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Effect of Ethanol on Critical Micelle Concentration of Sodium Dodecylsulphate in Mixed Solvent Media at 308.15K by Conductometric Measurement

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Abstract

The conductivity measurement of sodium dodecyl sulfate (SDS) in mixed solvent media was investigated. The results indicated that sharp increase with the increase in concentration and temperature of sodium dodecyl sulfate. The critical micelle concentration (CMC) decreased with the amount of ethanol increase which can be explained based on the nature of solvent mixed media and inter ionic attraction of ions. The graph of conductance versus concentration is used to determine the critical micelle concentration (CMC).

Keywords: SDS, CMC, conductivity, mixed solvent media, ethanol, ions

Introduction

A surfactant (surface active agent) is an organic compound, which contains two groups of molecules, one is the solvent-loving group called lyophilic (hydrophilic/polar group) and the other is the solvent heating/ fearing group, called lyophobic (hydrophobic/non-polar group) in their structure (Myers et al., 1988). They self-aggregate in an aqueous solution and aggregated form is called micelle due to the polar and non-polar groups present in the surfactants (Chakraborty et al., 2011). The tail of the surfactant represents the non-polar group and the head represents the polar group.

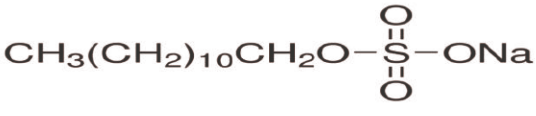

Figure 1. Surfactant

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In the field of chemistry, The CMC explains, the concentration of surfactants above which micelles forms. If added the additional surfactants to the system will form the micelles. The most important properties of the surfactants are the CMC. Before reaching the concentration of surfactant, the surface tension of the liquid change strongly after reaching the CMC surface tension remains constant or change the lower slope. The CMC of the surfactants depends upon the temperature, pressure, and also the presence of a concentration of the other surface active substance or electrolyte micelles only forms above the critical micelles temperature (CMT). For example, the value of CMC for sodium dodecyl sulfate in water (without other additives or salts) at 25 °C, atmospheric pressure, is 8x10–3 mol/L (Dominguez et al., 1997). The CMC is the concentration of the surfactants in the bulk at which micelles starts to form. The word bulk comes from the surfactants when it partitions between bulk and interface. CMC is independent of the interface. So, it is an important characteristic of surfactants. Surfactants are organic compounds. It is amphiphilic. It contains both hydrophobic groups (tails) and hydrophilic groups (heads). As a result, surfactants dispersed in the water phase and absorbed the interfaces between air and water or, in the event of water and oil mixing, the interfaces between oil and water. While the water-soluble head group stays in the water phase, the water-insoluble hydrophobic group may move from the bulk water phase into the air or the oil phase.

Surfactant manufacturing is reportedly 15 million tons per year. Linear alkyl benzene sulfonates (1.7 million tons/year), lignin sulfonates (600,000 tons/year), fatty alcohol ethoxylates (700,000 tons/year), and alkyl phenol ethoxylates (500,000 tons/year) make up about half of the soaps and other surfactants manufactured on a very large scale. Surfactants have complex behavior at equilibrium. Above the critical micelle concentration, surfactants molecule aggregate to form the micelle. Which are the unassociated surfactant molecules in the solution? Micelles could of the surfactants exist in various shapes like spherical, cylindrical lamellar, depending upon the temperature and concentration of surfactants in solution (Hamley, 2000). Surfactant micelles were created as a result of hydrophobic interactions between the hydrocarbon portions of the molecules, which had an equilibrium effect on hydration and electrostatic repulsion (Tanford, 1980). Surfactants have additional benefits, applications, uses, and activities. In addition to their usage as sensitizers, soap, lubricants, retarding agents, cationic softeners, and antistatic agents, they also exhibit antibacterial capabilities. Additional consumer use When a little amount of sodium salicylate is added, an aqueous solution of CTAB becomes incredibly viscous (NaSal). Some parameters, such as the inclusion of electrolytes, a buffer pH, temperature, the addition of organic modifiers, and the ionic strength of the aqueous solution, affect the CMC of the surfactants when determining the CMC in pure water (Behara & Pandey, 2007).

