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A Study of Acoustic Parameters of 2-(diphenylmethoxy)-*N*, *N*-dimethylethanamine in Different Mixture of Solvents at 299 K

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ABSTRACT

Ultrasonic studies provide information in understanding molecular behavior and intermolecular interactions of 2-(diphenylmethoxy)-*N*,*N*-dimethylethanamine drug in solvent mixtures. The Measurements of density, viscosity and speed of sound of 2-(diphenylmethoxy)-*N*,*N*-dimethylethanamine drug have been determined by experimental procedures in different medium. From the experimental data various acoustical parameters such as apparent molar compressibility ϕ_k), apparent molarvolume (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 299K in different solvents. The variation of these acoustic parameters is explained in terms of solute -solvent molecular interaction occurring in Drug solutions.

Introduction

Ultrasonic waves provided valuable information about the structure of solid[1]. The measurement of ultrasonic velocity has been adequately employed in understanding the nature of molecular interactions in pure liquids[2-5] and liquid mixtures[6-7]. 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[8-11]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. 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[12-14]. Excess thermionic properties of mixtures are useful in the study of molecular orientations and arrangements[15-16]

For the present study 2-(diphenylmethoxy)-*N*,*N*-dimethylethanamine [17] drug is selected. This drug is an antihistamine that reduces the effects of natural chemical histamine in the body. It is used for the treatments of sneezing,runny noise,watery eyes,hives,skin rash,itching and other cold or allergy symptoms. The acoustic properties of 2-(diphenylmethoxy)-*N*,*N*-dimethylethanamine have been studied in 30% Methanol-water, 30% Dioxane-water and 30% DMF-water solutions at 299 K.

Experimental

Solvents methanol, dioxane and 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 299 K 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 299 K.

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 $u = \lambda\upsilon$ ---------- (i)

Adiabatic compressibility $\beta_s = 1/ u^2_s \rho_s$ ---------- (ii)

Apparent molar volume $\varphi_v = 10^3(\rho_0-\rho_s)/m-\rho_0 \rho_s + M/\rho_0$ ---------(iii)

Apparent molar compressibility $\varphi_k = 10^3(\rho_0\beta_s-\rho_s\beta_0)/m-\rho_s \rho_0 + \beta_s M/\rho_s$ ---(iv)

Intermolecular free length $L_f = K (\beta_s)^{1/2}$ ---------- -------(v)

Specific acoustic impendence $Z = \rho.u$ --------- ----- ----------(vi)

Limiting apparent molar volume $\varphi_v = \varphi^0{}_v + S_v C^{1/2}$ ----------(vii)

Limiting apparent molar compressibility $\varphi_k = \varphi^0{}_k + S_k{}^{1/2}$----------(viii)

Table no.1

Experimental Data of Density, Ultrasonic Velocity and Viscosity of 2-(diphenylmethoxy)-*N*,*N*-dimethylethanamine in different solvent at 299K

Solvents	Conc.mol.dm^{-3}	Density ρ_s Kgm^{-3}	Ultrasonic Velocity(u)m/s	Viscosityx10^{-3} Nsm^{-2}
30% MeOH-Water Medium	0.02	1096.23	1676.5	1.21148
	0.04	1096.32	1684.0	1.21823
	0.06	1096.52	1687.2	1.21901
	0.08	1096.75	1691.1	1.21921
	0.1	1096.91	1695.1	1.22021
30% Dioxane-Water Medium	0.02	1082.09	1799.5	1.23251
	0.04	1082.16	1701.0	1.23602
	0.06	1082.66	1715.2	1.23856
	0.08	1082.94	1711.1	1.23936
	0.1	1083.15	1789.1	1.23250
30% DMF-Water Medium	0.02	994.19	1648.3	0.93239
	0.04	995.91	1677.4	0.93959
	0.06	997.05	1681.1	0.94282
	0.08	998.29	1682.2	0.94341
	0.1	998.89	1683.3	0.94957

Table no.2

Variation of some acoustical parameters with concentration of 2-(diphenylmethoxy)-*N*,*N*-dimethylethanamine in different solvents at 299 K

