I J R B A T, Vol. V, Issue (3), Sept-2017: 37-40 ISSN 2347 – 517X

INTERNATIONAL JOURNAL OF RESEARCHES IN BIOSCIENCES, AGRICULTURE AND TECHNOLOGY

www.vmsindia.org

THERMO-ACOUSTIC INVESTIGATIONS ON L-VALINE IN AQUEOUS SODIUM BROMIDE AT DIFFERENT TEMPERATURES

V. A. Giratkar[1]*, R. B. Lanjewar[2] and S. M. Gadegone[3]

[1]Department of Chemistry, Sardar Patel College, Chandrapur, 442403, Maharashtra, India
[2]Department of Chemistry, M.P. Deo Memorial Science College, Nagpur, Maharashtra, India
[3]Department of Chemistry, Kamla Nehru College, Nagpur, Maharashtra, India
giratkar.vandana@gmail.com

Abstract
The ultrasonic velocity (u), density (ρ) and viscosity (η) of an amino acid L-Valine of various concentrations in 2% of NaBr solutions have been measured. From these experimentally measured parameters thermodynamic parameters such as adiabatic compressibility (β_a), intermolecular free length (L_f), acoustic impedance (Z) and internal pressure (π_i) 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: L-Valine, Ultrasonic velocity, thermodynamic parameters, molecular interactions

INTRODUCTION

Salts have large effects on the structure and properties of proteins [1]. Proteins are the most abundant biomolecules of the living system of all the organic compounds. They are 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, 3]. These interactions are mainly those between the protein molecules and the solvent ions. Most of these interactions such as hydrogen bonding, electrostatic interactions, hydrophobic interaction etc., are non-covalent. The study of these interactions provides an important insight into the conformational stability and unfolding behavior of globular proteins. Due to complex molecular structure of proteins, their direct study is difficult and tedious. One approach that reduces the degree of complexity and requires less complex measurements techniques is to study the interactions in systems containing model compounds such as amino acids and peptides [4-6]. The standard α-amino acids have special importance among the other chemical groups since they are found in all naturally occurring proteins, which 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 [7-12]

L-Valine is an essential non-polar amino acid. It helps to remove extra nitrogen from liver and also stimulate muscle growth and the central nervous system. Deficiency of L-Valine causes degenerative nerve diseases. Many researchers have reported the physico-chemical properties of amino acids [13-18] but very scanty work on solution of amino acid in aqueous and aqueous electrolyte solutions.

MATERIALS AND METHODS

The compound L-Valine CAS No. 72-18-4, molecular weight 117.146 was obtained from HIMEDIA India Ltd. The purity of compound is 99%. It was used as supplied. Initially 2% aqueous NaBr 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 fresh L-Valine solutions under the study of different concentration in the given solvent were prepared. The densities of aqueous solvent and solution of different concentration (0.02M to 0.12M) at different temperature range T= (288.15 to 303.15) K were measured by specific gravity bottle by relative measurement method with accuracy of ±0.1 kg.m^{-3}. During the measurement of densities temperature was kept constant by using digital constant temperature water bath having an accuracy of ±0.1K. Owing to the importance of Ostwald's viscometer for the measurement of viscosity, the viscosity of solvent and solution under the study was measured. The ultrasonic velocity of solvent and solution of different concentration at different temperature range (288.15 K to 303.15 K) was measured by using digital ultrasonic interferometer at frequency 2MHz (VI Microsystems Pvt. Ltd. Perungudi, Chennai) with an accuracy of ±0.1%. The temperature of solution was kept constant during each measurement.

PHYSICAL PARAMETERS

Using experimentally measured basic parameters such as density, viscosity and ultrasonic velocity various thermodynamic parameters are evaluated by using the following mathematical equations.

Adiabatic compressibility (β)

$\beta = \frac{1}{\rho U^2}$ ---------- (1)

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

Intermolecular free length (L_f)

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

Where, K is Jacobson's constant.

This constant is a temperature dependent parameter whose value at any temperature (T) is given by $(93.875+0.345T)\ x10^{-8}$.

Acoustic impedance (Z)

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

Internal pressure (π_i)

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

M_{eff} - is the effective molecular weight

R- is gas constant

RESULT AND DISCUSSION

The variation of experimentally measured and derived thermoacoustic parameters of solution of L-Valine in 2% aqueous solution of sodium salt of different concentration (0.02 to 0.12) mol dm^{-3} at different temperature range T= (288.15, 293.15, 298.15 and 303.15) K are as given in fig. a-g.

Fig. 1(a) shows that density of L-Valine solution in 2 % aqueous NaBr increases with increase in concentration of solution; however it falls with the increase in temperature. This result is obvious as the volume of the solution increases with the rise in temperature [19] and mass of the solution increase with the increase in concentration.

