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# Introduction of ultrasonic interferometer and experimental techniques for determination of ultrasonic velocity, density, viscosity and various thermodynamic parameters

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**Abstract**
Experimental techniques employed in the present work for the measurement of density, ultrasonic velocity, viscosity and working principle of ultrasonic interferometer have been discussed in this paper. In addition to that, the present paper also includes a brief discussion on experimental setup, different parts, procedure of ultrasonic interferometer, and various thermodynamic parameters which have been evaluated using theoretical equations. Specifically, experimental techniques employed in the present paper are Principle of Interferometry Technique.

**Keywords:** Ultrasonic interferometer, high frequency generator, measuring cell, working principle, acoustical parameters.

## 1. Introduction
Ultrasonic, thermo-physical and thermodynamic properties of liquid mixtures are of great significance in obtaining an in depth knowledge of inter and intra-molecular interactions, structural and physiochemical behavior and also in verifying various liquid state theories which attempt in estimating the properties of liquid mixtures. Systematic study of thermodynamic properties of solutions with a new type of multi-frequency ultrasonic interferometer is done for precise measurement of the velocity of sound in liquids. The path length in the cell is varied by motion of a reflector, at the electrical reaction of the cell upon the oscillator is used to fix standing wave position at a standard frequency, and their locations are determined with a suitable cathetometer.
An investigation in the possible change of thermodynamic properties of mixtures and their degree of deviation from ideality has been found to be an excellent quantitative way to elicit information about molecular structure and intermolecular forces in liquid mixtures. This has given impetus to the theoretical and experimental investigation of excess thermodynamic properties of liquid mixtures. Measurement of physiochemical properties such as density and ultrasonic velocity of pure components and their binary mixtures are being increasable used as tools for investigations of the properties of pure components and the nature of intermolecular interactions between the components of liquid mixtures.
The significance reasons for the study of thermo-physical and thermodynamic properties of multi-component liquid mixtures are as follows:

- They provide way for studying the physical forces acting between molecules of different species.
- The study of liquid mixtures provides appearance of new phenomena, which are absent in pure liquids. The most interesting of these are the new types of phase equilibria, which are introduced by the variation in the promotion of the pure components.
- Liquid mixtures are the most direct source for studying the various parameters. The study of thermo-physical and thermodynamic properties of liquid mixtures helps in obtaining in depth knowledge about molecular interactions.

## 2. Theory

Ultrasonic interferometer is a simple and direct device which yields accurate and consistent data, from which one can determine the velocity of ultrasonic sound in a liquid medium with a high degree of accuracy. A crystal controlled interferometer (model M-83S) supplied by Mittal Enterprises, New Delhi, operating frequencies ranging from 1 to 12 MHz has been used to measure the ultrasonic velocity.

## 3. Ultrasonic

Ultrasonic sound refers to sound pressure with a frequency greater than the human available range (20 Hz to 20 KHz). When an ultrasonic wave propagates through a medium, the molecules in that medium vibrate over short distance in a direction parallel to the longitudinal wave. During this vibration, momentum is transferred among molecule. This causes the wave to pass through the medium.

## 4. Ultrasonic Interferometer

An Ultrasonic Interferometer is a simple and direct device to determine the ultrasonic velocity in liquid with a high degree of accuracy.


**Fig 1:** Experimental setup for ultrasonic interferometer.

The salient features of ultrasonic interferometer are given below:

**4.1** It is a simple in design, rugged and gives very accurate and reproducible results.

**4.2** Experiments may be performed over a wide range of temperature from -30 $^0$C to +80 $^0$C on all liquids except those which reacts with the plating of cell and crystal.

**4.3** Nearly 10 ml of experimental liquid is required.

**4.4** There is no danger of any change such as depolymerisation, due to ultrasonic effect since a very small ultrasonic energy is required.

