

## DENSITY AND VISCOSITY STUDIES OF GLUCOSE SOLUTION IN WATER AND AQUEOUS ELECTROLYTES AT 298.15, 303.15, 308.15 AND 313.15 K

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### ABSTRACT

The densities and viscosities of glucose are determined in water containing salt such as NaCl, NaBr, KCl and KBr at different temperature. From this density, apparent molar volumes ( $\phi_v$ ) of the electrolytes and ions in these mixtures have been evaluated. The limiting apparent molar volume ( $\phi_v^0$ ) has been interpreted in terms of solute-solvent interaction. The viscosity data have been analyzed with the help of Jones-Dole equation and the viscosity  $\beta$ -coefficients have been determined. Glucose has been found to be structure maker and breaker in aqueous halides from molar volume as well as viscosity studies.

**Keywords:** Glucose, Water, Density, Viscosity

### INTRODUCTION

The physical properties of solution such as density, viscosity, refractive index etc. mostly depend on the solvent and solute present in the system. These parameters are related with molecular interactions among the solute and solvent. Drug also interacts with solvent media. These interactions are important to understand mechanism of processes such as drug transport, protein binding, anesthesia [1] diffusion and dissolution rate control [2] of the drug. The binary solvent mixture is used as medium for study of complexation, electrochemical oxidation and ion solvation [3]. The density data of electrolyte has proved to be very useful in elucidating the nature of ion solvent interactions occurring in aqueous and non-aqueous solutions [4]. Measurements of viscosity in solutions provide an excellent method for obtaining data on ion-ion and ion-solvent interactions [5]. Therefore, it was decided to study the density and viscosity parameters of glucose in water solvent system in presence of electrolytes.

### MATERIALS AND METHODS

The salts KCl, NaCl, KBr, NaBr and nonelectrolyte glucose used were of AR grade. Water used was double distilled over alkaline  $\text{KMnO}_4$  and the purity of water was checked by comparing their measured densities and viscosities with those reported in the literature [6]. Viscosity measurements were performed by using Ostwald's viscometer.

Densities of glucose solution in water and aqueous alkali halides were measured using pycnometer with an accuracy of viscosity  $\pm 1 \times 10^{-4} \text{ g/cm}^3$ .

Viscosity values were determined using the relation

$$\eta_1 / \eta_2 = \rho_1 t_1 / \rho_2 t_2$$

The weighing was repeated thrice to ensure the accuracy in weights with a little interval of time. The reproducibility of the result was close to 100%. The viscometer was clamped vertically in a thermostatically controlled waterbath, whose temperature was maintained constant at 298.15, 303.15, 308.15 and 313.15 K ( $\pm 0.02$ ). The measurement of flow time of the solution between the two points on the viscometer was performed at least five times for each solution and the result was averaged.

### RESULTS AND DISCUSSION

The measure  $\rho$  values of glucose solutions in water and in aqueous NaCl, NaBr, KCl and KBr solutions at 298.15, 303.15, 308.15 and 313.15 K are used to calculate the apparent molar volumes  $\Phi_v$  using the equation

$$\Phi_v = [1000 (\rho_0 - \rho) / (c \times \rho_0)] + (M / P_0) \quad (1)$$

Where  $\rho$  and  $\rho_0$  are the densities of solution and solvent respectively,  $M$ , is the molecular weight of the solute,  $c$  is the concentration in  $\text{mol L}^{-1}$ . Figure 1 gives representative graphs of  $\Phi_v$  versus  $c$  for glucose in water and in aqueous NaCl at 298.15 K. The limiting partial molar volume of glucose in aqueous electrolyte solutions were obtained by computerized least square fitting of the equation.

$$\Phi_v = \Phi_v^0 + S_v C$$

Where  $\Phi_v^0$  is the limiting apparent molar volume at infinite dilution and  $S_v$  is the experimental slope. The  $\Phi_v^0$  and  $S_v$  values are presented in Table 1. The value of glucose in water and in aqueous NaCl, NaBr, KCl and KBr solution are large and positive.

