ScienSage

Journal of Advanced Scientific Research

Available online through http://www.sciensage.info/jasr

ISSN
0976-9595
Research Article

SOLUTE-SOLVENT INTERACTIONS OF GLYCINE, α-ALANINE, β-ALANINE AND PHENYL ALANINE IN AQUEOUS SUCROSE SOLUTIONS AT 298.15 K: AN ULTRASONIC STUDY

Sanjibita Das*, Upendra N. Dash

Department of Chemistry, Institute of Technical Education and Research, Siksha 'O' Anusandhan University, Khandagiri square, Bhubaneswar-751030, Odisha (India)

**Corresponding author: sanjibita124@yahoo.co.in*

ABSTRACT

Ultrasonic velocity of the solutions of glycine, α-alanine, β-alanine and phenyl alanine in aqueous sucrose solutions have been measured at 298.15 K. From the experimental data the derived acoustic parameters like isentropic compressibility (K_s), acoustic impedance (Z), molar compressibility(W), molar sound velocity(R), relative association(R_A), intermolecular free length(L_f), free volume (V_f), internal pressure(π_i), ultrasonic attenuation (α/f^2) and van der Waals constant (b) have been obtained. The non-linearity parameters (B/A), isothermal compressibility (β_T), co-efficient of thermal expansion (α) and heat capacity ratio (γ) have also been calculated. These parameters have been used to discuss the molecular interactions in the solutions.

Keywords: Sucrose, Amino acid, Ultrasonic velocity, Isentropic compressibility, Solute-Solvent interaction

1. INTRODUCTION

The measurement of ultrasonic velocity is an important tool in investigating the interactions that are operating between the component molecules. It provides qualitative information about the nature and strength of molecular interactions in solutions. The major applications of biomolecules are in the food, pharmaceutical, and cosmetic industries. Proteins are the biomolecules which play an important role in all the biochemical processes occurring in living organisms. The behavior of proteins is governed by their interactions with the surrounding environment. Due to the structural complexity of proteins, the convenient method is to study the low molecular weight model compounds, such as amino acids. As structural components of proteins, these amino acids participate in all the physiological processes of a living cell. Sucrose, commonly known as table sugar is mostly used in food, pharmaceutical and polymer industries.

There have been extensive volumetric, viscometric and ultrasonic studies of amino acids in aqueous solutions, but very few have been studied in aqueous saccharide solutions. Ultrasonic studies of L-histidine,L-arginine and L-Lysine in 0.5 M aqueous sucrose solution have been made at different temperatures by Palani et al [1] and they have reported that sucrose has a dehydration effect on the amino acids. Ultrasonic studies of L-asparagine, L-glutamine, L-serine and L-threonine in aqueous sucrose solution have been reported at 301.15 K by Thirumaran et al [2]. They have suggested the presence of strong molecular association in L-serine system as compared to other amino acid systems. In continuation of our earlier work [3, 4] on the measurements of ultrasonic velocity and density of the solutions of amino acids in aqueous solution of D-glucose and D-fructose, in this communication, we report the densities and speeds of sound of glycine, α-alanine, β-alanine and L-phenyl alanine in aqueous sucrose solutions (5 and 10 wt%) at 25 °C.

In the present investigation the acoustic parameters such as isentropic compressibility (K_s), acoustic impedance (Z), molar compressibility (W), molar sound velocity (R), relative association (R_A), intermolecular free length (L_f), free volume (V_f), internal pressure (π_i), ultrasonic attenuation (α/f^2), van der Waals constant (b), isothermal compressibility (β_T),co-efficient of thermal expansion(α), heat capacity ratio (γ) and non-linearity parameter (B/A) have been evaluated at 298.15 K. The results have been discussed in terms of molecular interactions.

2. MATERIAL AND METHODS

All chemicals used were of AnalaR grades and were used as such. To prepare solutions of sucrose (5 and 10 wt %) conductivity water (Sp.cond.~10^{-6} S cm^{-1}) was used and the solutions were used on the same day. The solutions of glycine, α-alanine , β-alanine and phenyl alanine were prepared on the molal basis and conversion of molality to molarity was done by using the standard expression [5] using the density values of the solutions obtained at 298.15 K. Solutions were kept for 2 hours in a water thermostat maintained at the required temperature accurate to within ±0.1K before use for density measurements. Density measurements were done by using a specific gravity bottle (25ml capacity) as described elsewhere [6]. At least five observations were taken and differences in any two readings did not exceed ±0.02%. An ultrasonic interferometer (Model No.F-81, Mittal Enterprises, New

Delhi) operating at a frequency of 2MHz and overall accuracy of ±0.5 m/s was used for the velocity measurement at 298.15K only. Viscosity measurements were made by an Ostwald viscometer (25 ml capacity) in a water thermostat whose temperature was controlled to ±0.05K. The flow time of water and flow time of solution were measured with a digital stop clock with an accuracy of 0.01s.The values of viscosity so obtained were accurate to within ± 0.3×10^{-3} cP. In all the solvents the amino acid content in the solutions was varied over a range of 0.01 to 0.08 M.

