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STUDY OF INTERMOLECULAR INTERACTIONS OF AMINO ACIDS IN AQUEOUS GLUCOSE SOLUTION AT DIFFERENT TEMPERATURES

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ABSTRACT

The data for density (ρ), viscosity (η) and ultrasonic velocity (u) of solutions of amino acids (DL-2 amino-n butyric acid and L–leucine) with aqueous glucose were determined at different temperatures (303.15, 308.15, 313.15, 318.15 and 323.15) K. Hydration number (n_H) and interaction coefficients have been calculated from these data. Using these data various interaction parameters viz. adiabatic compressibility (βs), apparent molar compressibility(φ_k), limiting apparent molal compressibility, apparent molar volume(φ_v) and their corresponding constants (S_k, Sv) have been calculated. The viscosity A and B coefficients have been determined using Jones-Dole equation. Volumetric parameters indicate the interactions of saccharide with amino acids. These studies are being increasingly used as tools for investigation of the properties of pure components and the nature of intermolecular interactions between the constituents of liquid mixture. The results were interpreted in terms of solute-solute and solute-solvent interactions in the solutions.

KEYWORDS: Molecular Interaction, Apparent Molar Volumes, Apparent Molar Compressibility, Viscosity A and B-coefficient

Amino acids have been known to be important regulators of protein synthesis (Chalikian, 2003). As amino acids behave as zwitterions in aqueous solutions, their hydration and interaction with proteins have resemblances. The interpretation of behaviour of amino acids is helpful in understanding by their thermodynamic properties (Bhat *et al.*, 2009). Proteins are complex macromolecules so the direct study of these important protein–water interactions is difficult. The small amino acid molecules incorporate some of the structural features found in proteins and have been used as model compounds for specific aspects of proteins in aqueous solution (Franks, 1979; Lilley, 1988). Thus it is suitable for better understanding of the interactions occurring between amino acid molecules and the entities present in the living cell. Hydration of proteins is an important factor responsible for maintaining their native structures in aqueous solutions. The specific interactions of water with various functional groups on the protein, as well as other solvent–related effects, contribute to the formation of the stable folded structure of proteins in solutions (Hvidt and Westh, 1998). Although protein synthesis can be stimulated by several isolated amino acids (Kimball and Jefferson, 2010) leucine has a particularly potent effect. The initiation of mRNA translation is the major mechanism by which leucine stimulates protein synthesis (Hong and Layman 1984; Brambilla *et al.*,1998; Anthony *et al.*, 2000; Anthony *et al.*, 1999). Leucine is an essential amino acid for protein synthesis. It is a dietary amino acid with the capacity to directly stimulate myofibrillar muscle protein synthesis (Etzel, 2004). The carbon skeleton of leucine can be used to generate ATP. However, leucine can also regulate several cellular processes such as protein synthesis, tissue regeneration and metabolism. Leucine metabolism occurs in many tissues in the human body; however, most dietary leucine is metabolized within the liver, adipose tissue and muscle tissue. Adipose and muscle tissue use leucine in the formation of sterols and other compounds. Combined leucine use in these two tissues is seven times greater than in the liver. (Rosenthal *et al.*, 1974). DL-2-Aminobutyric acid has been widely used in the synthesis of antibiotics (Ondetti and Thomas, 1965), brain-permeable polo-like kinase-2 (Plk-2) inhibitors (Scharow *et. al.*, 2016) matrix metalloproteinase inhibitors (Behrends *et al.*, 2015) and antiproliferatives (Behrends *et al.*, 2015). The protein stability in solutions may be increased by addition of certain low molecular weight substances like carbohydrates, salts etc. In aqueous protein solutions, the amino acids residues of a polypeptide chain interact with each other and with the surrounding water through various non-covalent forces. However, understanding of the stabilization mechanism of proteins is still incomplete due to the complex structure of the biological micromolecules (Hvidt and Westh, 1998).

