ULTRASONIC STUDIES ON BINARY MIXTURES OF TRICHLORO ETHYLENE WITH 1-HEXANOL AT ROOM TEMPERATURE

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Abstract:

Ultrasonic studies find extensive use in the studies of the behavior of liquids and liquid mixtures as these help in the determination of many thermodynamic properties in addition to indicating the presence of specific interactions.

Recently with the introduction of ultrasonic waves into variety of applications like acoustic microscopy, medical probing, non – destructive evaluating calculation etc., good acoustic medical processing, low ultrasonic velocity and absorption have been necessitated. The study of ultrasonic propagation in binary liquid systems has taken a new turn from conventional one. The interest now shifted to liquid mixtures possessing low ultrasonic velocity and low attenuation. Various thermo acoustic parameters of the binary mixtures of Trichloroethylene with the selected liquid were calculated by using experimental quantities such as ultrasonic velocity, density, viscosity. The work forms part of an overall program of investigation on the application of ultrasonic velocity to understand the nature of molecular interaction in a binary liquid mixture using trichloroethylene as a common component. One aromatic hydrocarbon has been chosen for this investigation.

Ultrasonic velocity in binary mixtures with a detailed description along with the experimental details for the measurement of ultrasonic velocity using interferometer of 2MHz**.** It is presented

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in this thesis. It also presents the Experimental Techniques and theoretical consideration relating to the measurement of density by specific gravity bottle method. The Experimental method for the measurement of viscosity adopting Oswald's Viscometer at room temperature (303.15K) is also included. It also describes the theoretical considerations and various standard equations used for evaluating several parameters and their excess quantities. The results are published in the light of earlier results.

Keywords: Binary mixtures, Trichloro Ethylene, hexanol

Introduction:

The measurement of ultrasonic velocity in liquids and liquid mixtures is used as an effective tool to probe into the properties of liquid-liquid mixtures which are thermodynamically very important as part of the studies of thermodynamic, acoustic and transport aspects. In a mixture the intermolecular forces of liquids shows a considerable effect on various physical and chemical properties[2]. There is a continuous need for reliable thermodynamic data of binary systems for chemical industries as the data is essential in the design of process involving chemical separation, heat transfer, mass transfer and fluid flow.

Ultrasonic technology finds many applications in the fields of Physics, Chemistry, Biology and Medicine. Ultrasonic measurements are useful in chemical & food processing, material testing, under water ranging and cleaning. Ultrasonic vibrations are mostly employed in mechanical machinery of materials[20], preparation of colloids or emulsions, the pregermination of seeds, imaging of biological tissues and in non-destructive testing (NDT). Ultrasonic AFM can improve fabrication technologies on nanometer scale[3]. Ultrasound eliminates friction at a nanometer scale[19].

Knowledge of density and viscosity is fundamental characteristics which are essential in the design processes involving chemical separations, equipment design, solution theory, heat transfer, fluid flow and molecular dynamics. The data on viscosity are useful for testing the theories and empirical relations of liquid mixtures and that is elucidated in the works of Grunberg and Nissan[5], Tamura and Kurata[18] Hind et al[8], Katti and Chaudhri[10], Heric[6]etc.

Mixing volume effects are also important both theoretical and practically. The above phenomenon is significant in many practical applications especially in paints, varnishes and printing ink industries where volume effects are also involved in the conversion of formulation from gravimetric to volumetric analysis[11]. The thermodynamic properties have a lot of importance in terms of their application to reduce capital costs by designing industrial equipment with better precision.

The excess thermodynamic functions introduced by Scatchard in the year 1931, provided a way to represent directly the deviation of solution from ideal behavior. The difference between the thermodynamic function of mixing for a real system and the value corresponding to a perfect solution at the same temperature, pressure and composition is called the excess thermodynamic parameters denoted by super script E.

Thus any excess parameter Y^E is given by

$$Y^E = Y^M_{real} - Y^M_{ideal}$$

Various theories of solutions have been developed to predict the properties of liquid mixtures composition and independently observable properties of pure components. These theories were formulated to account for the departure of a real solution from the ideal behavior. Theories concerning excess volumes of binary liquid mixtures had been thoroughly reviewed and discussed by Rowlingson[14], Flory[4], Scott and Fenby[16], Hijmens and Holleman[7], Baattino[1] and Kehiaian[12].

