Studies of acoustic and thermodynamic properties of Glycine in double distilled water at different temperatures

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ABSTRACT

Ultrasonic velocity ,density and viscosity have been measured for glycine in double distilled water at 303.15K,308.15K and 313.15K.Thrmodynamic parameters such as adiabatic compressibility(β), acoustic impedances(z),intermolecular free length(L_f), relative association number (R_A), relaxation amplitude(α/f^2) and relaxation time(τ) have been obtained from the experimental data for solutions of glycine with different concentrations and temperatures, with a view to investigate the nature of the molecular interactions. As adiabatic compressibility and intermolecular free length decreases with increase in concentrations and temperature and gradually increases with concentration of solutes. The nature of variation of these parameters with concentration and temperature has been used to understand the type and strength of interaction present in the system investigated.

Key words: Acoustic, thermodynamic parameters, glycine, molecular interaction.
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INTRODUCTION

During the last few decades ultrasonic velocity measurement of liquid systems has gained much importance in accessing the nature of molecular interactions and investigating the physico–chemical behavior of such. Thermodynamic and transport properties of liquid systems have been extensively used to study the departure of the real liquid system from ideality. A departure from the linear behavior of velocity as a function of concentration in liquid systems is an indication of the existence of the interaction between the different species. The study of solution properties of liquid mixtures consisting of polar as well as non polar components find applications in

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industrial and technology processes ,as such studies on liquid mixtures provides a wide range of solutions with appropriate properties.

Ultrasonic velocity measurement provides an important tool to study the liquid state. Ultrasonic and thermodynamic parameters derived from these measurements are extremely used to study the molecular interactions in liquid systems, aqueous solutions and liquid mixtures. In recent years, there has been considerable progress in the determination of thermodynamic, acoustic and transport properties of liquid systems from density and viscosity measurements. The measurement of viscosity, density and ultrasonic velocity and the thermodynamic properties derived from these are excellent tools to detect solute-solute and solute-solvent interaction. Among the various biologically important molecules, amino acids and peptides are the fundamental structural units of protein and depsipeptides .It is recognized that the investigations of the behavior of model compounds of proteins ,like amino acids and peptides in aqueous and mixed aqueous solvent help in understanding the factors governing the thermodynamic stability of the native structure of protein .The investigation of volumetric and thermodynamic properties of amino acids and peptides in aqueous and mixed aqueous solvents have been the area of interest of a number of researchers [1-8].The choice of water for preparing mixed liquid system of biological important molecules stems from its importance and unique role in determining the structure and stability of proteins .Since its presence is known to give rise to hydrophobic forces [9] which are of prime importance in stabilizing the native globular structure of proteins [10] .Even though the ultrasonic velocity data as such do not provide enough information about the native and the relative strength of various types of intermolecular /interionic interactions between the components ,their derived parameters such as acoustical impedance (z), adiabatic compressibility (β), intermolecular free length (Lf), relative association (RA), relaxation amplitude(α/f^2) and relaxation time(τ) and the excess parameters provide information on the type and strength of interactions presently. In view of above we have carried out a systematic experimental investigations of the ultrasonic velocity, density and viscosity measurements of aqueous solutions of amino acids of different concentrations at different temperature. Here we report the result of our study on aqueous glycine system.

Table-1: Ultrasonic velocities (u)**, densities** (ρ)**, viscosities** (η) **and derived parameters for glycine in double distilled water at 303.15K**

