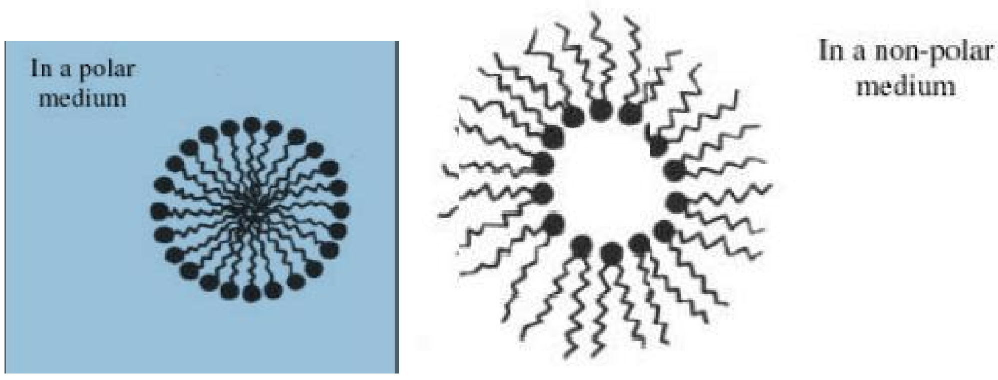
[2]We can calculate CMC by various methods like UV or IR spectroscopy, surface tension, osmotic pressure, conductivity, equivalent conductivity and interfacial tension. The physical and chemical properties of surfactant vary above and below the cmc value of the physical chemical properties of ionic surfactant like sodium dodecyl sulphate resembles of the strong electrolyte. Above the cmc values the physical and chemical properties changes that indicating a highly cooperative association process is taking place. The cmc values are important in many processes of industry surfactant applications, from mineral processing to formulation of personal care products and foods, to drug delivery systems and to new surfactant remediation technologies. In all these processes, surfactant must usually be present at a concentration higher than the cmc because the greatest effect of the surfactant, whether in interfacial tension lowering, [3] emulsification, suspension stabilization, as a delivery vehicle, or in promoting foam stability,[4] is achieved when a significant concentration of micelles is present. The general way

of obtaining the cmc value of a surfactant micelle is to plot an appropriate physico-chemical property versus the surfactant concentration and observe the break in the plot.

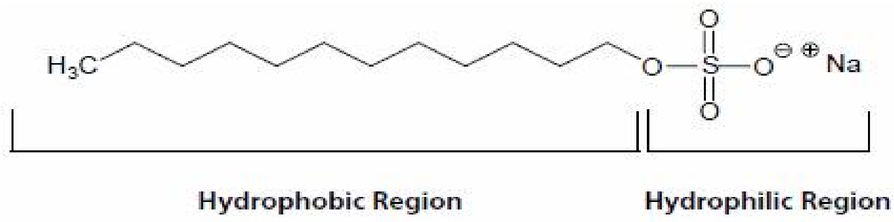
Spectroscopy is a technique that measure the interaction of the molecule with the electromagnetic radiation. Light in the near uv and visible range of the electromagnetic spectrum has an energy of about 150-400kj mol^{-1}. The energy of the light is used to promote the electrons from the ground state to an excited state. A spectrum is obtained when the absorption of the light is measured as a function of its frequency or the wavelength. Molecules with electrons in delocalized aromatic system absorbs light in the near UV or the Visible region[5].

1.1 Surfactant:

All the surfactants having a major role in our daily life with the variety of applications in biology, chemistry and pharmaceuticals industries[6]. Surfactants are also named as surface active agents. Surfactants are those compounds that have lower the surface tension between two liquids or between liquid or a solid. Surfactants may act as a detergents, emulsifier, foaming agents etc. On the basis of diphillic nature of substance surfactant can be classified in anionic surfactant, cationic surfactant, non ionic surfactant or zwitter ionic surfactant. Every surfactant molecule having physical property like critical micelle concentration. On the basis of CMC we find all the thermodynamic parameters. Micellization phenomenon is responsible for all kind of activity of surfactant. Micellization is due to diphillic nature of surfactant molecule having different special arrangement in different system[7].



For example: the anionic surfactant SDS when dissolve in the aqueous medium at low concentration of SDS always having specific or co-operative bonding. At high concentration of surfactant in aqueous medium always causes the specific or non co-operative always causes the micellization of surfactant. Inspite of hydrophilic and hydrophobic bonding of surfactant another factors such as temp, pressure also affect the behavior of micellization. The physical and chemical properties of diphillic substance has determined by traubey's law. The reactivity of diphillic substance will be triple fold by introducing the CH_2 group. As the hydrocarbon chain increases the large amount of energy is gained by the micellization and hence the value of CMC decreases as the length of hydrocarbon increases. The diphillic nature of surfactant molecules act as a electrolyte. It has been observed that the CMC values for all type of surfactant ranges from 0.5-20Mm/L[8].

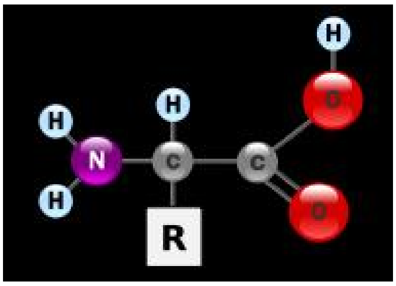


Sodium dodecyl sulphate is an anionic surfactant and it is an organosulphate consisting of 12 carbon atom attached to a chain with sulfate. The molecular formula of sodium dodecyl sulphate is $NaC_{12}H_{25}SO_4$. The molecular weight of SDS is 288.38g/mol and the melting point of SDS is the 208°C. In SDS one is hydrophobic region and one is hydrophilic region. SDS is used in many cleaning and hygiene products. SDS is used in detergents for laundry with many cleaning purposes. It is very highly effective surfactant and it is used in the removal of oily stains and residues. It is found in the higher concentration with many industrial products including engine degreasers and car wash soaps and many other purposes. It is also present in toothpaste, shampoos, shaving cream and bubble bath formulations and its ability to create lather. SDS is having a variety of laboratory applications. It is used to aid in lysing cell during DNA extraction and is used in preparing electrophoresis in SDS-PAGE technique[9]. Negative charge of SDS is signifies greater than the original charge of that amino acid. The electrostatic interaction is created by binding of SDS that causes protein to unfold in to a rod like shape thereby eliminating the differences in a shape as a factor for separation in gel. SDS is probably most researched anionic surfactant compound. Like all the detergents SDS removes the oils from the skin and can cause skin and eye irritation. SDS is also used in the analysis of hemoglobin. The hydrophobic group of SDS acts upon the globins subunit, it causes the conformational change. The hydrophilic part of the SDS binds with the oxidized iron subunit producing a stable reaction product which can be analyzed , giving a hemoglobin value which is used for complete blood count[10].

1.1 **Amino acid**:

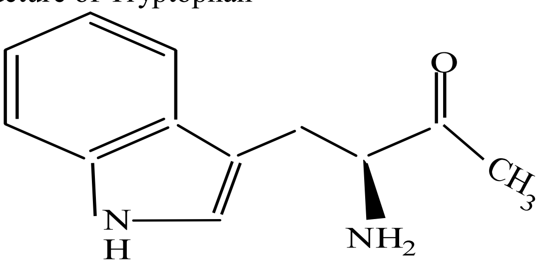
Amino acids are biologically organic compound composed of amine and carboxylic acid functional group along with a side chain specific to each amino acid. About 500 amino acids are known and can be classified in many ways. They can be classified according to the core structural functional group as alpha, beta, gamma, delta amino acids[11].

Structure of alpha amino acid



Tryptophan is an essential amino acid and it is used in human diet. It is soluble in water. It's molecular mass is 204.23g/mol. It is present in many food sources like chicken, cheese, egg, fish, milk, nuts, peanuts etc. Tryptophan act as a building blocks in protein biosynthesis.It is used as a dietry supplement and drugs[12.]

Structure of Tryptophan



Tryptophan

The IUPAC name of tryptophan is (2S)-2-amino-3-(1H-indol-3-3yl) propanoic acid. The molecular formula of tryptophan is the $C_{11}H_{12}N_2O_2$. The molar mass of tryptophan is 204.23g/mol. Tryptophan is soluble in distilled water and it is also soluble in hot alkali solutions . It is the standard amino acid which is very essential for the human diet. The L-stereoisomer is only used in the structural or enzyme proteins. In tryptophan it is U-V active because of its conjugation, but the R stereoisomer is found in pesticides[9]. In structural characteristics the tryptophan contain the functional group indol.. The biosynthetic is the industrial production of tryptophan and it is based on the fermentation of serine. .These strains prevent the amino groups present in protein.. The conversion is catalysed by the enzyme tryptophan synthase [13,14,15]. Tryptophan is a routine constituents of protein based food or dietry proteins. The main food resources of tryptophan is milk, cheese, egg, milk, fish, sunflower seeds, pupkin seeds, peanuts etc. Trytophan is used as a dietry supplement and drug. Tryptophan is converted in to 5-Hydroxy tryptophan which is subsequently converted in to the neurotransmitter serotonin, it has been purposed that the consumption of tryptophan of 5-HTP , it improve depression symptoms by increasing the level of serotonin in the brain[16]. L-tryptophan is an essential amino acid that helps the body make protein and certain brain-signaling chemicals. Tryptophan is an neural essential amino acid important for human growth. Tryptophan inhuman can’t be synthesized de novo and derived from dietary sources such as poultary and dairy products.