The addition of electrolytes in the surfactant solution decreases the CMC value (Fuguet et al., 2005). The thickness of the ionic atmospheric surrounding the polar head groups was reduced by the addition of surfactants in the solution. Which consequently decreases repulsion between them, due to the absence of high ionic strength and electro viscous effect when lowering the ionic strength thicker the particle diffuse layer. In absence of salt in the solution reduce the viscosity of the solution. Surfactant addition significantly reduces the viscosity of solutions (Abuin &Scaiano, 2005) demonstrated that this viscosity reduction is significantly more substantial than the straightforward charge screening brought on by the addition of monovalent saltsThis paper reported, the study of CMC of SDS in mixed solvent media at different percentage of ethanol at 308.15K.temperature in by conductometric method in mixed solvent media.

Method

Material and Methods

Materials

Ethanol (99.0% pure) was obtained from E. Merck, India. The anionic surfactant SDS was purchased from Loba Chemie Private Limited (Mumbai, India). SDS was highly pure (N99.0%) and used after drying for 1 h.

Preparation of ethanol-water mixed solvent media

All were prepared in triply distilled water with a specific conductance of b 0.6 μS/cm at 308.15 K. 0%, 10%, and 20% Ethanol–water mixtures were prepared at 308.15 K respectively by maintaining at constant temperature in a thermostat. The mixed solvents were further used after 24 h to make the solutions of SDS. Again, the solutions were kept for 24 h and the volume makeup of the solutions was done with the solvents at a constant temperature of 308.15 K.

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Preparation of ethanol-water mixed solvent media:-

Ethanol was brought from E. Merck, India, and was distilled with P2O5 and redistilled with Ca(OH)2. The collected fractions of ethanol have specific conductance of 3-4 µS/cm at room temperature and it was used for the preparation of mixed solvent. De-ionized water (Stanbio Reagent (P) Ltd., Kolkata, India) was double distilled in the presence of potassium permanganate, and the distilled water having specific conductance of 2-3 µ S/cm at room temperature (300±2 K) was obtained. By using the above ethanol 0%, 10%, and 20% ethanol-water mixed solvent media were prepared.10% ethanol mixed solvent media = 10 ml ethanol + 90 ml distilled water. 20% ethanol mixed solvent media = 20 ml ethanol + 80 ml distilled water. 0% ethanol mixed solvent media = 0 ml ethanol + 100 ml distilled water.

Preparation of SDS, Stock solution

Sodium dodecyl sulfate was brought from Loba Chem. i.e. Private Limited (Mumbai, India). These dried for one hour in a hot air oven at 373K. 0.28838 gm of Sodium dodecyl sulfate was dissolved in a 100 ml volumetric flask to prepare 0.01 M, solution in distilled water as well as in 10%, and 20% mixed solvent media. This is the sample of measurement of conductance for our research work.

Using a conductivity meter, the conductometric measurement was carried out at 308.15K temperature. To guarantee that the outcomes could be reproduced, many independent solutions were created and runs were carried out. A dip-type conductivity cell with a cell constant of 1.02 cm1 and an uncertainty of 0.01% was used in a digital conductivity meter from Systronics India Ltd. to test the specific conductivity of freshly prepared solutions. KCl solutions (0.1 M and 0.01 M) were used to calibrate the conductivity cell at 298.15 K (Lind et al., 1959).

Results and Discussion

Conductometric studies

One crucial tool for investigating the physicochemical characteristics of surfactant solutions is conductivity research. Figures 2, 3, 4, and 5 show plots of the specific conductance of SDS at 308.15 K in mixes of ethanol and water at various concentrations.

Verification of Sp. Conductivities of sodium dodecyl sulfate (SDS) with distilled water at temperature 308.15K.

