# Ultrasonic Analysis of Aqueous Ascorbic Acid at Temperature 303K

## V. G. Dudhe<sup>1</sup>, V. A. Tabhane<sup>2</sup>, O. P. Chimankar<sup>3</sup>

<sup>1</sup> Department of Physics, Shri Shivaji College, Rajura, Dist-Chandrapur,(M.S.), India – 442905

<sup>2</sup> Department of Physics, University of Pune, Ganeshkhind, Pune,(M. S.), India

<sup>3</sup> Department of Physics, R. T. M. Nagpur University, Nagpur, (M. S.), India – 440033

Abstract: The ultrasonic velocity (U), density ( $\rho$ ) and viscosity ( $\eta$ ) of different concentration of aqueous ascorbic acid (vitamin C) have been studied at temperature 303K. The measurement of ultrasonic velocity were carried out by using the ultrasonic pulse eco overlap (PEO) technique at frequency 5 MHz. Measurement of density have been carried out by using hydrostatic plunger method and viscosity by Oswald's viscometer. The temperature 303K have been kept constant using thermostat by circulating water. Experimental data have been used to estimate the thermo-acoustical parameter such as adiabatic compressibility ( $\beta$ ), acoustic impedance (z), free length ( $L_f$ ), free volume ( $V_f$ ) internal pressure (Pi), wada's constant (W) and Rao's constant (R). These parameters have been used to give the interpretations of solute solvent interaction of water and pyridoxine molecules. Furthermore these studies shows that the nature of molecular interaction and complex formation in solution of ascorbic acid (vitamin C) and it provide important information regarding molecular properties of solute and solvent interaction.

Keywords: Ultrasonic velocity, adiabatic compressibility, free volume ,internal pressure, Wada's constant, Rao's constant and ascorbic acid

### 1. Introduction

Ultrasonic velocity, density, viscosity and other thermo acoustical parameters have been play very important role to detect and assess weak and strong molecular interactions in binary and ternary mixture [1-4]. This gives a practical application in many pharmaceuticals and chemical industries. Ultrasonic velocity, density, viscosity and other

Vitamin is an organic compound and vial nutrient that an organism requires limited amount. An organic chemical compound is called vitamin. When the organism cannot synthesize the compound in a sufficient quantities and it must be obtained through the diets. Vitamins are substances that our body needs to grow and develop normally.

Ascorbic acid is a colorless and water soluble vitamin .The structure of L-ascorbic acid was first discovered by scientist Norman Haworth and for this work he got Nobel Prize on 1937. On 1967 Scientist Linus Pauling recommended high doses of ascorbic acid (he himself took 18 grm daily) as a prevention against cold and cancer. The physicochemical and thermodynamic properties of ascorbic acid are of considerable interest as it is an essential nutrient for human and certain other animal species, in which it functions as a vitamin. Ascorbic acid or L-ascobate is a strong reducing agent. When there are more free radicals (reactive oxygen species, ROS) in the human body, condition is called oxidative stress and has an impact on cardiovascular disease, hypertension, chronic inflammatory diseases and diabetes etc. [11].

The purpose of present work is to determine the ultrasonic velocity and thermo acoustical properties of aqueous ascorbic acid at temperature 303K. This Investigation give us

thermo acoustical parameter such as adiabatic compressibility, acoustic impedance, free length, free volume, internal pressure, Wada's constant and Rao's constant play key role to study the nature of intermolecular forces in liquid mixtures and it also give idea about association , dissociation and complex formation of molecules in a given components [5-10].

molecular interaction of ascorbic acid in water, which is helpful to chemist, biologist, pharmacist and industries etc.

## 2. Materials and Methods

The stock solution of ascorbic acid (vitamin C) was prepared in double distilled water. Solution of different concentration was prepared using water as solvent. The ultrasonic velocity of pure solvent and their solutions measurement were carried out with a highly versatile and accurate 'pulse echo overlap technique (PEO) method by using automatic ultrasonic recorder (AUAR-102) and frequency counter. The frequency of the pulses was kept at 5MHz. The density and viscosity were measured using hydrostatic plunger method and Oswald's viscometer respectively. Temperature 303K is maintained using thermostatically controlled water circulation system with accuracy of  $0.5^{\circ}$ C. The other thermo-acoustical parameters such as acoustic impedance, adiabatic compressibility, free length, free volume, Wada's constant and Rao's constant ware evaluated using ultrasonic velocity, density and viscosity. The experimental data of concentration (M), ultrasonic velocity (U), viscosity (ŋ), acoustic impedance (z), adiabatic density (p), compressibility ( $\beta$ ), free length (L<sub>f</sub>), free volume (V<sub>f</sub>), Wada's constant (W) and Rao's constantant (R) for different concentration of ascorbic acid are given in the table 1 and 2.

