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Viscosity β-coefficients and Some Thermodynamic Parameters of Niacin Drug at Different Temperatures in Aqueous Medium

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Viscosity, relative viscosity, specific viscosity of β-coefficient of niacin drug in water have been determined at five different temperatures. β-coefficient values have been found to be low but positive. This shows the niacin drug can be regarded to be structure-making in character. This is due to hydrophobic hydrations of the drug molecules. The activation parameters ΔH and ΔS have been found to be very high and positive.

Key Words: Viscosity β-coefficients, Niacin drug, Thermodynamic parameters.

INTRODUCTION

Drug action has been widely recognized to be the ultimate consequence of physico-chemical interactions between the drug and functionally important molecules in the living organism known as receptor.[1-3] Drugs-receptor interaction is necessarily complex involving a number of physico-chemical interactions like ionic and covalent bonding, ion-dipole interactions, charge transfer, hydrogen bonding, hydrophobic interaction[1-3], etc.

It is to be noted that drug action can be achieved with a small amount of drugs; as high concentrations are rarely achieved *in vivo*, so drug transport and ion solvent interactions are the controlling forces in dilute solution where ion-ion interactions are absent. It is natural to believe that the structures of the drugs are modified by the solvent or even the structure of the solvent may be modified by the drug. Thus, the information regarding the transport property of drug and the ion solvent interactions may be obtained from viscosity measurements. The resulting data may be helpful for a possible correlation between drug activities and viscosities.

The Jone-Dole[4] equation accounts for the observed viscosity-concentration dependence of dilute electrolyte solutions, while Bresalu Miller[5], Vand[6] and Thomson[7] equations account for the concentration dependence of viscosity in concentrated electrolyte solution.

Viscosities of concentrated aqueous electrolytic solutions at various concentrations have been determined by Bary and Irving[8]. Pandey and Yasmin[9] have measured viscosities and densities of aqueous binary electrolyte solutions of different molalities. Density and viscosity studies of sucrose and maltose in aq. NH_4Cl at different temperatures have been studied by Nikam *et al.*[10] But studies on the viscosity and thermodynamic parameters of niacin have been rarely attempted. These considerations led us to study viscosity, relative viscosity, specific viscosity, β-coefficient and thermodynamic parameters of water soluble drug (niacin) at different temperatures.

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RESULTS AND DISCUSSION

The observed densities (ρ) of the solution which are the mean of three series of many measurements at 299.15, 303.15, 308.15, 313.15 318.15 K are used to calculate viscosity. The data have been analysed using the Jones-Dole equation:

$$(\eta_r - 1)/\sqrt{c} = A + B\sqrt{c}$$

where $\eta_r = \eta/\eta_0$, η_r, η_0; η represent the relative viscosity of solution, η_0 viscosity of solvent and η viscosity of solution. c is the molar concentration, A and B are characteristic constants specific to the ion and the solvent. The data viscosity, relative and specific viscosity concentration and density (ρ) are reported in Tables 1 and 2. Viscosity measurements for different concentrations at different temperatures of niacin solution were used to determine relative and specific viscosities. Viscosity measurements at different temperatures are used to evaluate thermodynamic parameters by using the following expression:

$$\Delta G = -2.303R \times \text{Slope}, \quad \Delta G = \Delta H - T\,\Delta S$$

and

$$\log \eta_1 - \log \eta_2 = \Delta H/2.303R\,[1/T_1 - 1/T_2]$$

TABLE-1
VISCOSITY, RELATIVE VISCOSITY, Sp. VISCOSITY, DENSITY VALUES FOR NIACIN IN AQUEOUS MEDIUM AT 318.15 K

Concentration mol dm^{-3}	Density (ρ) g cm^{-3}	Viscosity (Cp)	Relative viscosity	Specific viscosity $\eta_{sp} = \eta_r - 1/\sqrt{c}$
0.10	0.9945	0.56389	0.93848	−0.19456
0.08	0.9940	0.55933	0.93089	−0.24437
0.06	0.9934	0.55132	0.91756	−0.33662
0.04	0.9933	0.55040	0.91603	−0.41985
0.02	0.9927	0.53901	0.89707	−0.72783

From Tables 1 and 2, it can be seen that viscosity increases with change in concentration and decreases with increase in temperature because of interaction between drug solute-solvent.

β-coefficient values are calculated (Table-3) by plotting the graph $(\eta_r - 1)/\sqrt{c}$ *vs.* $\sqrt{c}$ positive values show stronger interaction between drugs-solvent. Structure making behaviour obviously arises due to hydrophobic interactions. It gives drug-solvent interactions and drug activity. The study of these molecules is useful from physico-chemical point of view. It is observed from Table-3 that the β-coefficient value almost decreases with increase in temperature.

