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Acoustical Study on Molecular Interactions of Aqueous Ascorbic Acid (vitamin C) Solution at 298 K

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Abstract: ***Density (ρ) and viscosity (η and ultrasonic velocity (U) of different concentration of aqueous ascorbic acid (vitamin C) solution have been studied at temperature 298K. 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 298K have been kept constant using thermostat by circulating water. Experimental data have been used to estimate the thermo-acoustical parameter such as adiabatic compressibility (β), acoustic impedance (z), free length (L_f), free volume (V_f), relaxation time (T) and Rao's constant (R) Furthermore these studies shows that the nature of parameters have been used to give the interpretations of solute- solvent 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: Density, Viscosity, Ultrasonic velocity, Adiabatic compressibility, Free volume , Rao's constant and Ascorbic acid.

1. Introduction

Ultrasonic studies in a medium provide important tools for evolution of the structural , physical and chemical properties of medium . The nature of ultrasonic properties of aqueous vitamin solution shed more light on many chemical analyses as well as idea about complexity of vitamins molecules. The ultrasonic properties of liquid and biological media have been studies in details by many researchers [1-7] .

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. [8]

The purpose of present study is to determine the ultrasonic velocity and thermo acoustical properties of aqueous ascorbic acid (vitamin C) at temperature 298K.

2. Materials and Methods

The stock solution of vitamin ascorbic acid was prepared in double distilled water. Solution of different concentration ware 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 respective. Temperature 293K is maintained using thermostatically controlled water circulation system with accuracy of 0.5^0c. The other thermo-acoustical parameters such as acoustic impedance, adiabatic compressibility, free length, free volume, Relaxation time and Rao's constant ware evaluated using ultrasonic velocity, density and viscosity. The experimental data of concentration (M), ultrasonic velocity (U), viscosity (ŋ), density (ρ), acoustic impedance (z), adiabatic compressibility (β), free length (L_f), free volume (V_f), Relaxation time (T) 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: $\rho = \left[\frac{W_a - W_l}{W_a - W_w}\right] \times \rho_w$

Where, W_a = Weight of the plunger in air

W_l = Weight of the plunger in the experimental liquid

W_w = Weight of the plunger in water

ρ_w = Density of water

Where, t_l = Flow Time of experimental liquid

t_w = Flow Time of water

η_w = Viscosity of water

3] Viscosity : $\eta = \left[\frac{\rho \times t_l}{\rho_w \times t_w}\right] \times \eta_w$

Where, t_l = Flow Time of experimental liquid

t_w = Flow Time of water

η_w = Viscosity of water

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

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

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

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] Relaxation time : $(T) = = \frac{a}{a}\ \eta.\ \beta$

9] Rao's Constant : $(R) = (M_w/\ \rho) \times U^{1/3}$

Table 1

Concentration	Ultrasonic Velocity (u) cm/sec	Density (ρ) gm/cc	Viscosity (η) centipoise	Adiabatic compressibility ($\beta \times 10^{-11}$) cm^2 /dyne	Acoustic impedance ($Zx10^5$) gm. cm^{-2} s^{-1}
0	149599	0.9970	0.8900	4.4815	1.4916
0.02	149933	0.9985	0.8905	4.4550	1.4971
0.04	150328	1.0023	0.9005	4.4147	1.5068
0.06	150521	1.0030	0.8972	4.4004	1.5097
0.08	150533	1.0046	0.9195	4.3928	1.5122
0.10	150572	1.0068	0.9263	4.3811	1.5159

Table 2

Concentration	Free length ($L_f \times 10^{-11}$) cm	Free Volume ($V_f X\ 10^{-8}$) cm^3/mole	Relaxation time ($T \times 10^{-11}$) sec	Rao's constant(R) ($cm^{10/3}/sec^{1/3}$
0	1.3167	1.7870	5.3180	959.2504
0.02	1.3128	1.7758	6.2893	961.5097
0.04	1.3068	1.7530	6.3004	961.7152
0.06	1.3047	1.7498	6.2639	964.4725
0.08	1.3036	1.7480	6.3854	965.9876
0.10	1.3019	1.7427	6.4108	966.9701

4. Result and Discussion

The experimental data of density, viscosity, and ultrasonic velocity, adiabatic compressibility and acoustic impedance of nicotinic acid at 298K, are recorded in table 1, and Intermolecular free length, free volume, Relaxation time and Rao's constant are given in table 2.

