Thermo-acoustical study of aqueous Ascorbic acid at different temperature

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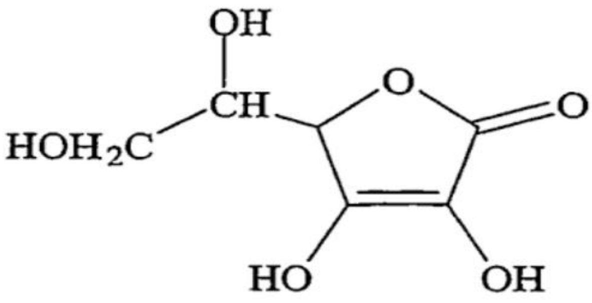
***Abstract* :** The density (ρ), viscosity (η) and ultrasonic velocity (U) of aqueous solution of ascorbic acid (vitamin C) at temperature 293K and 303K have been measured. Using this experimental data , other thermo-acoustical parameters such as adiabatic compressibility (β),relaxation time (τ), classical absorption (α/f^2), free volume (V_f), internal pressure (P_i), have been calculated and studied. These parameters have been used to give the interpretations of solute solvent interaction of water and ascorbic acid molecules. Furthermore these studies shows that the nature of molecular interaction in aqueous solution of ascorbic acid (vitamin C) and it provide important information regarding molecular properties of solute and solvent interaction. The obtained result show significant influence of concentration and temperature on the molecular aggregation, which is helpful in pharmaceutical and food industries to prepare various drug dosages, tablets, syrups, capsule, soft gel and injection in liquid form.

***Keywords* :** Ultrasonic velocity, adiabatic compressibility, free volume , internal pressure, and ascorbic acid.

I. Introduction

Density , viscosity, ultrasonic velocity 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. This gives a practical application in many pharmaceuticals and chemical industries. Density, viscosity, ultrasonic velocity and other thermo acoustical parameters such as adiabatic compressibility, relaxation time, classical absorption, free volume and internal pressure 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 mixture. [1-3]

Ascorbic acid is a colorless and water soluble vitamin. Ascorbic acid is present in all fresh fruits and vegetables. The richest source of vitamin C is the acerola fruit. Citrus fruits, tomatoes, melons, raw cabbage and green pepper are also rich source of it. New potatoes contain relatively large amount of vitamin C. Dried legumes and cereal contain very little vitamin C. In animals, the vitamin occurs in tissues and various glands or organs such as liver, adrenals, thymus, corpus luteum etc. Human milk has 3 to 4 times riches than cow's milk. However vitamin C is absent in fish, fats and oils. The structure of ascorbic acid was established mainly by Haworth. The chemical formula of ascorbic acid is $C_6H_8O_6$ and its molecular weight is 176.13. The structure of ascorbic acid is.



Structure of Ascorbic Acid

Vitamin C helps in the metabolism of tyrosine, folic acid and tryptophan. It also help in the metabolism of cholesterol. It also synthesis of the amino acid, carnitine and the catecholamines that regulate the nervous system. It also helps the body to absorb iron and to break down histamine. Absorption of iron in plants and drinking water is enhanced by vitamin C. One important function of vitamin C is in the formation and maintenance of collagens, the basis of connective tissues, which are found skin, ligaments, cartilages, vertebral discs, joint linings, capillary walls, bones and teethes. Collagen protein requires vitamin C for hydroxylation. Thus vitamin C is needed to give support and shape to the body to help wounds heal and to maintain, healthy blood vessels. It also protect small blood vessels from damage, this may help to prevent excessive menstrual blood loss [4].

This study give idea about molecular interaction in aqueous ascorbic acid through their properties like adiabatic compressibility, relaxation time, classical absorption, free volume, internal pressure, at temperature 293K and 303K , which is useful for pharmaceutical purpose and chemical industries.

