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Study of Thermo Physical Properties of Binary Liquid Mixtures of Pyridine with Methanol at 293 K

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ABSTRACT

Density and ultrasonic study for the binary mixtures of Pyridine and Methanol over the entire concentration range were measured at temperatures 293 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. Results confirm that weak bonded intermolecular interaction takes place between Pyridine and Methanol

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

I.INTRODUCTION

Ultrasonic Study and its analysis for aprotic 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[1-10]. In the present paper, variation of various parameters of binary mixtures containing Methanol and Pyridine at 2MHz frequency have been studied for entire range of concentration (0-100%). Methanol is a polar molecule of benzene family different than that of ketone family of Pyridine. When it is mixed with Pyridine, the weak bonded bonded interaction dominates. Pyridine is having very small size and its linear aliphatic configuration is the important factor which mainly contributes to the volume expansion of the mixture[11]. Methanol is relatively a complex molecule.. It is highly reactive even if at low temperature. Pyridine being polar protic solvent is quite expected to be involved in any weak interaction with the other components of the mixture [11-17].

II.EXPERIMENTAL

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

Solution Preparation: The solutions were prepared at different volume percentages of Methanol in Pyridine in steps of 10% at room temperature (droplets of Methanol are mixed in Pyridine with increasing volume percentage). These concentrations were prepared for 5 ml solution samples at room temperature, assuming ideal mixing behavior, with an accuracy ± 0.0006 ml.

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.

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,

$$Z = U.\rho$$

Where 'U is the ultrasonic velocity (of the mixture) and 'ρ' is the density of the mixture.

The adiabatic compressibility is given by,

$$\beta = 1/(U^2.\rho)$$

Where, 'U' and 'ρ' are the velocity and density of liquid mixture.

The general formula for calculating the excess parameters is given below

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

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

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

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

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

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III.RESULT AND DISCUSSION

Table-1 Density , ultrasonic velocity of Pyridine+Methanol

Volume farction of	Density (g/cm3)	Viscosity (cP)	Velocity (m/s)
0	0.795	0.61	1088
0.1	0.817	0.66	1120
0.2	0.832	0.68	1155
0.3	0.853	0.73	1195
0.4	0.890	0.84	1198
0.5	0.922	0.85	1218
0.6	0.927	0.89	1280
0.7	0.946	0.91	1317
0.8	0.963	1.06	1347
0.9	0.981	1.08	1374
1	0.992	1.49	1417

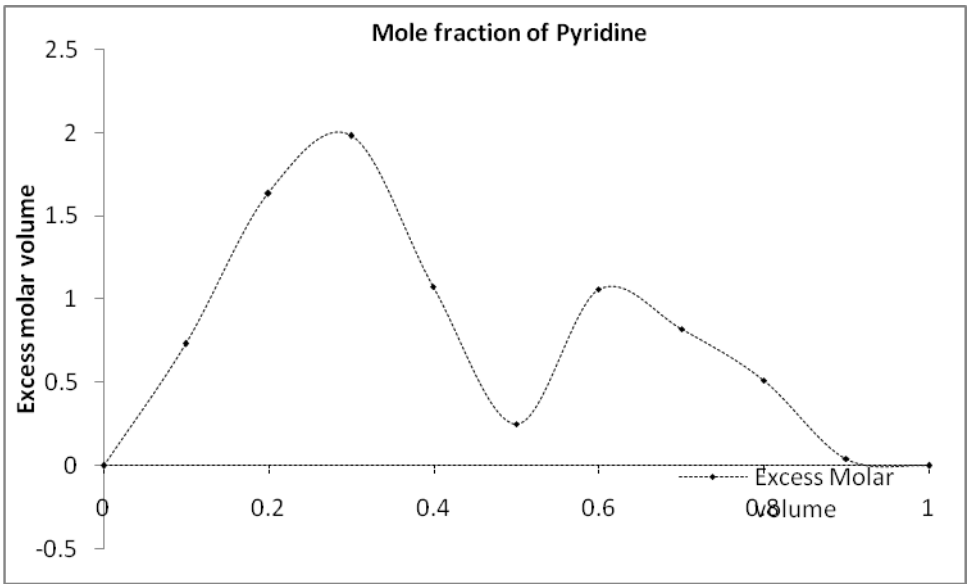

Fig 1- Excess Molar volume of Pyridine+Methanol

Fig 1 gives excess molar volume of Pyridine+Methanol. As concentration of Pyridine increases excess molar volume becomes negative. Positive values indicate that volume expansion takes place upon mixing due to cross association between dissimilar molecules. Postive values also attributed to weak dispersive interaction between unlike molecules.