Vander Waals and Van Laar proposed the initial theories of binary liquid mixtures. These theories successfully explained certain excess properties in critical region of liquid mixtures. In an attempt to improve Van Laar's theory, Hildebrand, Scott and Scatchard[15] used Hildebrand's[9] concept of regular solutions to formulate a relation for excess volume.

Redlich and Kister1[13] proposed an empirical equation to predict Y^E values for binary mixtures.

$$Y^E = X_1X_2[A_o + A_1(X_1 - X_2) + A_2(X_1 - X_2)^2$$

Where A_0, A_1 and A_2 are constants and X_1 and X_2 are the mole fractions of the two components.

In general, the excess thermodynamic functions such as excess compressibility, excess internal pressure, excess free volume and excess Gibb's free energy are much useful in understanding the nature of molecular interaction in binary and ternary liquid systems. The study of the ultrasonic velocity and their interpretation in the molecular structure had been made by several research workers.

Extensive studies of the ultrasonic velocity in liquids and liquid mixtures and their interpretation in the light of molecular structure have been made by several investigators[22]. From a study of ultrasonic velocity measurements in a large number of organic liquids, the following general conclusions have been drawn about the dependence on molecular structure.

1. Liquids having higher density give lower ultrasonic velocity but not necessarily in proportion.
2. Long molecules generally give rise to higher velocity even though their density is higher.
3. Aromatic compounds have usually higher velocities than the aliphatic compounds even though the density of aromatic compounds is higher.
4. A double bond of unsaturation in liquids is found to be resulting in low velocity.
5. Polar molecules like alcohols, ketones, acetic anhydride, nitrobenzene, aniline, acetophenone, cyclo hexanol and water have higher velocities.
6. A decrease in velocity is observed by substitution of a heavier atom in place of lighter atom.
7. In non-polar groups, the viscosity of amines and alcohols will not differ much and increase with increase in chain length.
8. In isomeric amines, the branched amines exhibit greater viscosity than those of the straight chains.

The literature survey on the ultrasonic studies indicates that enormous work has been carried out in binary and ternary liquid mixtures of weak and strong interacting systems. Moreover, thermodynamic properties of these liquid mixtures are of interest for different branches of science and engineering and also play significant role in technological processes, biological

process of living organisms and in nature. This fact has encouraged the author to carry out a series of systematic investigations on the solvent properties of these liquid mixtures.

In the Chemical industry, there exists a continuing need of reliable thermodynamic data of binary liquid systems. This is particularly true for systems involved in industrial process. With this objective in mind We have chosen Trichloroethylene, and 1-hexanol as components of binary liquid mixtures at the temperature of 303.15K over the entire composition range and measured the variations of the ultrasonic velocity (u) in ms^{-1}, density (ρ) in Kg m^{-3} and viscosity (η) cp of all the six binary liquid mixtures at the temperature of 303.15K over the entire composition range. From these measured values, the following thermodynamic and transport parameters, which are useful for understanding the nature of the interaction in the binary mixtures, are evaluated.

The data obtained can be used to understand intermolecular interactions between the unlike molecules and to test the theories of solutions. The departure of these real mixtures from ideal behavior can be explained in terms of effect of hydrogen bond breaking, loss of dipolar association, differences in size and shapes, dipole-dipole interactions between different component molecules.

Methodology:

The methods commonly used for the measurements of ultrasonic velocity of liquids are:

1. Methods based on the measurement of radiation pressure of plane progressive waves.
2. Interferometer methods.
3. Optical methods.
4. Echo – Pulse method (double crystal)
5. Pulse – Echo interferometer method (Single crystal)

Experimental Details of Ultrasonic Interferometer:

An Ultrasonic interferometer is a simple and direct device to determine the ultrasonic velocity in liquids and liquid mixtures with a high degree of accuracy. A variable path single crystal

interferometer has been employed for the study of ultrasonic velocity. The ultrasonic interferometer consists of the two parts.

(i) The high frequency generator

(ii) Measuring Cell

The High Frequency Generator:

The high frequency generator is designed to excite the Quartz crystal fixed at the bottom of the measuring cell. A micrometer to observe the changes in current and two controls for the purpose of sensitivity regulation and initial adjustment of the micrometer and provided on the panel of the high frequency generator.

