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Acoustic and Thermal Study of Biomolecule In Aqueous Potassium Chloride

V. A. Giratkar
Department of Chemistry, Sardar Patel College, Chandrapur, 442403, Maharashtra, India

ABSTRACT

The ultrasonic velocity (u), density (ρ) and viscosity (η) of Glycine in 2% of aqueous solutions of potassium chloride have been measured. Thermoacoustic parameters like adiabatic compressibility, intermolecular free length, acoustic impedance, internal pressure were calculated. It was found that there is certain degree of variation in these parameters with change in concentration and temperature. The variations of acoustic parameters with concentration and temperature indicate the existence of intermolecular interaction in the present systems.

Keywords: Glycine, Ultrasonic Velocity, Thermodynamic Parameters, Molecular Interactions

I. INTRODUCTION

Structure and properties of proteins are greatly affected by the interaction of aqueous salt.[1] Proteins are macromolecules and needed for the most important biological processes like cell growth and their maintenance, movement and defense. Proteins are complex molecules and their behavior in solutions is governed by a combination of many specific interactions.[2] These interactions involve hydrogen bonding, electrostatic interactions, hydrophobic interaction which are non-covalent in nature. These interactions are helpful to study conformational stability and unfolding behavior of globular proteins. As proteins are complex molecules, their direct study is difficult and tedious. Hence the study of interactions of model compounds like amino acids and peptides in aqueous systems makes the work easy.[3] The standard α-amino acids have special importance among the other chemical groups they play a vital role in nearly all chemical and biological process. There has been an increased interest in physicochemical properties of amino acids in aqueous and aqueous electrolytes media.[4]

II. METHODS AND MATERIAL

The compound Glycine of purity 99% was obtained from HIMEDIA India Ltd and was used as supplied. Initially 2% aqueous KCl stock solution was prepared by using double distilled water. The digital balance having an accuracy of ±0.1mg was used for the measurement of weights. The solutions of Glycine of concentration 0.02M to 0.12M were prepared at different temperature range. Densities of these solutions were measured by specific gravity bottle by relative measurement method with accuracy of ±0.1 kgm^{-3}. Viscosity of solvent and solution under the study was measured using Ostwald's viscometer keeping temperature constant by using digital constant temperature water bath having an accuracy of ±0.1K. The ultrasonic velocity of solvent and solution of different concentration at different temperature range (288 K to 303 K) was measured by using digital ultrasonic interferometer at frequency 2MHz (VI Microsystems Pvt. Ltd. Perungudi, Chennai) with an accuracy of ±0.1%.

THERMOACOUSTIC PARAMETERS

From density, viscosity and ultrasonic velocity various thermodynamic parameters were evaluated by using the following mathematical equations.

Adiabatic compressibility (β)

$\beta = 1/(\rho U^2)$ ---------- (1)

Where ρ and U are the density and ultrasonic velocity of solution

Intermolecular free length (Lf)

$Lf = K\beta^{(1/2)}$ ---------- (2)

Where, K is Jacobson's constant.

This constant is a temperature dependent parameter whose value at any temperature (T) is given by (93.875+0.345T) x 〖10〗 ^(-8).

Acoustic impedance (Z)

$Z = U\rho$ ---------- (3)

Internal pressure (π_i)

$\pi_i = bRT (K\eta/U)^{1/2} (\rho^{2/3}/M_{eff})^{7/6}$ -------- (4)

Where,

b - stands for cubical packing, which is assumed to 2 for all the liquids

K- is a dimensionless constant independent of temperature

T- is the absolute temperature in Kelvin Meff - is the effective molecular weight

R- is gas constant

III. RESULTS AND DISCUSSION

The variation of experimentally measured and derived thermoacoustic parameters of glycine solution in aqueous salt of different concentrations at different temperature are as given in fig. a-g.

