PHYSICO – CHEMICAL ANALYSIS ON CETYLPYRIDINIUM CHLORIDE (CPC) WITH ALCOHOL SOLUTION AT DIFFERENT TEMPERATURES - ULTRASONIC, UV AND FTIR ANALYSIS

V. KARIKALAN[a*], A. PANNEERSELVAM[b], K. VALLALPERUMAN[c]
[a]*PG Assistant in Physics, Government Model School, Mallur, India - 636203*
[b]*Department of Physics, Paavai Engineering College, Pachal, Namakkal, India- 637018*
[c]*Department of Physics, ThiruKolanjiappar Govt. Arts College, Vridhachalam, India- 606001*

The ultrasonic velocity, density and viscosity in the mixtures of Cetylpyridinium Chloride (CPC) with Water - Alcohols (Methanol, Ethanol and 1-Propanol) in different concentration ranges are measured at different temperatures 303, 313 and 323K with a view to determine the Critical Micelle Concentration (CMC). From the experimental data, other related acoustical parameters such as adiabatic compressibility (β), intermolecular free length (L_f), internal pressure (π_i), free volume (V_f), cohesive energy (C_E), relaxation time (τ), Rao's constant (R_a),absorption coefficient (α/f^2), acoustical impedance (Z_a) and solvation number (S_n) have been evaluated. All these parameters have utilized to study of various molecular interactions takes place in binary mixtures of (i) CPC + Water - Methanol, (ii) CPC + Water - Ethanol and (iii) CPC + Water -1- Propanol solution. The Critical Micelle Concentration (CMC) of (Cetyl Pyridinium Chloride (CPC) with Water - Alcohols) was determined to be 0.6%ofCetyl Pyridinium Chloride (CPC) with Water–Methanol and Water -Ethanol, 0.8% of Cetyl Pyridinium Chloride (CPC) with Water -1-Propanol system. The UV and FTIR studies were also used to characterize these samples. The results are discussed in molecular interactions, absorption and functional groups.

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*Keywords :*Ultrasonic study, Binary mixture, Cetyl Pyridinium Chloride (CPC), Critical Micelle Concentration (CMC).

1. Introduction

The study of propagation of ultrasonic waves in liquids and liquid mixtures is very much useful for examining the nature of inter and intra molecular interactions. Physico-chemical properties can be understand among the interacting components from ultrasonic velocity measurements and it can be coupled with other experimental data such as density and viscosity to calculate various acoustical parameters such as adiabatic compressibility, free length, acoustic impedance, relaxation time, free volume and internal pressure, which are useful in understanding the molecular interactions in binary mixtures [1-4]. Ultrasonic velocity is an important physical parameter having structural dependence [5-7]. CPC is cationic quaternary ammonium compound used in mouthwashes, toothpastes, throat and nasal sprays. The Micellization of Cationic Surfactant in these water-alcohol media have been found to be both dependent on nature as well as the concentration of alcohol in water [8].In ionic surfactant systems, ethanol addition makes the CMC decrease followed by an increase. However, in the systems of nonionic or cationic surfactants, ethanol addition just makes the CMC go up [9].The CMC values shift toward higher concentration with increase in alcoholic content up to certain concentration beyond which decrease in CMC is registered in case of all the alcohols [10,11].

In the present investigation, ultrasonic velocities have been measured in binary mixtures of (i) CPC + Water - Methanol, (ii) CPC +Water - Ethanol and (iii) CPC + Water - 1- Propanol

*Corresponding author: kariphy05@gmail.com

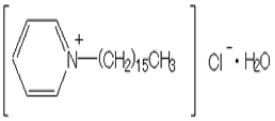
system to understand the molecular interactions. The acoustical parameters have been calculated for these three mixtures at different concentration and different temperatures 303, 313 and 323K. The effect of CPC with Water - Alcohols solution gives more information in pharmaceutics, cosmetics as well as their applications to emulsion stabilization.

Preparation of sample:

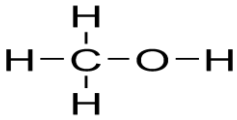
Cetylpyridinium Chloride (CPC) with Water - Alcohols (Methanol, Ethanol and1-Propanol) was obtained from Mercury Scientific Suppliers, Salem. The experimental solutions were prepared by adding a known weight of CPC with 0.4% concentration of Alcohols (Methanol, Ethanol and 1-Propanol) to a fixed volume of water and then stirring under reflux until clear solutions were obtained. Doubled distilled water was used to prepare the stock solution.

Structure of Sample:

Cetylpyridinium Chloride (CPC)



Methanol



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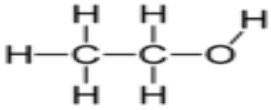
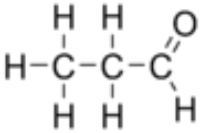


1- Propanol



2. Experimental methods

The ultrasonic velocity measurements in the CPC with Water - Alcohols (Methanol, Ethanol and 1-Propanol) solutions were made in the ultrasonic interferometer of fixed frequency 2MHz (Model F-81 Mittal enterprises, New Delhi) at different temperatures (303, 313 and 323 K). The temperature was maintained constant by circulating water from a thermostatically controlled (± 0.1°C) water bath. The values of densities at different temperatures were measured using specific gravity bottle by standard procedure and the viscosity was measured using Ostwald's viscometer with an accuracy of ± 0.001% calibrated with double distilled water.

