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Significance of Hydration Process of Sugars and Pseudo-sugar in Sweet Taste Chemoreception at 298 K.

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ABSTRACT

Densities (ρ)of dextrose, fructose and myo-inositol have been measured in concentrate aqueous solution, concentration range 0.1-0.9 M at 298 K. From the density data, the apparent molar volume(Φv) partial molar volume (Φ_v^o)and apparent specific volume (ASV)were calculated.From these parameters, results were correlated with hydration process of solute and its chemoreception properties.From ASV values, it is concluded; sugars and pseudo-sugar which are under studied are sweet in taste.

Keywords: Apparent molar volume, Partial molar volume, *ASV*, Sugar, Myoinositol, Pseudo-sugar.

INTRODUCTION

Molecular volume is very important property regarding to the biological perspective. Enzymes have active sites which bind with specific substrates. Minute change in the volume of substrate deviates the physiological path way of biological system. Molecular volumes of stimulus molecules are associated to other significance factors such as compressibility, hydrophobicity and surface tension [1]. The hydration of solutes with water may affect accession to, binding with receptor sites and affect their taste properties. So it is very important to understand the nature of sweeteners-water hydration interactions [2, 3].

In this regard densities were used for investigation of molecular interactions [4].Aqueous solution of sugars has been widely used in food and medicinal applications [5-9]. Monosaccharide and their derivatives are most important class of biomolecules and reveal their biological adaptability of various functions such as structure and protective metabolic recognition.

In addition to bioavailability and metabolic stability, sugar molecules show high receptor attraction and discrimination **[**10]. It is an essential constituent for maintaining cell feasibility, natural cell defensive agent as well as energy pool in many organisms[11-12].

Myo-inositol ($C_6H_{12}O_6$) is a cyclic sugar alcohol. It is also recognized as cyclitol. The chemistry of the cell is controlled by myo-inositol. Outer and inner environment of a cell is regulated by it. The calcium channels of cell membrane can be opened by the derivative of myo-inositol (inositol-1,4,5 triophosphate). It allows the calcium ions to enter into the extracellular fluids [13].

The objective of this work is to work out volumetric parameters such as apparent molar volume (Φv), partial molar volume (Φ_v^o) and *ASV* of dextrose, fructose and myoinositol in water by using density data at various concentration and at 298 K.

METHODOLOGY

Dextrose, fructose and myoinositol used in this work were analytical grade with purity of > 99% was procured from LobaChemie (dextrose and fructose) and myo-inositol from SHIMADZU. The water used for the preparation of solution was double distilled. The molar aqueous solutions of solutes were prepared by using digital electronic balance (Model-AJO20,aiwa) with an accuracy of ± 0.1 mg.

Densities (ρ) of aqueous solutions of dextrose, fructose and myo-inositol were measured by using specific gravity bottle by relative measurement method with accuracy of ±0.1 kg.m^{-3}.

RESULTS AND DISCUSSION

The density, ρ (g cm^{-3}) data of dextrose, fructose and myo-inositol measured at temperature 298 K as function of concentration, (moldm^{-3}) are given in Table 1. Apparent molar volume can be calculated from the density data by using eq. (1) [14]

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

Where Φ_v, C, ρ, $\rho_o$and M are the apparent molar volume, molarity, density of the solution, density of solvent (water) and molar mass of solute, respectively When a solute dissolved into water to make solution, there is changed in volume due to solute-solvent interactions; this shrinkage in the volume of solvent system is called electrostriction. This is also known as apparent molar volume. Apparent molar volume at infinite dilution where the solute-solute interaction is completely diminished is called partial molar volume [15].

Apparent molar volume and partial molar volume are used to reveal hydration of solute and solute-solvent structural interactions. The low apparent molar volume of solution compared to bulk solvent indicate strong hydration of solute molecule [16].