2.1. Theoretical Aspects

From the speed of sound, various acoustical and thermodynamics parameters have been calculated from the experimental data to investigate about the nature of molecular interaction between the components of the solution. The derived parameters such as K_s, Z, W, R, R_A, L_f, V_f, π_i, $K_{s,\Phi}$ and S_n were calculated using the following standard equations [7-18].

$$K_s = 1/U^2d \quad (1)$$

$$W = \overline{M}d^{-1}K_s^{-1/7} \quad (2)$$

$$Z = U\,d \quad (3)$$

$$R = \overline{M}\,d^{-1}\,U^{1/3} \quad (4)$$

$$R_A = (d/d_0)\,(U_0/U)^{1/3} \quad (5)$$

$$L_f = K'K_s^{1/2} \quad (6)$$

$$V_f = (\overline{M}U/K\eta)^{3/2} \quad (7)$$

$$\pi_i = b'RT(K\eta/U)^{1/2}(d^{2/3}/\overline{M}^{7/6}) \quad (8)$$

Where, b' is the packing factor of liquid and b' = 1.78 for close packed hexagonal structure and b' = 2 for cubic packing. For many liquids b' is equal to 2. K is a dimensionless constant and $K = 4.28 \times 10^9$, independent of temperature and nature of liquid. Further, d is the density of the solution, d_0 is the density of the pure solvent, U is the ultrasonic velocity of the solution and U_0 is the ultrasonic velocity of the pure solvent, η is the viscosity co-efficient of the solution, $\overline{M}$ is the effective molecular weight ($\overline{M} = \Sigma\, m_i\, x_i$), in which m_i and x_i are the molecular weight and the mole fraction of the individual constituents, respectively, K' is the Jacobson's constant which is temperature dependent and is obtained from the literature [10, 11].

The apparent isentropic molar compressibility, $K_{s,\Phi}$ has been computed from equation,

$$K_{s,\Phi} = 1000K_sc^{-1} - K_s^0d_0^{-1}(1000c^{-1}d - M_2) \quad (9)$$

To obtain $K_{s,\Phi}^0$ (the limiting apparent isentropic molar compressibility) the $K_{s,\Phi}$ data were fitted to equation

$$K_{s,\Phi} = K_{s,\Phi}^0 + F'c^{1/2} + G'\,c \quad (10)$$

where F' and G' are the empirical constants.

The solvation number, S_n of a solute can be related to the isentropic compressibility by equation [16]:

$$S_n = n_1n_2^{-1}\,[1 - VK_s\,(n_1v_1^0K_s^0)^{-1}] \quad (11)$$

where, V is the volume of the solution containing n_2 moles of solute.

V_1^0 is the molar volume of solvent and n_1 is the number of moles of solvent.

The variation of solvation number with molar concentration of the solute leads to the limiting solvation number, S_n^0 which was obtained from the relation

$$\lim_{c\to0} K_{s,\Phi} = -\,S_n^0\,V_1^0\,K_s^0 \quad (12)$$

The expression for the non-linearity parameter due to Hartmann and Balizer[17] is given as

$$B/A = 2 + (0.98 \times 10^4)/U \quad (13)$$

and from the empirical relation of Ballou employed by Hartmann [18], B/A is given below.

$$B/A = -0.5 + (1.2 \times 10^4)/U \quad (14)$$

From the thermodynamic relation [19], Isothermal compressibility

$$\beta_T = 17.1 \times 10^{-4}/\,(T^{4/9}\,d^{4/3}\,U^2) \quad (15)$$

Co-efficient of thermal expansion

$$\alpha = 75.6 \times 10^{-3}/\,(T^{1/9}\,d^{1/3}\,U^{1/2}) \quad (16)$$

and Heat capacity ratio (γ) = β_T/K_s (17)

3. RESULTS AND DISCUSSION

The experimental values of ultrasonic velocity (U) for different concentrations of glycine, α-alanine, β-alanine and phenyl alanine in aqueous sucrose solutions (5 and 10 wt %) at 298.15 K are shown in Figs 1(a) and 1(b) respectively.

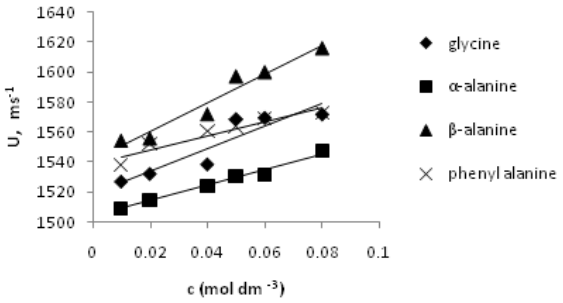

Fig.1(a): Plot of ultrasonic velocity, U vs concentration of amino acids in 5wt % Sucrose.