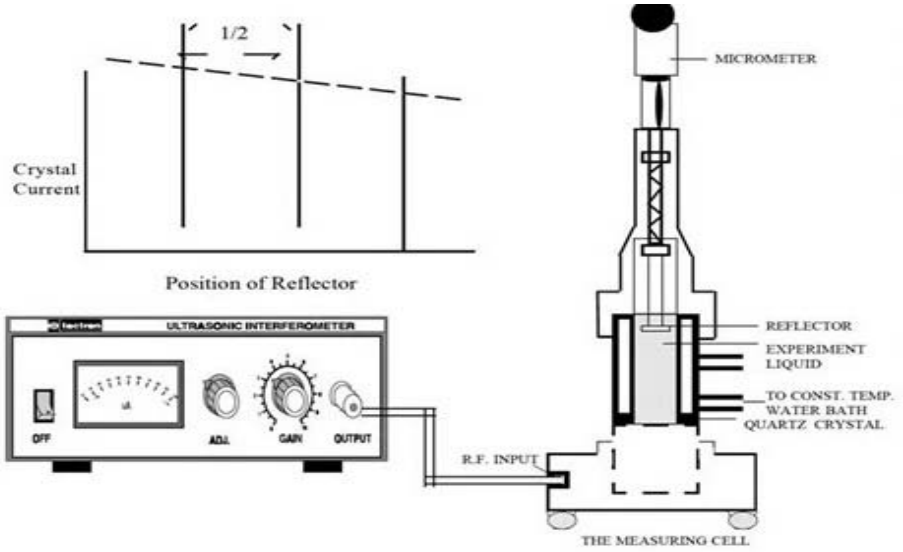


**Fig 2:** Cross section of the liquid cell and graph plotted position of reflector versus crystal current.

In an ultrasonic interferometer, the ultrasonic waves are produced by the piezoelectric methods. At a fixed frequency variable path interferometer, the wavelength of the sound in an experimental liquid medium is measured, and from this one can calculate its velocity through that medium. The ultrasonic cell is consists of a double walled brass cell with chromium plated surfaces having a capacity of 10 ml. The double wall allows water circulation around the experimental liquid to maintain it at a known constant temperature. The micrometer scale is marked in units of 0.01 mm and has an overall length of 25 mm. Ultrasonic waves of known frequency are produced by a quartz crystal which is fixed at the bottom of the cell. There is a movable metallic plate parallel to the quartz plate, which reflects the waves. The waves interfere with their reflections, and if the separation between the plates is exactly an integer multiple of half wave length of sound, standing waves are produced in the liquid medium. Under these circumstances, acoustic resonance occurs. The resonant waves are a maximum in amplitude, causing a corresponding maximum in the anode current of the piezoelectric generator.

The ultrasonic interferometer consists of the following mainly two parts:

**4.1.1.** The high frequency generator.

**4.1.2.** The measuring cell.

### 4.1.1. The high frequency generator

The high frequency generator is designed to excite the quartz crystal fixed at the bottom of the measuring cell at its resonant frequency to generate ultrasonic waves in the experimental liquid filled in the “measuring cell”. A micrometer to observe the changes in current two controls for the purpose of sensitivity regulation and initial adjustment of the micrometer are provided on the panel of the high frequency generator.

**4.1.2. The measuring cell**

The measuring cell is specially designed for maintaining the temperature of the liquid constant during the experiment. A fine digital micrometer screw (LC 0.001 mm) has been provided at the top, which can lower or raise the reflector plate in the liquid within the cell through a known distance. It has a quartz crystal fixed at its bottom.

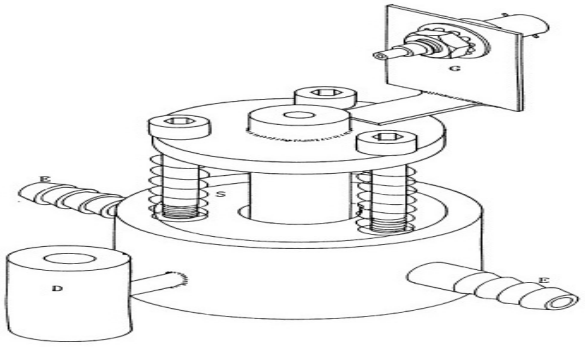

**Fig 3:** Ultrasonic interferometer cell liquid mixtures.

**5. Working principle**

The principle used in the measurement of velocity $(U)$ is based on the accurate determination of the wavelength $(\lambda)$ in the medium. Ultrasonic waves of known frequency (f) are produced by quartz crystal fixed at the bottom of the cell. These waves are reflected by a movable metallic plate kept parallel to the quartz crystal. If the separation between these two plates is exactly a whole multiple of the sound wavelength, standing waves are formed in the medium. This acoustic resonance gives rise to an electrical reaction on the generator driving the quartz crystal and anode current of the generator become a maximum. If the distance is now increased or decreased and the variation is exactly one half wavelengths $(\lambda/2)$ or multiple of it, anode current become maximum from the knowledge of wavelength $(\lambda)$ the velocity $(U)$can be obtained by the relation:

Velocity = Wavelength × Frequency

$$U = \lambda \times f \quad (1)$$

**6. Adjustment of ultrasonic interferometer**

For initial adjustment two knobs are provided on high frequency generator, one is marked with "ADJ" to adjust the position of the needle on the ammeter and the knob marked "GAIN" is used to increase the sensitivity of the instrument for greater deflection, if desired. The ammeter is used to notice the number of maximum deflection while micrometer is moved up or down in liquid.

