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Original Research Article

VISCOMETRIC STUDIES OF SODIUMDODECYL SULPHATE IN PRESENCE AND ABSENCE OF Na_2SO_4 AND $ZnSO_4$ IN AQUEOUS MEDIA AT ROOM TEMPERATURE

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Abstract: The precise measurement of viscosity of sodiumdodecyl sulphate (SDS) in presence and in absence of Na_2SO_4 and $ZnSO_4$ in aqueous media is reported. The concentration of sodiumdodecyl sulphate (SDS) varies from (0.06 to 0.004) $mol.lt^{-1}$ where as the salts concentrations as 0.01M Na_2SO_4 and 0.01M $ZnSO_4$. The results showed a sharp increase in viscosity with increase in concentration of sodiumdodecyl sulphate after the critical micelle concentration (CMC) in absence and presence of Na_2SO_4 and $ZnSO_4$. The viscosity values of SDS are found to be higher in presence of Na_2SO_4 than in presence of $ZnSO_4$ whereas the critical micelle concentration (CMC) value decreases more in presence of Na_2SO_4 and than $ZnSO_4$.

Key words: Sodiumdodecyl sulphate, viscosity, critical micelle concentration, Na_2SO_4, $ZnSO_4$.

Introduction

Surfactants are compounds with molecular structure consisting of a hydrophilic and a hydrophobic part. The hydrophobic part is generally a long hydrocarbon chain whereas the hydrophilic part consists of an ionic or polar group. Due to this characteristic structure, these compounds have special properties like lowering of the surface tension of solutions and association tendency. In diluted solutions the ionic surfactants are found as individual ions. At a concentration above a critical value named critical micelle concentration (CMC), surfactants molecules tend to aggregate forming micelles. CMC value depends on the surfactant molecule structure and is influenced by the presence of inorganic salts in the dispersion medium. CMC value must be known in many applications of surfactants like detergents and colloid stabilizations[1].

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Sodiumdodecyl sulphate (SDS) is an anionic surfactant. One end of the molecule is charged and therefore has an affinity for water, and the other end is non polar and soluble in fat/oil. SDS has a negatively charged sulfonate group as its “hydrophilic” end and a saturated 12-carbon for its "lipophilic" end. Sodiumdodecyl sulphate has significant application as very effective surfactant in a number of industrial products and in recent studies it is considered as a novel microbicide against different viruses[2, 3]. There is a very old work on viscosity of sodiumdodecyl sulfate in dilute solutions[4]. A viscosity measurement was performed on 0.3 M sodium dodecyl sulfate (SDS) micellar solutions containing different ammonium salts at different temperatures. The viscosity decreased, increased, and again decreased as the salt concentration was increased[5].

Addition of electrolyte in the surfactant solution decreases the CMC value[6]. In this paper, we have reported viscosities of SDS at room temperature in the absence and in the presence of Na_2SO_4 and $ZnSO_4$ in aqueous media at room temperature by viscometric method.

In viscometric determination of CMC of pure surfactant in presence and absence of Na_2SO_4, $ZnSO_4$, the viscosities (η) are plotted as a function of the logarithm of the surfactant.

Materials and Methods

Sodiumdodecyl sulphate was purchased from Loba Chemical, India. $ZnSO_4$ and Na_2SO_4 were purchased from Ranbaxy Chemical, India. The water used in the experiments was doubly distilled. The solutions prepared at room temperature.

Ostwald viscometer was used to determine the viscosities of SDS in distilled water and in presence of Na_2SO_4 and $ZnSO_4$. A well washed and dried viscometer was clamped vertically and 15ml distilled water was poured in it and time of flow was noted with the help of stop watch. This process was repeated for 3 times to get a constant time of flow.

After measuring the time of flow of distilled water, a suitable SDS solution in distilled water was selected and was subjected for viscosity measurements with a wide range of concentrations. 15ml of the selected solution was poured in the viscometer and time of flow was taken. Then after this first reading, 2 ml solution was ejected and 2ml distilled water was added to the internal dilution of the initial solution and respective time of flow was measured. Thus, following the same procedure 20 readings were taken. With the help of standard viscosity value of water at 30^{o}c , density of water, time of flow for distilled water and collected 20 readings, their respective viscosities were calculated for all concentrations.

