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INVESTIGATION ON SOME THERMO PHYSICAL PROPERTIES OF METHANOL AND NITROBENZENE BINARY MIXTURES

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ABSTRACT

Density, viscosity and ultrasonic study for the binary mixtures of Methanol and Nitrobenzene over the entire concentration range were measured at temperatures 303.15 K. The experimental data then used to calculate the compressibility, and acoustic impedance, molecular free length, Inverse relaxation time and Excess Parameters. The values of excess properties further fitted with Redlich–Kister polynomial equation to estimate the binary coefficients. The resulting excess functions were interpreted in terms of the interactions between the molecules in the binary mixtures.

Keywords: Compressibility, Acoustic Impedance Binary mixtures, Ultrasonic velocity, Excess parameters.

INTRODUCTION

Acoustic Study and its analysis for associated binary liquid mixtures containing polar- polar components is having significant importance in understanding intermolecular interaction and strength between the component molecules as they finds application in various industrial and technological processes[1]. Ultrasonic velocity and its derived acoustical parameters like adiabatic compressibility, free length, relaxation time, acoustic impedance with their excess parameters, gives important information about the molecular interactions and their strengths[1-5]. In the present paper, variation of various parameters of binary mixtures containing nitrobenzene and Methanol at 2MHz frequency have been studied for entire range of concentration (0-100%). Nitrobenzene is a polar molecule of benzene family different than that of Alcohol family of Methanol. When it is mixed with Methanol, the Hydrogen bonded interaction dominates. Methanol is having very small size and its linear aliphatic configuration is the important factor which mainly contributes to the volume contraction of the mixture. Nitrobenzene is relatively a complex molecule. Methanol belongs to the alcohol. It is highly reactive even if at low temperature. Methanol being polar protic solvent is quite expected to be involved in any strong interaction with the other components of the mixture[6-11].

EXPERIMENTAL

Chemicals

In the present system of Nitrobenzene+Methanol binary mixture Nitrobenzene is used of Analytical Reagent grade and is obtained from MERCK (99.99) and Methanol is of HPLC grade. Both the liquids are used without further purification.

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.

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 device is calibrated using the doubly distilled water and other pure liquids of known viscosity at 25^0C/room temperature and found to be in good agreement with standard value from literature. The accuracy of the instrument is =0.01cP.

Ultrasonic Velocity Measurements

The ultrasonic Velocity measurements are studied using Ultrasonic Interferometer (Model F-05, Mittal Enterprises, New Delhi).It is single crystal interferometer operating at 2MHz fixed frequency. The sample cell of the instrument is made up of steel and is double walled; the required amount of the sample is approximately 10cc.

Theory

The specific acoustic impedance is given by-

$$Z = U.\rho \tag{1}$$

Where 'U is the ultrasonic velocity (of the mixture) and 'ρ' is the density of the mixture.
The adiabatic compressibility is given by-

$$\beta = \frac{1}{(U^2.\rho)} \tag{2}$$

Where, 'U' and 'ρ' are the velocity and density of liquid mixture.
The general formula for calculating the excess parameters is given below-

$$A^E = A_m - (x_1 M_1 + (1 - x_1)M_2) \tag{3}$$

Where, A^E is the excess parameter such as excess density x_1 mole fraction.

The excess parameters are fitted to the Redlich-Kister polynomial equation[8] of third order and this equation is given by-

$$A^E = x_1 x_2 \sum_{i=0}^{n} A_i (1 - 2x_2)^i \tag{4}$$

Where x_i is the mole fraction of pure component-1 and 2.

RESULTS AND DISCUSSION

Figure- 1 gives excess molar volume of NB+Methanol. As concentration of methanol increases excess molar volume becomes negative. Negative values indicate that volume contraction takes place upon mixing due to cross association between dissimilar molecules. Negative values also attributed to strong interaction between unlike molecules through hydrogen bonding.

Figure- 2 gives Excess Viscosity of NB+Methanol. Positive values of η^E for the mixture can be explained on the basis of complex formation between unlike molecules through hydrogen bonding. Charge transfer, hydrogen bonding forces leading to the formation of complex species between unlike molecules results in positive deviation. Positive deviation of η^E also indicates that the interaction between binary mixture is strong.

