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# Acoustic Analysis of Clindamycin Aqueous Solution at Various Temperatures and different Concentrations

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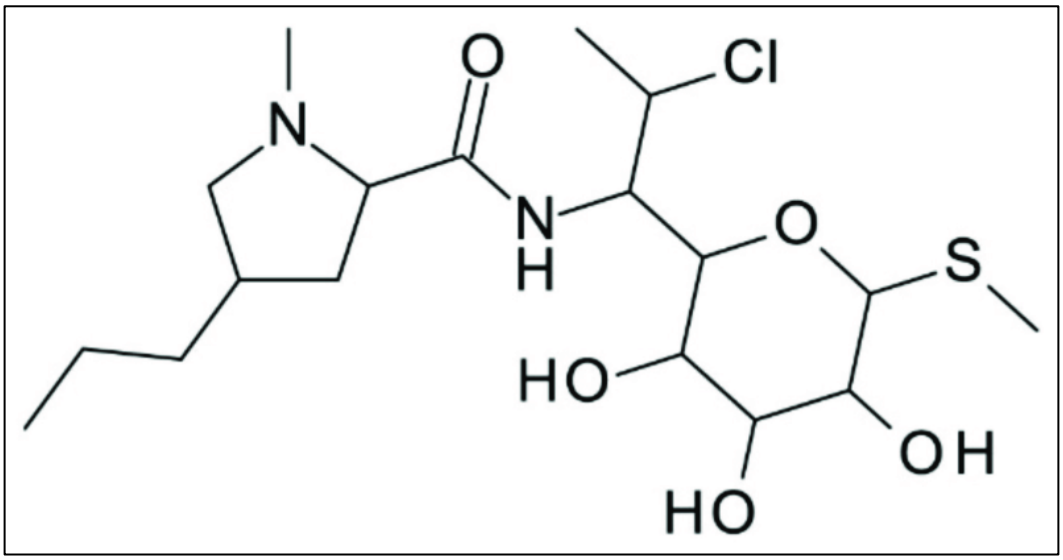
**Abstract**
These days, knowledge of interactions between molecules in solution is mostly dependent on ultrasonic velocity. Drugs are substances that have been utilized to treat medical conditions. Clindamycin is one medication that fights malaria. We measured the density, viscosity, and ultrasonic velocity of the aqueous solution at different temperatures and concentrations. The thermodynamic properties, such as Relative association Specific Relaxation time, were calculated using the experiment data. This assists in the predicting of chemical interactions.

**Key World: -** Ultrasonic velocity, Clindamycin, concentration, temperature, molecular interactions.

**Introduction**
Ultrasonic technology has several applications that promote human health and wellness. Ultrasonography, or ultrasound, is one of the most well-known uses of high-frequency electromagnetic radiation in medical diagnostics because it creates real-time images of internal organs, tissues, and blood flow. This non-invasive method is vital for monitoring the foetus's progress during pregnancy, diagnosing diseases of the kidneys, liver, heart, and other organs, and planning procedures like biopsies. Ultrasonography is used clinically in physical therapy to help with tissue healing and reduce pain by deep tissue heating. Additionally, a new technology called focused ultrasound targets cancerous regions and provides a non-invasive alternative to surgery for treating illnesses like lithotripsy, which breaks down kidney stones. Utilizing high-frequency vibrations to eliminate plaque and tartar, ultrasonic dental cleaning is another popular use. Ultrasonic technology plays a significant role in human diagnosis, treatment, and preventive healthcare in general. Right now, ultrasounds are advancing medical research[1-3].
In the modern world of food processing, material testing, chemical and pharmaceutical manufacture, and mechanical equipment, ultrasonic probes are indispensable. It is quite interesting to understand the intermolecular interactions in mixtures of liquids. Organic mixtures have largely been employed in the production process and subsequent formulation. The physical-chemical features of mixtures of both organic and pure liquids are important for manufacturing engineering and scientific study. Thermodynamic characteristics involving adiabatic compressibility and acoustic impedance are used to classify different types of intermolecular interactions between the solute and solvent in solution[4-8].
Ultrasonic technology is being used more and more in pharmaceutical research to investigate molecular interactions, which provides valuable information on how drugs interact with other biological components. Using high-frequency sound waves, ultrasonic methods can produce cavitation, a state in which microscopic bubbles form and burst, leading to locally raised temperatures and pressures. This might affect chemical structures and facilitate scientists' understanding of how specific conditions change the behaviour of molecules. Improved drug design and comprehension of drug-receptor interactions rely greatly on the study of molecule conformational changes, stability, and binding affinities—all of which are made feasible by ultrasonic techniques. Moreover, ultrasonication facilitates the study of complex molecular systems by enhancing dispersion and solubilization and permitting more accurate measurements of molecular interactions. This technique enhances the ability to investigate protein-ligand, enzyme-substrate, and other important molecular interactions, leading to more efficient drug discovery and development processes[9-12].
The antibiotic clindamycin treats a variety of bacterial infections by stopping bacteria from producing proteins. It is used for diseases of the skin and soft tissues, including as cellulitis, acne, and abscesses, in addition to being helpful in treatment bone infections like osteomyelitis. Pneumonia from aspiration and chronic sinusitis are two respiratory tract illnesses that are treated with clindamycin. It is also frequently used to treat dental infections, including abscesses, especially in people who are allergic to penicillin. Female pelvic inflammatory disease and bacterial vaginosis are treated with clindamycin. It aids in the management of both septicaemia and severe malaria when combined with other drugs. Clindamycin also has good efficacy against anaerobic bacteria, which are commonly implicated in abdomen or post-surgical infections. Before some procedures, it can also be taken as a prophylactic to protect individuals with cardiac problems from contracting bacterial endocarditis. Clindamycin's use must be carefully monitored, nevertheless, as it might have negative side effects include diarrhea and Clostridium difficile infections. The present study aimed to evaluate the ultrasonic velocity, density, and viscosities of an aqueous solution containing clindamycin at different concentrations and temperatures. These data may be used to calculate thermodynamic properties such as adiabatic compressibility and acoustic impedance. These predict the molecular interactions and reactivity of the medication[13-15].