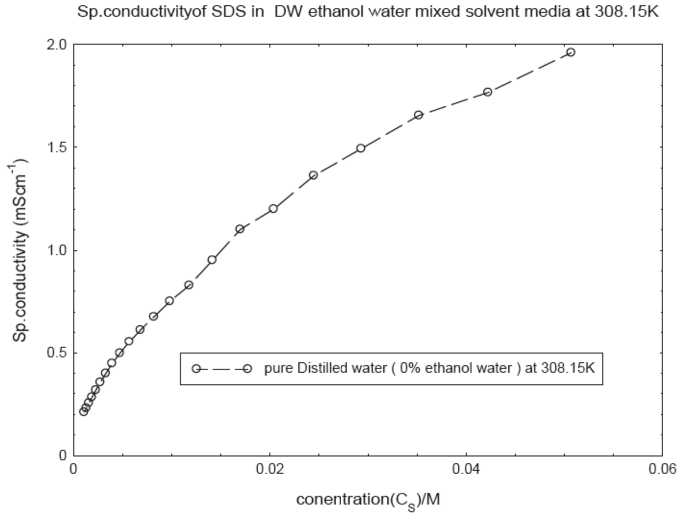

Figure 2. Sp. conductivity in distilled water

Verification of Sp. Conductivities of sodium dodecyl sulfate (SDS) with 10% ethanol-water mixed solvent media at temperature 308.15K.

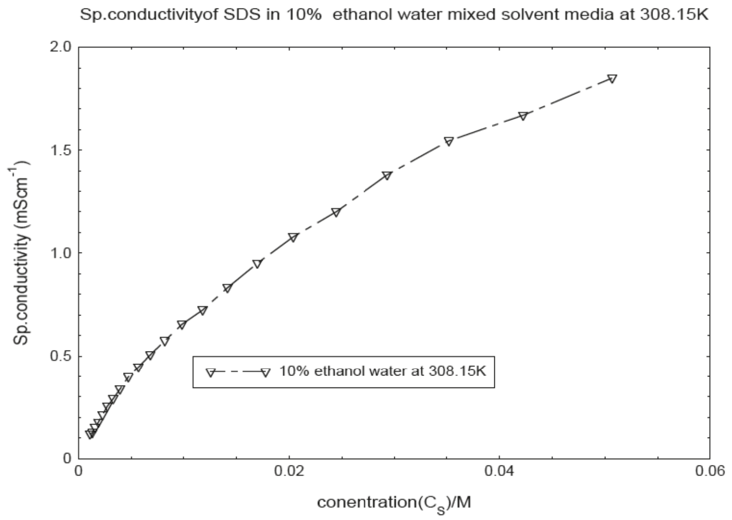

Figure 3. Sp. conductivity in 10% ethanol-water mixed solvent media

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Verification of Sp. Conductivities of sodium dodecyl sulfate (SDS) with 20% ethanol-water mixed solvent media at temperature 308.15K.

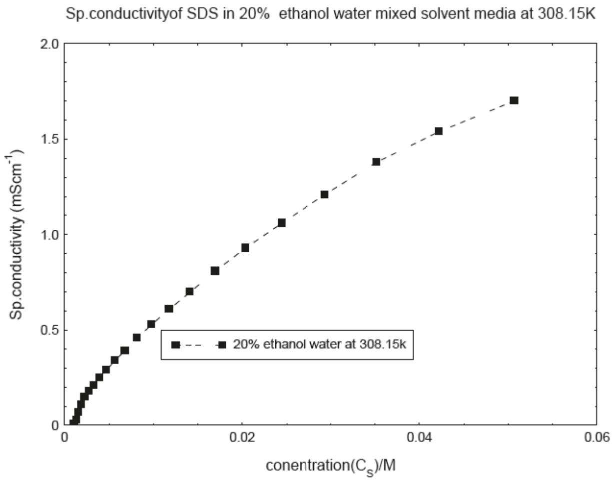

Figure 4. Sp. conductivity in 20% ethanol - water mixed solvent media

Comparative study of Sp. Conductivities of sodium dodecylsulphate (SDS) in distilled water, 10%, 20%, and ethanol -water mixed solvent media at temperature 308.15K.