REVIEW OF LITERATURE

S. Chauhan *et.al* studied the micellization characteristics of CTAB in variable concentration of leucine at variable temperature. They were plot different graph of specific conductance vs. concentration of CTAB to determine CMC of CTAB. They were seen the result of CMC value of surfactant with variation the concentration of leucine and temperature they conclude that when temperature low to high CMC value go up side. But when addition of leucine value of CMC goes down side. From the CMC data he determined the various thermodynamic parameters like Gibbs free energy, entropy, enthalpy. With the help of velocities and densities of sound data they find that the apparent volume and compressibility. All the calculated parameters are showing the interaction of leucine –CTAB –water system. They conclude that amino acid disturb the micellization of CTAB. In leucine –CTAB system give rise electrostatic interaction and it less effective when concentration of both are low. They also seen when concentration was increased of surfactant this was due to more hydrophobic forces in the medium. This study clearly shows that the CMC of CTAB gets decreased by amino acid different study like volumetric, compressibility and florescence study[17]. S. Pathania *et.al* studied the micellization due to protein-surfactant interaction of SDS in aqueous gelatin solution. They study that electrostatic interaction water repelling concentration that make undersize chain of water with hydrocarbon this effect shown by CMC with gelatin concentration seen the value with without between charge consumption of SDS. A consistent increase in CMC by adding DMSO is suggested due to structural consequences of intermolecular interaction. Change in micellization of entropy and enthalpy correlate well with the testimony that bears the head group contribution of SDS. Compensation is observed between change in micellization of enthalpy and entropy value is further supported by a weak gelatin concentration dependence of change in micellization of Gibbs free energy less than zero[18]. S. Chauhan *et.al.* studied the structural changes in lysozyme on the addition of the CTAB. The critical micelle concentration of cationic surfactant CTAB has been calculated from the surface tension measurement and it is found to be increase in lysozyme concentration increases with the temperature. Surface tension data has been used to calculate the interfacial parameter; maximum surface excess concentration , minimum area per molecule, standard free energy of adsorption, standard free energy of transfer that have direct bearing on the consequences of such interaction at the molecular level. Negative value of standard Gibbs energy changes indicate the spontaneity of micellization. They conclude that the cationic surfactant–lysozyme binding result is long range ordering of water molecule around the protein molecule. They suggested that unlike charged protein-surfactant system, the interaction between CTAB and lysozyme system induce no significant change in conformation of lysozyme. They consist that in such system the conformational changes due to the presence of surfactant are expected at only higher surfactant concentration[19]. S. Chauhan *et.al* studied the density, ultrasonic velocity and viscosity studies of SDBS and DTAB in water and in the aqueous solution of L-glutamine, L-Histidine and L-Methionine at different temperature. The apparent molar volume dependence on SDBS and DTAB concentration reflect the modification of the water-water interaction described as hydrophobic hydration of the surfactant molecule in the presence of the amino acid. The Increase in the relaxation time with increase in the concentration of the surfactant and decrease with temperature due to structural relaxation processes occurring as a result of rearrangement of the molecule. They conclude that the behavior of both these surfactant in aqueous solution of amino acid because this formalization is able to account for the relative contribution of electrostatic and hydrophobic interaction between surfactant and amino acids. It means that the interaction between surfactant and amino acid as inferred from the change in the micellar region of these surfactant that lead to the formation of complex aggregates of SDBS/ DTAB and amino acid which remained the hydrated temperature range. As increase in the viscosity values has been attributed to increase hydrophobic-hydophillic and hydrophilic-ionic interaction with increase in amino acid concentration may cause frictional resistence to flow of a solution. With the increase in temperature the viscosity decreases has been observed because of decrease in the extent of different intermolecular interaction present in such system[20]. S.Chauhan *et.al*. studied the carbohydrate-surfactant interaction and micellization behavior of anionic surfactant in aqueous solution of maltodextrin have been studied using density, sound velocity, viscosity and surface tension at the different temperature. Density and speed of sound data has been used to derive the parameters like isentropic compressibility, apparent molar volume and apparent molar isentropic compression. Surface tension is used to calculate the surface excess concentration , minimum area occupied by the surfactant and surface film pressure whereas the relaxation time is calculated by using the viscosity data. Volumetric measurement indicate that the apparent molar volume values are positive and increases with rise in temperature as well as with the increase in the percentage of maltodextrin. surface tension and relaxation time decreases with rise in temperature. They conclude that the volumetric studies point the delayed micellization for SDS in presence of maltodextrin which is further supported well by the surface tension studies. In case of maltodextrin with SDS, at low surfactant concentration there are electrostatic interaction but at higher concentration of surfactant , hydrophobic interaction play major role. Surface excess and minimum area occupied by surfactant complementing each other, thus, reveals the considerable amount of an association or interaction taking place in SDS-maltodextrin system[21]. Kundan Sharma *et.al* studied the densities and sound velocity of an ethoxylated alkyl phenol surfactant in aqueous solution of two amino acids, glycine and leucine has been measured in different temperature range by using velocity and sound analyzers. These data has been used to calculate the isentropic compressibilies, apparent molar volumes and apparent molar adiabatic compassions in order to explain amino acids-surfactant interaction. This result has been discussed in terms of the effect of amino acids on the micellization behavior of surfactant. They found that both the amino acid produce a decrease a decrease in the CMC value of nonionic surfactant but to different extent. They conclude that in both the cases the hydrophilic-hydrophillic and ion-hydrophillic interaction are more dominant in the pre-micellar region, but that in the post micellar region hydrophobic-hydrophobic interactions are favorable making micellization is a favorable process[22]. Soumen Ghosh et.al studied the interaction of bovine serum albumins (BSA) with alkyltrimethylammonium bromide (ATAB) under the experimental conditions of phosphate buffer at pH7 in the presence of sodium bromide for maintaining the overall solution which is used. BSA-ATAB corresponds to a polyion-surfactant system both bearing opposite charges. BSA precipitated out of the solution on addition of ATAB solution over a certain range of ATAB concentration. On the precipitation of oppositely charged polymer-surfactant the tensiometric profile for surfactant addition on polymer in the dispersion medium. In this study the precipitation process could hardly affect the smoothness affect the tensiometric profile. This indicates that the interaction process is operative in the bulk solution. Microcalorimetric profiles are also evidenced an extra pump in the interaction profile at lower surfactant concentration without much affecting the dilution enthalpograms in beyond the micellization. This interaction appeared unimodal and the extent of interaction increase with increasing tail length of ATAB evidencing the hydrophobic effect. Sodium bromide also affect the nature of interaction at lower concentration of sodium bromide the interaction was mildly assisted. The non ionic surfactant interacted with BSA. The anionic amphiphile SDS interact with BSA in two different stages as evidenced from tensiometric profile. The complexity of BSA-SDS tensiometric isotherm compared to that of BSA-ATAB arise from the presence of cationic binding sites adjacent of hydrophobic patches of BSA in its native sites so that the both the interaction electrostatic and hydrophobic interaction can cooperatively operate side by side with the surfactants. The interfacial saturation occurred at a lower concentration in the presence of BSA compared to the normal critical micelle concentration of SDS under identical solution condition in the absence of protein BSA which has slightly delayed the non ionic. Different experimental technique probe different physicochemical phenomena and to show the break point in different technique is only diluting the essence of this area. They conclude that the BSA-ATAB system represent oppositely charged polyelectrolyte-surfactant system the interaction profile using tensiometry are much simpler compound to a BSA-SDS system with similar charges. This is an outcome of the special peripheral topology of BSA in its native state. The cationic amino acid residue are peripherally distributed in such a way that the hydrophobic between the alkyl chain of SDS and hydrophobic pockets of globular , native state of protein BSA is reinforced by the electrostatic interaction between the surfactant and the cationic amino acid. The topology of native state of protein BSA structure increases the stability of native protein structure up to low. This topology is also increases the thermal stability of the native configuration of BSA against the denaturation aided by SDS. The stabilizing effect of BSA-SDS complex is absent for ATABs. Progressive additions for ATABs beyond charge neutralization therefore forces the biopolymer to unfold. The efficiency of ATABs towards unfolding of native BSA structure is also studied from the CD spectroscopy. In ATABs the extent of interaction decreases with decreasing chain length as expected from the interplay between electrostatic and hydrophobic interactions between the polymer-surfactant. The height of the initial pump in BSA –ATAB interaction enthalpograms also dies down with the decreasing alkyl chain length among the homologues representing the effectiveness of hydrophobic interaction. The close resemblance between the dilution and interaction enthalpograms beyond monomeric absorption indicate the interaction of BSA and ATAB in aggregated form. The completion of the initial pump is considered as the saturation concentration of BSA-ATAB interaction. Turbidity of the BSA solution result as expected from monomeric adsorption of ATAB on BSA and consequent desorption of water of solvation. This indicate that the process occur in a bulk solution and hardly hampers the solution interface pointing the unimodal interaction consisting of simultaneous denaturation and interaction of BSA and ATAB in the bulk solution[23]. R.G Srestha *et.al* discussed the formation of viscoelastic micelles in mixed amino acid-based anionic or non ionic surfactant in aqueous system in the absence of salt. They conclude that the solution viscosity increases constantly but after a certain concentration the elongated micelles forming a rigid network of wormlike micelles and the solution viscosity increases[24]. R.S *et.al* studied the interaction of anionic surfactant sodium dodecyl sulphate with aqueous PEG or PVP. CMC, standard free energy of micellization, standard enthalpy of micellization, standard entropy of micellization, apparent molar volume of SDS in aqueous polymer mixtures. The trends of variations obtained by the various parameters have been explained in terms of electrostatic as well as hydrophobic interactions pertaining in SDS-PEG/PVP-water systems. They conclude that the interaction of SDS with non ionic polymer suggest that the polymer which interact strongly with

SDS increases its micellar stability drastically and decrease CMC value to a large extent. At higher PVP concentration, it seems that PVP affects the CMC of SDS to a greater extent than the PEG due to the dominance of electrostatic interactions offered by polar PVP to the anionic surfactant. The thermodynamic parameters show that micellization of SDS is a spontaneous, endothermic and entropy controlled process for all the studied systems. These results were also affirmed by the conclusions drawn from the volumetric and compressibility parameters[25]. A.Z *et.al* studied the measurement of density, viscosity and conductivity and light scattering of aqueous solution of surfactants. In case of ionic surfactant the degree of surfactant dissociation in micelles was taken. There was also determined the standard Gibbs energy of micellization using hydrophobic , hydrophilic interfacial free energy and electrostatic intermolecular interactions. These results were compared with those obtained by the another methods. The presence of micelles at the concentration of aqueous surfactant solutions determined by the various methods was confirmed by the light scattering measurements[26]. K.S.Rao *et.al* studied the self aggregation of amino acid ionic liquid of surfactant in the aqueous solution has been estimate through various methods like surface tension, conductivity, dynamic light scattering and transmission electron microscopy(TEM). Surface tension measurement is to be used the surface absorption properties such as absorption frequency. Temperature dependent conductivity measurement has been used to obtain the thermodynamic parameters. The cac of was found much lower as compared to the conventional ionic surfactants or analogous imidazolium-based of the same alkyl chain length due to large size and high hydrophobicity of amino acid[27]. J.C Ahluwalia *et.al* discussed the effect of the binding and the conformational changes induced by anionic surfactant SDS and SOS on BSA using differential scanning calorimetry, CD and UV spectroscopic methods and various other techniques. The denaturation temperature, vant'hoff enthalpy and calorimetric enthalpy of BSA in the presence of SDS and SOS and urea at pH7 has been determined. The result indicate that the SDS play two opposite role in the folding and stability of BSA. It increases the stability of protein against thermal denaturation. At higher conc. Of SDS the binding of SDS to denatured protein is more prenominant and unfolding occurs[28]. C.C *et.al* studied the fluorescence study of surfactant and protein A from these porcine and human bronchoalveolar lavage is determining in the absence and in the presence of the lipids. After excitation at 275 or 295 nm, the fluorescence spectrum of both proteins was characterized by two maxima at about 326 and 337 nm, it clearly indicating the heterogeneity in the emission of the two tryptophan residues of SP-A, and also revealing a partially buriedcharacter for these fluorophore. They concluded that the interaction of some phospholipid vesicles with SP-A produces a conformational change on the protein molecule and that the interaction of SP-A with

DPPC is stronger than with other phospholipids[29]. A.V et.al studied the protein-surfactant interaction in aqueous medium. The globular protein BSA and lysozyme is used and the ionic and non ionic surfactant is used. Fluorescence study showed that at low sodium dodecyl sulfate whose concentration one micelle-like SDS cluster is bound to lysozyme. From dynamic light scattering results it was observed that lysozyme in the complex does not correspond to the fully unfolding of the protein. At high SDS whose concentration one compact and one more extended lysozyme-SDS complex coexist[30]. K.S *et.al* studied the association hydrophobic behavior modified by hydroxyethyl cellulose and its interactions with the two types of the surfactant in dilute solution have been described by various techniques like surface tension fluorescence spectroscopy, and viscometric. Florescence data shows that the hydrophobic group of the HMHEC associate to form the clusters above a critical micelle concentration is of around 500pm. The presence of hydrophobic group on the polymer enhances the interactions between the polymer and non ionic surfactant[31]. T.L *et.al* studied the UV absorption spectra of polystyrene. One absorption band is appeared at around 290nm in comparison with the ethylbenzene. Same absorption bands is also appeared for polymers like styrene polymer. The UV spectra tells that the complex formation of charge transfer between the polymeric and monomeric donors with electron acceptor[32]. F.L *et.al* studied the interaction between anionic surfactant PVP are analysed by using ^{13}CNMR , ESR sopectroscopy and surface tension measured at their air interphase. The behavior of single chain structure of AS compared to with the double chained surfactant. The AS micelles nucleats over the polymer sites as hydrophobic sites and the mobility of AS head group are not affected[33]. D.D *et.al* studied the volumetric and compressibility properties of some lithium salt in N,N –Dimethylacetamide from density and sound velocity measurement. The apparent molar compressibilies at infine dilution have been evaluated. The result shows that the size of anion increases electrostatic salvation has an increases tendency and compressibility of the solution decreases[34]. J.C *et.al* studied that the effect of interaction between the oppositely charged, the positively charged of gelatin and the sodium lauryl sulphate with negative charged beta-lactoglobulin in the solution and emulsification also has been studied. The concentration of the surfactant of the maximum degree of flocculation is higher than that of maximum precipitation in the bulk aqueous solutions. They conclude that the positively charged gelatin and anionic surfactant molecule form visible complexes over a range of protein and surfactant concentration. The pH condition and in the presence of another protein will affect the precipitation behavior[35]. M.Bloor *et.al* studied that the compressibility of the micellar solutions of the surfactant take sodium dodecyl sulphate, sodium decyl sulphate, sodium decyl sulphonate, sodium octyl sulphate has been determined from the sound velocity measurement. It was find that it is control the compressibility of the micellar aggregate is the nature of the surfactant head group. The micelle resembles with an micellar aggregate with an compressible core surrounded by a less compressible surface structure[36]. S.M *et.al* studied that the thermodynamics of surfactant, block copolymer and their mixture in water determined to the enthalpy function. It is also used to calculate the enthalpy of micellization of surfactant and block copolymer. The aqueous copolymer-surfactant mixture was determined by means of isothermal titration calorimetry and the enthalpy of the transfer of the copolymer[37]. A.Y.F.Cheung *et.al* studied the interaction between the different pairs of a synthetic polymer and surfactant in the aqueous solution. These systems are of inherent properties and it has useful properties. They conclude that the interaction between gelatin and SDS involves both the electrostatic contribution and hydrophobic contribution. The hydrophobic contribution of gelatin is easily removed from the water[38].

