Densities and partial molar volumes of fructose and sucrose in water and 0.05M (NaCl, NaBr, KCl, and KBr) aqueous solutions at 303.15K

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ABSTRACT
Measurements of densities of fructose and sucrose in water and 0.05M (NaCl, NaBr, KCl, and KBr) aqueous solutions have been undertaken as a function of molarity, at atmospheric pressure, and at $T = 303.15K$. Densities have been correlated with molarity of the solutions. Furthermore, partial molar volumes have been calculated from experimental density values. Results are interpreted in terms of solute-solute and solute-solvent interactions.

INTRODUCTION
The soaking operations include candying and semi candying, osmotic dehydration, brining and curing, emersion, chilling and freezing. In the field of soaking operations, the mixed blends (sugar + water + alkali halides) at low temperatures (303.15K) are used either for vegetable or animal tissues. To understand the soaking operations with mixed blends, it is necessary to take into account physical properties of (sugar + water + alkali halides).

Direct contacting of food stuff with aqueous solutions has been widely used in the field of engineering. The food includes fruit, vegetables, meat and fish. They can be osmotically treated proceeding the conventional processing. Binary and ternary aqueous solutions of sugars, inorganic salts, alcohol, and polyols can be used as osmotic agents. To understand the osmotic treatment, it is necessary to know in hand physical properties of (sugar + water + inorganic salts). The most important physical property density will useful for this. From densities of the aqueous solutions, partial molar volumes can be calculated. Partial molar volumes are useful to calculate the effect of the pressure on ion-equilibrium for engineering and oceanographic.

Therefore, in this paper, we report densities and partial molar volumes of fructose and sucrose in water and 0.05M (NaCl, NaBr, KCl, and KBr) aqueous solutions, at (303.15K), and at atmospheric pressure.

EXPERIMENTAL
Sucrose (A.R. Grade purity > 99.5%, BDH), NaBr (A.R. Grade purity > 99.5%, Loba Chem.),
KCl (A.R. Grade purity > 99.5%, E-Merck) and KBr (A.R. Grade purity > 99.5%, E-Merck) were used in the present investigation without further purification. Masses were recorded on a Dhona balance with a precision of \( \pm 1 \times 10^{-7} \text{kg} \). All the solutions were prepared in triply distilled deionized water. The densities (\( \rho \)) of aqueous solutions were measured with the help of a 15-\( \times \)10^{-6}m^3 double arm pycnometer^{1,2,3}. The pycnometer was placed in glass walled thermostat having the thermal stability of \( \pm 0.01 \text{K} \). The accuracy in the density measurements was \( \pm 1 \times 10^{-7} \text{kg} \cdot \text{m}^{-3} \).

### RESULTS AND DISCUSSION

Densities of fructose and sucrose in water and 0.05M (NaCl, NaBr, KCl, and KBr) aqueous solutions are reported in TABLE 1 and TABLE 2, respectively. Densities are correlated with molarity of solutions by polynomial equation.

\[
\rho = A_0 + A_1 M + A_2 M^2
\]  

(1)

\( M \) is molarity of the solution. TABLE 3 summarizes the correlation parameters \( A_0, A_1, \) and \( A_2 \).

Density values have been used to calculate the partial molar volumes of fructose and sucrose in water and
0.05M (NaCl, NaBr, KCl and KBr) aqueous solutions. To calculate apparent molar volumes ($V_{\phi,m}$) of fructose and sucrose in water and 0.05M (NaCl, NaBr, KCl and KBr) aqueous solutions following equation 4, 5 was used.

$$V_{\phi,m} = \left[ \frac{\text{Molar mass of solute}}{\rho} \right] - \left[ \frac{(\rho-\rho_0)}{(M \rho_0)} \right]$$ (2)

Here, $\rho$ is the molarity of the solution, $\rho$ and $\rho_0$ are densities of the solution and solvent, respectively. Apparent molar volumes ($V_{\phi,m}$) of fructose and sucrose in water and 0.05M (NaCl, NaBr, KCl and KBr) aqueous solutions are included in TABLE and TABLE 2. Partial molar volumes ($V_{\phi,m}$) have been calculated by using the Masson’s equation 6, 7.

$$V_{\phi,m} = V_{\phi,m}^\sigma + V_{S}^{\frac{1}{2}}$$ (3)

In this equation, $V_{\phi,m}^\sigma$, and $V_{S}$ are solute, solvent, and temperature dependent empirical parameters. $V_{\phi,m}^\sigma$ and $V_{S}$ have been calculated by the least square fitting of the apparent molar volume data in the equation 3. TABLE 4 compiles $V_{\phi,m}^\sigma$ and $V_{S}$ values of fructose and sucrose in water and 0.05M (NaCl, NaBr, KCl and KBr) aqueous solutions, respectively.

Information regarding solute–solvent and solute–solute interactions can be obtained from $V_{\phi,m}^\sigma$ and $V_{S}$ values. From TABLE 4, it is clear that the $V_{\phi,m}^\sigma$ values of fructose and sucrose are large and positive. The positive values of $V_{\phi,m}^\sigma$ indicate the strong solute–solvent interactions. The $V_{S}$ values are positive and smaller than $V_{\phi,m}^\sigma$ suggesting the dominance of solute–solvent interactions over solute–solute interactions. The $V_{\phi,m}^\sigma$ values of sucrose in water and 0.05M (NaCl, NaBr, KCl and KBr) aqueous solutions are larger than $V_{\phi,m}^\sigma$ values of fructose in water and 0.05M (NaCl, NaBr, KCl and KBr) aqueous solutions.

### CONCLUSIONS

1. Partial molar volumes of fructose and sucrose in water and 0.05M (NaCl, NaBr, KCl and KBr) aqueous solutions are positive.
2. Partial molar volumes of fructose in water and 0.05M (NaCl, NaBr, KCl and KBr) aqueous solutions smaller than partial molar volumes of sucrose in water and 0.05M (NaCl, NaBr, KCl and KBr) aqueous solutions.
3. The partial molar volumes of fructose and sucrose increase with the addition of alkali halides in solvent like water.

### REFERENCES