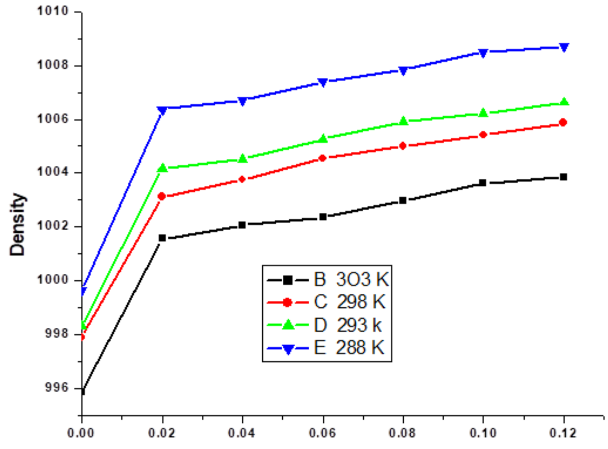

Fig1(a) Concentration in mole / dm^3 of Glycine in 2% KCl

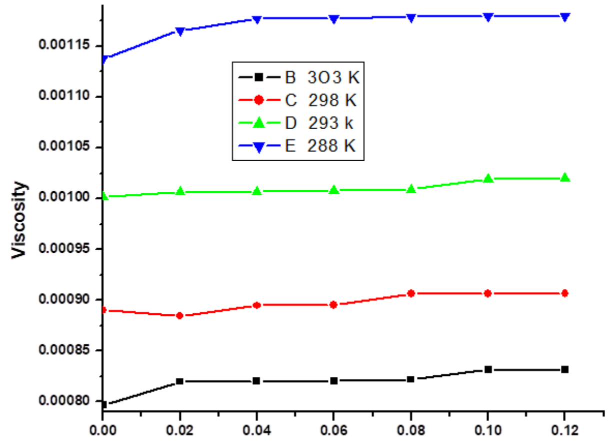

Fig1(b) Concentration in mole / dm^3 of Glycine in 2% KCl

Fig. 1(a) shows that density of glycine solution in 2 % aqueous KCl increases with increase in concentration and decreases with the increase in temperature. This result is obvious as the volume of the solution increases with the rise in temperature [5] and mass of the solution increase with the increase in concentration.

Viscosity is the parameter of the liquid, which is greatly affected by the concentration and the temperature. It is observed from fig. 1(b), that viscosity of glycine solution in 2 % aqueous electrolytes increases with increase in concentration. Increase in viscosity of solution with concentration suggests the strong interaction of solute and solvent molecule. the decrease in viscosity with rise in temperature indicates that the molecules in the solution acquires more and more thermal energy. The motion of molecules increases at the expense of cohesive forces acting between the molecules. Since the solution faces lesser resistance to flow, the viscosity of the solution will decrease.[6]

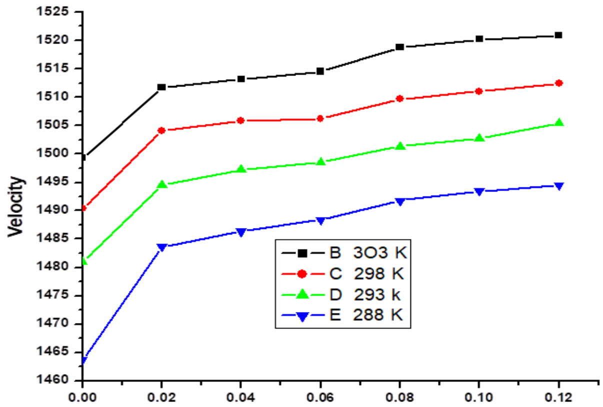

Fig1(c) Concentration in mole / dm^3 of Glycine in 2% KCl

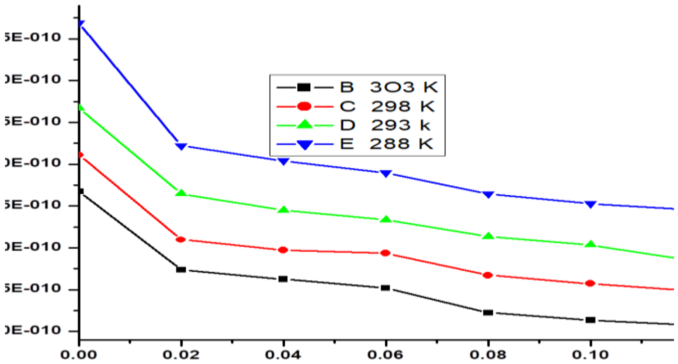

Fig1(d) Concentration in mole / dm^3 of Glycine in 2% KCl

The increase in ultrasonic velocity with concentration (fig. 1c) in any solution indicates the presence of solute-solvent interactions.[7] The increase in ultrasonic velocity with rise in concentration for the present system confirms the greater molecular association. As temperature increases, breaking of hydrogen bonding increases. This results in more and more number of monomeric water molecules. These molecules then enter in the cage-like water structure and get trapped to form closed packed structure. This closed-packed structure forms stiff material medium for the propagation of ultrasonic wave. Hence ultrasonic velocity increases with the rise in temperature.