The study of carbohydrates has become a subject of increasing interest due to its biochemical, physical, multidimensional and industrially useful properties of these compounds. In addition to their importance to the

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food, pharmaceutical and chemical industries, the simple saccharides have received considerable attention for their ability to protect biological macromolecules. Carbohydrates located at cell surfaces, are important as receptors for the bioactive structures of hormones, enzymes, viruses, antibodies etc. Therefore, the study of saccharide-protein interactions is very important for biosynthesis, pharmacology and medicine. The properties of pure and mixed solutions are important in many areas of applied chemistry and are essential for understanding the chemistry of biological systems (Perrin and Armarego, 1980; Srivastava *et al.*, 2010; Gupta, 2022) and act as a vehicles for pharmaceuticals when introduce into living organisms. There are studies on volumetric and thermodynamic properties of amino acids in different liquid mixed solvents (Saksena 2009; Saksena 2010), but very few in aqueous amino acid-carbohydrate solutions (Gupta and Srivastava, 2019; Srivastava, 2010; Srivastava *et al.*, 2014). probably due to the complex nature of their interactions. In the present paper, the densities (ρ), speeds of sound (u) and viscosities (η) of solutions of amino acids (DL-2 amino-n butyric acid and L–leucine) with aqueous glucose were determined at different temperatures (303.15, 308.15, 313.15, 318.15 and 323.15) K. Adiabatic compressibility (βs), apparent molar compressibility(φ_k), limiting apparent molal compressibility, apparent molar volume(φ_v) and their corresponding constants (S_k, Sv) have been calculated. The viscosity A and B coefficients have been determined using Jones-Dole equation. All these parameters are discussed in terms of solute-solvent and solute- solute interactions occurring in the amino acids (DL-2 amino-n butyric acid and L–leucine), glucose and water systems at different temperatures (303.15, 308.15, 313.15, 318.15 and 323.15) K.

MATERIALS AND METHODS

The data for density (ρ), viscosity (η) and ultrasonic velocity (u) of solutions of amino acids (DL-2 amino-n butyric acid and L–leucine) with aqueous glucose were determined at different temperatures (303.15, 308.15, 313.15, 318.15 and 323.15) K. Deionized and doubly distilled water was used for the preparation of the solutions. Solutions were freshly prepared and kept in airtight bottles to minimize the absorption of atmospheric moisture. All the chemicals used were purified by standard procedure, discussed by Perrin and Armarego. DL-2 amino-n butyric acid and L–leucine were recrystallized from ethanol and water mixtures and dried over phosphorous pentaoxide in a desiccators for 72 h before use. Glucose (Merck) was used after drying over anhydrous $CaCl_2$ in a vacuum desiccators for 48 h at room temperature. The solutions were prepared freshly by mass using an electronic balance (model GR-202R, Japan) with a precision of ± (0.01 mg) in doubly distilled deionized and degassed water. A double stem calibrated pyknometer and Ubbelohde type suspended level viscometer has been used to determine the density and viscosity of solvent and solutions. The capillary with graduated marks had a uniform bore and could be closed by a well-fitting glass cap. The marks on the capillary were calibrated using triple distilled water. The reproducibility of density measurements was within ± 0.01 kg m^{-3}. The ultrasonic velocity of pure components and their mixtures were measured by fixed frequency interferometer of 2 MHz (Model F-05, Mittal Enterprises). The calibration of ultrasonic interferometer was done by measuring the velocity in AR grade benzene and carbon tetrachloride. Standard value of ultrasonic velocity for benzene and carbon tetrachloride were calculated from the literature (Lide, 1995) at different temperature. The maximum estimated error in ultrasonic velocity measurements has been found to be ± 0.1m/s. The temperature of the test liquids during the measurements was maintained by circulating water from an electronically controlled thermostatic water bath (JULABO, model ME-3, M/s Mittal Enterprises) covered with cotton jacket to avoid thermal dissipation. The viscosity was measured by Ubbelohde type suspended level viscometer with a water circulation jacket has been used to determine viscosity of solvent and solutions. At least four time flow measurements were performed for each composition and temperature, and the results were average. The viscometer was kept vertically in a transparent walled bath about 30 min to attain thermal equilibrium. The times of flow were recorded with a digital stopwatch with an accuracy of ±0.01 second. The temperature of the test liquids in every experiment of density, viscosity, ultrasonic velocity was maintained by circulating water through the jacket from an electronically controlled thermostatic water bath by keeping short distanced rubber tubing wrapped with cotton. A thermostatically controlled well-stirred water bath, whose temperature was controlled to ±0.01 K, was used for the density, viscosity, ultrasonic velocity measurements. Mixtures were prepared by weighing the liquids in specially designed ground glass stopped bottles, taking extreme precautions to minimize preferential evaporation. Fresh solutions in double distilled water have been prepared by the variation of stock solutions of sugar and amino acids keeping the total volume constant in air tight stopper volumetric flasks.

