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ORIGINAL ARTICLE

Thermo-Acoustic Molecular Interaction Studies in Binary Liquid Mixtures of Thiophene and Hexanol-1 using Ultrasonic Technique at 27^{0}c.

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ABSTRACT

The ultrasonic studies in liquids are great use in understanding the nature and strength of molecular interaction. The thermo-acoustical parameters for binary liquid mixtures of thiophene and hexanol-1 have been estimated from the measured values of ultrasonic velocity (v), density (ρ) and viscosity (η). Using the measured data, some of acoustic parameters such as isentropic compressibility (βs) and intermolecular free length (L_f) are evaluated at the temperature 27^{0}C. The present paper represents the nonlinear variation of ultrasonic velocity and thermo-acoustical parameters lead to dipole-induced dipole interaction between thiophene and hexanol-1 molecules. The behavior of these parameters with composition of the mixture has been discussed in terms of molecular interaction between the components of the liquids.

Keyword: *ultrasonic velocity, acoustical parameters, molecular interaction, thiophene, hexanol-1*

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INTRODUCTION

Ultrasonic study is very much useful for characterizing the physico-chemical behavior of liquid mixtures and measurements are used to study molecular interactions in liquids. Kannappam and Chidambara Vinayagam (2006). The method of studying in molecular interaction from the knowledge of variation of acoustic parameters along with their excess values with change in mole fraction gives an Insight into the molecular process Voleisiene & Voleisis, (2008). The increase or decreases in ultrasonic velocities have been employed in understanding the nature of molecular interaction in the pure liquid binary mixtures. (Jain and Dhar. (1992) the studies of liquid mixtures containing of polar and non-polar components find applications in industrial and technological process.

The mixing of different give rise to solutions that generally do not behave ideally (Bhandakkar, V.D. (2012), Bedare. Bhandakkar and Suryavanshi (2013) Mistry., Bhandakkar and Chimankar (2012) Bhandakkar, Chimankar and Mistry (2013). Further those properties have been widely used to study the molecular interaction between the various species in the mixture (Verma *et al* (2017, 2018).

In the present study ultrasonic velocity, density and viscosity were measured experimentally for binary system namely thiophene and hexanol-1 at 27^{0}C. From the measured data, thermo-acoustical parameters have been computed and the results are analysed in the light of molecular interaction.

MATERIALS AND METHODS

Thiophene and hexanol-1 were used after single distillation. Binary mixtures were prepared by mixing known volume of each liquid in air tight Stoppard glass bottle. Care was taken to avoid contamination during mixing.

Ultrasonic velocity was measured by Ultrasonic Interferometer M-80 manufactured by M/S Mittal Enterprises, New Delhi having accuracy of about ±0.057%.

Density of pure liquid and binary mixtures was measured by using double walled Picknometer. The Picknometer was calibrated with distilled water. The value obtained were tally with the literature values. The viscosities have been determined by using Ostwald viscometer. The accuracy in viscosity measurement was ±0.0002c.p.

Isentropic compressibility (βs) has been calculated from ultrasonic velocity (v) and the density (ρ) usin the equation as:

$$Bs = 1/v2\rho \qquad (1)$$

Intermolecular free length (Lf) has been determined as:

$$Lf = KT(\beta s)1/2 \qquad (2)$$

Where KT is a Jacobson's constant.

Table 1: Experimental values of ultrasonic velocity (v), density (ρ) and viscosity (η) of pure liquids at 27⁰C

Liquid	Ultrasonic Velocity	Density	Viscosity
Thiophene	1392	0.9824	3.1518
Hexanol-1	1305	0.8356	0.3234

Table 2: Experimental values of ultrasonic velocity (v), density (ρ) and viscosity (η) for the binary liquid mixture of thiophene and hexanol-1 at 27⁰C

Mole Fraction of thiophene (X1)	Ultrasonic Velocity (v) ms-1	Density (ρ) Gml-1	Viscosity (η) Cp
0.0000	1305	0.8356	3.1518
0.1572	1334	0.8572	2.7676
0.2956	1366	0.8764	2.4308
0.4184	1416	0.8931	2.1254
0.5281	1454	0.9081	1.8535
0.6267	1485	0.9218	1.6083
0.7157	1460	0.9357	1.3808
0.7966	1437	0.9486	1.1730
0.8704	1427	0.9606	0.9828
0.9379	1410	0.9719	0.8054
1.0000	1392	0.9823	0.3234

Table 3: Experimental values of isentropic compressibility (βs) and intermolecular free length (Lf) for the binary liquid mixture of thiophene and hexanol-1 at 27⁰C