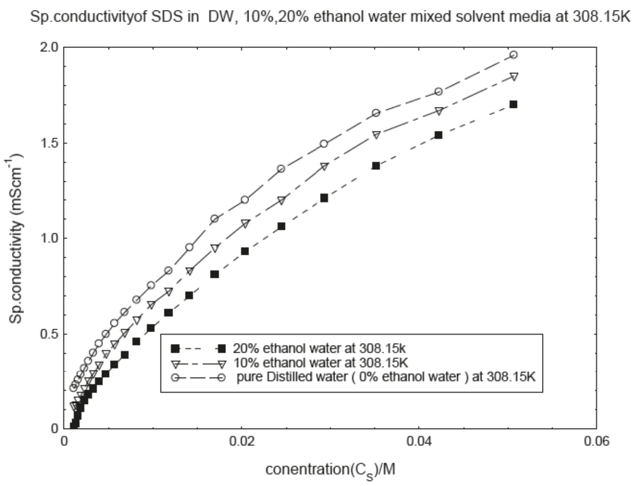

Figure 5. Comparative study of Sp. conductivity in distilled water, 10%, 20% ethanol - water mixed solvent media

Figure 5 shows the three curves. The curve of sodium dodecyl sulfate (SDS) in distilled water (0% ethanol-water mixed solvent medium) at 308.15K is indicated by an open circle (○). The curve of sodium dodecyl sulfate (SDS) in 10% ethanol/water mixed solvent media at 308.15K is indicated by an open triangle (Δ). The curve of sodium dodecyl sulfate (SDS) in 20% ethanol/water mixed solvent media at 308.15K is indicated by a closed square (■).

Specific conductivity is decreased with an increase in the amount of ethanol. An increasing amount of ethanol in the solution decreases the movement of ions in the solution and increases the amount of ethanol in the solution, due to this decrease in the viscosity of the solution. The viscous force of the solution is increased. That is why ions move with difficulty and slowly. Inter ionic force of attraction between ions is also increased due to an increase in the amount of ethanol

From Figures 2, 3, and 4, it is clear that, within the concentration range examined here, the specific conductivity exhibits a dramatic increase with increasing concentration. The conductivity increased as the solution's concentration rose. Because the amount of ions in the solution has increased relative to its volume.

According to the graph above, conductivity rises as solution concentration does. At varying solution concentrations, the slope will alter. The slope is determined by the spots where these two lines intersect. This contributes to what is considered to be a crucial micelle concentration (CMC). The ratio of the pre- to post-micellar slopes determines the degree of ionization (α). In this method, the conductance vs solution concentration plots, which show various variations in the pre-and post-micellar slopes, are mostly used to display the features of surfactant solutions. These two slopes change when ethanol is added, which affects the physicochemical characteristics of the solution. It is seen from Figures 2, 3, 4, and 5, the conductivity of SDS increases with an increase in the concentration of the solution contained in alcohol-water. Figure 5 also illustrates that the conductivity of SDS decreases with an increase in the amount of ethanol in the solution content in alcohol-water.

Alcohol's capacity to alter the structure of water and raise the medium temperature is used to explain this occurrence. The Physicochemical characteristics of the surfactant in the ethanol-water solution alter as a result of this difference in slopes. The fluctuation of slopes is influenced by the physiochemical characteristics of the mixture of cationic-anionic interaction surfactants. Also, effect an increase in ethanol. The dielectric constant of alcohol is lower than water. When alcohol is mixed with water, decrease the dielectric constant of the solvent. If the dielectric constant is low then low conducting power of the solution. In other words, the

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electrostatic forces between oppositely charged ions explain the tiny value of conductance in liquids with low dielectric constants, which have a little ionizing effect on surfactants. The opposite is also true; solvents with high dielectric constants produce more conductive solutions.

CMC of sodium dodecyl sulfate (SDS) distilled water at temperature 308.15K.