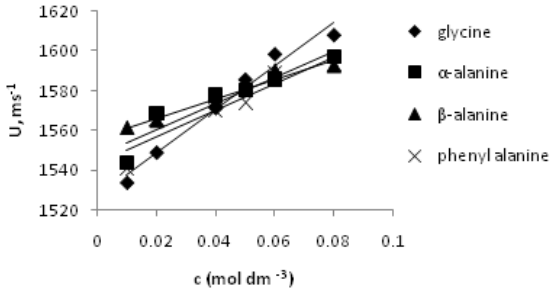

Fig.1(b): Plot of ultrasonic velocity, U vs concentration of amino acids in 10 wt % Sucrose.

As observed, the ultrasonic velocity increases with increase in concentrations of amino acids as well as with increase in

sucrose content in water. This increase in ultrasonic velocity (U) with solute concentration may be due to association between solute and solvent molecules [20, 21].

To throw more light on the molecular interaction, some acoustic parameters, such as isentropic compressibility (K_s), molar compressibility (W), acoustic impedance (*Z*), molar sound velocity (R), relative association (R_A), intermolecular free length (L_f), free volume (V_f), internal pressure (π_i), ultrasonic attenuation (α/f^2), van der Waals constant (b), S_n and $K_{s\Phi}$ are calculated and are given in Tables 1 and 2.

Table 1: Values of parameters K_s ($m^2 N^{-1}$), W ($N^{-1}m^{-1}$), Z ($Kgm^{-2}s^{-1}$), R ($m^{-8/3} s^{-1/3}$) , R_A and L_f (m) for glycine, α-alanine, β-alanine and phenyl alanine in water+sucrose at 298.15 K.

Conc. mol dm^{-3}	Isentropic compressibility $K_s \times 10^{10}$	Molar compressibility W	Acoustic impedance $Z \times 10^{-4}$	Molar sound velocity R	Relative association R_A	Free length $L_f \times 10^{10}$
glycine + 5wt% sucrose						
0.01	4.22	0.4061	155.22	0.2141	0.9962	4.22
0.02	4.19	0.4065	155.83	0.2143	0.9956	4.21
0.04	4.15	0.4071	156.65	0.2146	0.9953	4.19
0.05	3.99	0.4094	159.83	0.2161	0.9893	4.12
0.06	3.98	0.4095	159.99	0.2161	0.9887	4.11
0.08	3.97	0.4100	160.31	0.2164	0.9876	4.10
glycine+10wt% sucrose						
0.01	4.1	0.4208	158.97	0.2213	0.9980	4.16
0.02	4.02	0.4221	160.62	0.2220	0.9952	4.12
0.04	3.9	0.4239	163.11	0.2231	0.9914	4.06
0.05	3.83	0.4251	164.67	0.2238	0.9888	4.02
0.06	3.77	0.4261	166.07	0.2244	0.9866	3.99
0.08	3.72	0.4271	167.17	0.2250	0.9852	3.97
α-alanine + 5wt% sucrose						
0.01	4.32	0.4048	153.44	0.2133	1.0001	4.27
0.02	4.28	0.4054	154.07	0.2136	0.9992	4.26
0.04	4.23	0.4064	155.10	0.2142	0.9978	4.23
0.05	4.19	0.4071	155.81	0.2146	0.9968	4.22
0.06	4.19	0.4073	155.95	0.2147	0.9960	4.21
0.08	4.10	0.4089	157.65	0.2156	0.9940	4.16
α-alanine + 10wt% sucrose						
0.01	4.05	0.4216	160.06	0.2218	0.9959	4.14
0.02	3.92	0.4237	162.71	0.2230	0.9911	4.07
0.04	3.87	0.4247	163.73	0.2236	0.9898	4.05
0.05	3.86	0.4251	164.02	0.2238	0.9896	4.04
0.06	3.83	0.4257	164.67	0.2241	0.9888	4.02
0.08	3.78	0.4270	165.89	0.2249	0.9869	4.00
β-alanine + 5wt% sucrose						
0.01	4.07	0.4083	158.00	0.2154	0.9902	4.15
0.02	4.06	0.4085	158.24	0.2156	0.9901	4.14
0.04	3.98	0.4100	159.98	0.2164	0.9875	4.10
0.05	3.85	0.4121	162.60	0.2177	0.9827	4.04
0.06	3.84	0.4125	162.94	0.2179	0.9824	4.03
0.08	3.76	0.4141	164.59	0.2189	0.9793	3.99
β-alanine +10wt% sucrose						
0.01	3.96	0.4230	161.83	0.2226	0.9921	4.09
0.02	3.94	0.4234	162.27	0.2229	0.9918	4.08
0.04	3.89	0.4244	163.42	0.2234	0.9907	4.05