Mole Fraction of thiophene X1	Isentropic Compressibility (βs) $Cm^2dyne^{-1}x10^{12}$	Intermolecular Free length (L_f) A^0
0.0000	70.27	0.5290
0.1572	65.46	0.5106
0.2956	61.02	0.4960
0.4184	55.84	0.4950
0.5281	52.10	0.4930
0.6267	49.14	0.4912
0.7157	50.06	0.4890
0.7966	50.94	0.4880
0.8704	51.04	0.4850
0.9379	51.72	0.4845
1.0000	52.53	0.4840

Graphs (Fig. 1-5) shos variation of ultrasonic velocity (v), density (ρ), viscosity (η), isentropic compressibility (βs) and intermolecular free length (L_f) with respect to mole fraction at temperature 327^0C.

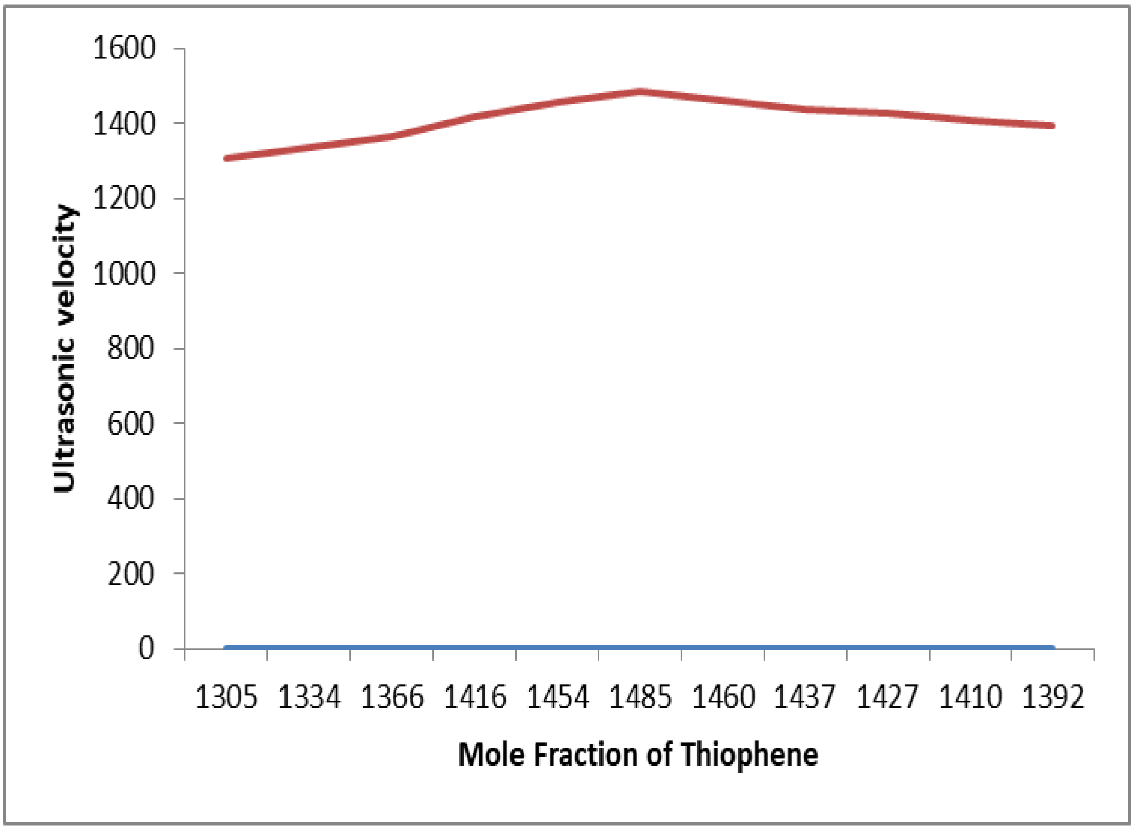

Fig. 1: Variation of Ultrasonic velocity with mole fraction

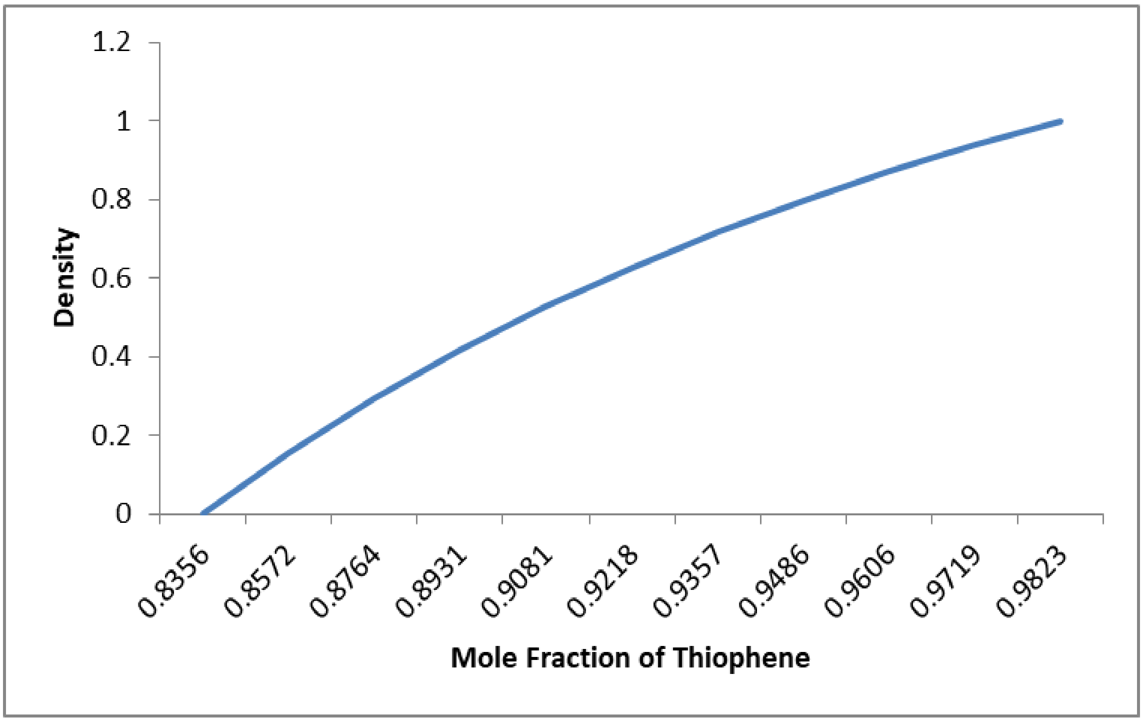

