Journal of Molecular Liquids 221 (2016) 526–534

Contents lists available at ScienceDirect

Journal of Molecular Liquids

journal homepage: www.elsevier.com/locate/molliq

Study of thermodynamic properties of sodium dodecyl sulphate in aqueous solutions of alkoxyalkanols at different temperatures

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ARTICLE INFO

Article history:
Received 11 May 2016
Received in revised form 6 June 2016
Accepted 7 June 2016
Available online 9 June 2016

Keywords:
Apparent molar volume
Apparent molar isentropic compression
Alkoxyalkanol
Sodium dodecyl sulphate
Ion-ion interactions

ABSTRACT

Densities, ρ, speed of sound, u , for aqueous solutions of alkoxyalkanols like ethylene glycol mono methyl ether (EGMME), ethylene glycol mono ethyl ether (EGMEE) and ethylene glycol mono butyl ether (EGMBE) have been measured in aqueous solutions of surfactant sodium dodecyl sulphate (SDS) at temperatures $T =$ (288.15, 298.15, 308.15 and 318.15) K have been measured. The different parameters such as apparent molar volume, limiting apparent molar volume, transfer volume, partial molar expansibility have been derived from density data to study the nature of interactions and also the aggregation behavior of surfactant with alkoxyalkanols. Experimental speeds of sound data were used to estimate apparent molar isentropic compression, limiting apparent molar isentropic compression, partial molar isentropic compression of transfer. The pair and triplet interaction coefficient have been calculated from both the properties. These parameters have been discussed in the light of ion-ion and ion-solvent interactions.

1. Introduction

Surfactants are extensively employed in pharmaceutical [1,2] and biotechnological process [3,4]. Surfactants are amphipathic substances composed of both hydrophilic and hydrophobic groups and are widely used in inducing unfolding of proteins [3]. It is well known that the micellar properties of both anionic and cationic surfactants are significantly influenced by the presence of various nonelectrolytes in solution [4]. Earlier it was thought that the ability of a solvent to form hydrogen bond is a necessary condition of micelle formation [5] but then it has been seen from the literature that micelle formation has been reported in solvents such as acetone, acetonitrile and dimethylsulphoxide where there is little or no hydrogen bonding [6,7]. Ionic surfactants are the major type of surfactant in use and therefore their physical and chemical properties have received much more attention [8] as compared with non ionic surfactants. Sodium dodecyl sulphate (SDS) is the most commonly used anionic surfactant. Its surface active properties make it important in hundreds of household and industrial cleaners, cosmetics, industrial manufacturing process, in pharmaceuticals, as wetting agents and also in number of biological and environment systems [9]. Numerous works has been done on studies of interaction of protein and surfactant [10] like volumetric studies of glutamine dipeptides with sodium dodecylsulphate [11]. Also the work on interaction of some amino acids and glycine peptides with aqueous sodium dodecyl sulphate and cetyltrimethylammonium bromide at 298.15 K [12] has also been done. Exhaustive work has also been done on SDS with Poly vinyl pyrrolidine [13], with liposomes [14], with enzymes such as *Aspergillus niger* catalase [15], with graphite water interface to study molecular dynamics simulations [16] but so far to the best of our Knowledge, no report is available in the literature on the thermodynamic properties of SDS with N-alkoxyalkanols. So, as to understand the interaction behavior of SDS with N-alkoxyalkanols in the present study we report the density and speed of sound of SDS with 10% and 20% of EGMME, EGMEE, EGMBE at T = (288.15 K, 298.15 K, 308.15 K and 318.15 K). Apparent molar properties and interaction parameters have been calculated from the experimental values of density and speed of sound.

2. Experimental

Ethylene glycol mono methyl ether (EGMME), ethylene glycol mono ethyl ether (EGMEE), and ethylene glycol mono butyl ether (EGMBE) with mass fraction purities ≥0.99 were obtained from Merck, Germany. Sodium dodecyl sulphate (SDS) with mass fraction purity ≥0.99 was procured from SD Fine Chemicals Ltd., India, All chemicals were obtained in their highest purity and the details of the chemicals used in the present work are also given in Table 1. They were used as such without further purification. All the solvents (alkoxyalkanols) were kept tightly sealed in dark bottles to minimize absorption of atmospheric moisture and carbon dioxide and were degassed under vacuum for density and speeds of sound measurements.