Continued…

Conc. mol dm^{-3}	Isentropic compressibility $K_s \times 10^{10}$	Molar compressibility W	Acoustic impedance $Z \times 10^{-4}$	Molar sound velocity R	Relative association R_A	Free length $L_f \times 10^{10}$
0.05	3.85	0.4252	164.27	0.2238	0.9895	4.03
0.06	3.81	0.4260	165.13	0.2243	0.9881	4.02
0.08	3.80	0.4266	165.47	0.2246	0.9880	4.01
Phenyl alanine + 5wt% sucrose						
0.01	4.16	0.4074	156.33	0.2148	0.9936	4.19
0.02	4.08	0.4089	157.83	0.2157	0.9910	4.15
0.04	4.04	0.4104	158.82	0.2165	0.9901	4.13
0.05	4.01	0.4111	159.25	0.2169	0.9898	4.12
0.06	3.99	0.4119	159.83	0.2174	0.9892	4.11
0.08	3.97	0.4131	160.34	0.2180	0.9891	4.09
Phenyl alanine + 10wt% sucrose						
0.01	4.06	0.4217	159.80	0.2218	0.9967	4.14
0.02	3.93	0.4241	162.43	0.2232	0.9927	4.08
0.04	3.91	0.4252	163.02	0.2238	0.9919	4.06
0.05	3.89	0.4261	163.44	0.2243	0.9911	4.05
0.06	3.81	0.4278	165.09	0.2253	0.9884	4.01
0.08	3.79	0.4290	165.63	0.2259	0.9883	4.00

As shown in Table 1, the isentropic compressibility (K_s) decreases with the increase in concentrations of amino acids and with increase in sucrose content in water. The decrease in K_s with concentration implies that the interstitial spaces of water are occupied by the solute molecules thus making the medium less compressible. Further, the decrease in compressibility with increase in sucrose content in water may be due to the filling of the interstitial spaces of water molecules by organic co-solvent, sucrose molecules thereby making a tight structure. The values of W increase with concentration of amino acids as well as with increase in sucrose content in water. Further, it is observed that the acoustic impedance, Z increases with increase in sucrose content in water as well as with increase in solute concentration [22].The increase in Z values with solute concentration can be attributed to the effective solute-solvent interactions. Similar type of behaviour has been observed for some amino acids studied in various solvent systems [3] (5, 10, 15 and 20 wt% D-glucose). Since the acoustic impedance is a measure of the resistance offered by the liquid medium to the sound wave and is a function of the elastic property of the medium, it gets affected by the structural changes of the solution .The increasingly higher values with increase in the solute concentration and also with increase in sucrose content in water shows that the solution medium in each case starts gaining its elastic property. As shown in Table 1, the molar sound velocity, R increases with increase in concentration of the solutions for all the amino acids. This type of behaviour is similar to that observed earlier [23, 24].

Another property [25] which also can be studied to know more about the ion-ion or ion-solvent interactions is the relative association, R_A. It depends on two factors: (i) breaking up of the associated solvent molecules on addition of the solute to it, and (ii) the solvation of solute molecules. The former leads to the decrease and the latter to the increase of relative association. In the present study, R_A decreases with increase in the solute concentration for all the amino acids in all solvents (typical plots of R_A vs conc. in 5wt% and 10 wt% sucrose for all the amino acids are shown in Figs 2(a) and 2(b) respectively).This implies that the breaking up of the associated solvent molecules on addition of the solute takes place in all solvents. It is known that when a solute dissolves in a solvent, some of the solvent molecules are attached to the ions (generated from the solute) because of ion-solvent interactions. Since the solvent molecules are oriented in the ionic field (*i.e.* electrostatic fields of ions) the solvent molecules are more compactly packed in the primary solvation shell as compared to the packing in the absence of the ions. This is the reason, why the solvent is compressed by the introduction of ions. Thus the electrostatic field of the ions causes compression of the medium giving rise to a phenomenon called electrostriction. Since the solvent molecules are compressed they do not respond to any further application of pressure. So the solution becomes harder to compress, *i.e.* the compressibility decreases. Positive values of π_i indicate the presence of some specific interactions between unlike molecules in the components.

Free volume, V_f is the effective volume accessible to the centre of a molecule in a liquid. The structure of a liquid is determined by strong repulsive forces in the liquid with the relatively weak attractive forces providing the internal pressure which held the liquid molecules together. The free volume seems to be conditional by repulsive forces whereas the internal pressure is more sensitive to attractive forces.

These two factors together uniquely determine the entropy of the system. Thus, the internal pressure, free volume and temperature seem to be the thermodynamic variables that describe the liquid system of fixed composition [26, 27].

Table 2: Values of parameters V_f (m^3 mol^{-1}), π_i (N m^{-2}), α/f^2, b (m^3 mol^{-1}), S_n and $K_{s,\Phi}$ for glycine, α-alanine, β-alanine and phenyl alanine in water+sucrose at 298.15 K.