The UV – Vis Spectrometer (Model – Lamber 35 – Perkin Elmer) the Surfactant / Water - Alcohol solutions at different concentrations. All the UV – Vis Spectrometry were recorded in the range (1000 – 400 Å). The FTIR Spectrum for these samples using Fourier Transform Infrared Spectrometer (Spectrum RX, Perkin Elmer). The powder samples of CPC/Methanol, CPC/Ethanol and CPC/ 1-Propanol at 1:1 ratio, these samples were mixed with KBr powder to form a pellet and placed in a sample cup and measured [12]. All the FTIR Spectrum were recorded in the range 4000 - 500 cm^{-1}

Measurement of Ultrasonic velocity (U), Viscosity (η) and Density (ρ) of liquids are useful to determine the thermodynamic and acoustic parameters of the binary mixtures. These acoustical and the thermodynamic properties help us understand the characteristics of the samples. The nature of the molecular interaction in the cationic surfactant with Water - Alcohols (Methanol, Ethanol and 1-Propanol) be proved by making use of the parameters such as adiabatic compressibility (β), Intermolecular free length (L_f), Internal pressure (π_i), Rao's constant (R_a),absorption coefficient (α/f^2), free volume (V_f), Cohesive energy (C_E), Relaxation time (τ), Acoustic impedance (Z_a) and Solvation number (S_n) were calculated from empirical Jacobson's relations [13].

Adiabatic compressibility $\beta = 1/U^2 \rho$ (1)

Intermolecular free length $L_f = K_T \beta^{1/2}$ (2)

Where K_T - Jacobson's constant (K_T=2.131x10^{-6})

Internal pressure $\pi_i = bRT [K \eta/u]^{1/2} \rho^{2/3}/M^{7/6}$ (3)

Where b - stands for cubic packing
T-absolute temperature in Kelvin, M_{eff} - Effective molecular weight of the mixture($M_{eff}=\sum m_i x_i$,where m_i and x_i are the molecular weight and mole fraction of individual constituents respectively, K -Temperature independent constant which is equal to 4.281x10^9 for all liquids, R - Universal gas constant, η-Viscosity of the solution).

Rao's constant $R_a = (M/\rho)(u)^{1/3}$ (4)

Absorption Coefficient $\alpha/f^2 = (8\pi^2\eta/3\rho u^2)$ (5)

Free Volume $V_f = (M_{eff}u/K\eta)^{3/2}$ (6)

Cohesive energy $C_E = V_f \pi$ (7)

Relaxation time $\tau = 4/3\beta\eta$ (8)

Acoustic impedance $z_a = \rho u$ (9)

Solvation number $S_n = M_2/M_1\left[1 - \left(\frac{\beta}{\beta o}\right)\right]\left[\frac{100-x}{x}\right]$ (10)

M_1-Molecular weight of the solvent , M_2- Molecular weight of the solute , β - adiabatic compressibility of solution and β_o - adiabatic compressibility of solvent.

3. Result and discussion

The values of ultrasonic velocity, density and viscosity of measured parameters and acoustical parameters of CPC+ Water - Methanol, CPC+Water - Ethanol and CPC+ Water -1-Propanol at different temperature 303, 313 and 323K are presented in tables 1 to 6. The acoustical parameters such as adiabatic compressibility (β), intermolecular free length (L_f), internal pressure (π_i), Rao's constant(R_a), absorption coefficient(α/f^2), free volume (V_f), cohesive energy(C_E), relaxation time (τ), acoustical impedance (Z_a) and solvation number (S_n) have been computed and are shown in tables 1 to 6.This suggests that there are molecular interactions between the components of mixtures. The plot of ultrasonic velocity against CPC +Water - alcohols (Methanol, Ethanol and 1-Propanol) initially increased acquires a maximum values at CMC and starts decreasing with increases in concentration for the three systems is given in figures 1, 5 and 9.

The ultrasonic velocity increases upto 0.4%, acquires a maximum at CMC with increase in concentration of CPC+ Water – Methanol (0.4%) and CPC + Water – Ethanol (0.4%) then decreases with increases in concentration. This may be due to the Micelle formation occurring in the solution of CPC + Water – Methanol and CPC +Water –Ethanol systems as shown in figures 1 and 5. From the figure ultrasonic velocity increases up to 0.6% then decreases with increase in concentration of CPC +Water - 1-Propanol (0.4%) system. At CMC aggregation to form micelles takes place hence at CMC ultrasonic velocity is maximum [14].

In all the three systems, the density increases with increase in concentration of CPC due to the presence Water – Alcohols. As the number of particles increases, the electrostriction and density increases. Tables 1, 3 and to 5 shows the increase in density with increase in concentration

and decrease with increase in temperature. It is also observed that density for CPC +Water - 1 - Propanol is greater than that for other two systems.

Viscosity is another important parameter that contributes to understanding the structure and molecular interaction occurring in the solution. The viscosity increases with increases of solute concentration and decreases with increases of temperature. The increasing trend indicates the existence of molecular interaction. It is quite higher for CPC + Water -1- Propanol system than CPC + Water - Methanol and CPC + Water – Ethanol systems due to strong interaction.

The plots of adiabatic compressibility against CPC + Water – alcohols for the three systems are given in figures2, 6 and 10. It may be noted that in all the three cases adiabatic compressibility decreases with increase in concentration of CPC + Water – alcohols indicating relatively stronger Hydrogen bonding over wide range of concentration. According to Fort and Moore, hydrogen bonding between unlike components makes a negative contribution to compressibility. The compressibility data alsoshows that dipole induced dipole attraction are stronger in CPC + Water -1-Propanol mixture than in CPC + Water-Methanol and in CPC + Water –Ethanol mixtures.

Intermolecular free length is related to ultrasonic velocity. As the ultrasonic velocity increases due to the increase in concentration, the intermolecular free length has to decrease and vice versa. Increase in concentration leads to decrease in gap between two species and which is referred by intermolecular free length. It may be noted that in all the three cases linear free length decreases with increase in concentration of CPC + Water –Alcohols. The decrease in free length with increase in solute concentration indicates that there is a significant interaction between the solute and solvent molecules, suggesting a structure promoting behaviour on the addition solute. Due to thermal expansion of liquids as increase in temperature causes free length to increase [15].This shows that dipole induced dipole attraction increases with the concentration of CPC + Water – alcohols. The linear free length for a given composition for CPC + Water - 1-Propanol binary mixture is greater than that for similar compositions in other two systems. This is further supported by expected decrease in adiabatic compressibility with increase in concentration of surfactant, signifies the probable interaction between the solute and solvent [16].

