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Volumetric properties of some drugs of pharmacological importance in water and 0.02 mol kg^{-1} $MgCl_2$. $6H_2O$ at 298.15 and 308.15 K

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ABSTRACT

The volumetric properties of four anti-tussive drugs viz., ephedrine HCl, dextramethorphan HBr, aminophylline and diphenhydramine HCl including Apparent molar volume, V_ϕ, partial molar volume, V^o, pair interaction parameter, S_V, partial molar expansivity, E^o_2 and isobaric thermal expansion coefficient, α_2 in water and 0.02 mol kg^{-1} $MgCl_2$. $6H_2O$ are determined at 298.15 K and 308.15 K. All these parameters have been computed from the measured solution densities obtained by an electronic vibrating tube density sound analyzer (DSA 5000). However, applications of volumetric measurements to the study of solvation of above mentioned drugs reflects theoretical frame work to rationalize the measured volumetric observables in terms of solute-solute and solute-solvent interactions in water and 0.2mol kg^{-1}. A least square fit method is used in computation of above mentioned properties.

KEYWORDS

Volumetric;
Solute-solute and solute-solvent interactions;
Partial molar volume;
Partial molar expansivity.

INTRODUCTION

There are many drugs which show their activity by interacting with biological membranes. Interactions of the drug with excipients can also affect their bioavailability and stability. Perceptible thermodynamic changes are found to be associated with the processes of drug activity[1,2]. In drug protein binding a strange behavior has been observed with respect to certain drugs[5]. Due to the complex structure of biomolecules it is difficult to carry out in physiological media. That is why it is suggested that each component of these systems must be studied individually before going to more complex systems. The thermodynamic methods are well known and better for studying the molecular interactions in fluids. The partial molar volume, Gibbs energy, is a sensitive parameter for evaluating the solute –solvent interactions. Since volume is an additive property, gross changes in volume of the system with its components can be assessed. Molecular interactions with in the system can also be assessed from volumetric data. Various processes in solutions such as electrostriction[8], hydrophobic hydration[9], micellization and co-sphere overlap during solute-solute interaction have been interpreted to large extent, from partial molar volume data of many compounds including amino acids, peptides and also some drug compounds[6].

Ephedrine HCl, diphenhydramine HCl, dextramethorphan HBr and aminophylline are well known cough suppressant and energy pills and provide

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the relief against cough and watery eyes and influenza. These drugs strongly bind to plasma proteins[10]. As a part of large term objective of present work is to investigate the thermodynamic aspects of biomolecular processes involving such drug macromolecule interaction, the results of determination of apparent molar volume, $V_{\phi,}$ partial molar volume (V^o), solute-solvent interaction parameter, S_v, partial molar expansivity, E^o_2, and isobaric thermal expansion coefficient, α_2 of four drugs mention above in water and 0.02 mol kg^{-1} $MgCl_2.6H_2O$ at 308.15 K are reported in this work.

RESULTS AND DISCUSSIONS

Apparent molar volume were first calculated using following equation[19]

$$V_{\phi,} = \frac{1000(d_\circ - d) + M/d}{mdd_\circ 1} \quad (1)$$

Where d, d_o, m and M are the densities of solution solvent, molality, and molar mass of solute. $V_{\phi,}$ data were found to vary linearly and were fitted to following equation[20]

$$V_\phi = V^o + S_v m \quad (2)$$

Where V^o is the partial molar volume of solute molecule. The values V^o and correlation coefficient have been estimated by the least square fitting of the apparent molar volume data in equation (2). Only V^o and S_v are sufficient to interpret the data.

The values of partial molar expansivity were then calculated[13] from the partial molar volume by the following relation[21]

$$E_2^0 = (\text{“}V^o/\text{”}T)_p \quad (3)$$

Since the changes in solution structure are very sensitive to temperature, the partial molar expansion is a better criterion for the detection of solute solvent interactions. From the partial molar volume, V^o, data the isobaric thermal expansivity coefficient of solute at infinite dilution, α_2 was also calculated by the following equation[22].

$$\alpha_2 = 1/V^o\ (\text{“}V^o/\text{”}T)_p \quad (4)$$

According to the scaled particle theory (SP)[16], the expression for partial molar volume of solute dilution is given as follows.

$$V^o = V_{cav} + V_{int} + \beta^o RT \quad (5)$$

Where V_{cav} and V_{int} are the contribution due the formation of cavity and from intermolecular interaction respectively, β^o is the isothermal compressibility of the solvent R is the gas constant T is the absolute temperature. The creation of cavity is a positive contribution to the partial molar volume of solute where as the attractive intermolecular solute-solvent interactions cause a negative contribution i.e shrinking the cavity.