The coefficient of viscosity of a given liquid can be calculated according to the following equation:

$$\eta_1 = \left(\frac{d_1}{d_2}\right)\left(\frac{t_1}{t_2}\right)\eta_2 \qquad (1)$$

η_1 = coefficient of viscosity of the solution
η_2 = coefficient of viscosity of the solvent
t_1 = time flow of the solution
t_2 = time flow of the solvent
d_1 = density of the solution
d_2 = density of the solvent

The density of any one solution must be known which is calculated by using the expression:

$$d_1 = \left(\frac{w_1}{w_2}\right)d_2 \qquad (2)$$

d_1 = density of liquid
d_2 = density of water
w_1= weight of liquid
w_2= weight of water

The calculated viscosities were plotted against logarithmic concentrations of SDS solution and CMC was also calculated.

Similarly, for the determination of viscosities of SDS in 0.01M Na_2SO_4 and 0.01M $ZnSO_4$ solution, suitable SDS solutions were selected. Before measuring the time of flow of SDS, the time of flow of respective solvents, were measured with the same viscometer. Then the values of viscosity for respective solvents were calculated with the standard value of water at 30^{o}c. Again 15ml of SDS solution was taken as initial solution and same volume was taken for the purpose of internal dilution as previous. 20 readings were taken for Na_2SO_4 and $ZnSO_4$ respectively for the determination of viscosities of SDS following the same process as for distilled water. The calculated viscosities were plotted against logarithmic concentrations of SDS in both the salts and CMC values of SDS were calculated for both of the solutions of Na_2SO_4 and $ZnSO_4$.

Results and Discussion

The specific viscosity decreases with decrease of concentration of SDS and there is a pronounced break and then remains constant. The breaking point is known as critical micelle concentration, CMC (Fig. 1-3). The viscosity of SDS in presence of Na_2SO_4 is more than in presence of $ZnSO_4$ (Table1), this is because while $ZnSO_4$ is absorbed on the surface of the micelle, Na_2SO_4 remains in the bulk of the solution. Addition of salt is known to decrease CMC of the solution[7,8]. Increasing the salt concentration reduces the electrostatic Debye screening length around the surfactant, which encourages the formation of longer micelles at equilibrium. This, in turn contributes to the changes in CMC. Fujio (1998) [9] found that spherical micelles associated to form into rod-like micelles when salt concentration exceeded a threshold concentration. Salts decrease the CMC in the order: $ZnSO_4 < Na_2SO_4$. Here Zn^{++} is least effective in decreasing the CMC due to small size and large hydrated radius and would act as a water-structure promoter decreasing the availability of water to the micelles. Therefore, upon addition of $ZnSO_4$ and Na_2SO_4 in SDS, Na_2SO_4 is more effective in reducing the CMC of SDS. Hence in our case Na_2SO_4 decreases the CMC of SDS more than $ZnSO_4$ (Table 2).

Table 1- Viscosities of SDS in distilled water, in aqueous solutions of Na_2SO_4 and $ZnSO_4$.

Solvent	Concentration (*mol/Lt*)	Viscosity(*m Pas*)
Distilled water (300.15K)	0.030067	9.187904
	0.026058	9.039003
	0.022584	8.890145
	0.019573	8.741327
	0.016963	8.592552
	0.014701	8.443825
	0.012741	8.295149
	0.011042	8.245273
	0.009570	8.195440
	0.008294	8.145651
	0.007188	8.095904
	0.006230	8.095562
	0.005399	8.095254
	0.004679	8.094979
	0.004055	8.094735

Na_2SO_4 (304.15K)	0.060000	8.670860
	0.052000	8.668239
	0.045067	8.616341
	0.039058	8.267541
	0.033850	8.216503
	0.029337	8.116041
	0.025425	8.016025
	0.022035	7.916074
	0.019097	7.865825
	0.016551	7.815767
	0.014344	7.716354
	0.012432	7.666428
	0.010774	7.616601
	0.009337	7.566904
	0.008092	7.517224
	0.007013	7.467604
	0.006078	7.467402
	0.005268	7.467248
	0.004566	7.467151
	0.003957	7.467057
$ZnSO_4$ (304.15K)	0.040114	8.120767
	0.034765	7.970595
	0.030130	7.870462
	0.026113	7.770275
	0.022631	7.670349
	0.019613	7.570671
	0.016998	7.421550
	0.014732	7.223175
	0.012768	7.123773
	0.011065	7.073948
	0.009590	6.925203
	0.008311	6.826022
	0.007203	6.776310
	0.006243	6.776147
	0.005410	6.726524
	0.004689	6.726369
	0.004064	6.726207
	0.003522	6.726130
	0.003052	6.676596
	0.002645	6.676442
	0.001764	6.676288

