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Research Article

ADIABATIC COMPRESSIBILITY, INTERMOLECULAR FREE LENGTH AND SPECIFIC ACOUSTIC IMPEDANCE OF ANTIBIOTIC AMPICILLIN SODIUM

SUNANDA S. ASWALE[1], SHASHICANT R. ASWALE[1], RAJESH S. HAJARE[2]

[1]Lokmanya Tilak Mahavidyalaya, Wani, Dist. Yavatmal, Maharashtra 445304, [2]Nilkanthrao Shinde College, Bhadrawati, Dist. Chandrapur, Maharashtra. Email: sraswale@gmail.com; ssaswale@rediffmail.com, rajeshhajare34@yahoo.com

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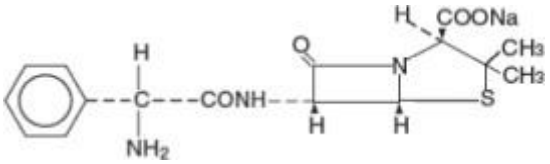
ABSTRACT

Research and development in the field of ultrasonics is growing steadily. Ultrasonic non-destructive testing is a resourceful technique that can be appropriate for the study of liquids, liquid mixtures and solutions. Ultrasonic studies may throw more light on the molecular interaction to know the behavior of solute and solvent molecules in liquid mixtures and solutions. Changes in concentration and temperature affect compressibility of solution, which in turn affects molecular interactions in liquid mixtures and solutions. Experimental measurement of ultrasonic velocity and density have been carried out on aqueous solution of ampicillin sodium at different concentrations, temperatures and different frequencies such as 2MHz, 4MHz and 6MHz. Ultrasonic velocity and density data have been used to calculate acoustical parameter such as adiabatic compressibility, specific acoustic impedance and intermolecular free length have been used to explain solute-solute, solvent-solvent and solute-solvent interaction and structure making and structure breaking properties of solute in aqueous solution of ampicillin sodium.

Keywords: Ultrasonic velocity, Adiabatic compressibility, Specific acoustic impedance, Intermolecular free length, moLecular interactions.

INTRODUCTION

The measurement of ultrasonic velocity in liquid mixtures and solutions has been found to be an important tool to study the physico-chemical properties of liquid mixtures and solutions. Liquids, liquid mixtures and solutions find wide applications in medical, pharmaceutical, chemical, lather, textile, nuclear and solvent, solution related industries. The study and understanding of the thermodynamic properties of liquid mixtures and solutions are more essential for their applications in these industries.[1-4] The measurement of ultrasonic velocity in the combination of density and viscosity have been used to study the molecular interactions in liquid mixtures and solutions. In recent years ultrasonic studies in aqueous antibiotic solution have drawn the attention of several researchers.[5-10] Ampicillin sodium is beta-lactum antibiotic derived from penicillin nucleus and 6-aminopenicillanic acid has been extensively used to treat bacterial infections in pharmaceuticals. It is used to treat urinary tract infections, otitis media, pneumonia, haemophilus influenza, salmonellosis and listeria meningitis.



(Ampicillin sodium)

Literature survey does not reveal any work reported on intermolecular interactions studies of ampicillin sodium by ultrasonic interferometry. In continuation of our earlier work, [11-17] with a view of technological demand in the present investigation, ultrasonic velocity and density measurement of aqueous solution of antibiotic ampicillin sodium have been carried out at different temperatures, concentrations and frequencies. Experimental data obtained have been used to calculate various acoustical parameters. The result obtained from derived acoustical parameters suggests the presence of molecular interaction in aqueous ampicillin sodium solution.

MATERIALS AND METHODS

Antibiotic drug ampicillin sodium obtained from Aristo Pharmaceuticals Private Limited was used. 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 and ultrasonic velocity measurement in which temperature variation was maintained within ±0.01^{0}C Multi frequency interferometer (Mittal Enterprises, Model F-83) with accuracy of ±0.03% was used in the present work for measurement of ultrasonic velocities of solutions. Densities of solutions were measured using specific gravity bottle. These values were accurate up to ± 0.1 kg/m^3. All the weighing was made on CA-124 (CB/CA/CT series, Contech) digital electronic balance having an accuracy of ± 0.0001g.

RESULT AND DISCUSSION

From the observed values the adiabatic compressibility, intermolecular free length and specific acoustic impedance were calculated.