The values of ΔG, ΔH and ΔS are summarised in Table-4. It is observed that ΔH and ΔS increase with increase in temperature. This is due to the increase in temperature that randomness of molecules increases which favours entropy change.

EXPERIMENTAL

The drug (niacin) used was obtained as gift from elsewhere and was used for the present study without further purification. Double distilled water was used for

TABLE-2
VISCOSITY, RELATIVE VISCOSITY, Sp. VISCOSITY, DENSITY VALUES FOR NIACIN IN AQUEOUS MEDIUM AT DIFFERENT TEMPERATURES

Concentration mol dm^{-3}	Density (ρ) g cm^{-3}	Viscosity (Cp)	Relative viscosity	Specific viscosity $\eta_{sp} = \eta_r - \frac{1}{\sqrt{c}}$	Density (ρ) g cm^{-3}	Viscosity (Cp)	Relative viscosity	Specific viscosity $\eta_{sp} = \eta_r - \frac{1}{\sqrt{c}}$
		At 299.15 K				At 303.15 K		
0.10	1.0031	0.86000	0.98432	−0.04958	1.0025	0.79404	0.9956	−0.01391
0.08	1.0013	0.83540	0.95616	−0.15490	1.0024	0.77920	0.9770	−0.08098
0.06	1.0009	0.81110	0.92836	−0.27250	1.0007	0.77910	0.9793	−0.09418
0.04	1.0003	0.80007	0.91653	−0.41734	1.0003	0.77670	0.9740	−0.12990
0.02	0.9998	0.77450	0.88641	−0.80280	1.0001	0.76390	0.9578	−0.29790
		At 308.15 K				At 313.15 K		
0.10	1.0026	0.71547	0.99453	−0.01729	0.9952	0.63399	1.00000	—
0.08	1.0023	0.70286	0.97700	−0.08132	0.9939	0.61516	0.97029	−0.09395
0.06	1.0009	0.68961	0.95859	−0.16908	0.9942	0.63912	0.00809	−0.02860
0.04	1.0003	0.68127	0.94699	−0.28505	0.9934	0.62327	0.98309	−0.08455
0.02	1.0001	0.68336	0.94990	−0.35426	0.9934	0.61276	0.96651	−0.23681

the preparation of solutions. Weighing was done on Mechanilki Zaktasy Precyzyineg Gdansk balance made in Poland (± 0.0001 g). Densities of solutions were determined by a bicapillary pyknometer (± 0.2%) calibrated with doubly distilled water. The viscosities were measured using Ostwald's viscometer (± 0.11% kg m^{-1} s^{-1}).

TABLE-3
DETERMINATION OF β-COEFFICIENT VALUES AT DIFFERENT TEMPERATURES

Temperature (K)	β-coefficient
299.15	3.3780
303.15	1.0312
308.15	2.4400
313.15	2.3830
318.15	2.1110

Both viscosity and density measurements were done in a water thermostat maintained at desired temperature controlled to ± 0.01°C. The accuracy of density and viscosity measurements are 3.0×10^{-4} kg m^{-3} and 4.0×10^{-5} kg m^{-1} s^{-1}. The viscosity and density data of water have been taken from literature.[11]

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TABLE-4
THERMODYNAMIC PARAMETERS ΔG, ΔH, ΔS AT VARIOUS TEMPERATURES IN DIFFERENT CONCENTRATIONS OF NIACIN

Conc. mol dm^{-3}	303.15 K			308.15 K			313.15 K			318.15 K		
	ΔG	ΔH	ΔS ($\times 10^{-2}$)	ΔG	ΔH	ΔS ($\times 10^{-2}$)	ΔG	ΔH	ΔS ($\times 10^{-2}$)	ΔG	ΔH	ΔS ($\times 10^{-2}$)
0.10	−19.1471	16.5862	11.7873	−19.1471	17.3280	11.8360	−19.1471	17.3660	11.5860	−19.1471	19.4878	12.1430
0.08	−14.7950	16.0889	10.1870	−14.7950	16.1775	10.2510	−14.7950	21.3100	11.53020	−14.7950	15.8230	9.6230
0.06	−10.7560	9.2970	6.6140	−10.7560	19.1435	9.7020	−10.7560	12.5570	7.3160	−10.7560	24.5770	11.1050
0.04	−14.8390	7.0418	7.2170	−14.8390	20.7070	11.5350	−14.8390	15.2314	9.6000	−14.8390	20.6250	11.1000
0.02	−17.4736	1.6594	5.7920	−17.4736	18.5329	11.8774	−17.4736	17.4459	11.1510	−17.4736	21.3107	12.1900