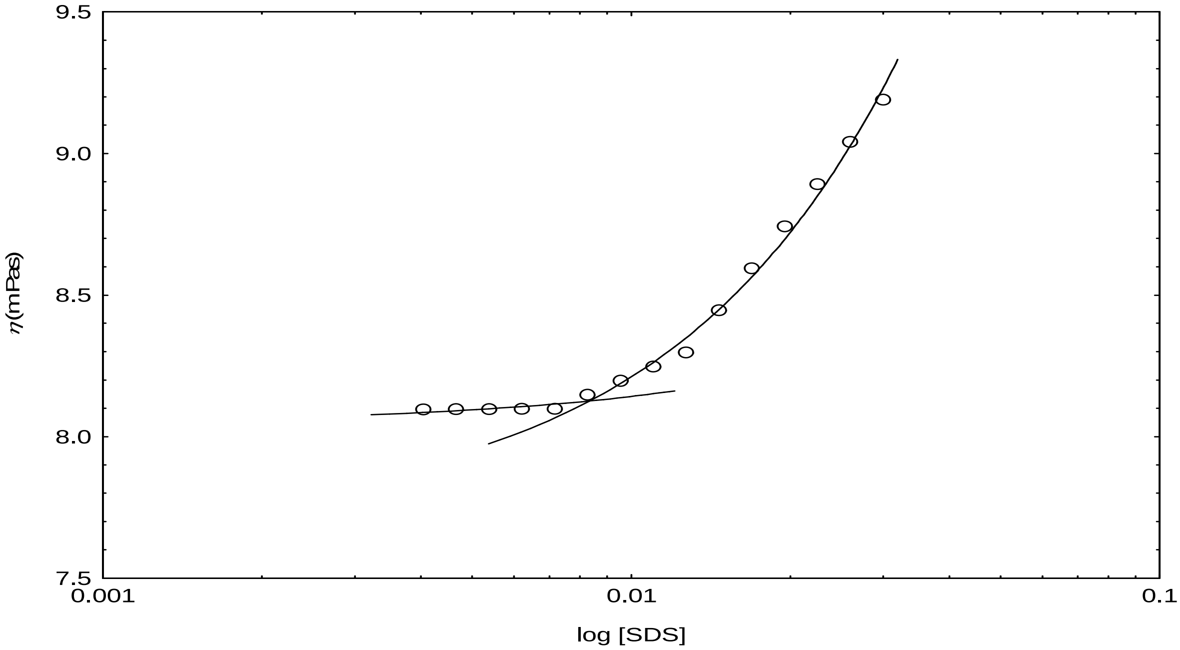

Fig. 1. Variation of viscosities of SDS with log [SDS] in distilled water at 300.15K.

