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A Study of Acoustical Behaviour of Prochlorperazine Maleate in DMF Water Solvent at Different Temperatures.

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ABSTRACT

The measurements of density, viscosity and speed of sound of **Prochlorperazine Maleate** drug have been determined by experimental procedures in DMF Water solvent at different temperatures. From the experimental data various acoustical parameters such as apparent molar compressibility (ϕ_k), apparent molar volume (ϕ_v), adiabatic compressibility (β_s), specific acoustic impendence (Z), intermolecular free length (L_f) have been evaluated. The concentration range is 0.02 to 0.1 mol dm^{-3}. The measurements are conducted at different temperatures in DMF Water solvent. The results are interpreted in terms of molecular interactions occurring in these solutions.

Keywords:compressibility (ϕ_k), apparent molar volume (ϕ_v), adiabatic compressibility (β_s), specific acoustic impendence (Z), intermolecular free length ($L_{f,}$) DMF Water solvent.

INTRODUCTION

In recent years the measurement of ultrasonic velocity has been adequately employed in understanding the nature of molecular interactions in pure liquids and liquid mixtures. Ultrasonic propagation parameters yield valuable information regarding the behaviour of liquid systems, because intramolecular and intermolecular association, dipolar interactions, complex formation and related structural changes affect the compressibility of the system which in turn produces corresponding variations in the ultrasonic velocity

The acoustical and thermo dynamical parameters obtained in ultrasonic study show that the ion solvation is accompanied by the destruction or enhancement of the solvent structure[1-2].Excess thermodynamic properties of liquid mixtures are of great interest to conveniently design industrial processes and also to provide useful information on the molecular interactions required for optimizing thermodynamic models [3]. When two or more liquids are mixed there occur some changes in physical and thermodynamic properties because of free volume change, change in energy and change in molecular orientations. Derived thermodynamic and acoustical parameters like internal pressure, free volume and acoustic impedance are of considerable interest in understanding the intermolecular orientations in binary liquid mixtures[4-6]. Excess thermodyamic properties of mixtures are useful in the study of molecular orientations and arrangements [7-8].

For the present study **Prochlorperazine Maleate** drug is selected. This drug is used as antipsychotic. The acoustic properties of **Prochlorperazine Maleate** have been studied in 20% DMF-water solutions at different temperatures.

METHODOLOGY

Solvent dimethyl formamide used in the present work were of AR grade and were purified and dried by the usual procedure. Densities, viscosities and ultrasonic velocities were measured at different temperatures over a wide range of composition. Densities were determined by using bicapillary pyknometer. The viscosities were measured by precalibrated Ostwald type viscometer. Ultrasonic velocity measurements were made by using an ultrasonic interferometer (Mittal Enterprises, New Delhi) at a frequency of 2MHz with a tolerance of ± 0.005%. All the measurements were carried out at different temperatures.

Theory
Acoustic parameters such as apparent molar compressibility (ϕ_k), apparent molar volume (ϕ_v), adiabatic compressibility (β_s), specific acoustic impendence (Z), intermolecular free length (L_f), Limiting apparent molar volume (ϕ^0_v), Limiting

apparent molar compressibility (ϕ^0_k) were determined using following relations.

Ultrasonic velocity

$$u = \lambda\upsilon \qquad -------------- \qquad 1$$

Adiabatic compressibility

$$\beta_s = 1/ u^2_s \rho_s \quad ----------------2$$

Apparent molar volume

$$\phi_v = 10^3(\rho_0-\rho_s)/m\text{-}\rho_0\,\rho_s + M/\rho_0 \quad 3$$

Apparent molar compressibility

$$\phi_k = 10^3(\rho_0\beta_s-\rho_s\beta_0)/m\text{-}\rho_s\,\rho_0 + \beta_s M/\rho_s ---- 4$$

