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Volumetric and Viscometric studies of vitamin (B6) in aqueous and acidic media at different temperatures

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Abstract:

Densities and viscosities of pyridoxine(B6) in aqueous and acidic solutions at 298.15-313.15K have been measured. By Masson equation the experimental values of densities were used to estimate some significant parameters, such as apparent molal volume(Φv), limiting apparent molal volume(Φv^0) and slop S_v, and the viscosity data have been investigatevia Jones-Dole equation, and the derived parameters, Jones-Dole coefficient B, and Falkenhagen coefficient A. The results were interpreted in term of solute-solute and solute –solvent interaction. The difference of *B* coefficient with temperature (dB/dT), was also determined the positive values indicate that pyridoxine(B6)in aqueous and acidic solutions is structure making.

Key words: Density, Masson equation, Apparent molar volume, Viscosity, Jones-Dole coefficient B, Pyridoxine(B6).

1- Introduction

Vitamins are small organic molecules that can perform chemical functions (often in enzyme catalysis) that cannot be performed by chemistry of ordinary amino acids, sugars or lipids, these are essential nutrients that the human body needs in small amounts to tune biological processes properly. It is known that these are not produced in the body and have to be supplemented from outside[1]. In general, the functionality and classification are based on solubility in water or bio-fluids. Viscometric, Volumetric data give important information about solute- solvent and solute- solute interactions. These interactions assist to improved thoughtful of the nature of solvent and solute, whether the added of solute modifies or deforming the structure of solvent[2]. In this work, the experimental data of viscosities and densities of pyridoxine(B6)have been reported in different temperatures in aqueous and acidic media. The apparent molar volumes, partial molar volumes, for pyridoxine(B6) have been evaluated by densities data. Jones-Dole equation have been used to obtain viscosity coefficients A and B from viscosities data [3],in electrolytic media the results have been discussed in type of solute - solvent and solute - solute interactions. This study aims to investigate the behavior of vitamin B6 as a solute in the aqueous and acidic solutions.

2- Exprimental

2-1Materials

Pyridoxine(B6) (99%) of molar mass (169.18 g mol^{-1}) was supplied by Himedia. The structural formula of pyridoxine(B6)was shown below. Hydrochloric acid with chemical formula (HCl) and specific gravity (1.16) and the molecular weight (36.46 g / mol.) produced from (Fluka AG) company in present (36%). Deionized water was used in all experiments had specific conductance of ~$10^{-6}\Omega\ cm^{-1}$. The solvent was used deionized water and0.1 M HCl. The experiments were carried out at 298.15, 303.15, 308.15 and 313.15 K.

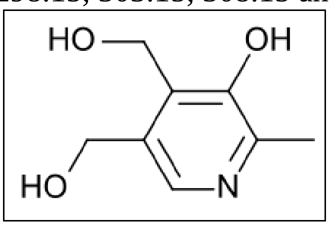

Figure (1) Pyridoxine structure

2-2 Density and Viscosity Measurements

The pyridoxine(B6) vitamin solutions were prepared by dissolving exact balanced quantity of (B6) in aqueous and acidic solutions (0.1-0.2 M).The density bottle and Ostwald viscometer was used to measure the density and viscosity respectively at 298.15, 303.15, 308.15 and 313.15 K. The measurement of mass was carried out by using digital electronic balance (Sartorius GC103). Through thermostatic water-bath temperature was managed by precision ±0.10. Via the following formula [4-5] $\eta/\eta^0 = t\rho / t^0\rho^0$ the viscosities were evaluated where, η was the absolute viscosity, t referred to time of flow and ρ represent to density of solution, while η^0,t^0 and ρ^0 are same quantities for the solvent water and (0.1M HCl). The absolute viscosities and densities of water at 298.15, 303.15, 308.15 and 313.15K were taken as 0.8904, 0.7975, 0.7194 and 0.6893centi-poise, 0.9983, 0.99707, 0.9956and 0.9947 $g.cm^{-3}$ respectively. The densities values of water were chosen as 0.9982, 0.99565 and 0.9922 $g.cm^{-3}$respectively [4-5].

3- Result and Discussion

3-1 Volumetric Study

Table (1) show the experimental results of densities (ρ) and viscosities(η) that measured at (298.15, 303.15, 308.15 and 313.15K) of pyridoxine(B6) in water and 0.1M HCl solutions at different molarities. The results indicate that the density and viscosity values decrease with increasing in temperature and increases with concentration of vitamin. Increasing values of density and viscosity refer to that there is mild attraction with solvent and solute molecules and decreased value with increasing temperature illustrates reducing in intermolecular forces as a result of rising thermal energy of the system[6] as shown in Table (1) and Figure (2a,b).