It is observed that the ultrasonic velocity is increases and adiabatic compressibility decreases with rise in concentration of ascorbic acid is indicate that, there is a significant interaction between the solute-solvent components of the aqueous ascorbic acid [9]which shown in **figure 1** and **figure 4**. This is also supported by the increase in density with concentration shown in **figure 2.**

In **figure 3** gives the viscosity of aqueous ascorbic acid increases linearly with the concentration, which suggests the increase in cohesive forces due to powerful interaction between molecules of vitamin and water. The acoustic impedance of aqueous ascorbic acid is increases with the increase in concentration shown in **figure 5** indicate that there is strong interaction between solute and solvent molecules [10].

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 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 [11].

The decrease in free length in **figure 6** shows that, there is enhanced molecular association take place in the increasing concentration of ascorbic acid, which show that compactness of the structure is increases. The variation of Relaxation time with concentration is shown in **figure 8.** The relaxation time increases with the increase concentration the existence of strong molecular interaction between the ascorbic acid and water molecules. .The variation of Rao's constant with concentration is shown in **figure 9** is also supports the facts shown by given thermo-acoustical parameters. [12-13]

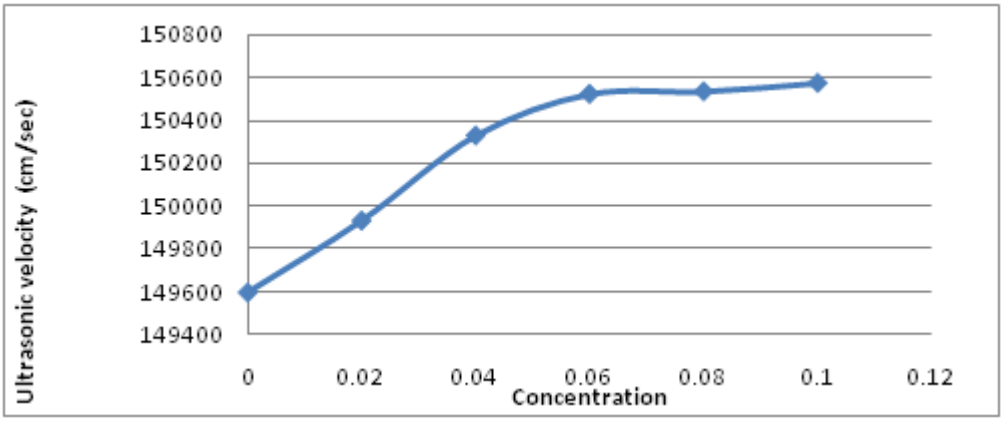

Figure 1: Variation of Ultrasonic velocity with Concentration

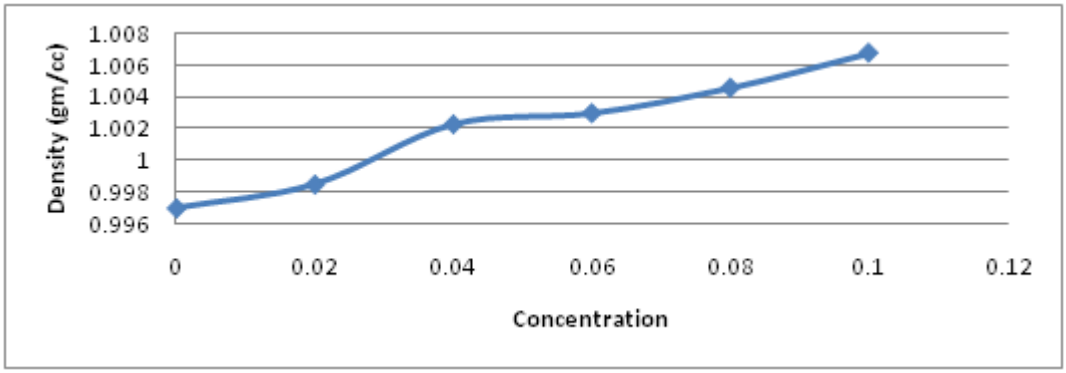

Figure 2: Variation of Density with Concentration

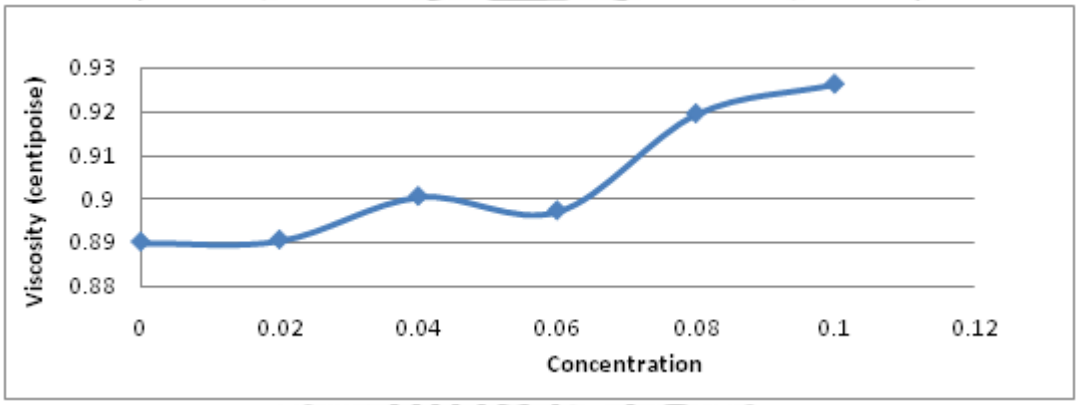

Figure 3: Variation of Viscosity with Concentration

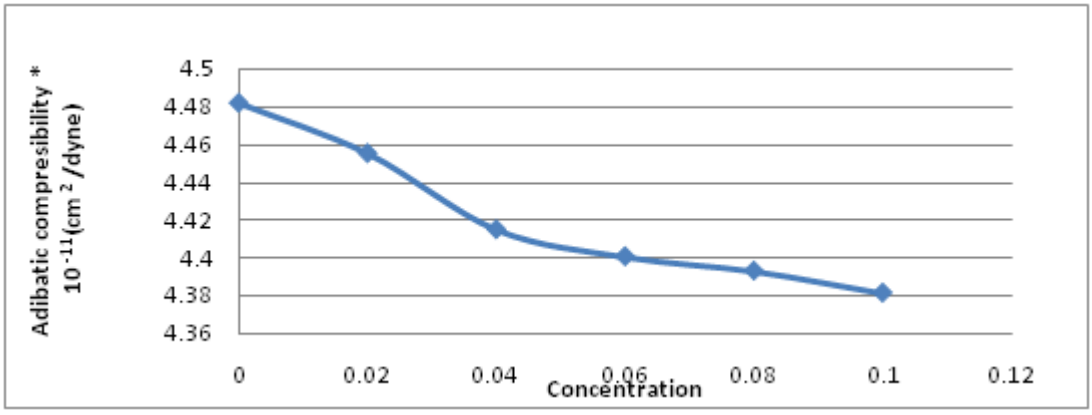

Figure 4: Variation of Adiabatic Compressibility with Concentration

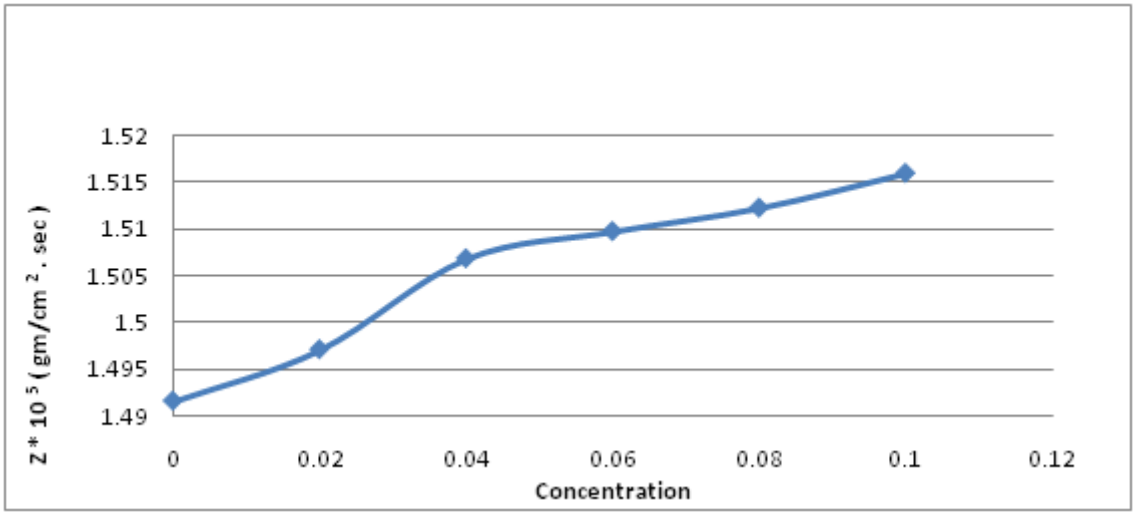

Figure 5: Variation of Acoustic Impedance with Concentration

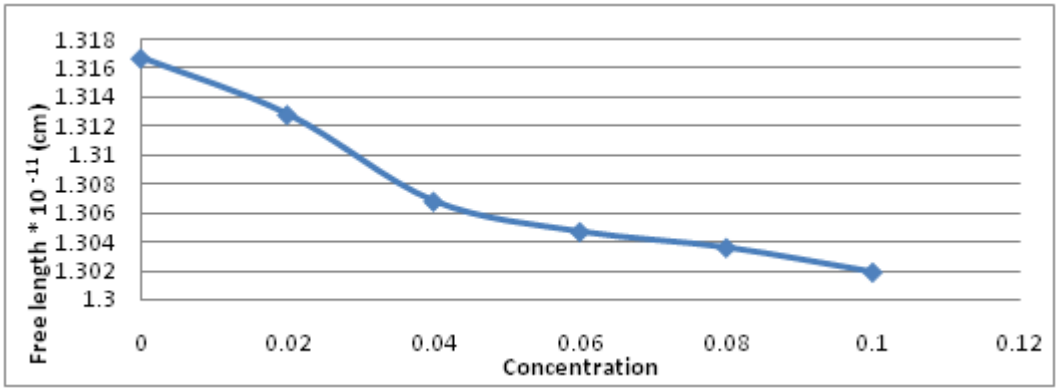

Figure 6: Variation of Free length with Concentration

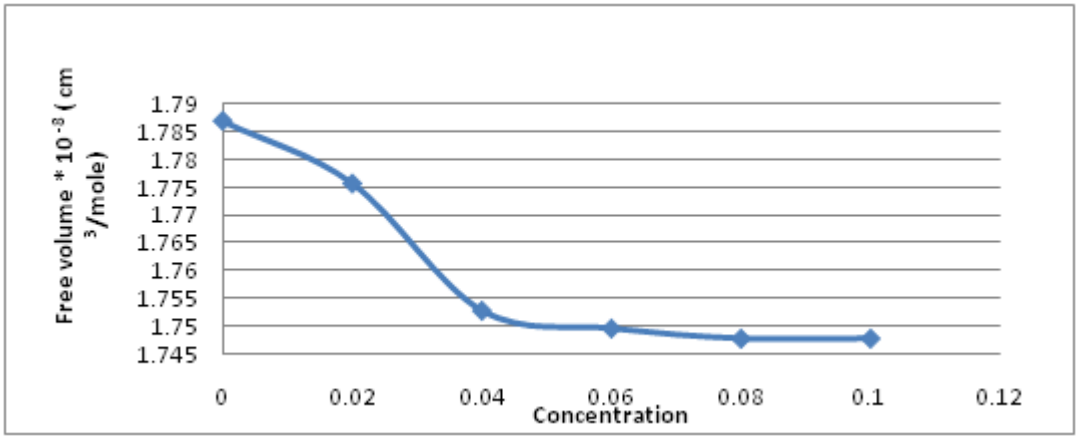

Figure 7: Variation of Free volume with Concentration

