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MICROWAVE DIELECTRIC CHARACTERIZATION OF COMPLEX SYSTEM

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ABSTRACT

Present paper reports microwave dielectric property like dielectric constant ε_s thermophysical parameters like Density (ρ), Viscosity (η) and refractive index n_D of Dimethyl sulphoxide (DMSO) and ethanol have been measured over entire volume concentration range at 298K. Measured properties are further used to determine Bruggeman factor, molar refaction & excess parameters. The deviation of the excess properties indicates the strength of interactions in the pure and mixed component and also predicts the nature of intermolecular interactions.

I. INTRODUCTION

The application of dielectric methods to probe the structural dynamics of liquid mixtures has been the subject of extensive research[1]. Thermodynamic and thermophysical properties, especially volumetric, viscometric and dielectric for binary mixtures involving polar molecular groups are interesting for process design and knowledge of molecular interactions[2-6]. Molar volumes, bruggeman factor, excess static dielectric constant are among the frequently determined properties of binary mixtures. To know the solute-solvent interaction behavior, the excess molar properties of polar solutions are significant. These works presents volumetric, viscometric and acoustic properties of Dimethylsulphoxide with Ethanol liquids.

Results can further used in contributing the nature of intermolecular interactions that exists between dissimilar groups of liquids in solution. Here dielectric constant, density, viscosity, refractive index measurements of liquid-liquid interaction data for binary liquid mixtures at 298 K is reported. From these data, the excess static dielectric constant, bruggeman factor excess density, excess viscosity, excess refractive index was obtained. Furthermore, data on volumetric, viscometric, acoustic behavior of DMSO + Ethanol solutions are adequate to provide existence of molecular interactions, strength of interactions and dynamics of solute solvent interactions. This study is expected to have a contribution from a mixture between the thermal motion of the Ethanol and DMSO molecules, which varies the strength of their interaction with respect to volume fraction of solute.

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II. RESULT AND DISCUSSION

Table1. Dielectric constant, Density, viscosity, refractive index of DMSO + Ethanol at 298 K

Volume fraction of ethanol	Dielectric constant	Density (g/cm^3)	Viscosity (cP)	RI
0	45.80	1.0960	2.04	1.476
0.1	43.30	1.0647	1.99	1.474
0.2	40.65	1.0240	1.98	1.472
0.3	37.21	0.9834	1.95	1.468
0.4	32.88	0.9527	1.85	1.464
0.5	30.42	0.9120	1.79	1.460
0.6	29.41	0.8914	1.65	1.450
0.7	28.79	0.8607	1.50	1.436
0.8	27.51	0.8301	1.40	1.422
0.9	25.14	0.8099	1.28	1.402
1	24.50	0.7894	1.09	1.383

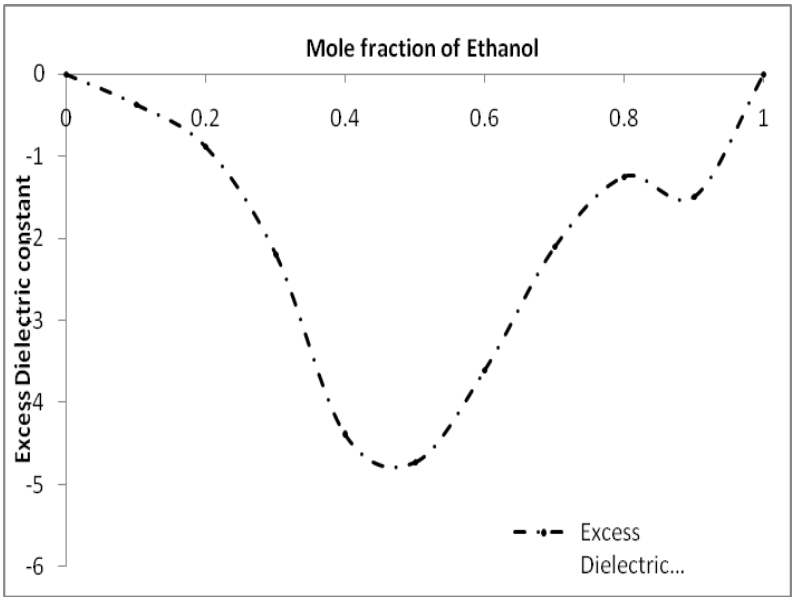

Fig 1 Excess static dielectric constant of DMSO+ethanol at 298K

Fig 1 gives Negative values of static dielectric constant indicates the solute and solvent interaction in such a way that the total effective dipole gets reduced. This suggests that the solute and solvent may form multimers leading to less effective dipoles or in other words there is a tendency of dipole to align in antiparallel direction.

