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Research Article

THARMO-ACOUSTICAL INVESTIGATION IN TERNARY MIXTURE AT 308.15K

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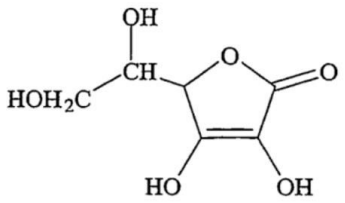
ABSTRACT
For the study of thermo-acoustical investigation in the ternary mixture (vitamin C, water, and KCL) at 308K, ultrasonic velocity, density, and viscosity have been measured at 5 MHz frequency. The measured value of ultrasonic velocity, viscosity, and density have been used to calculate the thermo-acoustical parameters namely adiabatic compressibility, Relaxation Time, Classical Absorption, free volume, Internal Pressure. This investigation is used to give the nature and strength of molecular interaction in a ternary mixture of aqueous vitamin C with 0.1M KCL solution. The obtained result support the occurrence of association, dissociation as well as complex formation due to the hydrogen bond and ionic interaction in this ternary liquid mixture.

Keywords: Vitamin C, Ultrasonic velocity, Classical Absorption, Internal pressure, Relaxation Time.

1. INTRODUCTION

Vitamin C is a colorless and water-soluble vitamin. The physicochemical properties of vitamin C are of the considerably interested as it is an essential nutrient for humans and certain other animal species. Vitamin C gives more impact on cardiovascular disease, hypertension, chronic inflammatory diseases, and diabetes, etc. [1]. It also increases the immunity power of the human body.

The chemical formula of ascorbic acid is $C_6H_8O_6$ and its molecular weight is 176.13. The structure of ascorbic acid is.



For the study of the molecular interaction of vitamin C, we used the ultrasonic technique, which has a powerful tool to study the molecular behavior of the liquid mixture. In recent years ultrasonic investigators find a large number of applications in the characterization of binary and ternary mixtures [2-6].

In the present paper, we have reported the ultrasonic velocity, density, and viscosity of aqueous vitamin C with 0.1M KCl solution at 308.15K over the entire range of the molar concentrations. Using this experimental value other thermo-acoustical parameters, namely adiabatic compressibility, Relaxation Time, Classical Absorption, free volume, and Internal Pressure has been calculated. The variation of these parameters in different molar concentration was found to be useful in understanding the nature of the interaction between the molecules of the ternary mixture.

2. MATERIAL AND METHODS

The ultrasonic Vitamin C used in the present work was of Analytical Reagent (AR) grade. The stock solution of vitamin C was prepared by using double distilled water. By using 0.1M KCl solvent, the different molar concentration of the solution was prepared. Velocity of different molar concentrations was measured using 'pulse-echo overlap' technique having an automatic ultrasonic recorder (AUAR-102) and frequency counter. The frequency of the pulses was kept at 5MHz. The density is measured using the hydrostatic plunger method and viscosity by Oswald's Viscometer. The thermostat is used for keeping constant temperature at 308.15K. The other thermo-acoustical parameters, namely adiabatic compressibility, relaxation time, classical absorption, free volume, and internal pressure are calculated using the following formulae [7-9].

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

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

2. Density: $\left[\frac{W_a - W_1}{W_a - W_w}\right] \times \rho_w \quad gram/cm^3$

Where, W_a = Weight of the plunger in air

W_1 = Weight of the plunger in the experimental liquid

W_w = Weight of the plunger in water

ρ_w = Density of water

3. Viscosity: $\eta = \left[\frac{\rho \times t_1}{\rho_w \times t_w}\right] \times \eta_w \quad Centipoise$

Where, t_1 = Flow Time of experimental liquid

t_w = Flow Time of 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: $\alpha/f^2_{class} = \frac{8\pi^2\eta}{3\rho u^3} N_p.cm^{-1}sec^2$

7. Free volume: $(V_f) = M_w u / k\eta$ $cm^3/mole$

Where, k = Time independent constant.

M_w = molecular weight of solution.