The Measuring Cell:

The measuring cell of the interferometer is a nickel coated double walled brass jacket of inner diameter 1.5 cm and outer diameter 4.4 cm. with a capacity of 12 ml. The temperature of the liquid in the cell can be maintained constant by circulating water through the annual space between the two walls. The bottom portion of the cell is partially closed leaving an opening of 1.95 cm in diameter. A gold plated x – cut quartz crystal of natural frequency 2 MHz is held in its position by three screws and tightened with optimum pressure by three nuts. The inner surface of the crystal touching the bottom of the cell acts as the ground terminal. The measuring cell is provided with a heavy pedestal having a cylindrical socket into which the former can be exactly fixed and taken out easily with high stability. By this arrangement, the measuring cell can be easily separated into three parts to facilitate its cleaning and to change the experimental liquid. The socket contains a mesh type material at the bottom, at the centre of which a small pin is fixed. The tip of this pin exactly fits into the central hole of the non conducting material attached behind the crystal to support the latter.

When the cell is placed into this socket, the tip of the pin comes in contact with the outer surface of the crystal through a spring and a circular brass strip attachment as shown in fig. The output of the high frequency generator can be directly fed to the cell through this pin to excite the crystal to its natural frequency. A fine micrometer screw has been provided at the top, by means of which the reflector plate can be moved in the liquid. The pitch of the screw used to move the

reflector is ½ mm and the head scale consists of 50 divisions. There is also provision of another venire having 10 divisions to read the head scale coincidence precisely. With these provisions, the least count of the micrometer is

$$L.C = 1/2 \text{ X } 1/50 \text{ X } 1/10 \text{ mm. } 1/1000\text{mm} = 0.01 \text{ mm}$$

Principle:

The crystal acting as a transducer is driven at its resonant frequency by a higher frequency generator, generating plane waves which travel through the liquid as before being reflected back to the transducer. Thus column of liquid terminated by the reflector acts like an acoustic transmission line so that the impedance seen by the transducer will be

$$Z_X = Z_O [Z_t + Z_o \tan h \{(\alpha + jk)(l-x)\}/Z_o + Z_t \tanh\{(\alpha + jk)(l-x)\}]$$

where Z_X is the impedance at a point x, 'l' the distance between the transducer and reflector. Z_o and Z_t are the acoustic impedances for the medium and the reflector respectively.

The absorption coefficient (α) for the medium and k the phase shift constant is given by k= 2P/l since the transducer is operating at resonance. This acoustic impedance will be transformed directly through the ideal transformer of the transducer equivalent circuit and appear as an electrical impedance in parallel with transducer's static capacitance. If this static capacitance is tuned out, by shunting it with an inductance to form a circuit resonating at the transducer's resonant frequency and the transducer is fed via a resistor R from constant amplitude source, the current flowing from the source will vary as the distance between the transducer and reflector is varied. If we denote the generator voltage by E and the acoustical impedances transformed through the transducer ideal transformer by Z_o^1 and Z_t^1 for the medium and the reflector respectively, the current 'i' flowing from the generator is given by

$$i = E[Z_o^1 + Z_t^1 \tan^2 kl / Z_o^{1\,2} + (R + Z_t^l)^2 + (R\, Z_t^1 + Z_o^l)^2 \tan^2 kl]$$

Neglecting the medium, and the electrical and mechanical losses of the transducer. The current shows maximum, when $1/\lambda = 2n+1/4$ and minimum when $1/\lambda = n/2$ where n is an integer.

Thus the maxima are spaced at λ/2 a part, as are also the minima. The variation in current with reflector position is shown in the Fig.1. The exact shape of the current variation with reflector position depends upon whether the medium is a gas or a liquid. With a gas, the current minima are more sharply defined than the maxima, while the opposite tends to hold for a liquid. This effect arises from the greater loading on the transducer produced by a liquid compared to a gas.

Since, the interferometer theory assumes that the waves traveling in the medium are perfectly plane, the transducer diameter has been made sufficiently large to cover many wavelengths. Alternatively, the transducer and the reflector have been made to cover the cross sectional area of the cylinder containing the liquid column, so that the column acts like a waveguide to make it possible for many modes of propagation. The lowest or plane wave mode will be propagated if the transducer acts like a piston. The transducer and the reflector are so made that their faces are plane for perfect parallelism between them. If the two surfaces are not parallel, the current curves become asymmetric broader than it should be and in extreme cases secondary peaks may appear. The electrical generator driving the transducer also has been made to exhibit a high degree of frequency stability by using a crystal controlled oscillator, so that the frequency does not shift appreciably during the time of taking the observations.

