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Determination of Density, Ultrasonic Velocity and Other Acoustic Parameters of Aqueous Binary Mixtures of Substituted Hydrazone at 298 K

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Abstract

The study of interaction between solute-solute and solute-solvent interaction of substituted Hydrazone in 70% of (DMF+water) solvents by measuring ultrasonic velocity and density in different concentration of solute in 70% of solvent has done. In the present investigation, different acoustical parameters, such as ultrasonic velocity (U), adiabatic compressibility (βs), partial molal volume (φv), intermolecular free length (Lf), apparent molal compressibility (φκ), specific acoustic impedance (Z), relative association (RA), solvation number (Sn) of substituted Hydrazone in 70% of DMF+water mixture at 298K have been studied. With the help of Experimental data,the effect of concentration of solute on different acoustical parameters in DMF-water mixtures has been studied.
Key words: *Substituted hydrazone, ultrasonic velocity, density.*

Introduction

The sound wave propagates through liquids. The frequency of waves more than 20 KHz are known as ultrasonic waves. In the recent year, an ultrasonic wave has acquired the status of an important tool for the study of structure and properties of matter in basic science. In medical science, the waves are being used for medical diagnosis [1], for the detection of bone fractures, cancer tumors and physiotherapy, bloodless surgery, cardiology[2,3], gynecology etc. Ultrasonic techniques are best suited for physico-chemical studies of a system. The measurements of ultrasonic waves are useful in study of molecular interactions in liquids, which provides valuable information regarding internal structure, complex formation, internal pressure and molecular association. Ultrasonic techniques reveal very weak intermolecular interactions due to its useful wavelength range.

In recent years, ultrasonic velocity and absorption studies in case of electrolyte solutions have led to new insight into the process of ion-association and complex-formation[4,5]. Number of workers such as Sonar[6], Thirumarun[7], Armstrong and Johnson[8], Kanhekar[9], Agrawal and Deosarkar[10] have made ultrasonic study of electrolytic solutions and discussed about the variation of ultrasonic velocity with ion concentration. Most of the ultrasonic work in non-aqueous systems possesses an interpretation of solute-solvent interactions[11]. Solvation numbers have been obtained from the study of non-aqueous solutions by Dudhe[12],Harish Kumar And Deepika[13]. Tadkalkar[14] have studied molecular velocity and molecular compressibility from ultrasonic data. Miss Pankati etal [15] have investigated the adiabatic compressibility and hydration numbers of amino acids in water solvent and water-dioxane mixtures.

Sawalakhe etal[16-17] have studied the adiabatic compressibility and apparent molar volume of diketones, pyrazoles and pyrazolines in water-dioxane, water-tetrahydrofuran and water-acetone mixture. Ikhe[18]have studied the adiabatic compressibility and apparent molal volume of some antibiotic drugs. Wadekar[19] have investigated the adiabatic compressibility, apparent molal compressibility and other parameter of ligand with Fe(III) metal. Kachare[20],Praharaj and Dondge [21-22] have studied apparent molal volume of alcohol in aqueous solutions at different temperatures. An effect of temperature on acoustical parameter and molecular interactions in liquid mixtures, salt solutions has been studied by many workers[23-24]. But compressibilities and apparent molal volumes of substituted hydrazone in 70% DMF at various concentration have not been studied so far.

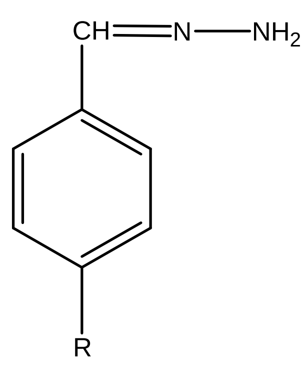
In the present communication the measurement in70%(DMF-Water)of solvent has done.,also the present attempt is made to study adiabatic compressibility (βs), partial molal volume(φv), intermolecular free length (Lf), apparent molal compressibility (φκ), specific acoustic impedance (Z), relative association (RA), solvation number (Sn) of substituted hydrazone in 70% of (DMF+water) mixture at different concentrations of ligand.