Adiabatic compressibility was calculated by using the equation

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

Specific impedance has been calculated by using the equation

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

Intermolecular free length (L_f) has been evaluated from adiabatic compressibility (β) by Jacobson's formula,

$$L_f = K.\sqrt{\beta_S} \quad \ldots\ldots\ldots (3)$$

The values of acoustic and thermodynamic parameters for aqueous solution of ampicillin sodium at different frequencies are tabulated in tables no. 1, 2 and 3.

Measured values of density, ultrasonic velocity, adiabatic compressibility, intermolecular free length and specific acoustic impedance of aqueous ampicillin sodium solution at different concentrations, temperatures and at different frequencies such as 2MHz, 4MHz and 6MHz are given in Table 1, 2 and 3. Respective graph of ultrasonic velocity, adiabatic compressibility, intermolecular free length and specific acoustic impedance as a function of concentration, temperature and frequency are presented in figures 1, 2, 3 and 4.

It is evident from Tables 1, 2 and 3, that the values of density of aqueous solution of ampicillin sodium increases with increase in concentration and same decreases with increase in temperature. Increase of concentration result in increase in number of particles in given region which leads shrinkage in volume of solution and hence density increases with increase of concentration. The decrease in values of density with increase in temperature is mainly due to decrease of intermolecular forces due to thermal agitation. The ultrasonic velocity increases with increase of concentration and

frequency and same is non-linear with increase of temperature as observed in Fig. 1 and Table 1, 2 and 3. As density increases number of particles in given region is increased, this leads to quick transfer of sound velocity and hence ultrasonic velocity increases with increase of concentration and frequency, this result is according to Kharkale et al.[18] The increase in ultrasonic velocity indicates maximum association among the molecules of aqueous ampicillin sodium solution due to effective solute-solvent interaction. At 4MHz at 308K whereas at 6MHz at 308K and 313K ultrasonic velocity slightly decreases up to 0.01M and then increases. This may be due to self-association of solvent molecules and very weak dipole-induced dipole interaction between components of molecules. The increasing values of density and ultrasonic velocity reflect presence of strong interaction among the molecules of aqueous ampicillin sodium solution.

Table 1: Thermodynamic parameters of Ampicillin sodium at 2MHz.

Temperature (K)	Concentration (M)	Ultrasonic Velocity (m/s)	Density (Kg/m^3)	Adiabatic compressibility$\beta x10^{-10}$	Specific acoustic impedance $Zx10^5$ ($Kgm^{-2}sec^{-1}$)	Intermolecular free length L_f (A^0)
303.15	0.001	1456.63	1024.94	4.59	14.9295	0.0134
	0.01	1528.85	1028.97	4.15	15.7314	0.0127
	0.1	1598.42	1033.77	3.78	16.5239	0.0122
308.15	0.001	1526.69	1019.55	4.21	15.5653	0.0129
	0.01	1526.79	1022.23	4.20	15.6073	0.0129
	0.1	1598.55	1027.55	3.18	16.4259	0.0123
313.15	0.001	1492.82	1017.30	4.41	15.1864	0.0133
	0.01	1563.28	1018.65	4.02	15.9243	0.0127
	0.1	1601.06	1025.79	3.80	16.4235	0.0129

Table 2: Thermodynamic parameters of Ampicillin sodium at 4MHz.

Temperature (K)	Concentration (M)	Ultrasonic Velocity (m/s)	Density (Kg/m^3)	Adiabatic compressibility$\beta x10^{-10}$	Specific acoustic impedance $Zx10^5$ ($Kgm^{-2}sec^{-1}$)	Intermolecular free length L_f (A^0)
303.15	0.001	1598.24	1024.94	3.81	16.3810	0.0122
	0.01	1598.32	1028.97	3.80	16.4462	0.0122
	0.1	1602.92	1033.77	3.76	16.5705	0.0121
308.15	0.001	1598.90	1019.55	3.84	16.3015	0.0123
	0.01	1594.92	1022.23	3.85	16.3037	0.0123
	0.1	1601.12	1027.55	3.80	16.4523	0.0123
313.15	0.001	1599.54	1017.30	3.84	16.2721	0.0124
	0.01	1599.94	1018.65	3.84	16.2977	0.0124
	0.1	1601.67	1025.79	3.80	16.4297	0.0123

Table 3: Thermodynamic parameters of Ampicillin sodium at 6MHz.

