



Physico – Chemical Analysis of Cetyl Pyridinium Chloride (CPC) Blended by Cellulose solution

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Abstract- The ultrasonic velocity, density and viscosity in mixtures of Cetyl Pyridinium Chloride (CPC) with Cellulose derivatives (Methyl Cellulose (MC), Ethyl Cellulose (EC) and Hydroxyl Propyl Methyl Cellulose (HPMC)) in different concentration ranges are measured at different temperatures 303, 313 and 323K in order to find out the Critical Micelle Concentration (CMC) of Surfactant / Cellulose interaction. From the experimental data, other related 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 evaluated. All these parameters have utilized to study of various molecular interactions takes place in the solutions of CPC – Cellulose derivatives (MC, EC and HPMC). The FTIR and UV analysis also used to characterize these samples. The results are discussed in molecular interactions that prevail by hydrogen bonding.

Keywords : Ultrasonic study, Cetylpyridinium Chloride (CPC), Critical Micelle Concentration (CMC)

I. INTRODUCTION

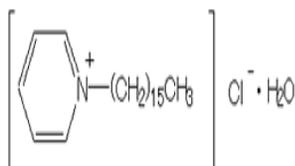
The study of intermolecular interaction in the complex formation of considerable importance in the explanation of the structural properties of the molecule [1-2]. The intermolecular actions influence the structural arrangement along with the shape of the molecule [3]. Water soluble cellulose polymers have been shown to interact with surfactant species to varying degrees depending on the properties of the cellulose polymers and surfactants [4]. Cellulose derivatives have gained acceptance for cosmetic, food, adhesives, textiles, packaging and pharmaceuticals uses. Surfactant and water soluble cellulose derivatives have very broad ranges of applications. CPC is a cationic compound used in some types of mouthwashes, lozenges, toothpastes, breath sprays, throat sprays and nasal sprays. Studies on surfactant – Cellulose derivatives complexes demonstrate the interest for the surface properties of such systems [5-7]. Several micellar systems have been investigated in the absence and presence of an external entity to explore the environment of the solubilization and to infer any change occurring in micellization behavior of surfactants [8-9]. Hydroxy Propyl Methyl Cellulose (HPMC) is nonionic, water-soluble cellulose ether. It is obtained by partial substitution of hydroxyl group of cellulose with hydrophobic hydroxypropyl and methyl groups. It has variety of applications in day to day life. The combined occurrence of surfactant and cellulose derivatives is found in diverse products such as cosmetics, paints, detergents, food, polymer synthesis and formulations of drugs and pesticides [10-11]. The presence of a non ionic cellulose polymer in aqueous solutions of cationic surfactants causes changes in the physical properties of the micelle aggregated formed by the surfactant. Some possible types of association involving either individual surfactant molecules or surfactant cluster were discussed [12-14]. Acoustical studies of surfactant and cellulose derivatives have become increasing and important in physical, biochemical and industrially useful applications. In the present study an attempt has been made to investigate the behaviour of Cetylpyridum Chloride (CPC) and Cellulose derivatives (Methyl Cellulose (MC), Ethyl Cellulose (EC) and Hydroxy Propyl Methyl Cellulose (HPMC)), in water at different concentration and temperature 303, 313 and 323K.

PREPARATION OF SAMPLE

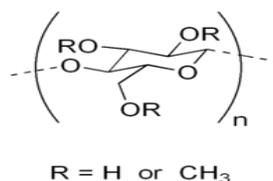
Cetyl Pyridinium Chloride (CPC), Methyl Cellulose (MC), Ethyl Cellulose (EC) and Hydroxy Propyl Methyl Cellulose (HPMC) were obtained from Himedia, Tamil Nadu, India. The experimental solutions were prepared by adding a known weight of Cellulose derivatives (MC, EC and HPMC) and different concentration of Cetylpyridinium Chloride (CPC) to a fixed volume of water and then stirring under reflux until clear solutions were obtained. Doubled distilled water used to prepare the stock solution.

STRUCTURE OF SAMPLE

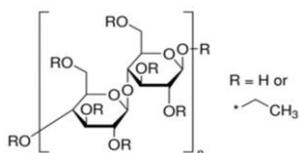
Cetyl Pyridinium Chloride (CPC)



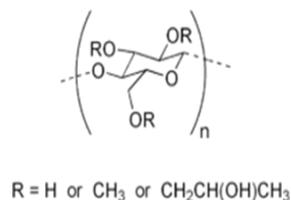
Methyl Cellulose (MC)



Hydroxy Propyl Methyl Cellulose (HPMC)



Ethyl Cellulose (EC)

**II. EXPERIMENTAL TECHNIQUES**

The ultrasonic velocity measurements in the Cetylpyridinium chloride (CPC) with Cellulose derivatives (MC, EC and HPMC) solutions were made in the ultrasonic interferometer of fixed frequency 2MHz (Model F 81 Mittal enterprises, New Delhi, India) and at different temperatures (303, 313 and 323 K). The temperature was maintained constant by circulating water from a thermostatically controlled ($\pm 0.1^\circ\text{C}$) digital water bath. The values of densities at different temperatures were measured using specific gravity bottle by standard procedure and the viscosity is measured using Ostwald's viscometer with an accuracy of $\pm 0.001\%$ calibrated with double distilled water. The FTIR Spectrum for these samples using Fourier Transform Infrared Spectrometer (Spectrum RX, Perkin Elmer). The powder samples of CPC/MC, CPC/EC and CPC/HPMC at 1:1 ratio, these samples were mixed with KBr powder to form a pellet and placed in a sample cup and measured [15]. The entire FTIR spectrums were recorded in the range of $4000 - 400 \text{ cm}^{-1}$. The UV – Vis Spectrometer (Model – Lamber 35 – Perkin Elmer) the surfactant / Cellulose derivatives aqueous solutions at different concentrations. All the UV sample were recorded in the range ($1000 - 400 \text{ \AA}$).