THEORY AND CALCULATIONS

The thermodynamical and acoustical parameters have been calculated using the following standard relations.

Adiabatic compressibility

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

The apparent molal compressibility has been calculated from the relation,

$$\varphi_k = \frac{1000}{m\,\rho 0}(\rho 0\beta - \rho\,\beta 0) + \left(\frac{\beta 0\, M}{\rho 0}\right) \quad (2)$$

where β, ρ and β0, ρ0 are the adiabatic compressibility and density of solution and solvent respectively, m is the molal concentration of the solute, and M is the molecular mass of the solute.

$$\varphi k = \varphi^0{}_k + S_k m^{0.5} \quad (3)$$

where $\varphi^0{}_k$ is the limiting apparent molal compressibility at infinite dilution and S_K is a constant. φk and S_K of equation (3) have been evaluated by least square method. The apparent molal volume φ_V has been calculated using the relation,

$$\varphi_v = \left(\frac{M}{\rho}\right) - \frac{1000\,(\rho - \rho 0)}{m\,\rho\,\rho 0} \quad (4)$$

The apparent molal volume φ_V has been found to differ with concentration according to Masson's empirical relation as

$$\varphi_v = \varphi^0{}_v + S_v m^{0.5} \quad (5)$$

where $\varphi^0{}_V$ is the limiting apparent molal volume at infinite dilution, m is the molal concentration of the solute and S_V is a constant and these values were determined by least square method. The viscosity A and B coefficients of glucose with amino acids in aqueous solutions were calculated from the Jones-Dole equation (Jones *et al.*, 1929).

$$\eta / \eta_0 = 1 + AC^{0.5} + BC \quad (6)$$

where, η and η_0 are the viscosities of the solution and solvent respectively. A is determined by the ionic attraction theory of Falkenhagen-Vernon and therefore also called Falkenhagen coefficient, B or Jones-Dole coefficient is an empirical constant determined by ion solvent interactions. The molal hydration number has been computed using the equation,

$$\text{Molal hydration number } n_H = \left(\frac{n_1}{n_2}\right)\left(1 - \frac{\beta}{\beta_0}\right) \quad (7)$$

