Study of Acoustic and Thermodynamic properties of Ternary liquid mixture of Aqueous Thiamine Chloride in KOH Solution

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Abstract:

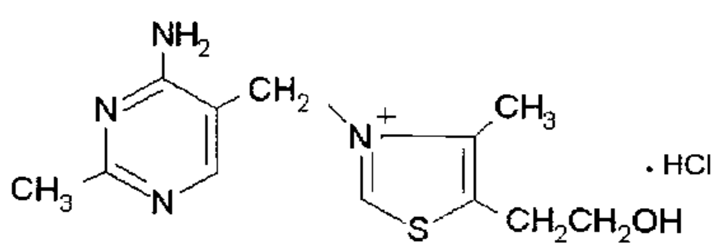
For the study of acoustic and thermodynamic properties of ternary liquid mixture of aqueous thiamine hydrochloride in KOH solution at temperature 293.15K, we measure three impartment parameters such as ultrasonic velocity (U), density (ρ) and viscosity (η). The measurement of ultrasonic velocity were carried out by using the ultrasonic pulse eco overlap (PEO) technique at frequency 5 MHz The density and viscosity ware measured using hydrostatic plunger method and Oswald's viscometer respectively. The temperature 293.15K was kept constant using thermostat. This experimental data have been used to calculate the thermo-acoustical parameters like adiabatic compressibility (β), acoustic impedance (Z), free length (L_f), free volume (V_f) , wada's constant (β_m) and Rao's constant (R). These parameters have been used to give the interpretations of solute- solvent interaction of aqueous thiamine hydrochloride and KOH molecules. This study also shows the nature of molecular interaction and complex formation in the given solution.

Keywords: Ultrasonic velocity, adiabatic compressibility, free volume, wada's constant, Rao's constant, Thiamin hydrochloride.

Introduction:

Thiamin hydrochloride was first isolated by scientist Jansen and Windaus in 1949. It is also known as vitamin B_1. Human body needs thiamine to process carbohydrates, fats and protein. Practically it is found in all plants and animal foods. It is found in outer layers of seeds of many plants including the cereal grains like rice, wheat etc. It also found in some animal organs like heart, liver and kidney.

The chemical formula of Thiamin hydrochloride is C_{12} H_{17} N_4OS HCL and its molecular weight is 337.27 gram. The structure of vitamin B_1 is



Structure of Thiamin Hydrochloride

Thiamin hydrochloride is a white crystalline substance. It is readily soluble in water, methanol, ethanol and glycerol but insoluble in ether, chloroform and benzene.

Thiamin hydrochloride helps to convert sugar and starches into energy. It promotes digestion, strong heart muscle, child growth. It is used to prevent fatigue and fat deposits in arteries. It also necessary for nerve cell functions. [1-3]

Acoustical and thermo dynamical properties of thiamin hydrochloride in KOH have been play very important role for studying weak and strong molecular interactions in binary and ternary mixture [4-7]. These parameters are also very helpful to study the nature of intermolecular forces in liquid mixtures and also give idea about association, dissociation and complex formation in a given mixture. It has practical application in many pharmaceuticals and chemical industries.

MATERIALS AND METHODS:

The aqueous thiamin hydrochloride solution (0.1M) was prepared using double distilled water. The solution of different concentration was prepared using 0.1M KOH solvent. The ultrasonic velocity for different concentration of aqueous thiamin hydrochloride with KOH solutions measurement were carried out with a highly versatile and accurate 'pulse echo overlap technique (PEO) method. 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 293.15K was maintained using thermostatically controlled water circulation system with accuracy of 0.5^0C. The other thermo-acoustical parameters such as adiabatic compressibility (β), acoustic impedance (Z), free length (L_f), free volume (V_f) , wada's constant (β_m) and Rao's constant (R) ware evaluated using ultrasonic velocity, density and viscosity. The experimental data of ultrasonic velocity (U), viscosity (ŋ), density (ρ), adiabatic compressibility (β), acoustic impedance (Z), free length (L_f), free volume (V_f) , wada's constant (β_m) and Rao's constant (R) for different molar concentration of thiamin hydrochloride with KOH are given in the table 1 and 2 .

