ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

# ULTRASONIC AND THERMODYNAMIC STUDIES IN ORGANIC BINARY LIQUID MIXTURE

**Segu Venkata Ranganayakulu [*], Sanathana Ravi**
[*] Rural Development Society (R&D Institution), Panjagutta, Hyderabad – 500082, Telangana State, India.

**DOI**: 10.5281/zenodo.800617

## ABSTRACT

The ultrasonic velocity (u), density (ρ), and viscosity (η) have been measured for the binary mixtures of Butanol +N,N Dimethyl acetamide m, Pentanol + N, N Dimethyl acetamide,and Hexanol + N, N Dimethyl acetamide at $30^0$C. The experimental data have been used to calculate the acoustical parameters namely adiabatic compressibility (β), intermolecular free length (Li), acoustical impedance (Z) ultrasonic absorption ($[\alpha/f^2]$), the excess values of some of the above parameters have also been evaluated. The results obtained here are used to explain the molecular interaction between the components of the binary mixture. Thermodynamic properties are useful for understanding the variations in liquid structure and the molecular interaction of the liquid mixtures. Ultrasonic investigation finds extensive applications in probing in to the physico-chemical behavior and properties of the liquid and binary liquid mixture. Investigation results are used in design processes in the chemical and petrochemical industries. The measurement of ultrasonic velocity in liquids and liquid mixtures is used as an effective tool to prove the properties of liquid mixtures. Pure liquids and liquid mixtures consisting polar & non-polar components are considerable importance in analyzing intermolecular interaction between component molecules and molecular structure accurately. The ultrasonic investigations of these studies find several applications in the field of research in science, technology and industries. The excess values of acoustical parameters of binary liquid mixture are useful in understanding the solute-solvent interactions. Ultrasonic studies provide a wealth of information about the state of liquid.

**KEYWORDS**: Ultrasonic Velocity, Acoustic Parameters, Molecular Interaction, Binary mixture.

## INTRODUCTION

The measurement of ultrasonic velocity in liquids and liquid mixtures is used as an effective tool to prove into the properties of liquid mixtures.[ 1].The ultrasonic studies are extensively used to estimate the thermodynamic properties and predict the intermolecular interactions in pure ,liquid mixtures [ 2 ]. Ultrasonic velocity and related thermodynamic parameters helps us for characterizing thermodynamic and physico-chemical aspects of binary liquid mixtures such as molecular association and dissociation [3-4]. Pure liquids and liquid mixtures consisting polar & non-polar components are considerable importance in analyzing intermolecular interaction between component molecules [5-7]. The ultrasonic investigations of these studies find several applications in industries. Such studies as variations in concentration and temperature are useful in giving insight in to structure and various bonding of associated molecular complexes [8-10] and other related molecular processes. The measurements of ultrasonic velocity have been adequately employed in understanding the nature *of molecular systems* [11]. Ultrasonic and viscosity measurements have been widely used in field of interactions structural aspect evaluations studies. . Empirical and semi empirical [12] and .statistical theories [13] have been used in evaluating ultrasonic velocity in binary liquid mixtures. The measurement of ultrasonic speed enables us to the accurate measurement of some useful acoustic and

Thermodynamic parameters and their excess values [14-17]. These excess values of ultrasonic velocity, adiabatic compressibility, molar volume and viscosity in binary liquid mixture are useful in understanding the solute-solvent interactions. The study of molecular association in binary liquid mixture having alcohol as one of component is of particular interest since alcohols are strongly self-associated liquids having three dimensional network of hydrogen bonding and can be associate with any other group having some degree of polar attraction

[18-21]. The variation in ultrasonic velocity gives information about the bonding between molecules and formation of complexes at various concentration and temperature through molecular interactions [22-25].