The variations of internal pressure with respect to the various concentration of CPC + Water – alcohols (Methanol, Ethanol and1-Propanol) for the three systems is also observed that internal pressure for CPC + Water -1- Propanol mixture is greater than that for the other two systems. The free volume (V_f) increases and internal pressure decreases with increases in molar concentration indicates the association through hydrogen bonding [17]. The reduction in internal pressure (π_i) may be due to the loosening of cohesive forces leading to breaking up the structure of solvent [18]. The non linear variation of Rao's constant (R_a) with concentration and increase in acoustic impedance (Z_a) with the increase in concentration predicts strong intermolecular association complexes between the molecules of CPC with Water – Alcohol molecules.

Table 1: Ultrasonic velocity and related acoustical parameters of Methanol (0.4%) in aqueous CPC at different temperature

Temp. K	Conc. %	U ms^{-1}	ρ kgm^{-3}	η $x10^{-3}$ Nsm^{-2}	β $X10^{-10}$ $N^{-1}m^2$	L_f Å	π_i $X10^8$ Pascal	R $X10^{-3}$
303	0	1086	792	0.532	10.705	0.652	3.263	1.165
	0.2	1089	798	1.324	10.566	0.648	3.494	1.618
	0.4	1094	809	1.348	10.328	0.641	2.651	2.053
	0.6	1086	802	1.339	10.572	0.648	2.089	2.522
	0.8	1080	811	1.361	10.571	0.647	1.753	2.939
	1.0	1075	821	1.397	8.822	0.592	1.454	3.442
313	0	1051	783	0.442	11.562	0.678	3.099	1.165
	0.2	1055	787	1.236	11.416	0.674	3.510	1.623
	0.4	1059	793	1.257	11.244	0.669	2.652	2.072
	0.6	1050	789	1.249	11.495	0.676	2.096	2.535
	0.8	1046	798	1.278	11.453	0.6752	1.764	2.955
	1.0	1040	807	1.310	11.456	0.6753	1.529	3.362
323	0	1025	771	0.401	12.345	0.701	3.053	1.174
	0.2	1030	777	1.213	12.131	0.694	3.601	1.631
	0.4	1035	782	1.231	11.937	0.689	2.714	2.085
	0.6	1029	779	1.220	12.123	0.694	2.142	2.551
	0.8	1026	787	1.256	12.070	0.693	1.805	2.978
	1.0	1021	793	1.277	12.096	0.694	1.554	3.400

Table 2: Ultrasonic absorption and related acoustical parameters for Methanol (0.4%) in aqueous CPC at different temperature

Temp. K	Conc. %	α/f^2 $X10^{-15}$ Np $m^{-1}s^2$	V_f $X10^{-15}$ m^3mol^{-1}	Cohesive energy $X10^{-8}$	τ $X10^{-12}$ sec	z_a $x10^6$ kgm^{-2} s^2	S_n
303	0	1.378	0.042	1.381	0.75	0.860	-
	0.2	3.377	0.276	9.644	1.86	0.869	-54.80
	0.4	3.345	0.415	11.01	1.85	0.885	-33.82
	0.6	3.427	0.548	11.46	1.88	0.870	-28.55
	0.8	3.502	0.715	12.54	1.91	0.875	-25.22
	1.0	3.601	1.044	15.17	1.96	0.964	-16.92
313	0	1.278	0.030	0.946	0.68	0.822	-
	0.2	3.516	0.237	8.333	1.880	0.830	-61.83
	0.4	3.509	0.356	9.452	1.884	0.839	-38.69
	0.6	3.595	0.470	9.856	1.913	0.828	-32.53
	0.8	3.679	0.620	10.947	1.951	0.834	-28.58
	1.0	3.794	0.789	12.080	2.000	0.839	-26.31
323	0	1.269	0.025	0.775	0.659	0.790	-
	0.2	3.756	0.222	8.018	1.961	0.800	-68.48
	0.4	3.733	0.333	9.058	1.958	0.809	-42.82
	0.6	3.779	0.440	9.429	1.971	0.801	-35.61
	0.8	3.885	0.587	10.604	2.020	0.807	-31.26
	1.0	3.978	0.739	11.495	2.059	0.809	-28.86

Table 3: Ultrasonic velocity and related acoustical parameters of Ethanol (0.4%) in aqueous CPC at different temperature

Temp. K	Conc. %	U ms^{-1}	ρ kgm^{-3}	η $x10^{-3}$ Nsm^{-2}	β $X10^{-10}$ $N^{-1}m^2$	Lf Å	π_i $X10^6$ Pascal	R $x10^{-3}$
303	0	1138	792	0.972	9.749	0.623	4.309	1.183
	0.2	1147	798	1.38	9.525	0.615	3.469	1.647
	0.4	1154	806	1.53	9.316	0.609	2.737	2.099
	0.6	1150	801	1.48	9.440	0.613	2.133	2.577
	0.8	1146	809	1.54	9.412	0.612	1.805	3.009
	1.0	1141	817	1.62	9.401	0.611	1.580	3.431
313	0	1109	786	0.897	10.344	0.641	4.310	1.182
	0.2	1116	791	0.963	10.150	0.635	3.021	1.646
	0.4	1124	797	1.22	9.931	0.628	2.538	2.104
	0.6	1119	793	1.08	10.070	0.633	1.893	2.579
	0.8	1115	802	1.27	10.029	0.631	1.709	3.008
	1.0	1111	811	1.35	9.989	0.630	1.505	3.426
323	0	1091	777	0.826	10.812	0.656	4.270	1.189
	0.2	1099	782	0.872	10.587	0.649	2.967	1.657
	0.4	1108	788	0.938	10.337	0.641	2.300	2.118
	0.6	1102	784	0.892	10.503	0.646	1.775	2.596
	0.8	1096	791	0.946	10.242	0.647	1.518	3.032
	1.0	1091	799	1.03	9.995	0.592	1.294	3.558