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

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}

M = Molecular weight

Table 1:

Concentration	Ultrasonic Velocity (u) cm s^{-1}	Density (ρ) g cm^{-3}	Viscosity (η) Centi poise	Adiabatic compressibility (β x 10^{-11}) cm^2 $dyne^{-1}$
0	152108	0.9991	0.7207	4.3206
0.02	151604	0.9977	0.6812	4.3609
0.04	152112	0.9994	0.7087	4.3245
0.06	152425	1.0006	0.7281	4.3016
0.08	151821	0.9992	0.7025	4.3419
0.10	152525	1.0028	0.7431	4.2865

Table 2:

Concentration	Relaxation Time (T X 10^{-11}) sec.	Classical absorption (α/f^2_{class} X 10^{-15}) $N_p.cm^{-1}sec^2$	Free Volume (V_f X 10^{-8}) cm^3/mole	Internal Pressure (Pi X 10^{11}) dyne/cm^2
0	4.1627	5.3966	1.8018	2.4843
0.02	3.9608	5.1519	1.8268	2.4097
0.04	4.0863	5.2974	1.8075	2.4508
0.06	4.1759	5.4024	1.7965	2.4778
0.08	4.0668	5.2823	1.8244	2.4307
0.10	4.2470	5.4908	1.7909	2.4943

3. RESULT AND DISCUSSION

The measured ultrasonic velocity, density, a viscosity of Aqueous vitamin C with KCL and calculated thermo-acoustical parameters, namely adiabatic compressibility, relaxation time, classical absorption, free volume, and internal pressure at 308.15K were shown in table 1 &2 and related graphical representations are shown in Fig. 1 to 8.

It is observed that ultrasonic velocity and adiabatic compressibility have an almost nonlinear variation with molar concentration are shown in Fig. (1) and Fig. (4). The ultrasonic velocity decreases at lower concentrations and after 0.02 molar concentrations, it is increasing. Thus the association takes place due to ionic interaction as well as the formation of the hydrogen bond. After 0.06 molar concentrations dissociation takes place due to the breaking of hydrogen bond and ionic interaction. Again, after 0.08 molar concentrations association takes place. The adiabatic compressibility has a reverse trend of ultrasonic velocity. Thus, in the given ternary mixture, association, dissociation, and complex formation take

place due to ionic interactions among the molecules and the creation and breaking of hydrogen bonds in the solution [10].

Fig. (2) and Fig. (3) shows the change in density and viscosity with molar concentration This indicating the existence of molecular interaction in the given mixture and it supports the above explanation [11].

The free volume and internal pressure has also nonlinear variation with an increase in molar concentration shown in Fig. (7) & Fig. (8). Free volume has a peak at 0.02 and 0.08 molar concentration and dips at 0.06 molar concentration. Whereas internal pressure has reversed the trend. This indicates the association, dissociation, and complex formation take place in the solution [12].

The relaxation time and classical absorption have a slight variation with molar concentration. Thus, in the ternary mixture have significant molecular interaction shown in Fig. (5) and Fig. (6).

