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Acoustical and Spectroscopical Analysis of Surfactant with Different Alcohols at Various Concentrations and Temperatures

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ABSTRACT

The ultrasonic velocity of molecules in medium supplies valid information about the binding forces between molecules. Surfactants are chemicals that self-assemble molecular clusters in a solution (oil or water phase) known as micelles. SLS has been suggested as a potentially effective topical microbicide for intravaginal usage to suppress and potentially prevent infection by various enveloped and non-enveloped viruses. The acoustical parameters such as ultrasonic velocity, density, and viscosity of a solution containing an anionic surfactant (SLS) and alcohols (Anise and Cinnamyl alcohol) are determined at various temperatures (303,313 and 323 K). Similarly, the acoustical parameters such as adiabatic compressibility (b), intermolecular free length (L_f), internal pressure (π) Rao's constant (Ra), absorption coefficient (a/f^2), free volume (V_f), cohesive energy (CE), relaxation time (τ), acoustic impedance (Za), and solvation number (Sn) were calculated from the observed values. At the end, it is concluded that SLS+water-Anise alcohol has been used as a best additive. This composite has a lower foaming tendency due to lower surface tension, leading to a newer product.

Keywords: Surfactants, Sodium Lauryl Sulphate, SLS, Anisyl alcohol, Cinnamyl alcohol.

INTRODUCTION

The study of ultrasonic has become increasingly fascinating in recent years. The ultrasonic study of liquids is significant for comprehending molecular interaction type and intensity. The character of inter- and intra-molecular interactions can be examined in great detail by studying how ultrasonic waves propagate through liquids and liquid mixtures[1].

Understanding the chemical interactions in paired mixes depends on the values of the acoustical

parameters. A crucial physical parameter with a physical dependence is ultrasonic velocity[2,3]. Studies on acoustic factors have evolved recently, according to hid[4,5]. Acoustic characteristics can be used to explain the solute-solvent interaction since they are sensitive to changes. Additionally, the detection and evaluation of both weak and strong molecule interactions have been effectively accomplished using ultrasonic velocity measurements[6,7].

Surfactants are chemicals that self-assemble molecular clusters in a solution (oil or water phase) known as micelles and adhere to the contact between a solution and another phase. The surfactants are classified as hydrophilic and hydrophobic depending on how easily they dissolve in water. Both hydrophilic and hydrophobic surfactants dissolve in lipids and water, respectively.The use of surfactants in industrial, agricultural, food, cosmetic, and pharmaceutical applications is widespread. Most of these substances are chemically created and may be poisonous and environmentally harmful[8,9].

The anionic surfactant chosen for the current investigation, sodium dodecyl sulphate, has a negative charge on its head group because of their lower degree of soil adsorption than cationic and non-ionic surfactants[10].

MATERIAL AND METHODS

Materials
An anionic surfactant and alcohols of AnalaR grade were purchased from SD fine chemicals, Mumbai, India. The experimental solutions were made by dissolving a known weight of anionic surfactant in distilled water and stirring under reflux until clear solutions were achieved. The stock solution was made with double the amount of distilled water. The ultrasonic velocity measurements in SLS with anise alcohol and cinnamyl alcohol were performed in an ultrasonic interferometer (model F81, Mittal Enterprises, New Delhi, India) at a fixed single frequency of 2 MHz and various temperatures (303, 313, and 323 K). The temperature was kept constant using circulating water from a thermostatically controlled (0.1K) water bath. The viscosity was measured with an Ostwald's viscometer and standardized with double distilled water with an accuracy of 0.001%.

Methods
The velocity of SLS in the presence of different alcohols (anise and cinnamyl alcohols) was determined at various temperatures using an ultrasonic interferometer with a fixed frequency of 2 MHz (303, 313, and 323 K). Densities were determined at a range of temperatures using a specific gravity bottle understandard procedures. The viscosity was obtained with a 0.001 percent accuracy using an Ostwald viscometer calibrated with double distilled water. The various velocity and absorption parameters were calculated to explore the molecular interactions between anionic surfactants and aromatic alcohols[11].