## MATERIALS AND METHODS

**The Chemicals used for the present study are**

- Butanol

| | | |
|---|---|---|
| Chemical formula | : | $CH_3 – (CH_2)_3 – OH$ |
| Molecular weight | : | 74.12 gm |
| Refractive index | : | 1.3968 |
| Density | : | 0.8169 gm/cm$^3$ |

- Pentanol

| | | |
|---|---|---|
| Chemical formula | : | $(CH_3) – (CH_2)_4 – OH$ |
| Molecular weight | : | 88.15 gm |
| Refractive index | : | 1.4100 |
| Density | : | 0.8146 gm/cm$^3$ |

- Hexanol

| | | |
|---|---|---|
| Chemical formula | : | $(CH_3) – (CH_2)_5 – OH$ |
| Molecular weight | : | 102.18 gm |
| Refractive index | : | 1.4128 |
| Density | : | 0.8108 gm/cm$^3$ |

- N,N Dimethyl Acetamide

| | | |
|---|---|---|
| Chemical formula | : | $CH_3C (O) N (CH_3)_2$ |
| Molecular weight | : | 87.12 gm |
| Refractive index | : | 1.4376 |
| Density | : | 0.9366 gm/cm$^3$ |

***Experimental Studies***

Ultrasonic measurements in megahertz (MHz) range are important in the study of the relaxation phenomenon in liquids, solutions, polymers and bio chemicals. In particular the ultrasonic measurements of some binary solutions provide important information about the dynamical properties of phase transition and critical phenomenon. The Ultrasonic Interferometer of 1 MHz (M/S Mittal enterprises, New Delhi) is used for the present study. The densities of pure liquids and liquid mixtures were measured by using a specific gravity bottle. The velocity of sound waves was found using an ultrasonic interferometer (Mittal Enterprises, New Delhi) at a fixed frequency of 1MHz with an accuracy of ±2ms-1 m.s$^{-1}$.Viscosity measurements were carried out with an Oswald's viscometer having time of efflux 0.01s and the accuracy was found to be ± 3x10-6Nm$^{-2}$s. Flow time measurements were performed using an automatic viscosity (time) measurement unit with a resolution of ± 0.1 second. The temperature around the viscometer was maintained within 0.1K in an electronically controlled thermostatic water bath.

## RESULTS AND DISCUSSION

Ultrasonic velocities (u), densities (ρ) and viscosities (η) in the above systems over entire range of composition at the room temperature of about 30$^0$ C have been measured. The velocities (u) are determined at a frequency of 2 MHz. These experimental values are used in computing various thermodynamic parameters such as Adiabatic compressibility ($\beta_s$), Molar Volume (V), Intermolecular free length ($L_f$), Rao's constant (R), Wada's Constant (W), and Excess properties of adiabatic compressibility ($\beta_s^E$), volume ($V^E$), viscosity ($\eta^E$) and Mean free length ($L_f^E$). These results along with the interaction parameter and interaction energy from viscosity (η), measurements are presented in Tables 1.1,1.2 &1.3. The variation of ultrasonic velocity (u) and densities (ρ) and viscosities (η) with volume component percentage of the systems of alcohols in N-N Dimethyl acetamide are shown in Fig. 1.1&1.3. From the figures it is observed that the velocity varies linearly with decreasing trend with the concentration. The densities (ρ) of the systems of alcohols in N-N Dimethyl acetamide decreases

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

linearly and viscosities (η) increases non-linearly.

***Table 1: Ultrasonic velocity (u), density (ρ) and viscosity (η) of binary mixture of Butanol and N,N Dimethyl acetamide at 300C temperature.***

| **Component Volume Percentage** | | **Velocity u ($ms^{-1}$)** | **Density ρ ($gm\ cm^{-3}$)** | **Viscosity η (cp)** |
|---|---|---|---|---|
| **N,N Dimethyl acetamide** | **Butanol** | | | |
| 100 | 0 | 1227.2 | 0.8022 | 2.1539 |
| 90 | 10 | 1258.4 | 0.8167 | 1.8081 |
| 80 | 20 | 1276.8 | 0.8315 | 1.6058 |
| 70 | 30 | 1291.2 | 0.8405 | 1.3725 |
| 60 | 40 | 1314.4 | 0.8565 | 1.2238 |
| 50 | 50 | 1336.8 | 0.8715 | 1.1905 |
| 40 | 60 | 1362.4 | 0.8842 | 1.0968 |
| 30 | 70 | 1387.2 | 0.8988 | 1.0161 |
| 20 | 80 | 1404.0 | 0.9084 | 0.9727 |
| 10 | 90 | 1434.0 | 0.9206 | 0.9395 |
| 0 | 100 | 1460.0 | 0.9359 | 0.8817 |