In magnesium chloride the expansivity of cavity takes place in diphenhydramineHCl and aminophylline on increasing the temperature but opposite trend in ephedrineHCl. Isobaric thermal coefficient of ephedrineHCl and dextramethorphanHBr decreases with increase in temperature. It means when temperature increases density decreases resulting in a decrease of partial molar isobaric thermal expansion (α_2). Similar trend was observed by Iqbal and Verall [6] but in other two drugs an opposite trend was observed i.e in diphenhydramineHCl and aminophylline this trend was comparable to Neal and Goring[17].

It has been observed that some drugs show positive S_v values. It is believed that solvent molecules are more structured in bulk phase than in the solvation sphere of bulk solvent[14], the characteristics of co sphere depends upon the drug structure, size, shape and solvophobicity[15]. It has been seen that partial molar volume, partial molar expansion E_2^o and isobaric thermal expansion α_2 are independent of concentration since the changes in the solution structure are very sensitive to temperature changes.

Transfer Volume of drugs from solutions in water to aqueous Magnesium Chloride solutions are calculated as,

$$V_{tr} = V^o \text{ (in aqueous magnesium chloride solution)} - V^o \text{ (in water)} \quad (6)$$

The Positive values of transfer volume indicate the effect of hydrophilic parts. Ion-hydrophilic group contributes positively to the volume transfer because of the water structure that is formed around this group as a result of co sphere overlap. This indicates that hydrophilic-hydrophilic interactions are dominant over hydrophobic-hydrophilic interactions.

EXPERIMENTAL

The drugs, dextramethorphanHBr, aminophylline,

ephedrineHCl, DiphenhydramineHCl were purchased from sigma, the purity exceeds 99 %. The solvent used were water and 0.02 mol kg^{-1} $MgCl_2.6H_2O$. The samples are purified by recrystalization from ethanol water mixture. Water used in this case is doubly distilled and degassed.

TABLE 1 : Partial molar volume V^0 and S_v in 0.02 mol $kg^{-1}MgCl_2.6H_2O$ at 308.15 K and 298.15 K

Compound	0.02 mol $kg^{-1}MgCl_2.6H_2O$ T= 308.15 K		0.02 mol $kg^{-1}MgCl_2.6H_2O$ T=298.15 K		Water T= 308.15 K	
	V^o (cm^3mol^{-1})	S_v (cm^3mol^{-1})	V^o (cm^3mol^{-1})	S_v (cm^3mol^{-1})	V^o (cm^3mol^{-1})	S_v (cm^3mol^{-1})
EphedrineHCl	149.906 ± 0.117	-5.662 ± 0.163	147.978 ± 1.20	-5.375 ± 0.161	134.212 ± 0.044	-9.354 ± 0.119
Aminophylline	320.559 ± 0.135	- 38.287 ± 0.515	316.830 ± 0.318	-29.577 ± 1.316	230.472 ± 0.083	-8.908 ± 0.335
DiphenhydramineHCl	232.182 ± 0.135	-7.668 ± 0.410	230.132 ± 0.558	-1.634 ± 2.338	285.183 ± 0.029	-3.915 ± 0.321
DextramethorphanHBr	343.508 ± 0.006	-8.151 ± 0.024	339.289 ± 0.043	-6.647 ± 0.174	306.183 ± 0.065	-24.777 ± 0.420

TABLE 2 : Transfer volume, V^0_{tr} at 308.15 K

Sr. No	Compound	V^0 in 0.02 m $MgCl_26H_2O$ (cm^3 mol^{-1})	V^0 in Water (cm^3 mol^{-1})	V^0_{tr} (cm^3 mol^{-1})
1	Ephedrine HCl	149.906	134.214	15.694
2	Diphenhydramine HCl	232.182	230.472	1.71
3	DextramethorphanHBr	343.508	285.183	58.326
4	Aminophylline	320.559	306.183	14.375

TABLE 3 : Calculated data for partial molar expansibilities (E^o_2)