II. MATERIALS AND METHODS

The stock solution of ascorbic acid (vitamin C) 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 is maintained using thermostatically controlled water circulation system with accuracy of 0.5^0c. The other thermo-acoustical parameters such as adiabatic compressibility, relaxation time, classical absorption, free volume, internal pressure, at temperature 293K and 303K were calculated using ultrasonic velocity, density and viscosity [5-7]. The experimental and calculated data for different concentration of ascorbic acid are given in the table 1 and 2.

III. THEORY

The ultrasonic velocity, density, viscosity and other thermo-acoustical parameters were calculated using following standard equation.

1] Ultrasonic velocity: $u = 2d / t$ cm/sec

Where, d = Separation between transducer & reflector

t = Traveling time period of ultrasonic wave.

2] Density : $\rho = \left(\frac{W_a - W_l}{W_a - W_w}\right) \times \rho_w$ g/cc

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

3] Viscosity: $\eta = \frac{\rho \times t_1}{\rho_w \times t_w} \times \eta_w$ centipoise

Where, t_l = Flowing time for liquid.

t_w = Flowing time for water.

η_w = Viscosity of water.

4] Adiabatic Compressibility : $\beta_a = \frac{1}{u^2 \times \rho}$ cm^2/dyne

5] Relaxation Time : $\tau = \frac{4}{3} \eta . \beta_a$ sec

6] Classical Absorption : $\alpha/f^2{}_{class} = \frac{8\pi^2\eta}{3\rho u^3} \frac{Np}{cm}.sec^2$

7] Free Volume : $V_f = \left(\frac{V}{u^3}\right)\left(\frac{\gamma R_1 T}{M}\right)^{3/2}$ cm^3/mole

Where, T = Experimental temperature in Kelvin

$\gamma = C_p/C_v$ = Ratio of sp. heats=1.4

V = Molar volume

R_1 = Rao's constant

M = Molecular weight

8] Internal Pressure: $P_i = b R T^3\left[\left(\frac{K_j\eta}{u\cdot}\right)^{1/2}\left(\frac{\rho^{2/3}}{M^{1/6}}\right)\right]$ dyne/cm^2

Where Kj = Jacobson's constant = 4.28×10^9

b = Vander Waal's constant

R = Gas constant = 8.3143×10^7 erg. $Mol^{-1} K^{-1}$

Table no. 1 Thermodynamic parameters at 293K

Con.	u cm/sec	ρ gm/cc	η centi. poise	$\beta \times 10^{-11}$ cm^2/dyne	$\tau \times 10^{-11}$ sec	$(\alpha/f^2)_{class} \times 10^{-15}$ $\frac{Np}{cm} sec^2$	$V_f \times 10^{-08}$ cm^3/mol	$P_i \times 10^{11}$ dyne/cm^2
0	148268	0.9982	1.002	4.5571	6.0881	8.0972	1.7761	2.8374
0.02	148405	1.0007	1.0314	4.5373	6.2395	8.2910	1.7665	2.8717
0.04	148472	1.0018	1.0375	4.5282	6.2639	8.3196	1.7652	2.8711

0.06	148633	1.0042	1.0385	4.5077	6.2415	8.2809	1.7554	2.8650
0.08	148790	1.0067	1.0442	4.4870	6.2469	8.2792	1.7454	2.8656
0.10	148916	1.0082	1.0564	4.4727	6.2998	8.3423	1.7407	2.8735

Table no. 2 Thermodynamic parameters at 303K

Con.	**u cm/sec**	**ρ gm/cc**	**η centi. poise**	**β x 10^{-11} cm^2/dyne**	**τ x10^{-11} sec**	**$(\alpha/f^2)_{class}$ x10^{-15} $\frac{Np}{cm}$ sec^2**	**V_f x10^{-08} cm^3/mol**	**P_i x10^{11} dyne/cm^2**
0	150645	0.9956	0.798	4.4259	4.7090	6.1643	1.8104	2.5933
0.02	150820	0.9981	0.8017	4.4046	4.7081	6.1559	1.7959	2.5927
0.04	150862	0.9988	0.8124	4.3991	4.7650	6.2284	1.7971	2.6012
0.06	150959	1.0009	0.8253	4.3842	4.8243	6.3019	1.7904	2.6151
0.08	151024	1.0030	0.8301	4.3713	4.8385	6.3171	1.7847	2.6162
0.10	151136	1.0044	0.8278	4.3587	4.8107	6.2769	1.7808	2.6045