$$\text{Molar refraction, } R_m = (n^2-1/n^2+2) \times V_m \quad (8)$$

$$\text{Rao's molar function } R = M(u^{1/3})/\rho \quad (9)$$

$$\text{Solvation no. } = M_2/(M_1(1- (\beta_s / \beta_0)(100-X)/X) \quad (10)$$

$$\text{Redlich- kister eqn. } Y^E = X_1(1-X_1) \sum A_k (2X_1-1)^k \quad (11)$$

$$Y^E = Yexp - Yid \quad (12)$$

where k is the number of estimated parameters and A_K, the polynomial coefficients were obtained by fitting the equation to the experimental results by least-squares regression method and Y may be any calculated physical parameter. An excess property of a solution is defined as the difference between the actual mixture property and that which would be obtained for an ideal solution at the same temperature, pressure and composition. So the excess molar properties represent the deviation from ideal behavior of the mixtures. The excess functions are found to be very sensitive towards mutual interactions between the component molecules of the binary mixtures. The sign and the extent of deviation of the functions from ideality depend on the strength of interactions between unlike molecules. In order to study the non-ideality of the liquid mixtures excess parameters (Y^E) of all the acoustic parameter were computed where X_1 is the mole fraction of the amino acid n_1 = no. of moles of solvent, n_2 = no. of moles of solute, M_{eff} = $M_1W_1+M_2W_2$, where M is effective molecular weight, 'K' is a dimensionless constant independent of temperature and nature of liquids and its value is 4.281×10^9, R is gas constant and T is the absolute temperature.

RESULTS AND DISCUSSION

The experimental data of density ρ, viscosity η and ultrasonic velocity u, for DL-2 amino-n butyric acid and glucose as system[i]; L–leucine and glucose as system[ii] in aqueous solution at different temperatures (303.15, 308.15, 313.15, 318.15 and 323.15) K are reported in Table (1-3). The results were discussed in terms of complex amino acid-water-saccharide interactions. Various thermodynamical and acoustical parameters like adiabatic compressibility (β), hydration number (nH), apparent molar compressibility (φk), apparent molar volume (φv), limiting apparent molal compressibility and their constants (S_K, S_V), viscosity A and B coefficient of Jones Dole equation (Jonnes and Dole,1929) were calculated from the density, viscosity and ultrasonic velocity data and the results are presented in Tables (4-8). All these parameters are discussed in terms of solute-solvent and solute-solute interactions occurring in the amino acids and saccharide solutions. Table (1) reveals the experimental data of density which shows that the values increase with increase in molal

concentrations of amino acids. This increasing behaviour suggests the moderate strong electrolytic nature in which the solute tends to attract the solvent molecules. The values of ultrasonic velocity (Table 3) increases with increase in the concentrations of DL-2 amino-n butyric acid in aqueous glucose solution and L–leucine in aqueous glucose solution showing that the molecular association is responsible for the increase in ultrasonic velocity in these mixtures. The increase in ultrasonic velocity may be attributed to the cohesion brought about by the ionic hydration in these solutions.

The data calculated for hydration number n_H are summarised in Table (4). The positive values of hydration number (Table 4) indicates an appreciable solvation behaviour of solutes (CRC handbook, 1995-1996). This behaviour supports the structure promoting nature of the solutes as well as the presence of a appreciable dipole-dipole interaction between solute and water molecules. This behaviour also suggests that the compressibility of the solution will be less than that of the solvent. As a result, solutes will gain mobility and have more probability of contacting solvent molecules. This may enhance the interaction between solute and solvent molecules. The increasing trend of hydration number shows the increase in solute-co-solute interaction with the increase in glucose concentration. This behaviour leads to the reduction in the electrostriction showing that glucose has a dehydration effect on the amino acids (Cerdeiriña *et al.*, 1997). The values of adiabatic compressibility, βs, summarised in (Table 5), decrease with increase in concentration of solute (DL-2 amino-n butyric acid and L–leucine) as well as increase in concentration of glucose in water. The decrease in adiabatic compressibility shows that there is enhanced molecular associations in these system on increase in solute content, as the new entities become compact and less compressible. It is attributed to the influence of the electrostatic field of ammonium ions and carboxylate ions on the surrounding solvent molecules (Iqbal *et al.*, 1987). The magnitudes of adiabatic compressibility values are larger in DL-2 amino-n butyric acid than L–leucine. The larger adiabatic compressibility values show molecular interaction are greater in aspartic acid than that of other amino acid. Amino acid molecules of neutral solution exist in the dipolar form and thus have stronger interaction with the surrounding water molecules (Ronero *et al.*, 1999). The increasing electrostrictive compression of water around the molecules results in decrease in the compressibility of solutions. The structural arrangement of molecule results in decreasing adiabatic compressibility by showing intermolecular interactions as reported in Table (5).

