ULTRASONIC STUDIES OF SOME WATER SOLUBLE AMINO ACIDS

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Abstract

The ultrasonic method plays an important role in understanding the physic-co-chemical behavior of liquid. The velocity gives information about the bonding between the molecule and formation of complexes at various temperatures through molecular interactions. Various workers have studied the acoustical properties of binary liquid mixtures, non-aqueous solutions aqueous solution and electrolytes. However, little work has been done for the solutions of drugs. In the present research work, the acoustical property of ultrasonic studies of amino acids at different temperatures and at different concentrations has been studied. In most of the chemical and industrial processes, the provide a wide range of mixtures of two or more components in varying proportions so as to permit continuous adjustments of desired properties of the medium. Ultrasonic velocity together with density and viscosity data furnished wealth of information about the interaction between ion, dipoles, hydrogen bonding, multipolar and dispersive forces. The liquid mixtures are of interest to organic chemists who want to know about the types of bond, type of molecular interaction, etc. further, the values of ultrasonic velocity, density, viscosity and adiabatic compressibility as a function of concentration will be of much help in providing such information.

Keywords: Ultrasonic velocity, Adiabatic Compressibility, Solvation number, Solute – Solvent interaction, free length.

Introduction

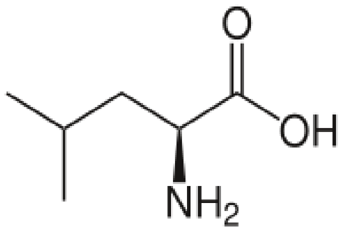
Ultrasonic study of liquid is useful technique for understanding its physicochemical properties. Ultrasonic measurements are extensively used to study the molecular interaction in pure liquids mixture an ionic interaction in solutions comprising of either single or mixed solute [1]. The Dielectric [2] and ultrasonic studies [3] have provided enormous data in precisely understanding the molecular interaction and structural behavior of molecular and their mixtures. Ultrasonic waves have been used by many scientist of investigate the nature of molecular interaction and physicochemical behavior of pure, binary and ternary liquid mixtures [4]. Mixed solvent rather than single pure liquids are practically important. In most of the chemical and industrial processes, the provide a wide range of mixtures of two or more components in varying proportions so as to permit continuous adjustments of desired properties of the medium. Ultrasonic velocity together with density and viscosity data furnished wealth of information about the interaction between ion, dipoles, hydrogen bonding, multipolar and dispersive forces. The liquid mixtures are of interest to organic chemists who want to know about the types of bond, type of molecular interaction, etc. further, the values of ultrasonic velocity, density, viscosity and adiabatic compressibility as a function of concentration will be of much help in providing such information. Twenty percent of the human body is made up of protein. Protein plays a crucial role in almost all biological processes and amino acids are the building blocks of it. A large proportion of our cells, muscles and tissue are made up of amino acids, meaning they carry out many important bodily functions, such as giving cells their structure. They also play a key role in the transport and the storage of nutrients. Amino acids have an influence on the function of organs, glands, tendons and arteries. They are furthermore essential for healing wounds and repairing tissue, especially in the muscles, bones, skin and hair as well as for the removal of all kinds of waste deposits produced in connection with the metabolism. The importance of amino acids for human well-being is on the increase Meirion Jones, a well-known BBC journalist, reported that contrary to years ago, many doctors have now confirmed that a supply of amino acids (also by way of nutritional supplements) can have positive effects. Jones and Erdmann explain the changes in medical opinion in the following way: “Unfortunately, in the real world countless factors are working to prevent our bodies from receiving a full and balanced supply of these all-important substances. Among these factors are the pollution caused by burning fossil-fuels, the hormones fed to cattle, the intensive use of fertilizers in agriculture, and even habits such as smoking and drinking, all of which can prevent our bodies from fully using what we eat. Worse still is the amount of nutrition that is lost from our food through processing before we actually get to eat it...By providing the body with optimal nutrition, amino acids help to replace what is lost and, in doing so, promote well-being and vitality. A recent study from Germany carried out by the DAK has revealed that older people in particular are more prone to suffering from malnutrition. “If the body is lacking in the minimum energy and nutrients, the body cannot carry out its bodily and mental functions. Without the necessary vitamins, proteins (amino acids), trace elements and minerals, there is a risk of debilities and metabolic disorders which can have serious consequences. Amino acids are the building blocks of protein and also muscle tissue. And they also play a major part in physiological processes relating to our energy, recovery, mood, brain function, muscle and strength gains, and also in our quest for fat loss. There are 23 amino acids and 9 of these are classed as essential or indispensable amino acids (IAA) that must be obtained from our nutritional intake. The others are termed dispensable amino acids (DAA) or non-essential due to the body being able to synthesize them from other amino acids