**7. Procedure**

**7.1** Unscrew the knurled cap of cell and lift it away from double walled construction of the cell. In the middle position of it pour experimental liquid and screw the knurled cap. Wipe out excess liquid overflowing from the cell.

**7.2** Insert the cell in the heavy base socket and clamp it with the help of a screw provided on its side.

**7.3** Connect the high frequency generator with cell by co-axial cable provided with the instrument. In ultrasonic interferometer frequency selector knob should be positioned at desired frequency (same frequency as that of liquid cell chosen).

**7.4** Move the micrometer slowly in either clockwise or anticlockwise direction till the anode current on the ammeter on the high frequency generator shows a maximum or minimum.

**7.5** Note the reading of micrometer corresponding to the maximum or minimum (which is sharper) in micro-ammeter. Take about 50 reading of consecutive maximum or minimum and tabulate them.

**7.6** Take average of all differences (λ/2).

**7.7** Once the wavelength (λ) is known the velocity (U) in the liquid can be calculated with the help of the relation.

**8. Sample calculations**

Sample: water

Average (λ/2): 0.375mm.

Ultrasonic velocity in sample: $U = \lambda \times f = 1480$ m/sec.

Density of the liquid = 996.458 Kg/m$^3$

Adiabatic compressibility $(\beta_{ad}) = 1/\rho v^2 = 1/996.458 \times (1480)^2$

$\beta_{ad} = 4.58 \times 10^{-10}$ N/m$^2$.

**9. Measurement of the density**

The density measurements were made by dilatometer. It was placed in a high precision water bath for temperature control. The dilatometer was calibrated initially using distilled water. The reliability of the dilatometer was checked for liquid like benzene and carbon tetrachloride at known temperatures. The densities measured for A.R. grade benzene and carbon tetrachloride were found to be 0.8735 and 1.5845 g/cc respectively at 298.15K. The literature values of densities for benzene and carbon tetrachloride were found to be 0.8737 and 1.5844 g/cc respectively. Thus, the measured values were good agreement with their literature values.

**10. Measurement of viscosity**

The viscosity measurements were done through Ostwald's viscometer. The viscometer is filled with reference liquid (distilled water) and then immersed in water bath. The water in the viscometer is allowed for some time to attain the experimental temperature. Using a suitable arrangement, the water is sucked above the marked level and then it is allowed to flow freely. The time taken for the flow of water is noted. The water is replaced with a mixture, whose viscosity is to be determined. Using the same procedure, the time taken for flow of liquid mixture at the experimental temperature was determined.

Using the time taken for the distilled water and mixture, the viscosity of unknown liquid mixture is determined:

$$\eta_s / \eta_w = \rho_s / \rho_w \times t_s / t_w \quad (2)$$

Where $\eta_w$, $\rho_w$ and $t_w$ are the viscosity, density and time flow of water respectively and $\eta_s$, $\rho_s$ and $t_s$ are the viscosity, density and time flow of unknown liquid mixture respectively.

Viscosity is an important transport property for process design in petroleum, petrochemical, chemical and other chemical industries involving fluid transportation, mixing agitation, heat exchange and concentration. The estimation of the viscosity of a mixture is more difficult than of the pure compound. The prediction of the viscosity of liquid mixtures is a goal of long standing with both experimental and theoretical importance. Many industrial, chemical processes or laboratory works need experimental data of viscosity at any given temperature and composition for the liquid mixtures.

## 11. Theoretical methods for the estimation of acoustical thermodynamic parameters of liquid and liquid mixtures

### 11.1. Ultrasonic velocity

Ultrasonic study of liquid and liquid mixtures has gained much importance in characterizing of thermodynamic and physio-chemical aspects of ternary liquid mixtures. A variety of empirical, semi – empirical and statistical theories in liquids are available in the literature for evaluating ultrasonic velocity in liquids and liquid mixtures.