Table 1: Densities (ρ) of systems at different temperature (K)

C(mol.m^{-3})/T(K)	303.15	308.15	313.15	318.15	323.15
	ρ x10^{-2}(kg m^{-3})				
0.000	9.974	9.944	9.944	9.974	9.944
System [i]					
0.006	9.939	9.890	9.879	9.834	9.826
0.007	9.940	9.890	9.879	9.857	9.841
0.008	9.955	9.945	9.885	9.859	9.856
0.011	9.957	9.947	9.916	9.893	9.877
0.018	10.100	9.988	9.957	9.952	9.899
0.042	10.120	10.010	9.960	9.957	9.903
System [ii]					
0.006	9.859	9.785	9.779	9.779	9.771
0.007	9.859	9.785	9.779	9.779	9.771
0.008	10.061	10.035	10.010	10.008	9.988
0.011	10.096	10.051	10.041	10.015	9.989
0.018	10.155	10.129	10.092	10.080	10.030
0.042	10.290	10.200	10.096	10.091	10.043

Apparent molar compressibility data are summarized as Table (6) for the interaction between the amino acids (DL-2 amino-n butyric acid and L–leucine) and glucose in aqueous medium. It is well known that solutes causing electrostriction lead to decrease in the compressibility of the solution. This is reflected by the values of φk of amino acids in aqueous glucose solutions. The apparent molar volume, φv and φk values (Tables 7, Table 6) with respect to the solute concentration in the systems studied indicates an existence of solute-solvent interaction (Gavin and Hedwig, 1991). Appreciable positive values of φk for the systems clear that the ionic-hydrophilic interactions are dominating over the ionic-hydrophobic interactions. Therefore the mutual overlap of the hydration spheres of solute and co-solute molecules will lead to an increase in the magnitude of hydrogen

bonding interactions between amino acid and –OH groups of saccharide molecules. It is observed from Table (2) that the values of viscosity increases with increasing concentrations of amino acids (DL-2 amino-n butyric acid and L–leucine) in aqueous glucose solution. This increasing trend indicates the existence of molecular interaction occurring in these systems. In order to have more clear picture, viscosity B-coefficient has also been obtained. From Table (8), it is observed the values of A and B are negative and positive in all the studied systems. Hydrophilic solutes often show negative compressibility that is introduced by them in water structure which is also indicated by the smaller magnitude of A values. Coefficient B is known as measure of order or disorder introduced by the solute into the solvent. It is also a measure of solute-solvent interaction and the relative size of the solute and solvent molecules (Yan *et al.*, 2004; Stokes *et al.*, 1965). The behaviour of B-coefficient in systems suggest the existence of strong ion-solvent interactions. The values of Sv provides information regarding solute-solvent interaction and S_K that of solute-solute interaction in the solution. The negative values of Sv provides the existence of solute-solvent interaction. This behaviour shows that the existence of ion-solute or solute-solute interaction in all the systems studied. In the studied systems, the positive values of S_K parameter represents the solute-solute interaction.

Table 2: Viscosities (η) of systems at different temperature (K)

C(mol.m^{-3})/T(K)	303.15	308.15	313.15	318.15	323.15
	η x10^{-2}(kgm^{-1}s^{-1})				
0	8.544	7.895	7.451	6.393	6.272
System [i]					
0.006	7.664	7.115	6.729	6.331	6.108
0.007	7.668	7.168	6.796	6.370	6.119
0.008	7.690	7.443	6.996	6.400	6.125
0.011	7.717	7.499	7.195	6.430	6.171
0.018	7.766	7.523	7.282	6.435	6.183
0.042	7.824	7.526	7.378	6.485	6.211
System [ii]					
0.006	7.273	6.458	6.417	5.913	5.626
0.007	7.273	6.458	6.417	5.913	5.626
0.008	7.299	6.473	6.468	5.966	5.627
0.011	7.454	6.617	6.483	5.967	5.647
0.018	8.110	6.714	6.692	6.118	5.746
0.042	8.545	7.207	6.774	6.174	5.755