Experimental Method

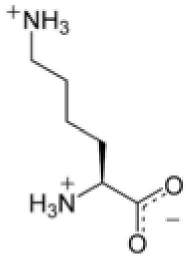
The chemicals used in this work were L-Leucine, L- Lysine mono hydrochloride, β-Phenyla nine, and DL- Threonine. All the chemicals are of G.R grade HI media Laboratories. They are taken without further purification. Double distilled water was taken as a solvent. The specifications of the chemicals used in this work are given in Table 1.The ultrasonic velocity in the liquid mixtures have been measured using an ultrasonic Interferometer (Mittal type -82, New Delhi, India) working at 2 MHz frequency with accuracy ±0.1 ms-1. The Interferometer is a fixed frequency variable path type. Ultrasound of constant Frequency is generated at the bottom of the cylindrical sample cell using quartz crystal and is sent into the medium under study. The propagated waves after getting reflected at the reflector Surface held at the top of the cell, again travels back through the same medium. These two Waves form stationary wave pattern and hence nodes and antinodes are formed in the medium. A fine micrometer screw is provided in the set up that allows for finer movements of the Reflector plate in the medium. Thus moving the reflector plate for a fixed number of antinodes (Or node) positions, the distance moved for a known number of waves can be known. Use of Frequency with these data will yield the sound velocity in the medium. The density and Viscosity are measured using a density bottle and an Ostwald's viscometer of accuracy of ±0.1 kgm^{-3} and 0.001 $mNsm^{-2}$ respectively. The values of density, viscosity and velocity of pure Samples are agreed well with the standard reference values.

The solutes chosen are

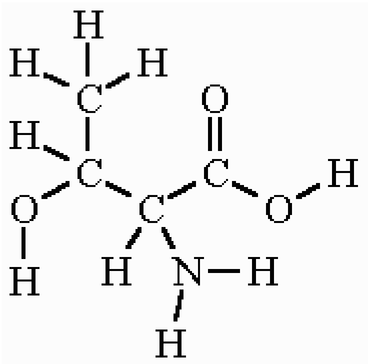
1. Leucin



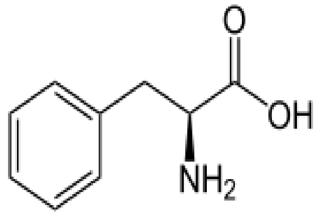
2. Lycine



3. Threonine



4. Phenylalanine



Measurement technique

Measurement of density

Density measurements were made by Density bottle. The accuracy in density measurement was found to be ±0.0001g. To get the accurate results, three sets of density measurements were done. Weighing was made on digital balance (±0.0001g). For each measurement, the solution was kept for sufficient time so as to maintain the required temperature.

Measurement of Ultrasonic velocity

For ultrasonic velocity measurements Ultrasonic Interferometer is used. Ultrasonic interferometer is a simple device which yields accurate and consistent data, from which one can determine the velocity of ultrasonic sound in a liquid medium. In an ultrasonic interferometer, the ultrasonic waves are produced by the piezoelectric method. In a fixed frequency variable path interferometer, the wavelength of the sound in an experimental liquid medium is measured, and from this one can calculate its velocity through that medium. The apparatus consist of an ultrasonic cell, which is a double walled brass cell with chromium plated surfaces having a capacity of 10 ml. the double wall allows water circulation around the experimental medium to maintain it at a known constant temperature. The micrometer scale is marked in units of 0.01 mm and has an overall length of 25 mm. ultrasonic waves of known frequency are produced by a quartz crystal which is fixed at the bottom of the cell. There is a movable metallic plate parallel to the quartz plate, which reflects the waves. The waves interfere with their reflections, and if the separation between the plates is exactly an integer multiple of half-wavelengths of sound, standing waves are produced in the liquid medium. Under these circumstances, acoustic resonance occurs. The resonant waves are a maximum in amplitude, causing a corresponding maximum in the anode current of the piezoelectric generator.

