iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** IV **Month of publication:** April 2018

DOI: http://doi.org/10.22214/ijraset.2018.4554

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue IV, April 2018- Available at www.ijraset.com

Study of Different Parameters for Binary Mixture of Liquid Using Ultrasonic Interferometer

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Abstract*: The binary mixtures of nitrobenzene with acetophenone containing different ultrasonic properties have been studied at room temperature at a fixed frequency of 2 MHz. The ultrasonic related physical parameters like velocity (U), density (ρ), viscosity (η), adiabatic compressibility (βad),effective mass, free volume (vf), , relaxatation time, intermolecular free length, isentropic compressibility(Ks) are determined. The result is interpreted in terms of molecular interaction such as dipole-dipole interaction through hydrogen bonding between components of mixtures.
Keywords; Ultrasonic Velocities, Thermodynamic Parameters,

I. INTRODUCTION

The adaptable non-destructive technique, Ultrasonic is highly useful for the investigation of various physic-chemical properties such as intermolecular free length, free volume, adiabatic compressibility and shear's relaxation time. Current developments have been found the utilization of ultrasonic energy in medicine, engineering and agriculture.[1-3]The study of molecular interaction has a key role in the development of molecular science. The molecular interactions and the structural behaviour of molecular and their mixtures can be recognized with the help of ultrasonic studies. Ultrasonic velocity jointly with density and viscosity data provide the wealth of information about the interactions between ions, dipoles, hydrogen bonding, multi-polar and dispersive forces. Ultrasonic, thermo-physical and thermodynamic properties of liquid mixtures have large scale implication in gaining the in depth knowledge of inter and intra-molecular interactions, structural and physiochemical behaviour and also in confirming 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 completed for accurate measurement of the velocity of sound in liquids. The path length in the cell is diverse by motion of a reflector, at the electrical reaction of the cell upon. The oscillator is utilized 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 the excellent quantitative way to elicit information about molecular structure and intermolecular forces in liquid mixtures. This has given momentum 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.

II. EXPERIMENTAL AND THEORETICAL WORK

A simple and direct device which is Ultrasonic interferometer produces precise and reliable data, from which one can determine the velocity of ultrasonic sound in a liquid medium with a high degree of accuracy. Mittal Enterprises, New Delhi deliver a crystal controlled interferometer (model number M-83S) operating frequencies ranging from 1 to 12 MHz has been utilized to calculate the ultrasonic velocity. The ultrasonic sound refers to the sound pressure with a frequency better than the human available range (20 Hz to 20 KHz). When an ultrasonic wave transmits 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 amongst molecule. The simplest and direct appliance which is Ultrasonic interferometer utilized to verify the ultrasonic velocity in liquid with a high amount of accuracy. The ultrasonic waves are formed in this device, by the piezoelectric technique. The wavelength of the sound in an experimental liquid medium is calculated at a particular frequency variable path interferometer. From this, one could estimate its velocity through that medium. The ultrasonic cell has a double walled brass cell with chromium plated surfaces which consist of the capacity of 10 ml. Water circulation is permitted by the double wall around the experimental liquid to maintain it at a known constant temperature. The μm scale is noticeable in units of 0.01 mm. It also has a general length of 25 mm. A quartz crystal forms the ultrasonic waves of known frequency which is fixed at the bottom of the cell. There is a variable metallic plate parallel to the

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quartz plate, which reflects the waves. The waves interfere with their reflections. If the separation between the plates is precisely a numeral multiple of half wave length of sound, standing waves will be formed in the liquid medium. Acoustic resonance occurs under these circumstances. The resonant waves are a maximum in amplitude. It produces a corresponding maximum in the anode current of the piezoelectric generator.

