Studies in Acoustic Parameters of Promethazine Drug in Dioxane-Water Solvent at Different Temperatures

U.S. WASNIK¹, R.M.JUMLE² AND P.R. RAJPUT³

¹-Department of Chemistry, Arts Science and Commerce College, Chikhaldara Dist : Amravati (M.S.)
²-Department of Chemistry, Shivaji College, AkotDist : Akola (M.S.) India
³-Department of Chemistry, VBMV, Amravati (M.S.) India

Corresponding author: us.wasnik@gmail.com

Abstract

Measurements of ultrasonic velocity have been carried out for Promethazine hydrochloride (PM) at three different temperatures. Viscosities and densities of present system have been measured at 303K, 308K & 313K. From this data various acoustic parameters such as apparent molar compressibility (φk), apparent molar volume (φv), adiabatic compressibility (βs), specific acoustic impedance (Z), intermolecular free length (Lf), molar compressibility (W) & relative association (RA) have been determined. From these derived parameters limiting apparent molal volume (φv₀), limiting apparent molal compressibility (φk₀) and Experimental slopes (S₀v & S₀k) have calculated by using Massons equation. The viscosity data are analysed using Jones – Dole equation. The results are interpreted on the basis of solute-solvent and solute-solute interactions.

Keywords: Promethazine hydrochloride, acoustic parameters.

Introduction

The studies on volumetric, ultrasonic and viscometric properties of liquid mixtures and their dependence on composition and temperature are of importance in many fields of applied research and find applications in many important chemical, textile, leather, industrial and biological process. Ultrasonic waves provide valuable information about the molecular interaction in pure liquids, aqueous solutions, liquid mixtures and also provide valuable information about the structure of solids¹⁻⁴.

Ultrasonic velocity measurements have been successfully employed to detect and assess weak and strong molecular interactions, present in binary liquid mixtures ⁵, ⁶. Ultrasonic studies have found wide applications owing to their ability to characterize the physico-chemical behaviour of solutions. The excess properties have been claimed to be an aid in the characterization of the molecular interactions that are present in solutions and liquid mixtures. This is achieved through elevation of ideal quantities. In recent years, considerable efforts have been given for the elevation of ideal and excess thermodynamic quantities of binary and ternary liquid mixtures ⁷, ⁸. The study of molecular interaction in the liquid mixtures is of considerable in the elucidation of the structural properties of the molecules.

The nature and degree of molecular interactions in different solutions depend upon the nature of the medium, the structure of the solute molecule and also the extent of solvation taking place in solution.
the present study drug \([\text{Dimethyl } 1-(10-H \text{ phenothiazin-10-yl) propan-2-yl]} \text{ amine}\) is selected. This drug is used as antihistaminic, sedative. Acoustic parameters provide a better insight into molecular environment to liquid mixtures, it seemed important to study molecular interactions, which motivated the authors to carry out the present investigation in the binary liquid mixtures of Promethazine hydrochloride (PM) with dioxane-water solvent at different temperatures using ultrasonic technique.

**Materials and Methods**

Solvent dioxane used in the present work was of AR grade, purified and dried by the usual procedure. Densities, viscosities and ultrasonic velocities were measured at different temperatures over a wide range of composition. Densities were determined by using bicapillary pyknometer. The Viscosities (\(\eta\)) of pure compounds and their mixtures were determined using Oswald’s Viscometer calibrated with double distilled water\(^8\).\(^9\). Ultrasonic velocity measurements were made by using an ultrasonic interferometer (Mittal Enterprises, New Delhi) at a frequency of 2MHz with a tolerance of \(\pm 0.005\%\). All the measurements were carried out at different temperatures.

Acoustic parameters such as apparent molar compressibility (\(\phi_k\)), apparent molar volume (\(\phi_v\)), adiabatic compressibility (\(\beta_s\)), specific acoustic impedance (\(Z\)), intermolecular free length (\(L_f\)), molar compressibility (\(W\)) & relative association (\(R_A\)) were determined using following relations:

