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Thermodynamic properties of Paracetamol (Pure form) in aqueous solutions at 303 & 308 K

S. N. Khachane, Ritesh R. Naik*,
Department of Applied Science, Padm. Dr. V. B. Kolte College of Engineering and Polytechnic, Malkapur,
Department of Chemistry, D.D. Bhoyar College of Arts &Science, Mouda, Dist: Nagpur-441104

ABSTRACT- In the present study, ultrasonic velocity (υ), density (ρ), and viscosity (η) have been measured at frequency 1 MHz in the binary mixtures of paracetamol with water in the concentration range (0.1 to 0.0125%) at 303 K and 313 K using a multifrequency ultrasonic interferometer. The measured value of density, ultrasonic velocity, and viscosity have been used to estimate the acoustical parameters, namely adiabatic compressibility (κ), relaxation time (τ), acoustic impedance (z), free length (L_f), free volume (V_f), and internal pressure (Πi),Wada's constant(W), The obtained results support the complex formation, molecular association by intermolecular hydrogen bonding in the binary liquid mixtures.
Keywords- paracetamol, free volme , acoustical parameter, ultrasonic velocity

INTRODUCTION

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 [1]. 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 [2]. 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 [3], and to detect shoals of fish. Acoustic sonograms have become an important medicinal diagnostic tool which is widely used nowadays [4-12]. In the present paper, acoustical studies have been studied in water at different temperatures over a wide range of paracetamol 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 [13-16].

MATERIALS AND METHODS

Paracetamol (pure form) used in the present work was of analytical reagent (AR) grade with a minimum assay of 99.9%, Solution of different concentration of paracetamol were prepared by water as solvent. The ultrasonic velocity (υ) has 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 densities (ρ) of these binary solutions were measured accurately using 25 mL specific gravity bottle in an electronic balance, precisely and accurately. The basic parameter υ, η, and ρ were measured at various concentrations (0.1 to 0.0125%) and temperatures (303 K & 313 K).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) [17] , , intermolecular free length[18] (Lf) , relaxation time [19] (Ƭ), free volume [20]

(Vf) , internal pressure [21] (Πi) , acoustic impedance [22] (Z), Wada's constant [23] (W), ultrasonic attenuation [24] (α/f^2), Rao's constant [25] (R), molar volume (Vm), and cohesive energy (CE) were calculated .

RESULT AND DISCUSSION

The measured values of ultrasonic velocity, density and related thermo-acoustical parameters like adiabatic compressibility (κ, intermolecular free length (L_f) , relaxation time (Ƭ), free volume (V_f) , internal pressure (Πi) , acoustic impedance (Z), Wada's constant (W), ultrasonic attenuation (α/f^2), Rao's constant (R), molar volume

(Vm),cohesive energy (CE) of paracetamol with water at 303 K & 308 K in different concentrations are shown in figure 1 to 14 .

Table 1- Ultrasonic velocity, Density, Viscosity, Adiabatic compressibility, Intermolecular free length, Free volume, Rao's constant of different % concentration of solution of compounds in water at 303 K& 308 K.

a) Solution of paracetamol in water at **303 K**.

Concentration (%)	Density (Kgm^{-3})	Viscosity$x10^{-3}$ (Nsm^{-2})	Ultrasonic Velocity (m/s)	Adiabatic compressibility $x10^{-4}$ (m^2 /N)	Intermolecular Free length $x10^{-8}$ (m)	Free Volume $x10^{-7}$(m^3 mol^{-1})	Rao's constant
0.0125	996	1.503	1529	4.29	4.111	56.731	15.52
0.025	997.6	1.552	1526	4.28	4.106	54.232	15.51
0.05	999.6	1.574	1529	4.28	4.102	53.266	15.49
0.1	1003.2	1.645	1537	4.25	4.088	50.243	15.46

b) Solution of paracetamol in water at **308 K**

Concentration (%)	Density (Kgm^{-3})	Viscosity$x10^{-3}$ (Nsm^{-2})	Ultrasonic Velocity (m/s)	Adiabatic compressibility $x10^{-4}$ (m^2 /N)	Intermolecular Free length $x10^{-8}$ (m)	Free Volume $x10^{-7}$(m^3 mol^{-1})	Rao's constant
0.0125	994	1.2634	1507	4.38	4.223	73.499	15.50
0.025	995.6	1.283	1510	4.37	4.21	72.02	15.49
0.05	996.8	1.293	1511	4.37	4.21	70.22	15.47
0.1	1000	1.36	1517	4.35	4.207	65.51	15.44

Table 2- Internal pressure, Acoustic Impedance, Relaxation time, Ultrasonic attenuation, cohesive energy and Molar volume, Wada's constant, at 303 K&308 K

a) Solution of paracetamol in water at **303 K**

Concentratin (%)	Internal pressure x10^{-4} (Nm^{-2})	Acoustic Impedance x10^{-6} (Kg^{-1} m^2 S^{-1})	Relaxation time x10^{-3} (S)	Ultrasonic attenuation x10^{-11} (s^2m^{-1})	Wada' s constant	Cohesive energy x10^{-4} (KJ/Mole)	Molar volume x10^{-2} (m^3/mol)
0.0125	23.0	1.516	4.668	1.125	4.085	31.17	134.97
0.025	23.4	1.522	4.831	1.153	4.080	31.62	134.76
0.05	23.6	1.52	4.909	1.160	4.073	31.79	134.49
0.1	24.1	1.541	5.166	1.189	4.063	32.38	134.01

b) Solution of paracetamol in water at **308 K.**

Concentratin (%)	Internal pressure x10^{-4} (Nm^{-2})	Acoustic Impedance x10^{-6} (Kg^{-1} m^2 S^{-1})	Relaxation time x10^{-3} (S)	Ultrasonic attenuation x10^{-11} (s^2m^{-1})	Wada' s constant	Cohesive energy x10^{-4} (KJ/Mole)	Molar volume x10^{-2} (m^3/mol)
0.0125	21.9	1.49	3.848	9.782	4.082	29.73	135.25
0.025	22.1	1.50	3.918	9.861	4.077	29.92	137.03
0.05	22.2	1.50	3.951	9.911	4.072	30.02	135.87
0.1	22.8	1.51	4.174	1.026	4.062	30.69	135.44

CONCLUSION

In the present paper the ultrasonic velocity(U), density, viscosity and acoustical parameters, viz. adiabatic compressibility ,intermolecular free length, relaxation time, acoustic impedance , attenuation, Rao's constant, molar volume, cohesive energy, Wada's constant have been measured at different concentrations. The parameters indicate that there is a strong molecular interaction between unlike molecules as the concentration of drug solution increases. The molecular interaction decreases with an increase in temperature.

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