IV. RESULT AND DESCUSSION

The experimental and calculated data of ultrasonic velocity, density, viscosity, adiabatic compressibility, relaxation time, classical absorption, free volume and internal pressure of aqueous ascorbic acid at 293K and 303K are recorded in table 1 and table 2 respectively. For systematic understanding the effect of concentration and temperature on these parameters, graphs have been plotted as shown in figures 1-8

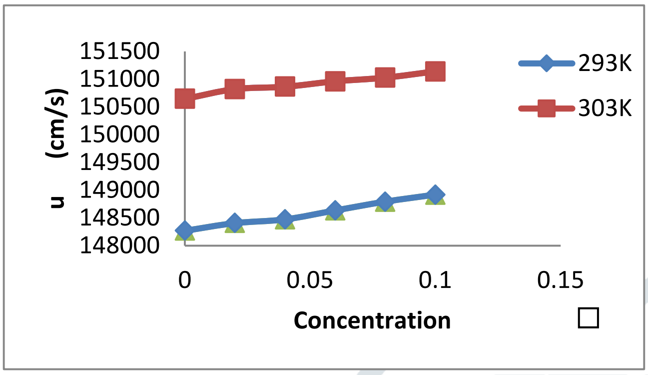
It is observed that the ultrasonic velocity is increases and adiabatic compressibility decreases with rise in concentration of ascorbic acid is indicate that, there is a significant interaction between the solute-solvent components of the aqueous ascorbic acid [8] which shown in **figure 1** and **figure 4**. This is also supported by the increase in density with concentration shown in **figure 2**

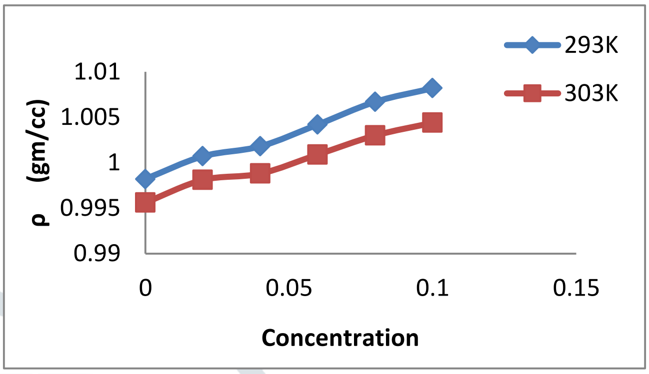
In **figure 3** gives the viscosity of aqueous ascorbic acid increases linearly with the concentration, which suggests the increase in cohesive forces due to powerful interaction between molecules of vitamin and water. The acoustic impedance of ascorbic acid is increases with the increase of concentration shown in **figure 5** indicate that there is strong interaction between solute and solvent molecules [9].

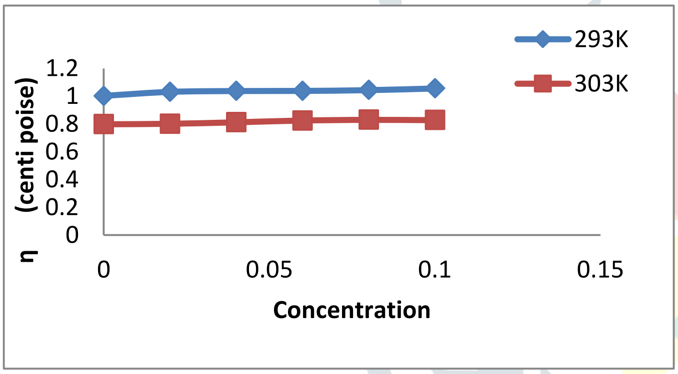
The molecule of liquid are not closely packed, there is always some space between them, this free space is known as free volume. The variation of free volume with concentration shown in **figure 7** which shows that solute and solvent molecules are coming close to each other and space between them is decreases with rise in concentration. This supports to the strong solute-solvent interaction in liquid solution [10-11].