A. Adiabatic compressibility (β)

Adiabatic compressibility were considered from the speed of sound (U) and the density of the medium (ρ)using Newton and Laplace equation as-

$$\beta = \frac{1}{U^{2\rho}}$$

B. Free volume (Vf)

Free volume obtained from the ultrasonic velocity (U) and the viscosity (η) of the liquid as-

$$Vf = \left(\frac{Meff\, U}{K\eta}\right)^{3/2}$$

C. Relaxation Time (τ)

Relaxation time calculated from the adiabatic compressibility and viscosity using the relation-

$$\tau = \frac{4}{3}\eta\beta$$

D. Isenotropic Compressibility

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

$$Ks = \frac{1}{U\rho}$$

This give rise the well-known Laplace's equation, where ρ Density of the medium and U is velocity. The importance of the isentropic compressibility is determining the physio-chemical behaviour of liquid mixtures.

E. Intermolecular free length (Lf)

Estimation of intermolecular free length in liquids and in liquid mixtures has been a subject of considerable interest and semi-empirical relation to achieve the concept of intermolecular free length in order to explain the ultrasonic velocity in liquids as, the intermolecular free length is the distance covered by wave between the surfaces of the neighbouring 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

$$Lf = KT\sqrt{\beta}$$

III. RESULTS AND DISSCUTION

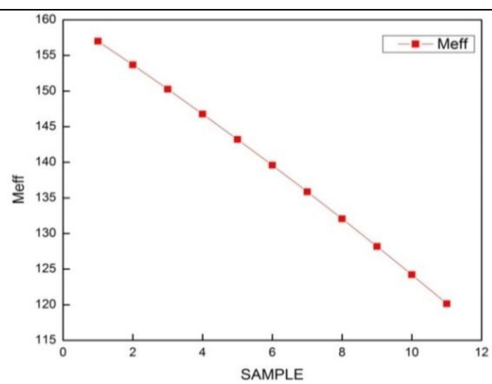

Fig 1:Effective mass of sample respectively nitrobenzene and acetophenone

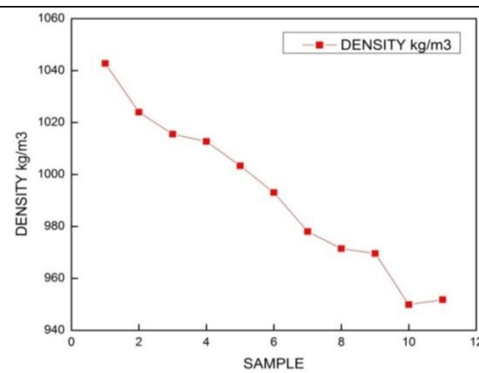

Fig 2: Density change with respect to sample

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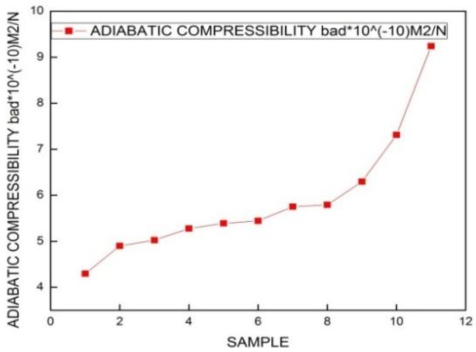

Fig 3: adiabatic compressibility change with respect to sample of ultrasonic velosity