We have, the velocity (ν) of a wave is related to its wavelength (λ) by the relation:

$$V = \lambda f$$

where f is the frequency of the wave.

Micrometer screw is attached to a hollow cylinder and reflector. Due to reflection from the reflector a system of stationary waves is from with nodes and antinodes. The reflected wave react on the quartz sources and change the plate current or tank current of the oscillator supplying the voltage to the quartz crystals. The plate current or tank current depends on the amplitude of vibration of crystal. The call of ultrasonic interferometer was filled fully with solution and the needle of ammeter was adjusted in the range of 40-60 with the help of 'add' knob. It was warned for 10 min so that the range should remain steady. Micrometer reading was noted. Screw was moved anticlockwise to get the maximum deflection of needle. Movement of screw- was continued to get 5 deflections. After returning the needle to original position micrometer screw reading was noted. The difference between these reading gave the distance travelled by the screw for getting five maxima. From this distances required through which micrometer screw should move for one maximum was calculated by dividing it by 5. The same procedure was repeated several times.

Viscosity Measurement

Viscosity is one of the important properties of liquid. It implies resistance to flow. There are intermolecular forces in liquid layers which are responsible for viscosity. Viscosity of liquid can be determined on the basis of flow time. In fact, viscosity is directly proportional to the flow time. Viscosity of the liquid mixtures was measured by an Ostwald`s viscometer. Ostwald`s viscometer is a u-shaped glass tube. In one arm, is attached to a capillary tube and a storage bulb in the second arm. Two marks are drawn above and below the first bulb. The time required to flow a given volume of a liquid is a measure of its viscosity. It may be looked upon as the force of friction between two layers of a liquid moving past one another with different velocities. Suppose, a cylindrical liquid layer of area 'A' moves over another similar layer at a distance 'dx' with a velocity difference 'du' ; then tangential force of friction (F), required to maintain a constant difference of velocity, is given by:

$$F = -A\,\eta\,du/dx$$

Where, 'A' is a constant at a given temperature, depending upon the nature of the liquid and is known as the coefficient of viscosity. If A is 1 cm, du is cm per second and dx is 1 cm, then F = dynes. The coefficient of viscosity of a liquid may, therefore, be defined as the force in dynes per sq. cm. required to maintain a difference of velocity of 1 cm per second between two parallel layers of the liquid held at a distance of 1 cm from one another. Viscosity measurement like other transport properties of electrolyte provides useful information about solute-solute and solute-solvent interactions. The viscosity was measured made by Ostwald's viscometer with an accuracy 0.001 Ns m^{-2}.

Thermostat

A mechanical thermostat arrangement was done for density, viscosity and velocity. A water bath made of glass insulated with thermo coal from all the sides. Temperature was maintained constant till all the reading has been taken.

Acoustical parameters (Mathematical formulae):

The relative viscosity of each solution is determine by the following empirical formula

$$\eta_s = \frac{\rho_s t_s}{\rho_w t_w}\eta_w$$

Where 'η_s'is relative viscosity of solute solution, 'ρ_s' is density of solution, 't_s'is the flow time of solution. 'η_w' is the viscosity of solvent i.e. water. 't_w' is flow time of water. 'ρ_w' is density of water.

'β_w' is adiabatic compressibility of pure solvent and 'β_s' is adiabatic compressibility of the solution, calculated using the equation:

$$\beta s = \frac{100}{u^2\rho}$$

And

$$\beta_w = \frac{100}{U_w^2\rho_w}$$

Where, 'U' is ultrasonic velocity in the solution in m/s:β_s is in bar^{-1}

The intermolecular free length (Lf), specific acoustic impedance (Z) and relative association (RA) [5] are calculated by using following equations:

$$Lf = K \times \sqrt{\beta}$$

$$Z = U \times \rho$$

$$RA = (U_s \times U_w)\,[\frac{U_w}{U_s}]^{1/3}$$

Apparent molar compressibility (ϕ_k), apparent molar volume (ϕ_v) and solvation number (Sn) are calculated by using following equations:

$$\phi_k = \left[\frac{1000\,(\rho_w\beta_s - \rho_s\beta_w}{m\rho_w\rho_s}\right] + [\frac{\beta_s M}{\rho_s}]$$

$$\phi_v = \left(\frac{M}{\rho_s}\right) + \left[\frac{1000(\rho_w - \rho_s)}{m\rho_w\rho_s}\right]$$

$$S_n = \frac{\phi_k}{\beta \times M \times \rho_w}$$

EXPERIMENTAL AND COMPUTED DATA

Table 1: Values of Ultrasonic velocity, viscosity, adiabatic compressibility, relaxation time, acoustic impedance, free length, relative association, apparent molar volume, and apparent molar compressibility of Leucine at different temperatures.