Temperature (K)	Concentration (M)	Ultrasonic Velocity (m/s)	Density (Kg/m^3)	Adiabatic compressibility$\beta x10^{-10}$	Specific acoustic impedance $Zx10^5$ ($Kgm^{-2}sec^{-1}$)	Intermolecular free length L_f (A^0)
303.15	0.001	1634.33	1024.94	3.65	16.7509	0.0119
	0.01	1634.72	1028.97	3.63	16.8207	0.0119
	0.1	1639.15	1033.77	3.60	16.9450	0.0118
308.15	0.001	1635.77	1019.55	3.67	16.6774	0.0120
	0.01	1635.03	1022.23	3.66	16.7137	0.0120
	0.1	1637.17	1027.55	3.63	16.8227	0.0120
313.15	0.001	1636.51	1017.30	3.67	16.6482	0.0121
	0.01	1636.03	1018.65	3.67	16.6654	0.0121
	0.1	1639.24	1025.79	3.63	16.8151	0.0121

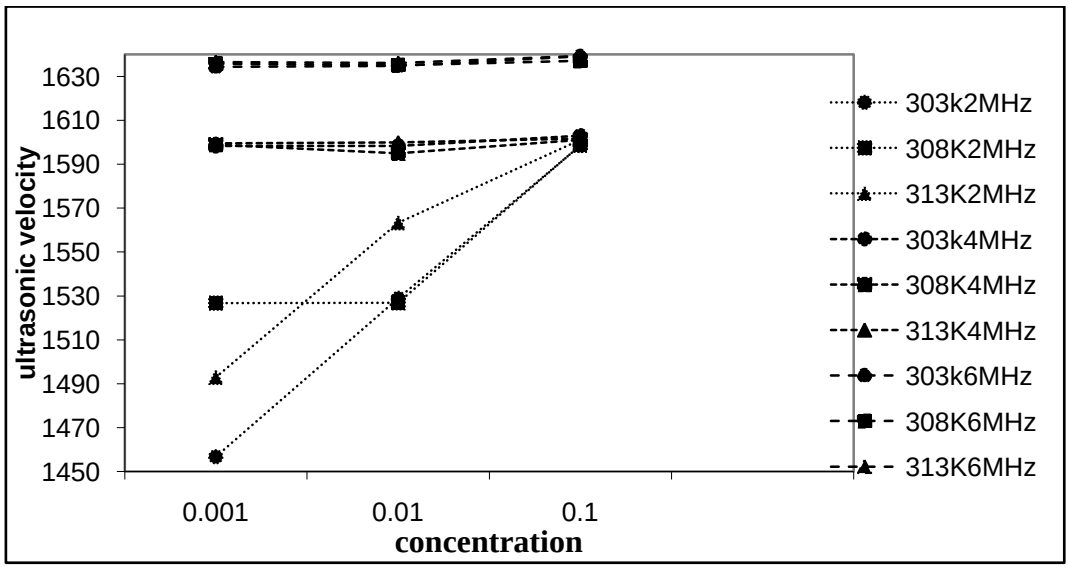


Fig. 1: Variation of ultrasonic velocity with concentration, temperature and frequencies.

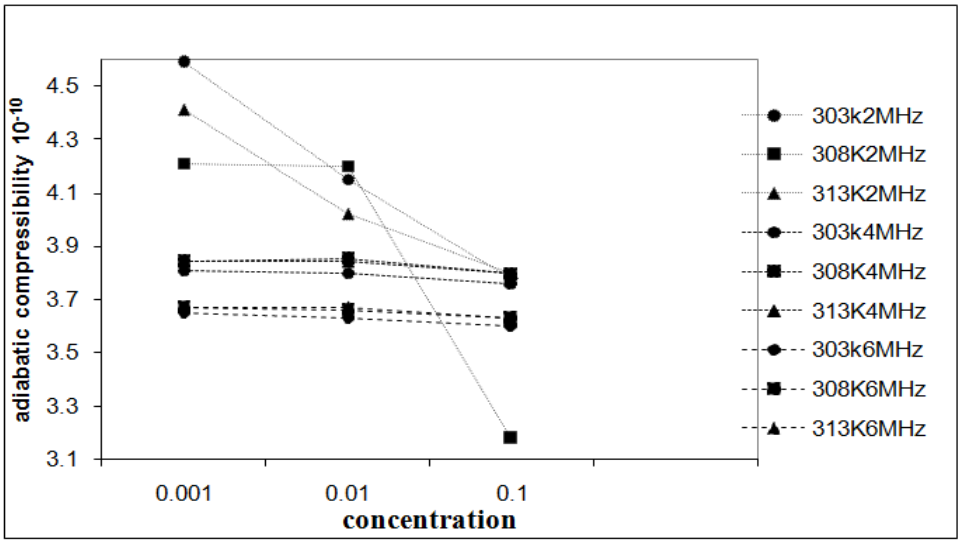


Fig. 2: Variation of adiabatic compressibility with concentration, temperature & frequencies.

