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The Study of Secondary Forces of Myo-Inositol In 10% Ethanol-Water by Volumetric and Viscometric Methods at Different Temperatures

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Abstract: *Densities (ρ) and viscosities (η) of myo-inositol have been measured in 10% ethanol-water solution at different temperatures. From the density, the apparent molar volume (Φv) and partial molar volume (Φ_v^o) were calculated. The viscosity coefficient B and A were calculated from the viscosity data using Jones-Dole equation at all the studied temperatures. From viscosity coefficient constant B and partial molar volume, association number (B/Φ_v^o) of solute was calculated. From derived parameters, results were attributed with solute-solute and solute-solvent interactions.*

Keywords: Apparent molar volume, Partial molar volume, Jone-Dole equation, myo-inositol, association number

I. INTRODUCTION

In recent years, the biomolecules such as carbohydrates, polyhydric alcohols, amino acids, nucleic acids play very crucial role of physicochemical processes [1,2]. Most of the enzymatic reactions relate to the non-covalent interactions such as hydrogen bonding and van der Waals' forces [3]. Aqueous solution of sugars, amino acids, vitamins and drugs is very important to understand the non-covalent mechanism [4]. In this study, myo-inositol (pseudosugar) is used. Myo-inositol derivative i.e phosphoinositol is associated with cellular signal transduction mechanism and linked to specific proteins to cell membrane [5]. myo-inositol phosphate and their lipid derivatives are very important and lead to understand the receptor - effectors based signals for pharmacological interventions states of diseases[6]. The objective of this work is to work out volumetric and viscometeric parameters such as apparent molar volume (Φv), partial molar volume (Φ_v^o), A and B Jone-Dole constant and association number of solute with solvent of 10% ethanol-water solution of myo-inositol by using density and viscosity at temperature 298.15, 303.15 and 308.15 K.

II. EXPERIMENTAL

Myo-inositol used is of analytical grade with purity of > 99% was procured from Loba Chemie. Distilled water was used for the preparation of solution. The molar 10% ethanol-water solution of solute was prepared by using digital electronic balance (Model-AJO20, aiwa) with an accuracy of ± 0.1 mg.

Densities (ρ) and viscosities (η) of 10% ethanol-water solutions of myo-inositol was measured by using specific gravity bottle with accuracy of ±0.1 $kg.m^{-3}$ and viscosity of solution was measured with an accuracy of 0.0001Nsm^2 by Ostwald's viscometer. Time flow of water and 10% ethanol-water solutions of myo-inositol were measured respectively.

III. RESULTS AND DISCUSSION

The density, ρ (g cm^{-3}) and viscosity data of myo-inositol measured at temperature 298.15 K, 303.15K and 308.15K as function of concentration, (mol dm^{-3}) are given in Table 1. Apparent molar volume can be worked out from the density data by using eq. (1) [7]

$$\Phi_v = M/\rho_o - 1000\,(\rho - \rho_o) / C\rho_o \qquad (1)$$

Where Φ_v, C, ρ, ρ_o and M are the apparent molar volume, molarity, density of the solution, density of solvent (10% ethanol-water) and molar mass of myo-inositol, respectively.

When solute is added into solvent, solute molecules get solvated or hydrated. Volume of solvated or hydrated solute is called apparent molar volume. At infinite dilution means at very low concentration, solute get strongly hydrated or solvated due presence of more numbers of solvent molecules per solute molecule. It is called partial molar volume where the solute-solvent interaction is more compared to the higher concentration range [8] [9].

The apparent molar volume (Φv) data for studied solute can be expressed by Messon's relation given by eq. (2). Least square fit method [10-11].

$$\Phi v = \Phi_v^o + S_v \sqrt{C} \quad (2)$$

Where, Φ_v^o, is limiting or partial molar volume, intercept of linear fit. Partial molar volume provides information about structure making and structure breaking properties of solute. It is observed that apparent molar volume Φv increased with increased in concentration up to 0.15M and decreased at 0.2M and then increased. This may be due to solvent effect. Water molecules have greater affinity compared to ethanol toward solute molecules because water has greater dipole moment than ethanol. Greater number of water molecules than ethanol in solvent system (10% ethanol-water). As concentration of solute increased, apparent molar volume increases. This may be due to like nature of ethanol and myo-inositol (polyhydric alcohol).

As temperature increases, partial molar volume (Φ_v^o) is also increased; actually it should be decrease with increase in temperature because at higher temperature kinetic energy of the bulk solvent as well as hydrated/ solvated molecules increased. This leads to reduced the size of hydrated or solvated solute. But partial molar volume (size) increased it may be due to water cavity formation at higher temperature. The values of Φ_v^o and S_v for myo-inositol at three different temperatures are listed in table 1.