Triple distilled water which has been freshly degassed having specific conductance $<10^{-6}$ S·cm^{-1} was used for the preparation of the

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http://dx.doi.org/10.1016/j.molliq.2016.06.027
0167-7322/

Table 1
Specification of chemicals.

Chemical	Source	Mass fraction purity[a]
Sodium dodecyl sulphate (SDS)	S.D. Fine Chemicals, India	≥0.99
Ethylene glycol monomethyl ether (EGMME)	Merck, Germany	≥0.995
Ethylene glycol monoethyl ether (EGMEE)	Merck, Germany	≥0.99
Ethylene glycol monobutyl ether (EGMBE)	Merck, Germany	≥0.99

[a] As declared by supplier.

aqueous solutions. All the solutions of sodium dodecyl sulphate, EGMME, EGMEE and EGMBE were prepared by mass on molality concentration scale on a Sartorius BP 210S balance having precision ±0.00001 g. Uncertainty in the solution concentration was estimated at $\pm 2 \times 10^{-5}$ mol kg^{-1} in calculations. All the samples were made afresh before use.

The densities, ρ and speed of sound, u of the solutions were simultaneously, and automatically measured, using an Anton Paar DSA 5000 M densimeter. A density check or an air/water adjustment was performed at 20 °C with doubly distilled, degassed water, and with dry air at atmospheric pressure. Before each series of measurements the densimeter was calibrated with double distilled and degassed water, cyclopentane,

Table 2
Densities (ρ), and speed of sound (u) of Sodium dodecyl sulphate in aqueous solutions of alkoxyalkanols at different temperatures.