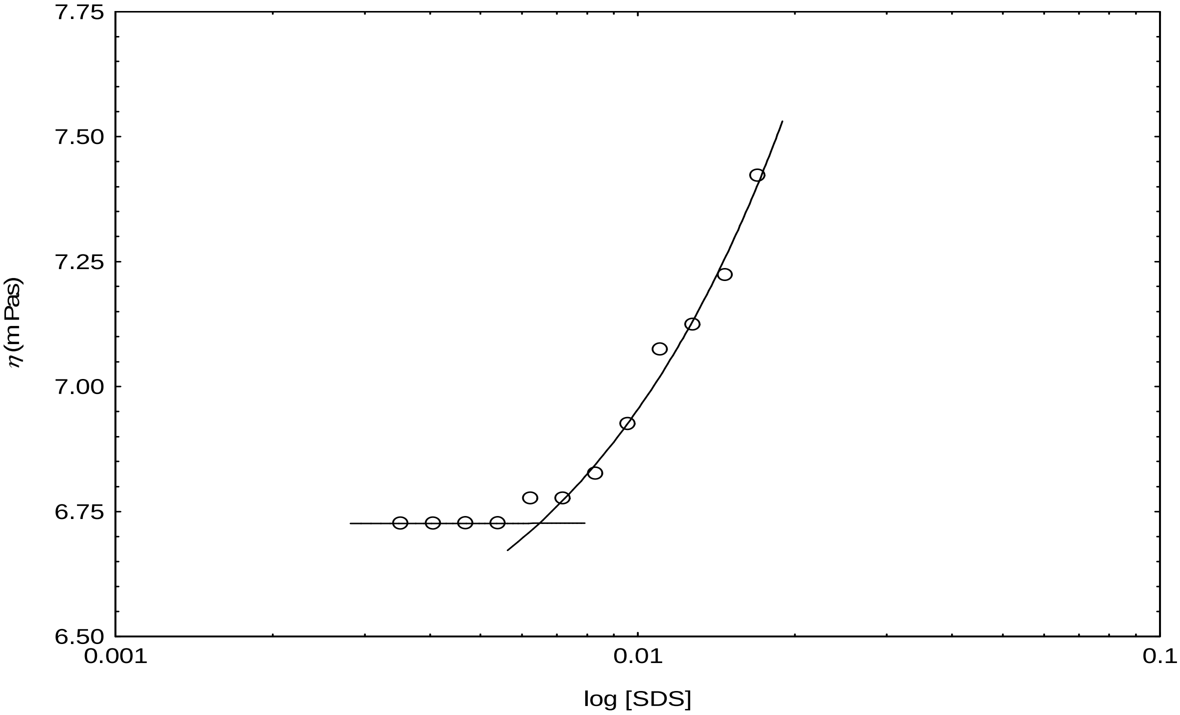

Fig. 2. Variation of viscosities of SDS with log [SDS] in aqueous solution of ZnSO4 at 304.15K.

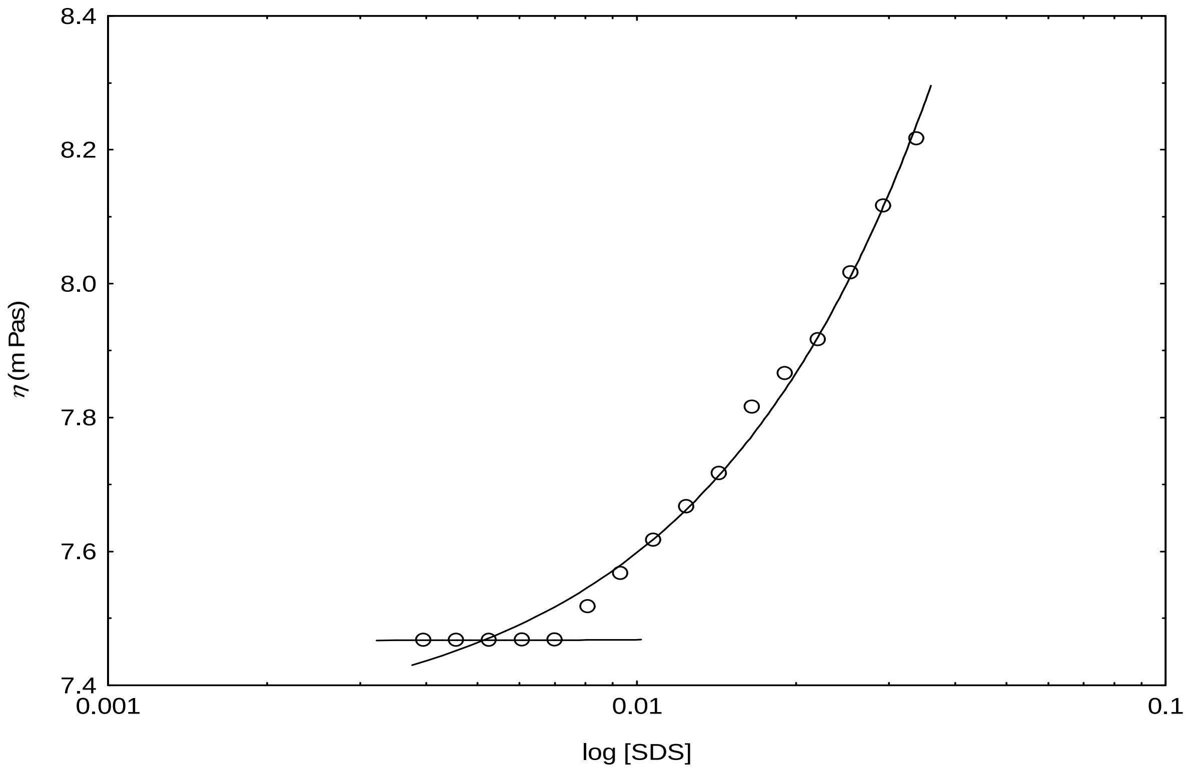

Fig. 3. Variation of viscosities of log [SDS] in aqueous solution of Na_2SO_4 at 304.15K.

Table 2- Critical micelle concentrations of SDS obtained from viscosity measurement in distilled water, aqueous solution of Na_2SO_4 and $ZnSO_4$

Solvent	Distilled water (300.15K) *CMC* (mM)	0.01M $ZnSO_4$(304.15K) *CMC* (mM)	0.01M Na_2SO_4(304.15K) *CMC* (mM)
Viscosity	8.40	6.52	5.24

Conclusions

The following conclusions have been drawn from above results and discussion. The results showed an increase in viscosity of sodiumdodecyl sulphate is found more in presence of Na_2SO_4 than $ZnSO_4$ in aqueous media whereas in the presence of Na_2SO_4, the CMC of sodiumdodecyl sulphate decreases more in comparison with presence of $ZnSO_4$.

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