RESULTS AND DISCUSSION

Results
The acoustical parameters such as adiabatic compressibility, free length, internal pressure and Rao's constant are estimated at all three temperatures from the measured values of ultrasonic velocity, density, and viscosity of the solutions. That are displayed in Tables 1 and 2 Tables 3 and 5.2.4 show the fluctuation of the ultrasonic absorption coefficient with concentrations in the solutions and other computed parameters at 303, 313 and 323 K.

Figures 1 to 6 display plots of SLS concentration vs ultrasonic velocity, viscosity and adiabatic compressibility of alcohols at various temperatures. FTIR analysis of the pure SLS, SLS+anise alcohol and SLS+cinnamyl alcohol spectra wasdone in a 1:1 ratio. The recorded FTIR spectra are shown in Fig. 7 and 8, respectively.

DISCUSSION

Ultrasonic velocity against SLS+(Anise alcohol and Cinnamyl alcohol) initially increased and attained a maximum value at CMC and started decreasing with an increase in concentration for the two systems, as given in Fig. 1 and 4. This may be due to the micelle formation occurring in the system.The percentages of solvated alcohol molecules per repetition unit could be explained in terms of propagated attractions, as Moore and Uddin (1970) noted[12].

It is observed that both density and viscosity increase with an concentration and decrease with

increase of temperature. The plot of viscosity versus concentration at three different temperatures is shown in Fig. 2 and 4. Aqueous surfactant is homogeneous solution and become more viscous, as the solute is included.The first type of mutual interaction, hydrodynamic screeningsignificantly determines the viscous flow characteristics of diluted surfactant solutions.[11]

The decrease in compressibility has been seen in surfactant solutions and is explained by a change in the compressibility of the solvent molecules involved in the solutions[12]. The decrease of internal pressure with a concentration of SLS+ alcohols confirmed the solute-solvent interactions. The closed packing of molecules within the shield imitates the decrease in intermolecular free length and internal pressure[13].

From the FTIR studies, the OH stretching bands at around 3445 cm^{-1} and the bending vibrations at 1656 cm^{-1} in the pure SLS spectrum demonstrate the vibrational frequencies of the functional groups[7]. But in SLS mixed AA spectrum, these peaks are shifted to 3392 and 1612 cm^{-1} whereas in SLS mixed with CA, the peaks are shifted to 3389 and 1707 cm^{-1}. The symmetric stretching vibrations of CH_3 are detected at 2848 cm^{-1} and the CH_3 asymmetric stretching band is found at 2914 cm^{-1} in pure SLS. The Peaks are observed at 2849 and 2918 cm^{-1} in SLS+AA, whereas in SLS+CA, it is observed at 2851 and 2916 cm^{-1}. These peaks indicate the presence of SLS in the complexes. Altogether the presence of SLS with the chemical structure ($C_{12}H_{25}NaSO_4$) in the composites is proved by symmetric stretching at 2843 cm^{-1} and asymmetric stretching at 2910 cm[-1][14]. In the investigation, from Fig. 5.4.2 and 5.4.3, the characteristic peaks observed at 2849 cm^{-1} and 2918 cm^{-1} in the SLS+AA system and at 2851 cm^{-1} and 2916 cm^{-1} in the SLS+AA system confirms the structure of SLS in alcohol system.

Table 1: Ultrasonic velocity and related acoustical parameters in the solution of SLS in anise alcohol