### 11.2 Schaaffs's collision factor theory (CFT)

On the basis of collision factor theory, Schaaffs developed the following formula for ultrasonic velocity; [29]

$$U_{mix} = U\infty - (\sum_{i=1}^{3} x_i S_i)(\sum_{i=1}^{3} x_i B_i) / V_m \quad (3)$$

Where, $U\infty$ = 1600 m/s, $x_i V_m$, $S_i$ and $B_i$ represent the mole fraction, molar volume, collision factor and actual volume of the molecule per mole for the pure components, respectively. The S and B values are calculated using the following equation; [29]

$$B = (4\pi/3)\, r^3_m\, N_A S = U_{mix} V_{mix} / B\infty \quad (4)$$

Where, $N_A$ is the Avogadro's number and $r_m$ is the molecular radius calculated as;

$$r_m = (3b/16\pi N_A)^{1/3} \quad (5)$$

Where, b is the Vander Waals constant.

### 11.3. Jacobson's free length theory (FLT)

Jacobson was the first to introduce the concept of intermolecular free length given by Eyring and Hirschfelder to evaluate sound velocity in pure liquid and liquid mixtures. According to Eyringet.al, intermolecular free length ($L_f$) is given by; [30]

$$L_f = 2V_a / Y \quad (6)$$

Where, $V_a$is the available volume and Y is the surface area per mole. $V_a$ and Y can be calculated as;

$$V_a = V_T - V_0,\ Y = (36\pi N a V_0^2)1/3 \quad (7)$$

Where, $V_T$ and $V_0$ are the molar volume at temperature T and zero degree absolute, respectively. $V_0$ can be obtained from the following relation;

$$V_0 = V_T (1 - T/T_C) \quad (8)$$

Assuming additive of surface area, the intermolecular free-length in the mixture is given by;

$$L_f = 2\{VT - (\sum_{i=1}^{3} x_i V_0)\} / \sum_{i=1}^{3} x_i Y_i) \quad (9)$$

On the basis of above relation, Jacobson obtained the following expression for sound velocity in liquid mixture as; [30]

$$U_{mix} = K/L_{fmix}\, \rho^{1/2}_{mix} \quad (10)$$

Where, K is the temperature dependent constant called Jacobson's constant and $\rho_{mix}$ is the density of the liquid mixture.

### 11.4. Nomoto's relation

Nomoto established the following relation for sound velocity in liquid mixtures as; [32]

$$U = (R/V)^3 = (\sum_{i=1}^{3} x_i R_i / \sum_{i=1}^{3} x_i V_i) \quad (11)$$

Where, Ri and Vi are the molar sound velocity and molar volume of pure components.

### 11.5. Van Dael's ideal mixing relation

The ideal mixing advanced by Van Dael and Vangeel yield the following relation for adiabatic compressibility $(\beta_{ad})_{im}$ as; [31, 34]

$$(\beta_{ad})_{im} = \sum_{i=1}^{3} \Phi_i \gamma_i / \gamma_{im} (\beta_{ad})_I \quad (12)$$

Where, $\Phi$ and $\gamma$ represent the volume fraction and specific heat respectively.

To avoid complication, Richardson and Blandamer assumed the following relation for $(\beta_{ad})_{im}$;

$$(\beta_{ad})_{im} = \sum_{i=1}^{3} \Phi_i (\beta_{ad})_i \quad (13)$$

But this relation is true only if the mixture is ideal and the condition, $\gamma_1 = \gamma_2 = \gamma_3 = \gamma_{im}$ is satisfied. Using the additional assumption V1 = V2 = V3, above equation can be transformed into a linear combination of mole fractions ($x_i$) as; [34]

$$(\beta_{ad})_{im} = \sum_{i=1}^{3} x_i (\beta_{ad})_i \quad (14)$$

On the basis of equation, Van Dael obtained the relation for ultrasonic velocity in liquid mixtures as;

$$(1/\sum_{i=1}^{3} x_i M_i)(1/U^2_{im}) = \sum_{i=1}^{3} x_I / M_i U^2_i \quad (15)$$

Where, $M_i$ and $U_i$ are the molecular weight and speed of sound for pure component.