#### 3. Theory

Ultrasonic velocity was measured by using pulse Echo overlap method at 5MHz. The interferometer was filled with test liquid and temperature was maintained by circulating water around the measuring cell from thermostat. From the experimental data of ultrasonic velocity, density and viscosity of given solution, the various thermo-acoustical parameters were calculated using following standard equation.

1] Ultrasonic velocity:  $u = \frac{2d}{t}$ 

Where, d = Separation between transducer & reflector t = Traveling time period of ultrasonic wave.

2] Density: W<sub>a</sub> – W<sub>1</sub>

$$\left[\frac{\rho = x \rho_w}{W_a - W_w}\right]$$

Where,  $W_a = W$ eight of the plunger in air  $W_1 = W$ eight of the plunger in the experimental liquid  $W_w = W$ eight of the plunger in water  $\rho_w = D$ ensity of water 3] Viscosity :  $\rho \ge t_1$ 

$$\left[\frac{\mathfrak{g} = x \mathfrak{g}_{w}}{\rho_{w} x t_{w}}\right]$$

Where,  $t_1 =$  Flow Time of experimental liquid  $t_w =$  Flow Time of water  $\eta_w =$  Viscosity of water

4] Adiabatic Compressibility:  $\beta = [1 / u^2 \rho]$ 

5] Acoustic impedance :  $Z = u. \rho$ 

6] Intermolecular free length:  $(L_f) = \frac{k}{u \rho_{14}^{1/2}}$ 

Where, k = Time dependent constant

7] Free volume :  $(V_f) = M_w u / k \eta$ Where, k = Time independent constant.  $M_{w}$  = molecular weight of solution.

8] Wada's Constant :  $(\beta_m) = (M_w / \rho) \times \beta^{-1/7}$ 

9] Rao's Constant : (R) = ( $M_w/\rho$ ) x u<sup>1/3</sup>

Table 1								
Concentration	Ultrasonic Velocity	Density (p)	Viscosity (η)	Adiabatic	Acoustic			
	(u) cm s <sup>-1</sup>	g cm⁻°	Centi poise	compressibility	impedance			
				(p x 10) cm dyne	(Zx10 <sup>-</sup> ) g cm s			
0	150645	0.9956	0.798	4.4259	1.4999			
0.02	150820	0.9981	0.8017	4.4046	1.5053			
0.04	150862	0.9988	0.8124	4.3991	1.5068			
0.06	150959	1.0009	0.8253	4.3842	1.5109			
0.08	151024	1.0030	0.8301	4.3713	1.5148			
0.10	151136	1.0044	0.8278	4.3587	1.5180			

Table 2							
Concentration	Free length (L <sub>f</sub> x 10 <sup>-11</sup> )cm	Free Volume (V <sub>f</sub> X 10 <sup>-8</sup> ) cm <sup>3</sup> /Mole	Wada"s constant (W) cm <sup>19/7</sup> /dyne <sup>1/7</sup>	Rao"s constant(R) cm <sup>10/3</sup> /s <sup>1/3</sup>			
0	1.3199	1.8104	545.3830	962.8111			
0.02	1.3168	1.7959	546.0963	963.7853			
0.04	1.3160	1.7971	547.5241	966.2224			
0.06	1.3137	1.7904	548.3539	967.4251			
0.08	1.3118	1.7847	549.1525	968.5651			
0.10	1.3099	1.7808	550.3335	970.4877			

## 4. Result and Discussion

The experimental data of ultrasonic velocity, density, viscosity, adiabatic compressibility and acoustic impedance of ascorbic acid at 303K, are recorded in table 1, and Intermolecular free length, free volume, Wada's constant and Rao's constant are given in table 2.

The variation of ultrasonic velocity and adiabatic compressibility with molar concentration are shown in figure (1) and figure (4). It is observed that ultrasonic velocity and adiabatic compressibility are increases and decreases with increase in molar concentration of ascorbic acid. This is indicate that, there is a strong intermolecular force between ascorbic acid and water molecules. This enhance the degree of association among molecules of solute-solvent components [12-14].

Variation of density with molar concentration is shown in figure (2), which indicate that, the density of aqueous ascorbic acid is increases with the increase in molar concentration of ascorbic acid.

In figure (3) gives the viscosity of aqueous ascorbic acid increases with the increase in molar concentration, which indicating the existence of molecular interaction in the given mixture and hence there is association between ascorbic acid and water molecules [15].