CHAPTER-2

EXPERIMENTOL WORK

(Materials, instrumentation and experimental procedure)

EXPERIMENTAL WORK

The experimental part of the dissertation has been dicussed in detailed as

MATERIALS:

Water:

Triple distilled water is prepared by double distillation in the presence of alkaline $KMnO_4$. The triple distilled water of conductivity range is 0-2x$10^{-7}Scm^{-1}$ and pH in the range 6.8-7.0 all at 25℃ was collected to use in all the experiments.

Sodium dodecyl sulphate:

Sodium dodecyl surfactant is an anionic surfactant was supplies by LOBA Chemie Pvt. Ltd. The salt consist of an organosulphate consisting of 12-carbon tail attached to a sulphate group having the molecular formula $NaC_{12}H_{25}SO_4$. The molecular weight of SDS is 288.38$gmol^{-1}$ and the melting point is 206℃

Dimethylsulphoxide (DMSO):

It is an organosulphur compound. The molecular formula of dimethylsulphoxide is $(CH_3)_2SO$. DMSO is an organic solvent which is used in biological studies as in drug tissues. In DMSO oxygen has two lone pair because of that lone pair when it interact with water form a strong bond just because of lone pair of oxygen. In DMSO two methyl group id their one sulphur or one oxygen is their. In DMSO molecule form strong bond with four molecule of water. In addition, the molecule causing effect of hydrophobic association of DMSO molecule. The combination of polar and non polar characteristics makes DMSO and its aqueous solution is important solvent in organic chemistry and fine chemical industries. The molecular weight of MDSO is 78.13g/mol. The boiling point of DMSO lies in the range between 189-192. The melting point lies in the range between 18-19c. The dipole moment of DMSO is 3.96D. DMSO was used a a solvent of AR grade and supplied by CDH research Lab. Pvt. Ltd.

Tryptophan:

Tryptophan is an essential amino acid and used in human diet. It is soluble in water and it's molecular weight is 204.23g/mol. Tryptophan act as building block in protein synthesis. Tryptophan was supplied by TITAN Biotech Ltd. Tryptophan is used as a dietry supplement and drug.

EQUIPMENTS:

Beaker, Water bath, conductivity meter, glass rod, micro-pipette,

INSTRUMENTATION:

Conductivity meter:

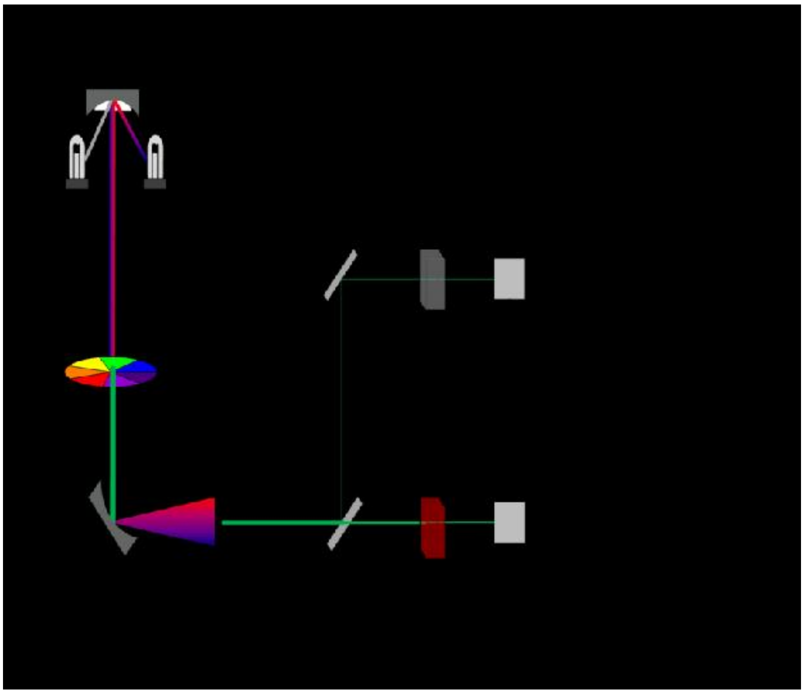
Digital conductometer operated by 9V battery measures the conductivity of any solution. Conductivity meter. Conductivity meter measure the conductance in the range from 2mS/cm to 20 mS/cm. At 25℃ , the cell constant of conductivity cell is determined.

.

Digital Water Bath:

Digital water bath is used to the temperature controller. It is a low label water sensor. Digital water bath is supplied by Bombay scientific pvt. Ltd. The temperature of the digital water bath maintained within ±0.1°C over the entire temperature range studied i.e., 25-35°C. The temperature of the water bath was continuously monitored with the help of a 1/100°C by a calibrated thermometer.

UV Spectrophotometer:



Ultra-visible spectroscopy is a type of absorption spectroscopy. The light use in the visible region. Molecules undergo transition in the region of electromagnetic spectrum.. This spectroscopy is also a fluorosence spectroscopy. In fluorosence spectroscopy it involves the promotion of electron from the ground state to the higher energy states. The electromagnetic radiation with a particular value of frequency is able to cause excitation. Those substances absorbed in the visible region it will appear colored to the human eye. The wavelength of absorbed radiation can be expressed in terms of frequency or energy in Kcal/mol. The absprption spectrum consist of absorption bands. It is helpful to measure the number of conjugated double bond and aromatic conjugated in the many molecules[39].

Principle of ultra-visible absorption

Those molecules which containing the non bonding electron or pi electron can absorb energy in the form of radiation to excite the electron to the higher molecular orbitals. Those electrom which is easily excited the electrons the longer the wavelength of light it can absorbs.

The U-V range divided in three parts like Far or vacuum ultraviolet region is between 10-200nm ,Near or quartz ultraviolet region is between 200-380nm ,Visible region is between 380-780nm .

U-V visible spectroscopy is used to measure the number of conjugated double bond in the various molecules. In a single beam instrument the light is passed through the sample as one time only one sample of U-V is taken. In U-V instrument first a cuvette is fill with a blank sample and select a base line in the system and select the base line and then removed the cuvette and add another sample and then start and then read the absorbance. The sequence of steps is maintained for every measurement . The output is noted in detector , maintained the sensitivity of output and detector. now we discuss the various part of U-V instrument. Radiation source is better spectrometric method , It has a high intensity. Radiation source is divided in to two parts thermal and electric charge source. Deuterium discharge lamp: the most common source of the visible radiation is the ordinary tungusten filament lamp. It consist of a thin coil of tungsten wire sealed in a evacuated glass bulb. Monochromator: Disperse the radiation according to their wavelength, it is the main purpose of the monochromator. It also disperse the light over the visible region of the spectrum. It is not transparent to radiation with wavelength between 350 and 200nm because glass absorbs strongly. In U-V spectra can be recorded in solution phase and the samples are placed in cuvette. Cuvettes may be made by quartz or glass or plastic. Plastic and glass are only visible for visible spectra.In cuvette first we put a blank sample and then put the solution sample. Detectors: The four common types of detectors used in uv spectroscopy Barrier cells, Phototube or photo-emmisive tubes,Photomultiplier tubes and Semiconductor devices are of two types one is Light dependent resistors and another is

Linear photodiode array. In detector we see the absorbance of samples. It is the main part of the U-V instrument. Without any detector we are not able to seen any data[40].

EXPERIMENTAL PROCEDURE:

Aqueous stock solution of SDS of different molar concentration in the range 2-12mM were prepared by the addition of small aliquots of concentrated stock solution of SDS to 50ml of 0.0005, 0.001, 0.005 and 0.01M tryptophan solutions prepared as a solvent medium. Conductivity has been measured with digital conductometer. The conductivity cell was calibrated with 0.01M KCl. At first, determine the cell constant of the given conductivity cell. Rinse the conductivity cell with the solution whose conductivity is to be measured. Taken 0.0102g tryptophan in 250ml beaker and dissolve it in 100ml water. It dissolve with a stirrer until it should be completely dissolve. Wash the conductivity cell with distilled water and then rinse it with given the tryptophan solution. Dip the cell in a solution taken in a beaker. Set the temperature control to the actual temperature of the solution under test. Taken the SDS 3gm in another 100ml beaker and it dissolve in 10ml water. Taken the 1ml pipette and suck the 0.1ml SDS solution with the help of pipette and added in to the beaker contain tryptophan solution. Stir and determine the conductivity . Repeat it after 1 minute and note down the readings. Taken 30 readings in this way at different temperature (20°C, 25°C, 30°C and 35°C). Repeat the procedure with change the concentration of tryptophan in 250 ml beaker and also dissolve in 100ml water and not change the concentration of SDS. And take the 0.45ml DMSO solution in a pipette and add in tryptophan solution. Set again the cell constant of the conductivity cell in the distilled water. Put the cell in to the beaker contain tryptophan solution. Take the 3gm SDS in another 100ml baker and dissolve it in 10ml f distilled water. Add the 0.1ml SDS in the tryptophan solution, stirr it and note the conductivity. Repeat it again at different temperature i.e 20°C, 25°C, 30°C and 35°C .and with the different concentration of tryptophan. Also change the concentration of DMSO. When the above procedure is completed. Again repeated the above procedure with change the concentration of DMSO and note the conductivity for this.

Xcmc (cmc in mole fraction) Determination by conductivity Measurements:

The Xcmc was determined by conductivity method. A series of concentration of SDS (2-12mM) was prepared by adding a known volume of stock solution of this surfactant by 10µL capacity micropipette. The beaker and cell were gently clamped and immersed in the water bath. Before reading the conductance value, the beaker and cell were attain to allow the temperature of the water bath. The conductivity, κ were plotted against the molar concentration of the surfactant and CMC values were determined as concentration corresponding to the break point between in κ vs. surfactant. However, each experiment was carried out at four different temperature 20°C, 25°C, 30°C and 35°C. Similar procedure has been used for the determination of CMC of SDS in aqueous mixture of 0.23mol%, 0.46mol%, 0.69mol% and 0.91mol% DMSO.

CMC values is used to estimate the thermodynamic parameters like standard enthalpy change of micellization $\Delta H°_m$, standard Gibbs free energy of micellization $\Delta G°_m$, standard entropy change of micellization $\Delta S°_{m.}$

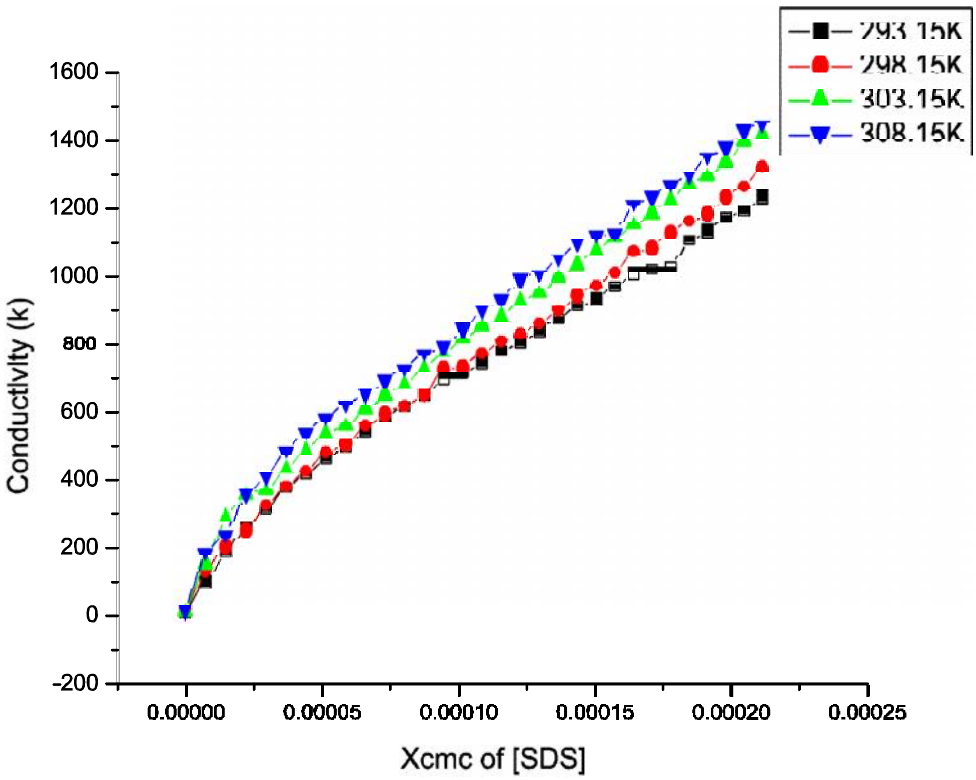


Figure 1: The plot of conductivity versus [SDS] in aqueous solution containing 0.001M w/v Tryptophan at different temperature.