### 11.6. Junjie's relation

Zhang Junjie gave following relation for the ultrasonic velocity in liquid mixtures as; [31, 34]

$$U_{mix} = \sum_{i=1}^{3} x_i V_i / [\sum_{i=1}^{3} x_i M_i]^{1/2} [\sum_{i=1}^{3} x_i\, U^2_i / \rho_i U^2_i]^{1/2} \quad (16)$$

### 11.7. Flory theory

According to Flory theory, sound velocity is given by; [33]

$$U_{mix} = (1/\beta_{ad}\rho)^{1/2} \quad (17)$$

Where, ρ is the density and $\beta_{ad}$ is the adiabatic compressibility.

$$\beta_{ad} = \beta_T - \alpha^2 TV/C_P \quad (18)$$

$$\rho = \sum_{i=1}^{3} x_i M_i / (\sum_{i=1}^{3} x_i V^*_i)\, V^- \quad (19)$$

Where, $V^*_i$, $V^-$, $\beta_T$, α and $C_P$ are the characteristic volume, reduced volume, isothermal compressibility, coefficient of thermal expansion and heat capacity.

The average percentage deviation (APD) between the experimental and calculated speed of sound for CFT, FLT, NR, IMR, JR, IR and FT is evaluated by the relation;

$$APD = 1/m\, (\sum Z_{exp} - Z_{cal} / Z_{exp}) \times 100 \quad (20)$$

Where, m is the number of experimental points and Z is the value of the property.

**12. The measured values of density (ρ), viscosity (η) and ultrasonic velocity (U) were used to determine various physical parameters**

**12.1. Adiabatic compressibility ($\beta_{ad}$)**

The adiabatic compressibility is the fractional decrease of volume per unit increase of pressure, when no heat flows in or out. These changes are related to the compressibility of the medium by thermodynamic relation; [18]

$$\boldsymbol{\beta}_{ad}=\frac{1}{v}[\boldsymbol{\partial v}/\boldsymbol{\partial} p] \quad (21)$$

It can also be calculated from the speed of sound (U) and the density of the medium (ρ) using the equation of Newton Laplace as;

$$\boldsymbol{\beta}_{ad} = \mathbf{1}/\mathbf{u}\rho^2 Kg^{-1}ms^2 \quad (22)$$

**12.2. Isentropic compressibility ($k_s$)**

The study of sound propagation both in the hydrodynamic treatment and relaxation process yields that in the limit of low frequencies; sound velocity in a fluid medium is expressed as; [19, 7]

$$U^2 = [\partial p/\partial \rho]_s = 1/k_s\rho \quad (23)$$

This gives rise the well-known Laplace's equation,
Where P is the pressure and ρ is the density of the medium. The importance of the isentropic compressibility is determining the physio-chemical behavior of liquid mixtures.

**12.3. Isothermal compressibility ($\boldsymbol{\beta}_T$)**

Isothermal compressibility ($\boldsymbol{\beta}_T$) can be calculated by using equation; [26]

$$\boldsymbol{\beta}_T = \boldsymbol{\beta}_s + TV\alpha^2/C_P \quad (24)$$

α = Thermal expansively, $C_P$ = Heat capacity at constant pressure.

**12.4. Volume change (dV)**

The volume change (dV) is the net change in volume after mixing of 100 ml of solvent mixtures by the volume. The volume may be decreases or increases. This can be understood on the basis of molecular interaction ie association or dissociation. The volume change (dV), can be calculated by using equation; [1]

$$dV = [\ (\beta_{ad}U^2M) - V] - 99.99969664 \times 10^{-4} \quad (25)$$

Where, $\beta_{ad}$ is the adiabatic compressibility. $U^2$ is the ultrasonic velocity. M is the mass of the binary mixture liquid. V is the total taken volume of both solvents.

**12.5. Available volume**

Available volume is the direct measure of compactness and strength of binding the molecule of liquid or liquid mixture. Another parameter which can be calculate from ultrasonic velocity is the available volume and is given by; [20]

$$V_a = V\ [1-U/U\infty]\ m^3mol^{-1} \quad (26)$$

Where U∞ is the Schaaf's limiting value taken as 1600 m/s for liquid mixture.