The different substituted hydrazone ligand used for present work-

Ligand A= (4-Bromo-benzylidene)-hydrazone

Ligand B= (4-Methoxy-benzylidene)-hydrazone

Ligand C= Benzylidene-hydrazone



Where,R= A= Br,

B= OCH3,

C= H

Experimental

The ligands of which physical parameter is to be explore are synthesized by using reported protocol.All the chemicals used were of AR grade. The density measurements were made with the precalibrated bicapillary pyknometer. All the weighings were made on one pan digital balance (petit balance AD_50B) with an accuracy of $\pm$ 0.001 gm.

The speed of sound waves was obtained by using variable path crystal interferrometer (Mittal Enterprises, Model MX-3) with accuracy of $\pm$ 0.03% and frequency 1MHz. In the present work, a steel cell fitted with a quartz crystal of variable frequency was employed. The instrument was calibrated by measuring ultrasonic velocity of water at 25^{o}C A special thermostatic arrangement was done for density and ultrasonic velocity measurements. Elite thermostatic water bath was used, in which continuous stirring of water was carried out with the help of electric stirrer and temperature variation was maintained within $\pm$ 0.1^{o}C.

Calculation

The sound velocity of one ligand was measured in the concentration range of 1 x 10^{-1} to 6.25 x 10^{-4} M in ,70% (DMF+water) mixture.

wavelength of ultrasonic wave is calculated using relation.

$$2D = \lambda \; \ldots\ldots\ldots\ldots (1)$$

Where λ is wave length and D is distance in mm. The ultrasonic velocity is calculated by using relation.

$$\text{Ultrasonic velocity (U)} = \lambda \text{ x Frequency x } 10^3 \; \ldots\ldots\ldots(2)$$

some acoustical parameters have been calculated using the standard relations.

The adiabatic compressibility of solvent and solution are calculated by using equations (βs)

$$\text{Adiabatic compressibility } (\beta s) = 1/ Us^2 x \text{ ds} \; \ldots\ldots\ldots\ldots\ldots (3)$$

$$\text{Adiabatic compressibility } (\beta_0) = 1/ U_0^2 x \; d_0 \; \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

$$\text{Acoustic impedance (Z)} = \text{Us x ds} \; \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where U_0, Us are ultrasonic velocity in solvent and solution respectttively. d_0 and ds are density of solvent and solution respectively

The apparent molal volume (ϕ_v) and apparent molal adiabatic compressibilities ($\phi_{k(s)}$) of substituted Hydrazone in solutions are determined respectively, from density (d_s) and adiabatic compressibility(β_s) of solution using the equations

$$\phi_v = (M/d_s) + [(d_o - d_s)\, 10^3] / m d_s d_o \;\ldots\ldots\ldots\ldots (6)$$

and

$$\phi_{k(s)} = [1000(\beta_s d_o - \beta_o d_s) / m d_s d_o] + (\beta_s M / d_s) \;\ldots\ldots\ldots\ldots.. (7)$$

where, d_o and d_s are the densities of the pure solvent and solution, respectively. m is the molality and M is the molecular weight of solute. β_o and β_s are the adiabatic compressibilities of pure solvent and solution respectively.

$$\text{Intermolecular free length (Lf)} = K\sqrt{\beta s} \;\ldots\ldots\ldots\ldots (8)$$

$$\text{Relative association (RA)} = (ds / d0) \times (U0 / Us)^{1/3} \;\ldots\ldots\ldots (9)$$

$$\text{Solvation number (Sn)} = \varphi^{\kappa} / \beta 0 x\, (M/ d0) \;\ldots\ldots\ldots.. (10)$$

The value of Jacobson's constant is calculated by using relation

$$K=(93.875+0.375xT)x10^{-8} \;\ldots\ldots\ldots\ldots.. (11)$$

where T is temperature at which experiment is carried out.