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Table(1): The pyridoxine(B6) values of densities and viscosities in aqueous and 0. 1 MHCl solutions at various molarities and temperatures.

C / ($mol.L^{-1}$)	ρ($g.cm^{-3}$)				η(mPas.s)			
	298.15K	303.15K	308.15K	313.15K	298.15K	303.15K	308.15K	313.15K
Pyridoxine(B6) + H_2O								
0.1	1.00132	1.00105	0.99884	0.99803	0.950311	0.86971	0.83972	0.81424
0.12	1.00149	1.00123	0.99906	0.99817	0.952157	0.87054	0.84542	0.815992
0.14	1.00152	1.00139	0.99923	0.99825	0.954918	0.87137	0.84622	0.816037
0.16	1.00161	1.00145	0.99937	0.99833	0.957232	0.87264	0.85194	0.816940
0.18	1.00169	1.0015	0.99948	0.99845	0.96044	0.87298	0.85531	0.817653
0.2	1.00174	1.00157	0.99952	0.99856	0.961643	0.87307	0.85892	0.818113
C / ($mol.L^{-1}$)	ρ($g.cm^{-3}$)				η(mPas.s)			
	298.15K	303.15K	308.15K	313.15K	298.15K	303.15K	308.15K	313.15K
Pyridoxine(B6)+ 0.1M HCl								
0.1	1.00899	1.00355	1.00209	1.00099	0.967344	0.91591	0.83125	0.72688
0.12	1.00917	1.00371	1.00227	1.00124	0.971836	0.916253	0.84157	0.72901
0.14	1.00929	1.00385	1.00239	1.00137	0.973121	0.921434	0.84745	0.73175
0.16	1.00934	1.00391	1.00246	1.0015	0.980253	0.930991	0.85067	0.73623
0.18	1.0094	1.00408	1.00259	1.00163	0.98158	0.931784	0.85539	0.73995
0.2	1.00953	1.00419	1.00266	1.00175	0.986134	0.936169	0.85911	0.74006

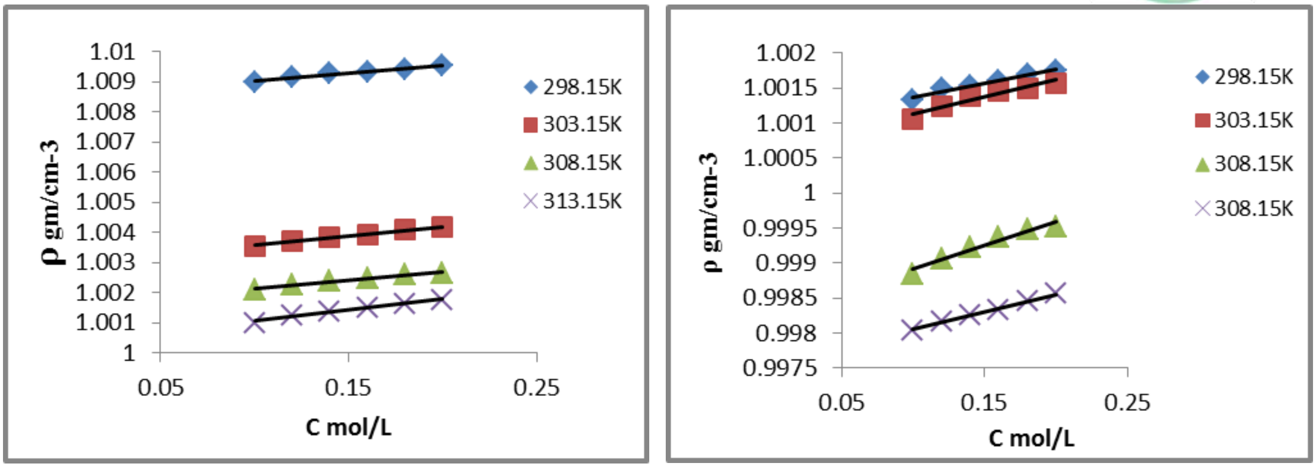

Figure (2-a) Plot of density (ρ) of (B6) vitamin against molarities (C) of aqueous and acidic solutions