- **Limiting apparent molar volume** (\(\phi^0_v\)), limiting apparent molar compressibility (\(\phi^0_k\)) and Experimental slopes (\(S^0_V\) & \(S^0_K\)) have calculated by using Massons equation.
- **Ultrasonic velocity** \(u = \lambda \nu\)  
- **Adiabatic compressibility** \(\beta_s = 1/ u^2 \rho_s\)
- **Apparent molar compressibility** \(\phi_k = 10^3 (\rho_0 \beta_s - \rho_0 \beta_0)/ m - \rho_0 + \beta_s M/ \rho_s\)
- **Apparent molar volume** \(\phi_v = 10^3 (\rho_0 - \rho_v)/ m - \rho_0 + M/ \rho_0\)
- **Specific acoustic impedance** \(Z = \rho . u\)
- **Intermolecular free length** \(L_f = K (\beta_s)^{1/2}\)
- **Molar compressibility** \(W = M x (\beta_s)^{1/7} \rho_s\)
- **Relative association** \(R_A = (\rho/ \rho_0) x (u_0/ u)^{1/3}\)
- **Limiting apparent molar volume** \(\phi_v = \phi^0_v + S_c C^{1/2}\)
- **Limiting apparent molar compressibility** \(\phi_k = \phi^0_k + S^{1/2}\)

In the present paper, we report densities (\(\rho\)) and Ultrasonic velocities of binary mixtures of Promethazine hydrochloride (PM) with dioxane-water solvent at different temperatures, over the entire composition range.
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Table 1: The Experimental values Density, Ultrasonic Velocity and related Parameters at different temperatures System- PM in 20% Dioxane-Water medium

<table>
<thead>
<tr>
<th>Temp T(K)</th>
<th>Conc. mol. dm⁻³</th>
<th>Density ρKgm⁻³</th>
<th>Ultrasonic Velocity (u) m/s</th>
<th>βₙ x10⁻¹⁰ Pa⁻¹</th>
<th>Φᵥ x10⁻⁶ m³mol⁻¹ Pa⁻¹</th>
<th>Φₖ x10⁻¹⁴ m³mol⁻¹ Pa⁻¹</th>
<th>Lᶠ x10⁻¹¹ (m)</th>
<th>Z x 10⁵ Kg m⁻² sec⁻¹</th>
<th>Relative association RA X10⁻³</th>
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</table>

Table 2. Limiting values of φᵥ and φₖ along with slope (Sᵥ&Sₖ) for PM indioxane-water medium at different temperatures

<table>
<thead>
<tr>
<th>Temp. T (K)</th>
<th>Medium</th>
<th>Φᵥ x10⁻⁶ m³mol⁻¹</th>
<th>Φₖ x10⁻¹⁴ m³mol⁻¹ Pa⁻¹</th>
<th>Sᵥ x10⁻³/² m³/² dm⁻¹/²</th>
<th>Sₖ x10⁻¹⁴ m³mol⁻¹³/² dm⁻¹³/² Pa⁻¹</th>
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<tbody>
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<td>-40.29</td>
<td>-273.3</td>
<td>194.1</td>
<td>820.8</td>
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<td>308K</td>
<td>20%D-W</td>
<td>-40.09</td>
<td>-274.3</td>
<td>205.9</td>
<td>818.5</td>
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</table>

Results and Discussion

Table 1 shows that density (ρ), ultrasonic velocity (u) and viscosity (η) increases with increase in concentration for all three systems. The increase in ultrasonic velocity is due to decrease in intermolecular free length (Lᶠ) as shown in Table. This suggests that there is a strong interaction between promethazine hydrochloride and solvent molecule. Adiabatic compressibility (βₙ) is a measure of intermolecular association or repulsion calculated from the measured ultrasonic velocity (u) and density (ρ). Adiabatic compressibility is found to decrease with increase in concentration¹⁰. Since adiabatic compressibility is inversely related to the product of density and ultrasonic velocity based on this the compressibility is expected to decrease which has observed in the present case.
When the sound waves travel through the solution, certain part of it travels through the medium and rest gets reflected by the ion i.e. restriction for flow of sound velocity by the ions. The character that determines the restriction movement of sound waves is known as acoustic impedance (Z). It has been found that acoustic impedance increases with increase in concentration. The apparent molar compressibility ($\phi_k$) explains the solute-solvent and solute-solute interactions in solution and was calculated by using the equation 3. The apparent molar volume ($\phi_v$) is defined as the change in volume of solution for the added one mole of a particular component at constant temperature and pressure. It is thermodynamic property which helps in elucidating solvation behavior of electrolyte in solution. Apparent molar volume was evaluated from the density of solution and solvent. It is evident from the Table 2 that $\phi_k^0$ values are negative for 20% Dioxane-water. The negative $\phi_k^0$ values are suggest solute-solvent interaction whereas positive values are due to solute-solute interaction. $S_v$ is a measure of solute-solvent interaction. It is observed from the Table 2 that The decreasing values of $\phi_v^0$, and increasing values of $S_v$ clearly indicates the decrease in solute-solvent and increase in solute-solute interactions with the rise of temperature which indicates the solute-solute interactions are stronger than solute-solvent interactions.

References