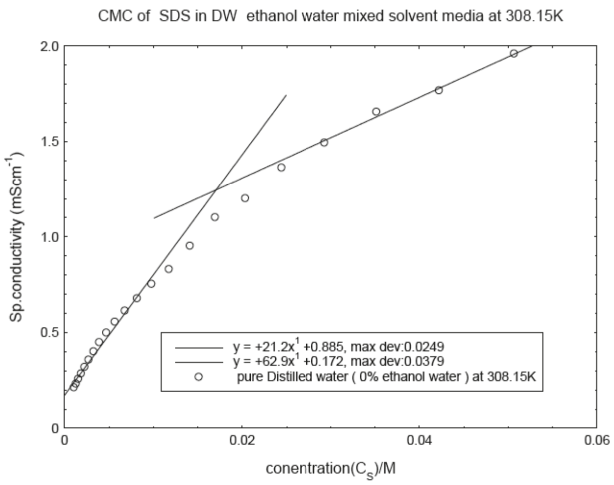

Figure 6. CMC in distilled water

CMC of sodium dodecyl sulfate (SDS) 10% ethanol water mixed solvent media at temperature 308.15K.

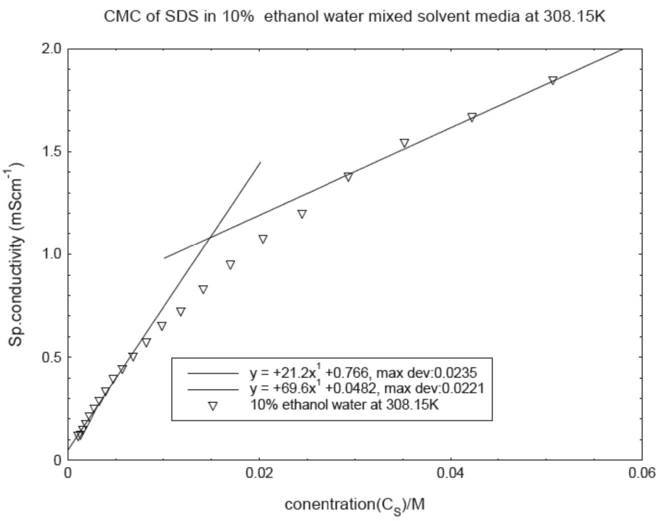

Figure 7. CMC in 10% ethanol -water mixed solvent media

CMC of Sodium dodecyl sulfate (SDS) in 20% ethanol water mixed solvent media at temperature 308.15K.

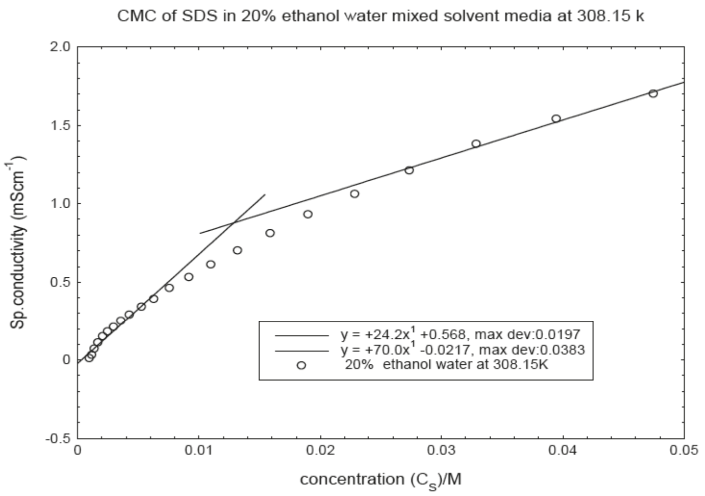

Figure 8. CMC in 20% ethanol - water mixed solvent media

Comparative study of CMC of sodium dodecyl sulfate (SDS) in distilled water, 10%, 20% ethanol water mixed solvent media at temperature 308.15K.