CHAPTER-3

RESULT, DISCUSSION AND CONCLUSION

Conductometric measurements:

The critical micelle concentration of SDS is calculated by plotting the graph of specific conductance of SDS in aqueous solution of different amino acid concentration like 0.0005, 0.001, 0.001 and 0.01M tryptophan at different temperature by the conductivity method. A general plot of conductivity v/s SDS in aqueous solution containing concentration 0.001M of tryptophan at different temperature as shown in the figure1. Before calculating all the thermodynamic parameters in SDS-tryptophan system, we have to determine the temperature dependence of Xcmc that is cmc in mole fraction of SDS in aqueous solution of tryptophan at each concentration of tryptophan. This clearly signifies that the cmc value of surfactant increases with the increase in temperature.

[41]The Xcmc data has been reported in the table were used to calculate the standard enthalpy of micellization $\Delta H°_m$ of SDS in aqueous solution of amino acid from the equation.

$$\Delta \quad = - \quad {}^{2} \quad \frac{\ln}{\quad} \tag{1}$$

In above equation $\frac{\ln}{\quad}$ is the slope of straight line is obtained by ploting ln Xcmc against T and at is the degree of the counter ion dissociation which has calculated from the relation.

$$\propto = \frac{\quad}{(\ _2) \quad\quad (\ _1)} \tag{2}$$

S_1 is the slope in the pre micellar region and S_2 is the slopes in the post miceller region determined from conductivity plots. The standard entropy of micellization $\Delta S°m$ and standard free energy of micellization $\Delta G°_m$ were calculated by using the following relations

$$\Delta \quad = \frac{\Delta \quad - \Delta}{\quad} \tag{3}$$

$$\Delta = 2 - \propto \tag{4}$$

Thermodynamic parameters of SDS in aqueous solution of tryptophan at different temperature are given in table1,2,3 and table4.

Table 1: Standard Thermodynamic Parameters of micellization of SDS in 0.0005 M Tryptophan containing different concentrations of DMSO at different Temperatures.

Temp (Kelvin)		0 mol% DMSO			
	X_{cmc} 10 ^{5}		ΔH kJ mol^{-1}	ΔG kJ mol^{-1}	ΔS JK^{-1}mol^{-1}
293.15	4.75	0.41	-16.92	-38.33	73.04
298.15	5.00	0.49	-16.95	-37.56	69.13
303.15	5.25	0.51	-16.38	-35.52	63.14
308.15	6.00	0.54	-17.16	-36.11	61.51
		0.23 mol% DMSO			
293.15	4.25	0.51	-17.62	-36.55	64.59
298.15	4.50	0.53	-17.98	-36.47	62.02
303.15	4.75	0.57	-18.08	-35.88	58.70
308.15	5.50	0.55	-18.95	-36.44	56.76
		0.46 mol% DMSO			
293.15	4.50	0.61	-26.56	-33.91	25.08
298.15	4.75	0.56	-28.46	-35.53	23.73
303.15	6.00	0.63	-27.99	-33.57	18.39
308.15	6.50	0.59	-29.77	-34.83	16.43
		0.69 mol% DMSO			
293.15	4.75	0.56	-12.80	-34.94	75.52
298.15	5.00	0.64	-12.50	-33.39	70.04
303.15	5.25	0.62	-13.12	-34.28	69.80
308.15	5.75	0.63	-13.45	-34.27	67.55
		0.91 mol% DMSO			
293.15	5.50	0.61	-12.98	-33.23	69.07
298.15	6.25	0.65	-13.04	-32.39	64.91
303.15	6.50	0.73	-12.68	-30.86	59.96
308.15	6.75	0.71	-13.31	-31.74	59.80

Table 2: Standard Thermodynamic Parameters of micellization of SDS in 0.001 M Tryptophan containing different concentrations of DMSO at different Temperatures.

Temp (Kelvin)			0 mol% DM SO		
	X_{cmc} 10^{5}		ΔH kJ mol^{-1}	ΔG kJ mol^{-1}	ΔS JK^{-1}mol^{-1}
293.15	4.75	0.41	-16.92	-38.33	73.04
298.15	5.00	0.49	-16.95	-37.56	69.13
303.15	5.25	0.51	-16.38	-35.52	63.14
308.15	6.00	0.54	-17.16	-36.11	61.51
		0.23 mol% DM SO			
293.15	4.25	0.51	-17.62	-36.55	64.59
298.15	4.50	0.53	-17.98	-36.47	62.02
303.15	4.75	0.57	-18.08	-35.88	58.70
308.15	5.50	0.55	-18.95	-36.44	56.76
		0.46 mol% DM SO			
293.15	4.50	0.61	-26.56	-33.91	25.08
298.15	4.75	0.56	-28.46	-35.53	23.73
303.15	6.00	0.63	-27.99	-33.57	18.39
308.15	6.50	0.59	-29.77	-34.83	16.43
		0.69 mol% DM SO			
293.15	4.75	0.56	-12.80	-34.94	75.52
298.15	5.00	0.64	-12.50	-33.39	70.04
303.15	5.25	0.62	-13.12	-34.28	69.80
308.15	5.75	0.63	-13.45	-34.27	67.55
		0.91 mol% DM SO			
293.15	5.50	0.61	-12.98	-33.23	69.07
298.15	6.25	0.65	-13.04	-32.39	64.91
303.15	6.50	0.73	-12.68	-30.86	59.96
308.15	6.75	0.71	-13.31	-31.74	59.80

Table 3: Standard Thermodynamic Parameters of micellization of SDS in 0.005 M Tryptophan containing different concentrations of DMSO at different Temperatures.

Temp (Kelvin)	X_{cmc} 10^{5}		ΔH kJ mol^{-1}	ΔG kJmol^{-1}	ΔS J$k^{-1}mol^{-1}$
		0 mol% DMSO			
293.15	5.00	0.58	-30.83	-34.27	11.74
298.15	5.50	0.68	-29.65	-32.09	8.20
303.15	6.75	0.62	-32.04	-33.40	4.48
308.15	7.75	0.65	-32.39	-32.74	1.13
		0.23 mol% DMSO			
293.15	4.25	0.52	-30.15	-35.91	19.65
298.15	5.50	0.56	-30.34	-35.35	16.80
303.15	6.75	0.54	-31.80	-35.48	12.12
308.15	7.25	0.55	-32.64	-35.54	9.42
		0.46 mol% DMSO			
293.15	4.75	0.53	-20.66	-35.67	51.19
298.15	5.75	0.50	-21.81	-36.30	48.63
303.15	6.00	0.64	-20.44	-33.32	42.49
308.15	6.50	0.73	-19.72	-31.37	37.80
		0.69 mol% DMSO			
293.15	5.50	0.62	-11.53	-32.99	73.21
298.15	5.75	0.55	-12.53	-35.09	75.69
303.15	6.25	0.61	-12.42	-33.91	70.92
308.15	6.50	0.66	-12.37	-33.10	67.28
		0.91 mol% DMSO			
293.15	4.00	0.51	-28.87	-36.77	26.96
298.15	5.00	0.64	-27.26	-33.39	20.55
303.15	5.75	0.60	-29.01	-34.45	17.95
308.15	6.00	0.64	-29.12	-33.87	15.42

Table 4: Standard Thermodynamic Parameters of micellization of SDS in 0.01 M Tryptophan containing different concentrations of DMSO at different Temperatures.

Temp (Kelvin)	X_{cmc} 10 ^{5}		ΔH kJ mol^{-1}	ΔG kJ mol^{-1}	ΔS Jk^{-1}mol^{-1}
		0 mol% DMSO			
293.15	5.50	0.50	-19.41	-35.86	56.11
298.15	6.25	0.60	-18.74	-33.59	49.83
303.15	6.75	0.60	-19.37	-33.89	47.88
308.15	7.25	0.70	-18.59	-31.75	42.71
		0.23 mol% DMSO			
293.15	4.50	0.48	-19.75	-37.08	59.10
298.15	5.25	0.59	-18.96	-34.44	51.95
303.15	5.50	0.66	-18.62	-33.13	47.84
308.15	6.00	0.69	-18.81	-32.63	44.83
		0.46 mol% DMSO			
293.15	4.00	0.56	-20.83	-35.54	50.17
298.15	4.25	0.60	-20.95	-34.93	46.89
303.15	4.50	0.54	-22.59	-36.83	46.98
308.15	5.50	0.61	-22.22	-34.93	41.24
		0.69 mol% DMSO			
293.15	4.75	0.49	-18.73	-36.64	61.08
298.15	5.50	0.55	-18.60	-35.25	55.84
303.15	5.75	0.60	-18.57	-34.45	52.39
308.15	6.25	0.67	-18.23	-32.98	47.89
		0.91 mol% DMSO			
293.15	6.00	0.57	-17.10	-33.88	57.23
298.15	7.00	0.64	-16.83	-32.25	51.74
303.15	7.50	0.71	-16.50	-30.88	47.44
308.15	7.75	0.69	-17.31	-31.77	46.91

Effect of temperature on Xcmc

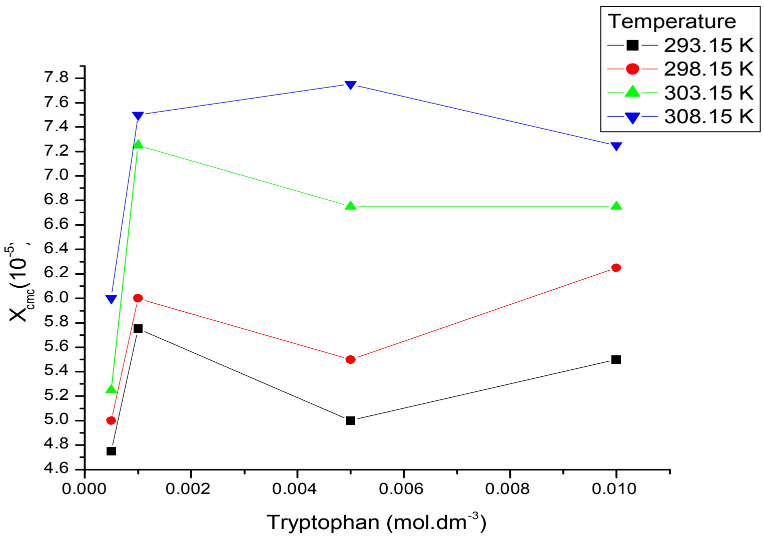


Figure-2 : X_{cmc} of SDS in aqueous mixtures of tryptophan at different temperatures.

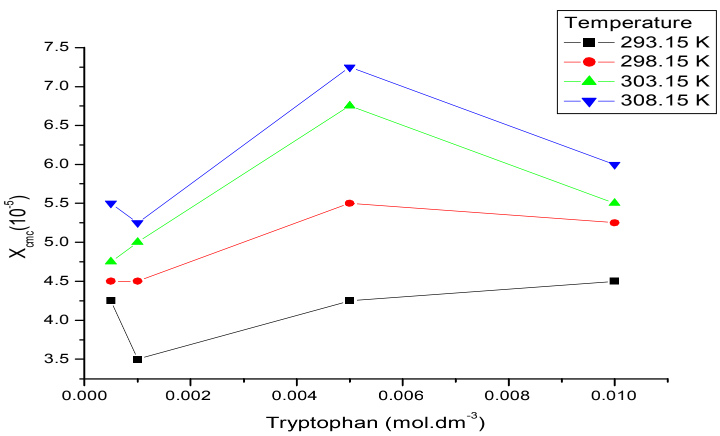


Figure-3 : X_{cmc} of SDS in aqueous mixtures of tryptophan containing 0.23 mol % DMSO at different temperatures.

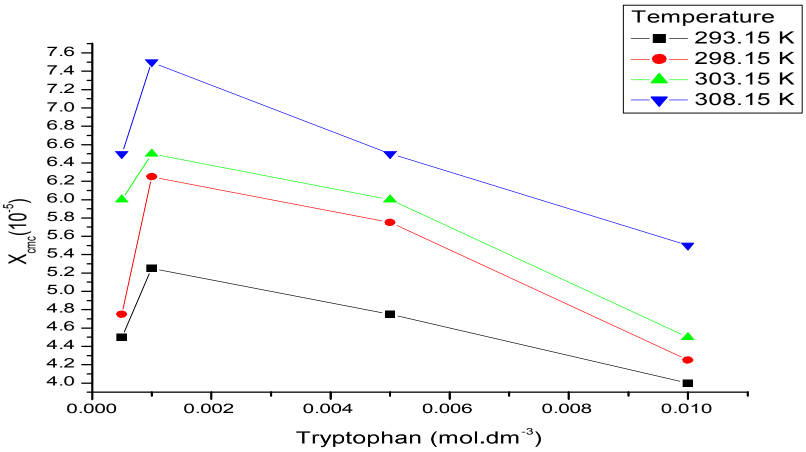


Figure-4 : X_{cmc} of SDS in aqueous mixtures of tryptophan containing 0.46mol % DMSO at different temperatures.