Table 4: Ultrasonic absorption and related acoustical parameters for Ethanol (0.4%) in aqueous CPC at different temperature

Temp. K	Conc. %	α/f^2 $X10^{-15}$ Np $m^{-1}s^2$	V_f $X10^{-15}$ m^3mol^{-1}	Cohesive energy $X10^{-8}$	τ $X10^{-12}$ sec	z_a $x10^6$ kgm^{-2} s^2	S_n
303	0	2.189	0.011	4.832	1.26	0.901	-
	0.2	3.004	0.316	10.972	1.74	0.915	-45.97
	0.4	3.239	0.542	14.858	1.89	0.930	-28.33
	0.6	3.202	0.698	14.906	1.86	0.921	-23.57
	0.8	3.329	0.944	17.065	1.93	0.927	-20.72
	1.0	3.505	1.249	19.745	2.02	0.932	-19.04
313	0	2.199	0.095	4.122	1.23	0.871	-
	0.2	2.302	0.177	5.370	1.30	0.882	-51.12
	0.4	2.824	0.371	9.422	1.60	0.895	-31.58
	0.6	2.557	0.417	7.897	1.45	0.887	-26.27
	0.8	3.012	0.681	11.640	1.70	0.894	-23.06
	1.0	3.196	0.916	13.799	1.80	0.901	-21.08
323	0	2.152	0.082	3.521	1.19	0.847	-
	0.2	2.208	0.149	4.440	1.23	0.859	-55.34
	0.4	2.300	0.246	5.660	1.29	0.873	-34.11
	0.6	2.235	0.305	5.423	1.24	0.863	-28.45
	0.8	2.388	0.424	6.450	1.32	0.866	-25.23
	1.0	2.000	0.673	8.721	1.20	0.951	-17.08

Table 5: Ultrasonic velocity and related acoustical parameters of 1- Propanol (0.4%) in aqueous CPC at different temperature

Temp. K	Conc. %	U ms^{-1}	ρ kgm^{-3}	η $x10^{-3}$ Nsm^{-2}	β $X10^{-10}$ $N^{-1}m^{2}$	L_f Å	π_i $X10^{6}$ Pascal	R $x10^{-3}$
303	0	1189	806	1.57	8.776	0.591	5.424	1.179
	0.2	1193	811	1.62	8.663	0.587	3.725	1.642
	0.4	1199	815	1.65	8.535	0.582	2.816	2.103
	0.6	1206	821	1.71	8.374	0.577	2.270	2.554
	0.8	1202	817	1.68	8.471	0.580	1.853	3.028
	1.0	1197	826	1.75	8.449	0.579	1.616	3.452
313	0	1161	793	1.41	9.355	0.610	5.318	1.189
	0.2	1169	799	1.45	9.158	0.603	3.648	1.655
	0.4	1174	802	1.50	9.046	0.600	2.767	2.122
	0.6	1179	807	1.55	8.914	0.595	2.233	2.579
	0.8	1176	804	1.52	8.993	0.598	1.821	3.054
	1.0	1172	812	1.59	8.965	0.597	1.586	3.486
323	0	1122	784	1.29	10.132	0.635	5.287	1.189
	0.2	1128	787	1.34	9.986	0.630	3.645	1.661
	0.4	1134	791	1.40	9.830	0.625	2.782	2.127
	0.6	1140	796	1.44	9.666	0.620	2.240	2.585
	0.8	1136	793	1.43	9.771	0.623	1.835	3.061
	1.0	1131	802	1.49	9.747	0.622	1.600	3.488

Table 6: Ultrasonic absorption and related acoustical parameters for 1- Propanol (0.4%) in aqueous CPC at different temperature

Temp. K	Conc. %	α/f^2 $X10^{-15}$ Np $m^{-1}s^{2}$	V_f $X10^{-15}$ $m^{3}mol^{-1}$	Cohesive energy $X10^{-8}$	τ $X10^{-12}$ Sec	z_a $x10^{6}$ kgm^{-2} s^{2}	S_n
303	0	3.050	0.246	13.36	1.84	0.958	-
	0.2	3.083	0.426	15.89	1.86	0.967	-38.66
	0.4	3.095	0.648	18.27	1.88	0.977	-24.08
	0.6	3.114	0.925	21.00	1.90	0.990	-18.86
	0.8	3.116	1.156	21.43	1.89	0.982	-17.05
	1.0	3.253	1.520	24.50	1.97	0.988	-15.62
313	0	2.993	0.202	10.77	1.76	0.920	-
	0.2	2.988	0.352	12.85	1.77	0.934	-42.71
	0.4	3.032	0.541	14.97	1.80	0.941	-26.77
	0.6	3.077	0.772	17.26	1.83	0.951	-21.17
	0.8	3.058	0.962	17.52	1.82	0.945	-19.02
	1.0	3.190	1.260	20.05	1.89	0.951	-17.42
323	0	3.055	0.167	8.84	1.73	0.879	-
	0.2	3.116	0.296	10.79	1.78	0.887	-50.22
	0.4	3.186	0.463	12.90	1.83	0.896	-31.34
	0.6	3.210	0.659	14.77	1.85	0.907	-24.74
	0.8	3.227	0.830	15.23	1.86	0.900	-22.28
	1.0	3.367	1.09	17.38	1.93	0.907	-20.44