Table 1: Ultrasonic velocity, density, adiabatic compressibility (βS),Specific acoustic impedance (Z) Intermolecular free length (Lf) in 70% DMF solvent at 298K.

Conc. (m) Moles lit[1]	**Density (ds) Kg m^{-3}**	**Ultrasonic Velocity(Us) m s^{-1}**	**Adiabatic Compressibility (β_S) x10^{-9} m^2N^{-1}**	**Inter molecular free length (Lf) x10^{-11} m**	**Specific acoustic impedance (Z) x10^5 kg $m^{-2}s^{-1}$**
Ligand A in 70% (DMF +water) solvent					
0.01	1030.08	867	1.2914	7.3896	8.9308
0.005	1025.37	837.6	1.3901	7.6665	8. 5884
0.0025	1017.88	813.6	1.4841	7.9216	8.2814
0.00125	1013	793.06	1.5695	8.1463	8.0336
0.000625	998.288	771.06	1.6848	8.4403	7.6973
Ligand B in 70% (DMF +water) solvent					
0.01	1027.51	878.4	1.2613	7.3028	9.0256
0.005	1026.95	826	1.4272	7.7682	8.4826
0.0025	1021.6	787.2	1.5796	8.1724	8.0420
0.00125	1019.38	743.2	1.7760	8.6656	7.5760
0.000625	1000.77	711.2	1.9755	9.1393	7.1174
Ligand C in 70% (DMF +water) solvent					
0.01	1031.62	879.2	1.2540	7.2816	9.0700
0.005	1031.7	845.2	1.3568	7.5742	8.7199
0.0025	1026.61	829.2	1.4166	7.7395	8.5126
0.00125	1015.87	816.8	1.4754	7.8984	8.2976
0.000625	996.66	789.4	1.6101	8.2509	7.8676

Table-2: Concentration (m), relative association (RA), apparent molal compressibility (φκ), apparent molal volume (φv), solvation number (Sn) at 70% (DMF+ water) solvent at 298K.

Conc (m) Moles/lit	**Apparent molal volume (φv) m^3mole^{-1}**	**Apparent molal compressibility (φk)$x10^{-10}$ m^2N^{-1}**	**Relative association (RA)**	**Solvation number (Sn)**
Ligand A in 70% (DMF +water) solvent				
0.01	1.1968	2.6099	1.0152	0.7003
0.005	2.2323	2.8168	1.0223	0.7558
0.0025	3.939	3.0144	1.0247	0.8089
0.00125	7.1759	3.1937	1.0285	0.857
0.000625	9.9465	3.4365	1.0291	0.9221
Ligand B in 70% (DMF +water) solvent				
0.01	0.7803	1.6972	1.0083	0.6729
0.005	1.5475	1.9389	1.0268	0.7688
0.0025	2.8438	2.1616	1.0398	0.857
0.00125	5.4757	2.4481	1.0576	0.9707
0.000625	7.247	2.7416	1.0577	1.087
Ligand C in 70% (DMF +water) solvent				
0.01	0.7411	1.499	1.0120	0.6637
0.005	1.4838	1.6348	1.0255	0.7238
0.0025	2.7576	1.7144	1.0270	0.759
0.00125	4.6003	1.7933	1.0283	0.794
0.000625	5.7228	1.9738	1.0285	0.8739

Fig 1- Plots of ultrasonic velocity Us in ms^{-1} of different ligand at different concentration in a 70% (DMF-water) solvent