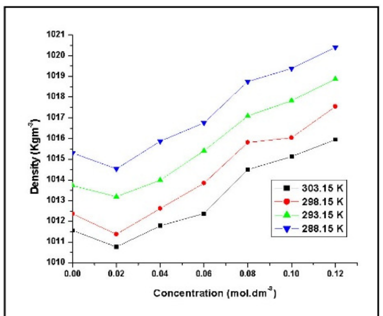

Fig.1 (a)

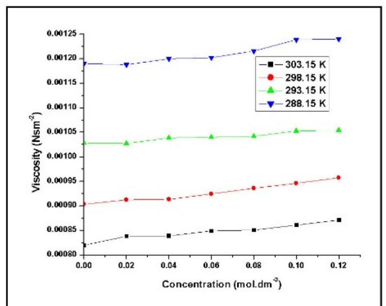

Fig.1 (b)

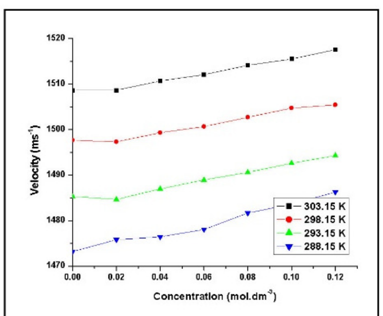

Fig.1 (c)

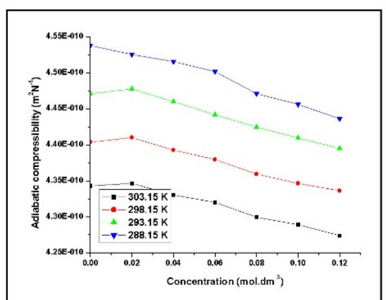

Fig.1 (d)

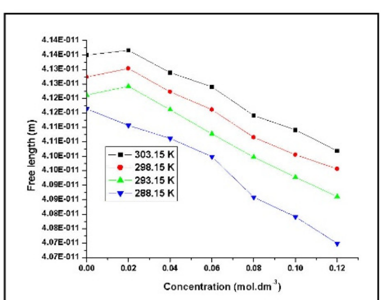

Fig.1 (e)

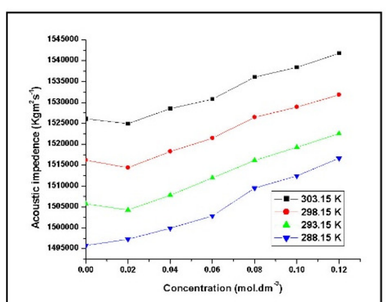

Fig.1 (f)

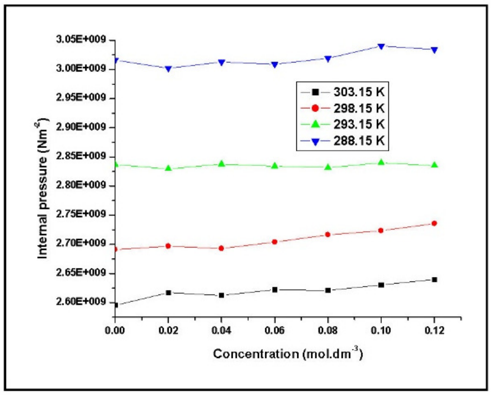

Fig.1 (g)

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 L-Valine solution in 2 % aqueous electrolytes increases with increase in concentration and decreases with increase in temperature. Increase in viscosity of solution with concentration suggests the strong interaction of solute and solvent molecule. With the rise in temperature 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 [20].

The increase in ultrasonic velocity with concentration (fig. 1c) in any solution indicates the presence of solute-solvent interactions [21]. 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.

The dependence of adiabatic compressibility of L-Valine solutions in 2% aqueous solution of sodium bromide 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 [22]. Adiabatic compressibility is inversely correlated with ultrasonic velocity which increases with increase in temperature. Hence adiabatic compressibility values decreases with increase in temperature.

The decrease in free length (fig. 1e) with rise in concentration of L-Valine 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 [23, 24] as well as the presence of dipole-dipole and acceptor-donor 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.

Acoustic impedance depends on the density of the medium and the speed of the sound wave. Fig.1 (f) shows the variation of acoustic impedance with concentration and temperature. The increase in acoustic impedance with the increase in concentration as well as temperature 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.

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.

CONCLUSIONS

Basic physical parameters such as ultrasonic velocity, density and viscosity of L-Valine solution in 2% aqueous salt of different concentration at different temperature were measured initially. Using these basic parameters various acoustical parameters were evaluated. The temperature effect on these parameters was discussed appropriately. These parameters were interpreted in connection with the molecular interactions. The addition of solute in solvent has structure making tendency through intermolecular hydrogen bonding.

REFERENCES

[1] Von Hippel, P. H. and Schleich, T. (1969): Ion effect on the solution structure of biological macromolecules. Acc. Chem. Res., vol 2: Pp 257-265.

[2] Thirumaran, S. and Sathish, K. (2011): Molecular interionic interaction studies of some divalent transition metal sulphates in aqueous ethylene glycol at different temperatures. Res. J. Chem. Sci., vol 8: Pp 63-71.

[3] Thirumaran, S. and Mary Christina Gardilya, D. (2011): Volumetric and ultrasonic studies on interionic interactions of some amino acids in aqueous magnesium acetate medium at

306.15K. Rec. Res. Sci. and Tech., vol 3(8): Pp 56-63.