**12.6. Intermolecular free length ($L_f$)**

The intermolecular free length is the distance covered by sound wave between the surfaces of the neighboring molecules. It is measure of intermolecular attractions between the components in binary mixture. The increase or decrease in free length indicates weakling and strengthen of intermolecular attraction. As the ultrasonic velocity increase due to the increases in concentration, the interaction free length has to decrease and vice-versa. It is related to ultrasonic velocity and density as; [14]

$$L_f = K/(\rho U)^{1/2}m \quad (27)$$

The adiabatic compressibility of a liquid can be expressed in terms of the intermolecular free length which is the distance between the surfaces of the neighboring molecules and is given by the relation, [19]

$$L_f = K_T\ \beta^{1/2} \quad (28)$$

Where, $K_T = (93.875+0.345T) \times 10^{-8}$

**12.7. Free volume ($V_f$)**

Free volume is one of the significant factors in explaining the variations in the physio-chemical properties of liquids and liquid mixtures. The free space and its dependent properties have close connection with molecular structure and it may show interesting features about interactions, which may occur when two or more liquids are mixed together. This molecular interactions between like and unlike molecules are influenced by structural arrangements along with shape and size of the molecules.

A liquid may be treated as if it were composed of individual molecules each moving in a volume $V_f$ in an average potential due to its neighbors. That is, the molecules of a liquid are not quite closely packed and there are some free spaces between the molecules for movement and the volume $V_f$ is called the free volume. Eyring and Kincaid defined the free volume as the effective volume in which particular molecule of the liquid can move and obey perfect gas laws. Free volume in terms of Ultrasonic velocity (U) and the Viscosity of the liquid (η) as; [15]

$$V_f = [M_{eff}U/K\eta]^{1/2} \quad (29)$$

Where
$\mathbf{M_{eff}}$ is the effective molecular weight.
$\mathbf{M_{eff}} = \mathbf{M_iX_i}$ in which Mi and Xi are the molecular weight and the mole fraction of the individual constituents respectively).
K is a temperature independent, constant which is equal to $4.28x10^9$ for all liquids.

**12.8. Relaxation time ( $\tau$)**

Relaxation time is the time taken for the excitation energy to appear as translational energy and it depends on temperature and on impurities. The dispersion of the ultrasonic velocity in binary mixture reveals information about the Characteristic time of the relaxation process that causes dispersion. The relaxation time (τ) can be calculated from the relation; [8]

$$\beta = \frac{4}{3}\beta\ \eta \quad (30)$$

**12.9. Acoustic impedance (Z)**

Sound travels through materials under the influence of sound pressure. Because molecules or atoms of a solid are bound elastically to one another, the excess pressure results in wave propagation through the solid.

The acoustic impedance (Z) of a materials is defined as the products of its density ($\rho$) and ultrasonic velocity (u) given as; [8]

$$Z = U\beta \quad (31)$$

**12.10. Internal Pressure ($\pi_i$)**

The measurement of internal pressure is important in the study of the thermodynamic properties of liquids. The internal pressure is the cohesive force, which is a resultant of force of attraction and force of repulsion between the molecules. Cohesion creates a pressure within the liquid of value between 103 and 104 atmospheres. Internal pressure also gives an idea of the solubility characteristics. Dissolved solutes exist under the internal pressure of the medium and their interactions with the solvent arise through hydrogen bonding, charge transfer, Columbic (or) Vander Waal's interaction. The term $a/v^2$ in Vander Waal's equation being the measure of attractive force of the molecule is called the cohesive (or) internal pressure.

The internal pressure is the single factor which varies due to all type of solvent-solute, solute-solute and solvent-solvent interactions. The internal pressure, ($\pi$i) can be calculated by using equation; [15]

$$\Pi_i = bRT\,[K\eta/U]^{1/2}[\rho^{2/3}/M^{7/6}] \quad (32)$$

Where K is a constant. T is the absolute temperature.$\eta$is the viscosity in $NSm^{-2}$. U is the ultrasonic velocity in $ms^{-1}$and$\rho$ is the density in $kgm^{-3}$of the liquid.

**12.11. Relative association**

Relative association is equal to density of solution divided by density of the solvent and is multiplied by cube root of ultrasonic velocity in solvent divided by cube root of ultrasonic velocity in solution. It is given by the using equation; [10]

$$Ra = [\rho/\rho_0]\,[U/U_0]^{1/3} \quad (33)$$

Where $\rho$ and $\rho_0$ are the densities of solution and solvent respectively and U, $U_0$are the velocities of solution and solvent respectively.