303 K							
m (kg mol^{-1})	U (m/sec)	ηs (Nsm^{-2})	Z ($kgm^{-2}S^{-1}$)	β sx10^{-6}(m^2N^{-1})	RA	ϕkx10^{-4}	ϕv
0.02	649	0.725	636.604	2.42	0.8746	3.1496	132.8754
0.04	678.4	0.791	676.975	2.177	0.8753	2.1258	132.3394
0.06	908	0.8469	906.093	1.215	0.9013	2.1663	132.7759
0.08	947.6	0.9219	930.733	1.134	0.9909	2.9344	131.5735
0.1	962	0.999	950.36	1.094	0.9933	2.2009	131.5735
308 K							
0.02	856.2	0.659	841.388	1.388	0.9347	3.1496	132.8754
0.04	945.6	0.6598	927.634	1.14	0.9373	2.1258	132.3394
0.06	946	0.6601	934.261	1.129	0.9406	2.1663	132.7759
0.08	948.2	0.6618	939.378	1.125	0.9487	2.9344	131.5735
0.1	957.4	0.7183	940.454	1.111	0.9705	2.2009	131.5735
313 K							
0.02	502.2	0.6006	494.265	4.029	0.959	2.0703	133.4452
0.04	755.8	0.6419	747.637	1.77	0.964	1.9217	133.3154
0.06	809.8	0.643	790.284	1.563	0.9835	1.8439	132.888
0.08	864.4	0.6467	845.037	1.369	1.0201	3.9281	132.8117
0.1	893.2	0.6474	878.194	1.275	1.1631	2.2116	132.4301
318 K							
0.02	572	0.5865	562.791	3.106	0.9988	1.8455	132.988
0.04	700.6	0.6387	689.32	2.071	1.042	2.271	132.988
0.06	809.8	0.6413	796.762	1.55	1.0463	1.5377	132.988
0.08	819.8	0.74	806.601	1.512	1.098	1.8148	132.988
0.1	930.8	0.8332	915.814	1.173	1.1748	3.1173	132.988
323 K							
0.02	660.4	0.5417	532.856	2.338	0.5826	3.1274	133.0115
0.04	805.2	0.5857	647.588	2.233	0.8683	3.78	164.4666
0.06	840.6	0.5877	792.236	1.568	0.8735	1.9719	131.8592
0.08	960	0.6339	953.568	1.092	0.9174	2.4225	132.7121
0.1	965.6	0.7417	955.268	1.084	0.9768	1.973	132.2221

Table 2: Values of Ultrasonic velocity, viscosity, adiabatic compressibility, relaxation time, acoustic impedance, free length, relative association, apparent molar volume, and apparent molar compressibility of Lysine at different temperatures

303 K							
m (kg mol^{-1})	U (m/sec)	ηs (Nsm^{-2})	Z ($kgm^{-2}S^{-1}$)	β sx10^{-6}(m^2N^{-1})	RA	ϕkx10^{-4}	ϕv
0.02	652.48	0.7259	643.933	2.38	0.9192	3.1083	132.4159

