Physicochemical Study of Complex Systems

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Abstract: physicochemical properties like Density (ρ), Viscosity (η) and refractive index n_D of ethanol+ water have been measured over entire volume concentration range at 293K. Measured properties are further used to determine excess parameters like excess molar volume, excess viscosity, excess refractive index and excess molar volume. 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.

Keywords: Excess Molar Volume, Excess Viscosity, Excess Molar Refraction

I. INTRODUCTION

The application of physicochemical methods to probe the structural insights of liquid mixtures has been the subject of extensive research [1]. Physicochemical properties, especially volumetric, viscometric and refractive for binary mixtures involving polar molecular groups are interesting for process design and knowledge of molecular interactions [2-4]. Such study facilitates most researchers in characterizing structural aspects binary solutions, which is of great importance in understanding the mechanism of complex system [4-6]. Molar volumes, molar refraction, are among the frequently determined properties of binary mixtures. To know the solute-solvent interaction behavior, the excess molar properties of polar solutions are most significant. These works presents volumetric, viscometric and refractive properties of ethanol + water liquid mixture. Results can further have used in contributing the nature of intermolecular interactions that exists between dissimilar groups of liquids in solution. Here physicochemical properties like density, viscosity, refractive index measurements of liquid-liquid interaction data for binary liquid mixtures at 293 K are reported. From these data, the excess molar volume, excess viscosity, excess refractive index was obtained. Furthermore, data on volumetric, viscometric, acoustic behavior of ethanol+ water solutions are adequate to provide existence of molecular interactions, strength of interactions and dynamics of solute solvent interactions.

II. RESULT AND DISCUSSION

Figure 1 and 2 gives nonlinear deviation in density, viscosity respectively it indicates presence of solute solvent interaction between the complex systems.