The apparent molar volume (Φv) data for dextrose, fructose and myoinositol can be expressed with Messon's relation given by eq. (2) least square fit method [17-18].

$$\Phi v = \Phi_v^o + S_{v\surd} C \qquad (2)$$

Where,Φ_v^o, is partial molar volume, first coefficient of fit and known as partial molar volume. Partial molar volume delivers information about solute-solvent interactions. Data of Φ_v^o and S_v for the dextrose, fructose and myoinositol at 298 K presented in Table 1, 2 and 3 respectively. The value of Φ_v^o and S_v were calculated with the help computer using the relation of Eq. (2). The Φ_v^o values are positive for dextrose, fructose and myo-inositol stating thereby positive interaction between solute and solvent molecules. The value S_v is negative for all the solutes, which indicates weak solute-solute interactions.

Table 1. Apparent molar volume (Φv), partial molar volume (Φ_v^o)and S_v,of dextrose at 298 K at different concentration

Concentration (mol dm^{-3})	$\sqrt{C}$	Φv (m^3 mol^{-1}) Glucose	ASV
0.1	0.3162	135.51	0.75218
0.2	0.4472	131.00	0.72713
0.3	0.5477	128.82	0.71508
0.4	0.6325	125.24	0.69514
0.5	0.7071	125.09	0.6943
0.6	0.7746	118.81	0.65943
0.7	0.8367	117.04	0.64962
0.8	0.8944	114.84	0.6374
0.9	0.9487	113.01	0.62727
Φ_v^o (m^3 mol^{-1})	147.84		
Sv (m^3 $Kg^{1/2}$ $mol^{-3/2}$)	-36.24		

Table 2. Apparent molar volume (Φv), partial molar volume (Φ_v^o), S_v, and apparent specific volume (ASV) of fructose at 298 K at different concentration

Concentration (mol dm^{-3})	$\sqrt{C}$	Φv (m^3 mol^{-1}) Fructose	ASV
0.1	0.3162	133.51	0.74105
0.2	0.4472	126.99	0.70487
0.3	0.5477	127.49	0.70766
0.4	0.6325	123.73	0.68679
0.5	0.7071	122.48	0.67983
0.6	0.7746	118.64	0.6585
0.7	0.8367	116.61	0.64724
0.8	0.8944	114.46	0.63531
0.9	0.9487	112.79	0.62604
Φ_v^o (m^3 mol^{-1})	143.42		
Sv (m^3 $Kg^{1/2}$ $mol^{-3/2}$)	-31.80		

Table 3. Apparent molar volume (Φv), partial molar volume (Φ_v^o), S_v,and apparent specific volume (ASV) of myoinositol at 298 K at different concentration

Concentration (mol dm^{-3})	$\sqrt{C}$	Φv (m^3 mol^{-1}) myoinositol	ASV
0.1	0.3162	123.48	0.6854
0.2	0.4472	123.98	0.68818
0.3	0.5477	117.47	0.65201
0.4	0.6325	115.21	0.63948
0.5	0.7071	111.05	0.61639
0.6	0.7746	111.28	0.61769
0.7	0.8367	109.87	0.60987
0.8	0.8944	106.69	0.59218
0.9	0.9487	104.65	0.5809
Φ_v^o (m^3 mol^{-1})	135.22		
Sv (m^3 $Kg^{1/2}$ $mol^{-3/2}$)	-31.66		

Table 1: Table heading must be type in Book Antiqua font size 10.

Applied kV (r.m.s.)	Ratio of count rate $(i_5/i_{50})_D$ in dark	$(i_5/i_{50})_L$ in light	$\Delta (i_5/i_{50})$	$\% \Delta (i_5/i_{50})$
0.28	00.00	00.00	0.00	00.00
0.70	48.29	00	- 48.29	- 100.00
1.05	09.120	11.160	+ 2. 08	+ 22.81
1.40	03.520	03.434	- 0.086	- 02.44
2.10	03.595	03.454	-0.141	-03.91
2.45	03.398	02.813	-0.58	-176.07

