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Research article

THERMODYNAMIC STUDY OF GLYCINE MOLECULE IN AQUEOUS SOLUTION OF NaI USING ULTRASONIC TECHNIQUE

Vandana Giratkar[1], Ratnakar Lanjewar[2] and Sunita Gadegone[3]

[1]Department of Chemistry, Sardar Patel College, Chandrapur (M.S.), India
[2]Department of Chemistry, M.P. Deo Memorial Science College, Nagpur (M.S.), India
[3]Department of Chemistry, Kamla Nehru College, Nagpur (M.S.), India

ABSTRACT: The ultrasonic velocity (u), density (ρ) and viscosity (η) of glycine solutions (0.02-0.12 mol.dm-3) in 2% of NaI solutions were measured at 288.15, 293.15, 298.15 and 303.15K respectively. The acoustic parameters such as adiabatic compressibility (β), free length (Lf), acoustic impedance (Z) and free volume (Vf) were calculated. These acoustic parameters with concentration and temperature were used to study the existence of intermolecular interaction in the present systems.

Key words: Ultrasonic velocity, compressibility, acoustic impedance, glycine.

*Corresponding author: Vandana Giratkar, Department of Chemistry, Sardar Patel College, Chandrapur (M.S.), India E-mail giratkar.vandana@gmail.com

INTRODUCTION

Ultrasonic is versatile and non destructive technique and provides an extensive application in characterizing thermodynamic and physiochemical behaviour of liquid mixtures (J. Thennarasu et al., 2011). The term "Ultrasonic" applied to sound refers to anything above the frequencies of audible sound, and nominally includes anything over 20,000 Hz. The study of intermolecular interactions plays an important role in the development of molecular sciences. The ultrasonic velocity in a liquid is fundamentally related to the binding forces between the atoms or molecules and has been successfully employed in understanding the nature of molecular interactions in pure liquids and binary and ternary mixtures (M. Sreenivasulu and P. R. Naidu, 1979). In recent years ultrasonic technique has become a powerful tool in providing information regarding the molecular behaviour of liquids and solids owing to its ability of characterizing physiochemical behaviour of the binary and ternary mixtures (R. N. Goldberg et al., 1991). The nature and extent of the patterns of molecular association and dissociation that exist in solutions have been investigated by ultrasonic techniques. The nature of relative strength of molecular interactions between components of liquid solutions has been successfully investigated by ultrasonic methods. Further, the measurement of excess thermodynamic properties is found to be very significant in studying the structural arrangements associated with the liquid solutions (T .S. Banipal et al., 2002).

Ultrasonic velocity studies have contributed significantly to chemical physics, industrial technology, biomedical sciences and food industries (A. Ali et al., 2000). The variation of ultrasonic velocity and related parameters throw much light upon the structural changes associated with the liquid mixtures having strongly interacting components as well as weakly interacting components (J. D. Pandey et al., 1999).

Therefore, the present work mainly deals with velocity studies of different concentrations of glycine in 2% sodium iodide. These solutions/mixtures are of significant importance in physiological processes of life. Many physiological processes depend on the concentrations of electrolytes and their interactions with aqueous medium in protoplasm of the cell (A. Ali et al., 1997). Nerve impulse also depends upon the concentration of aqueous solution of electrolytes. Hence, these electrolytes are chosen for the present investigation.

MATERIALS AND METHOD

All the chemicals used in this present work are analytical reagent (AR) grades; doubly distilled water has been used for preparing the solution of different concentrations of aqueous electrolytic solutions. 2% solution of NaI prepared as stock solution. It is used as a solvent for preparing the glycine solution of concentration range (0.02-0.12M). For weighing, an electronic digital balance having an accuracy of ±0.1mg was used. Densities were determined using specific gravity bottle by relative measurement method with accuracy of ±0.1 $kg.m^{-3.}$ An Ostwald's viscometer was used for viscosity measurement. An ultrasonic interferometer having the frequency 2MHz (VI Microsystems Pvt. Ltd. Perungudi, Chennai) with an accuracy of ±0.1% was used for velocity measurement. Constant digital temperature water bath was used to maintain the constant temperature with an accuracy of ±0.1K.