Table 3: Ultrasonic velocities (u) of systems at different temperature (K)

C(mol.m^{-3})/T(K)	303.15	308.15	313.15	318.15	323.15
	u x10^{-2}(kg m^{-3})				
0	1116.5	1118.0	1080.0	1062.3	1012.5
System [i]					
0.006	1130.5	1116.3	1099.5	1074.3	1024.5
0.007	1167.0	1133.4	1116.3	1091.5	1044.0
0.008	1216.3	1215.3	1213.8	1145.0	1136.5
0.011	1250.3	1234.5	1232.0	1224.5	1220.3
0.018	1261.5	1257.0	1243.0	1237.5	1223.3
0.042	1459.3	1398.0	1292.5	1256.5	1246.5
System [ii]					
0.006	1130.5	1116.3	1099.5	1074.3	1024.5
0.007	1130.5	1116.3	1099.5	1074.3	1024.5
0.008	1167.0	1133.4	1116.3	1091.5	1044.0
0.011	1216.3	1215.3	1213.8	1145.0	1136.5
0.018	1250.3	1234.5	1232.0	1229.8	1220.3
0.042	1261.5	1257.0	1243.0	1237.5	1221.0

Table 4: Hydration number (n_H) of systems at different temperature (K)

C(mol.m^{-3})/T(K)	303.15	308.15	313.15	318.15	323.15
	u x10^{-2}(kg m^{-3})				
System [i]		n_H			
10.0	0.927	1.079	1.229	1.270	1.456
12.5	0.944	1.087	1.233	1.273	1.451
16.5	1.018	1.155	1.302	1.343	1.525
25.0	1.083	1.216	1.365	1.405	1.591
50.0	1.165	1.299	1.454	1.488	1.678
100.0	1.461	1.629	1.802	1.837	2.060
200.0	1.529	1.694	1.873	1.918	2.128
System [ii]					
10.0	0.951	1.082	1.179	1.190	1.391
12.5	0.950	1.070	1.162	1.174	1.361
16.5	1.377	1.160	1.253	1.267	1.460
25.0	1.430	1.226	1.322	1.329	1.523
50.0	1.522	1.315	1.412	1.427	1.622
100.0	1.854	1.608	1.717	1.735	1.966
200.0	1.917	1.684	1.795	1.806	2.032

Table 5: Adiabatic compressibility (β_s) of systems at different temperature (K)

C(mol.m^{-3})/T(K)	303.15	308.15	313.15	318.15	323.15
	β_s x10^{10}(kg^{-1}ms^2)				
System [i]					
10.0	4.716	4.739	4.769	4.784	4.828
12.5	4.639	4.669	4.693	4.706	4.751
16.5	4.555	4.598	4.624	4.638	4.675
25.0	4.479	4.531	4.553	4.568	4.601
50.0	4.404	4.457	4.472	4.501	4.534
100.0	4.327	4.365	4.396	4.433	4.469
200.0	4.231	4.267	4.283	4.301	4.346
System [ii]					
10.0	4.699	4.766	4.908	4.990	5.028
12.5	4.622	4.694	4.834	4.910	4.953
16.5	3.947	4.620	4.759	4.834	4.872
25.0	3.889	4.528	4.659	4.744	4.780
50.0	3.834	4.460	4.590	4.660	4.702
100.0	3.765	4.387	4.524	4.592	4.626
200.0	3.677	4.274	4.399	4.474	4.508

Table 6: Ultrasonic velocities (u) of systems at different temperature (K)

