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INVESTIGATION OF ACOUSTICAL BEHAVIOR OF THIAMINE HYDROCHLORIDE AT 303K

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ABSTRACT

Density (ρ) and viscosity (η and ultrasonic velocity (U) of different concentration of aqueous Thiamine Hydrochloride (vitamin B1) 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 (β), acoustic impedance (z), free length (Lf), free volume (Vf), relaxation time (T) and Rao's constant (R) . Gibb's free energy (ΔG). These parameters have been used to give the interpretations of solute- solvent interaction of Thiamine Hydrochloride and H2O molecules. Furthermore these studies provide important information regarding molecular properties of solute and solvent interaction.

Keywords- *Density, Viscosity, Ultrasonic velocity, Adiabatic compressibility, Free volume , Gibb's free energy and Thiamine Hydrochloride.*

I. INTRODUCTION

The Molecular interactions of materials have been study by various experimental techniques. The ultrasonic wave passes through the medium , part of its energy is utilized in the weakening or breaking up of O-H-O bonds. This explanation finds some support from NMR studies , in which the hydrogen bonds tend to weaken when the protons are brought closer. Neutron and X-ray scattering helps in the study of molecular motion and configurations in the liquids. The spectroscopic technique provides useful information on the intermolecular interaction.

The study of molecular interaction liquids renders invaluable information pertaining to molecular association, internal structure, internal pressure, free volume, cohesive energy, complex formation etc. Therefore attempts have been made to develop more accurate methods for study of molecular interaction. The ultrasonic method are more accurate method for the study of molecular interaction [1-7]

Vitamins are important organic compounds which take role in enzyme processes as co-enzyme or their precursors and in genetic regulation processes. It is also act as anti oxidants. Most of vitamins cannot be synthesized by body and thus they must be taken through diets. Thiamine Hydrochloride is a water soluble vitamin , hence It is necessary to study aqueous solution of vitamin in order to understand the mechanisms of their action.

This paper give investigate of molecular interaction among the molecules of vitamin B_1 and water.

II. MATERIALS AND METHODS

The stock solution of Thiamine Hydrochloride (vitamin B_1) 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 303K 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 , Rao's constant and Gibb's free energy 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 nicotinic acid are given in the table 1 and 2.

III. 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 =

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

2] Density:

$$\rho = \left[\frac{W_a - W_1}{W_a - W_w}\right] \times \rho_w$$

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 :

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

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) =

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) == $\eta.\ \beta$

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

10] Gibb's Free Energy : $\Delta G = -K_B T \log_e [h / \tau K_B T]$

Where, K_B = Boltzmann's Constant = 1.380 X 10^{-16} erg /K
h = Planck's constant = 6.626 X 10^{-27} erg sec

Table no. 1

Concentration	**Ultrasonic Velocity (u) cm/sec**	**Density (ρ) gm/cc**	**Viscosity (η) Centipoises**	**Adiabatic compressibility ($\beta \times 10^{-11}$) cm^2/dyne**	**Acoustic impedance ($Zx10^5$) gm. cm^{-2} s^{-1}**
0	150645	0.9956	0.798	4.4259	1.4999
0.02	150971	0.9976	0.8039	4.3980	1.7140
0.04	151366	1.0006	0.8189	4.3620	1.7626
0.06	151633	1.0037	0.8266	4.3332	1.7756
0.08	151942	1.0055	0.8455	4.3079	1.8563
0.10	152276	1.0068	0.8566	4.2834	1.8921

Table no. 2

Concentration	Free length (L_f x 10^{-11}) cm	Free Volume (V_f X 10^{-8}) cm^3/mole	Relaxation time (T x 10^{-11}) sec	Rao's constant(R) ($cm^{10/3}/sec^{1/3}$	Gibb's free energy ($\Delta GX10^{-13}$) erg/mole
0	1.3200	1.8104	4.7090	962.8111	2.3810
0.02	1.3158	1.7992	4.7140	967.6052	2.3814
0.04	1.3104	1.7853	4.7626	971.6086	2.3857
0.06	1.3061	1.7748	4.7756	975.2778	2.3869
0.08	1.3023	1.7690	4.8563	980.3368	2.3939
0.10	1.2985	1.7647	4.8921	985.9727	2.3970

IV. RESULT AND DESCUSSION

The experimental data of ultrasonic velocity, density, viscosity, , adiabatic compressibility and acoustic impedance of Thiamine Hydrochloride at 303 K, are recorded in table 1, and Intermolecular free length, free volume, Relaxation time, Rao's constant and Gibb's free energy are given in table 2.

It is observed that the ultrasonic velocity is increases and adiabatic compressibility decreases with rise in concentration of Thiamine Hydrochloride is indicate that, there is a significant interaction between the solute-solvent components of the aqueous Thiamine Hydrochloride [10-11]which shown in **figure 1** and **figure 4**. This is also supported by the increase in density with concentration shown in **figure 2 [8]**

In **figure 3** gives the viscosity of aqueous Thiamine Hydrochloride 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 Thiamine Hydrochloride 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 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].