**Methodology:**
A Mittal type, model F-81) ultrasonic interferometer operating at 2MHz frequency and maintaining 298K, 303K, and 308K temperatures was used to test the ultrasonic velocities (U) of liquid mixtures made with pure AR grade components. A precision of ±0.1 ms-1 was achieved in the measurement of sound speed. Using an electrically digitally controlled temperature-controlled water bath, water is flowed through a steel double-walled measurement chamber containing an experimental solution at the necessary temperature. A relative measurement method and a density bottle were used to determine the density of both pure liquids and liquid mixtures to an accuracy of ±0.1 kg/m-3[16-17].
Structure of Clindamycin[18]




Molecular formula of Clindamycin:- $C_{18}H_{33}ClN_2O_5S$

**Ultrasonic velocity:**
An ultrasonic interferometer may be used to detect the ultrasonic velocity in liquids and liquid mixes directly. The relationship may be used to calculate the velocity of ultrasonic waves in a liquid given its wavelength (λ)[19].
$V = \lambda . f$ …….. (1)
Where,
λ is the wave length of ultrasonic wave.
f is the generator's frequency.

**Relative associations**
Relative association in ultrasonics describes how various materials or components relate to one another and impact the way ultrasonic waves propagate. The media that ultrasonic waves pass through interacts with them, and the various phases or materials within the medium affect how the waves travel, reflect, refract, or are absorbed. The phrase highlights the relative impacts of those interactions and aids in comprehending how various elements inside a system affect how ultrasonic waves behave. It may be computed using equation and is a function of the ultrasonic velocity[20].

$$RA = \frac{d_s}{d_o}\left(\frac{v_0}{v_s}\right)^{1/3} \quad \text{……(2)}$$

Where,
$v_0$ is the velocity of ultrasound in a solvent.
vs is the velocity of ultrasound in a solution.

**Specific relaxation time**
The relaxation time, or τ, is the amount of time required for a material to stabilize after being shocked by ultrasonic waves. Stated differently, it represents the rate at which energy in the material dissipates following the course of the ultrasonic wave. Substances with shorter relaxation durations return to equilibrium more rapidly, whereas those with greater relaxation times waste energy over a longer period.. The relation may be used to compute it[21].
$\Upsilon = 4/3\beta.\eta$ …….. (3)

**Result and Discussion**

| Sr. No | Concentration (M) | Ultrasonic velocity (m.s-1) | Density $10^3$ (Kg.m-3) | Viscosity $10^{-3}$(N.s.m$^2$) | Relative association(Ra) | Relaxation time ($\tau$ $10^{-13}$ s) |
|---|---|---|---|---|---|---|
| **1** | **0.001** | 1368.08 | 1010.2 | 0.9315 | 1.043 | 6.56 |
| **2** | **0.01** | 1378.16 | 1012.3 | 0.9632 | 1.043 | 6.68 |
| **3** | **0.1** | 1408.89 | 1033.6 | 1.1964 | 1.057 | 7.78 |