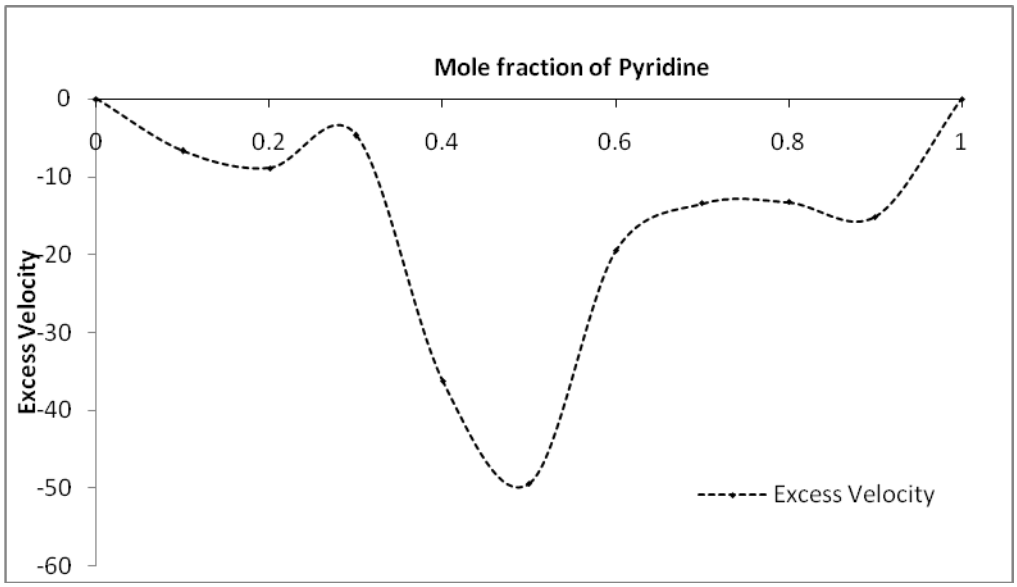

Fig 2- Excess Velocity of Pyridine+Methanol

As shown in Fig 2 Excess Velocity becomes negative as concentration of Pyridine increases. negative deviation and non linear dependence suggests the presence of weak interaction between the components of the mixture negative excess velocity can be concluded as the formation of the structure. Weak interaction arise among the components of the mixture leading to the formation of molecular aggregates and less 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 negative

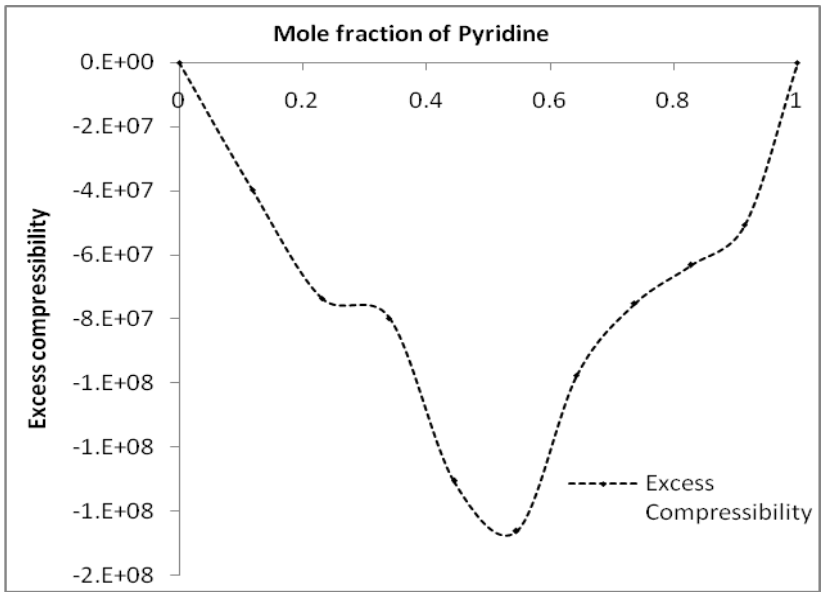

Fig 3- Excess compressibility of Pyridine+Methanol

Fig 3 indicates Excess compressibility of Pyridine+Methanol**.** negative excess compressibility of values are due to less packed molecules ,which accounts for the existence of weak molecular interaction between unlike molecules Sign of compressibility plays vital role in assessing the less compactness due to molecular interaction in liquid mixture through weak bonded interactions, leading to less compact structure making negative excess compressibility.