III. PHYSICAL PARAMETER

Thermodynamic parameters such as adiabatic compressibility (β), intermolecular free length (L_f), internal pressure (π_i), acoustic impedance (z_a) and solvation number (S_n) have been calculated from empirical Jacobson's relations [16].

- i) Adiabatic compressibility

$$\beta = 1/u^2 \rho \quad (1)$$

has been calculated from the u - ultrasonic velocity and ρ - density of the medium using the Newton - Laplace equation.

- ii) Intermolecular free length

$$L_f = K_T \beta^{1/2} \quad (2)$$

Where K_T - temperature dependent constant known as Jacobson's constant ($K_T = 2.131 \times 10^{-6}$) and β is the adiabatic compressibility

- iii) Internal pressure

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

(Where, b stands for cubic packing, which is assumed to be 2 for all liquids, T-absolute temperature in Kelvin, Where M_{eff} - effective molecular weight of the mixture ($M_{\text{eff}} = \sum m_i x_i$, where m_i and x_i are the molecular weight and mole fraction of individual constituents, respectively K is a temperature independent constant which is equal to 4.281×10^9 for all liquids, R is the universal gas constant, η -Viscosity of the solution).

(iv) Rao's constant

$$R_a = (M/\rho) (u)^{1/3} \quad (4)$$

(v) Relaxation time

$$\tau = 4/3\beta\eta \quad (5)$$

(vi) Acoustic impedance

$$Z_a = \rho u \quad (6)$$

(vii) Absorption coefficient

$$\alpha/t^2 = (8\pi^2\eta/3\rho u^2) \quad (7)$$

(viii) Free Volume

$$V_f = (M_{\text{eff}} u/K \eta)^{3/2} \quad (8)$$

(ix) Cohesive energy

$$CE = V_f \pi_i \quad (9)$$

(x) Solvation number

$$S_n = M_2/M_1 [1 - ((\beta)/\beta_0)] [(100-x)/x] \quad (10)$$

Where M_1 , M_2 - molecular weight of the solvent and solute, β and β_0 - adiabatic compressibility of the solution and solvent

IV. RESULTS AND DISCUSSION

The aqueous property of ultrasonic velocity, density and viscosity of CPC/MC, CPC/EC and CPC/HPMC at different temperature 303, 313 and 323K are presented in tables 1, 3 and 5. The thermo acoustical parameters such as adiabatic compressibility (β), intermolecular free length (L_f), internal pressure (π_i), Rao's constant (R_a), absorption coefficient (α/t^2), free volume (V_f), cohesive energy (C_E), relaxation time (τ), acoustical impedance (Z_a) and solvation number (S_n) were calculated using acoustical relations. From the variation of ultrasonic velocity values with the ratio of surfactant CPC / EC a velocity maxima is observed at the critical ratio 4:1. At the ratio of 4:1 the velocity attains its maximum value and then gradually drops down. However, in general CPC / MC and CPC / HPMC, velocity maximum is observed at the critical ratio 3:1 and then gradually decreases [17]. The above variation is shown in figures 1, 4 and 7. From the conformation of the surfactant and cellulose derivatives tend to form hydrogen bonding between them. This hydrogen bonding formation may reach a saturation value at a critical concentration ratio of 4:1 for CPC / EC, 3:1 for CPC / MC and CPC / HPMC. But the density variations, the maximum densities are recorded for CPC / EC whereas CPC / MC and CPC / HPMC density remains minimum.

From the figures 2, 5 and 8 the adiabatic compressibility is found to decrease with increases in the ratio of CPC / EC upto 4:1 and the ratio of CPC / MC and CPC / HPMC upto 3:1 beyond this ratio when the CPC concentration is increased the velocity tends to decrease and adiabatic compressibility is found to increase. This indicates the breaking of surfactant – cellulose derivatives complexes beyond the saturation point of 4:1 (CPC / EC) and 3:1 (CPC / MC and CPC / HPMC) which may cause the intermolecular free length (L_f) to increase beyond the critical micelle concentration. The decrease in intermolecular 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 of solute [18-19]. Due to thermal expansion of liquids as increase in temperature causes free length to increase [20]. Intermolecular free length is comparatively low and internal pressure is quite high [20] in the case of CPC / EC system. This may be due to the cohesion between solvent and solute molecules and reduction in the hydrodynamic volume. Such an observation is made in the case of Cellulose acetate in cyclohexane [21]. The value of internal pressure decreases with increase in concentration of solutes, whereas it decreases with elevation of temperature. The reduction in thermal pressure may be due to the loosening of cohesive forces leading to breaking up the structure of solvent [22].