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 [8].

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

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_1 = Weight of the plunger in the experimental liquid
W_w = Weight of the plunger in water
ρ_w = Density of water

3] Viscosity : $\eta = \frac{\rho \times t_1}{\rho_w \times t_w} \times \eta_w$
Where, t_1 = 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 = Jacobson's constant = $(93.875+0.345T) \times 10^{-8}$ (T is temperature)

7] Free volume : $(V_f) = M_w u / k\eta$
Where, k = Time independent constant = 4.28×10^9
M_w = molecular weight of solution

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

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

Table no. 1

Concentration	**Ultrasonic Velocity (u) cm s^{-1}**	**Density (ρ) g cm^{-3}**	**Viscosity (η) Centi poise**	**Adiabatic compressibility ($\beta \times 10^{-11}$) cm^2 $dyne^{-1}$**	**Acoustic impedance ($Z \times 10^5$) g cm^{-2} s^{-1}**
0	149149	1.0028	1.0232	4.4832	1.4955
0.02	149079	1.0030	1.0353	4.4861	1.4953
0.04	149263	1.0045	1.0549	4.4683	1.4993
0.06	149564	1.0084	1.0662	4.4332	1.5082
0.08	149877	1.0097	1.0835	4.4089	1.5133
0.10	150029	1.0098	1.0976	4.3996	1.5150

Table no. 2

Concentration	Free length (L_f x 10^{-11}) cm	Free Volume (V_f X 10^{-8}) cm^3/Mole	Wada's constant(βm) $cm^{19/7}/dyne^{1/7}$	Rao's constant(R) $cm^{10/3}/s^{1/3}$
0	1.3054	1.7366	542.5250	956.3466
0.02	1.3058	1.7473	545.3477	961.2608
0.04	1.3032	1.7450	547.8487	965.5178
0.06	1.2981	1.7290	549.3673	967.7535
0.08	1.2945	1.7240	552.1359	972.5448
0.10	1.2932	1.7287	2.8681	978.1871

RESULT AND DESCUSSION:

The experimental data of ultrasonic velocity, density, viscosity, adiabatic compressibility and acoustic impedance of aqueous thiamine chloride with KOH at 293.15K, are recorded in table 1, and Intermolecular free length, free volume, Wada's constant and Rao's constant are given in table 2.

Figure 1 and Figure 5 show the variation of ultrasonic velocity and acoustic impedance with molar concentration. It is observed that ultrasonic velocity and acoustic impedance shows the similar behavior. At lower concentration these parameter show nonlinear variation where as at higher concentration shows increasing trend. These parameters show small dip at 0.02 molar concentrations, hence complex formation at 0.02 molar concentrations whereas association takes place at higher concentrations. Hence in B_1+water+KOH, at lower concentration dissociation and complex formation take place due to breaking of hydrogen bond and ion- dipole interaction and at higher concentration association take place between solute and solvent molecules due to formation of hydrogen bonding[9]. The adiabatic compressibility has reverse trend as shown in figure (4).

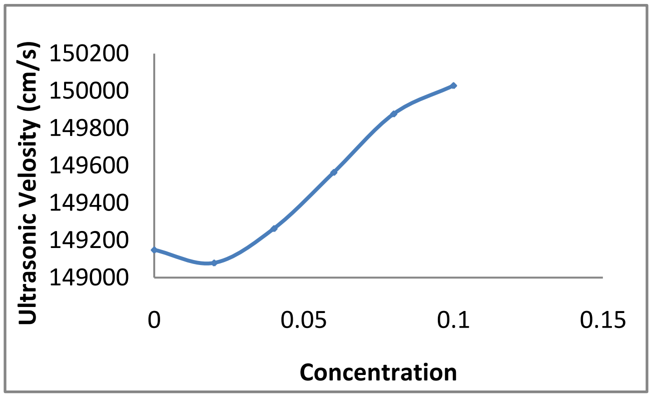
Figure2 shows the variation of density with molar concentration. It has non linear behavior with increase in molar concentration. This shows that there is association; dissociation and complex formation take place [10-11].