As shown in Figure- 3 Excess Velocity becomes positive as concentration of methanol increases. Positive deviation and non linear dependence suggests the presence of strong interaction between the components of the mixture Positive excess velocity can be concluded as the formation of the structure. Strong interaction arise among the components of the mixture leading to the formation of molecular aggregates and more compact structure then sound will travel faster through the mixture by means of longitudinal waves and hence speed of sound with respect to linear behavior will be positive.

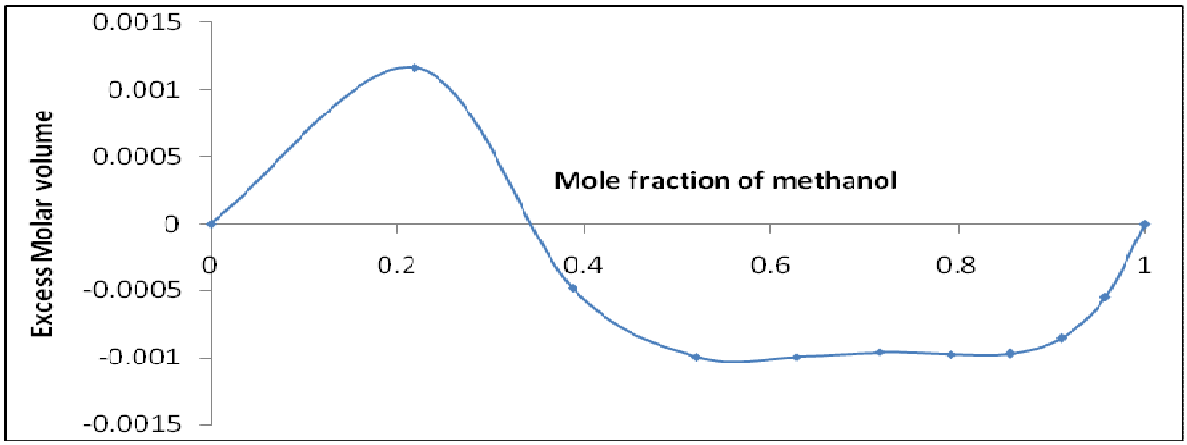

Fig.-1: Excess Molar volume of NB+Methanol

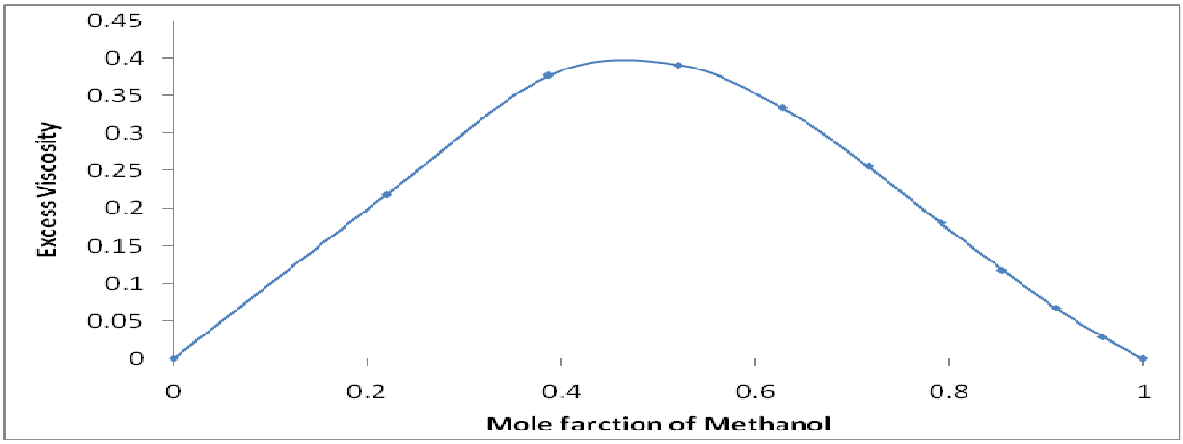

Fig.-2: Excess Viscosity of NB+Methanol

Table-1:Density , viscosity, ultrasonic velocity of NB+Methanol

Volume fraction of NB	Density g/cm^3	Viscosity cP	Ultrasonic velocity m/s
0	1.1948	1.73	3460
0.1	1.1427	1.67	3340