In this study, the Rao's constant increases with increase in concentration of surfactant solution in cellulose derivatives suggesting that solute – solvent interaction is varied and it is maximum at higher concentration of surfactant. The non – linear

variation of Rao's constant and the gradual increases of acoustic impedance in all the three systems clearly indicate the solute solvent interaction exists in the system but it is dominant in CPC + EC system than in the other two systems. From the figures 3, 6 and 9 the absorption coefficient (α/f^2) increases with increase in concentration and decreases with increases in temperature indicate the association through hydrogen bonding and strong interaction between the solute and solvent. However, if the concentration of CPC is increased, it can be seen that, the absorption coefficient also increases. This may due to the fact that the maximum reaction takes place at higher concentration. The cohesive energy also same fashion as that of absorption coefficient. Similar observations were reported for the solution of ethyl cellulose in alcohols [23]. If the internal Pressure decreases correspondingly free volume increases with increase in concentration of CPC. The relaxation time (τ) behaves in the same manner as that of free volume and the relaxation times is found to be high for CPC/EC system which confirms strong association between Surfactant / Cellulose – solvent in that system when compared to other two systems studied.

Table 1. Ultrasonic velocity and related acoustical parameters in aqueous CPC + MC at different temperatures

Temp. K	Conc. %	U ms^{-1}	ρ kgm^{-3}	$\eta \times 10^{-3} \text{ Nsm}^{-2}$	$\beta \times 10^{-10} \text{ N}^{-1}\text{m}^2$	L_r \AA	$\pi \times 10^6$ Pascal	R $\times 10^{-3}$
303	1:1	1525	1041	0.801	4.130	0.405	2.738	1.389
	2:1	1529	1046	0.832	4.089	0.403	2.085	1.779
	3:1	1534	1052	0.857	4.039	0.401	1.678	2.164
	4:1	1530	1056	0.876	4.045	0.403	1.402	2.546
	5:1	1526	1060	0.892	4.051	0.402	1.201	2.924
313	1:1	1532	1033	0.764	4.124	0.405	2.741	1.402
	2:1	1536	1039	0.793	4.079	0.403	2.089	1.794
	3:1	1541	1044	0.812	4.033	0.400	1.675	2.845
	4:1	1535	1050	0.824	4.041	0.401	1.399	2.563
	5:1	1530	1054	0.847	4.053	0.402	1.203	2.943
323	1:1	1537	1026	0.694	4.125	0.405	2.680	1.413
	2:1	1542	1031	0.723	4.079	0.402	2.043	1.810
	3:1	1546	1038	0.757	4.030	0.400	1.660	2.199
	4:1	1540	1043	0.776	4.042	0.401	1.390	2.583
	5:1	1534	1049	0.792	4.051	0.402	1.195	2.959

Table 2. Ultrasonic absorption coefficient and related acoustical parameters in aqueous CPC + MC at different temperature

Temp. K	Conc. %	$\alpha/f^2 \times 10^{-15} \text{ Np m}^{-1}\text{s}^{-2}$	$V_r \times 10^{-15} \text{ m}^3\text{mol}^{-1}$	CE $\times 10^{-8}$	$\tau \times 10^{-12} \text{ Sec}$	$z_a \times 10^6 \text{ kgm}^{-2} \text{ s}^{-2}$	S_n
303	1:1	5.705	0.215	5.905	4.41	1.587	-17
	2:1	5.850	0.333	6.965	4.53	1.599	20
	3:1	5.933	0.474	7.957	4.61	1.613	37
	4:1	6.089	0.626	8.789	4.72	1.615	29
	5:1	6.226	0.795	9.557	4.81	1.617	23
313	1:1	5.408	0.202	5.543	4.20	1.582	-22
	2:1	5.537	0.301	6.536	4.31	1.595	11
	3:1	5.588	0.440	7.375	4.36	1.608	31
	4:1	5.704	0.574	8.029	4.43	1.611	25
	5:1	5.899	0.738	8.915	4.57	1.612	21
323	1:1	4.897	0.175	4.714	3.81	1.576	-27
	2:1	5.028	0.273	5.600	3.93	1.589	8
	3:1	5.189	0.398	6.610	4.06	1.604	28
	4:1	5.356	0.527	7.339	4.18	1.606	20
	5:1	5.499	0.670	8.018	4.27	1.609	15

Table 3. Ultrasonic velocities and related acoustical Parameters in aqueous CPC + EC at different temperature