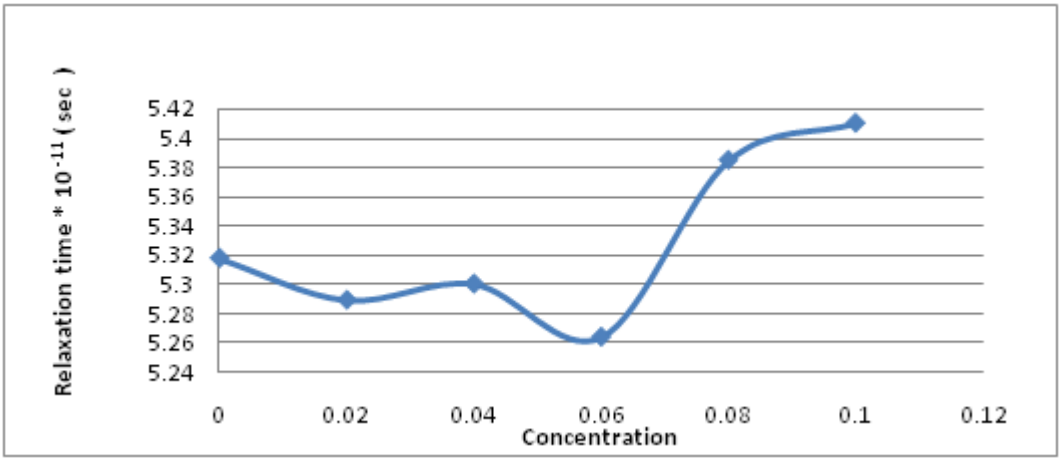

Figure 8: Variation of Relaxation time with Concentration

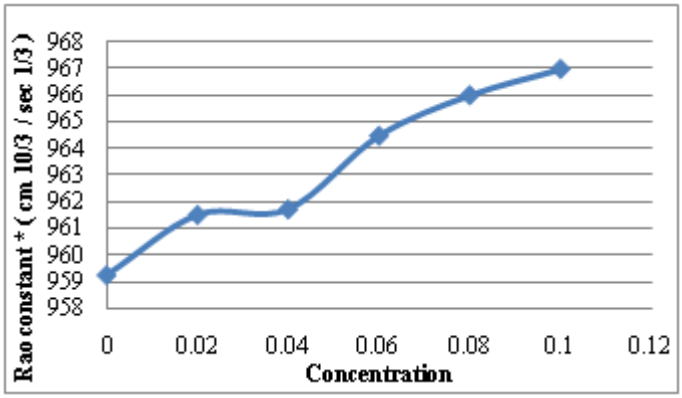

Figure 9: Variation of Rao's constant with Concentration

5. Conclusions

Ultrasonic velocity, density and viscosity are measured for aqueous solution of different concentration of ascorbic acid at 298K and other thermo-acoustical parameters are calculated. Ultrasonic velocity,dencity, viscosity acoustical impedance and Rao's constant are increases and the adiabatic compressibility, free length and free volume decreases with rise in concentration. This shows that strong solute-solvent interaction in a system are take place.

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