Conc. (mol dm^{-3})	$V_f \times 10^3$	$\pi_i \times 10^{-2}$	$\alpha/f^2 \times 10^{15}$	$b \times 10^2$	S_n	$K_{s,\Phi} \times 10^7$
glycine + 5wt% sucrose						
0.01	0.531	8717.18	7.47	1.8517	131.2	-10.87
0.02	0.529	8727.49	7.44	1.8518	84.4	-7.08
0.04	0.533	8709.13	7.35	1.8519	54.3	-4.65
0.05	0.543	8653.86	6.98	1.8521	82.8	-6.98
0.06	0.542	8657.70	6.98	1.8523	70.3	-5.96
0.08	0.527	8736.82	7.09	1.8535	54.8	-4.67
glycine + 10 wt% sucrose						
0.01	0.477	8846.54	8.21	1.9113	48.4	-3.88
0.02	0.482	8815.38	7.99	1.9115	74.0	-6.14
0.04	0.489	8770.08	7.69	1.9118	72.7	-6.11
0.05	0.495	8738.99	7.50	1.9122	75.7	-6.36
0.06	0.496	8730.59	7.37	1.9124	75.8	-6.38
0.08	0.475	8852.17	7.49	1.9135	63.9	-5.40
α-alanine + 5wt% sucrose						
0.01	0.527	8740.49	7.69	1.8517	10.5	-1.03
0.02	0.524	8751.79	7.66	1.8523	25.8	-2.28
0.04	0.512	8817.32	7.69	1.8538	29.4	-2.56
0.05	0.510	8825.98	7.65	1.8545	32.6	-2.82
0.06	0.508	8839.54	7.67	1.8550	28.4	-2.48
0.08	0.513	8799.96	7.46	1.8569	34.7	-2.98
α-alanine + 10 wt% sucrose						
0.01	0.482	8814.32	8.04	1.9114	115.8	-9.46
0.02	0.490	8764.58	7.71	1.9120	136.0	-11.26
0.04	0.489	8765.30	7.64	1.9135	81.9	-6.84
0.05	0.477	8840.55	7.75	1.9142	68.7	-5.76
0.06	0.473	8859.79	7.73	1.9148	63.1	-5.30
0.08	0.472	8864.37	7.65	1.9169	55.6	-4.68
β-alanine +5 wt% sucrose						
0.01	0.536	8688.49	7.17	1.8523	312.2	-25.61
0.02	0.535	8692.56	7.16	1.8528	162.3	-13.41
0.04	0.541	8657.98	6.97	1.8542	107.2	-8.90
0.05	0.552	8594.84	6.66	1.8549	116.5	-9.67
0.06	0.553	8589.97	6.64	1.8557	100.1	-8.33
0.08	0.561	8542.76	6.45	1.8580	86.7	-7.21
β-alanine +10wt% sucrose						
0.01	0.489	8773.51	7.79	1.9117	222.9	-18.25
0.02	0.487	8783.13	7.78	1.9122	123.5	-10.19
0.04	0.482	8809.94	7.74	1.9131	77.4	-6.48
0.05	0.483	8802.02	7.66	1.9138	71.3	-5.99
0.06	0.486	8781.51	7.56	1.9148	67.4	-5.66
0.08	0.486	8775.50	7.54	1.9164	52.6	-4.44
Phenyl alanine + 5 wt% sucrose						
0.01	0.531	8711.99	7.37	1.8537	205.3	-16.86
0.02	0.537	8672.31	7.19	1.8556	149.5	-12.35

Continued…

Conc. (mol dm^{-3})	$V_f \times 10^3$	$\pi_i \times 10^{-2}$	$\alpha/f^2 \times 10^{15}$	$b \times 10^2$	S_n	$K_{s,\Phi} \times 10^7$
0.04	0.540	8646.52	7.11	1.8595	89.2	-7.45
0.05	0.539	8644.84	7.09	1.8614	76.3	-6.40
0.06	0.540	8630.99	7.04	1.8634	69.1	-5.82
0.08	0.541	8615.14	7.01	1.8673	55.3	-4.69
Phenyl alanine + 10wt% sucrose						
0.01	0.462	8935.86	8.31	1.9125	98.8	-8.13
0.02	0.473	8862.79	7.93	1.9147	127.7	-10.59
0.04	0.475	8836.25	7.88	1.9183	71.2	-6.00
0.05	0.474	8838.24	7.87	1.9209	61.8	-5.21
0.06	0.474	8832.21	7.73	1.9230	66.8	-5.63
0.08	0.469	8848.22	7.76	1.9271	53.4	-4.54

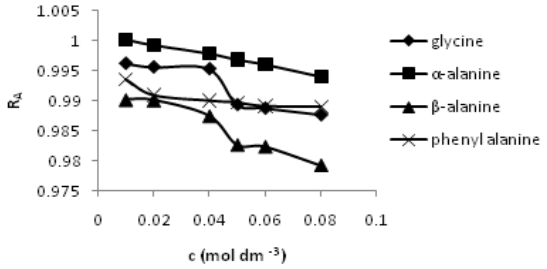

Fig. 2(a): Plot of R_A vs concentration of amino acids in 5wt% sucrose.