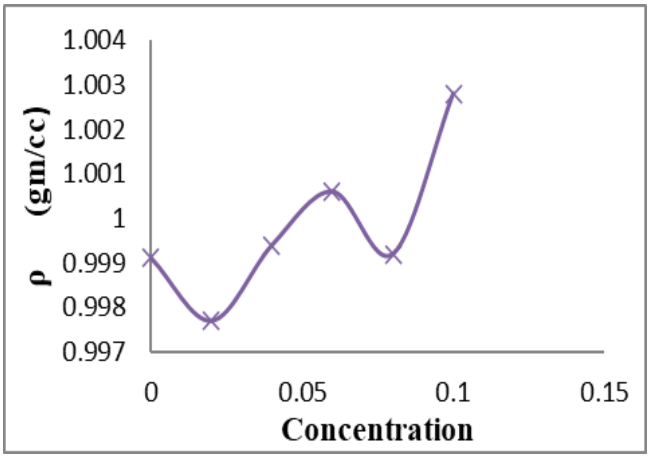


Fig. 1: Change in Ultrasonic velocity with Concentration

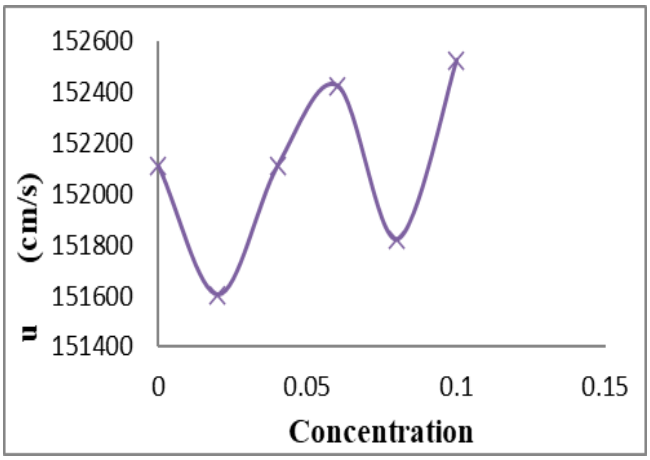


Fig. 2: Change in Density with Concentration

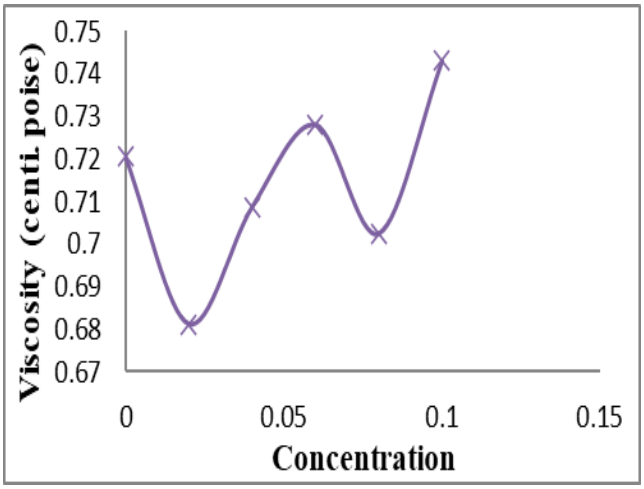


Fig. 3: Change in Viscosity with Concentration.

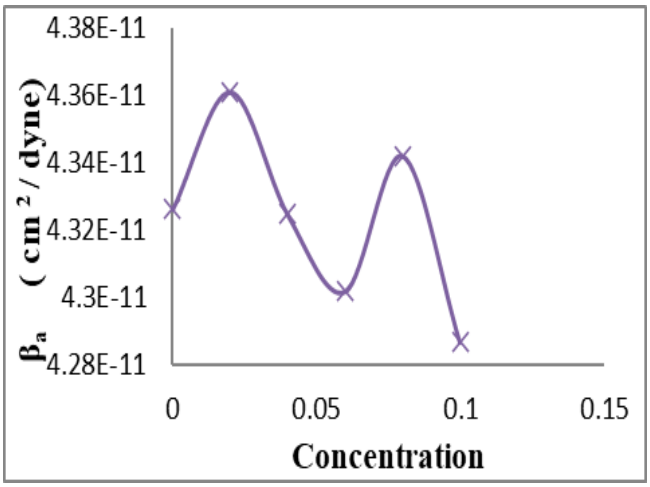


Fig. 4: Change in Adiabatic Compressibility with conc.