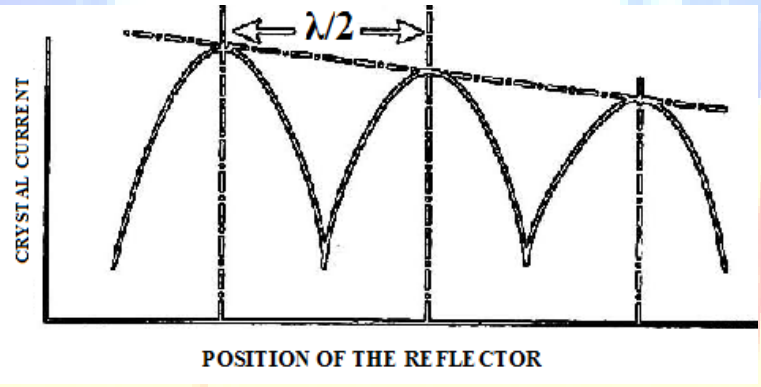

Fig.1: Interferometer transducer current as a function of the separation between transducer and the reflector

Adjustment of the Two Knobs:

The high frequency generator is connected with cell by co – axial cable provided with the instrument. For the initial adjustment, two knobs, on high frequency generator, one is marked with "Adj" and the other with "Gain" are provided. The position of the needle on the ammeter is adjusted with the knob marked, "Adj" and the knob marked "Gain" is used to increase the

sensitivity of the instrument for greater deflection. The numbers of maximum deflections while micrometer is moved up and down are noted with the micro ammeter.

Measurement of Ultrasonic Velocity:

The ultrasonic velocity can be determined using the relation.

Velocity = wavelength x Frequency

$c = \lambda \times f$

The frequency of the generator used in the studies is 2 MHz.

i.e., $f = 2 \times 10^6$ Hz.

After setting the instrument, the micrometer screw was slowly worked till the anode current meter on the high frequency generator shows a maximum.

Let the number of such maxima readings of the anode current as passed on while moving the micrometer screw is counted for n peaks. Then the total distance'd' thus moved on the micrometer will be

$$d = \frac{n\lambda}{2}$$

In the present study 20 peaks are counted so the above relation will be

$$d = \frac{20\lambda}{2} = 10\ \lambda \quad \text{.....1}$$

(or)

$$\lambda = \frac{d}{10}\ \text{mm.} \quad \text{..... 2}$$

$$= d \times \frac{1}{10} \times \frac{1}{1000}\ \text{meters}$$

Therefore $c = \lambda f = d \times \frac{1}{10} \times \frac{1}{1000} \times 2 \times 10^6$

$= 200\ d$ m/sec. 3

Where d is in mm.

Thus by multiplying the value of the distance through which the reflector is moved for 20 peaks with 200, we get the velocity directly in meters/sec.

The accuracy of the velocity mainly depends on the accuracy of the distance that can be measured by the micrometer as 'd' can be measured up to a least value of 0.001 mm. with the micrometer. Velocity measurements were accurate to ± 0.02%

Technical specifications:

1. High Frequency Generator

Main Voltage	:	220 V, 50c/s
Measuring Frequency	:	2 MHz.
Slow Lamp	:	6.3 V, 0.3A
Fuse	:	150mA
Size	:	41 x 30 x 13 cm.
Weight	:	3.5kg. approx

2. Measuring Cell:

Maximum displacement of the reflector : 25mm

Required quantity of liquid : 12cc.