Temp. K	Conc. %	U ms ⁻¹	ρ kgm ⁻³	$\eta \times 10^{-3}$ Nsm ⁻²	$\beta \times 10^{-10}$ N ⁻¹ m ²	L _r Å	$\pi \times 10^6$ Pascal	R X10 ⁻³
303	1:1	1528	1061	1.260	4.036	0.4008	3.474	1.364
	2:1	1534	1074	1.612	3.956	0.3969	2.949	1.734
	3:1	1540	1083	1.836	3.893	0.3937	2.500	2.105
	4:1	1547	1092	2.247	3.826	0.3903	2.283	2.471
	5:1	1542	1096	2.475	3.837	0.3908	2.041	2.837
313	1:1	1535	1048	0.999	4.049	0.4015	3.162	1.383
	2:1	1541	1059	1.150	3.976	0.3978	2.543	1.762
	3:1	1546	1072	1.456	3.902	0.3941	2.279	2.129
	4:1	1551	1081	1.867	3.845	0.3912	2.133	2.498
	5:1	1548	1085	2.179	3.851	0.3915	1.957	2.869
323	1:1	1542	1034	0.957	4.067	0.4024	3.158	1.404
	2:1	1548	1042	0.964	4.004	0.3993	2.372	1.793
	3:1	1554	1058	1.123	3.913	0.3947	2.043	2.161
	4:1	1560	1071	1.328	3.836	0.3908	1.839	2.252
	5:1	1557	1076	1.739	3.843	0.3911	1.790	2.898

Table 4. Ultrasonic absorption coefficient and related acoustical parameters in aqueous CPC + EC at different temperature

Temp. K	Conc. %	$\alpha/f^2 \times 10^{-15}$ Np m ⁻¹ s ²	V _r × 10 ⁻¹⁵ m ³ mol ⁻¹	CE × 10 ⁻⁸	$\tau \times 10^{-12}$ Sec	$z_a \times 10^6$ kgm ⁻² s ²	S _n
303	1:1	8.752	0.426	14.820	6.78	1.621	62
	2:1	10.932	0.905	26.696	8.50	1.647	83
	3:1	12.204	1.495	37.379	9.52	1.667	95
	4:1	14.612	2.617	59.790	11.46	1.689	111
	5:1	16.275	3.760	76.791	12.72	1.690	98
313	1:1	6.929	0.303	9.589	5.39	1.608	57
	2:1	7.802	0.549	13.968	6.09	1.631	76
	3:1	9.664	1.061	24.212	7.57	1.657	95
	4:1	12.170	1.990	42.462	9.57	1.676	106
	5:1	14.262	3.098	60.658	11.18	1.698	96
323	1:1	6.636	0.286	9.041	5.18	1.594	22
	2:1	6.557	0.424	10.065	5.14	1.613	48
	3:1	7.436	0.724	14.810	5.85	1.641	80
	4:1	8.587	1.204	22.161	6.79	1.670	101
	5:1	11.301	2.226	39.850	8.90	1.673	91

Table 5. Ultrasonic velocity and related acoustical Parameters in aqueous CPC + HPMC 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 _r Å	π X10 ⁶ Pascal	R X10 ⁻³
303	1:1	1526	1050	0.983	4.089	0.403	3.049	1.377
	2:1	1530	1062	1.137	4.022	0.400	2.461	1.752
	3:1	1536	1071	1.349	3.957	0.396	2.129	2.126
	4:1	1532	1075	1.736	3.963	0.397	1.996	2.501
	5:1	1529	1077	2.127	3.971	0.396	1.874	2.878
313	1:1	1533	1037	0.836	4.103	0.404	2.874	1.397
	2:1	1538	1049	0.981	4.030	0.400	2.336	1.777
	3:1	1543	1058	1.126	3.969	0.397	1.989	2.156
	4:1	1540	1062	1.479	3.970	0.398	1.883	2.536
	5:1	1536	1064	1.892	3.983	0.399	1.807	2.918
323	1:1	1539	1020	0.783	4.139	0.405	2.834	1.422
	2:1	1544	1038	0.827	4.041	0.401	2.194	1.798
	3:1	1549	1046	0.968	3.984	0.398	1.885	2.183
	4:1	1544	1050	1.173	3.994	0.399	1.715	2.563
	5:1	1539	1055	1.489	4.001	0.400	1.643	2.945

Table 6. Ultrasonic absorption coefficient and related acoustical Parameters in aqueous CPC + HPMC at different temperature

Temp. K	Conc. %	α/f ² x10 ⁻¹⁵ Np m ⁻¹ s ²	V _f x10 ⁻¹⁵ m ³ mol ⁻¹	CE x10 ⁻⁸	τ x10 ⁻¹² Sec	z _a x10 ⁶ kgm ⁻² s ²	S _n
303	1:1	6.926	0.293	8.949	5.359	1.602	17
	2:1	7.859	0.533	13.147	6.096	1.624	47
	3:1	9.138	0.937	19.977	7.116	1.645	67
	4:1	11.808	1.751	34.973	9.171	1.646	57
	5:1	14.526	2.935	55.020	11.260	1.649	50
313	1:1	5.883	0.231	6.659	4.572	1.589	12
	2:1	6.758	0.431	10.080	5.27	1.613	47
	3:1	7.616	0.720	14.326	5.958	1.632	65
	4:1	10.025	1.388	26.146	7.887	1.635	55
	5:1	12.901	2.479	44.816	10.046	1.634	48
323	1:1	5.536	0.211	5.985	4.320	1.569	-38
	2:1	5.691	0.335	7.369	4.454	1.602	28
	3:1	6.546	0.577	10.88	5.141	1.620	48
	4:1	7.979	0.984	16.887	6.246	1.621	38
	5:1	10.180	1.736	28.538	7.943	1.623	33