***Table 2: Ultrasonic velocity (u), density (ρ) and viscosity (η) of binary mixture of Pentanol and N,N Dimethyl acetamide at $30^0C$ temperature.***

| **Component Volume Percentage** | | **Velocity u ($ms^{-1}$)** | **Density ρ ($gm\ cm^{-3}$)** | **Viscosity η (cp)** |
|---|---|---|---|---|
| **N,N Dimethyl acetamide** | **Pentanol** | | | |
| 100 | 0 | 1266.4 | 0.8089 | 2.6672 |
| 90 | 10 | 1280.0 | 0.8200 | 2.2420 |
| 80 | 20 | 1315.2 | 0.8465 | 1.9190 |
| 70 | 30 | 1320.8 | 0.8502 | 1.7140 |
| 60 | 40 | 1340.8 | 0.8582 | 1.4822 |
| 50 | 50 | 1348.0 | 0.8735 | 1.3304 |
| 40 | 60 | 1379.2 | 0.8833 | 1.2621 |
| 30 | 70 | 1380.0 | 0.8984 | 1.0890 |
| 20 | 80 | 1402.4 | 0.9104 | 1.0435 |
| 10 | 90 | 1429.6 | 0.9235 | 0.9541 |
| 0 | 100 | 1460.0 | 0.9359 | 0.8814 |

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

*Table 3: Ultrasonic velocity (u), density (ρ) and viscosity (η)of binary mixture of Hexanol and N,N Dimethyl acetamide at 30$^0$C temperature.*

| Component Volume Percentage | | Velocity u (ms$^{-1}$) | Density ρ (gm cm$^{-3}$) | Viscosity η (cp) |
|---|---|---|---|---|
| N,N Dimethyl acetamide | Hexanol | | | |
| 100 | 0 | 1296.8 | 0.8136 | 3.5380 |
| 90 | 10 | 1308.0 | 0.8253 | 2.6380 |
| 80 | 20 | 1317.6 | 0.8370 | 2.2709 |
| 70 | 30 | 1333.6 | 0.8491 | 1.9065 |
| 60 | 40 | 1340.8 | 0.8624 | 1.7372 |
| 50 | 50 | 1368.0 | 0.8741 | 1.4685 |
| 40 | 60 | 1392.8 | 0.8879 | 1.3174 |
| 30 | 70 | 1404.8 | 0.8986 | 1.1880 |
| 20 | 80 | 1411.2 | 0.9107 | 1.1253 |
| 10 | 90 | 1437.6 | 0.9252 | 1.0503 |
| 0 | 100 | 1460.0 | 0.9359 | 0.8817 |

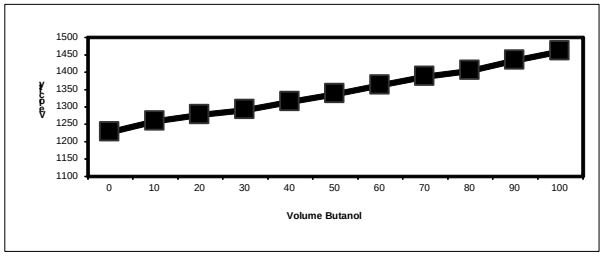


*Figure 1: The variation of Ultrasonic velocity (u) with volume component of binary mixture of butonal and N-N, Dimethyl acetamide at 30 degrees C*

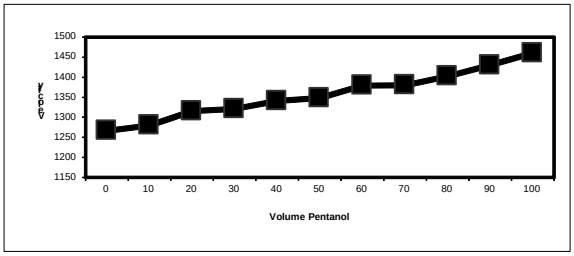


**Figure 2: The variation of Ultrasonic velocity (u) with volume component of binary mixture of Pentanol and N-N, Dimethyl acetamide at 30 degrees C**

