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Research Article

Densitometric and Viscometric Study of Sodium Salicylate in Pure Water at Different Temperatures.

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ABSTRACT

Apparent molar volumes (ϕ_v) and viscosity B-coefficients for sodium salicylate solutions in pure water solvent systems have been determined from density (ρ) and viscosity (η) measurements at 298.15 to 313.15 K using a pycknometer and Ubbelohde viscometer respectively. Seven different concentrations ranging from m = (8×10^{-3} to 1.99×10^{-2}) mol.L^{-1}, were prepared. The data were analyzed using Masson's equation to obtain limiting apparent molar volumes (ϕ_v^0) and experimental slope (S_v). The Jones-Dole equation was used to analyze viscosity data to obtain viscosity 'A' and 'B' coefficients. The drug interacts with various ions or molecules or biological membrane present in the biological system is an important phenomenon. The parameters derived from these equations have been interpreted in terms of solute-solute and solute-solvent interactions.

KEYWORDS

Sodium Salicylate, density, viscosity, B-coefficient.

1. INTRODUCTION

The partial molar volume and the related volumetric parameters of drug compounds in dilute aqueous solutions at different temperatures and pressures have been investigated by several authors [1-4]. It is well known that physicochemical characterization of drugs plays a crucial role in all the stages associated to design and development of pharmaceutical dosage forms, especially those intended to parenteral administration[5]. In this context, as a contribution to generation and systematization of physicochemical information about drugs' aqueous behavior, the main goal of this study was to evaluate the effect of concentration and temperature on the apparent molar volume of drugs in water. With that purpose, an interpretation in terms of solute-solvent interactions based on the corresponding volumetric behavior was developed. Drugs of the analgesics, antipyretics, and anti-inflammatory class include a heterogeneous group of compounds. Many of these agents affect pain, fever and inflammation and are referred to as the non-steroidal anti-inflammatory drugs (NSAIDS).

Non-narcotic analgesics have three important properties namely analgesics, antipyretics and anti-inflammatory (e.g. Aspirin and Paracetamol). The non-narcotics (salicylates) are called aspirin like or Non-steroidal Anti-inflammatory Drugs (NSAIDS). These drugs have common mechanism of inhibiting the cyclooxygenase (COX), the key enzyme responsible for biosynthesis of Prostaglandins (PG). Bio-pharmaceutics is the study of factors influencing the extent and rate of absorption. The rate and amount of drug absorption depends on biological and physicochemical factors. During their way to site of action, drug molecules have to cross one or more membranous barrier, which are lipoidal in nature and have different size of pores.

Physicochemical factors include lipid solubility, salt complexation, dissolution rate, Viscosity and drug stability in GIT. Lipid soluble drugs more unionized and easily absorbed Na and K salts of weak acid have higher absorption rate than acids.

All the drugs in any solid dosage form or suspension when administered will first change into drug solution in body fluids. So, dissolution rate is important factor affecting the rate of absorption. When a drug is more rapidly or completely absorbed from solution, it is very likely that its absorption will be dissolution limited.

Viscosity limits the dissolution rate and there by affect the rapid absorption. Eg. Aqueous Solution of Na-Salicylate showed its rapid appearance in plasma while the same drug in suspension form failed to reach the target as quickly as with aqueous solution[6].

The study of the volumetric behavior of electrolytes in solution provides information useful to elucidate ion–ion, ion–solvent, and solvent–solvent interactions. The concentration dependence of the apparent and partial molar volumes can be used to study ion–ion interactions, whereas the partial molar volumes at infinite dilution provide information on ion–solvent interactions. The data reported here were obtained by performing density measurements on aqueous solutions of sodium salicylate. It is used in medicine as an analgesic and antipyretic. Sodium salicylate also acts as non-steroidal anti-inflammatory drug (NSAID), and induces apoptosis in cancer cells and also necrosis. It is also a potential replacement for aspirin for people sensitive to it.