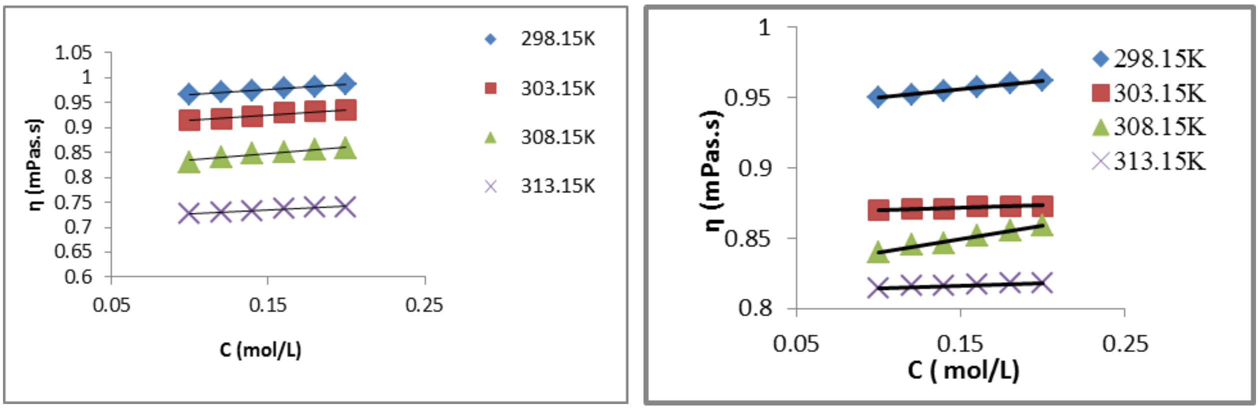

Figure (2-b) Plot of Viscosity (η) of (B6) vitamin against molarities (C) of aqueous and acidic solutions

The apparent molar volumes (Φv) of the vitamin in aqueous and acidic solution were evaluate by applying the data of density in to the following equation [7]:

$$\Phi v = M/\rho_0 - 1000(\rho-\rho^0)/\rho^0 C$$

Where (ρ) and (ρ^0) represent the densities of solution and solvent respectively, (M) refer to molecular weight of solute and (C)is the molar concentration .The results of Φv are tabulated in Table(2) and Figure (3). Result in Table (2) proved that the values of Φv increases with rising vitamin concentration and temperature in the aqueous and acidic solution suggesting that the solute-solvent interaction increase with the increase of vitamin concentration, it can be detected that Φv^0 value increase with temperature attributed to the decreasing of electrostriction that happen at higher temperature [6].

The study found that the relationship between Φv and √C are linear, this prove that the information's are fitted to Masson equation [8]. Through Masson equation can be determine the experimental slope and limiting partial molar volume.

$$\Phi v = \Phi v^0 + S_v \sqrt{C}$$

Where S_v represent is the experimental slope or volumetric pair wise interaction coefficient that give information about solute – solute interaction. While Φv^0 offer information concerning solute – solvent interaction. Table (3) illustrates the data of Φv^0 and S_v in aqueous and acidic solutions of (B6) at different temperatures. In the Table(3)explained that the aqueous and acidic solution of the vitamin pyridoxine(B6) have a positive values of the deviation parameter (S_v) at all the temperatures studied. Table (3) shows that Φv^0 values are generally positive and increased with an increase in the temperature for aqueous and acidic solutions thus suggestive

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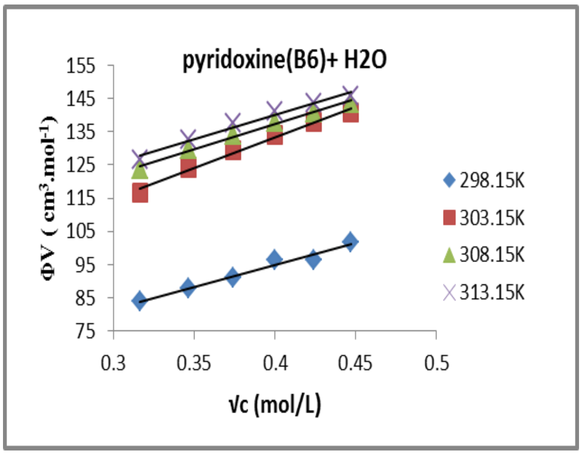
of that at higher temperatures the solute - solvent interaction can be get better due to rising in solvation of ions with the increase in temperature [9].

