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Study of Interactions in Water Solutions of Lemon Drops by Ultrasonic and viscometrical Measurements

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ABSTRACT
In the present study ultrasonic velocity (U), density (ρ) and viscosity (η) have been measured at frequency 1 MHz . The measured value of ultrasonic velocity, density and viscosity have been used to estimate the acoustical parameters namely adiabatic compressibility (βa), relaxation time (τ), acoustic impedance (z), free length (Lf), free volume (Vf) and internal pressure (Pi),Wada's constant to investigate the nature and strength of molecular interaction in solution with water. The obtained result supports the occurrence of complex formation, molecular association through intermolecular hydrogen bonding in the mixture.

Key Words: ultrasonic velocity, density, viscosity, molecular interaction, intermolecular hydrogen bonding**,**

INTRODUCTION
Ultrasonic non-destructive testing is resourceful technique that can be appropriate to study molecular interactions in liquids, liquid mixtures and solutions. Ultrasonic propagation parameters yield valuable information regarding the behavior of solutions, because intermolecular association, complex formation, dipole interaction and related structural changes affect the compressibility of the system which produces corresponding variations in the ultrasonic velocity. Ultrasonic technique has been adequately employed to investigate the properties of any substance to understand the nature of molecular interactions in pure liquid, [1] liquid mixtures [2-3] and solutions [4]. Drug action, although complex result from various kinds of physico-chemical interactions, e.g. Ion dipole, ionic or covalent, hydrogen bonding, charge transfer interactions, hydrophilic interactions etc.[5-6] All the form kinetic processes involve transport of drug across biological membranes, which can be understood by transport property measurements such as ultrasonic velocity, viscosity, thermal conductivity and diffusion. A number of researchers [7-12] have investigated the molecular interaction in aqueous solution of different antibiotics in the recent years. Acoustic and thermodynamic parameters have been used to understand different kinds of association, the molecular packing, molecular motion and various types of intermolecular interactions and their strengths influenced by the size in pure components and in the mixtures [13-17]. Excess parameters play a vital role in assessing the compactness due to molecular arrangement and the extent of molecular interactions in the liquid mixtures through charge transfer, dipole-dipole and dipole induced dipole interactions [18]. The sign and the extent of deviation of these functions from ideality depend on the strength of interactions between unlike molecules [19].In the present studies, the ultrasonic velocity of lemon juice in water have been measured and various acoustical parameters have been calculated. The results are interpreted in terms of molecular interaction occurring in the solution. Ultrasonic waves are used in many applications including plastic welding, medicine, jewelry cleaning, pipe inspection, and nondestructive test. Within nondestructive test, ultrasonic waves give us the ability to 'see through' solid / opaque material and detect surface or internal flaws without affecting the material in an adverse manner. It had been identified, about 200 years ago, that dogs could hear [20]. This canine ability is often used in police departmental work and by dog trainers. These sound waves are used by bats as a kind of navigational radar for night flying [21].Even blind people unconsciously develop a similar method by which obstacles are sensed by the reflected echoes of their footsteps or the tapping of a cane. In the field of technology, the waves are being used to measure depth of sea, directional signaling in submarine, and mechanical cleaning of surface soldering [22], and to detect shoals of fish. Acoustic sonograms have become an important medicinal diagnostic tool which is widely used nowadays [23]. Ultrasonic waves are used for both diagnosis and therapy. It includes the detection of wide variety of

anomalies, such as tumor, bloodless surgery, and proper extraction of broken teeth, cardiology, and stone fragmentation [24]. Ultrasound is more sensitive than X-rays in distinguishing various kinds of tissues. It is believed to be less hazardous than X-rays, although possible hazards of ultrasound have not yet been thoroughly explored [25]. The unique feature of sound wave property is that it gives direct and precise information of the adiabatic properties of solution. The data of velocity of sound in very few liquids were available up to 1930. The discovery of interferometry and optical diffraction method improved the investigation, both qualitatively and quantitatively. Most of the information extracted from ultrasonic study of fluids is confined to the determination of hydration number and compressibility [26-27]. The successful application of acoustic methods to physicochemical investigations of solution become possible after the development of adequate theoretical approaches and methods for precise ultrasound velocity measurements in small volumes of liquids [28-29]. In the present paper, acoustical studies have been studied in water at different temperatures over a wide range of concentrations. From the experimental values a number of thermodynamic parameters namely ultrasonic velocity, adiabatic compressibility, acoustic impedance, relaxation time, free length, free volume, internal pressure, Rao's constant, ultrasonic attenuation, cohesive energy, and molar volume, Wada's constant has been calculated. The variation of these parameters with concentration was found to be useful in understanding the nature of interactions between the components [30-35].

MATERIALS AND METHODS.

Chemicals were purchased from local commercial suppliers and are of laboratory grade. Lemon used in the present work Solution of different concentration were prepared by water as solvent. The ultrasonic velocity (U) have been measured in ultrasonic interferometer Mittal Model-F-05 with an accuracy of 0.1%. The viscosities (η) of binary mixtures were determined using Ostwald's viscometer by calibrating with doubly distilled water with an accuracy of ±0.001 PaSec. The density (ρ) of these binary solution were measured accurately using 25 mL specific gravity bottle in an electronic balance, precisely and accurately. For this, the water and lemon juice was taken in the measuring cell, for the purpose of calibration of instrument. The current in the micro-ammeter was adjusted to 40 μA for maximum deflection and suitable adjustments were made for the minimum. The reading of screw showing every 20 minima was noted. Ultrasonic velocity was calculated using the following formula. The frequency of ultrasonic wave is 1MHz. The basic parameter U, η, and ρ were measured at various concentrations. The various acoustical parameters were calculated from U, η, and ρ values using standard formulas. On using ultrasonic velocity ,density and viscosity the following acoustical parameters like adiabatic compressibility (κ) [36] , intermolecular free length [37] (Lf) , relaxation time [38] (Ʈ), free volume [39] (Vf) , internal pressure [40] (Πi) , acoustic impedance [41] (Z), Wada's constant [42] (W), ultrasonic attenuation [43] (α/f^2), Rao's constant [44] (R), molar volume (Vm), and cohesive energy (CE) were calculated by applying the following expressions.

