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Non destructive evaluation of dichlofenac sodium by ultrasonic technique

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ABSTRACT

In solution the study of propagation of ultrasonic waves is useful for analyzing certain physical parameters. Science and technology of ultrasonic is widely used in recent years for industrial and medicinal application .Dichlofenac Sodium is a potent non steroidal anti inflammatory drug widely used in pharmaceutical because of its anti-inflammatory analgesic and antipyretic effect. Physiochemical behavior and molecular interaction occurring in the aqueous solution of Dichlofenac Sodium can be studied with the help of ultrasonic velocity. Speed sound measurement has been done by multifrequency ultrasonic interferometer at 2MHZ frequency. From the values of ultrasonic velocity, density, viscosity the thermodynamic parameters such as free volume, Wada's constant evaluated. The results have been interpreted in terms of solute solvent interaction.

Key Words: Dichlofenac Sodium, ultrasonic, free volume, thermodynamic parameters

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INTRODUCTION

In the recent years many attempts have been made in the field of physical acoustics and ultrasound on solids, liquids and gases. The use of volumetric, acoustic and thermodynamic studies in liquids, binary mixtures and solution was carried out to study molecular interaction [1-8]. Drug macro molecular interactions are important phenomenon in physiology such as blood membrane and intra, extra cellular fluids [9-11]. All Pharmokinetics process involve transport of drugs across biology membrane which can well understood by transport property measurement such ultrasonic velocity, viscosity, diffusion, and thermal conductivity [12]. L. Fele Zilink etal [13] studied the solubility of sodium Dichlofenac in different solvent.

The present work deals with the measurement of ultrasonic velocity, viscosity and evaluation of acoustic and thermodynamic parameters for aqueous solution of Dichlofenac sodium at 303.15K at different concentration which is in continuation of our work [14-16]. From acoustical parameters effect of concentration on molecular interaction and solute solvent interaction through hydrogen bonding is interoperated.

MATERIALS AND METHODS

The chemicals used were of analytical grade. Double distilled water was used for preparation of solutions. A special thermostatic water bath arrangement was made for density, ultrasonic velocity and viscosity measurements, in which continuous stirring of water was carried out with the help of electric stirrer and temperature variation was maintained within $\pm 0.01^0$C multi frequency interferometer (Mittal Enterprises, Model F-83) with accuracy of ±0.03% and frequency 2 MHz was used in the present work for measurement of ultrasonic velocities of solutions. Densities of solutions were measured using specific gravity bottle of 10ml volume. These values were accurate up to

± 0.1 kg/m^3. All the weighing was made on Roy CCB-4 digital electronic balance having an accuracy of ± 0.0001g. Viscosities of the solution were measured by Ostwald's viscometer.

RESULT AND DISCUSSION

From the observed values the adiabatic compressibility, specific acoustic impedance, relative association, intermolecular free length, relaxation time, free volume, Rao's constant, Wada's constant were calculated.

Adiabatic compressibility was calculated by using the equation

$$\beta = 1/v^2.d \qquad \text{...... (1)}$$

Where, v = velocity & d = density

Specific acoustic impedance is determined from equations,

$$Z = v_s.d_s \qquad \text{...... (2)}$$

Relative association is a function of ultrasonic velocity and is calculated by the equation,

$$RA = \frac{d_s}{d_0}\left(\frac{v_0}{v_2}\right)^{\frac{1}{3}} \qquad \text{...... (3)}$$

Where, v_0 and v_s are ultrasonic velocities in solvent and solution respectively.

Intermolecular free length (L_f) is one of the important acoustic properties to study the intermolecular interactions. It has been evaluated from adiabatic compressibility (β) by Jacobson's formula,

$$L_f = K.\sqrt{\beta_S} \qquad \text{...... (4)}$$

Relaxation time is calculated by following equation

$$\tau = 4/3\ \beta\eta \qquad \text{...... (5)}$$

Free volume is calculated by following equation

$$V_f = [M_{eff}v/K\ \eta]^{3/2} \qquad \text{...... (6)}$$

Where, M_{eff} is effective molecular weight, K is a temperature independent constant which is equal to 4.28 x 10^9 for all liquids.

Rao's constant and Wada's constant is also a measure of interaction existing in the solution.

Rao's constant is calculated by using following equation.

$$R = [M_{eff}/d_s]v^{1/3} \qquad \text{...... (7)}$$

Wada's constant is calculated by following equation.

$$W = [M_{eff}/d_s]\ \beta^{-1/7} \qquad \text{...... (8)}$$

The experimentally determine values are listed in table -1.

Table 1: Ultrasonic Velocities, densities and viscosities of Dichlofenac sodium Solution at different concentrations

Concentration (M)	Ultrasonic Velocity (m/s)	Density (kg/ m^3)	Viscosityx10^{-3} (kg $m^{-1}sec^{-2}$)
0.001	1524.48	1009.61	0.8215
0.01	1563.58	1020.96	0.8567
0.1	1601.30	1038.33	0.9642

Table 2: Acoustical parameters of Dichlofenac Sodium solution at different concentrations

Concentration (M)	Adiabatic Compressibility $\beta x10^{-10}$	Specific Acoustic Impedance Zx10^4 (Kg$m^{-2}sec^{-1}$)	Intermolecular free length L_f (A^0)	Relative association R_A	Acoustic relaxation time $\tau x10^{-10}$ (Sec)
0.001	4.2	15.3913	0.01290	1.008	4.66
0.01	4.00	15.9653	0.01255	1.010	4.57
0.1	3.75	16.6347	0.01214	1.020	4.82

Table 3: Thermodynamic parameters of Dichlofenac Sodium solution at different concentrations

Concentration (M)	Free Volume Vfx10^{-8} (m^3/mole)	Rao's Constant R (m^3/mole)(m/s)$^{1/3}$	Wada's Constant W (m^3/mole)(N/m^2)$^{1/7}$
0.001	1.20	0.2052	0.3889
0.01	1.34	0.2052	0.3890
0.1	1.73	0.2087	0.3963

Velocity, viscosity and density increases as concentration increases shown in table 1. Increase in ultrasonic velocity in any solution with addition of solute is indicative of greater association of molecules due to effective solute-solvent interaction [17]. Ultrasonic velocity increases on increasing the concentration of solute may be attributed to cohesion brought about by the association among the molecule and greater solute -solvent interaction.

The adiabatic compressibility value decreases with increasing concentration indicates formation of strong hydrogen bonding between solute and solvent. Viscosity is another parameter in understanding structure as well as molecular interaction occurring in the solution. Increase in viscosity of the solution with increase in concentration shows strong molecular interaction in the solution. Intermolecular free length decreases as concentration increases shows strong interaction between solute and solvent. Relative association increases on increasing concentration shows molecular interaction due to hydrogen bonding between solute and solvent. Increase of free volume with increase in concentration of Dichlofenac sodium shows strong molecular interaction. Rao's constant has same value at 0.001M and 0.01M but increases at 0.1M shows molecular interaction strong at 0.1M. Wada's constant shows nonlinearity indicates presence of molecular interaction.

CONCLUSION

The acoustical and thermodynamic parameters calculated from measured properties suggest the strong hydrogen bonding at high concentration in the solution. Ultrasonic investigations in aqueous solution of Dichlofenac sodium at different concentrations give useful information in understanding interaction of solute with solvent.

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