For all the studied molecules, the apparent molar volume is found to decrease with increase in concentration of solute indicating strong association with solvent. It is also observed that myo-inositol strongly associated compared to fructose and dextrose respectively. This may be due to no. of hydroxyl groups, nature of hydroxyl group and cyclic or straight chain of solute. It seems that strength of intermolecular interaction of equatorial –OH groups is more. Dextrose has more percentage of equatorial –OH group. It should have strong association with watert molecules as compared to fructose and myo-inositol. The result shows that the trend of molecular association is in the order of dextrose < fructose < myo-inositol. This can be explained that dextrose is present as a pyranose ring, furanose and straight chain form. But most stable form of dextrose in aqueous medium is pyranose form. Fructose is present as a furanose ring as well as straight chain form which have five hydroxyl (–OH) group, but out of these five; two are attached to $–CH_2$ groups and not to the ring. It is known that the interactions between open chain aliphatic –OH groups and solvent molecules are more extensive than cyclic compounds with solvent [19]. Hence, fructose is somewhat more hydrated than dextrose. Myo-inositol is present as six member ring and has same number of equatorial –OH groups as like dextrose, but one –OH group is more than in dextrose and fructose and hence forms more number of hydrogen bonds and shows strong molecular interaction [20].

ASV is very important parameter to explore sweet taste. It allows comparing mass fraction of solutes and stimulating a finite population of receptors. It also reveals degree of hydration with surrounding water molecules. From experimental data about ASV of all the studied molecules fit within the range for parameter (ASV= 0.60-0.69 $cm^3\ g^{-1}$). Dilute solution of sugars (dextrose and fructose) is slightly out of range and for pseudo-sugar (myo-inositol), concentrated solution reveals deviation from chemoreception range.

CONCLUSION

polyols like myo-inositol sweet in taste at lower concentration range.

Conflicts of interest: The authors stated that no conflicts of interest.

REFERENCES

1. Gordon G. Birch et.al, Pure & Appl.Chem., vol.69, No.4, pp.685-692, 1997
2. M.A. Jamal,M.K.Khosa, M.Rashad, I.H.Bukhari and S.Naz, *Food Chemistry* 146(2014)460-465
3. Millero,F.S., Surdo A.,Shin,C, *Journal of Physical Chemistry*,82(1978)784
4. Kloftar,C, Horvat, J, &Tasic, R.D, *Journal of ActaChimicaSlovernica*, 53(2006) 274-283
5. S. Nithiyanantham, L. Palaniappan and R. Jayalaxami, *J. Comp. Theo. Nano Sci*., **9** (2012)1115-1119
6. S. Nithiyanantham and L. Palaniappan, *J. Comp. Theo. Nano Sci*, (2014)1-5
7. S. Nithiyanantham and L. Palaniappan, *Arab. J. Chem*., **5**(2012)25-30
8. G. Savaroglu and M. Ozdemir, *J. Mol.Liq*., **137**(2008)51-57
9. V. Vanathi, S. Mullainathan and S. Nithiyanantham, ,*J. Comp. Theo. Nano Sci***10** (2013) 1952-1955

10. J.F. Comesana, J.J. Otero, E. Garcia and A. Correa, *J. Chem. Eng. Data*. **48**(2003)362-366

11. K. Jumel, S.Harding and E.Hayler, *Carbohyd. Polys*.**29**(1996)105-109

12. S.Punitha, R.Uvarani, A.Panneerselvam and S. Nithiyanantham, *J. Saud. Chem. Soc*. **18**(2014) 657-665

13. Clayden, Greeves, Warren and Wothers, *Organic Chemistry*, Oxford University Press, *New York*, 2006.

14. F.J. Millero, A.L. Surdoand C. Shin, *J. Phy. Chem.*, 82 (1978) 781

15. M.A. Jamal, M.Rashad, M.K.Khosa, I.A.Bhatti and K.M Zia, *Food Chemistry* 153(2014)140-444

16. S. A. Galema and H.Hoiland, *J. Phys. Chem.*,95 (1991) 5321-5326

17. C. Klofuftar, C. Horvat, and R.D.Tasic, *J. Acta Chimica Slovenica*,53(2006) 274-283

18. D.O. Masson, *Philosophical magazine,* 8(1929) 218-235

19. S.S. Dhondge. *Ph.D. thesis*, Nagpur University, Nagpur, India, 1986.

20. J. F. Comesana, J.J. Otero, E. Garcia and A. Correa, *J. Chem. Eng. Data*, **48**(2003)362-366.