International Journal of Scientific Research in Chemistry (IJSRCH)
© 2019 IJSRCH | Volume 4 | Issue 3 | ISSN : 2456-8457

Ultrasonic Studies for Binary Mixtures of Sulphadrug Sulphadoxine and Dioxane at 308 K

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ABSTRACT

Densities, viscosities and ultrasonic velocities of binary mixtures of drug sulphadoxine with dioxane over entire composition range have been measured at 308 K. These data have been utilized to calculate acoustic parameters viz. isentropic compressibility, lowering isentropic compressibility, intermolecular free length, specific acoustic impedance, relative association and solvation number. The results are interpreted in terms of intermolecular interactions between the component of the mixtures.

Keywords :- Ultrasonic Velocity, Sulphadoxine, Dioxane, Isentropic Compressibility, Specific Acoustic Impedance , Intermolecular Free Length.

I. INTRODUCTION

Ultrasound studies are extensively used in probing the physico-chemical behaviour of binary liquid mixtures.1-2 Ultrasonic velocity is gaining importance in understanding the nature of drug-solvent interaction since physico-chemical properties of the drugs are of great interest to understand the drug action at molecular level3-5. Using the measured values of ultrasonic velocity, viscosity and density various acoustic and thermodynamic parameters such as isentropic compressibility, lowering isentropic compressibility, Shear's relaxation time, intermolecular free length can be computed.6-8 These parameters provide information about solute- solute and solute-solvent interactions. Sulpha drugs are the subject of interest due to its pharmacological and medicinal utility as antimicrobial agents. Several researchers9-12 have studied the molecular interaction of various drugs with organic solvents. However there is no data available on the interaction of drug sulphadoxine with organic solvents. This prompted us to undertake the present study.

II. EXPERIMENTAL

The ultrasonic velocity was measured using Ultrasonic Interferometer model F-81 containing quartz crystal working at a frequency of 2 MHz by standard procedure. The accuracy of ultrasonic velocity determination in the solution is +0.001%. The constant temperature of 30oC was maintained through thermostat. The density was measured using double walled bicapillary pyknometer. The viscosity was measured using Ostwald's viscometer which was earlier calibrated. Acoustical parameters were calculated from the measured values of density, viscosity and ultrasonic velocity.

III. RESULT AND DISCUSSION

From the observed calculated values of density, viscosity and ultrasonic velocity acoustic parameters such as isentropic compressibility, lowering isentropic compressibility, intermolecular free length, Shear's relaxation time, specific acoustic impedance and solvation number were calculated using the following relations (1-6).

Isentropic compressibility $\beta_S = \frac{1}{V^2\rho}$ .. (1)

where, V = Ultrasound velocity
r = Density

Lowering isentropic compressibility = $b_s - b_{so}$ …. (2)

Where
b_s = isentropic compressibility of drug solution
b_{so} = isentropic compressibility of solvent

Intermolecular free length, $L_f = K\sqrt{\beta_s}$ …. (3)

Where , K = constant depending on temperature

Shear's relaxation time, $t_s = \frac{4}{3}\eta\beta_s$ …. (4)

where, h = viscosity

Specific acoustic impedance, Z = V r …. (5)

Solvation number, $S_n = \frac{n_1}{n_2}\left[1 - \frac{\beta_s}{\beta_{s0}}\right]$ …. (6)

Where, n_1 = number of moles of solvent
n_2 = number of moles of solute

The measured values such as ultrasonic velocity (V), density (r) and viscosity (h) of binary system of drug sulphadoxine with dioxane are given in **Table 1**. The calculated values of parameters: isentropic compressibility, lowering isentropic compressibility, intermolecular free length, Shear's relaxation time, specific acoustic impedance and solvation number are listed in **Table 2.**

Table 1. Values of density (r), viscosity (h) and ultrasonic velocity (V) for Sulphadoxine + dioxane system at 308K

Molar conc. of Sulphadoxine	Ultrasound velocity (V) m/S	Density (r) g/mL	Viscosity (h) Nm^{-2}
0.0021	1290.5	0.9608	0.3323
0.0043	1292.8	0.9686	0.3345
0.0064	1298.7	0.9806	0.3366
0.0086	1301.6	0.9901	0.3388
0.0107	1309.8	1002.5	03409
0.0129	1315.5	1008.7	0.3431
0.0150	1320.6	1009.75	0.3452
0.0171	1326.8	1012.83	0.3473
0.0193	1389.5	1016.13	0.3495
0.0214	1401.6	1025.6	0.3516

Table 2

Values of Isentropic compressibility (b), lowering isentropic compressibility, Intermolecular free length (L_f), Relaxation time (t_s), specific acoustic impedance(Z) and solvation number(S_n) for Sulphadoxine + dioxane system at 308 K

Molar conc. of Sulphadoxine ($molL^{-1}$)	$b_s x10^{-14}$ (N/m2)	Lowering isentropic compressibility	$L_f x10^{-10}$ (m)	t_s	$Zx10^{-15}$	S_n
0.0021	6.098	0.44	0.5464	32.6584	0.5538	3.8655
0.0043	6.043	0.87	0.5449	32.6829	0.5585	4.8603
0.0064	6.032	1.31	0.5433	32.7063	0.5569	4.9763
0.0086	6.013	1.73	0.5418	32.7288	0.5553	5.2267
0.0107	5.950	2.16	0.5403	32.7504	0.5538	5.5385
0.0129	5.863	2.58	0.5388	32.7711	0.5522	5.6813
0.0150	5.750	3.00	0.5372	32.7908	0.5506	5.6840
0.0171	5.603	3.42	0.5357	32.8097	0.5491	5.6895
0.0193	5.508	3.83	0.5342	32.8277	0.5475	5.6903
0.0214	5.415	4.24	0.5328	32.8449	0.5460	5.9899

Table 1 shows that in Sulphadoxine-dioxane system , ultrasonic velocity increases with increase in the molar concentration of Sulphadoxine which indicates the strong interaction with increase in the concentration of drug. Density and Viscosity also increases with concentration of drug suggesting increased association between Sulphadoxine and dioxane .

From **Table 2** it is observed that isentropic compressibility(βs) decreases with increase in the concentration of Sulphadoxine which indicates the ordered arrangement of Sulphadoxine with the concentration of the drug . Intermolecular in free length (L_f) shows that solute-solvent molecules are coming closer in the system which may be the result of some weak interactions.

Decreasing values of isentropic compressibility, increase in the solvation number (S_n) and specific acoustic impedance (Z), decreases the intermolecular distance which indicates that in this system there is relatively less gap between the molecules and molecular interactions are associative in nature.[13-14] Since both Sulphadoxine and dioxane are polar molecules, the nonlinear variation of ultrasonic velocity with molar concentration of drug reveals the interaction between the solute and solvent molecules through hydrogen bonding.

IV. CONCLUSION

The concentration dependencies of ultrasonic velocity, density and viscosities have been measured at 313K for Sulphadoxine-dioxane system. The nonlinear variation of the related parameters isentropic compressibility, lowering isentropic compressibility, intermolecular free length, Shear's relaxation time, specific acoustic impedance and solvation number is in good agreement with the dipolar bonding between Sulphadoxine and dioxane i.e. through hydrogen bonding.

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Citation:

Anjul Singh, "Ultrasonic Studies for Binary Mixtures of Sulphadrug Sulphadoxine and Dioxane at 308 K", International Journal of Scientific Research in Chemistry (IJSRCH), ISSN : 2456-8457, Volume 4 Issue 3, pp. 40-43, May-June 2019.
URL : https://ijsrch.com/IJSRCH19429