Table 1: Apparent molar volume (*Φv*), partial molar volume (Φ_v^o) and S_v, Myo-inositol at 298 K, 303K and 308K at different concentration

Concentration (mol dm^{-3})	$\sqrt{C}$	*Φv (m^3 mol^{-1})* **Myo-inositol**		
		298K	**303K**	**308K**
0.05	0.2236	61.5700	78.0088	78.1449
0.1	0.3162	69.7574	72.8874	77.1188
0.15	0.3873	90.2262	90.3001	84.9853
0.2	0.4472	84.0856	84.6666	83.7882
0.25	0.5000	88.5887	90.7098	87.9951
0.3	0.5477	95.0022	94.7386	90.1156
0.35	0.5916	100.7530	98.7870	96.9072
0.4	0.6325	100.7164	99.7747	96.1010
0.45	0.6708	92.2731	92.1210	90.0016
Φ_v^o (m^3 mol^{-1})		48.62	64.41	67.23
Sv (m^3 Kg$^{1/2}$ mol$^{-3/2}$)		80	51.48	41.7

Therefore the relative viscosity values were plotted against different concentrations of studied solute and for all these molecules plot shows linearity. At zero concentration, intercept value is found to be minimum. The values of slope found for different studied solutes are presented in Table 3.

Table 2: Relative viscosities (η/η_o) for Myo-inositol at different concentrations and temperatures

Concentration(C) (mol dm^{-3})	$\sqrt{C}$	(η/η_o) for **Myo-inositol**		
		298K	**303K**	**308K**
0.05	0.2236	1.094318	1.071429	1.114286
0.1	0.3162	1.106818	1.094805	1.134921
0.15	0.3873	1.123864	1.111688	1.149206
0.2	0.4472	1.159091	1.131169	1.188889
0.25	0.5000	1.215909	1.148052	1.230159
0.3	0.5477	1.238636	1.171429	1.249206

0.35	0.5916	1.272727	1.192208	1.266667
0.4	0.6325	1.284091	1.219481	1.293651
0.45	0.6708	1.329545	1.296104	1.396825

Table 3: Values of parameters of *Jone-Dole* equation for Myo-inositol, at three different temperatures

Myo-inositol	$(\eta / \eta_o-1)/\sqrt{C}$ *versus* $\sqrt{C}$	$B\times 10^3/\Phi^o_v$
298K	$B = 0.19\ dm^3\ mol^{-1}$ $A = 0.233\ dm^{3/2}\ mol^{-1/2}$	3.91
303K	$B = 0.19\ dm^3\ mol^{-1}$ $A = 0.233\ dm^{3/2}\ mol^{-1/2}$	2.95
308K	$B = 0.138\ dm^3\ mol^{-1}$ $A = 0.396\ dm^{3/2}\ mol^{-1/2}$	2.053

The structure making and structure breaking properties of solute is also reported by considering *Jone-Dole* [12] eq. (4), in term of viscosity coefficient *B* and intercept *A*

$$\eta / \eta_o = 1+A+B\sqrt{C} \qquad (4)$$

Where, η / η_o is the relative viscosity, C is molar concentration of solute, *A* and *B* are constants for the studied solute. *A*-coefficient specifies the contribution for interionic electrostatic forces and the *B*- coefficient specifies chaos produced by the ions in case of electrolyte and solutes in case of non-electrolyte in the solvent structure [13]. Therefore $(\eta / \eta_o - 1)/\sqrt{C}$ values were plotted against $\sqrt{C}$ shows linearity for myo-inositol solution with slope *B* and intercept *A*. The values of both the constants are reported in Table 3 for myo-inositol at different temperature. The *Jone-Dole* equation is more informative for ionic solute because *A* gives information about ion-ion interaction. In our present study, myo-inositol is covalent (non-electrolytes). Therefore, the values of A for solute at all the studied temperatures are very small because the interionic interaction is poor in case of non-electrolytes. The very small values of intercept *A* may be due to secondary forces.

It is observed from the results (Table 3), the values of coefficients *B* is positive at all the studied temperatures designate that solute-solvent interactions / solute-solute interaction are more significant. As the temperature increases, non-covalent interactions become weak due to thermal agitation among solute solvent interactions. But at 308K, value of coefficients *B* is slightly greater than at 303K temperature.

The Φ_v^o value for myo-inositol solution is positive at all the studied temperature which suggests that solute interact with water molecules through hydrogen bonding (dipole-dipole interactions) of hydroxyl groups present in the solute molecules.

The observed constant *k* of myo-inositol solution has values in the same range of coefficient *B* which are reported in Table 3.

The solvation of any solute can be choosed from the magnitude of B/Φ_v^o. These values are important pointer as to whether a particular solute is hydrated or unhydrated. If the value is greater, greater would be association [14]. From Table 3, it is observed that B/Φ_v^o values decrease with increase in temperature indicates weak hydration at higher temperature.

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