**12.12. Absorption coefficient ($\alpha/f^2$)**

Absorption coefficient is also called attenuation coefficient is a characteristic parameter of the medium and it depends on external condition like temperature, pressure and frequency of measurement is given by; [24]

$$\alpha/f^2 = 8\pi_i^2\,\eta/[3\rho U^3]NPm^{-1}S^2 \quad (34)$$

**12.13. Molar compressibility or Wada's constant (B)**

Molar compressibility is also known as Wada's constant, which is dependent on adiabatic compressibility and density is given by; [21]

$$W = [M.\beta^{1/7}]/\rho \quad (35)$$

Where M is the molecular weight, $\beta$ is the adiabatic compressibility and $\rho$ is the density of the medium.

**12.14. Rao's constant or molar sound velocity (R)**

Rao's constant is also known as molar sound velocity and it is an additive property. It has been found to be invariant with temperature and pressure for organic and inorganic liquid. R is an relation between sound velocity and molar volume, which is given by; [27]

$$R = [M_{eff}/\rho]\,U^{1/3} \quad (36)$$

**12.15. Gibb's free energy ($\Delta G$)**

The relaxation time ($\tau$) is related to the activation free energyfor a given transition. The variation of $\tau$ with temperature can be expressed in the form of Eyring salt process theory and the rearranged equation is given as; [2]

$$\Delta G = -KT\log\,[h/KT\,\tau] \quad (37)$$

Where K is the Boltzmann constant and h is the plank's constant.

**12.16. Optical refractive index (n)**

Optical refractive index can be calculated by using equation; [5]

$$U = [10(S/h)]\,n^{1/x} \quad (38)$$

Where, S/h is the ratio of surface tension to the coefficient of viscosity.

$$x = 1/L_f \quad (39)$$

Where, 1 is mean free path of the molecule and $L_f$ is intermolecular free length.

**12.17. Solvation number (Sn)**

Solvation number (Sn) can be calculated by using equation; [11]

$$Sn = M/M_0\,[1-\boldsymbol{\beta}/\boldsymbol{\beta}_0]\,[100-x/x] \quad (40)$$

Where M and $M_0$ are molecular weight of solvent and solution respectively, $\boldsymbol{\beta}$ and $\boldsymbol{\beta}_0$ are adiabatic compressibility of solvent and solution respectively and x is the number of gram of salt in 100g of the solution.

**12.18. Mean square thermodynamic fluctuation**

Mean square thermodynamic fluctuation can be calculated by using equation; [20]

Mean square fluctuation of pressure;

$$(\Delta P)^2 = (kT\rho U^2/V) \quad (41)$$

Mean square fluctuation of temperature,

$$(\Delta T)^2 = kT^2\gamma/C_P \quad (42)$$

Number of molecule in a given volume,

$$(\Delta N/N)^2 = kT\gamma/\rho U^2 V \quad (43)$$

Correlation function of pressure and temperature fluctuations,

$$\Delta P.\,\Delta T = \alpha\rho U^2 kT^2/C_P \quad (44)$$

Where, k = Boltzmann's constant, T = temperature in kelvin, ρ = density, $\gamma$ = ratio of specific heats, $C_P$ = specific heat at constant pressure and α = coefficient of expansion.

**12.19. Excess parameters**

The excess values are calculated using the formula; [2]

$$A_{EXCESS} = A_{EXP} - A_{IDEAL} \quad (45)$$

Where, $A_{id} = \sum A_i X_i$, where $A_i$ is any acoustical parameter and $X_i$ is the mole fraction of liquid component.

**13. Investigation of organic compound**

In the present work, the organic compounds under taken for investigation are: Butylamine, tert-Butanol, benzaldehyde, Methanol, Ethanol etc. The chemicals used were obtained from Ranboxy Fine Chemicals Limited. All the chemicals were purified by standard procedures discussed by Perrin and Armarego before use and the purity of each chemical was verified by literature comparison of their physical parameters. [2]

**14. Conclusions**

A survey of authors' scientific investigations in the field ultrasound velocity measurements in electrolyte solutions and various liquid systems is presented.

The main experiments were provided with a specially design ultrasonic laser interferometer within the frequency range from 1 to 12 MHz. The structural properties of solutions were determined, such as kinetic parameters for the formation of inner sphere complexes. Hydration phenomenon was investigated across the lanthanide series in order to explain non-monotonous variation of relaxation parameters. Volume change provided molecular interactions such as solvent-solvent and dipole-dipole interactions. The computed acoustical parameters and their values point to the presence of specific molecular interaction in the mixture.

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