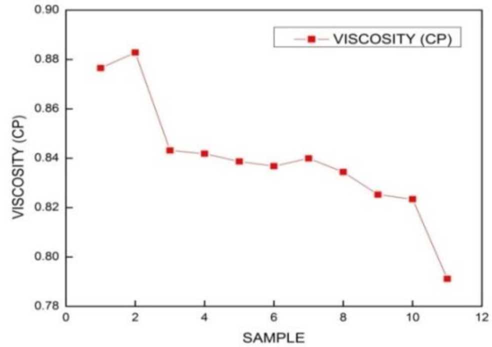

Fig 4: Viscosity change with respect to sample

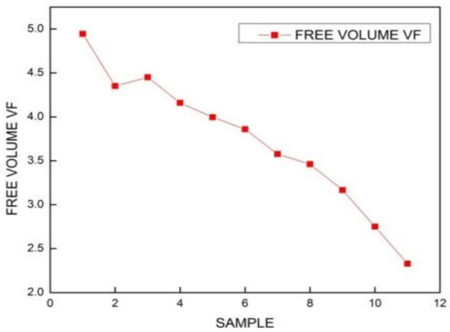

Fig 5: Graph of free volume increasing with refers to the sample

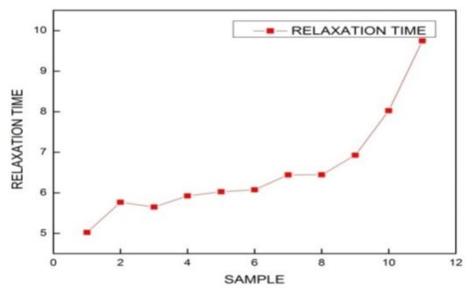

Fig6: Relaxation time with respect to sample

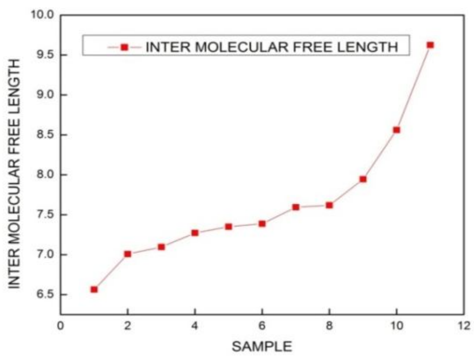

Fig7: Inter molecular free length with respect to sample

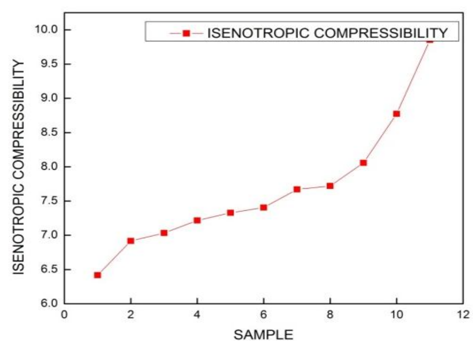

Fig8: Isenotropic compressibility with respect to sample

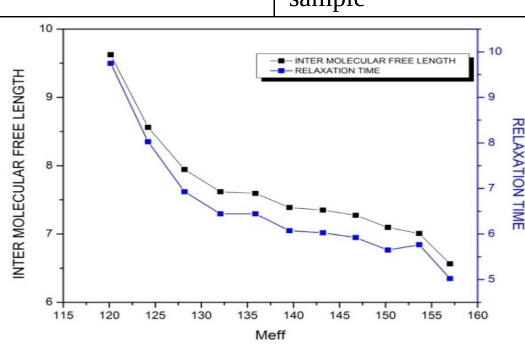

Fig 9: Relaxation time with respect to sample

Fig. 1 shows effective mass of sample respectively nitrobenzene and acetophenone. This graph is the simple arithmetic graph, as we are increased the acetone and decreased the nitrobenzene in sample there is linearly decreased the effective mass of samples. Fig 2 shows Density change with respect to sample. Density is measured with instrument. It can also calculate with effective mass. As we are increased the acetone and decreased the nitrobenzene in sample there is linearly decreased the Density of samples. Fig 3 shows adiabatic compressibility change with respect to sample of ultrasonic velocity Decreasing the nitrobenzene in the sample, the adiabatic compressibility is increased due to increased acetone in sample. Fig 4 shows Viscosity change with respect to sample. Viscosity is inversely proportional to the adiabatic compressibility. Means that adiabatic compressibility is increased at that time Viscosity is decreased. Fig 5 shows Graph of free volume increasing with refers to the sample. One of the significant factors in explaining the variations in the physio-chemical properties of liquids and liquid mixtures is free volume. Two or more liquids are mixed together. The free space and its dependent properties have close connection with molecular structure and it may show interesting features about interactions, which may occur. By structural arrangements along with shape and size of the molecules, this molecular interactions between like and unlike molecules are influenced. The molecules of a liquid are not quite closely packed and there are some free spaces between the molecules for movement and the volume Vf is called the free volume. The free volume as the effective volume in which particular molecule of the liquid can move and obey perfect gas laws is defined by Eyring and Kincaid. The free volume is decreased with decreased Nitrobenzene sample.