Using the measured data some acoustical parameters have been calculated using standard relations as,

Adiabatic compressibility can be calculated from speed of sound (U) and density (ρ) of the measurement:

$$\beta=1/U^2\rho$$

Intermolecular free length can be determined as: $L_f = K\ \beta^{1/2}$

Where, K values for different temperatures were taken from the work of Jacobson (B. Jacobson, 1952).

The acoustic impedance is the product of the velocity of ultrasound in a medium and its density can be calculated by the relation (I. Prigogine, 1957). $Z = U\ \rho$

The free volume (V_f) in terms of ultrasonic velocity (U) and the viscosity of liquid

V_f = $[M_{eff}. U / K\eta]$ M_{eff}.-effective molar mass, $K=4.28\times10^9$, η-viscosity of solution.

RESULT AND DISCUSSIONS

Density: From table 1, it is observed that density of glycine solutions in 2% aqueous solution of NaI is found to increase with increase in concentration of glycine and decrease with increase in temperature. Increase in density with concentration may be due to closed packing of the solute-solvent interactions among the constituent particles of the mixture (S. A. Mirikar et al., 2013). Due to polar nature of solute (glycine) interacts either with polar end of water molecules or with positive (Na^+) / negative (I^-) ions of electrolytes (NaI). The strength of interactions may be due to dipole-dipole or ion-dipole.

Ultrasonic Velocity: From table 1, it is observed that speed of sound of glycine solutions in 2% aqueous solution of NaI is found to increase with increase in concentration of glycine and increase with increase in temperature. The increase in ultrasonic velocity in any solution suggests the greater association among the components of the mixture (V.K. Pagare et al., 2007). The greater association is due to dipole-dipole, ion-dipole and hydrogen bonding between glycine and solvent (2% aqueous NaI) molecules. As temperature increases, the hydrogen bonds among water molecules disassociate and more water molecules are produced. These freed water molecules may enter into the free space present in the cage like water structures and thus get 'trapped'. As a result, the number of close-packed water structures increases with increase in temperature. This increase in close-packed water structures forms the stiff material medium for the propagation of ultrasonic waves. Thus, the ultrasonic velocity of glycine solution increases with the increase in temperature for the solvent (2% aqueous NaI) systems.

Viscosity: From table 1, it is observed that viscosity of glycine solution in 2% aqueous solution of NaI are found to increase with increase in concentration of glycine and decrease with increase in temperature. Increase in viscosity of solution indicates the greater association among the molecules of solution (R.Ezhil Pavai and S.Renuka, 2011). The strong association in glycine solution may be due to the intermolecular hydrogen bonding, dipole-dipole and ion-dipole interactions between solute and solvent molecules. As the temperature of glycine solution increases, the cohesion and frictional forces have been diminished due to thermal motion of molecules and relative velocity increases and hence viscosity is found to decrease with increase in temperature.

Table -1: The values of ultrasonic velocity, density ,viscosity, adiabatic compressibility, free length and free volume of glycine solutions of concentration 0.02 to 0.12M in 2% aqueous NaI solution at temperature 288.15, 293.15 298.15 and 303.15K are reported in table 1.