Least count of micrometer : 0.001 mm

Size : 10.5 X 11.5 X 31cms

Weight : 3.75 kg. approx

3. Shielded Cable:

Length of the connecting cable between the generator and the cell: 50 cu.ms. approx

4. Technical details :

Temperature Range	:	Ambient to 85 C
(Accuracy > 1 C or better.)		
Temperature Sensors	:	PT 100
Thermocouple Maximum load	:	500w

Experimental procedure:

The liquid mixture in which the ultrasonic velocity has to be determined is taken in the cell, which is placed over the pedestal. The micrometer head is gradually moved so that the reflector

is at a maximum position from the crystal. Now the micrometer head is gently rotated so as to enable the reflector to move towards the crystal. At a particular position of the reflector, the current in the microammeter shows a maximum. The exact reading of the micrometer in this position is noted. This reading corresponds to the 0^{th} peak. In the same manner the micrometer readings for the 1^{st}, 2^{nd}, 3^{rd}, 4^{th} and 20^{th}, 21^{st}, 22^{nd}, 23^{rd}, 24^{th} peaks are noted by rotating the head in the same direction, thereby eliminating back lash error. The difference between the micrometer readings corresponding to 0^{th} and 20^{th} peak gives the distance moved by the reflector for 20 peaks. In the same manner, the difference between the readings corresponding to 1^{st} and 21^{st}, 2^{nd} and 22^{nd}, 3^{rd} and 23^{rd}, 4^{th} and 24^{th} and 5^{th} and 25^{th} peaks are noted and finally the average value of the distance moved by the reflector for 5 peaks (d) is noted. Using the value of d, the ultrasonic velocity in the experimental solution is calculated using the relation c = 200 d m/sec. For studying the temperature variation of ultrasonic velocity the same interferometer is used along with a thermostat. Experimental set up of the same is as shown in fig. 2.

The different organic liquids used in the present study are of high grade purity. The liquids are further distilled before used. They have been mixed in the desired proportions using burette and are kept for 4 or 5 hours to attain thermal equilibrium before taking the experimental observations. The densities of all the liquids and liquid mixtures have been measured using a 10ml specific gravity bottle. The weightings are taken correct to 0.1 mg. by means of chemical balance. The viscosities have been determined by means of Ostwald's viscometer. The measurements of densities, viscosities and velocities for all the mixtures have been made at 303.15K. The temperature of the circulating liquid has been maintained to an accuracy of ± 0.05˚C by an electrically controlled thermostat. In the entire experimental work, measurements have been made three to four times for consecutive readings and the average values have been taken into consideration.

Fig. 2 Ultrasonic Interferometer with water bath

Purification of solvents:

Purity in a thermodynamic sense implies that the substance behaves in a system of more than one phase as one and the only independent component, so that it possesses a sharp defined chemical potential, which is the same in all operations. For practical purposes, it may be stated that a material is sufficiently pure if it does not contain impurities of such nature and in such quantity as to interfere with the use for which it is intended.

From the latter viewpoint, it is clear that the purity of a substance directs the experimental results to be accurate and precise or not. So, it is essential to ensure that the chemicals used for this study are of the purest form.

Various methods of purification have been described in the Literature[17,21] and these methods have been designed based upon the nature and functional groups of the chemicals to be purified. The different organic liquids used in the present study are of high quality samples. The liquids are distilled before use, and have been mixed in the desired proportions using burette and are kept for 5 or 6 hours to attain thermal equilibrium before taking the experimental observations. Dissolved gases in organic liquids are often a source of bubble formation, which introduces error in density measurements. In order to overcome this difficulty, all the liquids were degassed.

Measurement of density:

The densities of pure liquids and liquid mixtures have been measured by employing a 10ml specific gravity bottle. The volume of specific gravity bottle is standardized using double distilled water at 303.15K, the density of liquid is given by the relation.

Density = (Weight of liquid/Weight of water) x density of water at that Temperature.

The densities of water at the four temperatures studied have been taken from the literature. In order to maintain the temperature constant, the specific gravity bottle with the experimental solution is immersed up to the neck in the thermostat with the thermal stability of $\pm$0.05K. The accuracy in the measurement of density employing the specific gravity bottle is better than

±0.01%. Weight measurements in the present study are made employing a single pan electronic balance capable of measuring up to 0.5mg.The uncertainty of mole fraction computed from the measurement of mass and density is estimated to be less than $\pm 1 \times 10^{-4}$.

Measurement of viscosity:

Viscosity measurements of the mixed solvents and pure solvents have been carried out by the Ostwald's glass capillary viscometer. It consists of two limbs A and B. Limb 'A' consists of a large bulb at the bottom in which the liquid can be taken. Limb 'B' consists of a capillary and two markings are drawn on it. Initially the viscometer is thoroughly cleaned and dried using a hot air blower.

