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Ultrasonic Investigation of Molecular Interaction in Pyridoxine at 293 K

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Abstract

The ultrasonic velocity (U), Density (ρ) and viscosity (η) of different concentration of Pyridoxine (vitamin B_6) solution have been studied at temperature 293K. 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 293K 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), Vander wall’s constant (b) . These parameters have been used to give the interpretations of solute-solvent interaction of pyridoxine and water molecules. Furthermore these studies shows that the nature of molecular interaction and complex formation in solution of Pyridoxine (vitamin B_6) and it provide important information regarding molecular properties of solute and solvent interaction

Keywords : Ultrasonic velocity, Density, Viscosity, Adiabatic compressibility, Free volume and Pyridoxine.

Introduction

Ultrasonic studies is a very important tools for evolution of the structural , physical and chemical properties of materials . The thermo-acoustical parameters of aqueous vitamins shed more light on many chemical analyses as well as idea about association, dissociation and complexity of vitamins molecules. The ultrasonic properties of liquid and biological media have been studies in details by many researchers [1-10] .

Pyridoxine is a member of the water soluble family of B-complex vitamins. It’s required for proteins and glucose metabolism and need of vitamin B6 to make hemoglobin, which is a component of red blood cell that carry oxygen to all the parts of our body. Sufficient of pyridoxine (vitamin B6) are needed for normal immune system function because it helps to maintain the health of our thymus , spleen and lymph nodes. It also required for normal nervous system function.

Pyridoxine is found in many foods such as fish, meat, fruits and many vegetables. As per nutrition experts, our body need vitamin B6 (pyridoxine) as follows.

For male – 1 to 3 years - 0.5 mg/day , 4 to 8 years - 0.6 mg/day , 9 to 13 years – 1 mg/day, 14 to 30 years - 1.3 mg/day , 31 and above – 1.7 mg/day.

For female 1 to 3 years - 0.5 mg/day , 4 to 8 years - 0.6 mg/day , 9 to 13 years – 1 mg/day, 14 to 50 years - 1.3 mg/day , 51 and above – 1.5 mg/day. **For pregnant women** - 1.9 mg/day . **For breastfeeding women** - 2.0 mg/day .

By taking large doses of vitamin B_6, it causes a loss of control of our body movements, skin lesions, light sensitivity and gastrointestinal symptoms such as nausea and heartburn [11].

The purpose of present work is to determine the ultrasonic velocity and thermo acoustical properties of aqueous pyridoxine at temperature 293K. This Investigation give us molecular interaction of pyridoxine in water , which is helpful to chemist ,biologist, pharmacist and industries etc.

MATERIALS AND METHODS

The stock solution of Pyridoxine have been prepared in double distilled water. Different concentration of Pyridoxine solution ware prepared using water. 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 respectively. Temperature 293K is maintained using thermostatically controlled water circulation system. The other thermo-acoustical parameters such as acoustic impedance, adiabatic compressibility, free length, free volume, and Vander wall'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) and Vander wall's constants (b) for different concentration of pyridoxine 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

1] Ultrasonic velocity: $u = \frac{2d}{t}$

Where, d = Separation between transducer reflector

t = Traveling time period of ultrasonic wave

2] Density:

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

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 :

$$\eta = \left[\frac{\rho\ x\ t_1}{\rho_w\ x\ t_w} \right] x\ \eta_w$$

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 = Time dependent constant

7] Free volume : $V_f = M\ u / k\ \eta$

Where, k =Time independent constant.

M = Molecular weight of solution.

8] Vander wall's constant :

$b == V [1- (RT / Mu^2) (1 + Mu^2 / 3RT)^{1/2}]$

Where, V = Molar volume

R = Gas constant = 8.3143 x10^7 erg/mole K

Table no. 1 (Variation of u, ρ, η, and **β with different concentration of Pyridoxine)**

Conc M	Ultrasonic Velocity (u) cm/sec	Density (ρ) gm/cc	Viscosity (η) centipoises	Adiabatic compressibility (β x 10^{-11}) cm^2 /dyne
0	148268	0.9982	1.002	4.5571
0.02	148451	0.9998	1.0229	4.3386
0.04	148812	1.0007	1.0293	4.5125
0.06	149171	1.0022	1.0343	4.4841
0.08	149383	1.0047	1.0366	4.4603
0.10	149463	1.0058	1.0479	4.4506

Table no. 2 (Variation of Z, L_f, V_f and b with different concentration of Pyridoxine)