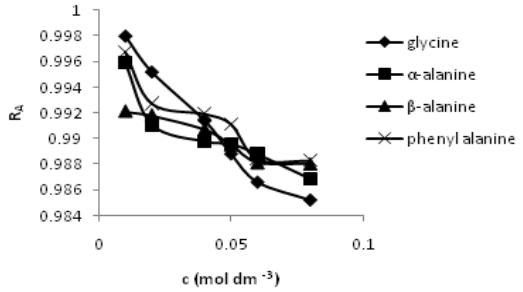

Fig. 2(b): Plot of R_A vs concentration of amino acids in 10 wt% sucrose.

It is seen that the free volume varies irregularly with solute concentration but decreases with increase in sucrose content in water. However, internal pressure changes in a manner opposite to that of free volume. The decrease of V_f (or increase of π_i) indicates the formation of hard and/or tight solvation layer around the ion [28, 29]. The fractional free volume (V_f / V) is a measure of disorderliness due to increased mobility of the molecules in a liquid. It is observed that mobility/ disorderliness decreases with concentration and also sucrose content in water. This indicates that the frictional force exerted by different layers of liquid increases with concentration as well as with sucrose content. As the frictional force increases, ultrasonic absorption increases [30]. In the present study, ultrasonic absorption or attenuation varies irregularly with concentration of amino acids but increases with increase in sucrose content. The van der Waals constant, *i.e.* b values are found to increase with increase in concentration of amino acids as well as with increase in wt% of sucrose. Large values of S_n indicate an appreciable solvation of solutes [31]. It supports the structure making nature of solutes and the presence of dipolar interactions between the solutes and water molecules. This parameter also indicates that the compressibility of the solution will be less than that of the solvent, resulting in more mobility of solutes and solutes have a more probability of contacting solvent molecules, which facilitates solute-solvent interaction.

The values of $K_{s,\Phi}$ and $K^0_{s,\Phi}$ are negative [32].The negative values may be explained by means of two different phenomena, viz., electrostriction and hydrophobic solvation. The loss of compressibility of the surrounding solvent molecules due to strong electrostrictive forces at the carboxyl group causes electrostrictive solvation *i.e.* a tight solvation layer is formed around the ion for which the medium is little compressed by the application of pressure. The $K_{s,\Phi}^0$ values are given in Table 3. The values of $K_{s,\Phi}^0$ of the amino acids follow the order: $K_{s,\Phi}^0$ (α-alanine) > $K_{s,\Phi}^0$ (glycine)> $K_{s,\Phi}^0$ (phenyl alanine)> $K_{s,\Phi}^0$ (β-alanine) in 5 wt% sucrose and $K_{s,\Phi}^0$ (glycine) > $K_{s,\Phi}^0$ (phenyl alanine)> $K_{s,\Phi}^0$ (α-alanine)> $K_{s,\Phi}^0$ (β-alanine) in 10 wt% sucrose.

Table 3: Values of $K_{s\Phi}^0$ (m^3 mol^{-1} pa^{-1}) and S_n^0 of glycine, α-alanine, β-alanine and phenyl alanine in water+sucrose at 298.15 K.

Amino acid	Sucrose	$S_n^0 \times 10^2$	$K_{s\Phi}^0 \times 10^{-7}$
Glycine	5wt%	12.2	-12.00
	10wt%	12.1	-4.20
α-alanine	5wt%	6.4	-0.58
	10wt%	12.1	-14.0
β-alanine	5wt%	24.5	-30.0
	10wt%	12.1	-22.0
Phenyl alanine	5wt%	12.2	-22.0
	10wt%	12.1	-12.0

This trend in $K_{s,\Phi}^0$ values implies that α-alanine in 5 wt% sucrose and glycine in 10 wt% sucrose show stronger electrostriction as compared to other amino acids. Specifically, the solvation layer formed around α-alanine and glycine is thick and / or hard in the solvent concerned.

Again, from Table 3 it is observed that the limiting solvation number, S_n^0 is larger in water+ sucrose mixtures than that in water [3]. The increase in S_n^0 value in the mixed solvent medium indicates a structure making process. Higher S_n^0 value indicates strong electrostriction in water+sucrose mixtures as compared to water. It is supposed that the solvation layer formed around the ion is thick and/or hard in water+ sucrose mixtures than in water. However, the variation of S_n^0 as well as of S_n values predicts the degree of hard electrostrictive solvation. It shows the structural effect of the solute on the solvent in a solution.

Table 4: Values of non- linearity parameter (B/A) of glycine, α-alanine, β-alanine and phenyl alanine in water+sucrose at 298.15 K using Hartmann and Balizer equation and Ballou relation.

