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Determination of Secondary Forces in Polar Organic Binary Mixture by Refractivity Method

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ABSTRACT

Densities and Refractive indices have been experimentally determined for the binary mixture of Methanol – Water at room temperature over the entire range of mole fraction. The experimental values of densities and refractive index are utilize to calculate excess refractive indices, molar refractions, excess molar refractions, excess molar volume and calculated molar refractions. Outcome obtained indicate that the refractive method is more useful as compare to the volumetric method. From the result it is found that strong association is observed in studied system.

Keywords: Mole Fraction, Density, Refractive Index, Excess Refractive Indices, Molar Refractions, Excess Molar Volume.

I. INTRODUCTION

Refractive index is also called as index of refraction, measure of bending of ray of light when passing from one medium to another transparent medium. Measurement of refractive index is a significant part of thermodynamics studies of liquid-liquid mixtures, used to explain intermolecular interactions present amongst the mixing components [1].It is also essential for the determination of composition of binary liquid mixture[2]. Complex formation in liquid mixtures has been widely studied using refractivity method .The behavior of solvent medium in presence of other species affect the structural properties of solution

In our present research work, we select polar molecule as methanol and water these molecule are very useful in a different field of a chemical science. In our present study densities and refractive index of binary liquid-liquid mixture of methanol-water system at room temperature [at 293 K] over the entire range of mole fraction have been determined. Along with densities and refractive index, excess refractive indices [Δn_D], molar refraction, excess molar volume [V^E], calculated molar refraction and excess molar refraction [R_M^E] have been calculated. The behavior of this parameter is used to investigate intermolecular interaction present amongst the component of the mixture.

II. METHODS AND MATERIAL

Methanol used was of A.R.grade. The water used for the preparation of binary mixture was distilled. The binary methanol-water systems were prepared by mole fraction method. The weighing was done by using electronic balance with precision of ± 0.1 mg. Refractive indices were measured by using Abbes refractometer with constant temperature thermostat

with the precision of ±0.001. Densities were measured by using specific density bottles at constant temperature.

III. RESULTS AND DISCUSSION

The density [ρ] and refractive index [η] data of methanol-water system over the entire range of mole fractions measured at 293 K from these experimental data excess refractive indices [Δn_D], molar refraction, excess molar volume [V^E], calculated molar refraction and excess molar refraction [R_M^E] have been calculated.

The values of excess refractive indices [Δn_D], excess molar volume [V^E] and excess molar refraction [R^E_M] for binary mixture of methanol-water system were calculated from density and refractive index data and molar mass using following equation.

$$\Delta n = n_D - (x_1 n_{D1} + x_2 n_{D2}) \text{ ……..(1)}$$

Where, x_1 and x_2 are the mole fractions.

n_D, n_{D1} and n_{D2} are the refractive index of mixture, methanol and water respectively.

Excess molar volume is the difference between value of molar volume of real mixture and the value of molar volume exist in an ideal solution under same condition.

$$V^E = \frac{x_1M_1+x_2M_2}{\rho} - \frac{x_1M_1}{\rho 1} - \frac{x_2M_2}{\rho 2} \text{ ……. (2)}$$

Where, x_1 and x_2 are the mole fractions.

M_1 and M_2 are the molar masses.

ρ, ρ_1 and ρ_2 are the densities of mixture, methanol and water respectively.

$$R_M^E = R_M - [x_1R_{M1} + x_2R_{M2}] \text{ ……. (3)}$$

Where, R_M, R_{M1} and R_{M2} are the molar refraction of binary mixture, pure methanol and water respectively.

Table no.1 - For pure liquids.

Compounds	Molar mass	Density (ρ) [g/cm³]	Refractive index [n]	Molar refraction (R_M) [cm³/mol]	Calculated molar refraction [cm³/mol]
Methanol	32.04	0.7931	1.319	7.9908	8.36
Water	18.02	0.9982	1.324	3.6209	3.37

Table no.2 – For Methanol–Water system.

X_1 [Methanol]	X_2 [Water]	Density (ρ) [g/cm³]	Refractive index [n]	Excess Refractive index	Molar refraction (R_M) [cm³/mol]	Excess Molar volume (V^E) [cm³/mol]	R_M Calculated [cm³/mol]	Excess Molar refraction (R_M^E) [cm³/mol]
0.1	0.9	0.9808	1.327	0.0035	4.0060	-0.4844	4.193	-0.05189
0.2	0.8	0.9463	1.330	0.0070	4.4892	-0.5155	4.656	-0.00568
0.3	0.7	0.9239	1.332	0.0095	4.9364	-0.6992	5.119	0.00453
0.4	0.6	0.9016	1.333	0.0110	5.3907	-0.7839	5.582	0.02184
0.5	0.5	0.8853	1.332	0.0105	5.8016	-0.9523	6.045	-0.00425
0.6	0.4	0.8588	1.329	0.0080	6.2602	-0.6821	6.508	0.01736
0.7	0.3	0.8412	1.328	0.0075	6.5813	-0.6061	6.971	-0.09853
0.8	0.2	0.8236	1.326	0.0060	7.1635	-0.4313	7.434	0.04668
0.9	0.1	0.8099	1.322	0.0025	7.5470	-0.3344	7.897	-0.00681

From the above observation it is found that the value of excess molar volume are negative for given system which indicate that resultant volume of binary mixture decreases due to some secondary forces in polar organic binary mixture i.e. intermolecular forces of interaction. This is again confirmed from the fact that experimental values are smaller than ideal value of Methanol-Water system. This information suggest that molecules of given components are closely associated than pure liquid.

The value of excess refractive index for polar-polar [methanol-water] system over entire range of mole fraction is positive which indicate that molecular association is weak in given solution. The value of experimental molar refraction and calculated molar refraction suggested that molar refraction is an additive and constructive property. The value of excess molar volume and excess refractive index for binary mixture suggest that refractivity method is more useful over volumetric method.

IV. CONCLUSION

From above discussion, It is concluded that in methanol-water system [i.e polar-polar binary mixture] shows molecular association but intermolecular forces of interaction are weak.

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