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Research Article

ULTRASONIC AND VISCOMETRIC STUDIES OF SOME ~ AMINO ACIDS IN AQUEOUS-DIOXANE SOLVENT SYSTEM

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Abstract

Ultrasonic and Viscometric studies of α amino acids have been carried out in aqueous dioxane systems at different percentage 20, 30, 40, 50, 60 and 70% respectively. Various Acoustic parameters such as Apparent molar Compressibility ($\emptyset k$), Apparent Molar Volume ($\emptyset v$),Relative association & Relative Viscosity (n_r) & Free path length (L_F) have been determined. The results are discussed in the terms of nature and extent of molecular interactions in these mixtures. All the result shows that there is strong interaction between the α-amino acids and solvent which is depends on structure of α-amino acids and percentage of dioxane in solution.

Keywords: Ultrasonic Velocities, Viscosity, Apparent molal volume ($\emptyset v$), Relative viscosity (n_r), free path length (L_F) .

Introduction

Ultrasonic investigation leads to a better understanding of the nature of interactions between the solute and solvent [1, 2]. The study of molecular interactions provides valuable information regarding molecular association, internal structure, and complex formation[3, 4].

Therefore the useful approach is to study simpler model compounds such as α- amino acids[5, 6.] Amino acids are the fundamental substance for building proteins. Ultrasonic studies of some amino acids are of great importance to obtain about various types of interactions in solutions and have been used to understand the factors responsible for the thermodynamic stability of proteins and their unfolding behaviour. The investigation of volumetric and thermodynamic properties of amino acids and mixed aqueous solvents has been the area of interest of a number of researchers[7, 8]. Mixed aqueous solvents are used extensively in chemistry and other field to control factors like stability, reactivity and solubility of system. 1,4- dioxane is a widely used solvent because it is non-bounded cyclic either, miscible with water in proportion with boiling point close to that of water. Moreover, its dipole moment is very less (0.45 D) and dielectric constant can be varied cover range (2.2-7.8) in its mixtures with water.

Materials and Methods

Amino acids used of analytical reagent (AR) grade with minimum assay of 99.9% and 1,4 dioxane were obtained E-Merck, Germany and S.D Fine chemicals. Water used in the experiments was deionised and distilled and degassed prior to making solutions. Aqueous solutions of 1,4 dioxane were prepared by mass and used on the day they were prepared. Solution of amino acids in the concentration range of 0.05M in different percentages solvent solutions. The density was determined using a specific gravity bottle on a monopan balance capable of reading accurately up to fourth place of chemical. Viscosity was measured with the help of calibrated Ostwald's Viscometer. Ultrasonic velocity measurements have been performed by the variable path Ultrasonic interferometer having frequency of ZMH_z(Mittal Enterprises, New Delhi) with an estimated error has been found to be ±0.002% which is accuracy 0.05%. The cell of ultrasonic interferometer was filled fully with the solution and the needle of ammeter was adjusted in the range of 10 to 50 with the help of adjustment Knob. It was warm for 10 minutes so that the range remains steady. Micrometer reading was noted. Movement of screw was continued to five deflections. After returning back to original position micrometer screw reading was noted. The difference between these

two readings gives the distance travelled by screw for getting maxima. From this distance required through which micrometer screw should move for one maxima was calculated just by dividing it by five and same procedure was repeated many times to get accurate value of 'D'[The distance travelled by screw to get 1 maxima] again cell was made empty. It was then washed with distilled water dried and filled with the same solution. The same procedure given earlier was repeated and the observations are noted.

Theory and Calculations:

Using the measured data the following mathematical equations was used to calculate ultrasonic velocity (μ) Apparent molal volume ($\emptyset v$)Isentropic Compressiblity (ßs), Apparent moral Compressiblity ($\emptyset k$). And other parameters have been calculated using the standard relations. 'D' mentioned above is the distance travelled by micrometer Screw to get maxima in ammeter. From this 'D' value wave length of ultrasonic wave was calculated using this equation

2D= Wave Length.

Where, D is the distance in mm.

The ultrasonic velocity was calculated using the expression

$$\mu = Wave\ length \times Frequency$$

Where μ is Velocity m/s

The partial volume ($\emptyset v$) is calculated in order to predict the solute solvent interaction.

The Apparent molal volume data are analysed in terms of Masson equation as

$$(\emptyset v) = (\emptyset^{\circ} v) + S_v\, m$$

Where, m is molarity and S_v is a constant and these values were determined by least square method.

Isentropic Compressiblity ($ß_S$) can be calculated from following equation.