Temp. K	Conc%	Ums[-1]	kgm[-3]	$\eta \times 10^{-3}$ Nsm[-2]	$\beta \times 10^{-10}$ N[-1]m[2]	L_fÅ	$\pi_i \times 10^6$ Pascal	RX10[-3]
303	0.0	1412	1127	1.349	4.450	0.421	1.568	2.728
	0.5	1419	1131	1.458	4.391	0.418	2.232	2.079
	1.0	1426	1137	1.574	4.325	0.415	2.640	1.842
	1.5	1436	1144	1.682	4.239	0.411	2.976	1.717
	2.0	1447	1149	1.776	4.157	0.406	3.212	1.642
	2.5	1440	1157	1.897	4.168	0.407	3.461	1.581
313	0.0	1396	1117	1.272	4.594	0.428	1.572	2.742
	0.5	1405	1126	1.338	4.500	0.423	2.214	2.082
	1.0	1417	1131	1.402	4.434	0.419	2.596	1.848
	1.5	1428	1137	1.495	4.313	0.414	2.895	1.724
	2.0	1438	1141	1.607	4.238	0.408	3.151	1.650
	2.5	1432	1146	1.715	4.255	0.412	3.387	1.593
323	0.0	1381	1107	1.218	4.648	0.434	1.587	2.756
	0.5	1392	1113	1.282	4.590	0.430	2.229	2.099
	1.0	1406	1121	1.347	4.506	0.424	2.620	1.859
	1.5	1418	1128	1.402	4.421	0.419	2.888	1.734
	2.0	1429	1133	1.483	4.364	0.410	3.119	1.659
	2.5	1422	1138	1.557	4.303	0.416	3.326	1.60

**Table 2: Ultrasonic velocity and related acoustical parameters in the solution of SLS in cinnamyl alcohol**

Temp. K	Conc%	Ums[-1]	kgm[-3]	$\eta \times 10^{-3}$ Nsm[-2]	$\beta \times 10^{-10}$ N[-1]m[2]	L_fÅ	$\pi_i \times 10^6$ Pascal	RX10[-3]
303	0.0	1360	1028	1.245	5.259	0.457	1.444	2.953
	0.5	1372	1131	1.343	4.697	0.432	2.213	2.028
	1.0	1380	1257	1.511	4.177	0.408	2.900	1.618
	1.5	1391	1291	1.621	4.003	0.399	3.296	1.475
	2.0	1385	1346	1.737	3.873	0.393	3.702	1.351
	2.5	1374	1417	1.821	3.738	0.386	4.082	1.247
313	0.0	1348	1007	1.183	5.465	0.464	1.440	3.006
	0.5	1361	1120	1.253	4.802	0.438	2.203	2.043
	1.0	1372	1177	1.321	4.514	0.424	2.686	1.725
	1.5	1384	1234	1.452	4.231	0.410	3.135	1.540
	2.0	1377	1300	1.621	4.057	0.402	3.620	1.396
	2.5	1371	1381	1.834	3.852	0.392	4.164	1.273
323	0.0	1336	999	1.104	5.608	0.473	1.392	3.021
	0.5	1347	1110	1.211	4.965	0.445	2.233	2.054
	1.0	1359	1151	1.300	4.704	0.433	2.722	1.758
	1.5	1371	1201	1.421	4.430	0.419	3.158	1.578
	2.0	1365	1281	1.579	4.190	0.408	3.667	1.413
	2.5	1356	1354	1.713	4.017	0.400	4.121	1.294

Table 3: Ultrasonic Absorption and Related Acoustical parameters in the solution of SLS in Anise alcohol

Temp. K	Conc%	$\alpha/f^2 \times 10^{-15} Npm^{-1}s^2$	$V_f \times 10^{-15} m^3 mol^{-1}$	Cohesive energy$\times 10^{-8}$	$\tau \times 10^{-12} sec$	$z_a \times 10^6 kgm^{-2} s^2$	S_n
303	0.0	1.117	1.352	21.194	0.800	1.591	-
	0.5	1.186	1.021	22.794	0.853	1.605	-18.143
	1.0	1.233	0.942	24.885	0.892	1.621	-7.242
	1.5	1.305	0.978	29.095	0.950	1.643	-2.949
	2.0	1.341	1.006	32.318	0.984	1.662	-0.907
	2.5	1.444	1.055	36.500	1.054	1.666	-0.808
313	0.0	1.101	1.217	19.131	0.779	1.559	-
	0.5	1.126	0.844	19.577	0.802	1.582	-25.741
	1.0	1.146	0.805	20.906	0.823	1.603	-10.205
	1.5	1.187	0.812	23.515	0.860	1.623	-4.857
	2.0	1.245	0.858	27.038	0.908	1.640	-2.381
	2.5	1.340	0.899	30.451	0.972	1.641	-2.149
323	0.0	1.098	1.122	17.800	0.770	1.529	-
	0.5	1.123	0.818	18.233	0.792	1.550	-34.958
	1.0	1.137	0.750	19.643	0.810	1.576	-14.034
	1.5	1.146	0.729	21.080	0.824	1.600	-7.154
	2.0	1.179	0.754	23.502	0.854	1.619	-3.908
	2.5	1.251	0.770	25.600	0.902	1.620	-3.467