**Table no 1 show the readings of ultrasonic velocity, Density, viscosity Relative association and Specific Relaxation time of clindamycin at 298.15k temperature.**

| Sr. No | Concentration (M) | Ultrasonic velocity (m.s-1) | Density $10^3$ (Kg.m-3) | Viscosity $10^{-3}$(N.s.m$^2$) | Relative association(Ra) | Relaxation time ($\tau$ $10^{-13}$ s) |
|---|---|---|---|---|---|---|
| **1** | **0.001** | 1376.96 | 1005.6 | 0.8355 | 1.042 | 5.84 |
| **2** | **0.01** | 1384.96 | 1009.6 | 0.8588 | 1.044 | 5.91 |
| **3** | **0.1** | 1417.24 | 1032.1 | 1.1229 | 1.059 | 7.22 |

**Table no 2 show the readings of ultrasonic velocity, Density, viscosity Relative association and Specific Relaxation time of clindamycin at 303.15k temperature.**

| Sr. No | Concentration (M) | Ultrasonic velocity (m.s-1) | Density $10^3$ (Kg.m-3) | Viscosity $10^{-3}$(N.s.m$^2$) | Relative association(Ra) | Relaxation time ($\tau$ $10^{-13}$ s) |
|---|---|---|---|---|---|---|
| **1** | **0.001** | 1380.72 | 1002.4 | 0.7437 | 1.041 | 5.19 |
| **2** | **0.01** | 1389.21 | 1007.6 | 0.7756 | 1.045 | 5.32 |
| **3** | **0.1** | 1424.67 | 1030.4 | 0.9843 | 1.059 | 6.28 |

**Table no 3 show the readings of ultrasonic velocity, Density, viscosity Relative association and Specific Relaxation time of clindamycin at 308.15k temperature**