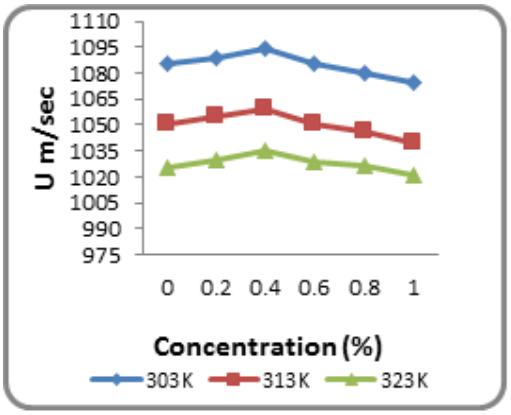


Fig. 1 Ultrasonic Velocity Vs Concentration of CPC+ Methanol in aqueous solution at different temperature

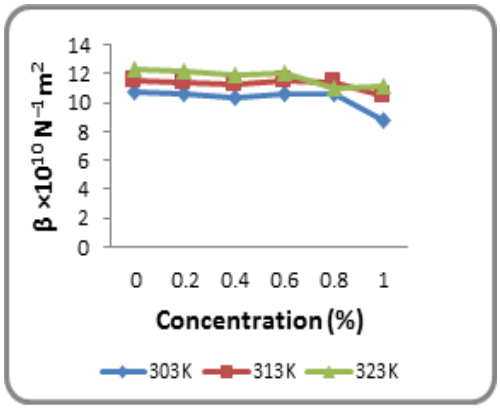


Fig. 2 Adiabatic compressibility Vs Concentration of CPC+ Methanol in aqueous solution at different temperature

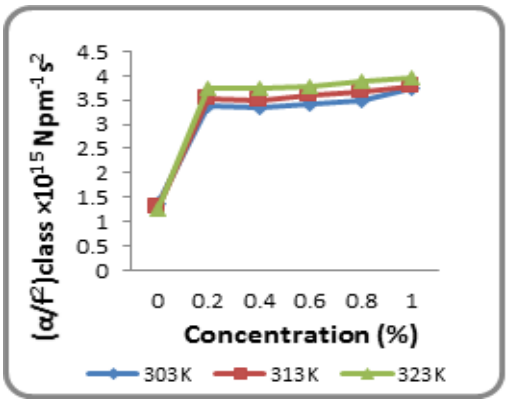


Fig.3 Absorption coefficient Vs Concentration of CPC+ Methanol in aqueous solution at different temperature

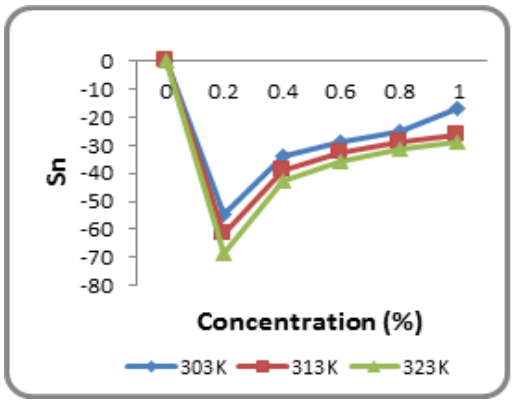


Fig. 4 Solvation number Vs Concentration of CPC+ Methanol in aqueous solution at different temperature

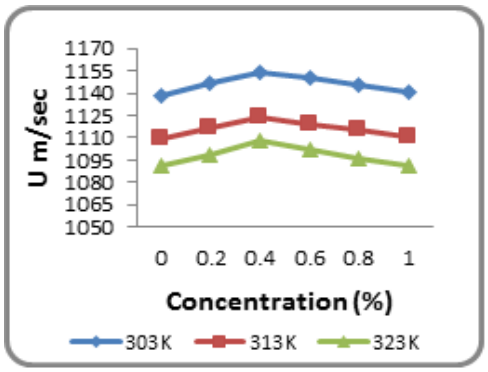


Fig. 5 Ultrasonic Velocity Vs Concentration of CPC+ Ethanol in aqueous solution at different temperature

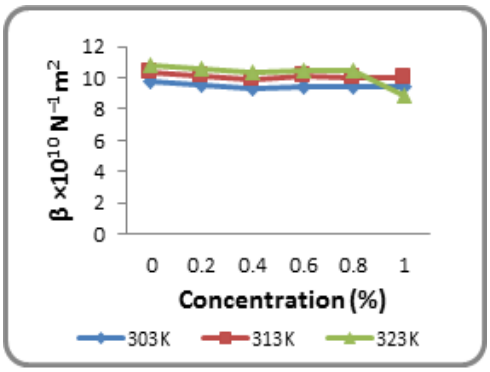


Fig. 6 Adiabatic compressibility Vs Concentration of CPC+ Ethanol in aqueous solution at different temperature

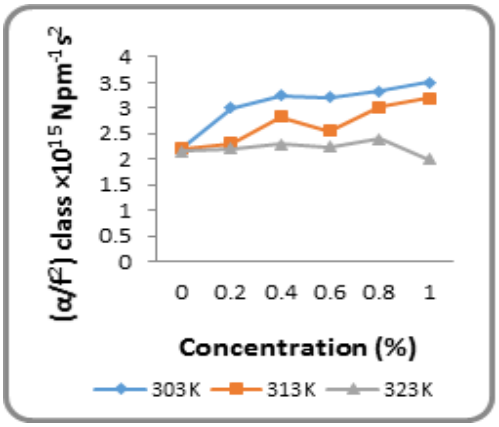


Fig. 7 Absorption coefficient Vs Concentration of CPC+ Ethanol in aqueous solution at different temperature