Solvents	Conc.mol.dm^{-3}	$\beta_{s\ x10^{-10}}$ Pa^{-1}	Φ_v x10^{-5} m^{3}mol^{-1}	Φ_k x10^{-14} m^{3}mol^{-1} Pa^{-1}	$L_{f\ x}10^{-11}$ (m)	Z x 10^5 Kg m^{-2} sec^{-1}
30% MeOH-Water	0.02	4.3858	-71.87	-73.943	4.2196	16.4159
	0.04	4.3669	-53.12	-32.731	4.2035	16.4345
	0.06	4.3458	-9.51	-21.458	4.0105	16.4496

Medium	0.08	4.3163	5.30	-9.0120	3.0096	16.4512
	0.1	4.2825	12.19	-7.0787	3.0041	16.4854
30% Dioxane-Water Medium	0.02	5.9694	-61.5	-82.7968	5.9366	15.2693
	0.04	5.8659	-9.87	-47.6369	5.1268	16.2832
	0.06	5.8256	7.95	-23.6684	5.0655	16.3171
	0.08	5.8125	10.61	-19.5196	5.0126	16.3468
	0.1	5.1253	15.93	-14.5892	5.0004	16.3422
30% DMF-Water Medium	0.02	3.6652	9.82	312.7213	5.4702	14.6341
	0.04	3.6128	21.1	148.5842	5.4628	14.6653
	0.06	3.5802	23.5	122.4264	5.4547	14.7015
	0.08	3.5659	25.4	87.1877	5.4456	14.7432
	0.1	3.5359	26.5	72.4595	5.4385	14.7640

Table-3 Limiting values of ϕ^0_v and ϕ^0_k along with slope (S_v & S_k) for 2-(diphenylmethoxy)-*N*,*N*-dimethylethanamine different medium at 299K temperature

Temp. T (K)	Medium	Parameters			
		$\phi^0_v \times 10^{-5}$ m^3mol^{-1}	$\phi^0_k \times 10^{-14}$ $m^3mol^{-1}pa^{-1}$	$S_v \times 10^{-5}$ $m^3mol^{-3/2}dm^{3/2}$	$S_k \times 10^{-14}$ $m^3mol^{-3/2}dm^{3/2}pa^{-1}$
299K	30% M-W	-141.612	-84.31	546.26	256.21
	30% D-W	-82.414	-122.32	411.108	332.314
	30% DMF-W	5.763	611.21	59.381	-1513.12

Table-4 A and β, coefficient values at 299K in different medium for 2-(diphenylmethoxy)-*N*,*N*-dimethylethanamine

Medium	Coefficient	Temp 299 K
30%Methanol-Water medium	A	**0.930**
	β	**-0.141**
30%Dioxane-Water medium	A	**1.435**
	β	**-0.179**
30% DMF-Water medium	A	**0.512**
	β	**-0.079**

Results and Discussion:

Table 1 shows that density (ρ), ultrasonic velocity (u) and viscosity (η) increases with increase in concentration for all three systems. The increase in ultrasonic velocity is due to decrease in intermolecular free length (L_f) as shown in table 2. This suggests that there is a strong interaction between 2-(diphenylmethoxy)-*N*,*N*-dimethylethanamine 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.(iv). 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 3 that φ^0_k values are negative for 30% MeOH-water and 30% Dioxane-water but for 30%DMF-water φ^0_k values are 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 for 30% DMF-water and negative for 30% MeOH-water and 30% Dioxane-water of the drug. S_v is a measure of solute – solvent interaction. It is observed from the table 3 that S_v values are higher in 30% MeOH-water and 30% Dioxane-water and low in 30% DMF-water solution. This confirms that in 30% DMF-water solution solute- solute interactions and in30% MeOH-water and 30% Dioxane-water solute – solvent interaction predominate.

The viscosity B-Co-efficient has been derived from Jones-Dole equation

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

Where $\frac{\eta}{\eta 0} = \eta_r$ is the relative viscosity A and β are the characteristics of the solute and solvent. A is Falkenhagen coefficient represent the contributor from solute-solute interaction and β 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 η_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.

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 in 30% methanol -water, 30% dioxane-water and 30% DMF-water mixture. The increase in viscosity with increase in concentration may be attributed to the increase in solute solvent interactions.

Viscosity β 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 β Coefficient is characterized as structure breakers indicating weak solute-solvent interactions. Such type of results is also shown by Reddyet al.[18-19]

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