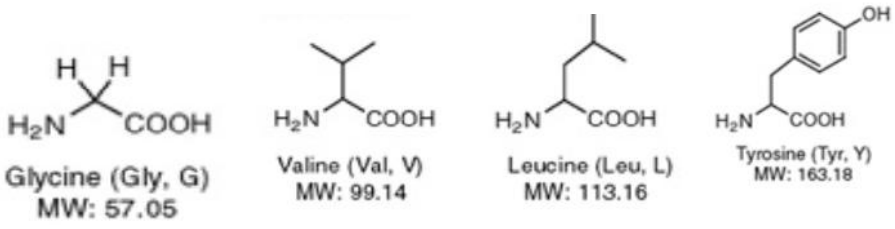
$ß_S = 1/ (U^2\ sds)$

$ß_0 = 1/ (U^2 odo)$

Apparent molal compressibility is a negative value of ratio of partial change in apparent molal volume per unit pressure which can be further simplified as

$$\emptyset k = \emptyset v / \delta p / T.$$

Structure of various ~-amino acids:



Results and Discussion

Variation in acoustic parameter for pure solution.

Acoustic Parameter	Glycine	Valine	Leucine	Tyrosine
Density/(gm/cm^3)	1.2887	1.3013	1.3012	1.3067
Viscosity (n) (cm/s)	0.9589	0.9735	0.9978	1.0153
Isentrophic Compressibility ßs	0.1506	0.1525	0.1493	0.146
Apparent molal Compressibility $\emptyset K\ m^3\ mole^{-1} bar^{-1}$	252.003	264.29	214.791	161.488
Apparent molal volume $\emptyset v\ (cm^3\ mole^{-1})$	197.887	79.3883	91.22	64.5097
Relative Association RA	0.3457	0.353	0.3492	0.3475
Specific Acoustic Impedance Z (m.sec^{-1} gm.cm^{-3})	29.2475	29.2024	29.519	29.9116
Relative Viscosity n_r (m/sec)	0.9586	0.9735	0.9978	1.0153
Free Path Length L_F A^o	210.849	384.153	383.99	164.183

Variation in acoustic parameter of 20% Dioxane- Water Mixture

Acoustic Parameter	Glycine	Valine	Leucine	Tyrosine
Density/(gm/cm^3)	0.9182	1.0617	0.9641	0.9523
Viscosity (n) (cm/s)	0.016	0.0186	0.0177	0.0161
Isentrophic Compressibility ßs	0.2096	0.1638	0.1986	0.1995
Apparent molal Compressibility $\emptyset K\ cm^3\ mole^{-1}bar^{-1}$	2548.74	1070.78	2113.99	2194.54
Apparent molal volume $\emptyset v\ (cm^3\ mole^{-1})$	5110.32	4705.48	5971.98	5458.56
Relative Association (RA)	0.233	0.2562	0.244	0.2401
Specific Acoustic Impedance Z (m.sec^{-1} gm.cm^{-3})	20.9266	25.4542	22.0316	21.8467
Relative Viscosity n_r (m/sec)	0.7378	0.831	0.8177	0.7439
Free Path Length L_F A^o	162.283	295.538	313.858	120.295

Variation in acoustic parameter of 30% Dioxane water mixture

Acoustic Parameter	Glycine	Valine	Leucine	Tyrosine
Density/(gm/cm^3)	0.9632	1.0447	0.9647	0.9713
Viscosity (n) (cm/s)	0.0187	0.0209	0.0197	0.0174
Isentrophic Compressibility ßs	0.1925	0.1717	0.1891	0.1957
Apparent molal Compressibility $\emptyset K\ m^3\ mole^{-1}bar^{-1}$)	2010.77	1276.72	1911.62	2036.83
Apparent molal volume $\emptyset v\ (cm^3\ mole^{-1})$	5110.32	4705.48	5971.98	5458.56
Relative Association (RA)	0.2355	0.2589	0.238	0.2449
Specific Acoustic Impedance Z (m.sec^{-1} gm.cm^{-3})	22.4301	24.682	22.6117	22.2816
Relative Viscosity nr (m/sec)	0.8621	0.9542	0.9116	0.8031
Free Path Length L_F A^o	189.60	332.694	349.918	129.844

Variation in acoustic parameter of 40% Dioxane water mixture

Acoustic Parameter	Glycine	Valine	Leucine	Tyrosine
Density/(gm/cm^3)	1.0042	1.0271	0.9654	0.9903
Viscosity (n) (cm/s)	0.0214	0.0233	0.0218	0.0187
Isentrophic Compressibility ßs	0.1754	0.1796	0.1794	0.192
Apparent molal Compressibility $\emptyset K\ m^3\ mole^{-1}bar^{-1}$	1472.8	1482.67	1709.25	1879.13
Apparent molal volume $\emptyset v\ (cm^3\ mole^{-1})$	5110.32	4705.48	5971.98	5458.56
Relative Association (RA)	0.2438	0.2507	0.2324	0.2498
Specific Acoustic Impedance Z (m.sec^{-1} gm.cm^{-3})	23.927	23.909	23.191	22.716
Relative Viscosity nr (m/sec)	0.9862	1.0775	1.0056	0.862
Free Path Length L_F A^o	216.92	369.851	385.979	139.393

