Density, Surface Tension, and Interfacial Properties of Potassium Oxalate in Sucrose–Water System at 298.15 K

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ABSTRACT

The study of physico-chemical parameters such as density and surface tension provides valuable insight into solute–solvent and solvent–solvent interactions in mixed liquid systems. In the present work, the density ( ) and surface tension ( ) of potassium oxalate in a sucrose water medium were measured at 298.15 K to understand interactions in mixed liquid systems. Surface tension indicates molecular interactions at the liquid-air interface, while density reveals structural arrangements in the solution. The study calculated thermodynamic quantities like apparent molar volume, surface tension deviations, and parachor values to assess interaction strength. Results show that sucrose significantly alters water's hydrogen-bond structure and that potassium oxalate further impacts it, leading to changes in density and surface tension. These findings are important for understanding how electrolyte-carbohydrate-water systems work and have practical applications in food chemistry, pharmaceuticals, and industrial processes.

KEY WORDS

Density, Surface Tension, Excess Molar, Volume.

INTRODUCTION

Model systems for understanding solute-solvent interactions, hydrogen bonding, and structural organization in aqueous solutions, sucrose-water solutions are frequently researched in physical chemistry. Information about molecular behavior may be gained by studying a variety of physico-chemical

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factors, including density, viscosity, surface tension, refractive index, and apparent molar volume. of such systems. Since both characteristics are influenced by molecular interactions and external conditions, surface tension and density are frequently investigated together. Additionally, both parameters are temperature sensitive, and their simultaneous assessment yields information on the cohesive energy density of liquids and mixtures. Density and surface tension correlations are utilized in materials science and nanotechnology to forecast solubility parameters, phase equilibrium, and the architecture of surfactant systems. In physical chemistry, the study of surface tension and density in binary solvent systems is important because these properties offer helpful information about intermolecular interactions and the behavior of solutions. Binary mixtures surface tension is caused by the balance between the cohesive forces inside each solvent and the adhesive forces between the two constituents. It is extremely composition sensitive and reflects the molecular structure at the liquid–air interface. For instance, the surface free energy changes when a polar solvent like water is combined with a less polar solvent like alcohol due to hydrogen bonding and molecular association. The fact that increasing alcohol concentration causes a decrease in surface tension, which is explained by the buildup of alcohol molecules on the liquid surface, is a well-known phenomenon. decreases cohesive water-water interactions . In addition, surface tension data are frequently utilized in the creation of solute-solvent compatibility and are used in the formulation of pharmaceuticals, surfactants, and emulsions.[3]. Density studies in binary systems are also crucial since density is a direct measurement of mass per unit volume and may be used to predict the composition of a mixture. can be used to calculate a variety of thermodynamic parameters, including partial molar quantities, isothermal compressibility, and excess molar volume. Density deviations from ideal behavior frequently point to particular molecular interactions like hydrogen bonding, ion-dipole interactions, or dipole-dipole forces. For instance, alcohol-water and amide-water Mixtures display negative deviations in excess molar volume, indicating significant hydrogen bonding between dissimilar molecules.

Density and surface tension analyses, taken together, provide a full picture of how molecules interact in binary solvent mixtures. Their combined analysis is essential to industrial formulations, chemical engineering, and solution chemistry, where a thorough understanding of non-ideal behavior influences the effectiveness of material design and separation procedures. The study of density and surface tension in sucrose-water mixtures is essential for comprehending molecular interactions, solution thermodynamics, and practical applications in the food, pharmaceutical, and chemical industries. The density of sucrose-water solutions rises logically with the sucrose concentration because the heavier sucrose molecules displace the less dense water molecules. Sucrose ($C_{12}H_{22}O_{11}$) is a non-volatile, highly polar solute with a high capacity for hydrogen bonding, thus its dissolution results in a more compact structure in the solvent matrix. This leads to densities that are higher than that of pure water. Important thermodynamic variables like compressibility, excess molar volume, and apparent molar volume, which shed light on solute-solvent interactions, can be computed using density data. For example, the apparent molar volume of sucrose decreases with increasing concentrations, suggesting stronger hydrogen bonding and association within the system. Furthermore, the solute concentration of sucrose-water mixtures affects their surface tension. Sucrose is not surface-active, unlike surfactants, and its molecules prefer to stay in the bulk phase rather than move to the liquid-air interface. Consequently, the addition of sucrose usually leads to an increase in surface tension because it strengthens the intermolecular cohesive forces in the solution. Sucrose's hydrophilic nature and its capacity to promote structural order in water are both reflected in this behavior [5].

The density and surface tension of sucrose-water solutions are analyzed together to help describe solute-solvent interactions, and this technique is commonly used in the food industry (e.g., syrups and drinks), pharmaceutical preparations, and biological processes. The excellent hydrogen bonding network between water and sucrose provides a model for studying molecular interactions in water-carbohydrate systems.