Amino acid	Conc	5wt% sucrose		10wt% sucrose	
	mol dm^{-3}	B/A Hartmann	B/A Ballou	B/A Hartmann	B/A Ballou
Glycine	0.01	8.42	7.36	8.39	7.32
	0.02	8.39	7.33	8.33	7.25
	0.04	8.37	7.30	8.24	7.14
	0.05	8.25	7.15	8.18	7.07
	0.06	8.24	7.14	8.13	7.00
	0.08	8.23	7.13	8.09	6.96
α-alanine	0.01	8.49	7.45	8.35	7.27
	0.02	8.47	7.42	8.25	7.15
	0.04	8.43	7.37	8.21	7.10
	0.05	8.40	7.34	8.20	7.09
	0.06	8.40	7.33	8.18	7.07
	0.08	8.33	7.25	8.14	7.02
β-alanine	0.01	8.30	7.22	8.28	7.19
	0.02	8.29	7.21	8.26	7.17
	0.04	8.23	7.13	8.22	7.12
	0.05	8.14	7.01	8.19	7.08
	0.06	8.13	7.00	8.16	7.05
	0.08	8.06	6.93	8.15	7.04
Phenyl alanine	0.01	8.37	7.30	8.36	7.29
	0.02	8.31	7.23	8.26	7.16
	0.04	8.28	7.19	8.24	7.14
	0.05	8.26	7.17	8.23	7.12
	0.06	8.25	7.15	8.17	7.05
	0.08	8.23	7.13	8.15	7.03

The B/A values as calculated from Hartmann and Ballou relation are presented in Table 4. It shows decreased trend with increase in concentration [33]. The B/A values represent the magnitude of the hardness of liquids. As the B/A values decrease with increase in concentration, it indicates that the interaction between the components of the binary mixtures is weaker at lower concentration of amino acids [34].

Isothermal compressibility decreases with increase in concentration as well as with increase in sucrose content. The decrease in isothermal compressibility is attributed to the influence of the electrostatic field of ions of the amino acids on the surrounding solvent molecules, called electrostriction. The magnitude of β_T values (isothermal compressibility) is larger in 5 wt% sucrose than in 10wt% sucrose solutions. The decrease in both isothermal and isentropic compressibility suggests that there is association of sucrose and water which leads to compression in volume.

As shown in Table 5, the co-efficient of thermal expansion (α) decreases with increase in the concentration of amino acids. It may be due to the fact that the increase in concentration causes more ion-solvent interactions resulting in compactness. Further, the heat capacity ratio (γ) of the solutions decreases with increase in concentration of amino acids and also with increase in the sucrose content in water.

Table 5: Values of Isothermal compressibility β_T (m^2N^{-1}), Co-efficient of thermal expansion α (N^{-1}) and Heat capacity ratio γ of glycine, α-alanine, β-alanine and phenyl alanine in water + sucrose at 298.15 K

Conc mol dm^{-3}	Isothermal compressibility $\beta_T \times 10^{15}$	Co-efficient of thermal expansion $\alpha \times 10^3$	Heat capacity ratio $\gamma \times 10^5$
	Glycine+5 wt% sucrose		
0.01	5.70	0.1021	1.3519
0.02	5.66	0.1019	1.3517
0.04	5.60	0.1017	1.3512
0.05	5.39	0.1007	1.3509
0.06	5.38	0.1006	1.3507
0.08	5.36	0.1005	1.3505
	Glycine+10wt% sucrose		
0.01	5.51	0.1012	1.3432
0.02	5.39	0.1007	1.3429
0.04	5.24	0.1000	1.3425
0.05	5.14	0.0995	1.3423
0.06	5.06	0.0991	1.3421
0.08	4.99	0.0988	1.3419
	α-alanine+5wt% sucrose		
0.01	5.84	0.1027	1.3519
0.02	5.79	0.1025	1.3517
0.04	5.72	0.1022	1.3514
0.05	5.67	0.1020	1.3512
0.06	5.66	0.1019	1.3511
0.08	5.54	0.1014	1.3509
	α-alanine+10 wt% sucrose		
0.01	5.43	0.1009	1.3431
0.02	5.26	0.1001	1.3429
0.04	5.19	0.0998	1.3426
0.05	5.18	0.0997	1.3425
0.06	5.14	0.0995	1.3423
0.08	5.07	0.0991	1.3422
	β-alanine+5wt% sucrose		
0.01	5.50	0.1012	1.3520
0.02	5.49	0.1011	1.3518
0.04	5.37	0.1006	1.3514
0.05	5.20	0.0998	1.3513
0.06	5.18	0.0997	1.3512
0.08	5.09	0.0992	1.3511
	β-alanine+10wt% sucrose		
0.01	5.32	0.1004	1.3432
0.02	5.29	0.1002	1.3430
0.04	5.22	0.0999	1.3426
0.05	5.17	0.0996	1.3424
0.06	5.11	0.0994	1.3423
0.08	5.08	0.0993	1.3421
	Phenyl alanine+5wt% sucrose		
0.01	5.62	0.1018	1.3520
0.02	5.52	0.1013	1.3518
0.04	5.45	0.1010	1.3514
0.05	5.43	0.1008	1.3512