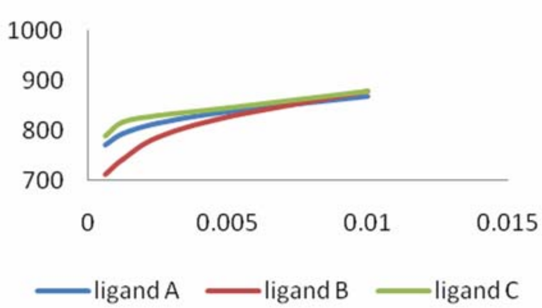


Fig 2- Plots of adiabatic compressibility β_S of different ligand at different concentration in 70%(DMF-water solvent)

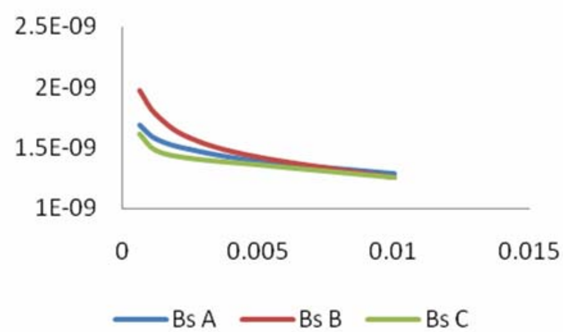


Fig 3-Plots of intermolecular free length Lf of different ligand at different concentration in a 70%(DMF+water) solvent

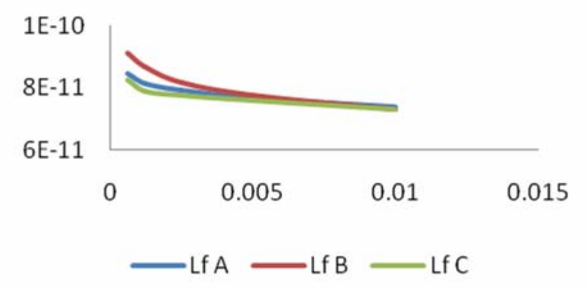


Fig 4- Plots of acoustic impedance (Z) of different ligand at different concentration in a 70% (DMF-water) solvent

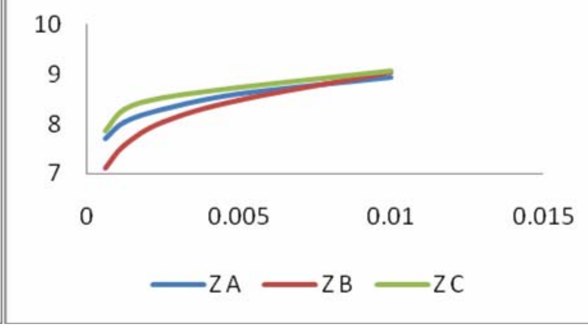


Fig 5-Plots of Apparent molal volume (ϕv) $m^3mole^{-1}$of differentligand at different Concentration in a 70%(DMF +water) solvent

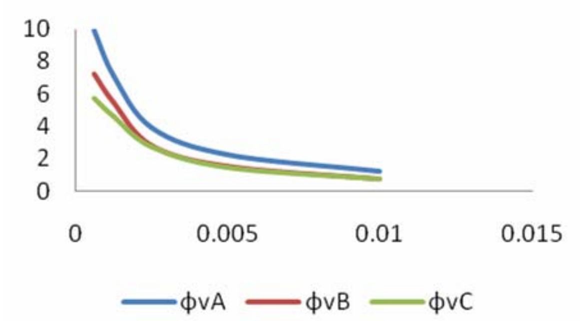


Fig 6- Plots of of Apparent molal compressibility (ϕk)$x10^{-10}$ m^2N^{-1} of different ligand at different concentration in a 70% (DMF+water) solvents