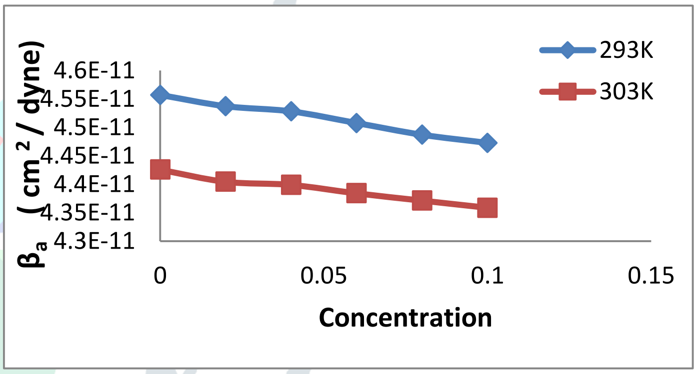
In this system, viscosity (η) relaxation time (τ), classical absorption $(\alpha/f^2)_{class}$, internal pressure (p_i) varies slightly with increase in molar concentration of vitamins. This indicates significant interaction take place between vitamins and water molecules.

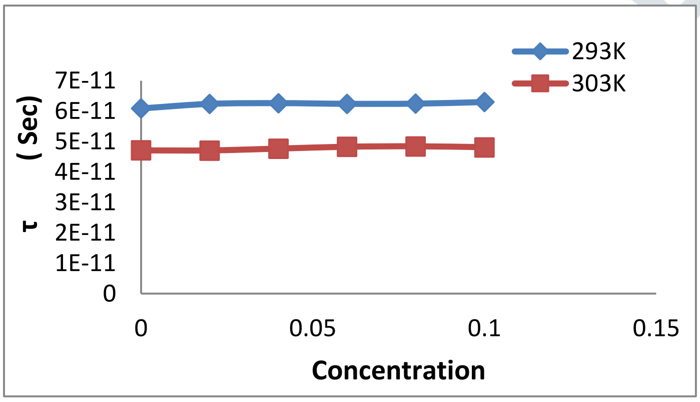
Ultrasonic velocity increases (u) and adiabatic compressibility (β_a) decreases with increase in temperature. This shows that, as the temperature increases the available thermal energy is used to breaking hydrogen bonds of solvent molecules into their monomers. These broken solvent molecules enter the vacant space present in the cage like structure and thus trapped. As a result, number of closed packed structure of solvent molecules increases with increase in temperature. This closed packed structure form a material medium for propagation of ultrasonic velocity. Thus ultrasonic velocity is large at 303K than 293K and adiabatic compressibility has reverse trend of ultrasonic velocity and it support the above discussion.