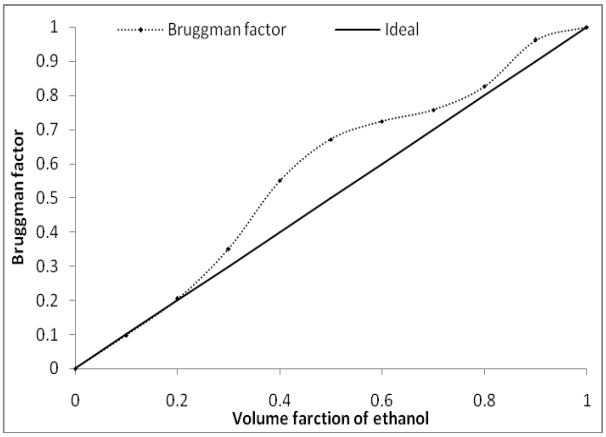

Fig 2. Bruggeman factor of DMSO+Ethanol at 298 K

Fig 2 indicates non linear deviation from ideal line. Deviation from ideal line indicates presence of intermolecular interactions within the system.

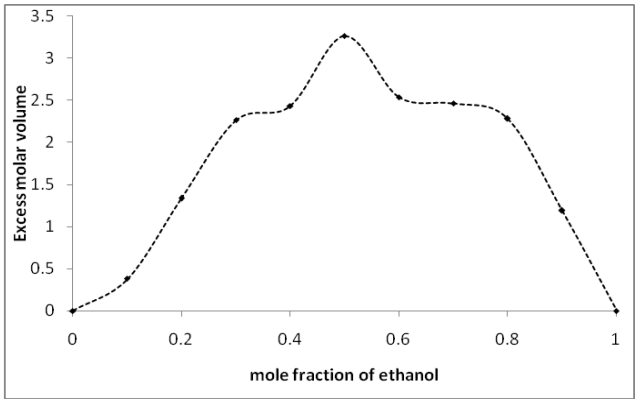

Fig.3. Excess Molar volume of DMSO + Ethanol

Fig 3 shows positive deviation of excess molar volume. Positive values attributed todipole –dipole interactions between unlike molecules. Positive values attributed to weak interaction between unlike molecules.

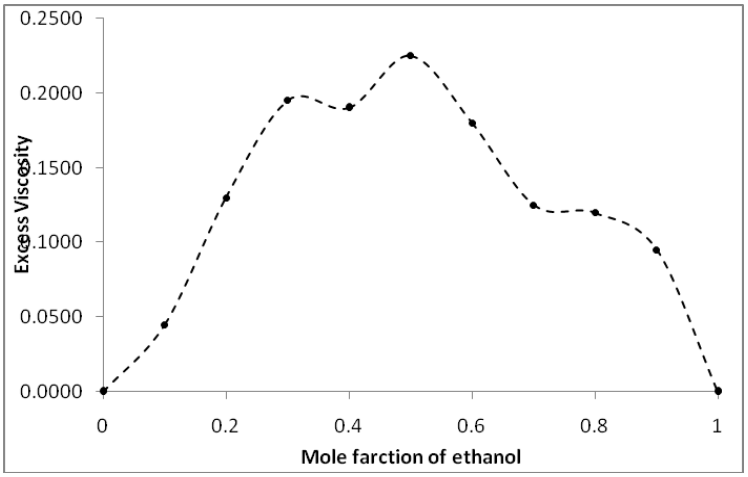

Fig. 4. Excess viscosity of DMSO+n-Ethanol

Fig 4 shows negative deviation of excess viscosity. Negative values of excess viscosity for mixture may be attributed to presence of specific interaction due to predominance Negative values of viscosity suggest the presence of specific intermolecular interaction upon mixing.