Compound	$E^o_{2/}$ cm^3 mol^{-1} K^{-1}
EphedrineHCl	-0.1928
Aminophylline	- 0.3729
DiphenhydramineHCl	-0.205
DextramethorphanHBr	-4.5894

TABLE 4 : Calculated data for partial molar isobaric thermal coefficient (α_2)

Compound	α_2 at 298.15 k	α_2 at 308.15 k
EphedrineHCl	-0.0013	-0.00128
Aminophylline	- 0.0012	-0.00116
DiphenhydramineHCl	-0.00089	-0.00088
DextramethorphanHBr	-0.0135	-0.01336

CONCLUSION

We have used the densimetric technique to measure the changes in apparent molar volume, transfer molar volume, partial molar expansivity and partial molar isobaric expansivity of four anti tussive drugs ephedrine HCl, dextramethorphan HBr, aminophylline and diphenhydramine HCl in water and 0.02 mol kg^{-1} $MgCl_2.6H_2O$ at 308.15 K. The results for all these four drugs can be interpreted by considering the changes of changes of the hydrophilic hydration around the polar head groups and hydrophobic hydration around the aromatic rings on these drugs. Higher values of partial molar volume were obtained when solvent–solvent interactions were higher than solute –solvent interaction.

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REFERENCES

[1] M.Iqbal, R.E.Verall; Journal of Physical Chemistry, **91**, 967 **(1987)**.
[2] M.A.Cheema, P.Taboada, S.Barbosa, M.Siddiq, Mosquera, V.Molecular; Physics, **104(20)**, 3203-3212 **(2006)**.
[3] S.Katz, R.G.Shinaberry, E.L.Heck, W.Squire; Biochemistry, **19**, 3805 **(1980)**.
[4] S.H.Roth; Annual.Rev.Pharmacol Toxicol, **19**, 159 **(1979)**.
[5] J.Judis; Journal of Pharmacological Sciences, **69**, 885 **(1980)**.
[6] M.Iqbal, R.E.Verall; Canadian Journal of Chemistry, **67**, 727 **(1989)**.
[7] M.J.Iqbal, Q.M.Malik; Canadian Journal of Chemical Thermodynamics, **37**, 1347 **(2005)**.
[8] H.S.Harned, B.B.Owen; The physical chemistry of electrolyte solution, Reinhold, New York, **(1958)**.
[9] C.Tanford; Hydrophobic effect; Formation of Micelles and Biological Membranes, 2nd Edition, Wiley, New York, **(1980)**.
[10] G.B.Katzung; Basic and clinical pharmacology, 4th Edition, Appleton and Lange, California, **(1989)**.
[11] Handbook of chemistry and physics, Editor in Chief

David R.Lide (Ed); 79th Edition, CRC, New York, **(1998)**.

[12] I.M.Klotz, R.M.Rosenberg; Chemical thermodynamics, Basic theory and methods, 3rd Editon, Benjamin, California, **(1972)**.

[13] M.Iqbal, M.Mateeullah; Canadian Journal of Chemistry, **68**, 725 **(1990)**.

[14] D.Rudan-Tasic, C.Klofutar; Monatsh Chemistry, **129**, 1245 **(1998)**.

[15] V.F.Stolipin, A.J.Mishstin; Journal of Physical Chemistry, **61**, 3226 **(1987)**.

[16] R.W.Gurney; Ionic Processes in Solutions, McGraw Hill; New York, **(1954)**.

[17] J.L.Neal, D.A.I.Goring; Journal of Physical Chemistry, **74**, 658 **(1970)**.

[18] C.Richardt; Solvents and solvent effects in organic chemistry, 2nd Editon, VCH, Weinheim, **(1988)**.

[19] M.Iqbal, M.A.Jamal; Canadian Journal of Chemistry, **72**, 1076 **(1994)**.

[20] T.Samanta, A.J.Ray; Journal of Chemical Thermodynamics, **42**, 262-266 **(2010)**.

[21] P.K.Banipal, S.Vicramjeet, T.S.Banipal; Journal of Chemical Thermodynamics, **42**, 90-103 **(2010)**.

[22] Q.Zhang, Z.Yan, J.Wang, H.Zhang; Journal of Chemical Thermodynamics, **38**, 34-42 **(2005)**.