Precautions:

1. The generator should not be switched on without filling the experimental liquid in the cell.
2. Cell should be kept clean and dry and the liquid should be removed immediately.
3. The micrometer should be kept open at 25mm. after use.
4. Sudden rise or fall in temperature of circulated liquid should be avoided to prevent thermal shock to the quartz crystal.
5. While cleaning the gold plating on the quartz crystal should not be scratched.
6. The generator should be on 15sec. before observations are taken for allowing it to warm up.

Theoretical considerations:

The variation of ultrasonic velocity and adiabatic compressibility can be explained with the knowledge of intermolecular forces existing in the liquid. Three kinds of forces existing between the neutral molecules have been recognized. These forces are due to dipole-dipole interaction, induced dipole interaction and dispersion interaction. The dipole-dipole interaction is the strongest of the three and dispersion interaction is the weakest. These interactions vary as $1/R^6$, where R is the intermolecular separation.

The adiabatic compressibilities are computed from the equation

$\beta_{ad} = 1/\rho U^2$ ……..4

In the case of liquid mixtures, Jacobson has established a relation between the intermolecular free length (L) and the ultrasonic velocity as

$U L_f \rho^{1/2} = K$ ……. 5

$L_f^2 = K^2/\rho U^2 = K^2 \beta_{ad}$ …… 6

where K is Jacobson's constant

Properties of liquids chosen for study:

Trichloroethylene (HCIC=CCICI):

It is used as a refrigerant heat exchange liquid, solvent for pains. It is miscible with common organic solvents. Slightly Soluble in Water. It is non flammable. It is toxic on inhalation. It is used in metal degreasing, extraction of solvents for oils, fats, waxes, solvent for dyeing, dry cleaning, refrigerant and heat exchange liquid. Fumigant, cleaning and drying electrical parts, diluents in paints, textile processing, chemical intermediate, aerospace operations.

Theoretical Values at 303.15K :

Density = 1.4556gm/cc

Boiling point = 80.1 C (176.2 F)

Solubility in water = 1.8 gm/l

1 - Hexanol ($C_6 H_{13}$ OH):

Colourless liquid with characteristic odour.

Boiling point = 157C

Melting point = -44.6C

Relative density = 0 .82 gm/cc

Solubility in water = g/100ml

Theoretical Values at 303.15K :

Density = 0.81165 gm/cc

Viscosity = 4.683 centipoise

Velocity = 1273 m/sec

Results:

The present work deals with the ultrasonic studies of binary liquid mixtures of trichloroethylene with 1-Hexanol as a function of increasing molefraction at 303.15K temperature. A number of acoustic parameters based on ultrasonic velocity have been evaluated. These include adiabatic compressibility ($ß_s$), Intermolecular free length (L_f), Rao's constant(R), Wada's constant (W) and Acoustic impedence(Z). The variations of these parameters explain the nature and strength of interactions between the molecules of binary liquid systems.

Trichloroethylene + 1-Heptanol

TEMPERATURE-303.15 k

Mole fraction X	(u) m/s)	$\rho\times10^{-3}$ kg/m3	η cp	V_m cm^{-3} mol^{-1}	B_{ad} 10^{12} M^2 N^{-2}	L_f 10^{-10} m	R	W	Z
0.0000	1275.5	0.8117	4.68344	125.8839	75.7257	0.5456	6337	3514	1035.32
0.1342	1248.31	0.8792	4.1688	120.6817	72.9930	0.5357	6031	3386	1097.48
0.2586	1219.40	0.9464	3.6798	115.9456	71.0606	0.5285	5750	3266	1154.05
0.3741	1190.40	0.0135	3.2179	111.6024	69.6288	0.5232	5490	3153	1206.47
0.4818	1163.12	0.0801	2.7812	107.6382	68.4395	0.5187	5254	3048	1256.23
0.5824	1137.27	0.1460	2.3671	104.0072	67.4654	0.5150	5039	2952	1303.33
0.6766	1112.52	0.2111	1.9695	100.6860	66.7103	0.5121	5843	2862	1347.41
0.7650	1089.06	0.2752	1.5900	97.6525	66.1187	0.5098	4663	2779	1388.75
0.8480	1066.64	0.3379	1.2258	94.8880	65.6958	0.5082	4500	2703	1427.06
0.9262	1045.25	0.3988	0.8755	92.3869	65.5397	0.5077	4351	2633	1460.74
1.0000	1016.00	1.4559	0.5365	90.2466	66.5397	0.5115	4211	2566	1479.19