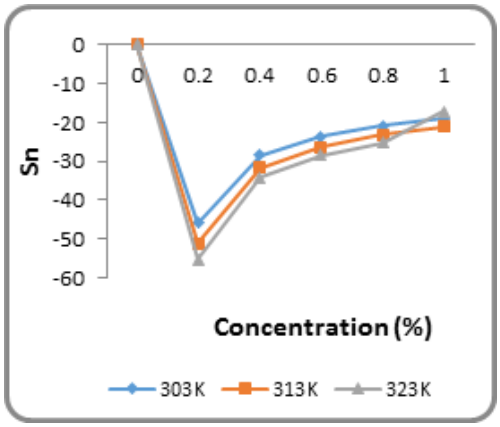


Fig. 8. Solvation number Vs Concentration of CPC+ Ethanol in aqueous solution at different temperature

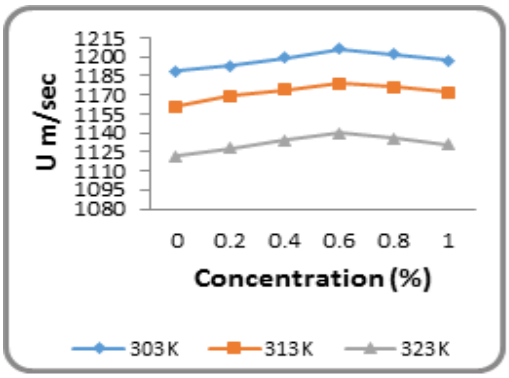


Fig. 9 Ultrasonic Velocity Vs Concentration of CPC+1- Propanol in aqueous solution at different temperature

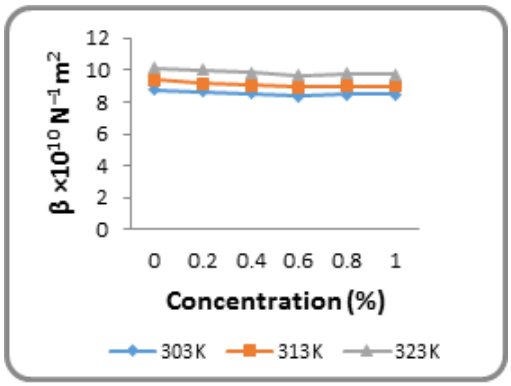


Fig. 10 Adiabatic compressibility Vs Concentration of CPC+ 1- Propanol in aqueous solution at different temperature

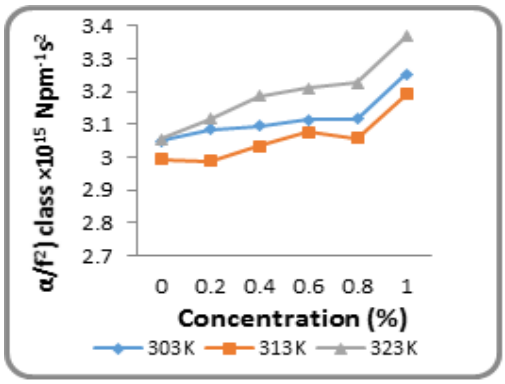


Fig. 11 Absorption coefficient Vs Concentration of CPC+ 1 - Propanol in aqueous solution at different temperature

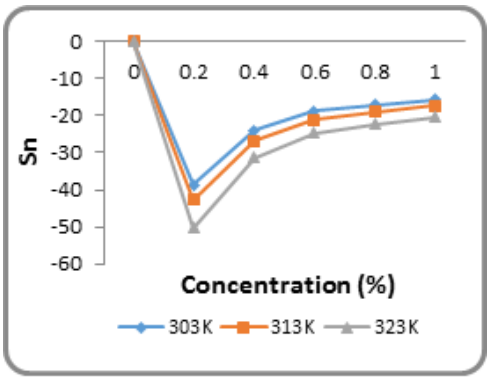


Fig.12 Solvation number Vs Concentration of CPC+ 1- Propanol in aqueous solution at different temperature

From the figures 11 CPC + Water - 1-Propanol system, the absorption Coefficient (α/f^2) and cohesive energy (C_E) values increases with increase in concentration and this trend suggest that the extent of complication increases with increase in concentration and temperature. This indicates the association through hydrogen bonding and strong interaction between the solute and solvent [19]. The absorption Coefficient (α/f^2) of CPC + Water – Methanol and CPC + Water – Ethanol values non – linear variations with increase in concentration as shown in figures 3 and 7. This indicates the week interaction between solute and solvent. Free volume for the molecules of liquids are not closely packed to each other, there is always a free space between them. Moreover it is inverse function of internal pressure.

The relaxation time (τ) increases with increase in concentration of CPC + Water - alcohols (Methanol, Ethanol, 1-Propanol) for all the three systems. This shows that molecular interaction is strong at lower concentration of CPC + Water - alcohols (Methanol, Ethanol and 1-Propanol) and relatively weak at higher concentration. It is also observed that relaxation time for CPC + Water - 1-Propanol mixture is greater than that for other two systems.

The acoustic impedance increases with increase in concentration of CPC + Water - alcohols in all the three systems studied. The increase in acoustic impedance with the concentration can be explained on the basis of interaction between solute and solvent molecules which increases the intermolecular distance, making relatively wider gap between the molecules. It is also observed that acoustic impedance for CPC + Water - 1-Propanol mixture is greater than that for the other two systems. Acoustic impedance increases with increase in chain length of alcohols. Solvation number increases with increase in concentration and temperature for all three systems as shown in figures 4, 8 and 12. Solvation number is found to be quite higher for CPC + Water - 1-Propanol system than CPC + Water - Methanol and CPC + Water - Ethanol systems due to strong interaction. Negative value of solvation number emphasize the solution is more compressible than the solvent [20].