Fig 6 shows Relaxation time with respect to sample. The time taken for the excitation energy to appear as translational energy and it depends on temperature and on impurities is the relaxation time. Causes of dispersion is the dispersion of the ultrasonic velocity in binary mixture reveals information about the Characteristic time of the relaxation process . Fig7 shows Inter molecular free length with respect to sample. The distance covered by the sound wave between the surfaces of the neighboring molecules is the intermolecular free length. Intermolecular attractions between the components is in binary mixture is measured by Inter molecular free length. Weakling and strengthen of intermolecular attraction is indicated by the increase or decrease in free length. As the ultrasonic velocity increase due to the increases in concentration, the interaction free length has to decrease and vice-versa,

Fig 8 shows Isentropic compressibility with respect to sample. Isenotropic compressibility is linearly increased with sample. Fig 9 shows Relaxation time with respect to sample. 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.

Table:1 Experiment result density and calculated effective mass, adiabatic compressibility, viscosity, free volume, relaxation time, Isenotropic compressibility and free length

SAMPLE	DENSITY Kg/M^3	MEFF	ADIABATIC COMPRESSIBILITY	VISCOSITY (CP)	FREE VOLUME VF	RELAXATION TIME	ISENOTROPIC COMPRESSIBILITY	FREE LENGTH
1	1042.73	157.01	4.2966	0.8765	4.9441	5.0215	6.4191	6.5631
2	1023.97	153.66	4.8982	0.8828	4.3514	5.7658	6.9163	7.0076
3	1015.53	150.25	5.0239	0.8431	4.4504	5.6480	7.0335	7.0970
4	1012.72	146.77	5.2763	0.8418	4.15994	5.9224	7.2180	7.2731
5	1003.34	143.21	5.3885	0.8387	3.9967	6.0258	7.3284	7.3500
6	993.03	139.57	5.4445	0.8367	3.8588	6.0743	7.4045	7.3880
7	978.02	135.86	5.7525	0.8399	3.5763	6.4425	7.6692	7.5941
8	971.46	132.06	5.7913	0.8344	3.4616	6.4432	7.7210	7.6197
9	969.58	128.18	6.2949	0.8252	3.16601	6.9265	8.0575	7.9441
10	949.89	124.21	7.3107	0.8233	2.7506	8.0261	8.7728	8.5611
11	951.77	120.15	9.2390	0.7911	2.3276	9.7458	9.8525	9.6242

Table shows that as increased acetophenone in binary mixture we are achieved experiment results are decreased relatively binary mixture. Calculated values are effective mass decrease 157.01 to 120.15, adiabatic compressibility is increased 4.2966 to 9.2390, Viscosity is increased with 0.8765 to 0.7911,free volume is decreased 4.9441 to 2.3276, Relaxation time is increased 5.0215 to 9.7458.Isenotropis compressibility is increased 6.4191 to 9.8525 and free length is increased from 6.5631 to 9.6242.

IV. CONCLUSION

A survey of authors' scientific investigations in the field ultrasound velocity measurements in binary liquid systems is presented. The main experiments were provided with a specially design ultrasonic interferometer within the frequency range from 1 to 12 MHz. Kinetic parameters for the formation of inner sphere complexes the structural properties of solutions were determined. Volume change provided molecular interactions such as solvent-solvent and dipole-dipole interactions. Our simple experimental set up we are achieved good agreement results comparing other experiment data. In binary mixture as we increasing acetophenone there are decreased density, effective mass and free volume. But there are increased adiabatic compressibility, viscosity, relaxation time, isentropic compressibility and free length. The computed acoustical parameters and their values point to the presence of specific molecular interaction in the mixture.