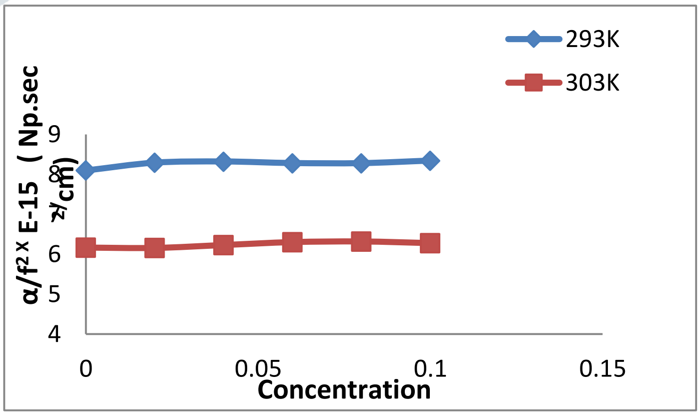


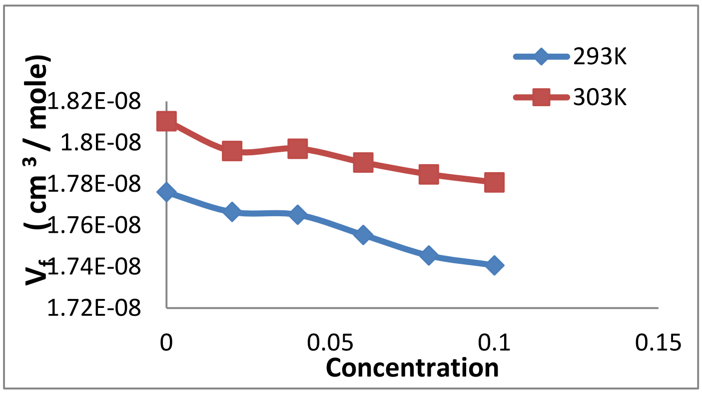


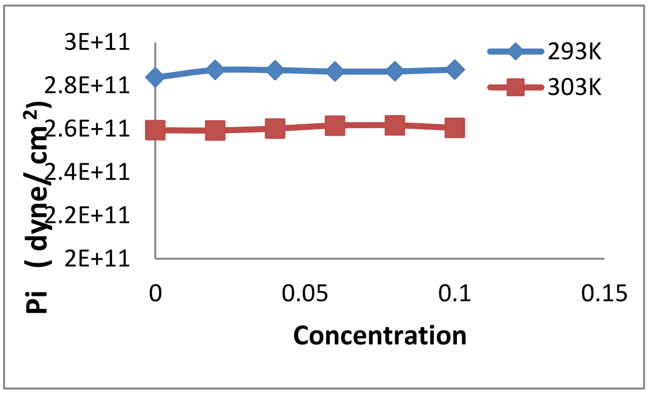












V. CONCLUSIONS

Ultrasonic velocity, density and viscosity are measured for aqueous solution of different concentration of Ascorbic acid at 293K and 303K and other thermo-acoustical parameters are calculated. The graph is plotted between various parameters and concentration. This shows that, binary liquid systems containing vitamins C and water have strong intermolecular attraction between vitamin and water due to hydrogen bonding and hence association takes place in the mixture.

REFERENCES

1]. V. A Tabhane, Sangita Agrawal, K.G. Rewatkar, J. Acoustic soc. India Vol. 28, no.1-4, pp.369-372, 2000.

2]. P. V. Tabhane, O. P. Chimimankar, C. M. Dudhe and V. A. Tabhane, Der Chemic Sinica, 3(4) pp.944-947 2012.

3]. O. P. Chimankar, Rangeeta Shrivas and V. A. Tabhane Archives of Applied Science research 2(6) pp. 285-289, 2010.

4]. A. N.Sonar, J. Chem. And Pharmaceutical Research, 3(4), pp. 485-489, 2011.

5]. Arti Gupta,Roli Strivastava and Archana Pandey ,Global Adraneed Research J.Chem and mat. sci vol 1(3) PP 039-054, 2012.

6]. G. Akgul, E. Bayram and E Ayranci , J. Solution Chem. 35, pp. 1655-1972, 2006.

.7] C. M. Dudhe , K. C. Patil, Int.J. of Natural Product research, 2(4) , pp. 76-78, 2012

8] V. G. Dudhe, V. A. Tabhane and O. P. Chimankar, Int.J. of Innovative Science, Engineering & Technology, vol 2(8), 2015

9] A. N.Sonar, N. S. Pawar, Rasayan J. Chem. Vol 3 no. 1 ,38-43, 2010.

10] S.Punitha, A. Panneer selvam , R. Uvarani , Int. J Pharm Bio Sci,, vol. 4(1), pp. 540-548, 2013

11] O. P. Chimankar, Rangeeta Shrivas, P. S. Chopade and V. A. Tabhane , J. Chem. Pharm Res. 3(3) pp. 579- 586, 2011.