The molecule of liquid are not closely packed, there is always some space between them, this free space is known as free volume. The variation of free volume with molar concentration shown in figure (7) which shows that solute solvent molecules are coming close to each other and space between them is decreases with rise in concentration. This supports to the strong solute-solvent interaction in liquid solution [16].

The decrease in free length in figure (6) shows that, there is enhanced molecular association in the system , which show that compactness of the structure is increasing and it is less compressible [17] . However the acoustical impedance in figure (5) is increasing with the concentration of ascorbic acid. This in turn shows that molecular interaction is associative [18]. The variation of Wada's constant with concentration is shown in fig. (8). To study the existence of molecular interaction. Wada's constant is also very important. It is observed that Wada's constant increase with increasing molar concentration. This indicate that solute-solvent molecules are very close and hence interaction is increases. The variation of Rao's constant with molar concentration is shown in fig. (9). It is observed that Rao's constant increases with rise in molar concentration which supports the facts shown by other thermo-acoustical parameters.



Figure 1: Variation of Ultrasonic velocity with Concentration Figure 2: Variation of Density with Concentration



Figure 3: Variation of Viscosity with Concentration Figure 4: Variation of Adiabatic Compressibility with concentration



Figure 5: Variation of Acoustic Impedance with Concentration Figure 6: Variation of Free length with concentration





Figure 7: Variation of Free volume with Concentration





Figure 9: Variation of Rao's constant with Concentration

#### 5. Conclusions

Ultrasonic velocity, density and viscosity of aqueous solution of ascorbic acid of different concentration are measured at 303K and thermo-acoustical parameters are calculated. Ultrasonic velocity, density, viscosity, acoustical impedance are increases with concentration shows that solute-solvent interaction are present in the solution. The adiabatic compressibility, free length and free volume are decreases with rise in concentration. This shows that there is strong solute-solvent interaction in a system and hence association take place. Wada's constant and Rao's constant are increases with increase in concentration. This give support to the above discussion.

#### References

- Anyranci. G, et al, J. Chem. Themodyn (2007), doi:10,1016/j jet 2007.04.009.
- [2] Ali A., Nain A. K., (1996), Acoustic let. 19-53
- [3] Tabhane.P.V, Chimankar.O.P., Dudhe.C.M, . Tabhane.V.A, (2012) Der Chemic Sinica, 3(4) 944-947.
- [4] Tabhane.P.V, Chimankar.O.P., Dudhe.C.M, Tabhane.V.A, (2012), Lop Conf. series material sci & Engg. 42 012033, doi: 10.1088/1757-899A/42/012033.
- [5] Chimankar.O.P, Shrivas Ranjeeta, Tabhane.V.A,(2010), Archives of Applied science research. 2(6):285-289
- [6] Chimankar.O.P, Shrivas Ranjeeta, Chopade Prach S., Tabhane.V.A., (2011), J.Chem. Pharm Res, 3(3):579-586.
- [7] Bhandakar.V.D., Chimankar.O.P, Mistry.A.A, (2011), Pelagia Research Library, Advance in Applied Research, 2(63), 70-76.

- [8] Akgul G., Bayram E, Ayranci E., (2006), J. Solution Chem. 35,1655-1972.
- [9] S. Annuradha, S. Prema, K. Rajgopal, (2005), J. Pure., Appl. Ultrasonic 27, 49-54.
- [10] Ravat M.K., Sangeeta, (2008), Indian Journal of pure and Applied physics, 46, 187-192.
- [11] Jain J. L.(1999), Fundamentals of biochemistry, 511-569.
- [12] Gupta Arti, Strivastava Roli, Pandey Archana, (Sept. 2012.), Global Adraneed Research J.Chem and mat. sci vol 1(3) PP 039-054.
- [13] Sonar A.N., Pawar N.S., (2010) Rasayan, J. Chem Vol 3 (1),38-43.
- [14]Bhandakar.V.D., Chimankar.O.P, Pawar N.R., (2010), J.chem. pharm. Res., 2(4), 873.
- [15] Arul G., Palaniappan L., (Oct. 2005), Indian Journal of pure & applied physics vol. 43, PP 755-758.
- [16] Dudhe C.M., Patil K.C., (2012), Int.J. of Natural Product research, 2(4) 76-78.
- [17] Sonar A.N., Pawar N.S., (2010), Rasayan J. Chem. Vol 3 no. 1,38-43.
- [18] Tabhane V. A., Agrawal Sangita and Rewatkar K.G., (2000), J.Acous.soc. India vol. 28 no.. 1-4, 369-372.