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Variation of acoustic parameters with temperature for sulphathiazole and dioxane binary system

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Abstract: Densities, viscosities and ultrasonic velocities of binary mixtures of drug sulphathiazole with dioxane at a particular composition have been measured at 303K, 308 and 313 K temperature. These data have been utilized to calculate acoustic parameters viz. isentropic compressibility, intermolecular free length, specific acoustic impedance, relative association and solvation number. The results are interpreted in terms of the effect of change in temperature on intermolecular interactions between the component of the mixtures.

(**Keywords:** Ultrasonic velocity, sulphathiazole, Dioxane, isentropic compressibility, Specific acoustic impedance , intermolecular free length)

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 level[3-5]. 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.Sulphadrugs are the subject of interest due to its pharmacological and medicinal utility as antimicrobial agents. Several researchers[9-12] have studied the molecular interaction of various drugs with organic solvents. The literature survey reveals that there is no data available on theeffect of temperature on the drug sulphathiazole-organic solventdioxane interaction. This prompted us to undertake the present study.

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 30°C was maintained through thermostat. The density was measured using double walled bicapillarypyknometer. 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.

Results 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

$$\beta_s = \frac{1}{V^2 \rho} \qquad \text{.....(1)}$$

where, V = Ultrasound velocity
ρ = Density

Lowering isentropic compressibility

$$= \beta_s - \beta_{so} \qquad \ldots.(2)$$

where,
β_s = isentropic compressibility of drug solution
β_{so} = isentropic compressibility of solvent

Intermolecular free length,

$$L_f = K\sqrt{\beta_s} \qquad \ldots.(3)$$

Where,
K = constant depending on temperature

Shear's relaxation time,

$$\tau_s = \frac{4}{3}\eta\beta_s \qquad \ldots.(4)$$

where, η = viscosity

Specific acoustic impedance,

$$Z = V\rho \qquad \ldots.(5)$$

Solvation number,

$$S_n = \frac{n_1}{n_2}\left[1 - \frac{\beta_s}{\beta_{s0}}\right] \qquad \ldots.(6)$$

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

The measured values such as ultrasonic velocity (V), density (ρ) and viscosity (η) of binary system ofdrug sulphathiazole 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 (ρ), viscosity (η) and ultrasonic velocity (V) for 0.0102 M concentration of Sulphathiazole + dioxane system at 303,308 and 313K temperature

Temp.	303K	308K	313K
Ultrasound velocity (V) m/S	1290	1268	1256
Density (ρ) g/mL	0.8712	0.8600	0.8488
Viscosity (η) Nm^{-2}	0.4644	0.3404	0.2164

Table 2
Values of Isentropic compressibility (β),Intermolecular free length (L_f), Relaxation time (τ_s), specific acoustic impedance(Z) and solvation number(S_n) for Sulphathiazole(0.0102M) + dioxane system at 308 K

Temp.	**303K**	**308K**	**313K**
β_sx10^{-14} (N/m2)	68.98	72.32	74.68
L_fx10^{-10}(m)	0.5241	0.5413	0.5548
τ_s	42.7110	32.8247	87.7080
Zx10^{-15}	1.1239	1.0905	1.0661
S_n	0.2354	0.2456	0.2482

Table 1 shows that in sulphathiazole-dioxanesystem ,ultrasonic velocity decreases with increase in the temperature which indicates the breaking of the association between the sulphathiazole and dioxane. Density and viscosity also show decreasing trend with temperature further supporting the disruption of interaction between Sulphathiazole and dioxane .

From Table 2 it is observed that isentropic compressibility(βs) increases with increase in the temperature of the system which indicates the disordered arrangement of sulphathiazole with the temperature. Increase in the intermolecular free length (L_f) shows that solute-solvent molecules bonding which may be of weak type breaks with increasing temperature.

Increasing values of isentropic compressibility, increase in the solvation number (S_n) and decreasing 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 Sulphathiazole 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 is through hydrogen bonding. As the temperature of the system raises this bonding dissociates leading to the unassociated molecules.

Conclusion :

The temperature dependencies of ultrasonic velocity, density and viscosities have been measured at three different temperatures for Sulphathiazole-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 Sulphathiazole and dioxanei.e. through hydrogen bonding . This is further supported by the reversal of the different acoustic values with temperature.

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