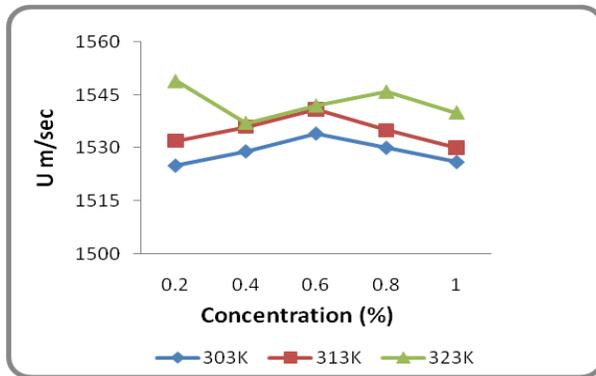


Figure 1. Ultrasonic Velocity Vs Concentration of CPC+MC in aqueous solution at different temperature

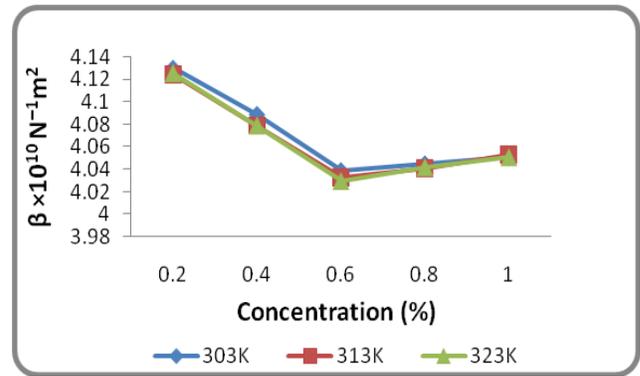


Figure 2. Adiabatic compressibility Vs Concentration of CPC+MC in aqueous solution at different temperature

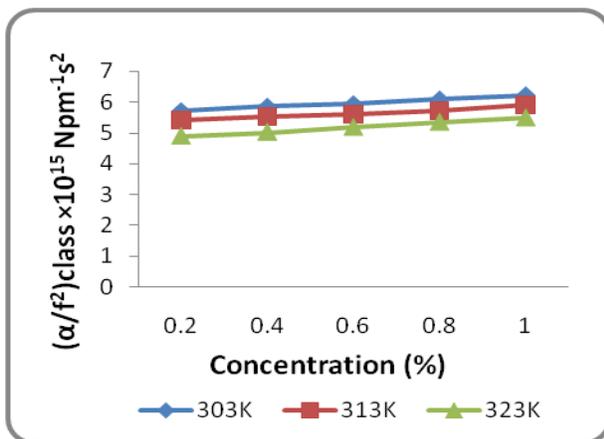


Figure 3. Absorption coefficient Vs Concentration of CPC+MC in aqueous solution at different temperature

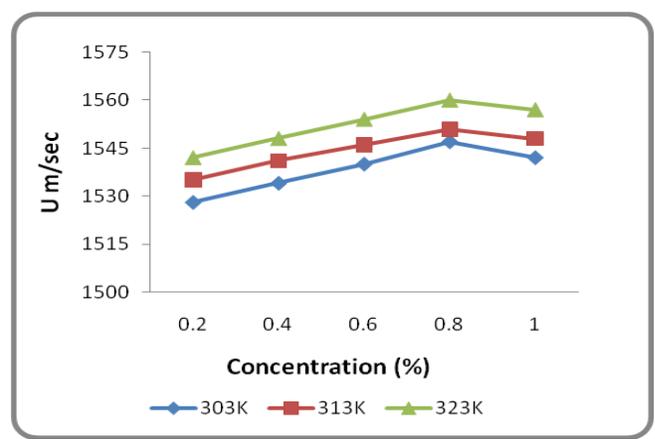


Figure 4. Ultrasonic Velocity Vs Concentration of CPC+EC in aqueous solution at different temperature

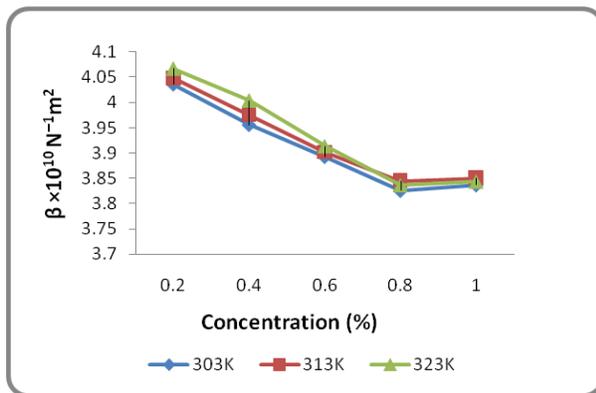


Figure 5. Adiabatic compressibility Vs Concentration of CPC+EC in aqueous solution at different temperature

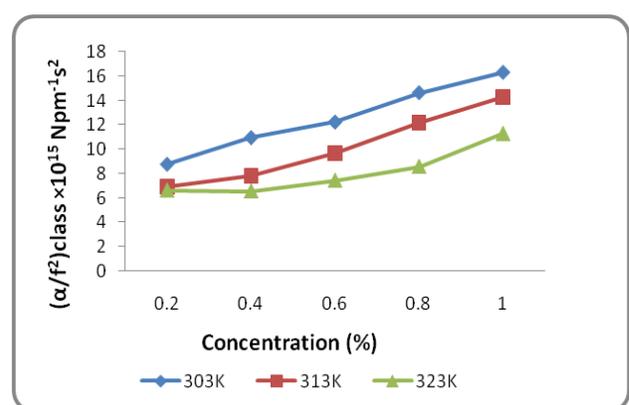


Figure 6. Absorption coefficient Vs Concentration of CPC+EC in aqueous solution at different temperature