Table 4: Ultrasonic absorption and related acoustical parameters in the solution of SLS in Cinnamyl alcohol

Temp. K	Conc%	$\alpha/f^2 \times 10^{-15} Np\,m^{-1}s^2$	$V_f \times 10^{-15} m^3 mol^{-1}$	Cohesive energy $\times 1^{0-8}$	$\tau \times 10^{-12}_{sec}$	$z_a \times 10^6 kgm^{-2} s^2$	S_n
303	0	1.266	1.133	16.355	0.873	1.398	-
	0.5	1.209	0.841	18.616	0.841	1.552	-37.970
	1.0	1.203	0.843	24.413	0.841	1.735	-2.273
	1.5	1.227	0.855	28.175	0.865	1.796	2.442
	2.0	1.277	0.882	32.636	0.897	1.864	4.103
	2.5	1.303	0.893	36.978	0.907	1.947	5.173
313	0	1.261	1.036	14.913	0.862	1.357	-
	0.5	1.167	0.749	16.497	0.805	1.524	-46.616
	1.0	1.143	0.683	18.342	0.795	1.615	-13.941
	1.5	1.167	0.719	22.547	0.819	1.708	-2.976
	2.0	1.256	0.788	28.937	0.877	1.790	0.766
	2.5	1.355	0.900	37.549	0.942	1.893	3.466
323	0	1.148	0.842	11.725	0.777	1.335	-
	0.5	1.174	0.701	15.645	0.802	1.495	-56.332
	1.0	1.183	0.657	17.900	0.815	1.564	-20.541
	1.5	1.207	0.686	21.680	0.839	1.647	-7.642
	2.0	1.274	0.748	27.415	0.882	1.749	-1.611
	2.5	1.334	0.799	23.919	0.917	1.836	1.122
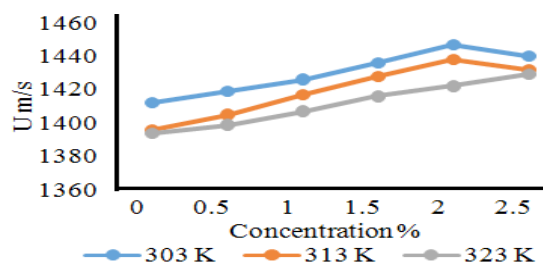
Fig. 1. Velocity Vs concentration of SLS in Anise alcohol
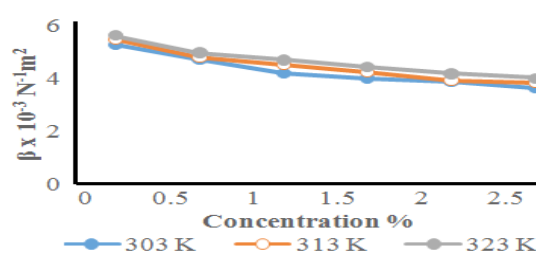
Fig. 3. Adiabatic compressibility Vs concentration of SLS in Anise alcohol
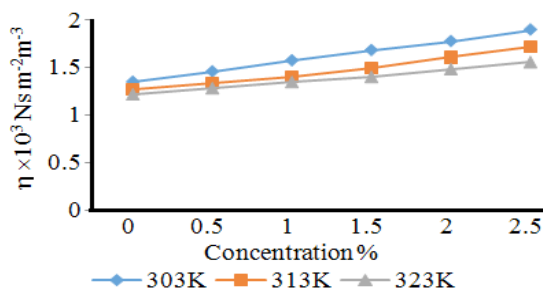
Fig. 2. Viscosity Vs concentration of SLS in Anise alcohol
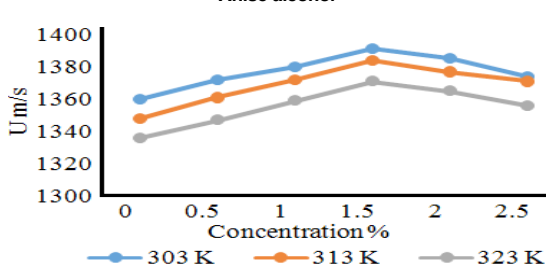
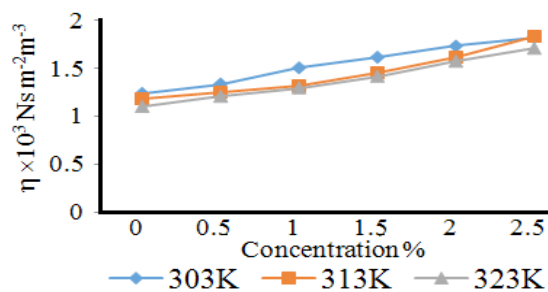Fig. 4. Ultrasonic velocity Vs concentration of SLS in Cinnamyl alcohol