0.2	1.1092	1.64	3280
0.3	1.0956	1.42	2840
0.4	1.0582	1.39	2780
0.5	1.0011	0.95	1900
0.6	0.9565	0.97	1940
0.7	0.9257	0.85	1700
0.8	0.8869	0.61	1220
0.9	0.8565	0.54	1080
1	0.7868	0.48	960

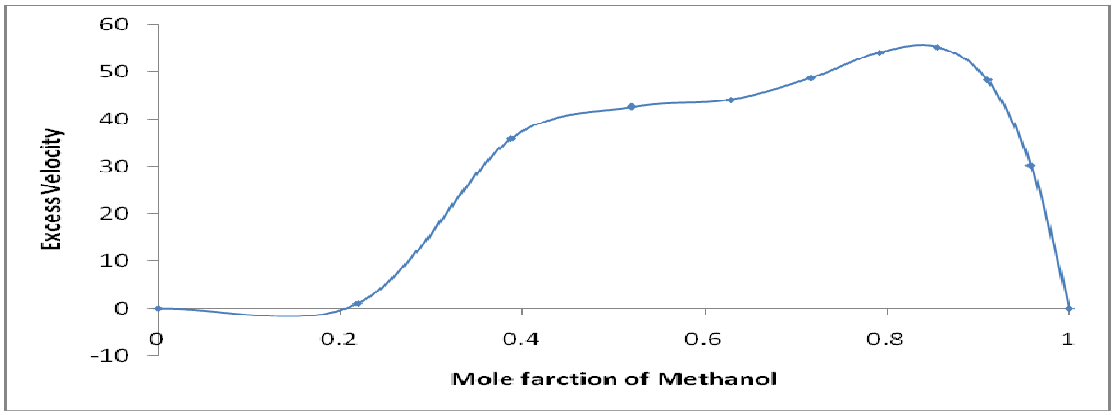

Fig.-3: Excess Velocity of NB+Methanol

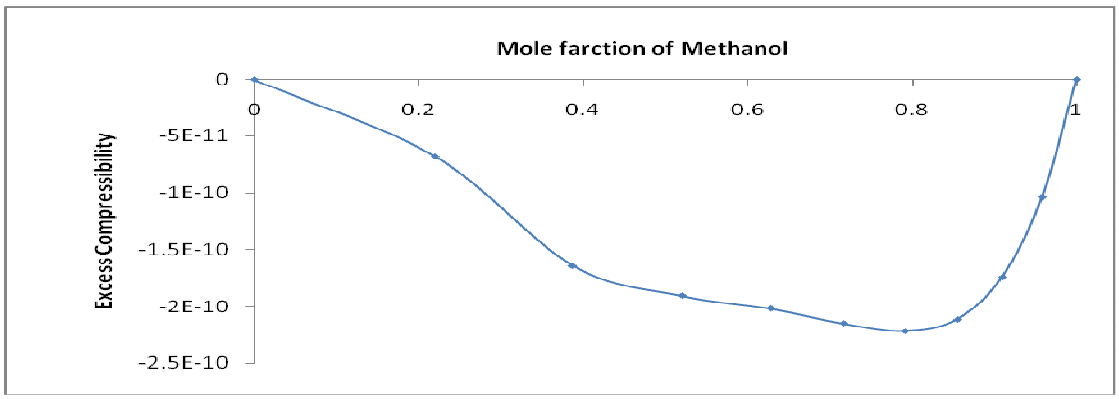

Fig.-4: Excess compressibility of NB+Methanol

Figure-4 indicates Excess compressibility of NB+Methanol**.** Negative excess compressibility of values are due to closed packed molecules ,which accounts for the existence of strong molecular interaction between unlike molecules Sign of compressibility plays vital role in assessing the compactness due to molecular interaction in liquid mixture through hydrogen bonding, charge transfer, dipole- dipole interactions and dipole induced–dipole interaction, interstitial accommodation and orientational ordering, leading to more compact structure making negative excess compressibility.