0.04	716.6	0.7259	703.845	1.983	0.9192	2.4671	132.7759
0.06	810.8	0.7896	799.935	1.542	0.9254	2.4269	132.4695
0.08	816.2	0.7899	801.672	1.528	0.96	2.4697	132.4389
0.1	826.4	0.7902	814.996	1.485	0.9952	2.8135	132.7759
308 K							
0.02	649.92	0.6093	638.221	2.411	0.9892	2.0058	132.764
0.04	674.08	0.6596	662.149	2.24	0.9903	2.0258	132.5581
0.06	745.4	0.6598	735.188	1.825	1.0202	2.237	132.5084
0.08	806	0.662	792.056	1.566	1.05071	2.5347	132.7924
0.1	815.8	0.6625	804.052	1.525	1.0632	2.6553	132.8137
313 K							
0.02	669.44	0.5478	658.863	2.267	0.9595	2.5942	132.8117
0.04	724.16	0.5968	710.546	1.943	0.9983	2.1096	132.9109
0.06	764	0.6004	755.443	1.733	1.0161	2.184	132.4606
0.08	791.2	0.6017	777.67	1.625	1.0264	1.7856	132.2927
0.1	913.2	0.6454	904.981	1.21	1.0569	2.3525	133.0407
318 K							
0.02	737.44	0.5424	727.558	1.864	0.9127	2.2147	133.4831
0.04	811.6	0.5455	793.664	1.552	0.9478	2.1836	133.021
0.06	816.6	0.5858	803.126	1.525	0.959	2.0194	132.5507
0.08	870.4	0.5883	861	1.334	0.9626	1.9247	133.8379
0.1	929.2	0.6431	904.669	1.19	0.999	2.456	132.7652
323 K							
0.02	608.32	0.5875	598.344	2.747	0.9499	3.1076	132.6486
0.04	656.32	0.5877	647.985	2.351	0.9672	3.1248	132.4036
0.06	660.8	0.5881	650.624	2.326	0.9806	2.9518	132.7121
0.08	687.2	0.5891	676.136	2.152	0.9855	3.4913	132.7393
0.1	730.72	0.5897	720.709	1.899	1.007	2.7172	132.4943

Table 3: Values of Ultrasonic velocity, viscosity, adiabatic compressibility, relaxation time, acoustic impedance, free length, relative association, apparent molar volume, and apparent molar compressibility of Threonine at different temperatures

303 K							
m (kg mol^{-1})	U (m/sec)	ηs (Nsm^{-2})	Z ($kgm^{-2}S^{-1}$)	β $sx10^{-6}$(m^2N^{-1})	RA	φ$kx10^{-4}$	φv
0.02	553.44	0.7272	551.503	3.276	0.9789	3.09674	131.9794
0.04	650.88	0.7336	641.66	2.39	0.9905	2.96845	132.5921
0.06	652.16	0.7883	646.063	2.378	0.9923	3.12095	132.6457
0.08	663.84	0.791	655.808	2.297	1.0018	3.77474	131.6807
0.1	680.8	0.7979	670.316	2.191	1.0616	3.04322	132.3394
308 K							
0.02	581.76	0.6103	571.696	3.007	1.0356	2.54851	132.3167
0.04	640.8	0.6132	635.866	2.454	1.0561	2.55896	132.6504
0.06	667.36	0.6153	657.355	2.278	1.0614	3.07508	132.764
0.08	667.84	0.6576	660.019	2.27	1.0794	2.44188	133.0267
0.1	696.8	0.6601	682.167	2.104	1.104	2.67471	132.0824
313 K							

0.02	363.48	0.5972	357.628	7.693	1.0166	2.66883	132.8346
0.04	655.52	0.5974	644.966	2.365	1.0497	2.52972	132.8346
0.06	682.56	0.5974	671.571	2.182	1.0541	6.70331	132.8346
0.08	685.76	0.6472	678.56	2.149	1.064	2.49851	132.4072
0.1	750.6	0.6509	738.215	1.805	1.2951	2.24481	132.8651
318 K							
0.02	746	0.5354	727.574	1.842	1.0278	1.72991	133.1035
0.04	785.8	0.5891	770.241	1.652	1.0467	1.92251	133.1035
0.06	787.2	0.5917	773.424	1.642	1.0529	1.9326	133.2933
0.08	798.2	0.6384	781.917	1.602	1.0547	2.09258	133.6976
0.1	850.6	0.6406	835.715	1.407	1.0659	1.89234	133.3428
323 K							
0.02	767.4	0.5354	759.649	1.715	0.9106	2.33182	132.4943
0.04	786.8	0.5891	779.404	1.631	0.9215	2.42698	132.4671
0.06	801.2	0.5917	790.464	1.579	0.9308	2.46517	132.1042
0.08	829.6	0.6384	818.234	1.473	0.9379	2.54337	132.1677
0.1	855.2	0.6406	836.3	1.398	0.8937	2.28207	133.2564

Table 4: Values of Ultrasonic velocity, viscosity, adiabatic compressibility, relaxation time, acoustic impedance, free length, relative association, apparent molar volume, and apparent molar compressibility of Phenylanine at different temperatures