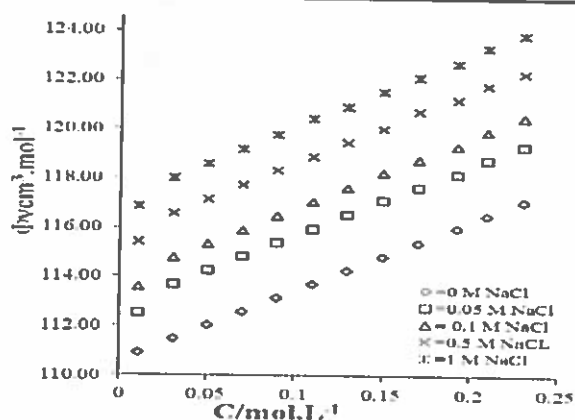


Figure 1.  $\Phi_v$  vs C for Glucose in water and in aqueous NaCl at 298.15 K

This indicates the presence of strong solute-solvent interactions. It is further observed that  $\Phi_v$  in all system increase slightly with increase in temperature suggesting decrease in solute-solvent interactions at elevated temperatures. The  $\Phi_v$  values of glucose in aqueous solution in the presence of added electrolytes are higher than those for glucose in pure water. The  $\Phi_v$  are positive and increase in solutions with increasing concentration of each electrolyte.

Table 1.  $\Phi_v$  and  $S_v$  values of glucose in water and in aqueous NaCl, NaBr, KCl and KBr solution at different temperatures.

	$\Phi_v(\text{cm}^3\text{mol}^{-1})$				$S_v(\text{cm}^3\text{L}^{-1/2}\text{mol}^{3/2})$			
	298.15K	303.15K	308.15K	313.15K	298.15K	303.15K	308.15K	313.15K
Glucose in Water	110.61	110.7	111.56	112.01	28.02	30.06	31.51	32.15
0.05M NaCl	111.66	112.12	112.61	113.08	28.33	30.31	31.72	32.32
0.1M NaCl	112.72	113.2	113.66	114.13	28.71	30.72	32.01	32.66
0.5M NaCl	114.49	115.36	115.85	116.29	29.16	31.13	32.32	32.86
0.1M NaCl	115.94	116.41	116.91	117.33	29.32	31.25	32.45	32.92
0.05M NaBr	114.85	115.83	116.74	117.7	30.51	32.62	33.73	34.84
0.1M NaBr	116.2	117.15	118.05	118.93	30.93	33.07	34.15	35.24
0.5M NaBr	116.2	117.15	118.05	118.93	30.93	33.07	34.15	35.24
0.1M NaBr	120.86	121.75	122.9	123.82	31.76	33.93	34.85	36.05
0.05M KCl	112.21	12.67	113.01	113.36	29.22	31.21	33.71	34.36
0.5M KCl	114.42	14.81	115.25	115.58	31.35	33.35	35.83	36.68
0.05M	116.61	117.62	118.61	119.81	31.22	33.2	35.71	36.36
0.5M KBr	121.98	122.76	123.66	124.38	33.35	35.36	37.84	38.68

This suggests that the structure-making tendency of glucose is enhanced in the presence of ions of electrolyte. The  $\Phi_v$  values of glucose in aqueous NaBr are always higher than those in aqueous NaCl. The  $\Phi_v$  values of glucose in aqueous KBr are higher than those in aqueous KCl presumably due to introduction of voluminous  $\text{Br}^-$  ion.

The relative viscosity ( $\eta_r$ ) data of glucose solution in water as well as in aqueous alkali solution are analyzed with the help of equation

$$\eta_r = 1 + BC$$

The Figure 2 gives representative graphs of  $\eta_r$  versus C for glucose in water and in aqueous NaCl at 298.15 K.

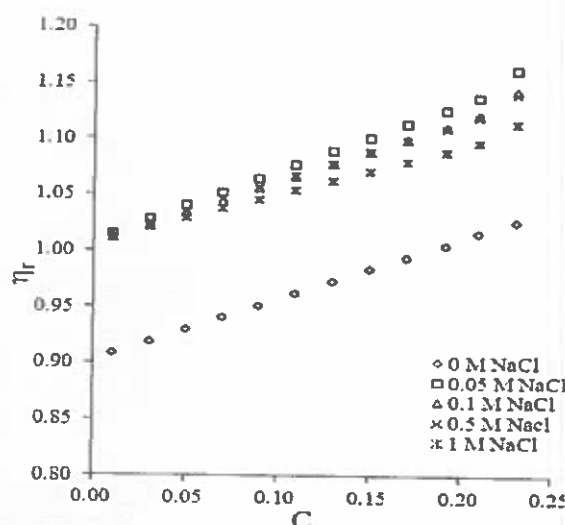


Figure 2  $\eta_r$  vs C of Glucose in water and in aqueous NaCl at 298.15 K

Similar plots have been obtained for other solutions at all temperatures. The values of B obtained from the slopes of these plots are listed in Table 2

