INTERNATIONAL JOURNAL OF RESEARCHES IN BIOSCIENCES, AGRICULTURE AND TECHNOLOGY
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www.vmsindia.org

A Study Of Acoustical Behaviour of Terbunafine in Binary Liquid Mixtures At 303K

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ABSTRACT
The measurements of density, viscosity and speed of sound of **Terbunafine** 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 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 303K in different solvents. These parameters are found to be more sensitive towards the nature and the extent of intermolecular interactions in the binary liquid mixtures.

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 thermomic properties of mixtures are useful in the study of molecular orientations and arrangements[7-10].

For the present study Terbunafine drug is selected. This drug is used as fungal infections. The acoustic properties of Terbunafine have been studied in 20% Methanol-water, 20% Dioxane-water and 20% DMF-water solutions at 303 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 303 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 303 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	$u = \lambda \upsilon$	---------- 1
Adiabatic compressibility	$\beta_s = 1/ u^2_s \rho_s$	---------- 2
Apparent molar volume	$\phi_v = 10^3(\rho_0-\rho_s)/m-\rho_0 \rho_s + M/\rho_0$	---------- 3
Apparent molar compressibility	$\phi_k = 10^3(\rho_0\beta_s-\rho_s\beta_0)/m-\rho_s \rho_0 + \beta_s M/\rho_s$	---- 4
Intermolecular free length	$L_f = K (\beta_s)^{1/2}$	---------- 5
Specific acoustic impendence	$Z = \rho.u$	---------- 6
Limiting apparent molar volume	$\phi_v = \phi^0_v + S_v C^{1/2}$	----------7
Limiting apparent molar compressibility	$\phi_k = \phi^0_k + S_k 1/2$	----------8

Table 1: Experimental Data of Density, Ultrasonic Velocity and Viscosity of Terbunafine in different solvent at 303K

Solvents	Conc.mol.dm^{-3}	Density ρ_s Kgm^{-3}	Ultrasonic Velocity (u) m/s	Viscosity x10^{-3} Nsm^{-2}
20% MeOH-Water Medium	0.02	1052.09	1679.5	1.03157
	0.04	1052.16	1683.0	1.03826
	0.06	1052.66	1686.2	1.04259
	0.08	1052.94	1690.1	1.04876
	0.1	1053.15	1694.1	1.05651
20% Dioxane-Water Medium	0.02	1062.09	1689.5	1.17071
	0.04	1062.16	1693.0	1.18503
	0.06	1062.66	1696.2	1.18846
	0.08	1062.94	1697.1	1.18935
	0.1	1063.15	1699.1	1.19470
20% DMF-Water Medium	0.02	994.19	1470.3	0.90231
	0.04	994.91	1477.4	0.90974
	0.06	995.05	1481.1	0.91234
	0.08	995.29	1482.2	0.92321
	0.1	995.68	1483.3	0.92950

Table 2: Variation of some acoustical parameters with concentration of Terbunafine in different solvents at 303 K

Solvents	Conc.mol.dm^{-3}	β_s x10^{-10} Pa^{-1}	Φ_vx10^{-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}
20% MeOH-Water Medium	0.02	4.9288	-85.87	-55.943	4.2139	16.4068
	0.04	4.9312	-27.12	-25.731	4.2012	16.4267
	0.06	4.9423	-6.51	-16.458	4.0182	16.4441
	0.08	4.9198	3.30	-7.0120	4.0103	16.4513
	0.1	4.1800	9.19	-4.0787	4.0094	16.4930
20% Dioxane-Water Medium	0.02	3.8989	-57.3	-76.7934	3.9916	16.2691
	0.04	3.8943	-9.37	-35.6904	4.1023	16.2836
	0.06	3.8836	5.71	-22.6303	4.0962	16.3173
	0.08	3.8755	10.3	-16.5036	4.0631	16.3479
	0.1	3.8342	15.9	-13.5927	4.0661	16.3450
20% DMF-Water Medium	0.02	4.6212	9.85	372.723	4.4700	14.6379
	0.04	46047	21.0	189.584	4.4621	14.6694
	0.06	4.5893	24.2	128.426	4.4546	14.7016
	0.08	4.5700	25.5	97.1877	4.4452	14.7433
	0.1	4.5586	26.7	79.4595	4.4397	14.7651

Table-3 Limiting values of ϕ_v and ϕ_k along with slope (S_v & S_k) for Terbunafine in different medium at 303K temperature

Temp. T (K)	Medium	Parameters			
		ϕ^0_v x 10^{-5} m^{3}mol^{-1}	ϕ^0_k x 10^{-14} m^{3}mol^{-1}pa^{-1}	S_v x 10^{-5} m^{3}mol$^{-3/2}$dm$^{3/2}$	S_k x 10^{-14} m^{3}mol$^{-3/2}$dm$^{3/2}$pa^{-1}
303K	20%M-W	-147.1	-81.33	530.4	266.1
	20%D-W	-95.22	-111.5	341.8	341.2
	20%DMF-W	6.760	601.2	66.31	-1753.0

Table-4 A and β, coefficient values at at 303K in different medium for Terbunafine

Medium	Coefficient	Temp 303 K
20%Methanol-Water medium	A	0.9500
	β	-0.101
20%Dioxane-Water medium	A	1.527
	β	-0.174
20% DMF-Water medium	A	0.453
	β	-0.039

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 Terbunafine 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 3 that ϕ^0_k values are negative for 20% MeOH-water and 20% Dioxane-water but for 20% 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 20% DMF-water and negative for 20% MeOH-water and 20% 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 20% MeOH-water and 20% Dioxane-water and low in 20% DMF-water solution. This confirms that in 20% DMF-water solution solute- solute interactions and in 20% MeOH-water and 20% Dioxane-water solute – solvent interaction predominate.

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

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

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 B 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 20% methanol -water, 20% dioxane-water and 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 Reddy et al.[11-14]

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