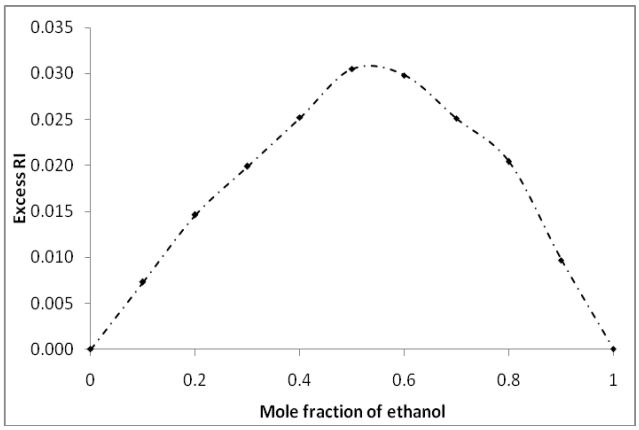

Fig. 5. Excess Refractive index of DMSO + Ethanol

Fig 5 shows positive deviation of excess refractive index. Positive values accounts for the existence of specific molecular interaction between unlike molecules.

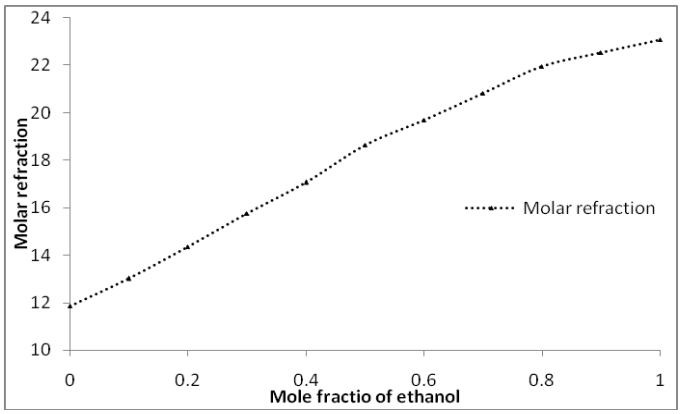

Fig. 6 Molar refraction of DMSO+ ethanol at 298K

Non linaer deviations in molar refraction suggest presence of dipole dipole nteractions within the system.

2.1 Theory

The general formula for calculating the excess parameters is given below

$$A^E = A_m - (x_1 M_1 + (1 - x_1) M_2)$$

Where, A^E is the excess parameter such as Excess Molar volume x_1 mole fraction. And the excess parameters are fitted by

III. EXPERIMENTAL

3.1 Chemicals: In the present system of DMSO + ethanol binary mixture. DMSO and ethanol and both are of HPLC grade. Both the liquids are used without further purification. The liquid mixtures of different composition were prepared by measuring appropriate volumes of each composition.

3.2 Dielectric Measurements: The complex permittivity spectra were studied using time domain reflectometry. The Hewlett-Packard HP 54750 sampling oscilloscope with HP 54754 .A TDR plug- in module was used. A

fast rising step voltage pulse of about 39 ps rise time generator was propagated through a coaxial line system of characteristic impedance of 50 generated by a pulse ohm.

3.3 Density Measurement**:** The Density measurements were carried out by portable Digital Density meter (DMA-35, Anton Paar) for pure liquids and binary mixture. This Digital Density meter uses the vibrating U-tube principle to calculate the Density of the sample. The required quantity of sample is approximately 2ml. Accuracy of the instrument used is =0.0001 g/cm^3.

3.4 Viscosity Measurements: Viscosity of the sample in the present study were measured by using Brookfield Viscometer (Brookfield Viscometer, Model: LV DV-II+ Pro, Cone-plate Model with CPE 40 spindle).The required sample is very low in quantity (0.5ml). The accuracy of the instrument is =0.01cP.

IV. CONCLUSION

This study reveals the measurement of dielectric constant, density, viscosity, refractive index of DMSO + ethanol solution was studied in different concentrations at 298K. The experimental data and excess parameters provides valuable information regarding the solute-solvent interactions in the measurements, it can be concluded that at 298.15K concentration of the DMSO affects and gives rise to specific intermolecular interaction. Increase in concentration of Ethanol plays an important role in forming intermolecular interactions in the solutions. All the parameters supports each other and conforms that with increase in concentration of Ethanol affects the strength of bonding in the system.

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