2. MATERIALS AND METHODS

2.1. Materials

Sodium salicylate of high purity was obtained from LobaChemiePvt Limited, Mumbai, recrystallized and then used. Deionized water with a specific conductance of < 10^{-6} S.cm^{-1} was used for the preparation of solutions at room temperature in a molarity range (8.0×10^{-3} to 1.99×10^{-2}) mol.L^{-1}. The precision of balance used was $\pm1\times10^{-5}$g.

2.2. Density measurements

The pycknometer was calibrated by measuring the densities of triple distilled water. The densities of distilled organic liquids like acetone, alcohol, benzene, carbon tetra chloride, aniline, and nitrobenzene were evaluated with respect to density of water. The density was measured with an uncertainty of $\pm$ 1.48×10^{-4}g.cm^{-3}.

2.3. Viscosity measurements

The solution viscosities were measured with an uncertainty of $\pm$ 2.4×10^{-4} mPa.s by using Ubbelohde viscometer. The viscosity measurements were performed at 298.15, 303.15, 308.15, 310.15 and 310.15K. The temperature of thermostat is maintained to desired temperature, by using demerstat with an accuracy of ±0.1 K. The flow time will be measured at the accuracy of ±0.01 s.

The different compositions (0.0199M to 0.0080M) of solutions of Sodium salicylate were prepared in pure water. The viscosities were measured at different temperatures for seven different concentrations.

Data Evaluation

The apparent molar volumes, ϕ_v, were obtained from the density results using the following equation[7-10]

$$\phi_v = \frac{1000\,(\rho_0-\rho)}{C\rho_0} + \frac{M_2}{\rho} \qquad (1)$$

where M_2, C, ρ and ρ_0 are the molar mass of the naproxen sodium, concentration (mol.L^{-1}), and the densities of the solution and the solvent, respectively.

The apparent molar volumes (ϕ_v) were plotted against the square root of concentration ($C^{½}$) in accordance with the Masson's equation[11]

$$\phi_v = \phi_v^0 + S_v.C^{½} \qquad (2)$$

Where ϕ_v^0 is the limiting apparent molar volume and S_v a semi-empirical parameter which depends on the nature of solvent, solute and temperature.

The viscosity results for the aqueous solutions of drugs were plotted in accordance with Jones-Dole equation[12]

$$\frac{\eta_{r-1}}{C^{½}} = A + BC^{½} \qquad (3)$$

Where $\eta_r = (\eta/\eta_o)$ and η ,η_o are viscosities of the solution and solvent respectively, C is the molar concentration. The linear plots for $(\eta_r\text{-}1)/C^{½}$ versus $C^{½}$ were obtained for the naproxen sodium. The B-coefficients were obtained from the linear plots using the least-square fitting method. The

A- coefficient reflects solute-solute interaction[13] and the B-coefficient reflect the solute-solvent interactions.

Table 1: Densities and apparent molar volumes of Sodium salicylate solution in pure water at different temperatures.

Molar Conc. of Sodium salicylate (C) mol/dm^3	**Temperatures**				
	298.15K	303.15K	308.15K	310.15K	313.15K
Densities (ρ), (g.cm^{-3})					
0.0080	0.99775	0.99634	0.99464	0.99387	0.99277
0.0100	0.99792	0.99648	0.99475	0.99393	0.99285
0.0120	0.99807	0.99662	0.99487	0.99401	0.99294
0.0140	0.99823	0.99677	0.99498	0.99411	0.99301
0.0160	0.99839	0.99690	0.99509	0.99419	0.99308
0.0180	0.99852	0.99703	0.99520	0.99428	0.99315
0.0199	0.99866	0.99716	0.99530	0.99438	0.99325
Apparent molar volumes (Φ_v) (cm^3.mol^{-1})					
0.0080	71.562	80.446	89.38	93.222	93.325
0.0100	72.314	82.455	92.649	100.77	98.868
0.0120	74.487	83.794	93.991	104.13	101.72
0.0140	75.323	84.033	95.667	105.09	105.20
0.0160	75.950	85.467	96.925	107.06	107.81
0.0180	78.109	86.583	97.903	108.04	109.84
0.0199	78.927	87.108	98.877	108.06	109.70

Table 2: Masson's parameters Φ_v^0(cm^3.mol^{-1}) and S_v(cm^3 .mol$^{-3/2}$ .L$^{1/2}$) of sodium salicylate solutions in pure water at different temperatures.