303 K							
m (kg mol^{-1})	U (m/sec)	ηs (Nsm^{-2})	Z (kg $m^{-2}S^{-1}$)	β $sx10^{-6}$(m^2N^{-1})	RA	$\phi kx10^{-4}$	ϕv
0.02	783	0.7835	778.224	1.641	0.8929	2.53253	131.8798
0.04	804	0.7843	786.99	1.58	0.9092	2.41802	132.9755
0.06	804.2	0.7854	788.644	1.577	0.9204	2.51296	133.0516
0.08	836.8	0.7958	819.729	1.458	0.9226	2.30721	133.0056
0.1	882.4	0.8443	864.046	1.312	0.9432	2.50667	132.8754
308 K							
0.02	756.6	0.6105	740.484	1.785	0.964	2.02218	132.4374
0.04	792.2	0.6574	782.377	1.613	0.9849	2.00622	132.6291
0.06	815.8	0.6592	805.439	1.522	0.9909	2.21716	133.048
0.08	824.2	0.6632	811.507	1.495	1.001	1.90483	132.8634
0.1	870	0.6634	853.731	1.346	1.0073	2.08645	132.4161
313 K							
0.02	789.4	0.5441	773.77	1.637	0.9457	2.0612	133.1704
0.04	810	0.5944	792.638	1.556	0.9792	1.95198	132.7125
0.06	810.8	0.5947	793.395	1.556	0.9848	1.79872	133.2162
0.08	845	0.5952	832.748	1.421	0.9871	2.06339	133.3154
0.1	919.4	0.6482	900.001	1.209	0.9963	2.1218	133.117
318 K							
0.02	788.6	0.5885	768.57	1.65	0.9937	1.80705	133.5656
0.04	825.2	0.5885	807.211	1.501	1.0059	1.62048	133.4006
0.06	827.6	0.589	808.482	1.495	1.0313	1.55293	133.4583
0.08	897.4	0.6352	878.465	1.268	1.0337	1.81132	133.4583
0.1	928.8	0.6367	908.552	1.185	1.0455	1.93614	133.7554
323 K							

0.02	835.6	0.5871	824.654	1.451	0.8825	2.20886	132.7393
0.04	874	0.5875	859.666	1.331	0.8893	2.13752	132.8028
0.06	886.8	0.5883	873.409	1.291	0.8903	2.09908	131.9227
0.08	902	0.5895	886.576	1.25	0.8924	2.31064	132.4399
0.1	904.6	0.6423	897.906	1.231	0.9089	2.16997	132.6213

Table 5: Values of limiting apparent molar volume, limiting apparent molar compressibility, Sk, Sv of Leucine & Lysine

Temp. (K)	ϕ^0k x10^{-4} (m^2N^{-1})	S_{K} ($N^{-1}m^{-1}mol^{-1}$)	ϕ^0V x10^{-4}(m^3mol^{-1})	S_V ($m^3kg^{-1/2}mol^{-3/2}$)	ϕ^0k x10^{-4}(m^2N^{-1})	S_K ($N^{-1}m^{-1}mol^{-1}$)	ϕ^0V x10^{-4} (m^3mol^{-1})	**S_V ($m^3kg^{-1/2}mol^{-3/2}$)**
303	-0.000389	0.0003	7.574386	134.02	0.00048	0.00031	1.286	132.37
308	0.000537	0.0002	0.4949253	132.49	-0.00053	0.00033	1.42	132.86
313	0.0005274	0.0001	5.747202	134.34	0.00075	0.00035	3.47	132.85
318	0.0004278	0.0001	0	132.99	0.00087	0.00029	5.06	133.52
323	-0.000828	0.0005	0.000596	154.52	0.00089	0.00039	6.92	132.58

Table 6: Values of limiting apparent molar volume, limiting apparent molar compressibility, Sk,Sv of Threonine & Phenylanine.