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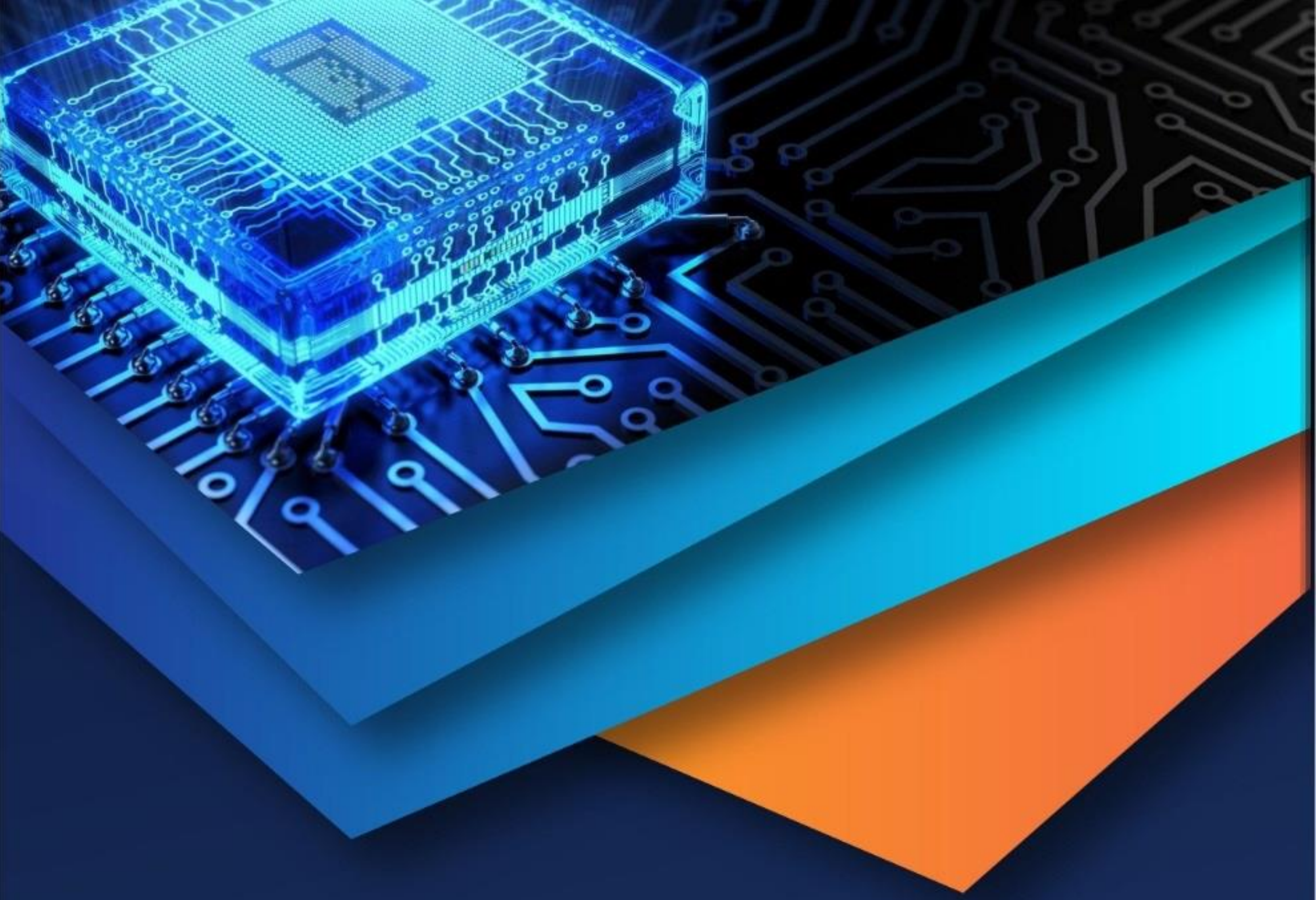

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