	$\rho\times10^{-3}$ (kg m^{-3})				u (ms^{-1})			
#m (mol kg^{-1})	T = 288.15 K	T = 298.15 K	T = 308.15 K	T = 318.15 K	T = 288.15 K	T = 298.15 K	T = 308.15 K	T = 318.15 K
SDS + water								
0.00000	0.999223	0.997111	0.993955	0.990323	1467.33	1497.73	1520.78	1537.14
0.00102	0.999342	0.997252	0.994236	0.990411	1466.79	1496.76	1519.74	1536.33
0.00198	0.999360	0.997313	0.994291	0.990440	1467.23	1496.98	1519.88	1536.43
0.00317	0.999400	0.997340	0.994307	0.990470	1467.28	1497.62	1520.45	1536.62
0.00399	0.999430	0.997385	0.994350	0.990500	1467.72	1497.28	1520.18	1536.68
0.00479	0.999470	0.997420	0.994390	0.990530	1467.87	1497.50	1520.36	1536.83
0.00600	0.999530	0.997480	0.994400	0.990570	1468.70	1498.08	1520.83	1537.22
0.00690	0.999570	0.997510	0.994447	0.990600	1468.06	1498.22	1520.90	1536.94
0.00798	0.999620	0.997540	0.994493	0.990640	1468.56	1498.61	1521.25	1537.47
0.00856	0.999650	0.997580	0.994512	0.990672	1468.47	1498.01	1520.77	1537.15
0.00977	0.999700	0.997620	0.994560	0.990713	1468.82	1498.21	1520.94	1537.31
0.01069	0.999746	0.997664	0.994623	0.990760	1468.70	1498.21	1520.91	1537.31
0.01212	0.999810	0.997763	0.994723	0.990820	1468.94	1498.21	1520.88	1537.25
0.01290	0.999860	0.997782	0.994735	0.990870	1468.76	1498.24	1520.89	1537.24
0.01429	0.999910	0.997820	0.994834	0.990910	1468.87	1498.75	1521.26	1537.23
0.01494	0.999950	0.997860	0.994816	0.990950	1468.90	1498.24	1520.85	1537.28
0.01645	0.999987	0.997892	0.994838	0.990982	1468.83	1498.18	1520.81	1537.13
SDS + 10% EGMME								
0.00000	1.002064	0.999341	0.995750	0.991419	1534.68	1552.42	1564.63	1571.73
0.00110	1.001562	0.998945	0.995430	0.991152	1526.61	1545.85	1559.33	1567.71
0.00203	1.001587	0.998957	0.995444	0.991167	1527.27	1546.42	1559.81	1567.91
0.00294	1.001613	0.998986	0.995471	0.991179	1527.16	1546.19	1559.42	1567.72
0.00401	1.001616	0.998995	0.995474	0.991192	1528.03	1547.06	1560.31	1568.35
0.00474	1.001680	0.999042	0.995513	0.991247	1526.96	1545.91	1559.42	1567.74
0.00601	1.001728	0.999084	0.995546	0.991283	1528.25	1547.47	1560.84	1568.90
0.00750	1.001745	0.999103	0.995579	0.991295	1527.41	1546.57	1559.80	1568.29
0.00841	1.001803	0.999161	0.995627	0.991311	1528.12	1546.99	1560.19	1568.22
0.00878	1.001796	0.999180	0.995614	0.991331	1528.42	1547.17	1560.43	1568.57
0.01000	1.001846	0.999195	0.995660	0.991353	1528.35	1547.20	1560.33	1568.52
0.01101	1.001875	0.999227	0.995682	0.991382	1528.34	1547.05	1560.26	1568.33
0.01250	1.001924	0.999266	0.995721	0.991400	1528.60	1547.34	1560.46	1568.51
0.01329	1.001943	0.999281	0.995736	0.991422	1528.53	1547.32	1560.41	1568.43
0.01436	1.001967	0.999308	0.995757	0.991439	1528.84	1547.47	1560.67	1568.60
0.01495	1.002072	0.999418	0.995845	0.991485	1543.67	1559.41	1570.01	1575.74
0.01604	1.002121	0.999467	0.995905	0.991529	1543.82	1559.52	1570.22	1575.99
SDS + 20% EGMME								
0.00000	1.006643	1.002661	0.998019	0.992766	1606.48	1608.76	1607.63	1603.18
0.00113	1.006959	1.002915	0.998198	0.992888	1609.49	1610.93	1609.08	1604.04
0.00210	1.006970	1.002936	0.998222	0.992896	1609.85	1611.34	1609.55	1604.53
0.00309	1.007022	1.002968	0.998211	0.992915	1610.66	1611.49	1609.66	1604.61
0.00446	1.007029	1.002992	0.998274	0.992949	1609.13	1610.59	1608.77	1603.70
0.00526	1.007066	1.002994	0.998262	0.992966	1610.04	1609.52	1609.52	1604.42
0.00575	1.007019	1.002996	0.998285	0.992951	1608.66	1610.25	1608.57	1603.65
0.00758	1.006215	1.002408	0.997890	0.992743	1609.71	1611.07	1609.14	1603.98
0.00930	1.006277	1.002450	0.997904	0.992780	1597.97	1602.05	1602.52	1599.5
0.01028	1.006327	1.002509	0.997966	0.992790	1598.65	1602.62	1603.00	1599.81
0.01154	1.006374	1.002538	0.997965	0.992816	1598.81	1602.64	1602.95	1599.73
0.01230	1.006358	1.002539	0.998007	0.992845	1599.18	1603.00	1603.28	1599.96
0.01311	1.006436	1.002592	0.998048	0.992884	1598.59	1602.46	1602.78	1599.63
0.01437	1.006463	1.002667	0.998080	0.992902	1599.24	1603.04	1603.23	1600.47
0.01499	1.006430	1.002593	0.998045	0.992895	1599.33	1603.04	1603.22	1599.87
0.01607	1.006515	1.002652	0.998065	0.992917	1598.93	1602.80	1603.03	1599.80

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