Temp. (K)	ϕ^0k x10^{-4}(m^2N^{-1})	S_K ($N^{-1}m^{-1}mol^{-1}$)	ϕ^0V x10^{-4} (m^3mol^{-1})	**S_V ($m^3kg^{-1/2}mol^{-3/2}$)**	ϕ^0k x10^{-4}(m^2N^{-1})	S_K ($N^{-1}m^{-1}mol^{-1}$)	ϕ^0V x10^{-4} (m^3mol^{-1})	**S_V ($m^3kg^{-1/2}mol^{-3/2}$)**
303	0.0004675	0.0003	0.0004556	132.28	-0.000456	0.0003	2.947	131.52
308	0.000467	0.0003	0.00045	132.5	0.00972	0.0002	2.42	132.48
313	0.00048	0.0003	0.0003309	132.97	0.00361	0.0002	1.82	132.86
318	0.000526	0.0002	0.000226	132.71	0.000856	0.0002	1.89	133.34
323	0.000651	0.0002	82.4	131.96	0.000325	0.0002	1.097	132.9

RESULT AND DISCUSSION

Ultrasonic Velocity (U):

For all the compounds data reveals increase in ultrasonic velocity (U) with increase in the concentration of solute. This suggests presence of solute-solvent interactions [5]. The increase suggests a structure-making capacity of these solutes in solution. Moreover, the increase in ultrasonic velocity indicates the possibility of H-bond formation between solute and solvent. There is also an indication of greater association among the molecules.

Viscosity (η):

From the computed data given in Table-1-4, for all the solutes viscosity increases with concentration of solute. This may be due to the formation of cage like structure during solute-solvent interactions. Again the increase suggests the H-bond forming tendency of the solute. The solutes are of structure-maker type. Viscosity data were analysed in the light of Jones-Dole equation [6].

$$\eta / \eta_o = 1 + AC^{1/2} + BC$$

which can be written as

$$[\eta / \eta_o - 1] / \sqrt{C} = A + BC^{1/2}$$

where A and B are the Falkenhagen and Jones-Dole Coefficients. Others are with usual notations. Here A (i.e. intercept gives the value of magnitude of solute-solute interaction) and B (i.e. slope gives the value of magnitude of solute-solvent interaction) have been computed by the least square method from the linear plot of $[\eta / \eta_o - 1] / \sqrt{C}$ Vs $\sqrt{C}$ and are tabulated in Table–1-4.

Adiabatic Compressibility (βs):

When an ion is added to a solvent, it attracts certain solvent molecules towards itself by wrenching the molecule species from the bulk of the solvent. Hence, less number of solvent molecules will be made available for the next incoming species. This is known as compression. Every solvent has a limit for compression and is known as limiting compressibility. From Table 1-4 it has been observed that for the all the compounds the adiabatic compressibility decreases with increase in concentration of solute. This may be due to the aggregation of solvent molecules around the ions supporting solute-solvent interaction. The results are in accordance with the findings of earlier authors [7-8]. As concentration increases, a larger portion of the water molecules are electro restricted and the amount of bulk water decreases causing the compressibility to decrease. Decrease in adiabatic compressibility indicates the formation of large number of tightly bound systems

.

Relative Association (RA):

Relative association is influenced by two important factors:

1. Breaking up of the associated solvent molecules on addition of solute into it.
2. The solvation of solute molecules that is simultaneously present [9].

The variation of RA values with increase in concentration is shown in Table-1 to 4. It depicts that for all the compounds relative association (RA) increases with increase in concentration. This increase indicates solvation of solute molecules. A similar increase in the value of RA has been found in case of sucrose solution by Syal *et al.*[10].

Acoustic Impedance (Zs):

Acoustic impedance is the product of ultrasonic velocity and density. As density and velocity both increase with increase in concentration for the solutes the Zs value also increases as shown in table–I which indicates the interaction between the solute and solvent molecules. A similar type of behaviour has been obtained for tetraalkylammonium and alkali metal salts in methanol-chlorobenzene mixtures by Syal *et al.*[11].

Apparent Molar Compressibity (Φ_k):

The comparative high values of Φ^0_k for solutes may be due to local compressibility of solvent near solute. Solute-solvent interaction predominates solute-solute interaction which is reflected from the lower values of S_k.

Apparent Molar Volume (Φ_v):

Φ^o_v gives the information about solute-solvent interactions. Table–5-8 reveals for the solutes, Φ^0_v values are positive and large, indicating the presence of strong solute-solvent interactions.

Summary and Conclusion

From the Ultrasonic measurements we can find a general conclusion about strong Intermolecular interaction between the components in the mixtures, measured and calculated Acoustical parameters, solute-solvent and solute-solute interactions are predicted, but solute solvent Interactions are higher than solute-solute interaction.

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