Table(2): Apparent molar volumes of pyridoxine(B6) in aqueous and 0. 1M HCl solutions at various molarities and temperatures

C / (mol. L^{-1})	Φv($cm^3.mol^{-1}$)			
	298.15K	**303.15K**	**308.15K**	**313.15K**
Pyridoxine(B6) + H_2O				
0.1	83.96105	116.5764	123.69492	126.4793
0.12	87.83089	123.95817	129.59573	132.6014
0.14	91.02428	129.37411	134.16981	137.4056
0.16	96.54306	134.06386	137.78895	141.0086
0.18	96.54306	137.76692	140.77149	143.5875
0.2	101.68911	140.62934	143.62477	145.7008
C / (mol. L^{-1})	**Φv($cm^3.mol^{-1}$)**			
	298.15K	**303.15K**	**308.15K**	**313.15K**
Pyridoxine(B6)+ 0.1M HCl				
0.1	69.64756	92.54032	103.2498	107.0452
0.12	86.29259	96.3494	112.8602	115.4563
0.14	95.98739	99.35603	120.1553	122.3572
0.16	104.8505	103.6117	125.9405	127.4781
0.18	111.6772	105.3097	130.1053	131.4854
0.2	116.7933	110.7686	133.7385	134.6962



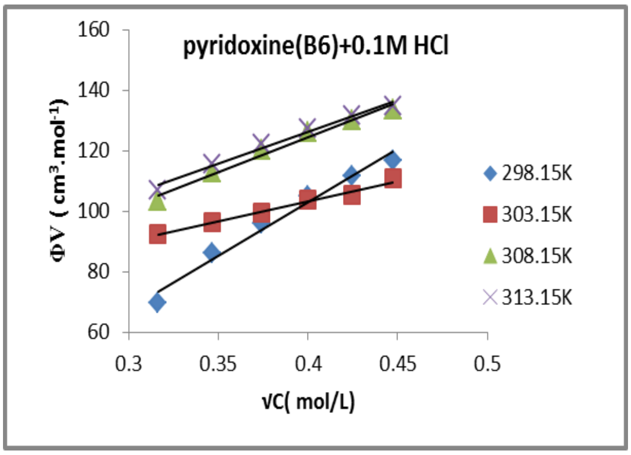


Figure (3): Apparent molar volumes (ΦV) as a function of square root of molar concentration ($\sqrt{C}$) of pyridoxine(B6) in aqueous and acidic solutions at temperature range 298.15 K-313.15K.

Table(3): limiting apparent molar volumes and Experiment slope S_v, ofpyridoxine(B6) in aqueous and 0.1M HCl solutions at various molarities and various temperatures.

Temp.	**298.15K**	**303.15K**	**308.15K**	**313.15K**
Solution **Pyridoxine(B6)+ H_2O**				
$\Phi V^o(cm^3.mol^{-1})$	38.12	59.99	77.10	81.55
S_v $(cm^3.mol^{-2}kg)$	144.1	183	150.3	146.1
Temp.	**298.15K**	**303.15K**	**308.15K**	**313.15K**
Solution **pyridoxine(B6)+ 0.1M HCl**				
$\Phi V^o(cm^3.mol^{-1})$	32.06	38.43	42.00	50.04
S_v $(cm^3.mol^{-2}kg)$	353.4	133.2	231.2	210.7

3-2ViscometricStudy:

Through linear relation of $[(\eta/\eta^0)-1]/\ C^{1/2}$ with $C^{1/2}$ by least square method of Jones-Dole equation [10], the viscosity data (B6) in aqueous and 0.1M HCl solutions in different molarities has been evaluated. Table (4) illustrates the values of viscosity coefficient A and B [11] that determined from the intercepts and slopes.

$$\eta/\ \eta^0 = \eta_r = 1 + A\ C^{1/2} + BC$$

Where η_r refer to relative viscosity, and C represent the molar concentration, whereas η, η^o are the viscosities of solution and solvent respectively. The solute – solute interactions can be describes by Falkenhagen coefficient A while the experimental Jones-Dole coefficient B to evaluate structural changing that carried out by solute-solvent interactions[12].