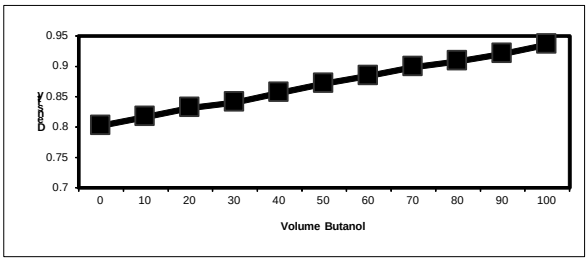


*Figure 3: The variation of Ultrasonic velocity in m/s (u) with volume component of binary mixture of Hexanol and N-N,Dimethyl acetamide at 30 degrees C*

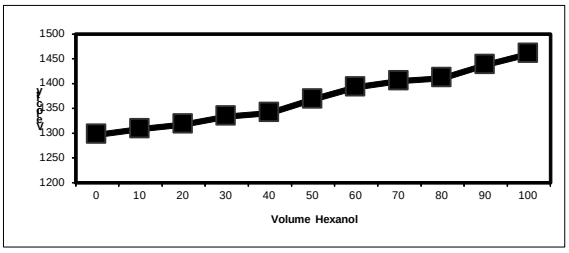


*Figure 4: The variation of Density with volume component of binary mixture of butonal and N-N,Dimethyl acetamide at 30 degrees C*

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

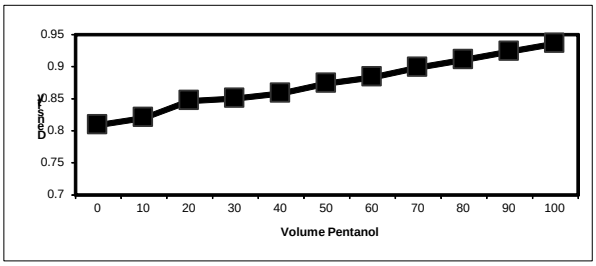


*Figure 5: The variation of Density with volume component of binary mixture of Pentanoland N-N,Dimethyl acetamide at 30 degrees C.*

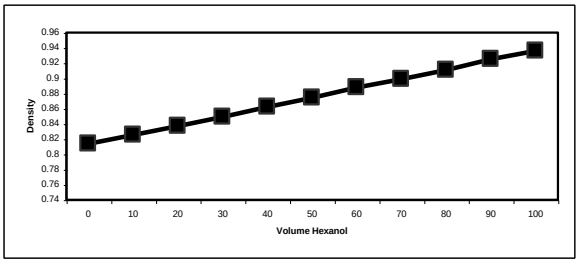


*Figure 6: The variation of Density with volume component of binary mixture of Hexanoll and N-N,Dimethyl acetamide at 30 degrees C.*

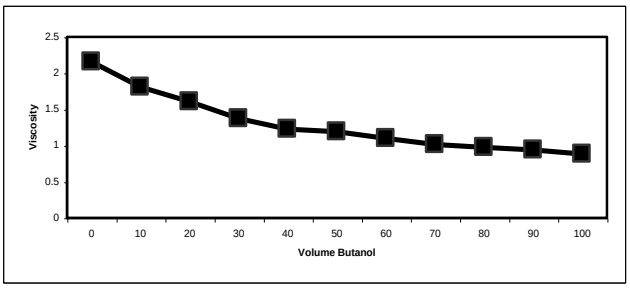


*Figure 7: The variation of Viscosity with volume component of binary mixture of butonal and N- N,Dimethyl acetamide at 30 degrees C.*

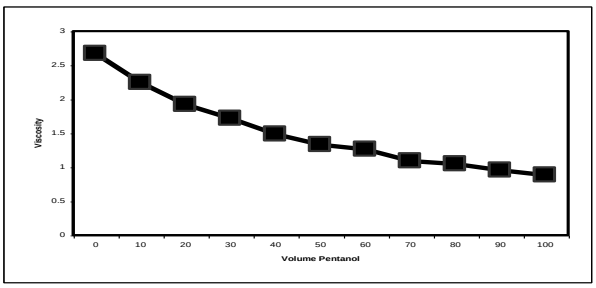


*Figure 8: The variation of Viscosity with volume component of binary mixture of Pentanoland N-N,Dimethyl acetamide at 30 degrees C*