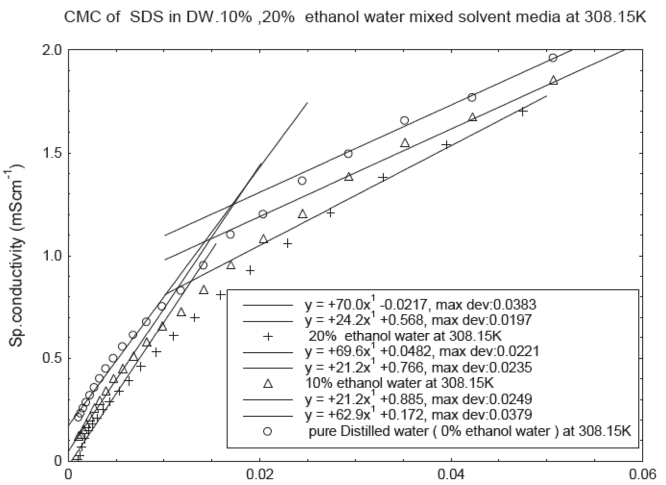

Figure 9. Comparative study of CMC of (SDS) in distilled water, 10%, 20% ethanol - water mixed solvent media

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Figure 9 indicates the three curves. The curves are denoted by an open circle (○) which is situated at the upper level of the curve. It is the curve of sodium dodecyl sulfate (SDS) in distilled water (0% ethanol-water mixed solvent media) at 308.15K,

Critical micelles concentration (CMC) of sodium dodecyl sulfate (SDS in distilled water (0% ethanol-water mixed solvent media) at 308.15K was calculated by solving the two straight-line equations.

Pre-straight line, y = +62.9x1 +0.172

Post straight line, y = +21.2x1 + 0.885

Then CMC is the intersection point of these two lines i.e. CMC is 0.0170M.

The curve is denoted by an open triangle (Δ), which is situated in the middle level of the curve .it is the curve of sodium dodecyl sulfate (SDS) in 10% ethanol-water mixed solvent media at 308.15K. Critical micelles concentration (CMC) of sodium dodecyl sulfate (SDS in 10% ethanol-water mixed solvent media at 308.15K was obtained by solving the two straight line equation.

Pre straight line y = +69.6x1 +0.0482

Post straight line y = +21.2x1 +0.766

Then CMC is the intersection point of these two lines i.e. CMC is 0.014M.

The curve is denoted by the closed square (×), which is situated at a lower level of the curve .it is the curve of sodium dodecyl sulfate (SDS) in 20% ethanol-water mixed solvent media at 308.15K

Pre straight line y = +70.0x1 +0.0217

Post straight line y = +24.2x1 + 0.568

Then CMC is the intersection point of these two lines i.e. CMC is 0.0119M.

Compared to water, alcohol has a lower dielectric constant. The dielectric constant of the alcohol-water medium dropped when alcohol was added. An earlier conductivity investigation also established that the relative permittivity of the metal reduces with increasing methanol content at a particular temperature. The specific conductance of the mixed surfactant solutions is shown against the concentration for crucial micelle concentration determinations. The critical micelle concentration is the point at which the curves break, indicating micelle production, and are observed (CMC). Specific conductivity levels vary differently before and after the CMC. Due to the creation of micelles with lesser ionic mobility after the CMC, the conductivity falls. By resolving the simultaneous set of two equations for straight lines, as shown in the example figure, the CMC can be calculated (Fig. 9). The degree of dissociation is determined by comparing the slopes of the two lines in the conductivity against surfactant concentration plots. For SDS solutions in both pure water and ethanol-water mixture solvents, the CMC is calculated. The conductivity against surfactant concentration plot's slopes above and below the CMC are compared, and the result is the degree of dissociation (α), which is provided by the formula: α=S2S1, where S1 is the pre-CMC slope and S2 is the post-CMC slope. The biggest pre-CMC slopes (S1) and shortest post-CMC slopes may be seen in the mixed surfactants (S2). The capacity of alcohol to disrupt the structure of water and enhance medium viscosity is used to explain this phenomenon. The physicochemical properties of the surfactant in the methanol-water and ethanol-water systems alter as a result of this variation in slopes. Based on the variation in slopes with increasing methanol concentration, the physicochemical properties of a mixture of cationic and anionic surfactants.

Conclusion

The effect of the amount of ethanol in mixed solvent media of sodium dodecyl sulfate (SDS) has been studied by measuring the specific conductivity by the conductometric method. From the Above results. It concluded that decrease in specific conductance. Critical micelles concentration (CMC) decreased with an increase in the amount of ethanol in the solution.

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