Table (4): Values of Falkenhagen coefficient A, Jones-Dole coefficient B of pyridoxine(B6) in aqueous and (0. 1M) HCl solutions at various molalities and different temperatures

T/ (K)	**A / $(L^{3/2}.mol^{-0.5})$**	**B/ $(L.mol^{-1})$**	**A / $(L^{3/2}.mol^{-0.5})$**	**B/ $(L.mol^{-1})$**
	pyridoxine(B6) + H_2O		**Pyridoxine(B6) + 0.1M HCl**	
298.15	0.042	1.145	0.067	0.628
303.15	0.196	0.721	0.244	0.375
308.15	0.029	0.558	0.152	0.319
313.15	0.120	0.185	0.148	0.108

There are two explanation about the importance of viscosity coefficient; the first explains supplied information regarding to the structure of the solvent in the close to environment of the solute molecules and the solvation of solutes and how can effect in solvent structure. The second explanation suggests that the viscosity coefficient B can be used to find some activation parameters of viscous flow. The viscosity coefficient B consider an experimental term were used to describe the relative size of the solvent and solute molecules and solvent – solute interactions. A system, which has positive and bigger values of viscosity B-coefficient, refer to a structure making action of the solute on solvents**.** The obvious from the Table (4) the positive values of viscosity B-coefficient that is mean a pyridoxine(B6) act as structure-making with solvent and also the strong ion–solvent interactions that occurs [13].

Slope of the curve resulting from drawing the relationship between viscosity coefficient values with the temperature used in the calculation of values (dB / dT) [14] and which are listed in Table 5. The structure making and breaking ability of solute in solvent can be determined from the sign of (dB/dT) value. Generally if a system was structure making which mean has a negative value of (dB/dT), or positive for structure breaking. These are in identical agreement with the conclusion drawn from Hepler equation.

Table (5): Hepler and dB/dT Constant of pyridoxine(B6)Inaqueous and 0.1 M Solutions At Different temperatures (298.15, 303.15,308.15 and 313.15 K)

Solutions	Hepler constant	dB/dT constant
Pyridoxine(B6) + H_2O	19.25	-0.060
Pyridoxine(B6) + 0.1M HCl	10.23	-0.032

At high temperatures decrease the value of viscosity factor B, therefor temperature derivatives such as (dB/dT) are negative. The making - breaking characteristic of the solute in the solvent can be determined by a dB / dT sign [15]. Figure 4 showing the negative values of dB/dT for pyridoxine(B6)in aqueous and acidic solutions thus represent the structure- making ability of pyridoxine(B6). Therefor B6can be consider as a structure maker in aqueous and 0.1M HCl solutions. These are in identical agreement with the conclusion drawn from Hepler equation as discussed earlier. Such the values of coefficient A and B supports the behaviors of Φv^0 and S_v and which all suggest solute-solvent interaction predominant over solute-solute interaction.

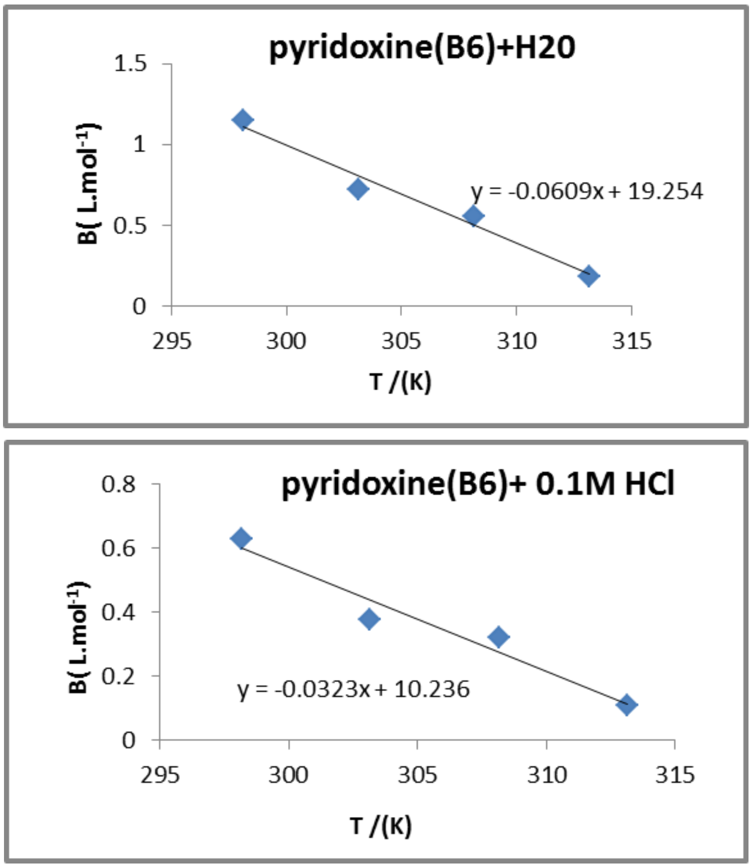


Figure (4): dependence of B-coefficient on Temperature

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