Conc.	Acoustic impedance (Z x 10^5) gm/cm^2.s	Free length (L_f x 10^{-11}) cm	Free Volume (V_f X 10^{-8}) cm^3/mole	Vander wall's constant (b) cm^3/mole
0	1.4780	1.3161	1.7761	16.3453
0.02	1.4842	1.3134	1.7701	16.3828
0.04	1.4892	1.3096	1.7620	16.4333
0.06	1.4950	1.3055	1.7513	16.4742
0.08	1.5008	1.3020	1.7407	16.4978
0.10	1.5033	1.3006	1.7401	16.5436

RESULT AND DESCUSSION

The experimental data of ultrasonic velocity, density, viscosity and adiabatic compressibility of pyridoxine at 293K are recorded in table 1 and acoustic impedance, intermolecular free length, free volume and Vander wall's constant are given in table 2.

It is observed that the ultrasonic velocity is increases and adiabatic compressibility decreases with increase in concentration of pyridoxine in water. But the variation is non linear at higher concentration .This indicate that, there is a significant interaction between the solute-solvent components of the aqueous pyridoxine at lover concentration but strong molecular association and complex formation take place at higher concentration. This may due to larger probability of hydrogen bonding between the molecules.[12] which shown in **figure 1** and **figure 4**. This is also supported by the increase in density with concentration shown in **figure 2** which is due to hydrophilic property of solvent due to hydrogen bonding.

In **figure 3** gives the viscosity of aqueous pyridoxine increases slightly with the concentration, which suggest the significant interaction between solute and solvent molecules [13]. The acoustic impedance of pyridoxine is increases with the increase of concentration shown in **figure 5** indicate that there is strong interaction between solute and solvent molecules due to hydrophilic property [14].

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 [15].

The decrease in free length in **figure 6** shows that, there is enhanced molecular association take place in the increasing concentration of aqueous pyridoxine, which shows that compactness of the structure is increases.The variation of Vander wall constant with concentration increases shown in **figure 8**. This indicates the associative tendency of molecules inside the shell [16].