Intermolecular free length

$$L_f = K\,(\beta_s)^{1/2} -------------------- \qquad 5$$

Specific acoustic impendence

$$Z = \rho.u \qquad --------- \qquad 6$$

Limiting apparent molar volume

$$\phi_v = \phi^0_v + S_v C^{1/2} ------------- \qquad 7$$

Limiting apparent molar compressibility

$$\phi_k = \phi^0_k + S_k^{1/2} ---------- \qquad 8$$

RESULTS AND DISCUSSION

Table 1 shows that density (ρ), ultrasonic velocity (u) and viscosity (η) increases with increase in concentration for different temperatures. The increase in ultrasonic velocity is due to decrease in intermolecular free length (L_f) as shown in table . This suggests that there is a strong interaction between Prochlorperazine Maleate and solvent molecule. Adiabatic compressibility (β_s) is a measure of intermolecular association or repulsion calculated from the measured ultrasonic velocity (u) and density (ρ). Adiabatic compressibility is found to decrease with increase in concentration. Since adiabatic compressibility is inversely related to the product of density and ultrasonic velocity based on this the compressibility is expected to decrease which has observed in the present case. When the sound waves travels through the solution, certain part of it travels through the medium and rest gets reflected by the ion[6] i.e. restriction for flow of sound velocity by the ions.

The character that determines the restriction movement of sound waves is known as acoustic impendence (Z). It has been found that acoustic impendence increases with increase in concentration. The apparent molar compressibility (ϕ_k) explains the solute-solvent and solute- solute interactions in solution and was calculated by using the equation no. 4. The apparent molar volume (ϕ_v) is defined as the change in volume of solution for the added one mole of a particular component at constant temperature and pressure. It is thermodynamic property which helps in elucidating solvation behavior of electrolyte in solution. Apparent molar volume was evaluated from the density of solution and solvent.

It is evident from the table 2 that ϕ^0_k values are negative but for 218K ϕ^0_k value is positive. The negative ϕ^0_k values are suggest solute- solvent interaction whereas positive values are due to solute-

solute interaction, is further confirmed by ϕ^0_v values which are positive of. S_v is a measure of solute – solvent interaction. The viscosity β -Co-efficient has been derived from Jones-Dole equation

(c > 0.1m) $\eta_r - 1 / C^{1/2} = A + B C^{1/2}$

Where η_r is the relative viscosity. A and B are the characteristics of the solute and solvent. A is Falkenhagen coefficient represent the contributor from solute-solute interaction and B is Jones Dole coefficient known to depend on the size of the solute particle and on the interaction between solute and solvent.

They were obtained by a least – squares treatment as intercept and slope of the linear plot of $\eta_r - 1 / C^{1/2}$ Vs $C^{1/2}$. The graph for each system given linear straight line showing validity of Jones-Dole equation. The slope of straight line gives value of β co-efficient.

Table no.1: Density, Ultrasonic Velocity and related Parameters at different temperatures System- PCP in 20% DMF-Water medium