Con. (mol. dm^{-3})	P (Kg/m^3)	η x10^{-4} ($Nm^{-2}s$)	U (m/s)	β x10^{-10} (m^2N^{-1})	Lf x10^{-11} (m)	Z x10^6 ($Kgs^{-1}m^{-2}$)	Vf x10^{-8} (m^3)
Temp 303.15 K							
2%	1003.03	8.12492	1499.973	4.43118	4.1766	1.50452	2.23497
0.02	1000.99	8.20497	1501.347	4.43207	4.17702	1.50284	2.20903
0.04	1001.45	8.20892	1502.036	4.42594	4.17414	1.50423	2.21261
0.06	1001.90	8.20996	1502.725	4.41993	4.1713	1.50558	2.21737
0.08	1002.60	8.32071	1504.105	4.40874	4.16602	1.50802	2.17983
0.1	1002.79	8.32299	1504.795	4.40386	4.16371	1.509	2.18403
0.12	1002.95	8.32481	1505.487	4.39911	4.16146	1.50993	2.18841
Temp 298.15 K							
2%	1004.81	8.96378	1491.097	4.47615	4.16114	1.49827	1.91161
0.02	1002.87	9.14141	1491.097	4.48478	4.16515	1.49539	1.85924
0.04	1003.17	9.14559	1491.777	4.47935	4.16263	1.49651	1.86231
0.06	1003.47	9.14751	1492.456	4.47394	4.16012	1.49764	1.86607
0.08	1004.02	9.16315	1493.136	4.4674	4.15707	1.49915	1.86564
0.1	1004.67	9.16704	1494.499	4.45637	4.15194	1.50149	1.87008
0.12	1004.99	9.26688	1495.191	4.45087	4.14937	1.50265	1.84425
Temp 293.15 K							
2%	1005.25	9.98793	1480.987	4.53548	4.15072	1.48876	1.60876
0.02	1003.76	10.3	1480.317	4.54631	4.15567	1.48589	1.54318
0.04	1004.00	10.3	1480.317	4.54521	4.15517	1.48625	1.54476
0.06	1004.37	10.3	1481.656	4.53532	4.15065	1.48814	1.54907
0.08	1005.08	10.4	1481.656	4.53215	4.1492	1.48918	1.52446
0.1	1005.41	10.4	1483.669	4.51835	4.14288	1.4917	1.52905
0.12	1006.43	10.5	1484.342	4.50967	4.1389	1.4939	1.51034
Temp 288.15 K							
2%	1006.45	11.6	1470.352	4.59584	4.14245	1.47984	1.27682
0.02	1005.01	12.1	1465.091	4.63551	4.16029	1.47244	1.18966
0.04	1005.54	12.1	1465.091	4.63306	4.15919	1.47322	1.19072
0.06	1005.94	12.1	1465.747	4.6271	4.15651	1.47446	1.19287
0.08	1006.32	12.1	1467.059	4.61708	4.15201	1.47633	1.19349
0.1	1006.97	12.1	1469.033	4.60169	4.14508	1.47928	1.1968
0.12	1008.11	12.2	1470.352	4.58825	4.13903	1.48228	1.18346

Compressibility and free length: From table 1, it is observed that adiabatic compressibility and free length of glycine solution in 2% aqueous solution of NaI are found to decrease with increase in concentration of glycine and decrease with increase in temperature. Decrease in adiabatic compressibility and free length may due to the influence of the electrostatic field of solute molecules on the surrounding solvent molecules. Decrease in compressibility and free length indicates that there is enhanced molecular association in this system upon increment of solute (S. R. Kanhekar et al., 2013). It is found that the compressibility decreases with increase in temperature but free length increase in temperature. This may be due to anomalous behaviour of water. As explained earlier about the speed of sound. Compressibility is inversely correlated with ultrasonic velocity and density of the mixture. Variation in density with temperature is not much appreciable. Compressibility values mainly depend on the speed of sound. Thus, compressibility decreased with raised in temperature**.**

Acoustic impedance: From table1, it is observed that acoustic impedance of glycine solutions in 2% aqueous solution of NaI are found to increase with increase in concentration of glycine and increase with increase in temperature. The increase in acoustic impedance in any solution suggests the greater association among the components of the mixture (M. Praharaj et al., 2013). The greater association is due to dipole-dipole, ion-dipole and hydrogen bonding between glycine and solvent molecules. This suggests that the strong intermolecular hydrogen bonding between solute and solvent molecule.

As the temperature increases, the acoustic impedance of glycine solution increases. But actually it should be decreased because the density of the medium decreases as temperature increases. But, the ultrasonic velocity increase as temperature increases. Here, density factor will not contribute to the acoustic impedance. Ultrasonic velocity is predominant over density and hence, acoustic impedance increase as temperature increases of glycine solution.

Free Volume: From table1, it is observed that free volume of glycine solution in 2% aqueous solution of NaI are found to slightly decrease with increase in concentration of glycine and increases with increase in temperature. Decrease in free volume may be due to strengthing of cohesive forces which result into making up structure of water. The decrease of free volume with increase in concentration of glycine may be due to strong association between solute and solvent molecules through intermolecular hydrogen bonding or ion-dipole interactions. Free volume of glycine solution increases with increase in temperature also confirms the solute–solvent interaction.

CONCLUSION

It is concluded that strength of intermolecular interaction increases with increase in concentration of glycine which indicates solute-solvent interactions.

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