Fig. 2: Variation of density with mole fraction

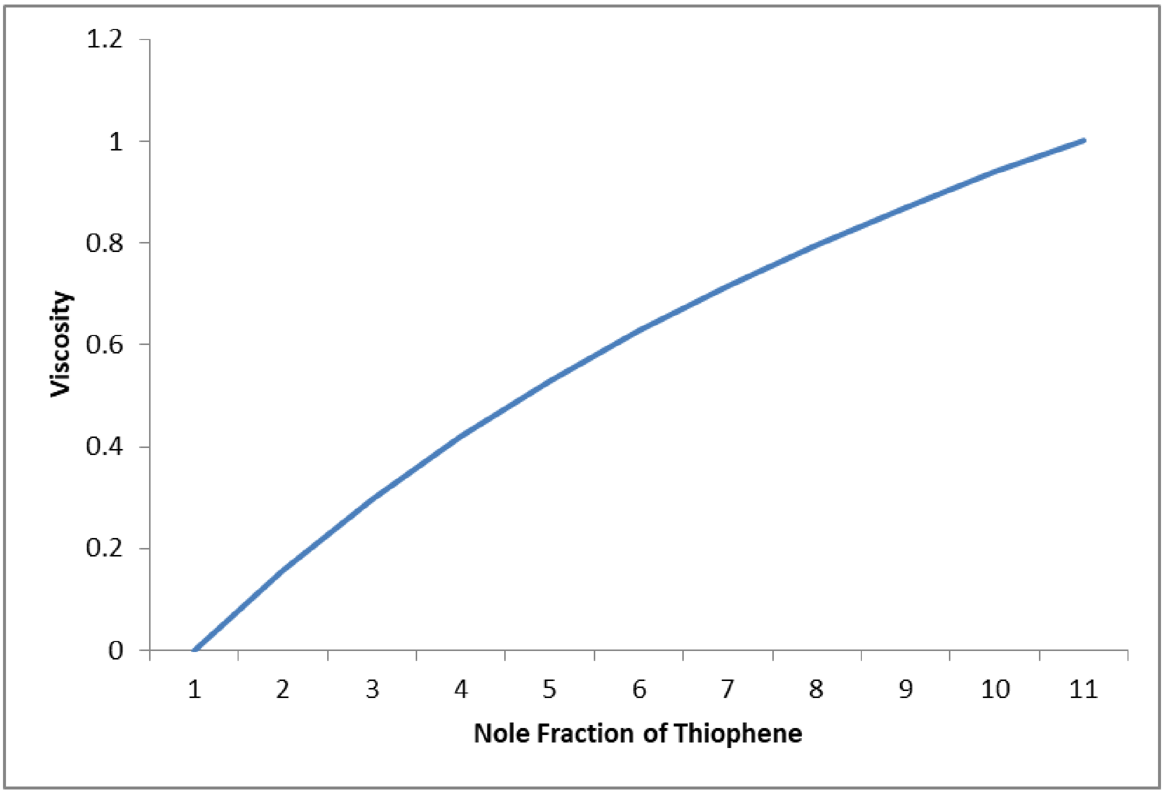

Fig. 3: Variation of viscosity with mole fraction

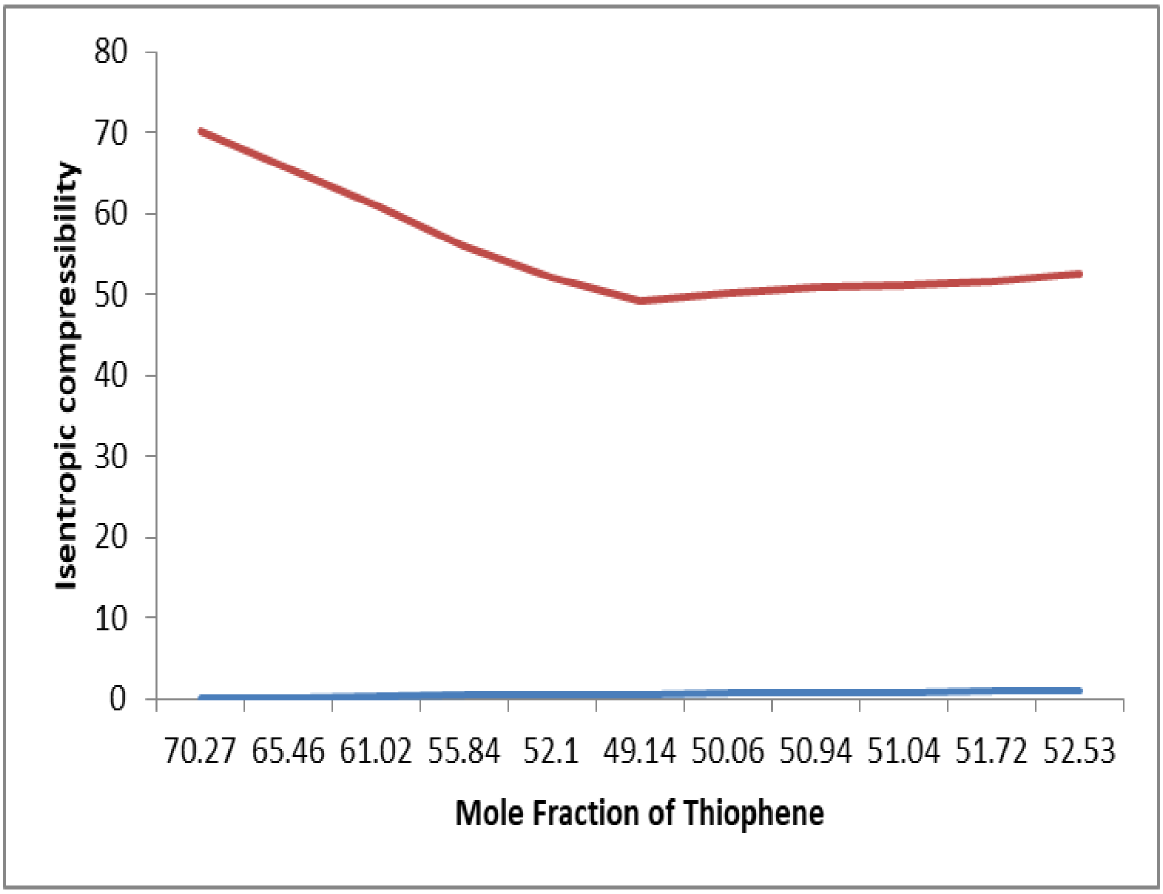

Fig. 4: Variation of isentropic compressibility with mole fraction

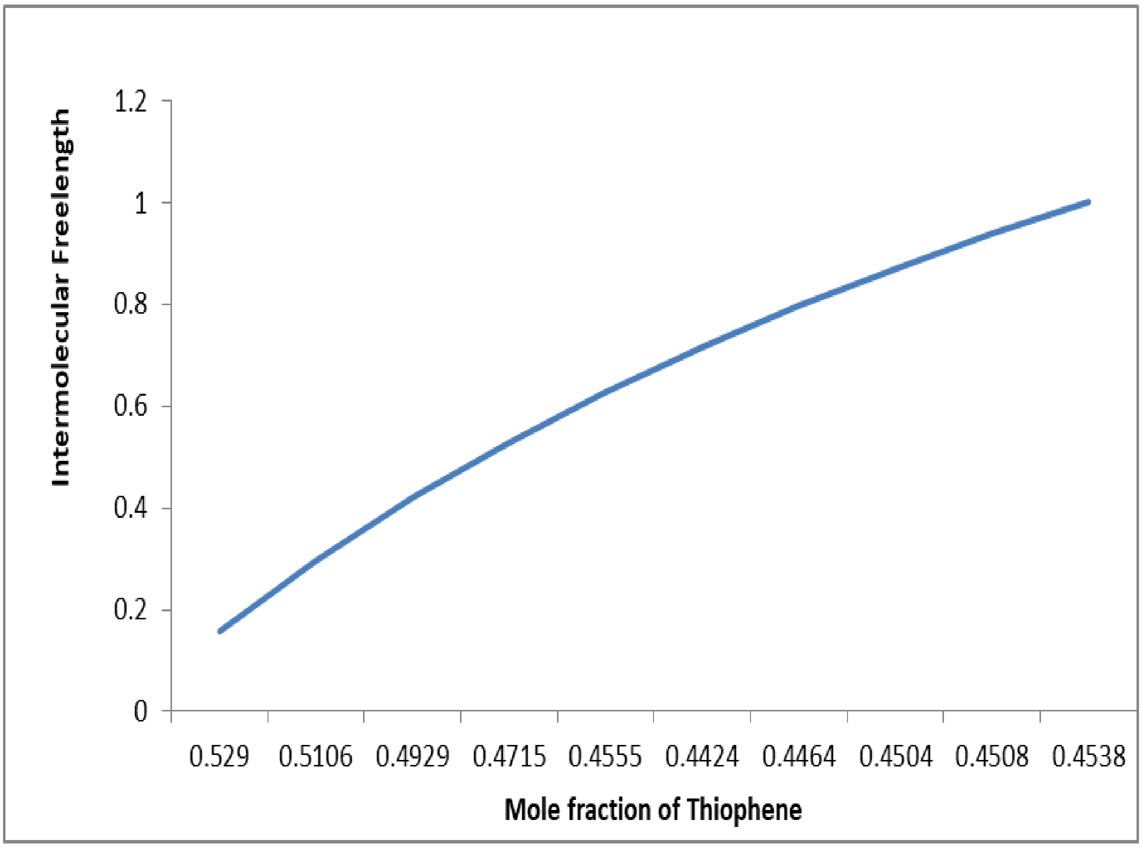

Fig. 5: Variation of intermolecular free length with mole fraction

RESULTS AND DISCUSSION

The experimentally measured values of ultrasonic velocity, density and viscosity for pure liquids at 27⁰C are presented in Table-1. Experimental values of ultrasonic velocity, density and viscosity for binary mixture at 27⁰C are given in Table-2.

The thermodynamic parameters such as isentropic compressibility (βs) and intermolecular free length (L_f) are listed in Table-3. The variation of ultrasonic velocity, density and viscosity at 27⁰C are shown in Fig.1, 2 and 3 respectively. While other thermodynamic s parameters such as isentropic compressibility (βs) and intermolecular free length (L_f) at 27⁰C are shown in Fig. 4 and 5 respectively.

From Table-2 it is observed that, the ultrasonic velocity (v) and density (ρ) increases with increase in mole fraction for theophany and hexanol-1 system and viscosity (η) decreases with increasing mole fraction. The increases in ultrasonic velocity are due to the increase in isentropic compressibility and intermolecular free length of the liquid mixtures. This may lead to presence of dispersive force (London force) between the molecules of the liquid mixture. The isentropic compressibility and intermolecular free length are the deciding factors of ultrasonic velocity in binary mixtures.

As hexanol-1 is non-polar molecule does not possess dipole moment, when it interacts with thiophene which is polar molecule possess dipole moment then hexanol-1 possess induced dipole moment. This induced dipole-dipole interaction between hexanol-1 and thiophene molecules.

CONCLUSION

From ultrasonic velocity, related acoustic parameters for thiophene with butanol-1 for various concentrations at 27⁰C, it has been found that there exists a dipole-induced dipole interaction between thiophene and hexanol-1.

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