Temp T (K)	Conc. mol. dm^{-3}	Density ρ_s Kgm^{-3}	Ultrasonic Velocity(u) m/s	β_s x10^{-10} Pa^{-1}	Φ_v x10^{-5} m^{3}mol^{-1}	Φ_k x10^{-14} m^{3}mol^{-1} Pa^{-1}	L_f x10^{-11} (m)	Z x 10^5 Kg m^{-2} sec^{-1}	Relative association R_A X10^{-3}
298K	0.02	1014.36	1623.5	3.7403	-64.4141	-108.50	3.9880	16.4628	1021.98
	0.04	1016.88	1626.8	3.7159	-8.5675	-51.547	3.9750	16.5426	1023.82
	0.06	1017.11	1629.9	3.7009	13.7665	-29.671	3.9670	16.5779	1023.41
	0.08	1019.89	1632.0	3.6813	21.7116	-20.551	3.9565	16.6446	1025.76
	0.1	1023.05	1634.1	3.6605	26.0488	-15.403	3.9453	16.7176	1028.50
303K	0.02	1011.84	1629.7	3.7211	-74.1970	-116.30	4.0111	16.4900	1023.87
	0.04	1012.65	1631.9	3.7081	-9.1698	-51.044	4.0041	16.5255	1024.32
	0.06	1013.86	1633.8	3.6951	11.8019	-29.608	3.9971	16.5645	1025.06
	0.08	1014.34	1636.0	3.6834	23.1912	-18.414	3.9908	16.5946	1025.08
	0.1	1015.64	1638.2	3.6688	29.1641	-12.348	3.9829	16.6383	1025.94
308K	0.02	1008.43	1632.2	3.7223	-68.4230	-88.192	3.8772	16.4596	1024.72
	0.04	1008.54	1634.0	3.7137	-4.4319	-35.195	3.8727	16.4795	1024.46
	0.06	1009.87	1636.1	3.6992	14.8220	-19.327	3.8652	16.5225	1025.37
	0.08	1011.35	1638.0	3.6853	24.2190	-11.461	3.8579	16.5660	1026.48
	0.1	1012.84	1640.5	3.6686	29.8234	-705.90	3.8492	16.6157	1027.47
313K	0.02	1008.23	1633.6	3.7166	-82.3380	-76.739	4.0735	16.4705	1029.46
	0.04	1008.65	1635.8	3.7051	-12.1620	-30.515	4.0672	16.4995	1029.42
	0.06	1008.74	1637.1	3.6953	11.7710	-14.661	4.0618	16.5222	1029.08
	0.08	1008.91	1639.1	3.6892	23.6330	-6.3088	4.0585	16.5371	1029.00
	0.1	1009.29	1642.8	3.6712	30.5243	-2.6517	4.0486	16.5807	1028.61

Table-2: Limiting values of ϕ_v and ϕ_k along with slope (S_v & S_k) for Prochlorperazine Maleate in DMF Water at different temperatures

Temp.T (K)	Medium	Parameters			
		ϕ_v^0 x10^{-5} m^{3}mol^{-1}	ϕ_k^0 x10^{-14} m^{3}mol^{-1}pa^{-1}	S_vx10^{-5} m^{3}mol$^{-3/2}$dm$^{3/2}$	S_k x10^{-14} m^{3}mol$^{-3/2}$dm$^{3/2}$pa^{-1}
298K	20%D-W	193.4	3.586	-392.3	41.79
303K	20%D-W	171.1	-36.26	-326.8	159.8
308K	20%D-W	166.4	-48.46	-312.2	192.8
313K	20%D-W	159.3	-78.45	291.0	282.5

Table-3 : A and B, coefficient values in DMF Water at different temperatures for Prochlorperazine Maleate

Temp T (K)		298 K	303 K	308 K	313 K
20% DMF-Water medium	A	0.741	1.185	1.378	1.863
	B	-1.488	-2.450	-2.875	-4.048

The viscosity A coefficient represent the ion-ion interactions and negative values have shown some physical significance. However negative A values have also been reported to be in other solvents in some studies[7-9].

The large and small value of 'A' shows the stronger and weaker solute – solute interactions respectively. When solute is introduced into solvent of organic-water mixture it will interfere with the ordered structure of water in the solutes co-sphere. As only one solute is present so such variation in the values of A can be explained.

In the present study viscosity of liquid solutions increases with increase in concentration of drugs solution at different temperatures in 20% DMF-water mixture. The increase in viscosity with increase in concentration may be attributed to the increase in solute solvent interactions.

Viscosity B coefficients have been established to arise from ion- solvent interactions and are responsible for introducing order or disorder in the structure of the solvent. Solute with negative B Coefficient is characterized as structure breakers indicating weak solute-solvent interactions. Such type of results is also shown by Eyring et al.[9] and several other workers[11].

Conflicts of interest: The authors stated that no conflicts of interest.

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