The decrease in free length in **figure 6** shows that, there is enhanced molecular association take place in the increasing concentration of nicotinic 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, there is existence of strong molecular interaction between the Thiamine hydrochloride 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.

The Gibb's free energy suggest the existence of molecular association or dissociation between unlike molecules [11]. The increase value of ΔG indicate the closer approach of unlike molecules is due to intermolecular forces which is shown in **figure 10**

Fig.1: Variation of Ultrasonic velocity with concentration

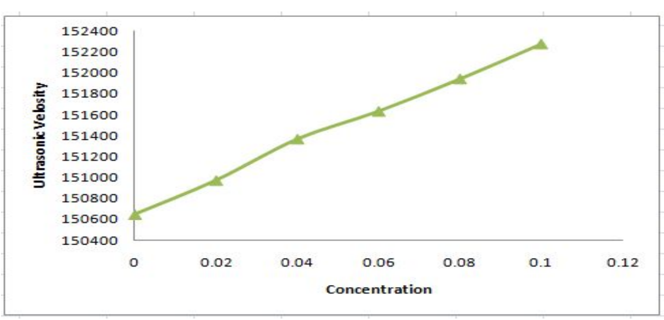
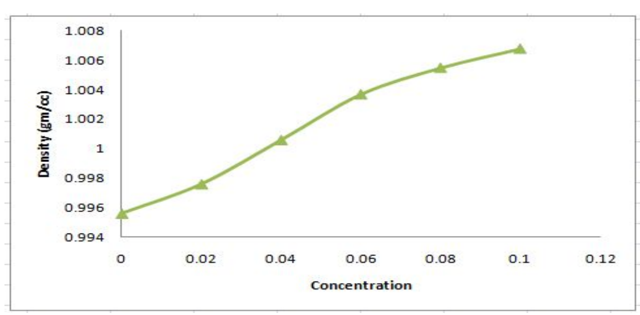