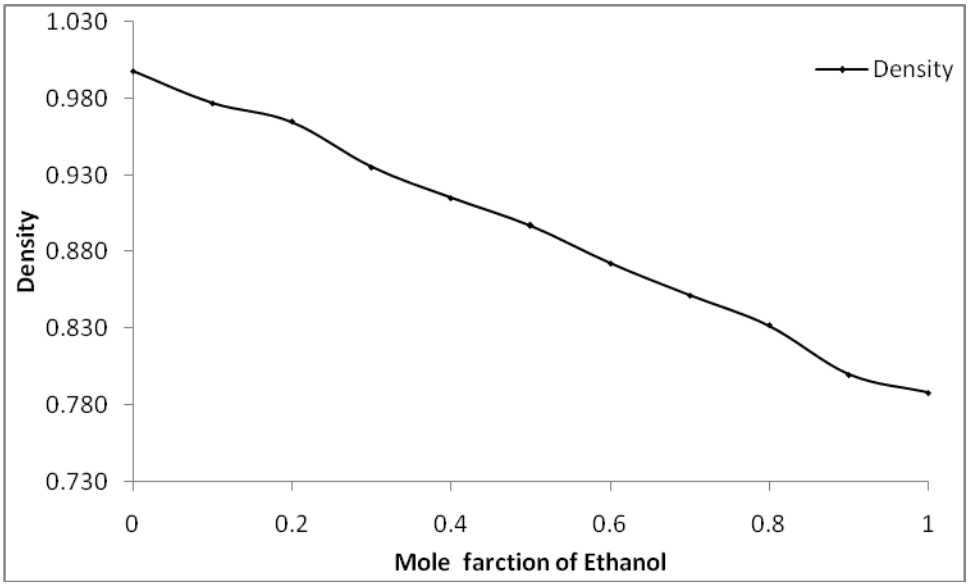

Figure 1: Density of ethanol+ water at 293K

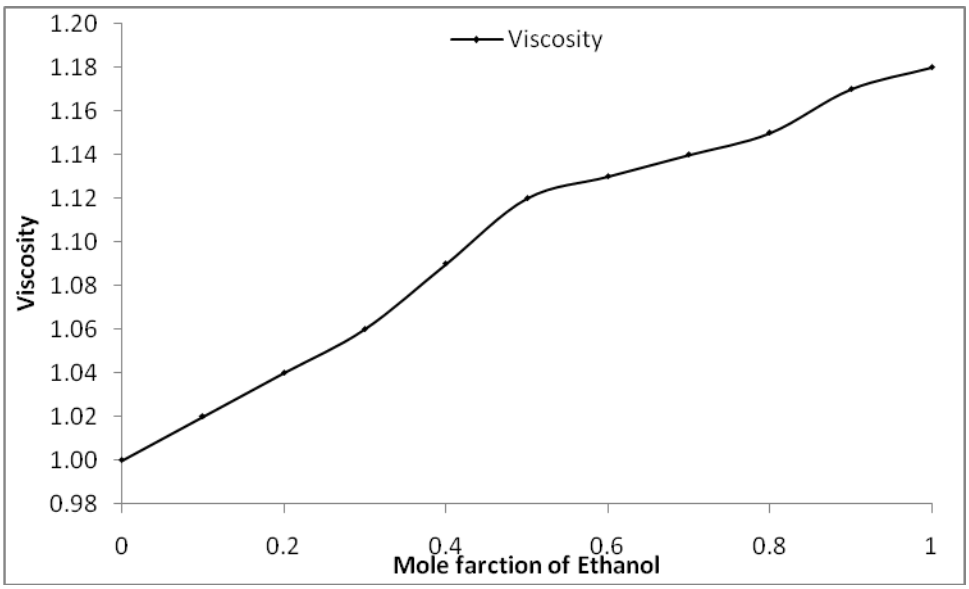

Figure 2 : Viscosity of ethanol+ water at 293K

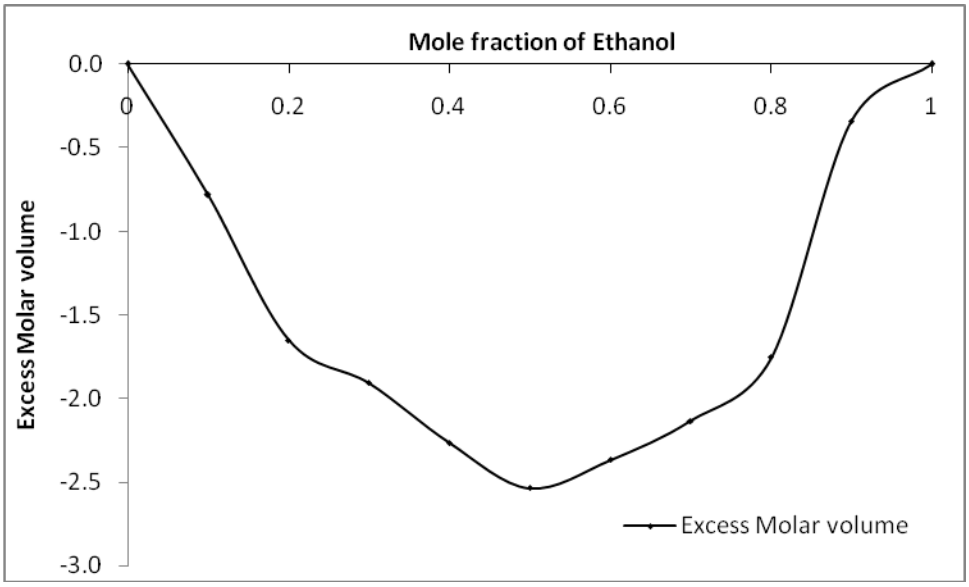

Figure 3: Excess molar volume of ethanol+ water at 293K

Figure 3 shows negative deviation of excess molar volume. Negative values attributed to strong hydrogen bonding between unlike molecules. Negative values are also attributed contraction of volume formed by closed packed association of unlike molecules which results in hydrogen bonding. Molecules of Ethanol cooperates with molecules of water hence its attraction increases and effective radius decreases. Solute act as structure maker.