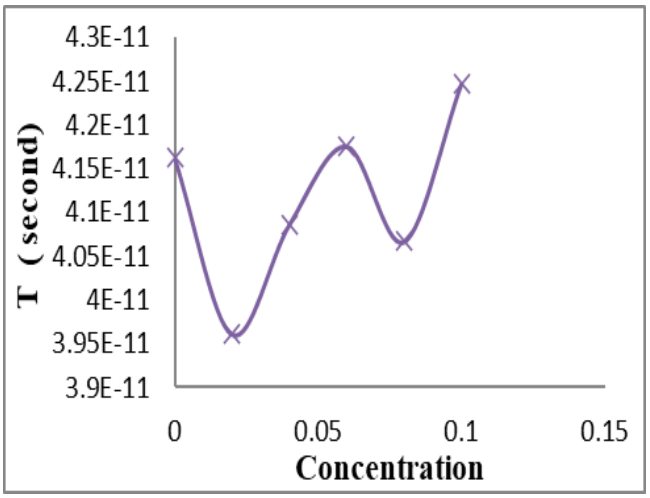


Fig. 5: Change in relaxation time with Concentration

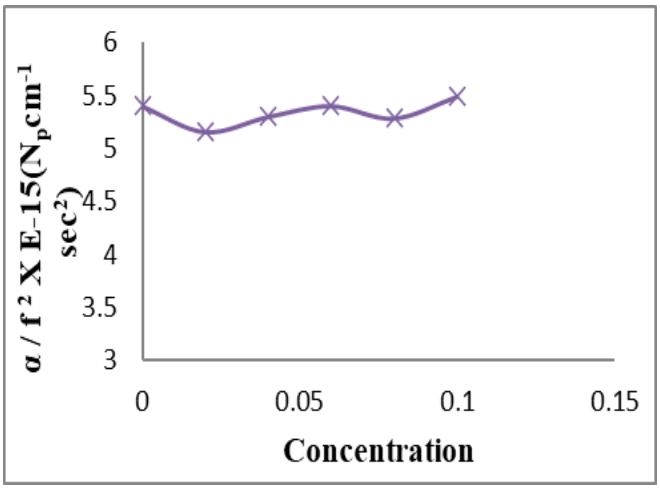


Fig. 6: Change in Classical absorption with conc.

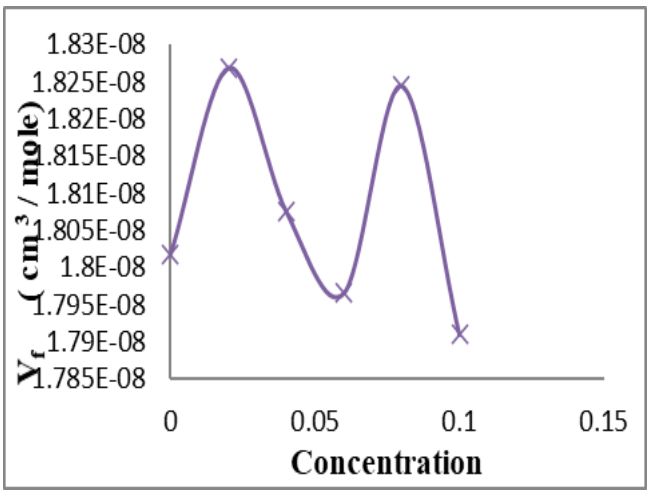


Fig. 7: Change in Free volume with Concentration

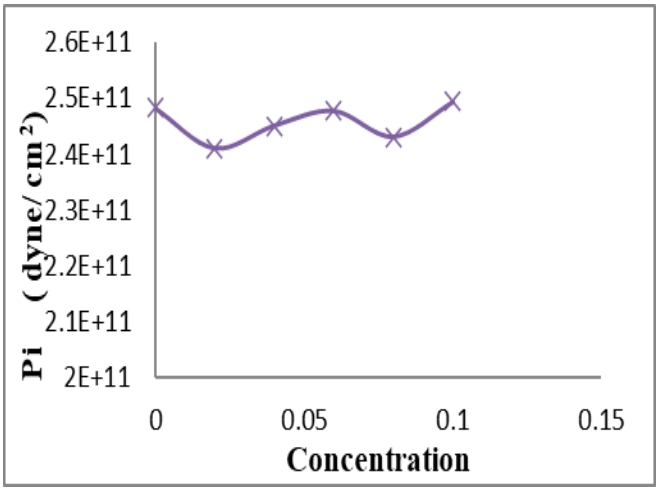


Fig. 8: Change in Internal pressure with concentration

4. CONCLUSION

All parameters are non-linearly varied with the increase in molar concentration of aqueous vitamin C with KCL solution. Thus the association, dissociation and complex formation take place in the liquid mixture may be due to the formation and breaking of hydrogen bond as well as ionic interaction between solute and solvent molecules.

5. ACKNOWLEDGEMENTS

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