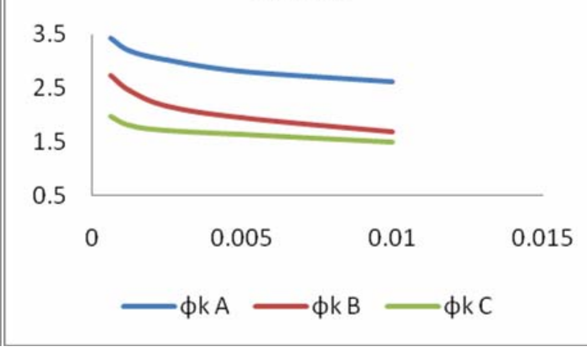


Fig 7- Plots of relative association RA of different ligand at different concentration in a 70%(DMF +water) solvent

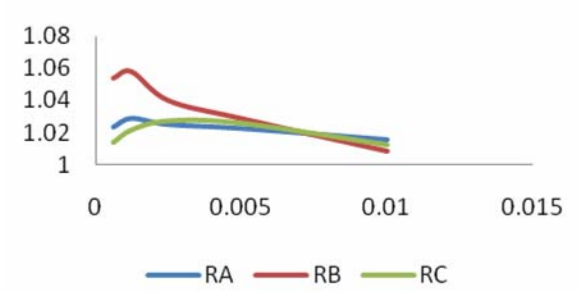
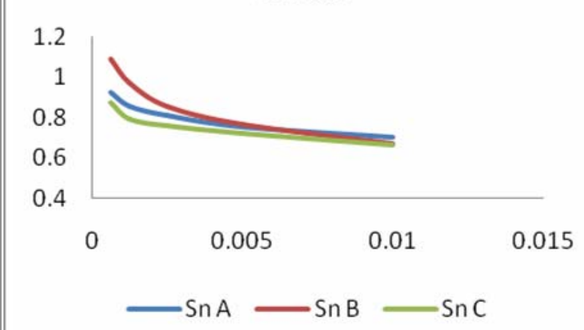


Fig 8-Plots of Solvation number (Sn) of different ligand at different Concentration in a 70%(DMF +water) solvents



Result and Discussion

From Table 1, it is found that ultrasonic velocity decreases with decrease in concentration for all systems(fig 1) .This indicates that, there is significant interaction between ion and solvent molecules suggesting a structure promoting behavior of the added electrolyte. The substituent which decrease the electron density on hydrazone ring have high ultrasonic velocity than ring activating substituent's. The increase of adiabetic compressibility with decrease of concentration of solution may be due to the dispersion of solvent molecules around ions supporting weak ion solvent interactions (fig. 2). Adiabatic compressibility is more in case of bulky and less polar substituents. It was found that, intermolecular free length increases linearly on decreasing the concentration of substituted hydrazone in different solution of DMF+water mixture (fig. 3). The intermolecular free length increase due to greater force of interaction between solute and solvent by forming hydrogen bonding and less interaction between two solute molecules. The value of specific acoustic impedance (Z) decreases with decrease in concentration for all substituted hydrazone in (DMF+water) mixture (fig.4). From Table 2, it is observed that apparent molal volume increases with decrease in concentration in all systems indicates the existence of strong ion-solvent interaction(fig.5). the value of apparent molal volume is high in case of more polar substituent than less polar substituents. The value of apparent molal compressibility increases with decrease in concentration of all systems in (DMF+water) mixture (fig.6), showing weak electrostatic attractive force in the vicinity of ions causing electrostatic salvation of ions. Compressibility is more in case of bulky substituents. The value of relative association increases with decrease in concentration in all systems (fig.7). It is found that there is weak interaction between solute and solvent. Relative association is more in case of bulky and more poalar substituents. The solvation number increase with decrease in concentration due to weak solute-solvent interaction (fig.8). The Solvation number in all system increases with decrease in concentration solute indicates the large solvent molecule are present around the solute molecule which increase the solubility of solute.

Conclusion

In the present study mentions the Experimental data for ultrasonic velocity, density and at 298K for all substituted Hydrazone drugs in (DMF-water) mixture. From the Experimental data it is concluded that there is a weak solute- solvent and solvent- solvent interaction between substituted Hydrazone ,water and DMF molecules.

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