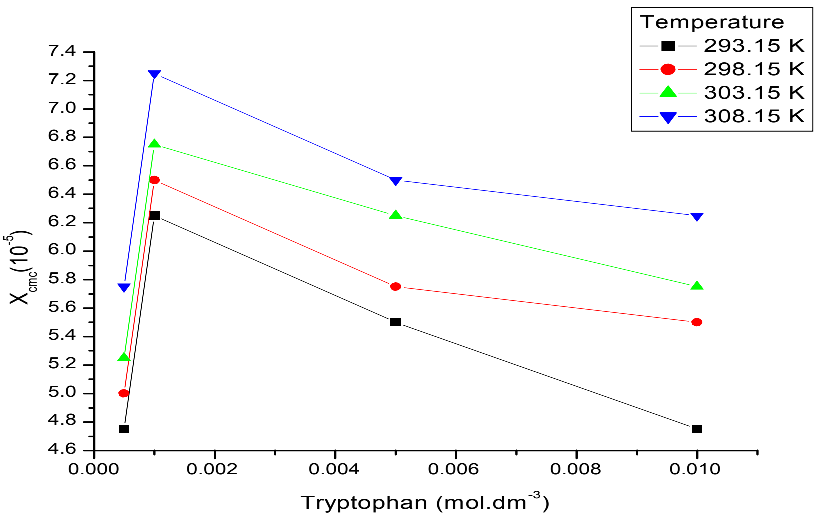


Figure-5 : X_{cmc} of SDS in aqueous mixtures of tryptophan containing 0.69 mol % DMSO at different temperatures.

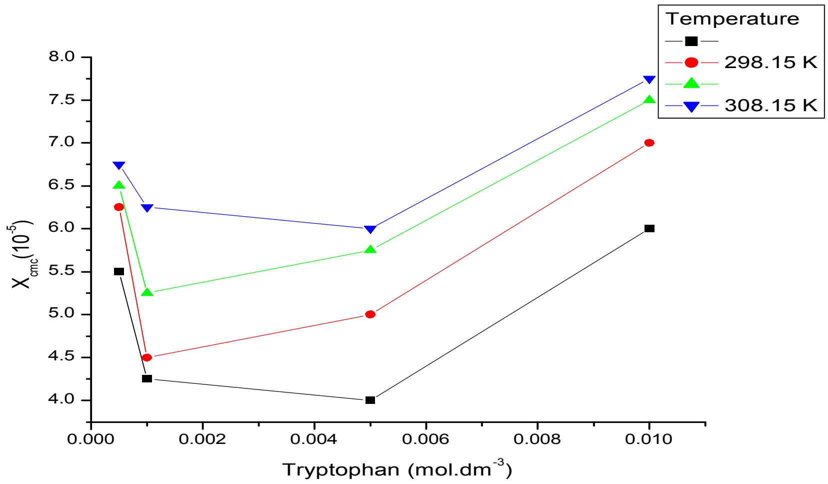


Figure-6 : X_{cmc} of SDS in aqueous mixtures of tryptophan containing 0.91mol % DMSO at different temperatures.

Effect of DMSO

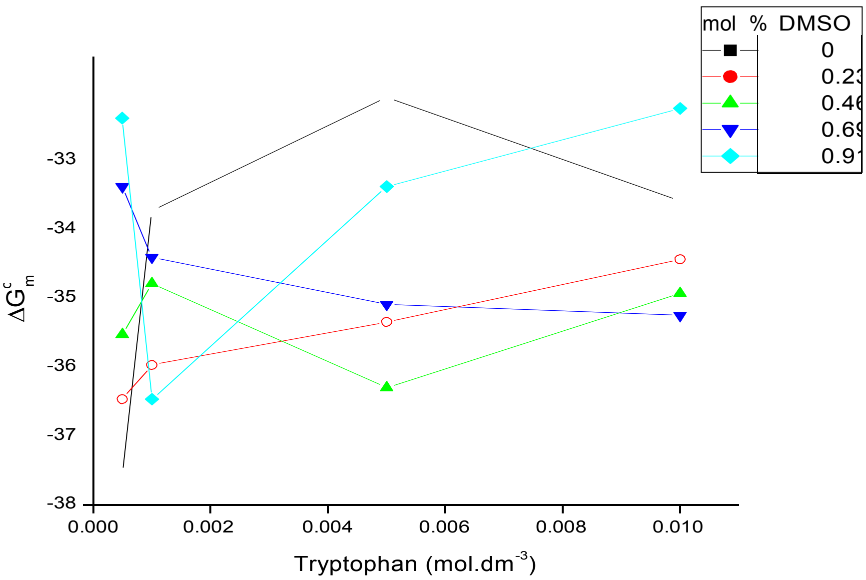


Figure-7 : Δ Vs. tryptophan concentration in aqueous rich mixtures of DMSO at 298.15 K.

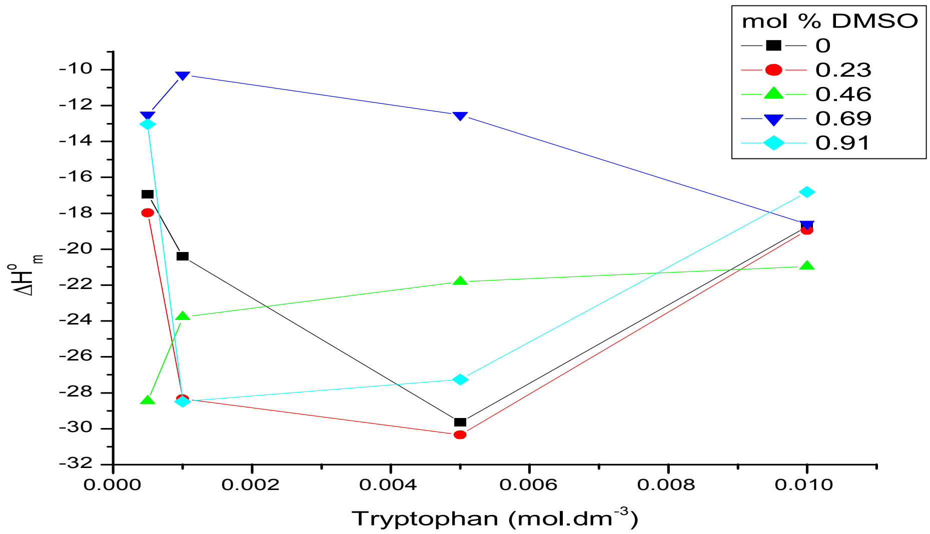


Figure-8 : Δ Vs. tryptophan concentration in aqueous rich mixtures of DMSO at 298.15 K.

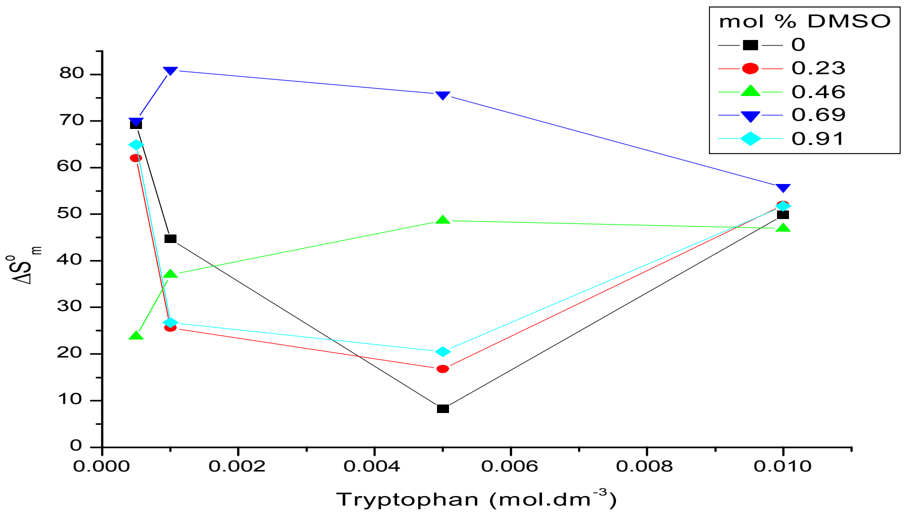


Figure-9 : Δ Vs. tryptophan concentration in aqueous rich mixtures of DMSO at 298.15 K.

UV measurement

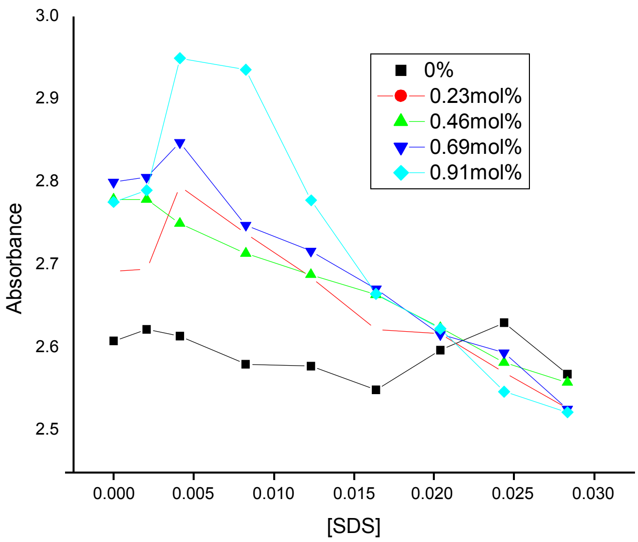


Figure-10: [SDS] v/s absorbance of tryptophan at aqueous rich mixture of DMSO .

In this chapter micellization behaviour of SDS has been traced to tryptophan – surfactant interactions. Experimentally determined κ and corresponding molar concentrations of the surfactants under different experimental conditions have been summarized in APPENDICES – I and II. These results have been presented however in Figs. 1 All curves in these figures present a similar picture arranged to the apparent discontinuity in the relationship between κ and surfactant concentration, C. However, at low surfactant concentration region, the behavior of κ as a function of C in the case of SDS – Tryptophan

CMC of SDS in Aqueous rich mixtures of Tryptophan:

The X_{CMC} values of SDS have been summarized in Tables 1 - 4. However, the dependence of X_{CMC} on Tryptophan. A perusal of these plots reveals that the X_{CMC} behavior of SDS in striking contrast up to 0.46 mol % DMSO. In the case of SDS, X_{CMC} increases with the addition of Tryptophan, whereas in the. Above 0.69 mol % of DMSO the X_{CMC} of SDS behave in a similar manner. The data further indicate that above 0.001M concentration of tryptophan, the X_{CMC} of these surfactants become relatively insensitive to the tryptophan concentration. Another common feature of these data is the apparent increase in X_{CMC} value with the increase in temperature.

In view of the fact that SDS – Tryptophan is an oppositely charged system, the expected electrostatic binding between polar headgroup, — OSO_3^- of SDS and cationic amino acid residues of tryptophan is believed to reduce the electrostatic repulsion between them, allowing the alkyl chains of the surfactant to interact relatively more effectively. Consequently, micellization of SDS is favoured in the presence of tryptophan. Such interdependence between the packing of polar headgroups and hydrocarbon chains may have important implications in the behaviour of biological membranes.

A representative plot indicating the proposed effect of DMSO on micellization of SDS is also presented in Fig.(7-9) at 25 ^oC. Increasing DMSO concentration is seen to inhibit micellization, which is found to be consistent with the above reasoning.

These observations seem to indicate clearly that Tryptophan – surfactant interactions are governed by the behaviour of the tryptophan in solutions. This is also significant from the view point of the fact that cooperative binding of surfactant molecules commonly observed in Tryptophan – surfactant system leading to denaturation of tryptophan. Thus, the headgroup of ionic surfactant is found to play a central role in determining the interactions between surfactant and protein. Whearas figure 10 represent the variation of absorbance as a function of [SDS] which further support the strong interactions of tryptophan with [SDS].