Table – 1: The experimental data of binary mixtures of trichloroethylene with 1-Heptanol

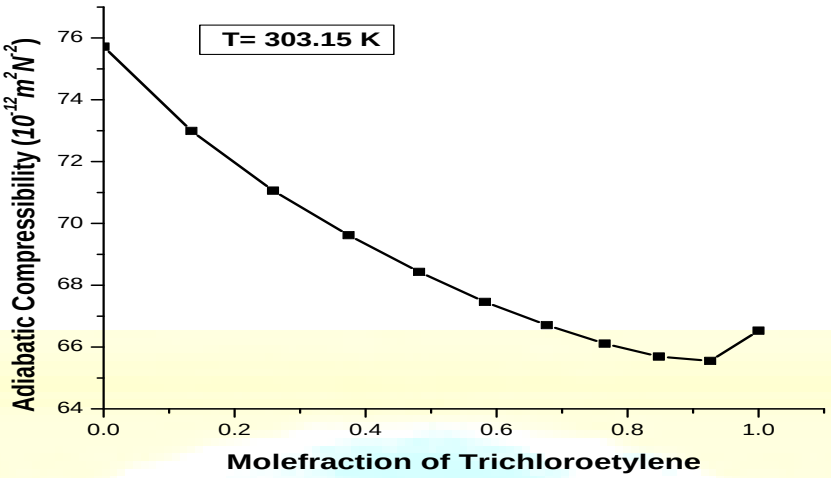

Fig.3: Variation of Adiabatic compressibility with mole fraction of trichloroethylene

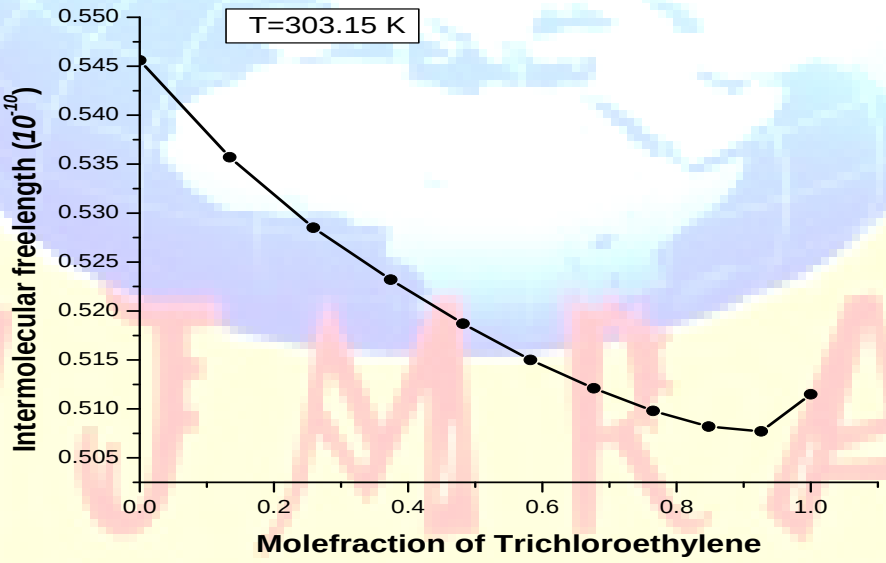

Fig.4: Variation of intermolecular free length with mole fraction of Trichloroethylene.

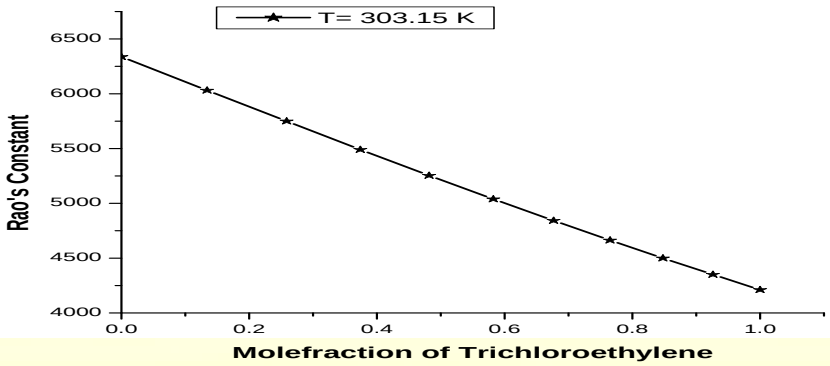

Fig.5: Variation of Rao's constant with mole fraction of Trichloroethylene.