m mol kg^{-1}	u ms^{-1}	ρ kgm^{-3}	η Nm^{-2}s	β $\times 10^{-10}$ m^{2}N^{-1}	$z \times 10^6$ Nm^{-2}	L_f A^0	R_A	α/f^2 $\times 10^{-14}$ s^{2}m$^-$	$\tau \times 10^{-13}$ sec
0.0000	1508.50	1010.0	8.1050	4.3501	1.5236	0.4318	0.8528	6.1464	4.7011
0.0089	1634.56	1020.0	8.9706	3.6694	1.6672	0.3965	0.8673	5.2948	4.3881
0.0176	1638.64	1034.0	9.9393	3.6017	1.6943	0.3929	0.8562	5.7431	4.7731
0.0262	1638.88	1062.0	10.8604	3.5057	1.7404	0.3876	0.8337	6.1081	5.0765
0.0347	1639.04	1070.0	11.9276	3.4789	1.7538	0.3860	0.8275	6.6562	5.5326
0.0430	1639.28	1078.0	13.8779	3.4520	1.7671	0.3846	0.8214	7.6838	6.3876

Where m, mole fraction; ρ,density of the solution ; η,viscosity of solution; u, ultrasonic velocity;β, adiabatic compressibility; Lf, intermolecular free length; RA, relative association ; α/f², relaxation amplitude; τ, relaxation time;

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EXPERIMENTAL SECTION

Glycine (99.8%), of AR grade, obtained from Fine Chem. Industries, Mumbai was kept in a desecrator containing CaCl2 for 24 hrs after desiccation it is mixed in double distilled water with different concentration. The prepared solution was used within 12 hrs.

Table-2: Ultrasonic velocities (u), densities (ρ), viscosities (η) and derived parameters for glycine in double distilled water at 308.15K

m mol kg^{-1}	u ms^{-1}	ρ kgm^{-3}	η Nm^{-2}s	β ×10^{-10} m^{2}N^{-1}	z×10^6 Nm^{-2}	L$_f$ A^0	R$_A$	α/f^2 ×10^{-14} s^{2}m^{-1}	τ×10^{-13} sec
0.0000	1522.70	1008.0	7.1980	4.2787	1.5349	0.4323	0.8571	5.3178	4.1064
0.0089	1652.80	1024.0	9.5565	3.5749	1.6924	0.3951	0.8671	5.4345	4.5550
0.0176	1668.80	1048.0	10.0131	3.4263	1.7481	0.3868	0.8491	5.4053	4.5744
0.0262	1643.44	1052.0	10.8604	3.5194	1.7289	0.3920	0.8424	6.1150	5.0963
0.0347	1638.48	1078.0	11.4969	3.4554	1.7662	0.3885	0.8212	6.3748	5.2968
0.0430	1638.88	1086.0	12.6682	3.4282	1.7799	0.3869	0.8153	6.9674	5.7906

Where m, mole fraction; ρ,density of the solution ; η,viscosity of solution; u, ultrasonic velocity;β, adiabatic compressibility; Lf, intermolecular free length; RA, relative association ; α/f^2,relaxation amplitude; τ, relaxation time;

Table-3: Ultrasonic velocities (u), densities (ρ), viscosities (η) and derived parameters for glycine in double distilled water at 2MHz at 313.15K

m mol kg^{-1}	u ms^{-1}	ρ kgm^{-3}	η Nm^{-2}s	β ×10^{-10} m^{2}N^{-1}	z ×10^6 Nm^{-2}	L$_f$ A^0	R$_A$	α/f^2 ×10^{-14} s^{2}m^{-1}	τ×10^{-13} sec
0.0000	1528.00	1001.0	7.5220	4.2788	1.5299	0.4364	0.8641	5.5380	4.2913
0.0089	1635.60	1028.0	9.7195	3.6362	1.6813	0.3988	0.8607	5.6813	4.7123
0.0176	1636.16	1052.0	10.6447	3.5509	1.7212	0.3983	0.8412	6.0739	5.0397
0.0262	1638.08	1056.0	11.5580	3.5291	1.7298	0.3926	0.8383	6.5461	5.4386
0.0347	1639.08	1084.0	12.2598	3.4338	1.7768	0.3872	0.8168	6.7528	5.6121
0.0430	1639.76	1098.0	13.4864	3.3871	1.8004	0.3847	0.8065	7.3246	6.0908