1.Ultrasonic velocity (υ): The relation used to determine the ultrasonic velocity is given by,

$$\upsilon = f \times \lambda \ ms^{-1}$$

Where, f - Frequency of ultrasonic waves, λ - Wavelength

2. Adiabatic compressibility (κ): Adiabatic compressibility is defined as,

$$\kappa = (1/\upsilon^2 \rho)\ kg^{-1}\ ms^2$$

Where, υ – Ultrasonic velocity, ρ – Density of the solution.

3. Free volume (V_f): Free volume in terms of the ultrasonic velocity (υ) and the viscosity of the liquid (η) are calculated by formula

$$Vf = (M\,\upsilon/k\eta)^{3/2}\ m^3$$

Where, M is the molecular weight and 'k' is a temperature-independent constant equal to 4.281×10^9 for all liquids.

4. Acoustic impedance (Z): The acoustic impedance is computed by the formula

$$Z = \upsilon \times \rho\ kg\ m^{-2}\ s^{-1}$$

5. Free length (Lf): It is calculated on using formula,

$$L_f = (K\sqrt{\kappa})$$

K - Jacobson temperature dependent constant defined as $K = (93.875 + 0.345T) \times 10^{-8}$, κ =Adiabatic compressibility.

6. Ultrasonic Attenuation (α/f^2): It is calculated by,

$$\alpha/f^2 = 8\pi^2\eta/3\rho\upsilon^3$$

7. Viscous relaxation time (Ʈ): It is calculated by using the relation,

$$Ʈ = 4\eta/3\rho\upsilon^2$$

8. Rao's Constant (R): Rao's constant is calculated by using formula,

$R = V . \upsilon_{3}^{1}$ or $R = \left(\frac{M}{\rho}\right) \upsilon_{3}^{1}$

M= Molecular Weight.

9.Wada's constant (W): It was calculated by formula,

$W = M. \kappa^{-1/7} / \rho$

10. Internal pressure(Πi): On using below-cited formula, Internal pressure is calculated,

$$\Pi i = b \ RT \left[\frac{k \ \eta}{v}\right]^{2} \frac{\rho_{3}^{2}}{M_{6}^{7}}$$

11.Molar volume: It is the ratio of density & molecular weight.

$$Vm = \frac{\rho}{M}$$

12.Cohesive energy (CE) **:** Cohesive energy is calculated by formula quoted below,

$CE = \Pi i Vm$

RESULT AND DISCUSSION

From the table of ultrasonic velocity in different concentration of lemon juice in water are slightly decreases and increases at room temperature, this is may be due to the breaking and making of hydrogen bonds in water medium .The ultrasonic velocity of acidic water is near about the ultrasonic velocity of distilled water. It gives the approximately ultrasonic properties of water and acidic water remains unchanged.

Table:-ultrasonic velocity v/s no of lemon juice drop in 50 ml water

Sr. No.	No. of lemon drop in 50 ml water	Ultrasonic velocity(m/s)
1	0	1500
2	1	1502.1
3	2	1498.94
4	3	1500
5	4	1503.15
6	5	1501
7	6	1501
8	7	1502.1
9	8	1501.05
10	9	1501.05
11	10	1501.05
12	11	1503.16
13	12	1497.89
14	13	1498.94
15	14	1500.00
16	15	1503.15

The following figure shows the variation of ultrasonic velocity of water when lemon drops are added.

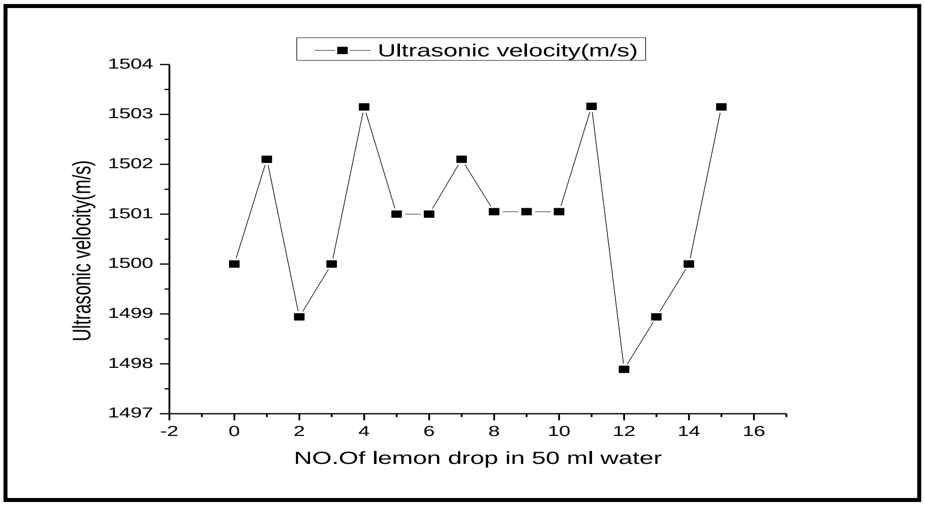

Figure: Ultrasonic velocity v/s no. of lemon drop in water

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