Variation in acoustic parameter of 50% Dioxane water mixture

Acoustic Parameter	Glycine	Valine	Leucine	Tyrosine
Density/(gm/cm^3)	1.0045	1.0198	0.9661	1.0093
Viscocity (n) (cm/s)	0.0241	0.0257	0.0239	0.0218
Isentrophic Compressibility ßs	0.1583	0.1875	0.1697	0.189
Apparent molal Compressibility $\emptyset K\ m^3\ mole^{-1} bar^{-1}$	934.83	1688.62	1506.88	1721.43
Apparent molal volume $\emptyset\ v\ (cm^3\ mole^{-1}$	5110.32	4705.48	5971.98	5458.56
Relative Association (R_A)	0.2521	0.2425	0.2281	0.2547
Specific Acoustic Impedance Z (m.sec^{-1} gm.cm^{-3})	25.423	23.136	23.771	23.151
Relative Viscosity nr (m/sec)	1.1103	1.2008	1.0996	0.921
Free Path Length L_F A^o	244.24	467.008	422.04	148.942

Variation in acoustic parameter of 60% Dioxane water mixture

Acoustic Parameter	Glycine	Valine	Leucine	Tyrosine
Density/(gm/cm^3)	1.0048	1.0125	0.9667	1.0283
Viscosity (n) (cm/s)	0.0268	0.284	0.0260	0.0249
Isentrophic Compressibility ßs	0.1412	0.1954	0.1593	0.186
Apparent molal Compressibility $\emptyset K\ m^3\ mole^{-1} bar^{-1}$	396.86	1893.57	1304.51	1563.73
Apparent molal volume $\emptyset\ v\ (cm^3\ mole^{-1})$	5110.32	4705.48	5971.98	5458.56
Relative Association (R_A)	0.2604	0.2343	0.2238	0.2638
Specific Acoustic Impedance Z (m.sec^{-1} gm.cm^{-3})	27.372	22.363	24.351	23.586
Relative Viscosity nr (m/sec)	1.2344	1.3241	1.1936	0.980
Free Path Length L_F A^o	271.56	564.165	458.101	158.491

Variation in acoustic parameter of 70% Dioxane water mixture

Acoustic Parameter	Glycine	Valine	Leucine	Tyrosine
Density/(gm/cm^3)	1.0051	1.0052	0.9674	1.0473
Viscosity (n) (cm/s)	0.0295	0.0311	0.0281	0.0280
Isentrophic Compressibility ßs	0.1241	0.2033	0.1496	0.183
Apparent molal Compressibility $\emptyset K\ m^3\ mole^{-1} bar^{-1}$	198.68	2098.52	1102.14	1406.03
Apparent molal volume $\emptyset\ v\ (cm^3\ mole^{-1})$	5110.32	4705.48	5971.98	5458.56
Relative Association (R_A)	0.2687	0.2267	0.2195	0.2729
Specific Acoustic Impedance Z (m.sec^{-1} gm.cm^{-3})	29.921	21.591	24.931	24.021
Relative Viscosity nr (m/sec)	1.3585	1.4475	1.2876	1.039
Free Path Length L_F A^o	298.88	661.322	498.162	168.04

From these data, for density, viscosity and some acoustical parameters of some α-amino acids in aqueous – dioxane solvent systems have been calculated and studied to explain the intermolecular interaction of ionic, dipolar and hydrophobic interactions are operating between amino acids and aqueous – dioxane [9]. The observation shows that increase in concentration of solute increases the density and viscosity which is due to presence of more number of hydrated solute molecules across the fluid stream lines[10]. Apparent molal Compressibility $\emptyset K$ and Apparent molal volume $\emptyset v$ regularly decreases from Glycine to Tyrosine which indicates that structure of anion is prime factor in determination of these parameters.[11]The regular increases in Isentrophic Compressibility ßs value of these electrolytes are indicative of enhancement in interaction by forming hydrogen bond with solvent i.e., water induced ion-ion interaction.[12-17] Relative Association (R_A) also support the stronger ion-ion interaction. The Free Path Length (L_F) goes on increasing for Glycine, Valine, Leucine which support the lowering of solute-solvent interaction but for Tyrosine Free Path Length (L_F) suddenly decreases which may be due to of phenolic OH group of Tyrosine with solvent. It is concluded that here is a significant interactions between solute and solvent molecules. All the results were interpreted in the light of ion -ion and ion – solvent interactions and of structural effect of solutes in solutions.

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