REFERENCES

1. Narayanan, J.; Liu, X. Y., Protein Interactions in Undersaturated and Supersaturated Solutions: A Study Using Light and X-Ray Scattering. *Biophys. J.* 2003, *84* (1), 523-532.

2. Kamal, M. S.; Sultan, A. S.; Hussein, I. A., Screening of amphoteric and anionic surfactants for cEOR applications using a novel approach. *Colloids and Surfaces A: Physicochemical and Engineering Aspects* 2015, *476* (0), 17-23.

3. Bordes, R.; Holmberg, K., Amino acid-based surfactants – do they deserve more attention? *Adv. Colloid Interface Sci.* (0).

4. Luo, Z.; Gao, M.; Ye, Y.; Yang, S., Modification of reduced-charge montmorillonites by a series of Gemini surfactants: Characterization and application in methyl orange removal. *Applied Surface Science* 2015, *324* (0), 807-816.

5. Sánchez Rojas, F.; Bosch Ojeda, C., Recent development in derivative ultraviolet/visible absorption spectrophotometry: 2004–2008: A review. *Anal. Chim. Acta* 2009, *635* (1), 22-44.

6. Muntaha, S.-T.; Khan, M. N., Natural surfactant extracted from Sapindus mukurossi as an eco-friendly alternate to synthetic surfactant – a dye surfactant interaction study. *Journal of Cleaner Production* 2015, *93* (0), 145-150.

7. Batıgöç, Ç.; Akbaş, H.; Boz, M., Micellization behaviour and thermodynamic parameters of 12-2-12 gemini surfactant in (water + organic solvent) mixtures. *The Journal of Chemical Thermodynamics* 2011, *43* (9), 1349-1354.

8. Bielawska, M.; Chodzińska, A.; Jańczuk, B.; Zdziennicka, A., Determination of CTAB CMC in mixed water + short-chain alcohol solvent by surface tension, conductivity, density and viscosity measurements. *Colloids and Surfaces A: Physicochemical and Engineering Aspects* 2013, *424* (0), 81-88.

9. Chen, J.-R.; Liao, C.-W.; Mao, S. J. T.; Chen, T.-H.; Weng, C.-N., A simple technique for the simultaneous determination of molecular weight and activity of superoxide dismutase using SDS–PAGE. *J. Biochem. Biophys. Methods* 2001, *47* (3), 233-237.

10. Xia, S.; Yuan, H.; Chen, Y.; Liang, Z.; Zhang, L.; Zhang, Y., Integrated SDS removal and protein digestion by hollow fiber membrane based device for SDS-assisted proteome analysis. *Talanta* (0).

11. Engelking, L. R., Chapter 2 - Properties of Amino Acids. In *Textbook of Veterinary Physiological Chemistry (Third Edition)*, Engelking, L. R., Ed. Academic Press: Boston, 2015; pp 7-11.

12. Wang, J.-Z.; Xi, L.; Lin, T.; Wang, Y.; Zhu, G.-F.; Du, L.-F., The structural and functional role of the three tryptophan residues in Pin1. *Journal of Photochemistry and Photobiology B: Biology* 2015, *146* (0), 58-67.

13. (a) Ghazaryan, V. V.; Fleck, M.; Petrosyan, A. M., l-Tryptophan l-tryptophanium chloride. *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy* 2015, *136, Part B* (0), 743-750; (b) Kowalska-Baron, A.,

14. Theoretical study of the complexes of tyrosine and tryptophan with biologically important metal cations in aqueous solutions. *Computational and Theoretical Chemistry* 2015, *1057* (0), 7-14.

15. Yang, F.; Xie, Q.; Zhang, H.; Yu, S.; Zhang, X.; Shen, Y., Simultaneous determination of ascorbic acid, uric acid, tryptophan and adenine using carbon-supported NiCoO2 nanoparticles. *Sensors and Actuators B: Chemical* 2015, *210* (0), 232-240.

16. Wang, J.-Z.; Xi, L.; Lin, T.; Wang, Y.; Zhu, G.-F.; Du, L.-F., The structural and functional role of the three tryptophan residues in Pin1. *Journal of Photochemistry and Photobiology B: Biology* 2015, *146* (0), 58-67.

17. Chauhan, S.; Sharma, K.; Rana, D. S.; Kumar, G.; Umar, A., Conductance, apparent molar volume and compressibility studies of cetyltrimethylammonium bromide in aqueous solution of leucine. *Journal of Molecular Liquids* 2012, *175* (0), 103-110.

18. Chauhan, M. S.; Kumari, N.; Pathania, S.; Sharma, K.; Kumar, G., A conductometric study of interactions between gelatin and sodium dodecyl sulfate (SDS) in aqueous-rich mixtures of dimethylsulfoxide. *Colloids and Surfaces A: Physicochemical and Engineering Aspects* 2007, *293* (1–3), 157-161.

19. Chauhan, S.; Chauhan, M. S.; Sharma, P.; Rana, D. S., Thermodynamics and micellization of cetyltrimethyl ammonium bromide in the presence of lysozyme. *Journal of Molecular Liquids* 2013, *187* (0), 1-6.

20. Sharma, K.; Chauhan, S., Apparent molar volume, compressibility and viscometric studies of sodium dodecyl benzene sulfonate (SDBS) and dodecyltrimethylammonium bromide (DTAB) in aqueous amino acid solutions: A thermo-acoustic approach. *Thermochimica Acta* 2014, *578* (0), 15-27.

21. Chauhan, S.; Sharma, V.; Sharma, K., Maltodextrin–SDS interactions: Volumetric, viscometric and surface tension study. *Fluid Phase Equilibria* 2013, *354* (0), 236-244.

22. Kumar, K.; Chauhan, S., Volumetric, compressibility and viscometric studies on sodium cholate/sodium deoxycholate–amino acid interactions in aqueous medium. *Thermochimica Acta* 2015, *606* (0), 12-24.

23. Ren, H.; Xin, X.; Wang, L.; Ju, H.; Zhamanding, A. D.; Xu, G., A direct comparison of the interaction of bovine serum albumin and gelatin with sodium deoxycholate in aqueous solutions. *Journal of Molecular Liquids* 2015, *207* (0), 164-170.

24. Shrestha, R. G.; Shrestha, L. K.; Aramaki, K., Wormlike micelles in mixed amino acid-based anionic/nonionic surfactant systems. *J. Colloid Interface Sci.* 2008, *322* (2), 596-604.

25. Harutyunyan, N. G.; Harutyunyan, L. R.; Harutyunyan, R. S., Volumetric properties of amino acids in aqueous solution of nonionic surfactant. *Thermochimica Acta* 2010, *498* (1–2), 124-127.

26. Zdziennicka, A.; Szymczyk, K.; Krawczyk, J.; Jańczuk, B., Critical micelle concentration of some surfactants and thermodynamic parameters of their micellization. *Fluid Phase Equilibria* 2012, *322–323* (0), 126-134.

27. Nacham, O.; Martín-Pérez, A.; Steyer, D. J.; Trujillo-Rodríguez, M. J.; Anderson, J. L.; Pino, V.; Afonso, A. M., Interfacial and aggregation behavior of dicationic and tricationic ionic liquid-based surfactants in aqueous solution. *Colloids and Surfaces A: Physicochemical and Engineering Aspects* 2015, *46* (0), 224-234.

28. Lu, R.-C.; Cao, A.-N.; Lai, L.-H.; Zhu, B.-Y.; Zhao, G.-X.; Xiao, J.-X., Interaction between bovine serum albumin and equimolarly mixed cationic–anionic surfactants decyltriethylammonium bromide–sodium decyl sulfonate. *Colloids and Surfaces B: Biointerfaces* 2005, *41* (2–3), 139-143.

29. Casals, C.; Miguel, E.; Perez-Gil, J., Tryptophan fluorescence study on the interaction of pulmonary surfactant protein A with phospholipid vesicles. *Biochem. J.* 1993, *296 (Pt 3)*, 585-93.

30. Kun, R.; Kis, L.; Dekany, I., Hydrophobization of bovine serum albumin with cationic surfactants with different hydrophobic chain length. *Colloids and surfaces. B, Biointerfaces* 2010, *79* (1), 61-8.

31. Sivadasan, K.; Somasundaran, P., Polymer—surfactant interactions and the association behavior of hydrophobically modified hydroxyethylcellulose. *Colloids and Surfaces* 1990, *49* (0), 229-239.

32. Cheng, T. L.; Chuang, K. H.; Chen, B. M.; Roffler, S. R., Analytical measurement of PEGylated molecules. *Bioconjug. Chem.* 2012, *23* (5), 881-99.

33. Ali, M. S.; Suhail, M.; Ghosh, G.; Kamil, M.; Kabir ud, D., Interactions between cationic gemini/conventional surfactants with polyvinylpyrrolidone: Specific conductivity and dynamic light scattering studies. *Colloids and Surfaces A: Physicochemical and Engineering Aspects* 2009, *350* (1–3), 51-56.

34. Nawaz, H.; Pires, P. A. R.; El Seoud, O. A., Kinetics and mechanism of imidazole-catalyzed acylation of cellulose in LiCl/N,N-dimethylacetamide. *Carbohydrate Polymers* 2013, *92* (2), 997-1005.

35. Chen, J.; Dickinson, E., Protein/surfactant interfacial interactions part 1. Flocculation of emulsions containing mixed protein + surfactant. *Colloids and Surfaces A: Physicochemical and Engineering Aspects* 1995, *100* (0), 255-265.

36. Zieliński, R.; Ikeda, S.; Nomura, H.; Kato, S., Adiabatic compressibility of alkyltrimethylammonium bromides in aqueous solutions. *J. Colloid Interface Sci.* 1987, *119* (2), 398-408.

37. Alexandridis, P., Poly(ethylene oxide)/poly(propylene oxide) block copolymer surfactants. *Current Opinion in Colloid & Interface Science* 1997, *2* (5), 478-489.

38. Chauhan, S.; Jyoti, J.; Kumar, G., Non-ionic surfactant interactions in aqueous gelatin solution: A physico-chemical investigation. *Journal of Molecular Liquids* 2011, *159* (3), 196-200.

39. Skoog, et al. Principles of Instrumental Analysis. 6th ed. Thomson Brooks/Cole. 2007, 349-351.

40. Skoog et al. *Principles of Instrumental Analysis* (6th ed.). Belmont, CA: Thomson Brooks/Cole. (2007). pp. 169–173.

41. Chauhan, S.; Sharma, K.; Rana, D. S.; Kumar, G.; Umar, A., Conductance, apparent molar volume and compressibility studies of cetyltrimethylammonium bromide in aqueous solution of leucine. *Journal of Molecular Liquids* 2012, *175* (0), 103-110.

APPENDIX-1

Molar concentration, C and corresponding conductivity, K of SDS in aqueous solution of tryptophan at different temperature with aqueous rich mixture of DMSO.