Temperature (K) →	**298.15**	**303.15**	**308.15**	**310.15**	**313.15**
Φ_v^0(cm^3.mol^{-1})	58.19	69.63	74.44	72.75	65.70
S_v(cm^3 .mol$^{-3/2}$ .L$^{1/2}$)	145.6	125.0	176.1	265.0	325.4

Table 3: Viscosities and relative viscosities of sodium salicylate solution in pure water at different temperatures.

Molar Conc. of Sodium salicylate (C) mol/dm^3	**Temperatures**				
	298.15K	303.15K	308.15K	310.15K	313.15K
Viscosities (η) (Nm^{-3}.s)					
0.0080	0.90185	0.80945	0.73155	0.70289	0.66215

0.0100	0.90331	0.81106	0.73298	0.70433	0.66308
0.0120	0.90448	0.81219	0.7347	0.70538	0.66398
0.0140	0.90596	0.81369	0.73575	0.7066	0.66479
0.0160	0.90718	0.81536	0.73726	0.70818	0.66603
0.0180	0.90909	0.81668	0.73863	0.70966	0.66701
0.0199	0.91073	0.81795	0.73988	0.71098	0.66817
Relative viscosities (η_r)					
0.0080	1.00915	1.01903	1.01251	1.01182	1.00937
0.0100	1.01079	1.01291	1.01449	1.01389	1.01079
0.0120	1.01210	1.01432	1.01687	1.01540	1.01216
0.0140	1.01375	1.01620	1.01832	1.01716	1.01340
0.0160	1.01512	1.01828	1.02041	1.01943	1.01529
0.0180	1.01725	1.01993	1.02231	1.02156	1.01678
0.0199	1.01909	1.02152	1.02404	1.02346	1.01855

Table 4: Jones-Dole parameters of sodium salicylate solutions in pure water.

Parameters of Jone-Dole equation					
T	298.15K	303.15K	308.15K	310.15K	313.15K
A($dm^{3/2}mol^{-1/2}$)	0.045	0.067	0.087	0.071	0.056
B($dm^3.mol^{-1}$)	0.614	0.599	0.589	0.655	0.509

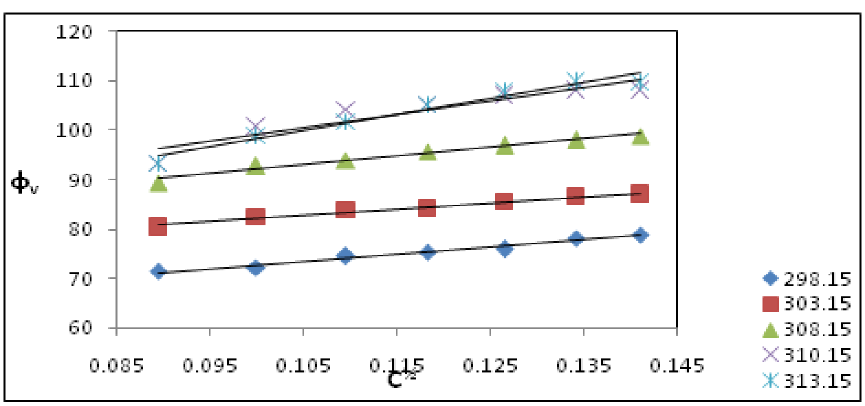

Figure 1. Plot of Φ_v($cm^3.mol^{-1}$)Versus $C^{½}$ ($mol^{1/2}.dm^{-3/2}$) for sodium salicylate solution in pure water at different temperatures.

