



Study of Refractive Index and Related Parameters of Potassium Oxalate in DmsO-Water System at Room Temperature

ORIGINAL ARTICLE



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Abstract

The refractive index is a key physical property that helps in characterizing pure liquids and their mixtures. In this study, potassium oxalate was investigated in a binary solvent system of dimethyl sulfoxide (DMSO) and water at room temperature, with varying concentrations. Measurements of refractive index and density were carried out, and from these, related parameters such as molar refraction and specific refraction were calculated. The DMSO-water solvent system is particularly significant in biochemical and pharmaceutical research due to its strong solvating ability and compatibility with a wide range of compounds. Therefore, the findings from this work are not only relevant to fundamental chemical studies but also have potential applications in various industrial and research settings.

Key Words

Density, Refractive Index, Molar Volume.

Introduction

The refractive index is an essential physicochemical property widely used to characterize pure liquids and their mixtures. It provides valuable information about the optical behavior of a substance and reflects molecular structure and interactions [1]. In the present study, potassium oxalate has been examined in a binary solvent system composed of dimethyl sulfoxide (DMSO) and water at room temperature. The investigation was carried out by systematically varying the concentration of potassium oxalate to evaluate its effect on the refractive index and other related properties of the solution. Alongside refractive index, the density of the solutions was also measured. These two primary properties were used to derive additional parameters such as molar refraction and specific refraction, which are important for understanding the nature of solute-solvent interactions [2]. The study focuses on exploring these interactions within the DMSO-water medium, a widely used binary solvent system known for its strong solvating power and compatibility with both polar and non-polar solutes [3].

The experimental data collected from this investigation serve as a basis for calculating several important physicochemical parameters. These include insights into the extent of ion-solvent and ion-ion interactions, which are critical for interpreting solution behavior and for predicting solubility, reactivity, and molecular association [4]. Moreover, the refractive index values play a significant role in the interpretation of spectroscopic

data, as they influence how light interacts with the solution [5]. This study also highlights the broader applications of the findings. The DMSO-water solvent system is frequently employed in biochemical, pharmaceutical, and industrial processes due to its favorable physical properties and ability to stabilize a wide variety of compounds [6]. The information gained from this research may thus contribute to advancements in areas such as drug formulation, analytical chemistry, and material science, where accurate knowledge of solution behavior is crucial.

Experimentation

Stock solution of 1.0M was prepared by dissolving desired in 100ml of mixed solvent. Mass dilution technique was applied to prepare the solution of different concentration, ranges from 0.01M to 1.0M. Densities of solutions in mixed solvent were determined using 10 cm³ double armed pycnometer at temperatures 303.15K. The pycnometer was calibrated at these temperatures with distilled water and benzene. The estimated accuracy of density measurement. Refractive indices were measured with the help of thermostated Abbes refractometer. Calibration of the instrument was done by measuring the refractive indices of double distilled water and toluene at known temperatures. The sample mixtures were directly injected into the prism assembly of the instrument by means of an air tight hydrodynamic syringe. When the liquid mixtures attained constant temperature, the refractive index measurements were made. The error in refractive index measurements was less than 0.0001 unit.

Results and Discussion

Densities

Densities of potassium oxalate in 5%(v/v) in DMSO -water,[7]

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

Where,

W and W₁ are weight of potassium oxalate in DMSO -water respectively,

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

Densities of potassium oxalate solutions were determined as a function of their concentration at 298.15°K temperature in 5 % (v/v) DMSO -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, ϕ_v , is calculated by following the equation,[8]

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

Where, c is Molarity of the solution, M is Molar mass of the solute, ρ and ρ_1 Density of solution and solute. The result of ϕ_v of potassium oxalate are reported in Table-1.

ϕ_v^0 were calculated by the method of least square and fit to plot of ϕ_v vs $c^{1/2}$ in accordance with the Masson's empirical relation,[9]

$$\phi_v = \phi_v^0 + S^* c^{1/2} \quad [3]$$

Where, $S^* =$ Experimental slope.

The slopes were obtained by the extrapolation of the plots to zero concentration (using Microsoft Excel). The values of ϕ_v^0 and S^* are listed in Table-1. 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.

TABLE 1:Density, Apperent Molar Volume, Molarvolme of Potassium Oxalate in Dms0- Water System at Room Temperature.