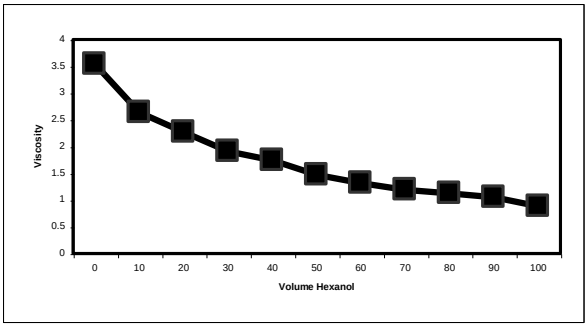


*Figure 9: The variation of Viscosity with volume component of binary mixture of Hexanol and N-N,Dimethyl acetamide at 30 degrees C.*

## CONCLUSION

Ultrasonic Investigation studies are carried out on Butanol, Pentanol, Hexanol and N,N Dimethyl acetamide mixtures at room temperature of about $30^0$C. Density (ρ) of the mixture was measured by specific gravity bottle and viscosity (η) was measured by Ostwald's viscometer.Several excess parameters like excess adiabatic compressibility ($\beta_s^E$), excess viscosity ($\eta^E$) and excess intermolecular free length ($L_f^E$) were to be evaluated from the measured data of velocity (u), density (ρ) and viscosity (η) for understanding the variations in liquid structure and the molecular interactions of the liquid mixtures.

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

## REFERENCES

[1] Joshi S.S. Ind. J. Tech. 29 (1991) 425. Aminabhavi, T.M. and Joshi, S.S. Ind. J.Tech 30, (1992) 197.

[2] Palaniappan l. and Karthikeyan V., Indian J .Phy.,2005,79(2),155.

[3] Manohar Murthi N and Nagbhushnam, Indian J chem., 1984, 23, 510.

[4] Khasare S B, Indian J Pure &Appl Phys, 1987, 25, 182.

[5] Tabhane V A and Patki B A, Acostica, 1982, 52, 44.

[6] Tabhane V A, Acoustic letters, 1988, 6, 8.

[7] Marvin B L and Bhat S N, Acostica 1987, 64, 155.

[8] Johari G K and Misra R C Indian J Pure &Appl Phys, 1987, 29,155.

[9] Nikam P S and Hirey, Indian J Pure &Appl Phys, 1991, 29,155.

[10] Grunberg L and Nissan, Nature 1946,164, 799.

[11]G. V Ramarao A viswanatha sarma, J Siva rama Krishna and C. Rambabu, Theritical evaluation of Ultrasonic velocity in binary Mixtures of o-chorophenol at different Temperature, Indian Journal of pure and Applied Physics ,vol 43,no.5pp.345-354,2005

[12] Seshagiri Rao M G .Indian Jpure Appl Phys., 1971,9,169

[13] P J Floy. J Am. Chm. Sc. 87 (1%5) 1833

[14] Jacobson B, Acta chem., 1985, 6, 148.

[15] Bhatti S S and Singh D P, Indian J Pure &Appl Phys 1983, 21, 506.

[16] Sheshadri A T and subramanyam B, J Phys conds matter, 1990, 2, 7353.

[17] Manohar Murthi N, Shivkumar K V, Rajgopal E and subramanyam S V, Acostica 1981, 48 , 341.

[18] Miyanga Stamura K and Murakami S, J chem. Thermodynamics, 1992, 48, 1767.

[19] P Vigourex, Ultrasonics, Chapman and hall, London, 1952.

[20] Rajgopal K and Chenthilnath, Indian J Pure & Appl Phys, 2010, 48, 326.

[21] Hirschfelder J O, Kurtiss C F and Bird R B ,Molecular theory of gases and Liquids (John Willy, New York- 01, 1954,256.

[22] Sumathi T and Uma Maheswari, Indian J Pure &Appl Phys, 2009, 47, 782.

[23] Rajedren V, Indian J Pure &Appl Phys 1996, 34, 52.

[24] Shanti N, Subrathinam P L and Emayavayramban M, 2010, 7, 648.

[25] Bhatti S S, Vivek J S and Singh D P, Acoustica, 1982, 50, 291.

## CITE AN ARTICLE

**Ranganayakulu, S. V., & Ravi, S. (2017). ULTRASONIC AND THERMODYNAMIC STUDIES IN ORGANIC BINARY LIQUID MIXTURE. *INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY*, *6*(5), 700-705. doi:10.5281/zenodo.800617**