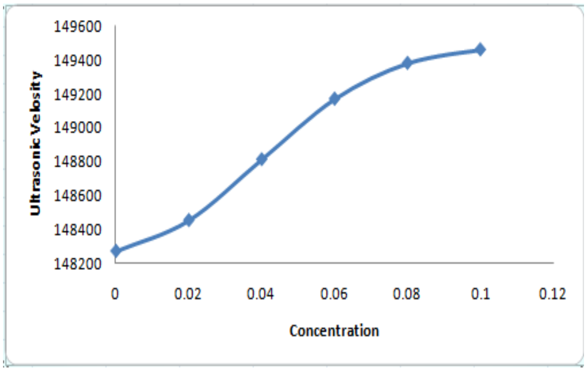


Fig. 1: Variation of Ultrasonic velocity with Concentration

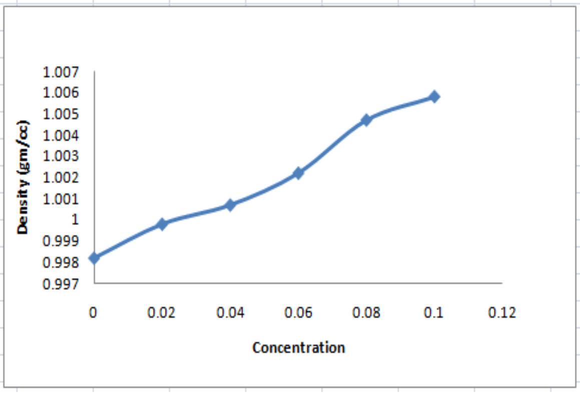


Fig.2 Variation of Density with concentration

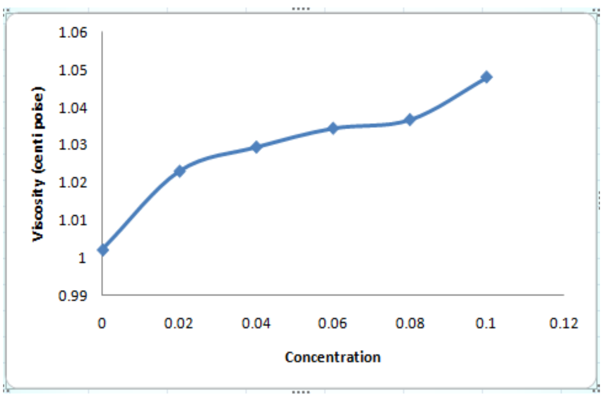


Fig. 3: Variation of Viscosity with Concentration

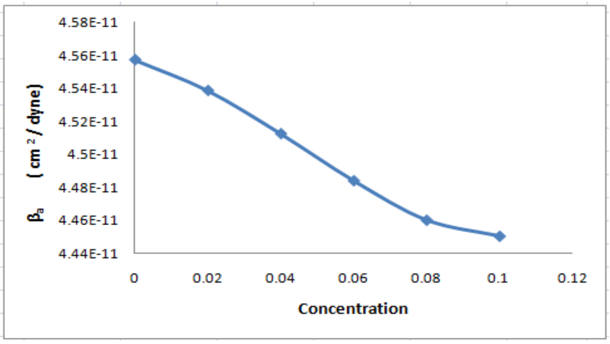
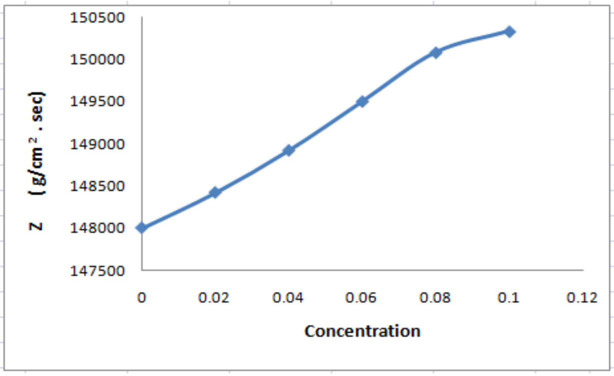


Fig.4 Variation of adiabatic compressibility with



concentration

Fig. 5 Variation of acoustic impedance with concentration

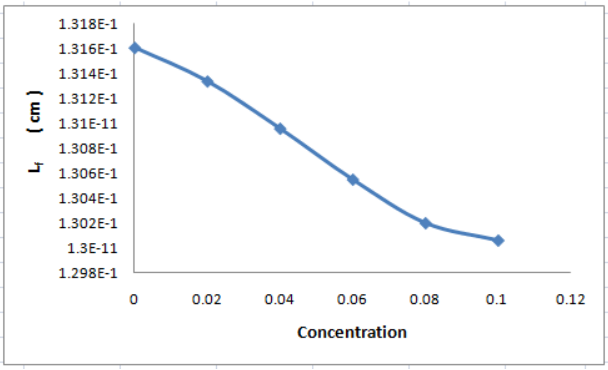


Fig.6: Variation of free length with concentration

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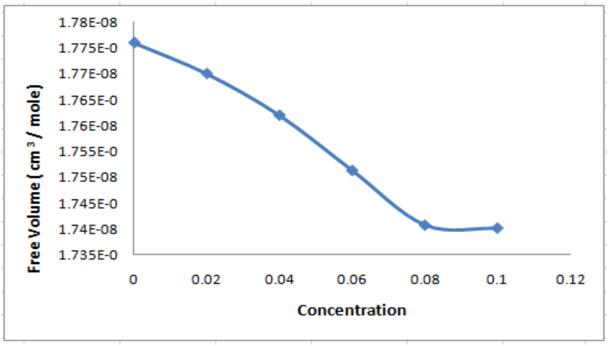

Fig.7: Variation of free volume with concentration

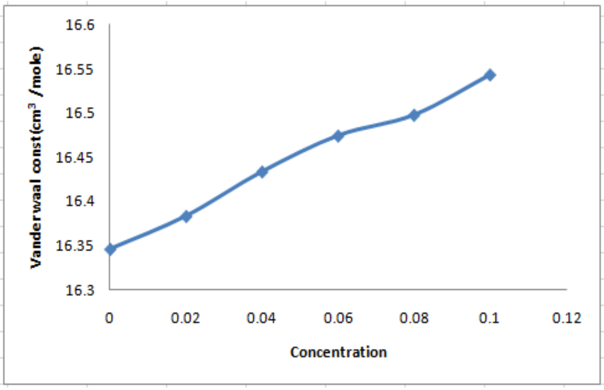

Fig.6: Variation of Vander wall's constant with concentration

CONCLUSIONS

Ultrasonic velocity, density and viscosity are measured for different concentration of aqueous pyridoxine at 293K and other thermo-acoustical parameters are calculated. Ultrasonic velocity, viscosity, acoustical impedance and Vander wall'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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