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Experiment

In a 5% (w/v) sucrose-water system, a stock solution containing 1.0000M of each potassium oxalate is produced at 298.15K. The process of mass dilution is employed to prepare different concentrations. The experiment's solution concentrations were determined to range from between 0.01 and 0.10 molar concentration. Using the mass dilution technique, a solution with varying concentration ranges of 0.01 M to 0.10 M was prepared at 298.15 K. Solution of densities are measured with a 10 cm³ double-armed pycnometer. At these temperatures, pure water and benzene were used to calibrate the pycnometer. The solution's density was measured with an estimated precision of 0.00004 g cm–3. Stalagmometer was used for the measurement of surface tension of potassium oxalate solutions. The apparatus was kept in vertical position. The solution was allowed to drop very slowly, ensuring that every drop is fully formed. A definite volume of solution determined by marks in the stalagmometer was allowed to come out and the numbers of drops were counted. The calibration of stalagmometer was done with triple distilled water.[6]

Results and Discussion

Densities of ammonium oxalate monohydrate in 5% (w/v) sucrose-water,

$$\rho/\rho_1 = W/W_1 \quad [1]$$

Where W and W_1 are weight of potassium oxalate , sucrose -water respectively.

ρ is density potassium oxalate solution and ρ_1 is density of sucrose -water solution .

Densities of potassium oxalate solutions were determined as a function of their concentration a 298.15°K temperature in 5 % (v/v) sucrose -water solution . The densities of solute were obtained as an intercept of plot between concentration and density of solutions (using Microsoft Excel). The data is reported in Table -1.

Apparent molar volume, ϕv , is calculated by following the equation,[7]:

$$\phi v = (\rho_1 - \rho)/c\rho\rho_1 + M/\rho \quad [2]$$

Where, c is Morality of the solution, M is Molar mass of the solute, ρ and $\rho 1$ Density of solution and solute. The result of ϕv of potassium oxalate are reported in Table- 1.The apparent molar volume at infinite dilution ϕ^0_v were calculated by the method of least square and fit to plot of ϕv vs $c^{1/2}$ in accordance with the Masson's empirical relation , [8]

$$\phi_v = \phi0 \, v0 \, v + S^* \, v^* \, v \, c^{1/2} \quad [3]$$

Where, $S^* v$ is experimental slope. The slope is calculated by the extrapolation of the plots to zero concentration (using Microsoft excel). The positive and less negative values of experimental slope are generally associated with the solutes showing an overall hydrophilic character as in the present investigation. The values of apparent molar volume are reported in Table 1.

The molar volumes of solutions are derived from the following expression , [9]

$$V = (X_1 M_1 + X_2 M_2)/r \quad [4]$$

Where, X_1 and X_2 are Mole fraction of mixed solvent and Mole fraction of solute. M_1 and M_2 Molecular weight of solvent and Molecular weight of solute is density of solution respectively. The data of molar volume of solution is reported in Table 1.

Table 1: Density, Apparent Molar Volume, Molar Volume of Potassium Oxalate in Sucrose–Water System At 298.15 K

Concentration	Density (d)	Apparent molar volume : ϕv	S_V^*	ϕ_V^0	Molar volume
0.0100	1.0057	79.6032	140.4060	53.9158	19.6627
0.0250	1.0078	140.3316			19.6887
0.0500	1.0100	160.6326			19.7321
0.7500	1.0122	182.4979			21.1176
0.1000	1.0165	170.7386			19.8178
0.2500	1.0338	176.8182			20.0721
0.5000	1.0685	178.8173			20.4749
0.7500	1.0837	179.5376			20.9063
1.0000	1.1075	179.8780			21.3201
c in mol dm^{-3}	d in gm cm^{-3}	ϕv in cm^{3}mol^{-1}	S_V^* in cm^{3}dm$^{3/2}$mol$^{-3/2}$	ϕ_V^0 in cm^{3}mol^{-1}	V in cm^{3}mol^{-1}

The surface tension of sucrose: water 5%(w/v) mixed solvent was determined using following expression, $\gamma 1/\gamma 0 = n1 \ x \ \rho_0 \ / \ n0 \ x \ 1$ [5]

$$\gamma_1/\gamma_0 = n_1 \ x \ \rho_0 / \ n_0 \ x_1 \ [5]$$

Where,γ_0 was Surface tension of solvent n_0 was Number of drops of solvent . ρ_0 was density of solvent and $..._1$ were density of solution.