Fig.2: Variation of Density with concentration



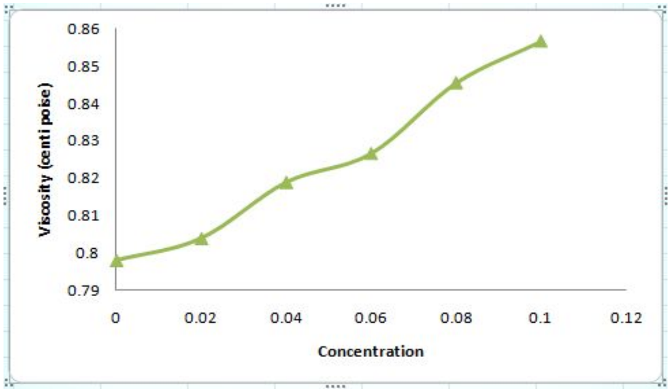


Fig. 3: Variation of viscosity with Concentration

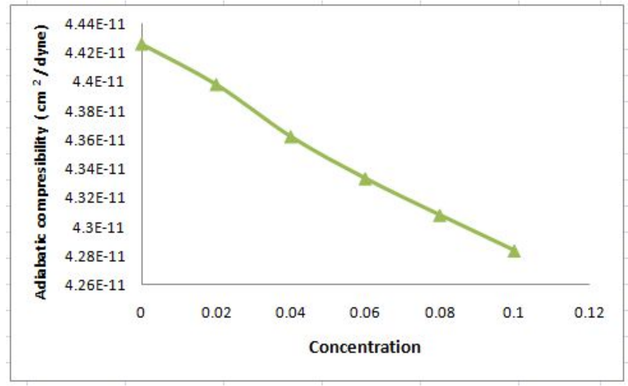


Fig. 4: Variation of Adiabatic comp. with Concentration

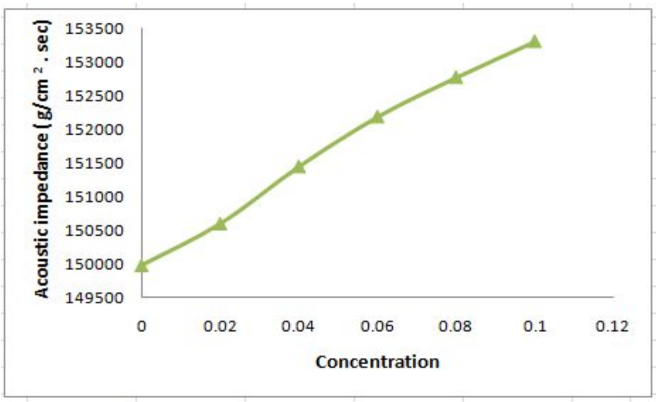


Fig. 5: Variation of Acoustic impedance with Concentration

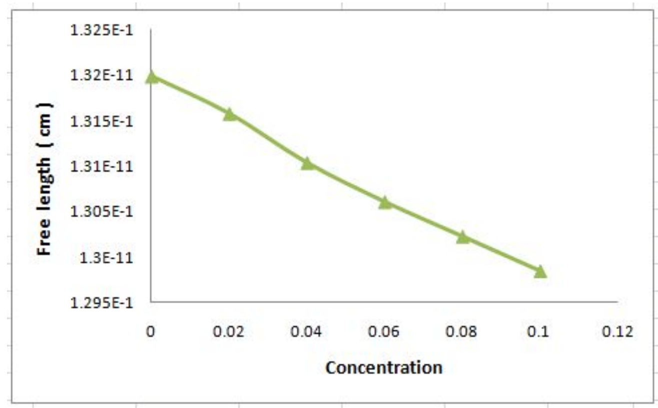


Fig. 6: Variation of Free length with Concentration

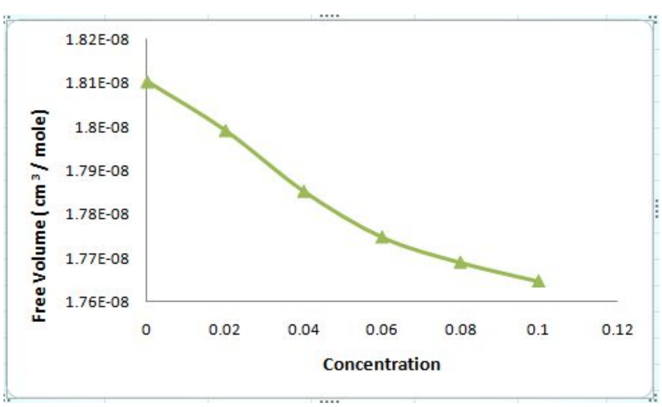


Fig 7: Variation of Free volume with Concentration

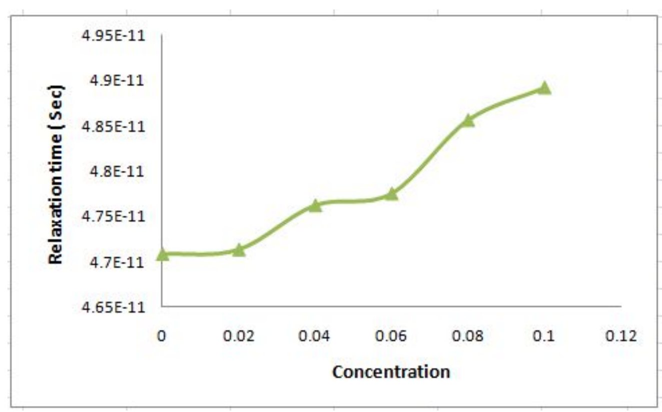


Fig 8: Variation of Relaxation time with Concentration

Fig 9: Variation of Rao's constant with Concentration

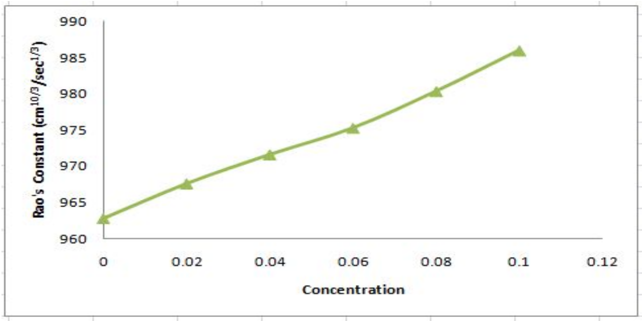
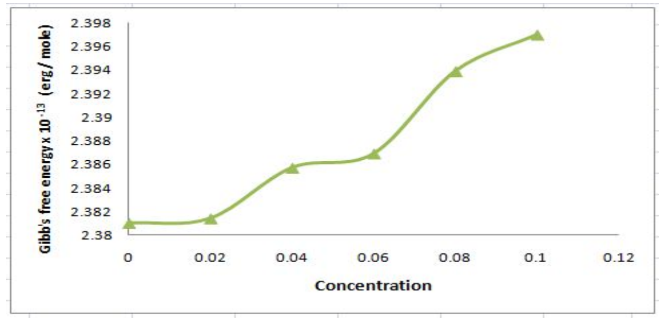


Fig 10: Variation of Gibb's free energy with concentration



V. CONCLUSIONS

Ultrasonic velocity, density and viscosity are measured for aqueous solution of different concentration of Thiamine hydrochloride at 303K and other thermo-acoustical parameters are calculated. Ultrasonic velocity, viscosity, acoustical impedance, relaxation time and Gibb's free energy 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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