0.0005Mtryptophan

C, 10^3	K(μScm^{-1})			
	293.15	298.15	303.15	308.15
0	8	9	10	12
2.075848303	80	88	109	105
4.143426295	168	176	215	198
6.2027833	220	253	249	274
8.253968254	312	327	340	329
10.2970297	396	388	393	396
12.33201581	438	440	463	467
14.35897436	463	468	519	521
16.37795276	481	522	542	569
18.38899804	522	575	596	598
20.39215686	565	606	649	635
22.38747554	619	657	686	695
24.375	627	687	727	734
26.35477583	667	726	776	770
28.32684825	693	749	804	810
30.29126214	738	795	849	828
32.24806202	750	828	897	882
34.19729207	781	876	927	925
36.13899614	843	899	966	974
38.07321773	863	944	995	1027

40	874	974	1023	1053
41.9193858	909	994	1045	1076
43.83141762	921	1034	1081	1099
45.73613767	940	1059	1103	1136
47.63358779	997	1115	1138	1157
49.52380952	1036	1122	1179	1189
51.40684411	1052	1162	1202	1222
53.28273245	1070	1178	1237	1263
55.15151515	1088	1201	1274	1288
57.01323251	1101	1229	1297	1321
58.86792453	1126	1258	1321	1347

0.0005M Tryp+0.23mol%

C, 10^3	K(μScm^{-1})			
	293.15	298.15	303.15	308.15
0	25	23	28	20
2.075848303	128	136	128	116
4.143426295	240	219	219	212
6.2027833	362	317	315	338
8.253968254	412	422	375	410
10.2970297	524	474	456	469
12.33201581	572	544	536	537
14.35897436	580	581	589	588
16.37795276	637	650	631	664

18.38899804	701	684	675	693
20.39215686	720	714	741	744
22.38747554	829	782	772	770
24.375	844	839	817	824
26.35477583	895	867	861	884
28.32684825	933	900	906	913
30.29126214	976	960	937	994
32.24806202	1054	984	998	1036
34.19729207	1094	1033	1050	1076
36.13899614	1127	1096	1085	1086
38.07321773	1194	1130	1141	1112
40	1203	1215	1227	1157
41.9193858	1270	1245	1234	1221
43.83141762	1309	1270	1264	1232
45.73613767	1348	1312	1300	1266
47.63358779	1392	1350	1351	1317
49.52380952	1450	1419	1410	1403
51.40684411	1520	1441	1441	1414
53.28273245	1573	1487	1485	1482
55.15151515	1602	1546	1521	1502
57.01323251	1632	1602	1563	1573
58.86792453	1650	1642	1604	1614

0.0005M Tryp+0.46mol%

C, 10^3	K(μScm^{-1})

	293.15	298.15	303.15	308.15
0	24	20	30	24
2.075848303	134	113	114	110
4.143426295	247	226	292	223
6.2027833	325	373	353	314
8.253968254	391	412	381	389
10.2970297	459	500	478	451
12.33201581	543	541	513	545
14.35897436	592	596	562	600
16.37795276	662	673	644	653
18.38899804	697	713	687	703
20.39215686	742	766	725	754
22.38747554	802	843	804	803
24.375	847	891	826	860
26.35477583	909	943	883	950
28.32684825	997	975	944	960
30.29126214	1027	1005	961	1017
32.24806202	1063	1072	997	1067
34.19729207	1113	1112	1052	1123
36.13899614	1173	1160	1083	1127
38.07321773	1249	1213	1138	1150
40	1299	1248	1178	1209
41.9193858	1322	1309	1215	1239
43.83141762	1347	1345	1254	1273
45.73613767	1437	1395	1300	1342
47.63358779	1482	1452	1359	1384
49.52380952	1521	1495	1391	1443
51.40684411	1557	1533	1458	1489
53.28273245	1602	1589	1513	1541

55.15151515	1629	1631	1551	1596
57.01323251	1702	1667	1608	1623
58.86792453	1714	1702	1629	1657

0.0005M Tryp+0.69mol%

C, 10^3	K(μScm^{-1})			
	293.15	298.15	303.15	308.15
0	15	17	23	26
2.075848303	116	132	131	116
4.143426295	211	243	259	218
6.2027833	294	314	305	312
8.253968254	373	399	380	387
10.2970297	457	425	452	440
12.33201581	525	487	499	526
14.35897436	574	543	597	554
16.37795276	625	600	634	633
18.38899804	705	665	678	682
20.39215686	727	724	726	722
22.38747554	778	775	788	765
24.375	813	810	830	811
26.35477583	860	868	880	852
28.32684825	915	912	940	930
30.29126214	951	971	998	969
32.24806202	993	1015	1042	1017
34.19729207	1070	1085	1083	1053
36.13899614	1094	1115	1123	1083
38.07321773	1162	1200	1170	1094
40	1186	1231	1216	1134
41.9193858	1226	1272	1252	1181

43.83141762	1289	1307	1295	1232
45.73613767	1324	1367	1346	1295
47.63358779	1360	1422	1402	1370
49.52380952	1415	1457	1438	1442
51.40684411	1450	1505	1480	1456
53.28273245	1515	1558	1505	1500
55.15151515	1548	1595	1555	1551
57.01323251	1602	1660	1600	1615
58.86792453	1642	1696	1641	1661

0.0005M Tryp+0.91mol%

C, 10^3	K(μScm^{-1})			
	293.15	298.15	303.15	308.15
0	27	18	21	30
2.075848303	134	120	130	170
4.143426295	239	237	238	267
6.2027833	303	329	328	332
8.253968254	364	360	352	394
10.2970297	441	427	419	460
12.33201581	521	505	480	538
14.35897436	562	575	528	577
16.37795276	619	606	597	652
18.38899804	682	671	640	734
20.39215686	730	709	689	753
22.38747554	751	758	732	780
24.375	805	852	787	876
26.35477583	868	868	833	906

28.32684825	924	910	878	928
30.29126214	989	942	919	990
32.24806202	1006	984	954	1008
34.19729207	1053	1057	1003	1057
36.13899614	1117	1109	1045	1084
38.07321773	1146	1149	1090	1124
40	1190	1191	1143	1196
41.9193858	1228	1248	1189	1216
43.83141762	1279	1293	1243	1267
45.73613767	1325	1341	1275	1338
47.63358779	1376	1380	1314	1420
49.52380952	1403	1431	1381	1480
51.40684411	1441	1470	1430	1550
53.28273245	1482	1503	1466	1570
55.15151515	1564	1580	1554	1637
57.01323251	1604	1608	1589	1650
58.86792453	1626	1642	1611	1682

0.001M Tryp+0mol%

$C, 10^3$	$K(\mu Scm^{-1})$

	293.15	298.15	303.15	308.15
0	9	9	8	12
2.075848303	94	123	148	179
4.143426295	177	197	281	231
6.2027833	258	245	352	353
8.253968254	311	320	363	407
10.2970297	372	374	425	480
12.33201581	412	420	479	534
14.35897436	459	475	531	578
16.37795276	498	501	556	618
18.38899804	543	559	604	650
20.39215686	580	590	645	689
22.38747554	613	614	673	725
24.375	648	648	724	770
26.35477583	696	727	769	789
28.32684825	713	729	811	841
30.29126214	743	769	849	900
32.24806202	775	807	878	929
34.19729207	802	825	923	987
36.13899614	840	859	949	1006
38.07321773	869	899	995	1053
40	911	941	1032	1098
41.9193858	930	968	1074	1120
43.83141762	966	1009	1109	1124
45.73613767	1003	1069	1151	1213
47.63358779	1016	1081	1184	1233
49.52380952	1022	1127	1222	1269
51.40684411	1106	1161	1272	1298
53.28273245	1132	1182	1294	1353

55.15151515	1169	1232	1335	1379
57.01323251	1194	1262	1395	1429
58.86792453	1233	1319	1419	1450

0.001M Tryp+0.23mol%

C, 10^3	K(μScm^{-1})			
	293.15	298.15	303.15	308.15
0	36	47	46	28
2.075848303	135	143	162	151
4.143426295	186	194	253	230
6.2027833	294	273	353	303
8.253968254	365	350	404	396
10.2970297	403	436	456	485
12.33201581	476	475	496	539
14.35897436	524	508	542	591
16.37795276	575	557	598	648
18.38899804	627	603	649	696
20.39215686	678	651	706	748
22.38747554	719	736	748	810
24.375	745	738	760	875
26.35477583	789	828	814	890
28.32684825	827	831	852	931
30.29126214	853	883	886	981
32.24806202	905	936	905	1037
34.19729207	933	970	960	1086

36.13899614	947	1038	998	1123
38.07321773	1009	1052	1011	1176
40	1023	1086	1038	1224
41.9193858	1082	1118	1126	1264
43.83141762	1117	1167	1163	1290
45.73613767	1142	1196	1204	1337
47.63358779	1198	1236	1241	1395
49.52380952	1239	1282	1263	1445
51.40684411	1249	1307	1287	1482
53.28273245	1292	1313	1369	1526
55.15151515	1320	1339	1396	1583
57.01323251	1360	1358	1416	1616
58.86792453	1370	1389	1451	1646

0.001M Tryp+0.46mol%

C, 10^3	K(μScm^{-1})			
	293.15	298.15	303.15	308.15
0	53	53	40	42
2.075848303	151	151	117	162
4.143426295	297	225	217	210
6.2027833	358	315	321	305
8.253968254	406	381	413	404
10.2970297	510	442	466	461
12.33201581	523	553	548	500
14.35897436	554	570	594	542

16.37795276	589	600	634	620
18.38899804	649	635	710	642
20.39215686	700	674	739	692
22.38747554	777	733	777	758
24.375	807	772	839	792
26.35477583	842	834	866	820
28.32684825	867	844	931	874
30.29126214	936	859	966	924
32.24806202	965	925	1042	946
34.19729207	997	970	1112	1013
36.13899614	1024	981	1154	1066
38.07321773	1076	1045	1203	1090
40	1079	1056	1237	1124
41.9193858	1132	1097	1292	1170
43.83141762	1172	1122	1331	1209
45.73613767	1190	1194	1342	1255
47.63358779	1236	1216	1409	1296
49.52380952	1279	1270	1442	1332
51.40684411	1302	1323	1460	1372
53.28273245	1332	1352	1529	1431
55.15151515	1342	1409	1562	1465
57.01323251	1361	1422	1606	1506
58.86792453	1437	1444	1619	1565

0.001M Tryp+0.69mol%

C, 10^3	K(μScm^{-1})			
	293.15	298.15	303.15	308.15
0	59	41	41	33
2.075848303	202	119	124	81
4.143426295	237	203	233	187
6.2027833	331	280	336	327
8.253968254	398	342	367	393
10.2970297	461	401	441	499
12.33201581	528	458	465	554
14.35897436	562	503	528	603
16.37795276	586	544	562	662
18.38899804	628	596	627	703
20.39215686	702	655	648	773
22.38747554	745	678	697	800
24.375	803	714	749	873
26.35477583	860	756	797	910
28.32684825	899	789	823	962
30.29126214	965	818	890	983
32.24806202	995	846	926	1041
34.19729207	1031	887	972	1088
36.13899614	1067	923	1010	1125
38.07321773	1124	972	1045	1176
40	1158	993	1079	1180
41.9193858	1191	1031	1165	1227
43.83141762	1215	1049	1192	1291
45.73613767	1266	1080	1224	1362
47.63358779	1311	1112	1266	1374
49.52380952	1351	1143	1300	1452
51.40684411	1382	1186	1351	1456

53.28273245	1408	1229	1378	1487
55.15151515	1468	1247	1437	1546
57.01323251	1498	1300	1463	1585
58.86792453	1522	1321	1475	1613

0.001M Tryp+0.91mol%

C, 10^3	K(μScm^{-1})			
	293.15	298.15	303.15	308.15
0	42	31	26	45
2.075848303	145	123	118	177
4.143426295	238	210	228	240
6.2027833	347	282	306	322
8.253968254	409	359	368	440
10.2970297	472	413	430	498
12.33201581	533	456	507	559
14.35897436	576	516	566	655
16.37795276	624	549	590	697
18.38899804	676	551	683	758
20.39215686	733	584	726	794
22.38747554	777	635	753	862
24.375	823	661	845	892
26.35477583	862	703	858	950
28.32684825	900	743	897	996
30.29126214	940	768	931	1025

32.24806202	988	791	995	1087
34.19729207	1038	849	1011	1101
36.13899614	1062	874	1066	1184
38.07321773	1110	903	1103	1236
40	1138	957	1145	1253
41.9193858	1186	1009	1200	1294
43.83141762	1228	1023	1225	1336
45.73613767	1272	1057	1275	1374
47.63358779	1299	1101	1320	1393
49.52380952	1331	1121	1356	1455
51.40684411	1357	1138	1395	1480
53.28273245	1398	1188	1426	1560
55.15151515	1428	1229	1462	1586
57.01323251	1456	1283	1497	1650
58.86792453	1467	1306	1550	1677

0.005M Tryp+0mol%

$C, 10^3$	$K(\mu Scm^{-1})$			
	293.15	298.15	303.15	308.15
0	11	12	13	13
2.075848303	87	86	108	109
4.143426295	150	170	166	201
6.2027833	206	234	241	258
8.253968254	281	285	341	366

10.2970297	344	354	395	406
12.33201581	397	418	460	447
14.35897436	447	454	487	513
16.37795276	493	482	531	552
18.38899804	540	538	585	585
20.39215686	592	572	612	653
22.38747554	620	625	657	675
24.375	662	673	689	710
26.35477583	706	709	713	775
28.32684825	763	758	741	784
30.29126214	789	788	759	801
32.24806202	831	840	835	836
34.19729207	870	887	881	870
36.13899614	917	915	918	899
38.07321773	937	964	933	924
40	998	1006	972	969
41.9193858	1018	1045	1032	1031
43.83141762	1037	1097	1051	1064
45.73613767	1041	1127	1103	1101
47.63358779	1117	1169	1153	1142
49.52380952	1125	1210	1186	1193
51.40684411	1155	1245	1223	1231
53.28273245	1183	1282	1253	1263
55.15151515	1211	1315	1298	1303
57.01323251	1243	1350	1332	1341
58.86792453	1261	1371	1368	1382