Figure3 shows the variation of viscosity with molar concentration. This parameter has slightly increasing and decreasing trend with increase in the molar concentration [12].

Figure 6 and Figure 7 shows the variations of free length and free volume with molar concentration. These parameters have non linear behavior at lower concentration and at higher concentration they have decreasing trend. They have peak at 0.02 molar concentrations, this show the complex formation at 0.02 molar concentration [13].

Figure 8 and Figure 9 shows the variation of Rao's constant and Wada constant with molar concentration. These parameters shows increasing trend with increase in molar concentration.

This indicates that there is strong molecular interaction between solute and solvent molecules due to hydrogen bonding and ion-dipole interaction [14-15].



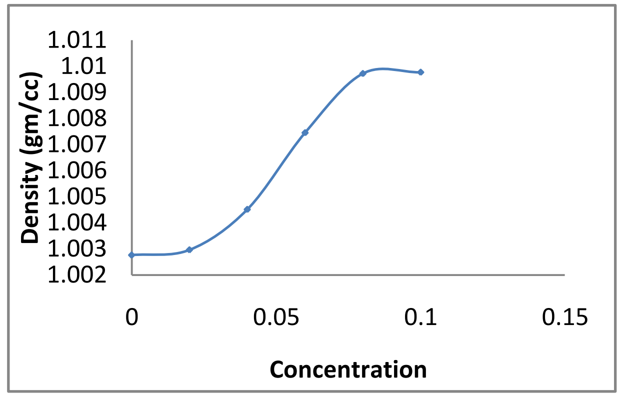
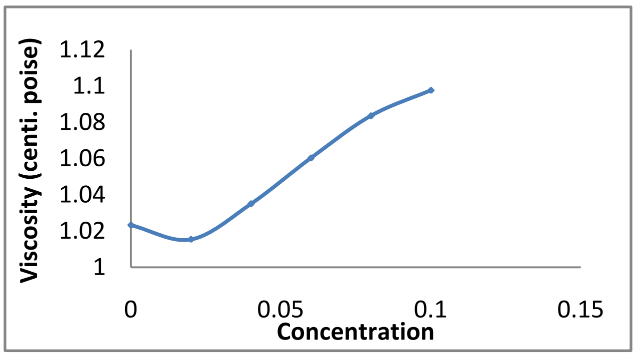


Fig. 1: Variation of ultrasonic velocity with conc.Fig.2 Variation of density with conc.



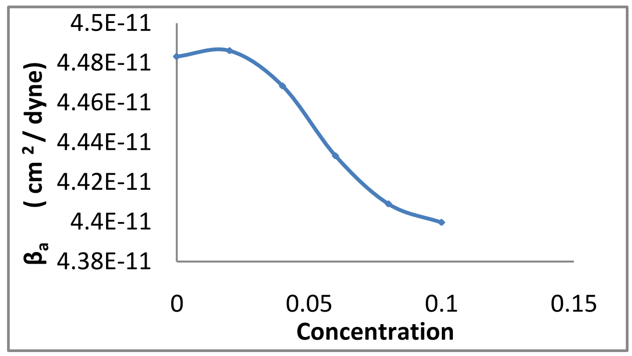
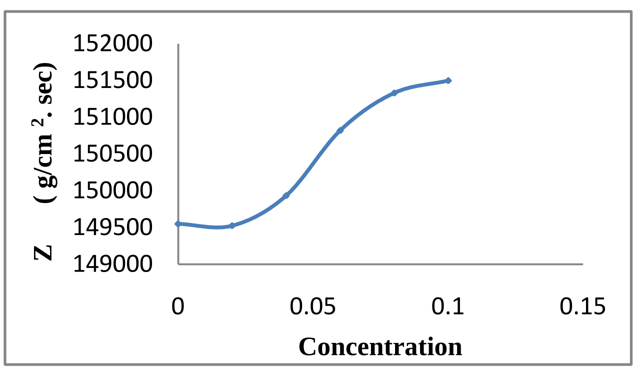


Fig. 3 Variation of viscosity with conc.Fig. 4 Variation of adia compressibility with conc.