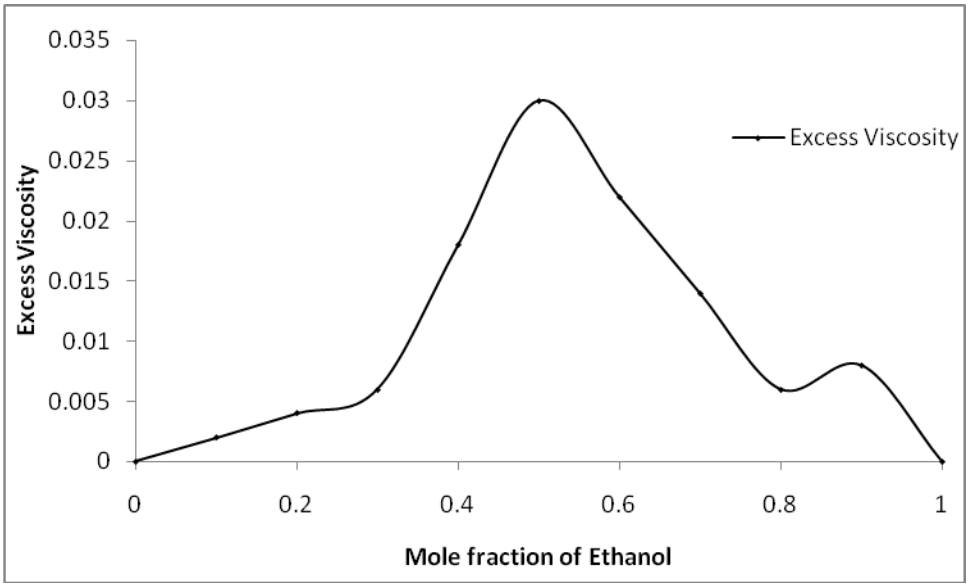

Figure 4: Excess viscosity ethanol+ water at 293K

Figure 4 illustrates deviation of excess viscosity of ethanol+ water at 293K. Positive values of excess viscosity for mixture may be attributed to presence of specific interaction through hydrogen bonding. Positive values of η^E for the mixture can be explained on the basis of complex formation between unlike molecules through strong hydrogen bonding. Negative deviation of η^E also indicates that the interaction between binary mixtures is strong. The observed values of these parameters indicate that association of the ethanol aggregates predominates over association between the solute

molecules. The addition of little quantity of diluents ethanol i.e. lower alcohol is usually to get into interstices and causing an infinitesimal degree of formation of hydrogen bonds between molecules of water.