[4] Banipal, T. S., Kaur, J. and Banipal P. K (2008): Study of interactions between amino acids and zinc chloride in aqueous solutions through volumetric measurements at T=(288.15 to 318.15) K. J. Chem. Eng. Data., vol 53: Pp 1803-1816.

[5] Pal, A. and Kumar, S. (2005): Volumetric properties of L-alanine, and L-valine in aqueous sucrose solutions at T= (288.15 and 308.15) K. J. Chem. Thermodyn., vol 35: Pp 1085-1092.

[6] Nain, A. K. and Chand, D. (2009): Volumetric, ultrasonic, and viscometric behavior of glycine, DL-alanine, and L-valine in aqueous 1,4-butanediol solutions at different temperatures. J. Chem. Thermodyn., vol 41: Pp 243-249.

[7] Pinho, S. P. (2008): Water Activity in Aqueous Amino Acid Solutions, with and without KCl, at 298.15 K. J. Chem. Eng. Data., vol 53: Pp 180-184.

[8] Wang, J. and Feng, R. (1990): Ultrasonic velocity of aqueous solutions of amino acids, Ultrasonics. vol l28: Pp 37-39.

[9] Thirumaran, S. and Sabu, K. J. (2009): Ultrasonic investigation of amino acids in aqueous sodium acetate medium. Ind. J. pure and Appl. Phys., vol 47: Pp 87-96.

[10] Sumathi, T. and Varalakshmi, M. (2010): Ultrasonic velocity, density and viscosity measurement of methionine in aqueous electrolytic solutions at 303K. Rasayan J. Chem., vol 3(3): Pp 550-555.

[11] Thirumaran, S. and Kannappan, A. N. (2009): Volumetric and ultrasonic studies of some amino acids in aqueous sodium butyrate solution. Global J. Mol. Sci., vol 4: Pp 160-166.

[12] Riyazuddeen, and Basharat, R. (2006): Intermolecular/ interionic interactions in l-isoleucine, l-proline, and lglutamine-aqueous electrolyte systems. J. Chem. Thermodyn., vol 38: Pp 1684-1695.

[13] Nagaraj, S., Subha, M.C.S., Nagamani, C. and Chowdoji Rao K. (2016): Ultrasonic velocity studies of amino acids in aqueous tertiary butyl alcohol at 303.15K. World J. Pharm. and Pharmace. Sci., vol 5(1): Pp 1423-1441.

[14] D' Souza, R. and Meenakshi, G. (2015): Investigation of molecular interaction of amino acids in aqueous n-propanol solutions at 308.15 K. Int. J. Res. Engi. and Techn., vol 4(1): Pp 96-100.

[15] Sathish, M. and Meenakshi, G. (2014): Ultrasonic study of some amino acids in aqueous salt solution of KNO3 at 303.15K. Int. J. Res. Engi. and Techn., vol 3(2): Pp 312-317.

[16] Sarvazyan, A. P. and Chalikian, T. V. (1990): Acoustic nonlinearity parameter B/A of aqueous solutions of some amine acids and proteins. J. Acoust. Soc. Am., vol 88(3): Pp 1555-1561.

[17] Riyazuddeen, and Khan I. (2008): Viscosity studies of (L-alanine-, L-proline, L-valine, L-leucine + aqueous KCl/KNO3) solutions at different temperatures. J. Chem. Thermodyn., vol 40: Pp 1549–1551.

[18] Sumathi, T. and Alphonsa, K. J. (2013): Densities and speeds of sound of L-valine in aqueous sodium bromide solutions at various temperatures. Global Research Analysis, vol 2(8): Pp 172-174.

[19] Rajathi, K., Ali, S. J. and Rajendran, A. (2011): Ultrasonic study of molecular dynamics in some binary mixtures. J. Chem. Pharm. Res., vol3 (5): Pp 348-358.

[20] Kaur, K. and Kumar, H. (2013): Viscometric measurements of L-serine with antibacterial drugs ampicillin and amoxicillin at different temperatures: (305.15 to 315.15) K. J. Mol. Liq., vol 177: Pp 49-53.

[21] Godhani, D. R., Dobariya, P. B. and Sanghani, A. M (2012): Effect of temperature and solvents on ultrasonic velocity and thermodynamic parameters of 1, 3, 4-oxadiazole derivative solutions. J. Mol. Liq., vol 168: Pp 28-35.

[22] Iqbal, M. and Verrall, R. E. (1989): Apparent molar volume and adiabatic compressibility studies of aqueous solutions of some drug compounds at 25°C. Can. J. Chem., vol 67 (4): Pp 727-735.

[23] Kanhekar, S., Pawar, P. and Bichile, G. (2010): Thermodynamic properties of electrolytes in aqueous solution of glycine at different temperatures. Ind. J. Pure and Appl. Phys., vol 48: Pp 95-99.

[24] Sethu Raman, M., Ponnuswamy, V., Kolandaivel, P. and Perumal, K. (2010): Ultrasonic and DFT study of intermolecular association through hydrogen bonding in aqueous solutions of d(−) arabinose. J. Mol. Liq. vol 151: Pp 97-106.