Table 2. B Values of glucose in water and in aqueous NaCl, NaBr, KCl and KBr solution at different temperatures

	$B(\text{dm}^3\text{mol}^{-1})$			
	298.15K	303.15K	308.15K	313.15K
Glucose in water	0.603	0.545	0.494	0.432
0.05M NaCl	0.613	0.557	0.506	0.444
0.1M NaCl	0.554	0.506	0.458	0.413
0.5M NaCl	0.530	0.481	0.435	0.396
0.1M NaCl	0.425	0.419	0.413	0.406
0.05M NaBr	0.620	0.603	0.581	0.559
0.1M NaBr	0.559	0.486	0.451	0.438
0.5M NaBr	0.470	0.458	0.446	0.437
0.1M NaBr	0.458	0.446	0.432	0.418
0.05M KCl	0.410	0.395	0.382	0.370
0.5M KCl	0.468	0.441	0.431	0.412
0.05M KBr	0.477	0.469	0.460	0.454
0.5M KBr	0.434	0.420	0.404	0.388

NaCl, NaBr, KCl and KBr at all temperatures which suggest that glucose acts as structure promoter in these solution. The B values of glucose solution in aqueous NaCl, NaBr, KCl, KBr are lower than those in pure water. This could be explained on the basis that electrolyte is the hydrated and reacts with glucose. This leaves less water for sugar molecules for hydration. The positive B and negative dB/dT values in all solutions studies in the present investigation, make glucose as a structure promoter.

## CONCLUSION

Glucose has been found to be a structure maker and breaker in aqueous halides from molar volume as well as viscosity studies. Thus glucose as an structure promoter solute and this tendency enhances in presence of electrolytes. The results of density and viscosity measurements of the multicomponent solution are in good agreement with earlier reported work [3].

## REFERENCES

1. M. Iqbal, R E Verrall (1989), Apparent molar volume and adiabatic compressibility studies of aqueous solutions of some drug compounds at 25 °C. *Can. J. Chem.*, 67,727-735.
2. T. C. Bai, W. Wang, T. Wang, C. W. Zhu (2009), Viscosity, density, electric conductance and activation parameter of viscous flow for sodium salicylate in aqueous poly vinyl alcohol solution, *J. Mol. Liq.* 145, 82-87.
3. (a) P. S. Nikam, M. Hasan, K. H. Kapadnis, T. B. Pawar. Density and viscosity studies of glucose solutions in water and in aqueous NaCl, NaBr, KCl and KBr Solutions at 298.15, 303.15, 308.15 and 313.15 K, *J. Indian Chem. Soc.*, (2008), 85, 1089-1092. (b) P. S. Nikam, T. B. Pawar A. B. Sawant, M. Hasan., Limiting ionic partial molar volumes of R<sub>4</sub>N<sup>+</sup> and br in aqueous ethanol at 298.15 K, *J. Molecular Liquids*, (2006), 126, 19-22. (c) H. A Zarei, M
- Z. Lavasani, H. Iloukhani, Densities and volumetric properties of binary and ternary liquid mixtures of water (1) + acetonitrile (2) + dimethyl sulfoxide (3) at temperatures from (293.15 to 333.15) K and at ambient pressure (81.5 kPa). (2008), *J. Chem. Eng. Data*, 53, 578-585.
4. F. J. Millero, The partial molal volumes of electrolytes in aqueous solutions water and aqueous solutions (Structure, Thermodynamics, and Transport Processes), Ed. by R. A. Horne (Wiley Intersci., New York, 1972), Ch. 13.
5. R. W. Gurney, Ionic Process in Solutions (McGraw Hill, New York, 1953).
6. P. B. Raghuvanshi, P. V. Mahalle, (2014), Measurement and correlation of density and viscosity in dioxane and ethanol solvent at 293 K, *Sci. Revs. Chem. Commun.*, 4(1), 25-30.

  
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