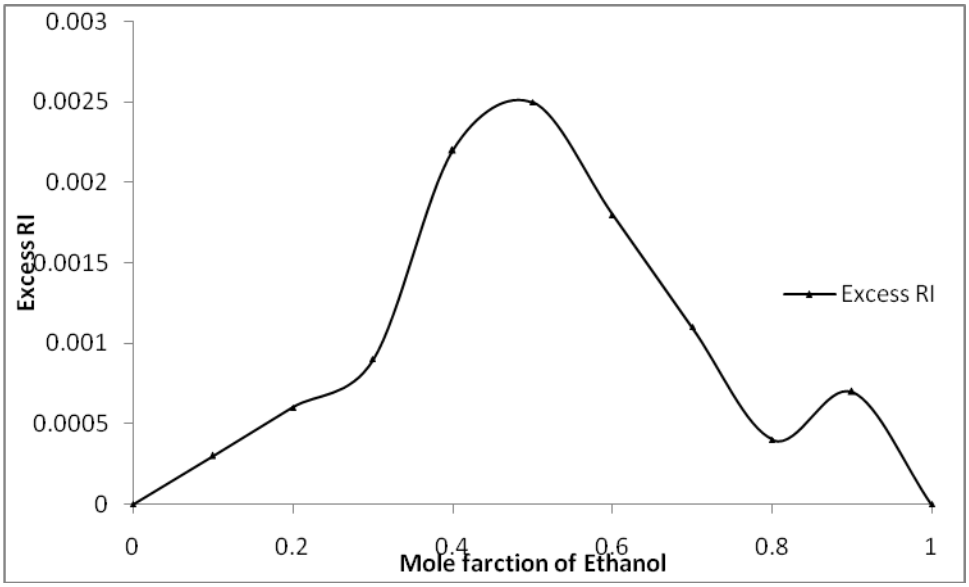

Figure 5**:** Excess Refractive index of ethanol+ water at 293K

Figure 5 shows positive deviation of excess refractive index. Positive values are due to closed packed molecules, which accounts for the existence of strong molecular interaction between unlike molecules.

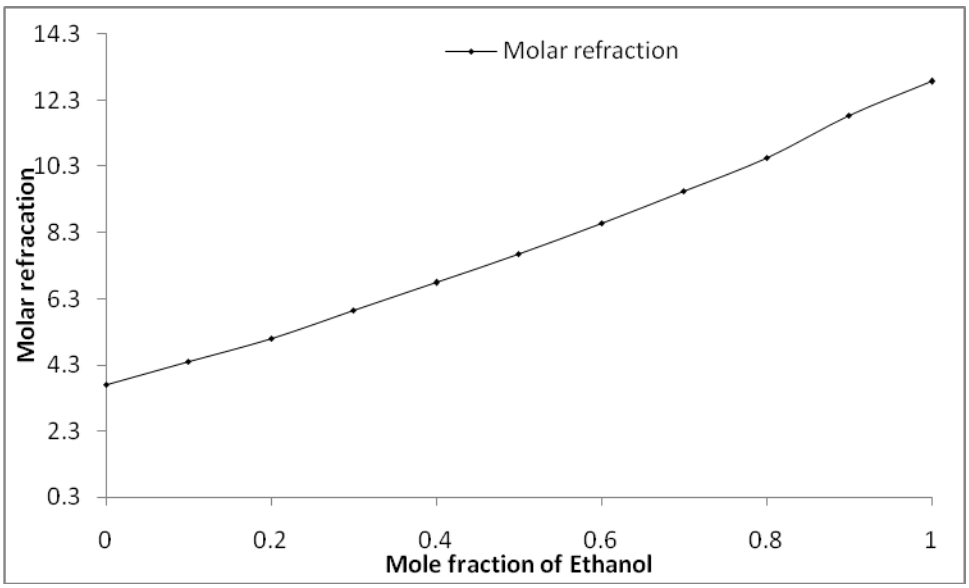

Figure 6: Molar refraction of ethanol+ water at 293K

Molar refraction values increase as concentration of ethanol increases it indicates presence of specific interaction in the complex system.

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. EXPERIMENTS

1. Chemicals: In the present system of ethanol+ water binary mixture, ethanol is of HPLC grade. ethanol used without further purification. The liquid mixtures of different composition were prepared by measuring appropriate volumes of each composition.

2. 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. 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.

4. Refractive Index Measurements: Abbeys Refractometer is used for measurement of refractive index.

IV. CONCLUSION

In this study, the measurement of density, viscosity, refractive index and other derived parameters of ethanol in water solution were studied in different concentrations at 293K. The measured experimental data and other derived & excess parameters provides valuable information regarding the solute-solvent interactions in the measurements, it can be concluded that the concentration of the ethanol affects the strength of intermolecular interaction and gives rise to strong hydrogen bonded interaction. Increase in concentration of ethanol plays vital role in structuring strong hydrogen bonded interaction in the solutions.

Conflict of interest: The authors declare that they have no conflict of interest.

Ethical statement: The authors declare that they have followed ethical responsibilities.

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