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EVALUATION OF ULTRASONIC PARAMETERS OF AQUEOUS SOLUTION OF DICHLOFENAC SODIUM

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ABSTRACT

The ultrasonic study can give the information of complex formation through hydrogen bonding in the system. Ultrasonic is an area of intense scientific and technological research. Ultrasonic parameters provide valuable information about various inter and intra interaction in solutions. Dichlofenac Sodium is an analgesic and used in pharmaceuticals. Ultrasonic velocity, density and viscosity were reported for aqueous solution of Dichlofenac Sodium at different temperatures. The ultrasonic velocity and its derived parameters were employed to investigate solute-solvent interaction.

Key words: Ultrasonic velocity, Solute solvent interaction.

INTRODUCTION

The study of intermolecular interaction plays an important role in the development of molecular science. The large number of studies have been made on the molecular interaction in liquid system by various physical methods like dielectric constant[1,2] infra red[3,4] and ultrasonic method[5-8]. The study of ultrasonic waves through the solution is used for knowing the nature and strength of the intermolecular forces and their interaction in pure liquids and their mixtures.

In the present paper in continuation of our work [9-11] by measuring ultrasonic velocity, density and viscosity at different temperatures the thermodynamic parameters such as adiabatic compressibility, acoustic impedance, intermolecular free length, and free volume Rao's constant were calculated. The results were interpreted in terms of molecular interaction. The effect of temperature on molecular interaction is interpreted.

EXPERIMENTAL

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 ± 0.01^0C multi frequency interferometer (Mittal

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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 ± 0.0001 g. Viscosities of the solution were measured by Ostwald's viscometer.

RESULTS 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

$$\beta = 1/v^2.d \quad \ldots(1)$$

Where, v = velocity & d = density

Specific acoustic impedance is determined from equations,

$$Z = v_s.d_s \quad \ldots(2)$$

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

$$RA = \frac{d_s}{d_0}\left(\frac{v_0}{v_2}\right)^{\frac{1}{3}} \quad \ldots(3)$$

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,

$$L_f = K.\sqrt{\beta_s} \quad \ldots(4)$$

Relaxation time is calculated by following equation

$$\rightarrow = 4/3\ \beta\sigma \quad \ldots(5)$$

Free volume is calculated by following equation

$$V_f = [M_{eff}v/K\ \sigma]^{3/2} \quad \ldots(6)$$

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.

$$R = [M_{eff}/d_s]v^{1/3} \quad \ldots(7)$$

Wada's constant is calculated by following equation.

$$W = [M_{eff}/d_s]\ ß^{-1/7} \quad \ldots(8)$$

The experimentally determine values are listed in Table 1.

Table 1: Ultrasonic velocities, densities and viscosities of dichlofenac sodium solution at different temperatures

Temperature (K)	Ultrasonic velocity (m/s)	Density (kg/ m^3)	Viscosity x 10-3 (kg m-1sec^{-2})
303.15	1601.30	1038.83	0.9642
308.15	1564.25	1036.96	0.7957
313.15	1526.12	1030.52	0.7550

Table 2: Acoustical parameters of dichlofenac sodium at different temperatures

Temperature (K)	Adiabatic compressibility β x 10^{-10}	Specific acoustic impedance Z x 10^4 (K $gm^{-2}sec^{-1}$)	Intermolecular free length (L_f)	Relative association (R_A)	Acoustic relaxation time $\rightarrow$ x 10^{-10} Sec.
303.15	3.75	16.6347	0.01214	1.0200	4.82
308.15	3.94	16.6206	0.01253	1.0350	4.18
313.15	4.16	15.7269	0.01298	1.0398	4.19

Table 3: Thermodynamic parameters of dichlofenac sodium at different temperatures

Temperature (K)	Free volume V_f x 10^{-7} (m^3/mole)	Rao's constant (R) (m^3/mole) $(m/s)^{1/3}$	Wada's constant (W) (m^3/mole) $(N/m^2)^{1/7}$
303.15	1.730	0.2087	0.3963
308.15	1.252	0.2075	0.3942
313.15	1.120	0.2071	0.3963

At 303.15 K and 308.15 K the ultrasonic velocities of aqueous solution of dichlofenac sodium is higher than water while at 313.15 K it is lower than water. It means that at lower temperatures there is greater association of molecule in them .It is due to phenomenon like hydrogen bonding or ionic hydration of solutes. At lower temperature hydrogen bonding strong so ultrasonic velocity is more.

As temperature increases the N-H bond in dichlofenac sodium becomes weaker and hence thermal vibration in the molecule increases which causes increase in adiabatic compressibility. The presence of electron withdrawing group on benzene ring decreases its electron densities and hence degree of self association is less at high temperature increasing the free length. Due to presence of electron donor of N-H bond in dichlofenac sodium dipole-dipole interaction is dominant which gives compact structure and hence free volume decreases as temperature increases.

Variation in acoustic relaxation time is mainly due to the change in the viscosity of the solution due to change in temperature. As temperature increases relative association increases while Rao's constant, Wada's constant decreases shows that weak solute – solvent interaction present in the solution.

CONCLUSION

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

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