0.005M Tryp+0.23mol%

$C, 10^3$	$K (\mu S cm^{-1})$			
	293.15	298.15	303.15	308.15
0	13	27	14	19
2.075848303	56	142	115	109
4.143426295	187	263	224	223
6.2027833	299	333	290	271
8.253968254	367	369	368	346
10.2970297	455	418	423	404
12.33201581	509	480	455	455
14.35897436	568	539	520	514
16.37795276	623	578	584	573
18.38899804	647	633	629	595
20.39215686	716	668	693	676
22.38747554	741	697	712	707
24.375	813	735	742	744
26.35477583	885	790	793	772
28.32684825	934	836	824	830
30.29126214	956	863	879	862
32.24806202	988	906	893	892
34.19729207	1024	940	951	914
36.13899614	1075	1013	980	953
38.07321773	1138	1019	1045	1005
40	1172	1055	1075	1024
41.9193858	1225	1085	1122	1051
43.83141762	1267	1114	1150	1078
45.73613767	1322	1163	1210	1112
47.63358779	1366	1188	1239	1144
49.52380952	1416	1230	1271	1180
51.40684411	1442	1267	1307	1223

53.28273245	1498	1288	1361	1276
55.15151515	1532	1312	1434	1288
57.01323251	1562	1353	1452	1300
58.86792453	1605	1411	1498	1329

0.005M Tryp+0.46mol%

C, 10^3	K(μScm^{-1})			
	293.15	298.15	303.15	308.15
0	9	26	22	32
2.075848303	95	118	137	93
4.143426295	210	218	228	168
6.2027833	284	336	320	224
8.253968254	374	384	381	275
10.2970297	435	440	433	349
12.33201581	477	482	490	399
14.35897436	562	563	543	449
16.37795276	610	609	578	487
18.38899804	646	629	621	542
20.39215686	696	686	665	586
22.38747554	762	711	717	614
24.375	780	754	769	644
26.35477583	816	770	803	702
28.32684825	852	822	849	714
30.29126214	936	837	908	768
32.24806202	979	890	952	806

34.19729207	1024	906	987	847
36.13899614	1060	947	1035	877
38.07321773	1100	985	1059	920
40	1141	1028	1112	954
41.9193858	1181	1067	1134	1002
43.83141762	1204	1097	1201	1061
45.73613767	1232	1122	1216	1090
47.63358779	1289	1159	1269	1146
49.52380952	1320	1208	1293	1180
51.40684411	1343	1252	1303	1230
53.28273245	1369	1270	1390	1240
55.15151515	1414	1296	1436	1285
57.01323251	1437	1339	1472	1318
58.86792453	1505	1368	1500	1351

0.005M Tryp+0.69mol%

C, 10^3	K(μScm^{-1})			
	293.15	298.15	303.15	308.15
0	5	18	34	29
2.075848303	126	70	116	105
4.143426295	189	162	230	187
6.2027833	270	232	270	264
8.253968254	365	313	338	372
10.2970297	439	365	406	462
12.33201581	495	408	452	490

14.35897436	567	447	506	526
16.37795276	614	477	611	600
18.38899804	700	533	627	632
20.39215686	755	565	654	700
22.38747554	784	613	695	719
24.375	857	660	742	751
26.35477583	891	693	779	806
28.32684825	925	723	833	832
30.29126214	988	762	860	905
32.24806202	1037	797	903	918
34.19729207	1090	830	928	957
36.13899614	1134	871	975	1021
38.07321773	1210	910	1038	1067
40	1244	946	1061	1114
41.9193858	1304	990	1088	1173
43.83141762	1340	1016	1117	1193
45.73613767	1390	1049	1174	1273
47.63358779	1428	1080	1260	1286
49.52380952	1465	1103	1262	1345
51.40684411	1513	1137	1308	1375
53.28273245	1546	1163	1327	1436
55.15151515	1579	1199	1360	1511
57.01323251	1593	1231	1393	1520
58.86792453	1655	1267	1415	1553

0.005M Tryp+0.91mol%

C, 10^3	K(μScm^{-1})

	293.15	298.15	303.15	308.15
0	6	15	22	24
2.075848303	91	160	122	113
4.143426295	202	189	193	260
6.2027833	326	290	272	289
8.253968254	385	317	341	372
10.2970297	461	360	430	423
12.33201581	499	432	482	446
14.35897436	559	454	537	489
16.37795276	628	499	580	522
18.38899804	667	561	617	560
20.39215686	722	578	666	605
22.38747554	769	632	720	638
24.375	839	648	756	680
26.35477583	856	705	821	751
28.32684825	899	746	854	763
30.29126214	967	792	891	786
32.24806202	999	815	927	831
34.19729207	1081	845	961	870
36.13899614	1103	877	1007	904
38.07321773	1159	916	1075	965
40	1187	955	1100	979
41.9193858	1244	1002	1137	1015
43.83141762	1265	1046	1205	1059
45.73613767	1304	1067	1224	1101
47.63358779	1347	1132	1247	1119
49.52380952	1386	1174	1284	1152
51.40684411	1445	1192	1320	1202
53.28273245	1481	1254	1382	1231

55.15151515	1517	1290	1416	1265
57.01323251	1587	1305	1487	1304
58.86792453	1615	1348	1518	1332

0.01M Tryp+0mol%

C, 10^3	K(μScm^{-1})			
	293.15	298.15	303.15	308.15
0	10	11	13	14
2.075848303	122	92	103	104
4.143426295	182	156	187	207
6.2027833	239	240	264	253
8.253968254	298	300	331	303
10.2970297	358	345	373	381
12.33201581	408	402	447	440
14.35897436	448	446	490	493
16.37795276	488	490	541	551
18.38899804	547	524	574	592
20.39215686	562	569	607	615
22.38747554	596	596	642	672
24.375	628	628	709	715
26.35477583	659	661	719	743
28.32684825	700	702	751	786
30.29126214	727	745	791	818
32.24806202	756	793	814	855

34.19729207	787	814	859	894
36.13899614	834	850	892	952
38.07321773	842	881	938	985
40	886	912	975	1005
41.9193858	909	953	983	1061
43.83141762	925	967	1011	1129
45.73613767	970	1001	1041	1162
47.63358779	1006	1039	1078	1203
49.52380952	1019	1066	1149	1212
51.40684411	1060	1092	1175	1273
53.28273245	1082	1123	1199	1307
55.15151515	1110	1138	1228	1330
57.01323251	1149	1182	1272	1372
58.86792453	1182	1226	1298	1428

0.01M Tryp+0.23mol%

C, 10^3	K(μScm^{-1})			
	293.15	298.15	303.15	308.15
0	33	22	24	25
2.075848303	108	109	145	129
4.143426295	243	219	217	285
6.2027833	288	311	304	341
8.253968254	367	417	383	424
10.2970297	433	469	473	461
12.33201581	487	519	544	548

14.35897436	512	574	575	572
16.37795276	560	618	618	625
18.38899804	596	688	676	690
20.39215686	627	725	729	740
22.38747554	675	760	779	791
24.375	695	826	823	854
26.35477583	730	869	885	892
28.32684825	772	931	940	946
30.29126214	830	969	983	994
32.24806202	898	1005	1076	1047
34.19729207	902	1058	1124	1078
36.13899614	924	1099	1173	1119
38.07321773	963	1155	1225	1167
40	1028	1187	1281	1211
41.9193858	1054	1225	1304	1260
43.83141762	1094	1337	1347	1320
45.73613767	1116	1373	1396	1359
47.63358779	1133	1412	1430	1435
49.52380952	1181	1457	1483	1454
51.40684411	1211	1492	1523	1505
53.28273245	1245	1529	1578	1541
55.15151515	1289	1572	1632	1589
57.01323251	1332	1632	1670	1651
58.86792453	1364	1665	1685	1694

0.01M Tryp+0.46mol%

$C, 10^3$	$K(\mu Scm^{-1})$

	293.15	298.15	303.15	308.15
0	19	23	21	28
2.075848303	102	116	147	123
4.143426295	179	219	238	240
6.2027833	263	290	350	320
8.253968254	324	385	466	390
10.2970297	399	459	506	460
12.33201581	458	517	561	513
14.35897436	524	570	611	670
16.37795276	569	614	655	628
18.38899804	624	690	691	698
20.39215686	674	753	749	730
22.38747554	760	805	805	793
24.375	805	856	843	842
26.35477583	830	899	890	885
28.32684825	892	947	933	941
30.29126214	925	980	985	1012
32.24806202	966	1073	1015	1034
34.19729207	996	1130	1100	1079
36.13899614	1028	1188	1123	1123
38.07321773	1057	1221	1176	1153
40	1108	1271	1204	1184
41.9193858	1132	1312	1264	1252
43.83141762	1167	1364	1284	1293
45.73613767	1200	1395	1335	1333
47.63358779	1246	1430	1387	1440
49.52380952	1264	1400	1444	1493
51.40684411	1344	1534	1520	1520
53.28273245	1374	1578	1550	1590

55.15151515	1393	1621	1584	1628
57.01323251	1426	1681	1632	1674
58.86792453	1462	1721	1684	1735

0.01M Tryp+0.69mol%

C, 10^3	K(μScm^{-1})			
	293.15	298.15	303.15	308.15
0	24	18	19	24
2.075848303	106	120	149	117
4.143426295	202	218	216	201
6.2027833	306	326	308	326
8.253968254	420	478	392	406
10.2970297	443	527	463	490
12.33201581	491	569	532	576
14.35897436	580	632	567	626
16.37795276	601	680	651	674
18.38899804	643	747	669	745
20.39215686	692	796	726	811
22.38747554	725	850	778	875
24.375	769	930	830	962
26.35477583	827	936	906	1000
28.32684825	860	987	983	1031
30.29126214	887	1044	1021	1117
32.24806202	939	1107	1061	1145

34.19729207	995	1138	1076	1177
36.13899614	1031	1203	1125	1240
38.07321773	1097	1261	1162	1283
40	1150	1273	1205	1370
41.9193858	1181	1335	1270	1415
43.83141762	1205	1384	1327	1462
45.73613767	1234	1447	1355	1525
47.63358779	1310	1473	1380	1603
49.52380952	1322	1502	1422	1621
51.40684411	1365	1557	1455	1669
53.28273245	1404	1599	1512	1739
55.15151515	1441	1655	1541	1773
57.01323251	1465	1689	1561	1820
58.86792453	1498	1734	1618	1870

0.01M Tryp+0.91mol%

C, 10^3	K(μScm^{-1})			
	293.15	298.15	303.15	308.15
0	18	20	19	28
2.075848303	114	106	119	119
4.143426295	204	224	214	215
6.2027833	297	372	306	342
8.253968254	368	430	382	414
10.2970297	440	480	449	479

12.33201581	493	526	505	560
14.35897436	549	602	562	616
16.37795276	607	647	620	681
18.38899804	673	671	667	750
20.39215686	707	724	721	802
22.38747554	756	778	772	824
24.375	801	817	830	868
26.35477583	849	862	870	919
28.32684825	902	958	934	965
30.29126214	949	975	946	1021
32.24806202	1021	1002	1029	1068
34.19729207	1048	1039	1053	1118
36.13899614	1074	1088	1102	1172
38.07321773	1137	1140	1146	1230
40	1179	1162	1175	1270
41.9193858	1201	1211	1260	1323
43.83141762	1238	1272	1316	1419
45.73613767	1268	1300	1363	1450
47.63358779	1292	1403	1400	1504
49.52380952	1337	1446	1467	1542
51.40684411	1382	1500	1497	1579
53.28273245	1430	1530	1527	1625
55.15151515	1460	1575	1595	1673
57.01323251	1500	1611	1634	1718
58.86792453	1527	1668	1661	1730

APPENDIX-II

Molar concentration, C and corresponding absorbance, A of SDS in aqueous solution of tryptophan 0.0005 M at room temperature with aqueous rich mixture of DMSO.

	Absorbance				
C, 10^3	0%DMSO	0.23%DMSO	0.46%DMSO	0.69%DMSO	0.91%DMSO
0	2.608	2.692	2.779	2.8	2.776
2.075848303	2.622	2.695	2.779	2.806	2.79
4.143426295	2.614	2.795	2.75	2.848	2.95
8.253968254	2.58	2.738	2.714	2.748	2.936
12.33201581	2.578	2.685	2.688	2.717	2.778
16.37795276	2.549	2.622	2.664	2.671	2.665
20.39215686	2.597	2.617	2.624	2.616	2.623
24.375	2.63	2.57	2.582	2.594	2.547
28.32684825	2.568	2.527	2.558	2.526	2.522