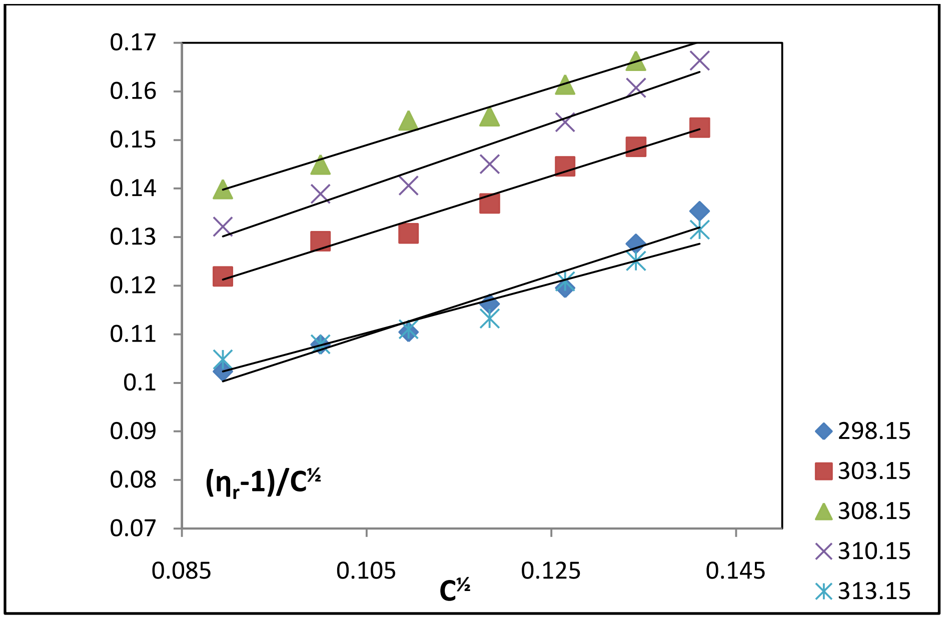

Figure 2. Plot of $(\eta_r-1)/C^{½}$ vs $C^{½}$ for sodium salicylate solutions in pure water at different temperatures.

3. RESULTS AND DISCUSSION

The values of the densities (ρ) and apparent molar volumes (ϕ_v) of sodium salicylate solution in pure water at 298.15, 303.15, 308.15, 310.15 and 313.15K temperature are shown in Table 1. The densities and ϕ_v values of solutions increases with increase in concentration of solution. Figure 1 shows the linear plots of ϕ_v vs $C^{½}$ for sodium salicylate solutions in pure water at different temperatures. Masson's parameters Φ_v^0 and S_v were obtained from linear plots are reported in table 2. The values of Φ_v^0 and S_v values obtained are positive for the systems studied furnish important information regarding the solute-solvent and solute-solute interactions.

The values of the viscosity and relative viscosities of sodium salicylate in pure distilled water at 298.15, 303.15, 308.15, 310.15 and 313.15K temperature are given in Table 3. In this set the viscosities of solutions increases with increase in concentration of solution, while viscosity decreases with increase in temperature. Figure 2 shows the variation of $(\eta_r-1)/C^{½}$ against square root of concentration at different temperatures in pure water.

However, positive A value in pure water are very small as expected by Falkenhegan theory. The present system obeyed Masson's and Jones-Dole equation. 'A' is constant independent of concentration and 'B' is Jones-Dole coefficient represents measure of order and disorder introduced by solute into the solution; positive 'B' coefficient shows strong alignment of solvent towards solute and is related to the effect of the ions on the structure of water [14]. The Jones-Dole parameters are given in Table 4. The positive values of 'B' at all temperatures indicate water structuring[15].

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