The study of excess and mixture property is normally used to get information about molecular processes that can occur during the mixing phenomena .

$$\gamma^E = \gamma - (x_1\gamma_1 + x_2\gamma_2) \ [6]$$

Where,γ_1 was Surface tension of mixed solvent and γ_2 was Surface tension of solute. The data are collected in Tables 2. All the values are positive showing solute-solvent interaction. Excess surface tension is important in physical chemistry because it helps understand how ions interact with solvents and how interfaces are structured. It helps determine how ions adsorb, how hydration affects them, and the properties of electrolyte solutions. By measuring surface tension at various concentrations, chemists can analyze how specific ions affect these properties and the role of hydration energy at interfaces. Studying excess surface tension is key in surface chemistry and has practical uses in areas like electrochemistry, colloid science, and biological systems involving electrolytes.

Parachor, P

Parachor of solutions were calculated using the surface tension data .

$$P = V \ x \ \gamma^{1/4} \ [7]$$

where,

P = Parachor of potassium oxalate solution.

V = Molar volume of potassium oxalate solution.

The values are presented in Tables-2. Parachor is important because it links molecular volume and surface properties. It reflects intermolecular forces through surface tension, providing insights into these forces in various compounds. Parachor is widely used in physical and organic chemistry to identify the molecular structure of unknown compounds, differentiate isomers, and confirm the presence of double bonds or aromatic features. It is especially useful in structural chemistry when paired with other properties like refractivity or viscosity.[10]

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Table 2: Surface Tension, Parachor and Excess Surfacetension of Potassium Oxalate in Sucrose–Water System at 298.15 K

Concentration	Surface Tension	Parachor	Excess Surface Tension
0.0100	57.2190	4.5385	2.5531
0.0250	59.3902	4.5097	4.7231
0.0500	63.6226	4.4672	8.9533
0.7500	65.8159	4.4394	11.0778
0.1000	70.2289	4.4004	15.5553
0.2500	73.5276	4.3254	18.8409
0.5000	78.1652	4.2042	23.4564
0.7500	81.4771	4.1544	26.7445
1.0000	85.5202	4.0877	30.7631
c in mol dm^{-3}	γ in dynes cm^{-1}		γ^E in dynes cm^{-1}

CONCLUSION

The data show that the density of a substance increases with concentration and decreases with temperature. The density of potassium oxalate in the specified range is 1.0074. A positive value of apparent molar volume denotes stronger solute-solvent interactions. The apparent molar volume of the solution is seen to decrease with increasing temperature. The system has high and positive values for infinite apparent molar volume, which indicates the existence of solute-solvent interactions. Potassium oxalate is surface active because the surface tension drops with rising concentration. The surface tension of potassium oxalate is worth 1.1474. The positive surface tension values indicate a favorable solute-solvent interaction. With rising temperature and concentration, the interaction became less intense. The value of parachor determined will be helpful for additional QSAR analysis.

REFERENCES

1. Adamson, A. W. & Gast, A. P. (1997) *Physical Chemistry of Surfaces,* 6th ed., Wiley-Interscience, New York, NY 10158-0012, USA.

2. Atkins, P. & de Paula, J. (2010) *Atkins' Physical Chemistry,* 9th ed., Oxford University Press, Oxford, United Kingdom.

3. Cibulka, I. (1982) Density and Excess Volume of Binary Systems Containing Alcohols, *Journal of Chemical & Engineering Data*, 27(1), 1–7.

4. Millero, F. J. (1971). The Apparent Molar Volumes of Electrolytes in Solution, *Chemical Reviews*, 71(2), 147–176.

5. Nikam, P. S.; Swant, A. B.; Aher, J. & Khaimer, R. S. (2000). Densities and Viscosities of Aqueous Solutions of Sucrose at Different Temperatures, *Journal of the Indian Chemical Society*, 77, 197–200.

6. RMaravkova, L.; Linek, J. (2003) Excess molar volumes of (benzene +isopropylbenzene, or 1, 3, 5-trimethylbenzene, or 1,2,4 trimethylbenzene)at temperatures between 298.15 to 328.15 K"; J. Chem, T*hermodyn,* 35, 1139–1149, 2003.

7. Giner, B.; Lafuente, C.; Villares, A.; Haro, M.; Lopez, M. C. (2007) Volumetric and refractive properties of binary mixtures containing 1,4-dioxane and chloroalkanes, J. Chem. *Thermodyn,* 39, 148–157, 2007.

8. Emmerling, U.; Figurski, G. (1998) Densities and Kinematic Viscosities for the Systems Benzene + Methyl Formate, Benzene + EthylFormate, Benzene + Propyl Formate, and Benzene + Butyl Formate; *J. Chem. Eng. Data,* 43, 289 292.

9. B. E Levitt (1973) *Findlay's Practical Physical Chemistry,* 9th edn., Longman, London.

10. Rice, E and Teja, A. S. (1982) A generalized corresponding-states method for the prediction of surface tension of pure liquids and liquid mixtures, *J. Colloid and Interface Science,* 86(1), 158-163.

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