UV analysis

UV – Visible spectrum of the aqueous solution of Cationic Surfactant (CPC) with water – alcohol viz, Methanol, Ethanol and 1- Propanol system as shown in figures 13 to 15. The spectrum shows a peak with absorbance value increasing with increase in concentration. A typical Lambert – Beer behavior has been followed. The CPC + Water - Methanol spectra shows only one characteristic peaks at 222.41 nm. The CPC + Water - Ethanol and CPC + Water -1- Propanol shows only one characteristic peaks at 229.84 nm and 233.22 nm. To study the effect of polarity on the UV absorption data (Table 7). The plot concentration versus absorbance is drawn and linear regression analysis has also been carried out as shown in figures 13 to 15.For the UV absorption analysis, a mixture of CPC + Water - 1-Propanol is extremely good correlation $R^2 = 0.983$ (figure 15) is obtained, but CPC + Water - Methanol and CPC + Water -Ethanol is poor correlation $R^2 = 0.93$ (figure 13) and $R^2 = 0.952$ (figure 14). All the correlation depends upon the solute - solvent interaction.

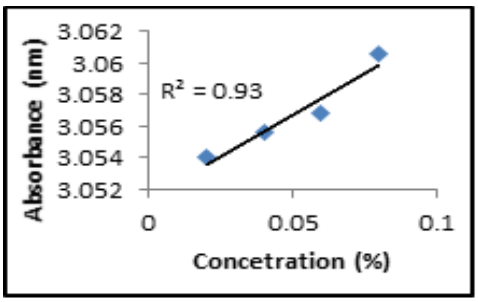


Figure.13.Lamberts – Beer linear plots for aqueous Solutions of CPC + Water - Methanol

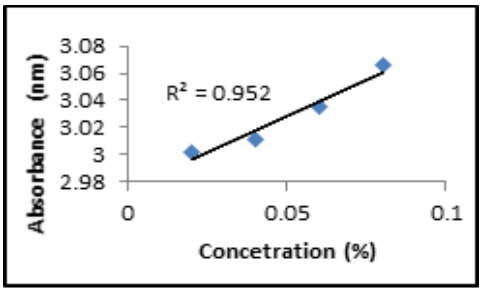


Figure.14. Lamberts – Beer linear plots for aqueous solutions of CPC + Water - Ethanol

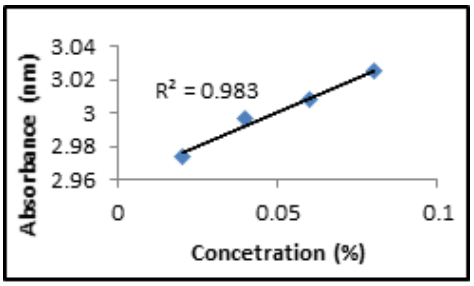


Figure.15.Lamberts – Beer linear plots for aqueous Solutions of CPC + Water - 1 - Propanol System

Table 7 UV-vis absorbance values of CPC+ Water - Methanol, CPC +Water - Ethanol and CPC +Water - 1 - Propanol System

Compounds	**Concentration ($\times 10^{-3}$) mol dm^{-3}**	**Absorption (nm)**
CPC+ Water-Methanol	0.02	3.054
	0.04	3.055
	0.06	3.056
	0.08	3.060
	0.10	3.087
CPC+ Water-Ethanol	0.02	3.002
	0.04	3.011
	0.06	3.035
	0.08	3.065
	0.10	3.103
CPC+ Water-1-Propanol	0.02	2.973
	0.04	2.996
	0.06	3.007
	0.08	3.025
	0.10	3.049

FTIR analysis

The FT-IR spectra of pure Cationic Surfactant (CPC) and CPC with Methanol, Ethanol and 1-Propanol were recorded in the transmittance mode in the range of 4000-500 cm^{-1}. The representative spectrum for CPC is shown in figures 16 to 18 along with the corresponding spectra of Methanol, Ethanol and 1-Propanol blended in the ratio of 1: 1 respectively.

The spectrum of CPC shows the characteristic absorption of band positions and intensities observed in FTIR spectra with wave number and intensities. Figures 16 to 18 show the IR spectra

of pure CPC and CPC with different alcohols such as Methanol, Ethanol and 1 - Propanol. Pure CPC showed characteristic IR absorption bands at 1020 cm^{-1} indicating the presence of C-N group, 1118 cm^{-1} indicates the presence of C-O-C group in aromatic ring, 1345 cm^{-1} indicates the presence of C-F group, 1625 cm^{-1} indicates the presence C=N group, 1700 cm^{-1} indicates the presence of stretching of C=O group, 3506 cm^{-1} indicates the presence of bending of N-H group, 3168 cm^{-1} indicates the presence -OH group, which are associated with the CPC before the chemical treatments. After CPC loaded with Methanol, Ethanol and 1 – Propanol these bands are not observed in the FTIR spectrum. The effect of this chemical purification can be observed through main spectral bands which must be emphasized at 1572 cm^{-1}. The band at 1572 cm^{-1} is absent and the band at 1250 cm^{-1} is reduced drastically in the FTIR spectrum of CPC loaded with Methanol, Ethanol and 1- Propanol. The spectral band observed in the region 1630–1674 cm^{-1} for Methanol, Ethanol and 1- Propanol are due to the O–H bonding due to adsorbed.

The results of FTIR studies show solute – solute – solvent interaction via hydrogen bond formation through the O-H groups. The strength of Hydrogen bond formation depends on the close approach of the interesting molecules. The O-H frequency of CPC is affected in the blend compositions, showed the presence of intermolecular interaction. The FTIR result revealed that CPC – alcohols blend was miscible. However, CPC loaded Water - 1-Propanol (figure: 18) reveals significant chemical interaction which is realized by observing all spectral bands of CPC even 1-Propanol loaded. Besides, FTIR studies showed that the 1- Propanol distribution in the CPC was homogeneous. From the FTIR spectra, the result suggests that CPC + 1- Propanol blend has stronger intermolecular interaction than CPC + Methanol and CPC + Ethanol blends.