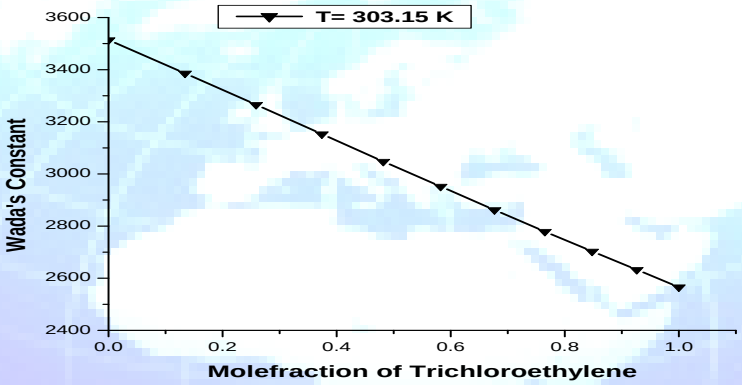

Fig.6: Variation of Wada's constant with mole fraction of Trichloroethylene.

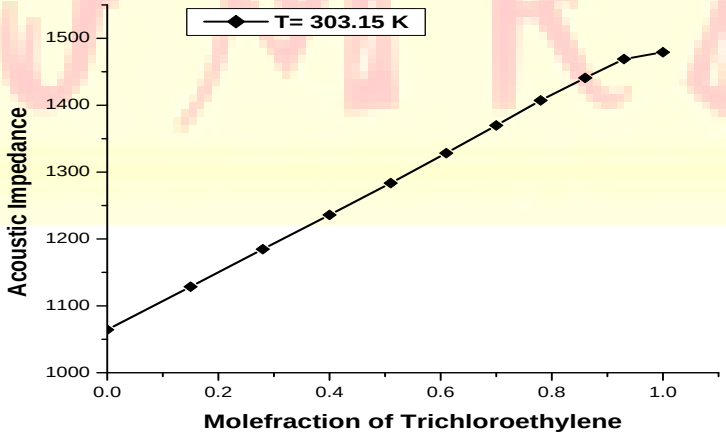

Fig.7: Variation of Acoustic impedance with mole fraction of Trichloroethylene

Discussion:

The experimental data of ultrasonic velocity (u), density (p) and calculated values of adiabatic compressibility ($ß_s$), Intermolecular free length (L_F), Rao's constant(R), Wada's constant (W) and Acoustic impedence (Z) of binary mixtures of trichloroethylene with 1-Heptanol are reported in the Table – 1.

Fig.3 shows Ultrasonic velocity (u) of all these systems shows a linearity variation with mole fraction of trichloroethylene. This linearity has been described to the existence of molecular association of trichloroethylene with 1-Hexanol.

Density (p) of the binary mixtures of trichloroethylene with 1-Hexanol shows linearity behavior.
Fig.4 shows Intermolecular free length (L_f) is the distance between two adjacent surface molecules and the variation of liquid mixture systems shows linearity behavior.
From Fig. 5 and Fig.6, it is observed that ultrasonic velocities (u) is in increasing trend while inter molecular free lengths (L_f) is in decreasing trend in binary liquid systems. Selected both are inversely proportional to each other.

Fig.7 shows Variation of acoustical impendence (Z) indicates linearity and increasing trend and adiabatic compressibility ($ß_s$) values show a in decreasing trend which presents in the respective graphs.
Acoustical impendence (Z) and adibatic compressibility ($ß_s$) values obtained in the present interaction are in agreement with the values reported in literature.

Conclusion:

The ultrasonic parameters such as. Adiabatic compressibility (β_s), intermolecular free length (L_f), Rao's constant (R), Wada's constant (w), Acoustic constant (Z), are calculated for the binary liquid mixtures of trichloroethylene with 1-Hexanol at 303.15K . It is found that, there is a presence of molecular association in all the systems

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