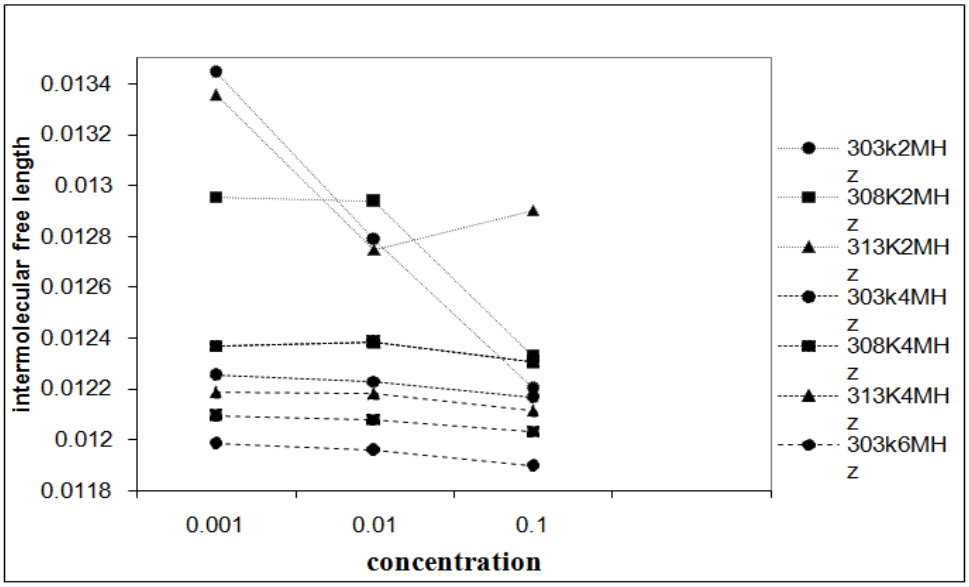


Fig. 3: Variation of intermolecular free length with concentration, temperature and frequencies.

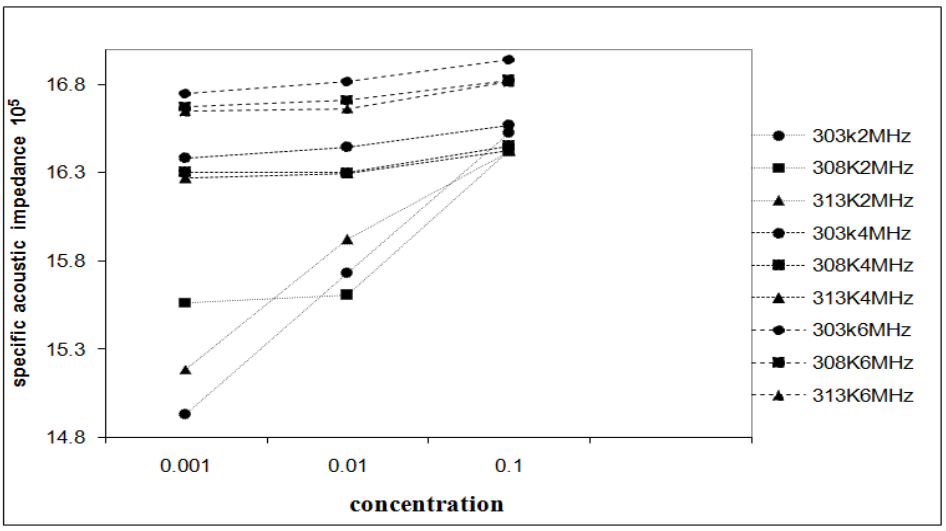


Fig. 4: Variation of specific acoustic impedance with concentration, temperature & frequencies.

Specific acoustic impedance is defined as the impedance offered to the sound wave by the components of mixture. Mathematically it is directly proportional to ultrasonic velocity and inversely proportional to that of adiabatic compressibility and shows similar behavior to that of ultrasonic velocity and opposite to that of adiabatic compressibility. It can be seen from Fig. 4 and Table 1, 2 and 3 that specific acoustic impedance increases with increase of concentration and frequency. At 2MHz it shows non-linear behavior where as at 4MHz and 6MHz it decreases. Increase in specific acoustic impedance with increase of concentration and variation with increase of temperature shows that molecular interactions in aqueous ampicillin sodium solution is associative.[20] This suggests increase in molecular packing in medium and it may further support strengthening of molecular interactions due to hydrogen bonding in aqueous ampicillin sodium solution.

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