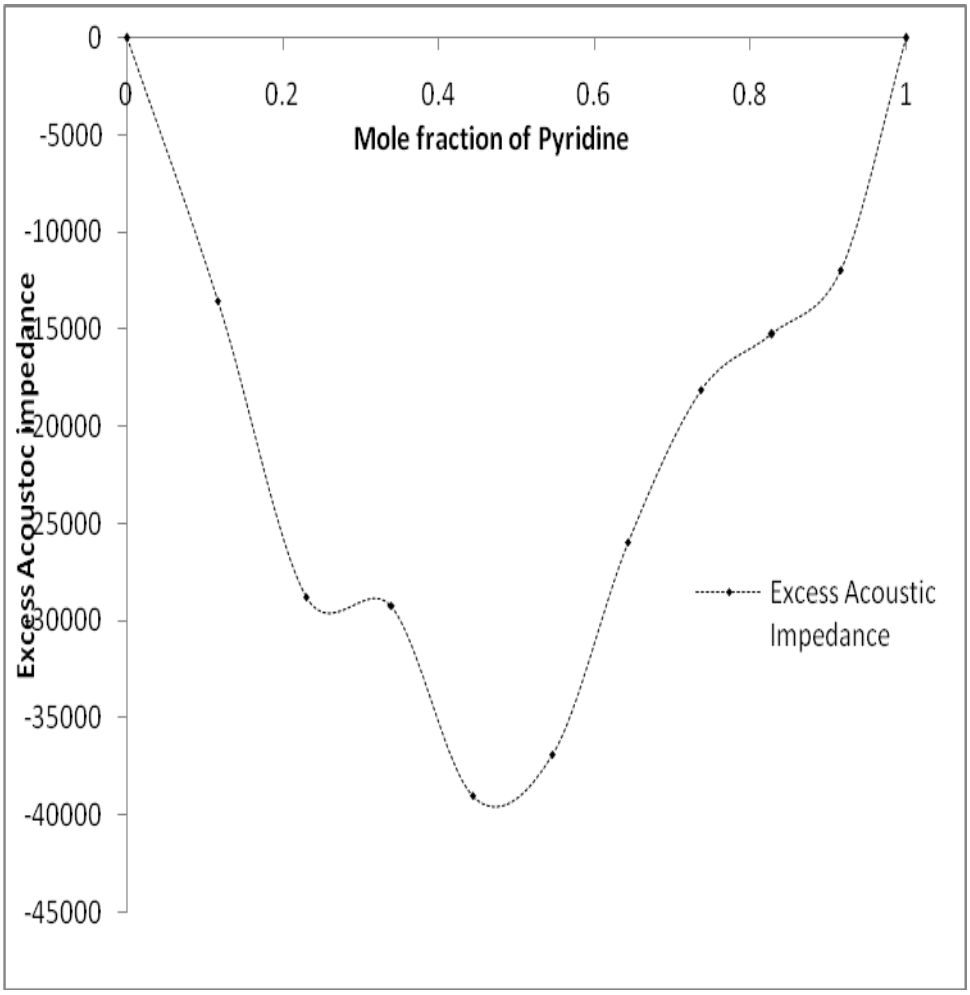

Fig 4- Excess acoustic impedance of Pyridine+Methanol

Negative values of acoustic impudence as shown in fig 4 hint to the possibility of presence of weak attractive forces between the reacting components of the mixture. negative deviation also suggests that Pyridine molecules does not cooperate with Methanol molecules hence weak intermolecular interactions occurs between them.

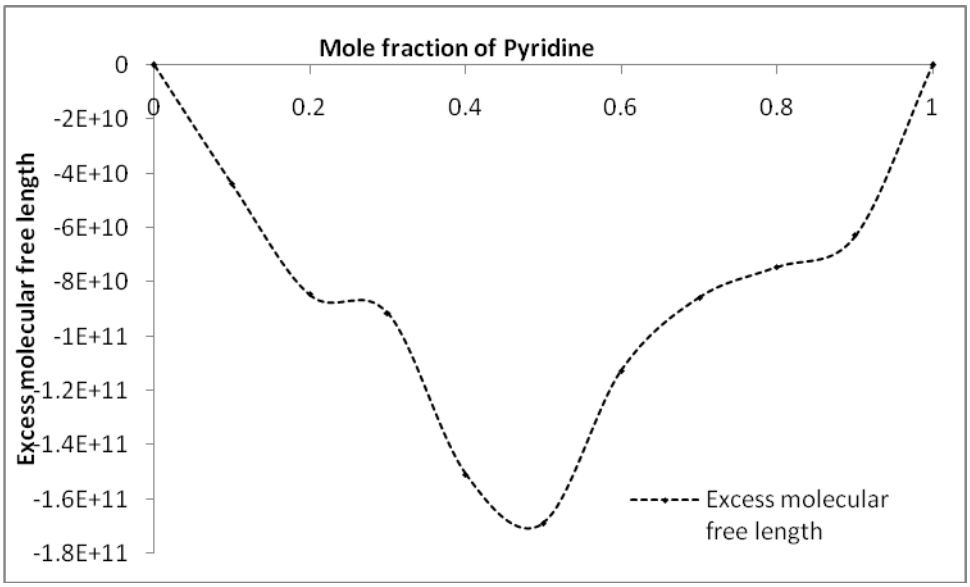

Fig 5- Excess molecular free length of Pyridine+Methanol

Negative values exhibit weak interaction. Increase in values of free length with concentration can be concluded as there is significant interaction between two liquids. Negative values also suggests that As Pyridine molecules are mixed with Methanol molecules their intermolecular distance increases and gives rise to weak bonded interaction between them.

IV.CONCLUSION

In this work, the measurement of density, ultrasonic velocity and other acoustical parameters of Pyridine in Methanol solution was studied in different concentrations at 293 K. Positive excess molar volume V_m^E values indicate the presence of weak weak bonded interactions. It has been observed that the excess velocity values become more negative with rise in concentration of Pyridine. 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 Pyridine affects and gives rise to weak weak bonded interaction. Our volumetric and ultrasonic study suggest that Pyridine acts as structure breaker Increase in concentration of Pyridine plays an important role in forming weak bonded interactions in the solutions.

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