Where m, mole fraction; ρ,density of the solution ; η,viscosity of solution; u, ultrasonic velocity;β, adiabatic compressibility; Lf, intermolecular free length; RA, relative association ; α/f^2,relaxation amplitude; τ, relaxation time;

The ultrasonic velocities in pure solvent as well as in mixed solutions were measured using multi frequency ultrasonic interferometer (Model-F-81, supplied by M/s Mittal Enterprises, New Delhi) at a constant frequency 2 MHz .The temperature of the solutions placed in the interferometer cell was changed through 5^{0}C (from 303.15K to 313.15K) --by circulating water around the cell from a thermostat. The viscosity of the solutions at different temperatures and concentrations were measured with Oswald's viscometer apparatus. The density measurements were made by a 25 ml specific gravity bottle, the accuracy in density measurements was found to be ± 0.001g/cc. All the weighing were made on digital balance with an accuracy of ±1x10^{-5}kg.

RESULTS AND DISCUSSION

From the measured vaules of density (ρ), ultrasonic velocity (u) and viscosity (η) the adiabatic compressibility (β), intermolecular free length (Lf), relative association (RA), relaxation amplitude (α/f^2) and relaxation time (τ) calculated by using following standard relation [11-12]

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$$\beta = 1/u^2\rho \qquad\qquad\qquad\qquad ……................... (1)$$

$$z = \rho.u \qquad\qquad\qquad\qquad ……... ....(2)$$

$$Lf = K/\beta^{1/2} \qquad\qquad\qquad\qquad ………............. (3)$$

$$RA = (\rho_0/\rho) \times (u_0/u)^{1/2} \qquad\qquad ....…….(4)$$

$$\alpha/f^2 = 8\Pi^2\eta/3\rho c^3 \qquad\qquad\qquad ....…….. (5)$$

$$\tau = 4\eta/3\rho c^3 \qquad\qquad\qquad\qquad …………….(6)$$

Where K is Jacobson [13] constant which is temperature dependent but independent of the nature of liquid. Jacobson tabulated the values of K empirically between 0 to 50 ^{0}C, ρ, ρ_0 and u,u_0 are the densities of solution and solvent and velocities of solution and solvent. The experimental values of density (ρ), ultrasonic velocity (u) and viscosity (η) along with the calculated values of adiabatic compressibility (β), intermolecular free length (Lf), relative association (RA), relaxation amplitude (α/f^2) and relaxation time (τ) of glycine as the function of mole fraction at 303.15 K ,308.15 K and 313.15K are presented in Table 1-3.

From the Tables 1-3 we observe the trends of all acoustical parameters with variation in concentration and temperature. The ultrasonic velocity increases with molar concentration of solute as well as rise in temperature. This increase in ultrasonic velocity in the aqueous solution of glycine may be attributed to the cohesion brought by the ionic hydration .The increase in density with molar concentration suggest a solute-solvent interaction exist between the glycine and water .In other words the increase in density may be interpreted to the structure maker of the solvent due to H-bonding[14-15].The viscosity is an important parameter in understanding the structure as well as molecular interaction occurring in the solutions. From above tables, values of viscosities increase with concentration but decreases with temperature. These variations attributed to structural changes [16].The values of adiabatic compressibility (β) show decreasing trend with concentration as well as temperature which suggest the making and breaking of H-bonding. The intermolecular free length depends upon the intermolecular attractive and repulsive forces. Eyring and Kincaid [17] have proposed that Lf is a predominating factor in determining the variation of ultrasonic velocity of solution. The values of intermolecular free length listed in the tables show decreasing trend with concentration and temperature Hence it can be concluded that there is significant interaction between solute and solvent molecules due to which the structural arrangement is also affected. Thus it is clear from the above parameters that there is a strong association between water and amino acid molecules showing hydrophilic nature.

CONCLUSION

A strong intermolecular H-bonding interaction exists between glycine and water. From the acoustical parameters it is concluded that H-bonding interaction is very strong at higher temperature and concentration.

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Acknowledgement

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