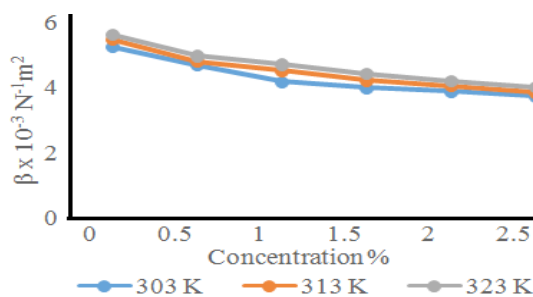**Fig. 5. Viscosity Vs concentration of SLS in Cinnamyl alcohol**

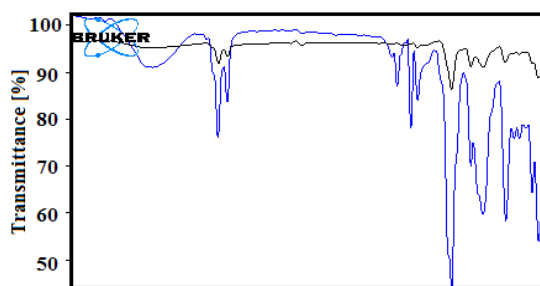**Fig. 6. Adiabatic compressibility Vs concentration of SLS in Cinnamyl alcohol**

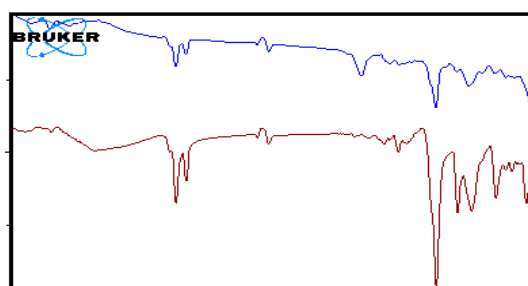**Fig. 8. FTIR spectra of Sodium Lauryl Sulphate (SLS)+Anisyl alcohol**

Fig. 9. FTIR spectra of Sodium Lauryl Sulphate (SLS) +Cinnamyl alcohol

CONCLUSION

The cleaning agent, surfactant sodium lauryl sulphate (SLS) is primarily utilized in personal care and cleaning products. Anisyl Alcohol is a primary alcohol that belongs to the fragrance structural group Aryl Alkyl Alcohols. Cosmetics and personal care products can benefit from anisyl alcohol as a scent component. The present study reveals that the intermolecular interaction of SLS with alcohols (Anise alcohol and Cinnamyl alcohol) and the existence of SLS and alcohol interaction is taking place through hydrogen bonding with an increase of SLS concentration. Different alcohol groups, the potency of interaction are more in SLS+water-Anise alcohol compared to SLS+water-Cinnamyl alcohol system. Finally, it is concluded that SLS+water-Anise alcohol has been used as the best additive. This composite has a lower foaming tendency due to lower surface tension, leading to a newer product. Additionally, the solvent used in surfactants is less toxic to human society. In this regard, anisyl alcohol is less harmful and toxic to human society when used as a solvent for SLS.

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Conflict of interest

The author declare that we have no conflict of interest.

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