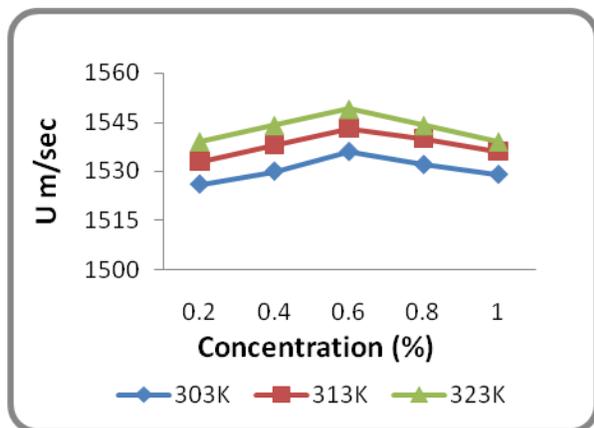


Figure 7. Ultrasonic Velocity Vs Concentration of CPC+HPMC in aqueous solution at different temperature

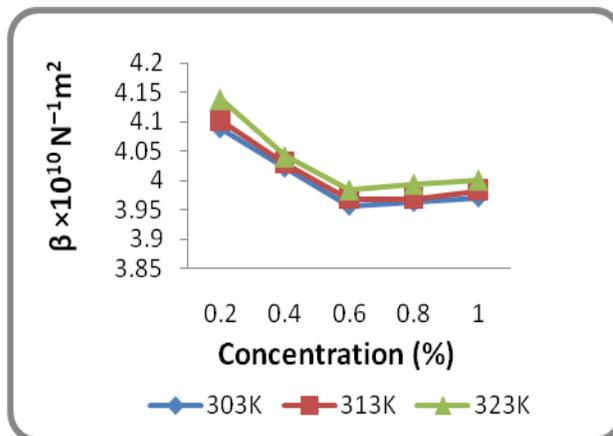


Figure 8. Adiabatic compressibility Vs Concentration of CPC+HPMC in aqueous solution at different temperature

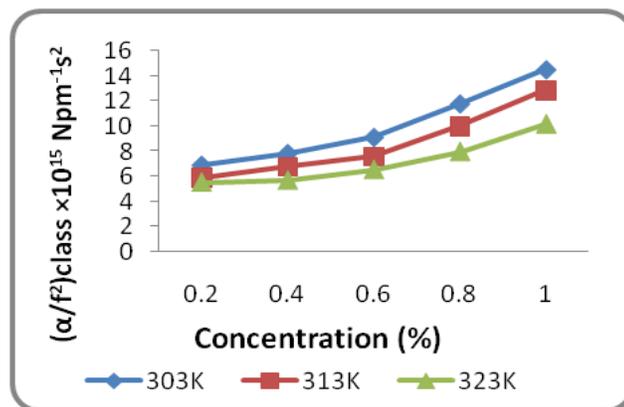


Figure 9. Absorption coefficient Vs Concentration of CPC+HPMC in aqueous solution at different temperature

Solvation is the attraction of molecules in the solvent [15]. The Solvation number (Sn) increases with increase in concentration upto the CMC level 4:1 of CPC / EC and 3:1 of CPC / MC and CPC / HPMC and then decreased. However, the solvation number decreased with the increases in temperature [24]. This suggests significantly strong interaction in both the systems. The increase in (Sn) supports Structure Maker (SN) tendency of surfactants. But decreases in the value of (Sn) at higher temperature favor presence of solute – solvent interaction. Interaction of EC with aqueous CPC is stronger as compared to interaction of MC, HPMC with CPC.

The interaction level changes in the following order
 CPC+EC > CPC+HPMC > CPC+MC

Hence it may be concluded from the above discussion, the critical concentration of 4:1 of CPC / EC there is possibility from formation of molecular association complexed between Surfactant / Cellulose than compare to CPC / MC and CPC / HPMC.

FTIR ANALYSIS

The Fourier transform infrared analysis is conducted to verify the possibility of interaction of chemical bonds between Cationic Surfactant and cellulose. FTIR is an attractive technique to evaluate structural variations on samples due to the chemical treatments. The FT-IR spectra of pure Cationic Surfactant (CPC) and CPC mixed with Methyl Cellulose, Ethyl Cellulose and Hydroxypropyl Methylcellulose samples were recorded in the transmittance mode in the range of 4000-400 cm^{-1} at a resolution of 1.0 cm^{-1} . The representative spectrum for CPC is shown in figure 10 to 12 along with the corresponding spectra of pure Methyl Cellulose, Ethyl Cellulose and Hydroxypropyl Methylcellulose 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. Figure 10 to 12 shows the IR spectra of pure CPC and CPC mixed with different cellulose derivatives (MC, EC and HPMC). From the figure, 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} and -OH group, which are associated with the CPC before the chemical treatments. After CPC loaded with EC, MC and HPMC sample, 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 EC, MC and HPMC as shown in figures 10 - 12. The spectral band observed in the region 1630–1674 cm^{-1} for CPC and CPC loaded EC, MC and HPMC are due to the O–H bending due to adsorbed.