Concentration	Density	Apparent molar volume : ϕ_v	S^*_v	ϕ_{ov}	Molar Volume
0.0100	0.9489	88.26487	143.8862	48.5478	19.6651
0.0250	0.952768	143.6873			19.6942
0.0500	0.9547	162.3367			19.7431
0.7500	0.9566	179.8786			21.3190
0.1000	0.9585	171.6612			19.8409
0.2500	0.9757	177.2090			20.1291
0.5000	1.0045	179.0555			20.5968
0.7500	1.0371	179.6578			21.0386
1.0000	1.0563	179.9862			21.5150
C in mol dm ⁻³	in gm cm ⁻³	W_v in cm ³ mol ⁻¹	S^*_v in cm ³ dm ^{3/2} mol ^{-3/2}	W_{ov} in cm ³ mol ⁻¹	V in cm ³ mol ⁻¹

Refractive Index

The experimental refractive indices presented in tale -2 show an increasing trend with increase in concentration of hydroxamic acids in the mixed sol vent. This indicates that the refractive index is directly related to the interactions in the solutions.

Refractivity, μ_2

From the Table, refractivity of hydroxamic acids have been calculated following the equation,[10]

$$\mu_2 = n_2 - 1 \quad [5]$$

where, n_2 = Refractive index of solute.

MOLAR REFRACTION, R_M

Expression of Molar refraction is proposed by LorentZ-Loren z,[11]

$$R_M = (n^2 - 1/n^2 + 2) \times V \quad [6]$$

TABLE2: Refractive Index, Refractivity and Molar Refraction of Potassium Oxalate in Dms0- Water System at Room Temperature

CONCENTRATION	REFRACTIVE INDEX	REFRACTIVITY	MOLAR REFRACTION
0.0100	1.364	0.364	0.8546
0.0250	1.365	0.365	0.8515
0.0500	1.366	0.366	0.8502
0.7500	1.367	0.367	0.8488
0.1000	1.368	0.368	0.8475
0.2500	1.369	0.369	0.8329
0.5000	1.379	0.379	0.8115
0.7500	1.382	0.382	0.7880
1.0000	1.388	0.388	0.7757
C in mol dm ⁻³			RM in Cm ³ mol ⁻¹

Polarizability of Solutions, a

Polarizability is a fundamental molecular property of great importance. It contributes in two ways, first one measuring the ability with which the molecules will be deformed by an electric field and the other due to the orientation of molecular dipoles under the action of this field. The first effect is independent on temperature where as second effect is temperature dependent. Polarizability of system is derived from expression, [12]

$$a = 3 R_M / 4\pi N \quad [7]$$

where, N = Avogadro's No. (6.023×10^{-23}), $\pi = 3.14$

The values of polarizability are reported in the Tables 3. Value increases with increase in concentration and decreases with increase in temperature.

Excess Molar Refraction, R_M^E

Excess molar refraction R_M^E is calculated by following expression,[13]

$$R_M^E = R_M - (X_1 R_{M1} + X_2 R_{M2}) \quad [8]$$

The value of R_M^E are listed in Tables 3.

TABLE 3: Polarizability and Excess Refractive Index of Potassium Oxalate in Dms0- Water System at Room Temperature

CONCERNTRATION	POLARZABILITY(10^{-24})	EXCESS REFRACTIVE INDEX
0.0100	1.939E ⁻²¹	-0.0070
0.0250	1.933 E ⁻²¹	-0.0058
0.0500	1.929 E ⁻²¹	-0.0048
0.7500	1.964 E ⁻²¹	7.6800 E ⁻⁰⁵
0.1000	1.9233 E ⁻²¹	-0.0025
0.2500	1.8902 E ⁻²¹	-0.0008
0.5000	1.8417 E ⁻²¹	0.0074
0.7500	1.7884 E ⁻²¹	0.0147
1.0000	1.7604 E ⁻²¹	0.0220
C in mol dm ⁻³	α in cm.mol ⁻¹	

Conclusion

In a 5% (v/v) DMSO-water mixed solvent system at 298.15 K, the experiment provides a thorough physicochemical analysis of potassium oxalate. The observed density data showed a linear increase with concentration, allowing for accurate determination of the apparent molar volume (ϕ_v) and its extrapolated value at infinite dilution. The positive and somewhat negative slopes (S^*v) from the Masson equation point to substantial solute-solvent interactions and imply that potassium oxalate has an overall hydrophilic character in the mixed medium. The existence of greater intermolecular forces in more concentrated solutions was corroborated by the higher refractive index measurements as concentration increased. The structural arrangement and dielectric properties of the solute in solution were further confirmed by the consistent trends seen in the derived refractive parameters, such as refractivity (μ^2), molar refraction, and polarizability (). Furthermore, variations caused by particular solute-solvent interactions are highlighted by the excess molar refraction values, which account for optimal mixing behavior. The data back up the idea that potassium oxalate dissolves well and interacts favorably in the DMSO-water system, making this mixed solvent a good candidate for additional pharmaceutical or physicochemical research involving similar solutes.

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