C(mol.m^{-3})/T(K)	303.15	308.15	313.15	318.15	323.15
System [i]	φ_k x10^5				
0.006	3.860	3.580	2.826	2.931	3.804
0.007	3.010	3.018	2.321	2.359	3.080
0.008	1.807	1.419	0.740	1.165	1.147
0.011	1.083	0.895	0.390	0.238	0.194
0.018	0.603	0.470	0.188	0.071	0.101
0.042	-0.008	-0.003	-0.001	-0.004	0.002
System [ii]					
0.006	3.565	3.313	2.654	2.703	3.643
0.007	1.465	1.493	1.170	1.180	1.511
0.008	0.651	0.517	0.248	0.392	0.393
0.011	0.378	0.319	0.125	0.058	0.058
0.018	0.128	0.095	0.033	0.009	0.017
0.042	-0.007	-0.006	-0.005	-0.006	-0.004

Table 7: φ_v of systems at different temperature (K)

C(mol.m^{-3})/T(K)	303.15	308.15	313.15	318.15	323.15
System [i]	φ_v x10^5				
10.0	0.131	0.131	0.132	0.132	0.132
12.5	0.131	0.131	0.132	0.132	0.132
16.5	0.131	0.131	0.132	0.132	0.132
25.0	0.131	0.132	0.132	0.132	0.132
50.0	0.131	0.132	0.132	0.132	0.132
100.0	0.131	0.132	0.132	0.132	0.133
200.0	0.131	0.132	0.132	0.132	0.132
System [ii]					
10.0	0.130	0.130	0.131	0.131	0.131
12.5	0.130	0.131	0.131	0.131	0.131
16.5	0.130	0.131	0.131	0.131	0.132
25.0	0.131	0.131	0.131	0.131	0.132
50.0	0.131	0.131	0.132	0.132	0.132
100.0	0.131	0.132	0.132	0.132	0.132
200.0	0.131	0.132	0.132	0.132	0.132

Table 8: Various constants for systems at different temperature (K)

C(mol.m^{-3})/T(K)	303.15	308.15	313.15	318.15	323.15
	Sv x 10^5(Masson's)				
System [i]	5.418	3.863	3.265	4.872	5.377
System [ii]	10.845	9.998	10.582	11.478	11.346
	□□□□□^0_k x 10^{10}				
System [i]	9.139	8.877	8.999	9.002	9.552
System [ii]	7.240	7.334	7.558	7.733	7.834
	S_k x 10^9				
System [i]	0.109	-0.066	-0.079	0.123	0.550
System [ii]	-0.223	-0.898	-0.871	-0.817	-0.853
	B x 10^4(Jones-Dole)				
System [i]	-8.474	1.107	-14.689	-38.726	-24.586
System [ii]	-13.962	-4.119	-21.969	-18.742	-36.260
	A(Jones-Dole) Falkenhagen coefficient				
System [i]	-0.847	0.111	-1.469	-3.873	-2.459
System [ii]	-1.396	-0.412	-2.197	-1.874	-3.626
	B(Feaking constant)				
System [i]	0.102	0.102	0.103	0.103	0.103
System [ii]	0.101	0.101	0.101	0.101	0.102

CONCLUSION

Density, ρ, viscosity, η, and ultrasonic velocity, u, measurements have been carried out on amino acids; DL-2 amino-n butyric acid and glucose; L–leucine and glucose as systems in aqueous solution at temperatures (303.15, 308.15, 313.15, 318.15 and 323.15) K solution. These measurements have been performed to evaluate some important parameters, viz, adiabatic compressibility (β), molar hydration number (n_H), apparent molar compressibility(φ_k), apparent molar volume(φ_v), limiting apparent molar volume, viscosity A and B-coefficients of Jones–Dole equation, variation of B with temperature. These parameters have been interpreted in terms of solute-solute and solute-solvent interactions and structure making or breaking ability of solutes in the given solution. The acoustical interpretations in biological medium would be interesting to discuss behaviour with respect to concentrations and temperatures.

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