The results of FTIR studies show solute – solute – solvent interaction via hydrogen bond formation through the O-H groups [25]. 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. However, CPC loaded with Ethyl Cellulose reveals (figure: 11) significant chemical interaction which is realized by observing all spectral bands of CPC even after Ethyl Cellulose loaded. Besides, FTIR studies showed that the Ethyl Cellulose distribution in the CPC was homogeneous. From the FTIR spectra, the result suggests that CPC + Ethyl Cellulose blend has stronger intermolecular interaction than CPC + Methyl Cellulose and CPC + Hydroxy Propyl Methyl Cellulose blends.

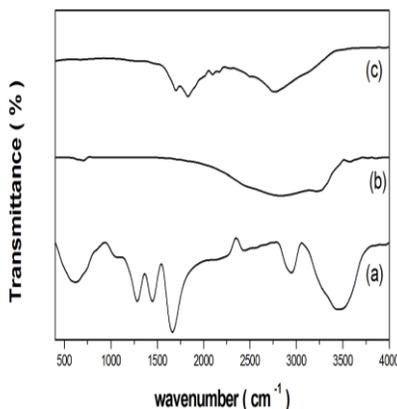


Figure 10. Overlapped FTIR Spectra for a) CPC, b) MC and c) CPC + MC

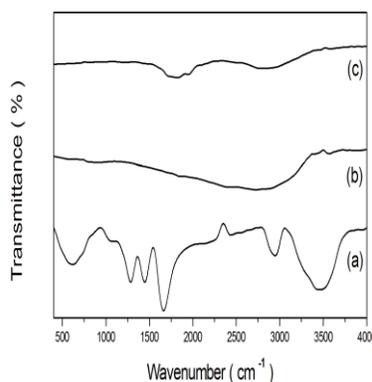


Figure 11. Overlapped FTIR Spectra for a) CPC, b) EC and c) CPC + EC

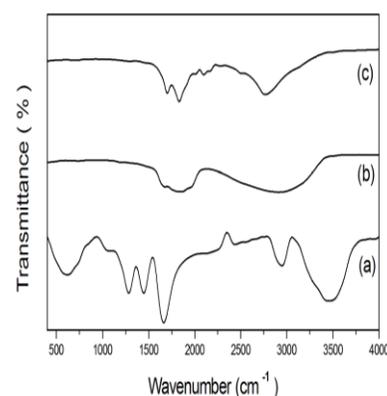


Figure 12. Overlapped FTIR Spectra for a) CPC, b) HPMC and c) CPC + HPMC

UV ANALYSIS

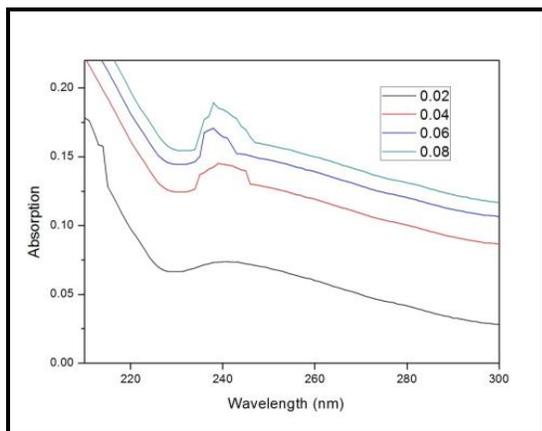


Figure 13. UV-VIS spectra for CPC + MC

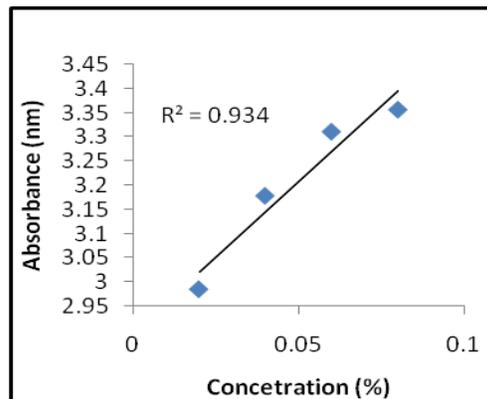


Figure 16. Lamberts – Beer linear plots for aqueous solutions of CPC+ MC

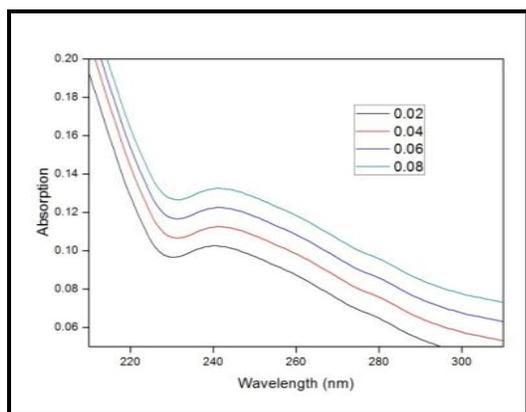


Figure 14. UV-VIS spectra for CPC + EC

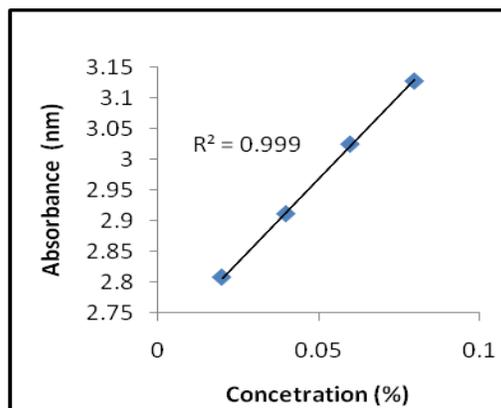


Figure 17. Lamberts – Beer linear plots for aqueous solutions of CPC + EC

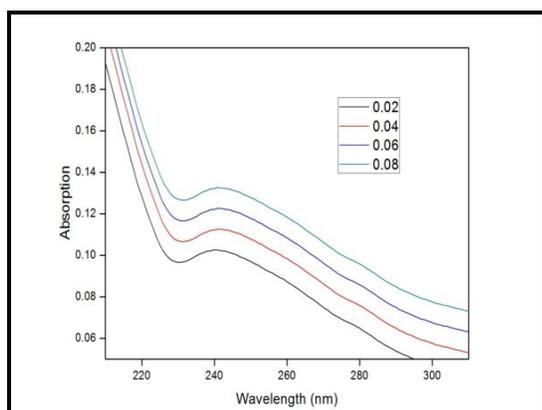


Figure 15. UV-VIS spectra for CPC+HPMC

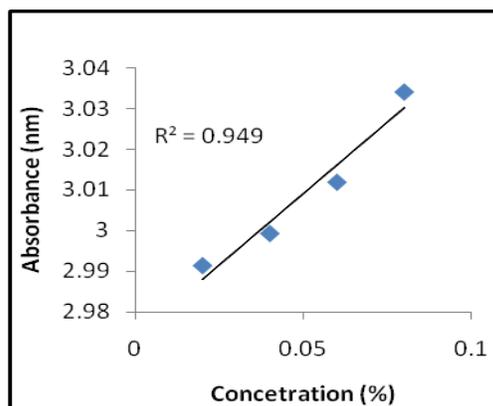


Figure 18. Lamberts - Beer linear plot for aqueous solution of CPC+HPMC

Figure 13 to 15 shows the UV – Vis spectrum of the aqueous solution of Cationic Surfactant (CPC) with Methyl Cellulose, Ethyl Cellulose and Hydroxy Propyl Methyl Cellulose at room temperature. The spectrum shows a peak with absorbance value increasing with increase in concentration. A typical Lambert – Beer behavior has been followed. The CPC + Methyl Cellulose spectra shows only one characteristic peaks at 236.4 nm. The CPC + Ethyl Cellulose and CPC + Hydroxypropyl Methylcellulose shows only one characteristic peaks at 248.04 nm and 238.38 nm. To study the effect of polarity on the UV absorption data (Table: 7). The plot concentration versus absorption is drawn and linear regression analysis has also been carried out.