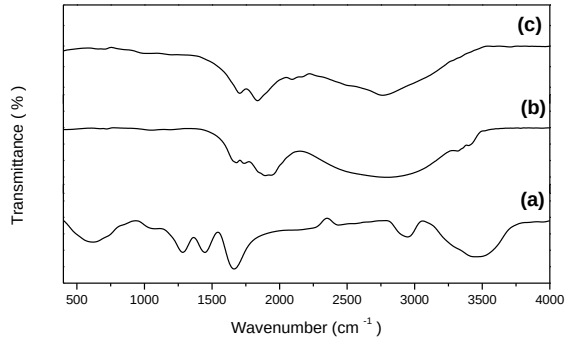


Figure.16. Overlapped FTIR Spectra for a) CPC, b) Methanol and c) CPC + Methanol

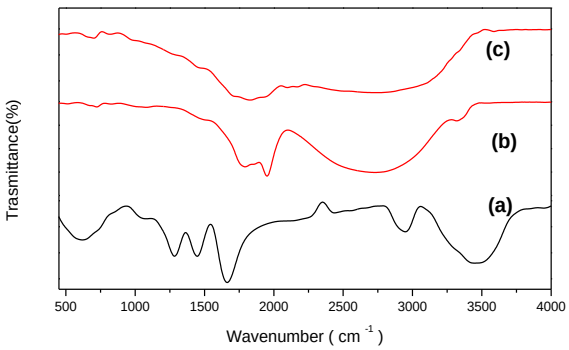


Figure.17. Overlapped FTIR Spectra for a) CPC, b) Ethanol and c) CPC + Ethanol

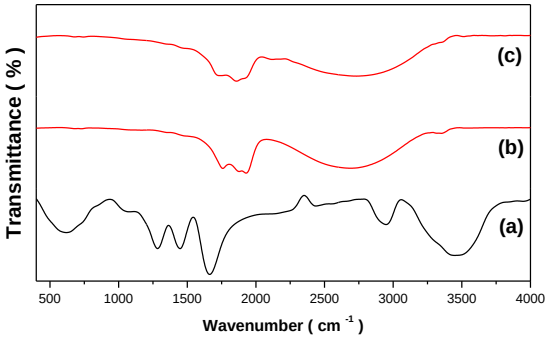


Figure.18. Overlapped FTIR Spectra for a) CPC, b)1- Propanol and c) CPC + 1 – Propanol

4. Conclusions

The molecular association of CPC +Water - 1- Propanol system is quite high compare to CPC +Water -Methanol and CPC + Water -Ethanol systems. For the UV – absorption analysis a mixture of CPC + Water -1- Propanol system is extremely good correlation $R^2 = 0.9863$, but other two system is extremely poor correlation. From the FTIR spectra, CPC mixed with 1- Propanol reveals significant chemical interaction which is realized by observing all spectral bands of CPC even 1-Propanol loaded. Besides, FTIR studies showed that the 1-Propanol distribution in the CPC was homogeneous. FTIR spectra, the result suggests that CPC + 1 - Propanol blend has stronger intermolecular interaction than CPC + Methanol and CPC + Ethanol blends. Finally we conclude that CPC + 1 - Propanol has been used as a best additive in pharmaceuticals, perfumes, and food industry.

References

[1] K. Rajathi, S. J. Askar Ali and A.Rajendran, J. Chem. Pharm. Res.**3,** 348 (2011).
[2] P.S.Nikam, T.R.Mahale, M.Hasan, Acustica ActaAcoust. **84**, 579 (1998).
[3] P.S.Nikam, M.C. Jadhav and M. Hasan, Volumetric, J. Mol. Liq. **76**, 1 (1998).
[4] L.Palaniappan, Asian Journal of Material Science. **4**, 21 (2012).
[5] V. Rajendran, Indian J. Pure and Appl. Phys.**34**, 52 (1996).
[6] G.Ganapathi Rao, M.V.K.Mehar, K.V.Prasad, K.Samatha, International Journal of Innovative Research in Science, Engineering and Technology.**4**, 7 (2015).
[7] Pandharinath S. Nikam, Bapu S. Jagdale, Arun B. Sawant and Mehdi Hasan, J. Chem. Eng. Data **45** (2), 214 (2000).
[8] NighatNazir , Journal of Dispersion Science and Technology**30**, 51 (2009).
[9] J.B.Huang, M.Mao and B.Y.Zhu, Colloids and Surfaces A: Physico chem. Eng. Aspects. **155**, 339 (1999).
[10] NighatNazir , M. Syed, Ahanger and Arif Akbar, Journal of Dispersion Science and Technology **30**, 51 (2009).
[11] K. Sujit,Sujeet K. Chatterjee and AjayaBhattarai, Conductometry.**2, 10**(2013).
[12] Mayyas AI. Remawi, J. Applied Science. **12**(8),727, (2012).
[13]R.Palani, S.Balakrishnan, Indian J.Pure Applied Physics. **48,** 544, (2010).
[14] A.A.Patil, Journal of Chemical and Pharmaceutical Research.**5** (3), 19, (2013).
[15]S. Punitha, R. Uvarani, A. Panneerselvam and S. Nithiyanantham, Journal of Saudi Chemical Society.**18**, 657, (2014).
[16] B.Sundarson and A.Shrinivasarao, Polymer Journal, **26**, 1286, (1994).
[17] Ritesh R. Naik, S.V. Bawankar, African Journal of Science and Research,**3,** 1, (2014).
[18] P.K. Banipal, A.K. Chakal, T.S. Banipal, J. Chem. Thermodynamic. **41**, 452, (2009).
[19] M.Umadevi, R. Kesavasamy, International journal of Chemical Environment and

Pharmaceutical Research.**3**, 72, (2012).
[20] K .Seethalakshmi, E. Jasmine Vasantha Rani, International Journal of Science and Research. **6**, 2190, (2017).