Adiabatic compressibility is inversely correlated with ultrasonic velocity which increases with increase in temperature. Hence adiabatic compressibility values decreases with increase in temperature.The dependence of adiabatic compressibility of glycine solutions in 2% aqueous solution of potassium chloride on concentration at different temperature is as shown in the fig. 1(d). The decrease in adiabatic compressibility values with concentration indicate that the hydrogen bonding between the unlike components in the solution decreases. [8]

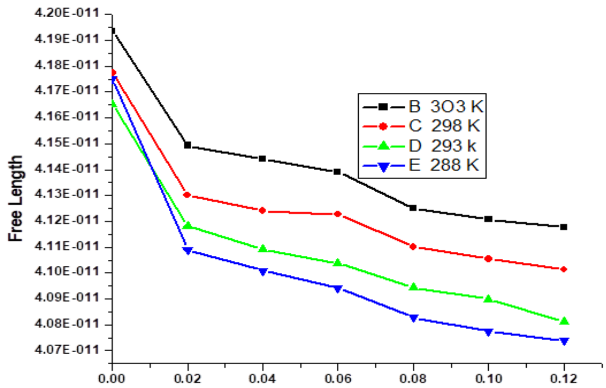

Fig1(e) Concentration in mole / dm^3 of Glycine in 2% KCl

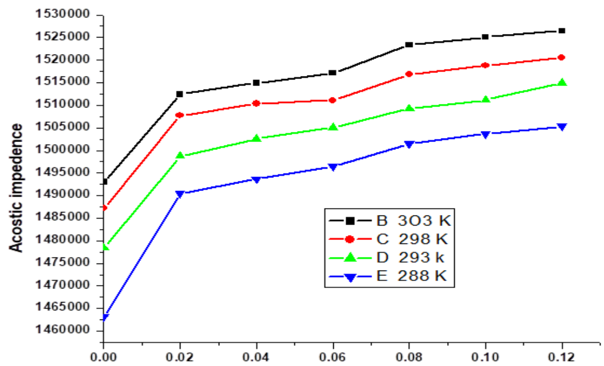

Fig1(f) Concentration in mole / dm^3 of Glycine in 2% KCl

The decrease in free length (fig. 1e) with rise in concentration of glycine solution in 2% aqueous electrolytic solution suggest that there is a significant interaction between solute and solvent molecules. It also suggests the structure promoting behavior [9,10] as well as the presence of dipole-dipole and acceptordonor interaction between solute and solvent molecules. The higher values of free length for higher temperature are due to more spacing among the components of the medium.

The increase in acoustic impedance with the increase in concentration as well as temperature Fig.1 (f) suggests the greater association of solute and solvent through hydrogen bonding. Thus increase in acoustic impedance indicates associative nature of solute and solvent and enhancement in molecular interaction.

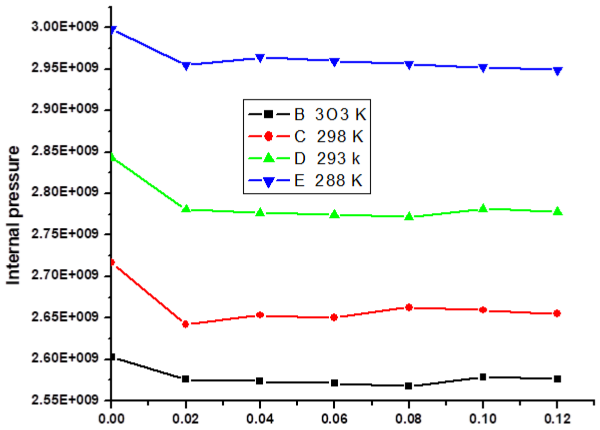

Fig1(g) Concentration in mole / dm^3 of Glycine in 2% KCl

The internal pressure is the cohesive force or binding force, which is a resultant force of attraction and repulsion between the molecules. From fig. 1(g) it is observed that decrease in internal pressure with increase in temperature is due to the thermal agitation of molecules which reduces the interaction between the molecules in the system.

IV. CONCLUSION

From experimentally determined parameters of glycine solution in 2% aqueous salt of different concentration at different temperature various acoustical parameters were evaluated. The temperature and concentration effects on these parameters were studied. These parameters were interpreted in connection with the molecular interactions. The addition of solute in solvent has structure making tendency through intermolecular hydrogen bonding.

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