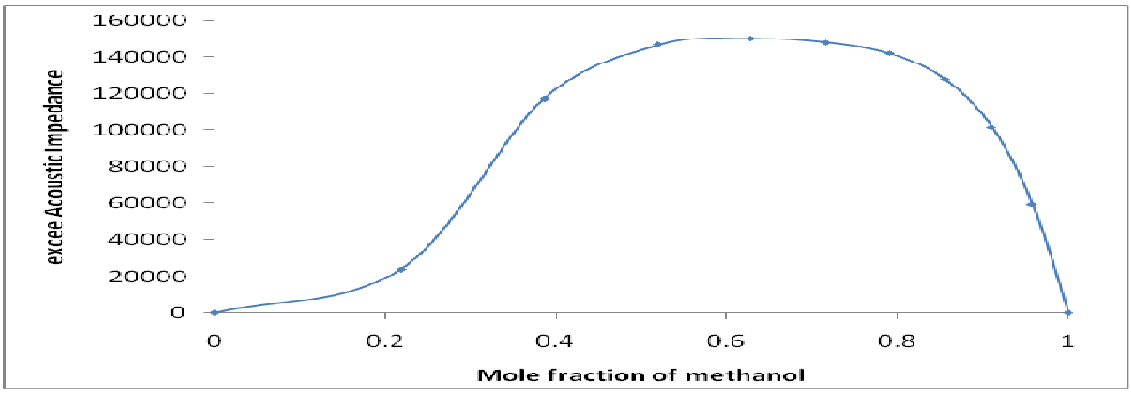

Fig.-5: Excess acoustic impedance of NB+Methanol

Positive values of acoustic impudence as shown in fig.-5 hint to the possibility of presence of strong attractive forces between the reacting components of the mixture.

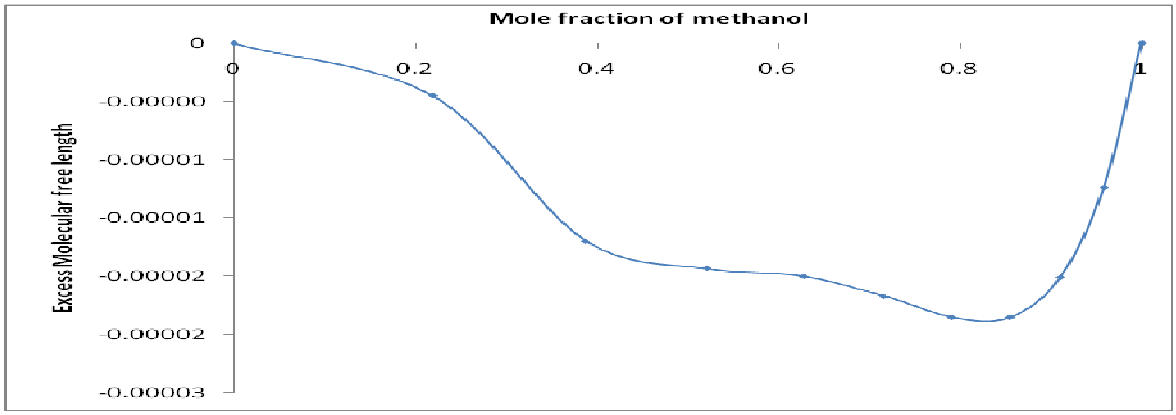

Fig.-6: Excess molecular free length of NB+Methanol

Negative values exhibit strong interaction. Decrease in values of free length with concentration can be concluded as there is significant interaction between two liquids.

CONCLUSION

In this study, the measurement of density, viscosity, ultrasonic velocity and other acoustical parameters of NB in Methanol solution was studied in different concentrations at 303K. The experimental ultrasonic velocity data and other acoustical parameters contain valuable information regarding the solute-solvent interactions in the measurements, it can be concluded that the concentration of the Methanol affects and gives rise to strong hydrogen bonding interaction. Increase in concentration of Methanol plays an important role in forming hydrogen bonding interactions in the solutions.

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