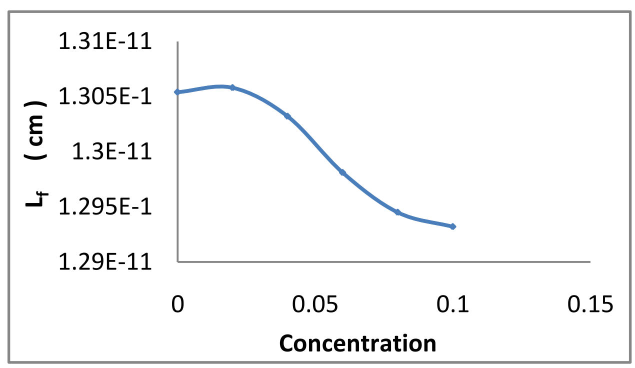
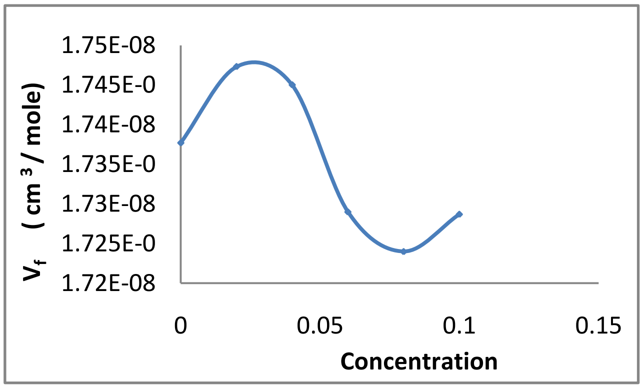


Fig. 5 Variation of acoustic impedance with conc.Fig. 6 Variation of free length with conc.



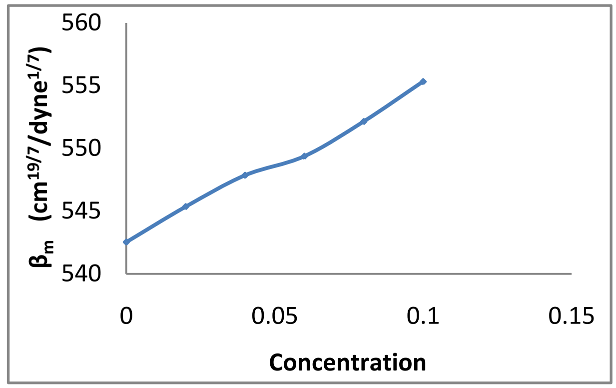


Fig. 7 Variation of free volume with conc.Fig. 8 Variation of wada' constant with conc.

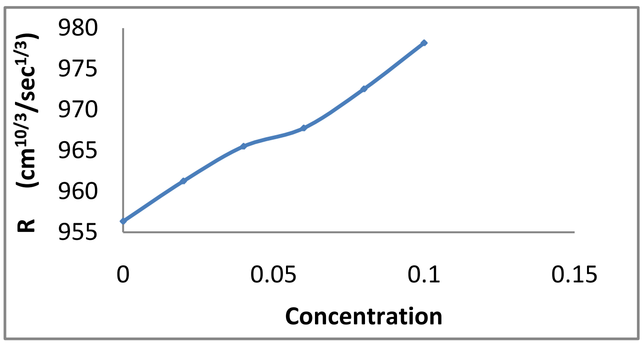


Fig. 9 Variation of Rao's constant with conc.

CONCLUSION :

Ultrasonic velocity, density and viscosity of different concentration of aqueous ascorbic acid with KOH are measured at 298.15K and thermo-acoustical parameters are calculated. The non linear variation in ultrasonic velocity and other acoustical parameters indicates that there is a strong molecular interaction between vitamin B_1,water and KOH molecules with complex formation at 0.02 molar concentration.

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