Table 7. UV-VIS absorption values of CPC+MC, CPC +EC and CPC+ HPMC

Compounds	Concentration ($\times 10^{-3}$) mol dm ⁻³	Absorption (nm)
CPC+MC	0.02	2.9864
	0.04	3.0179
	0.06	3.0311
	0.08	3.0356
	0.10	3.0707
CPC+EC	0.02	2.8076
	0.04	2.9112
	0.06	3.0251
	0.08	3.1281
	0.10	3.1784
CPC+HPMC	0.02	2.9914
	0.04	2.9993
	0.06	3.0119
	0.08	3.0341
	0.10	3.0476

For the UV absorption analysis, a mixture of CPC + Ethyl Cellulose is extremely good correlation $R^2 = 0.985$ (figure: 17) is obtained, but CPC + Methyl Cellulose and CPC + HPMC is poor correlation $R^2 = 0.873$ (figure: 16) and $R^2 = 0.974$ (figure: 18). All the correlation depends upon the solute - solvent interaction [25, 26].

V. CONCLUSION

From the structure of CPC with Cellulose derivatives the interaction is predominant and stronger in CPC + Ethyl cellulose when compared to CPC + Methyl cellulose and CPC + Hydroxy Propyl Methyl Cellulose. It is well know that internal pressure increases in hydrogen bonded systems. The increase in the value of acoustical impedance is an indication of strong interaction between CPC + Ethyl cellulose. Comparing the effect of addition of CPC + Ethyl cellulose shows maximum molecular interaction than CPC + Methyl cellulose and CPC + HPMC. From the FTIR spectra, CPC mixed with Ethyl cellulose reveals significant chemical interaction which is realized by observing all spectral bands of CPC even Ethyl cellulose loaded. Finally in the FTIR spectra, the result suggests that CPC + Ethyl cellulose blend has stronger intermolecular interaction than CPC + Methyl cellulose and CPC + HPMC. For the UV analysis, CPC + Ethyl cellulose is extremely good correlation compare to other two mixtures. Finally we conclude that CPC + Ethyl cellulose has been used as a best additive in pharmaceuticals and food industries.

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