Continued…

Conc mol dm^{-3}	Isothermal compressibility $\beta_T \times 10^{15}$	Co-efficient of thermal expansion $\alpha \times 10^3$	Heat capacity ratio $\gamma \times 10^5$
0.06	5.39	0.1007	1.3510
0.08	5.36	0.1005	1.3506
Phenyl alanine+10wt% sucrose			
0.01	5.45	0.1010	1.3430
0.02	5.28	0.1002	1.3429
0.04	5.25	0.1000	1.3424
0.05	5.22	0.0999	1.3424
0.06	5.12	0.0994	1.3422
0.08	5.09	0.0992	1.3419

4. CONCLUSION

The results of the study on the amino acids in aqueous sucrose solutions show that the increase in sound velocity is due to the increase in their mass. The isentropic compressibility (K_s) decreases with increase in the solute concentration which may be due to the occupation of the interstitial spaces of water by the solute molecules. The decrease in the relative association (R_A) values with increase in the concentration of the solutions suggests that the breaking up of the associated solvent molecules on addition of the solute takes place in all solvents. The variation of S_n^0 values with the amino acids predicts the degree of hard electrostrictive solvation, i.e., it represents the structural effect of the amino acid on the solvent in the solution. Specific ion-ion, ion-solvent and solvent-solvent interactions play a major role for explaining the acoustic parameters. However, any deviation from the usual behaviour is attributed to characteristic structural changes in the particular system.

5. REFERENCES

1. Palani R, Balakrishnan S, Arumugam G, *J. Physical Science*, 2011; 22:131–141.
2. Thirumaran S, Karthikeyan N, *Orient J Chem*, 2014; 30:133-148.
3. Das S, Dash UN, *J.Chem. pharm.research*, 2012; 4:754-762.
4. Das S, Dash UN, *Int. J. Pharm. Sci. Rev. Res.*, 2013; 21:212-220.
5. Robinson RA, Stokes RH. Electrolyte Solutions. London: Butterworths Scientific Publication; 1955, p30.
6. Dash UN, Supkar S, *Acoustic Letters*, 1992; 16:135-141.
7. Prakash, S. and Pandey, J.D., *J. Sci .Indus.Res.*, 1962, 21B, 593.
8. Wood AB.A Text Book of Sound. 3rd Edn. London:G. Bell;1960,51 and 577.
9. Wada Y, *J.Phys.Soc.Japan*, 1949; 4:280-283.
10. Jacobson B,*Chem. Physics*,1952; 6:927-928.
11. Nikam PS, Nikam N,Hassam M, Suryawanshi BS, *Asian J. Chem.*, 1994;6:237-245.
12. Suryanarayana CV, *J.Acoust.Soc.Ind.*, 1976;7:107-117.
13. Suryanarayana CV, *J. Acoust.Soc.Ind.*, 1979; 7:131-136.
14. Vigoureux P. Ultrasonics. London:Chapman and Hall Ltd.;1952, 109.
15. Ali A, Nain AK, *J. Pure Appl.Ultrason.*, 2000; 22:10-15.
16. Passinsky A, *Acta Physico. Chim.*, 1938;8:357-360.
17. Pandey JD, Dey R, Sanguri V, Chhabra J et al. *Pramana J. Physics*, 2005; 65: 535-540.
18. Hartmann B, *J.Acoust.Soc. America*, 1979; 65:1392-1396.
19. Pandey JD, Verma R, *J.Chem. Phys* ,2001;270:429-438.
20. Kannapan AN, Palani R, *Indian J. Pure Appl. Phys*, 2007; 45:573-579.
21. Sumathi T, Varalakshmi M, *Indian J. Pure Appl. Phys*, 2012; 50:105-109.
22. Mehra R, Vats S, *Int.J. Pharma and Bio Sc.*, 2010; 1: 523-530.
23. Dash UN, Roy GS, Mohanty S , *Indian J. Chem. Tech.*,2004;11:178-184.
24. Moharatha D, Talukdar M, Roy GS, Dash UN, *Researcher*, 2011; 3:6-12.
25. Eyring H, Kincaid JF, *J. Chem. Phys.*,1938;6:220–229.
26. Thirumaran S, Sabu KJ, *Indian J.Pure Appl.Phys.*, 2009; 47:87-96.
27. Prabhakar S, Rajagopal K, *J. Pure Appl.Ultrason*, 2005; 27:41-48.
28. Syal VK,Chauhan S,Gautam R,*Ultrasonics*,1998;36:619-623.
29. Singh S, Singh R, Prasad N, Prakash S, *Indian J.Pure Appl.Phys.*,1977;629-634.
30. Aminabhavi TM, Aralaguppi MI, Joshi SS, Khinnavar RS et al., *Indian J.Tech.*, 1992; 30:303-307.
31. Nain AK, Pal R, *J. Chem. Thermodyn.*, 2013; 64:172-181.
32. Baluja SH, Solanki A, Kachhadia N, *Russian J. Phys. Chem. A*, 2007; 81:742-746.
33. Ravichandran S, Ramanathan K, *Rasayan J. Chem*, 2010; 3:375-384.]
34. Manwar BG, Kavthia SH, Parsania PH, *J.Pure.Appl.Ultrason*, 2004; 26:49-57.