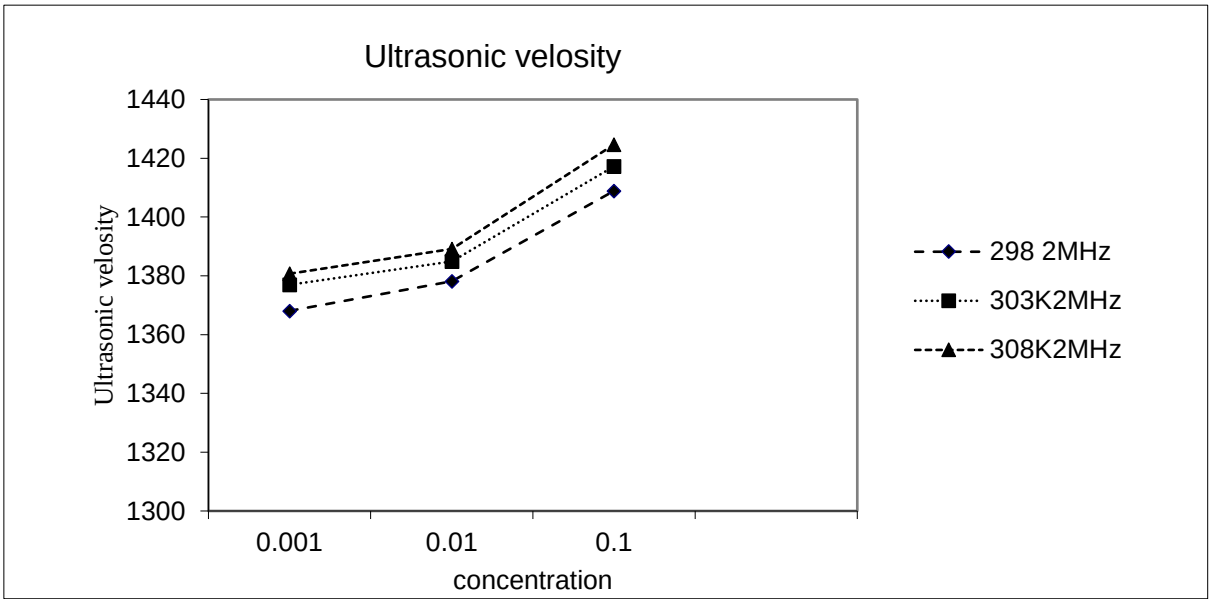



**Fig. a. Temperature and concentration-dependent changes in ultrasonic velocity.**

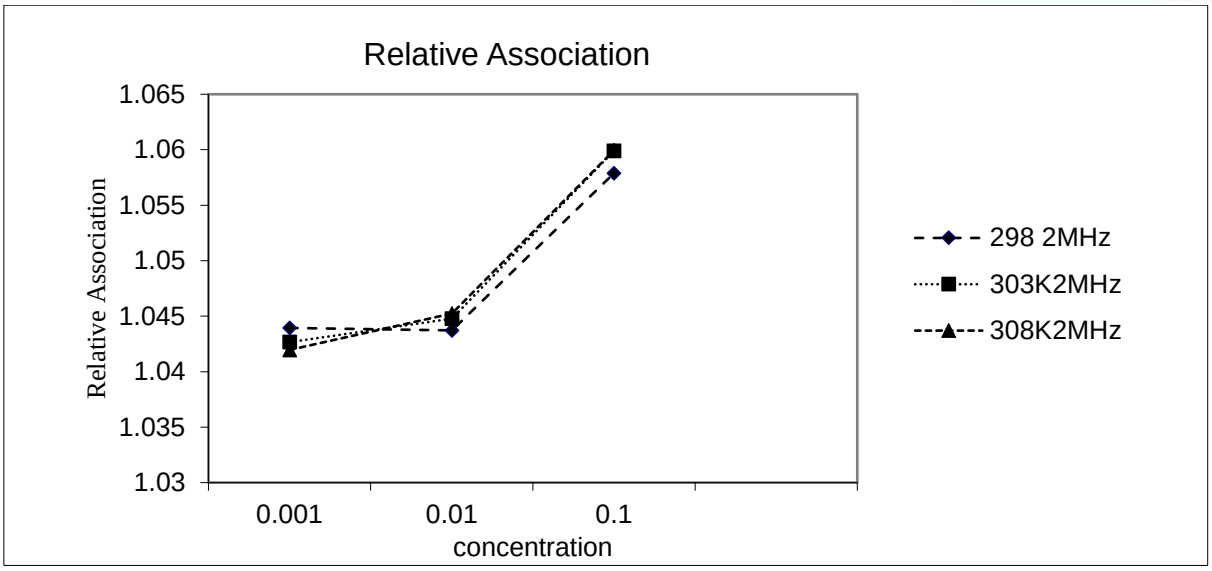



**Fig. b. Temperature and concentration-dependent changes in Relative association.**

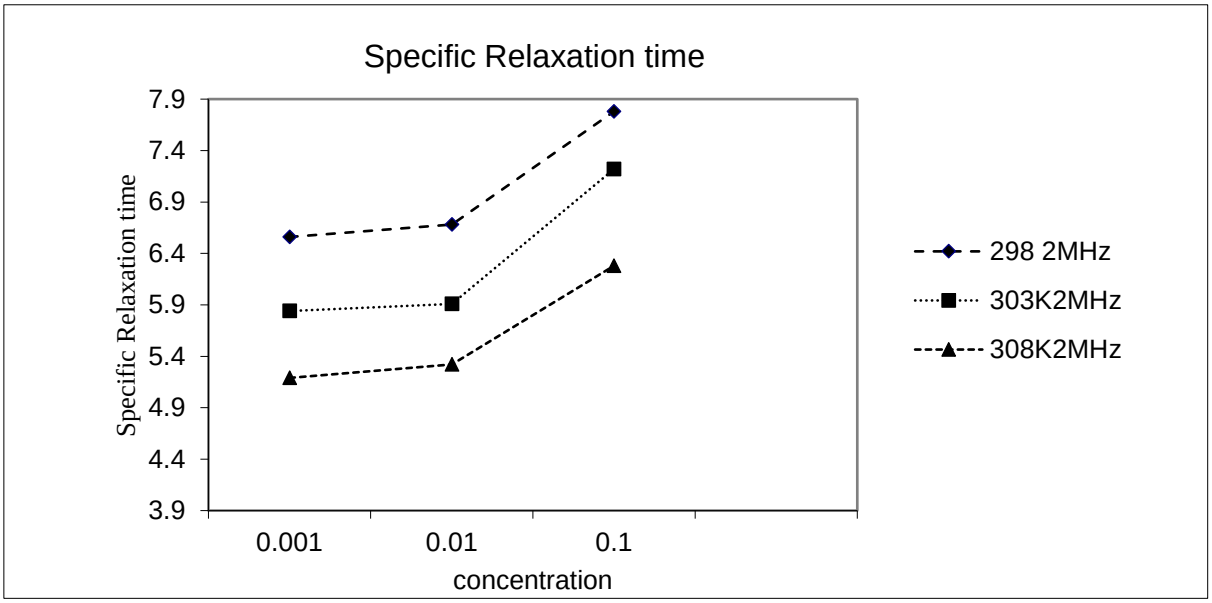



**Fig. c. Temperature and concentration-dependent changes in Specific relaxation time**

The values of density, viscosity, and ultrasonic velocity that were measured experimentally, as well as the different thermoacoustic parameters like relaxation time and the relative association of clindamycin aqueous solution at different concentrations (0.001,0.01, and 0.1M) and temperatures (298.15, 303.15, and 308.15) K, are presented in Figures a, b, and c.

Temperature and concentration have a significant impact on ultrasonic velocity, a crucial characteristic that reveals the kind and degree of molecular interaction. The way a liquid solution changes throughout its propagation determines its elastic characteristics. As seen in Fig. 1, the solution's ultrasonic velocity rises with temperature and concentration. Compressibility of the resulting solution reduces with concentration, and as a result, ultrasonic velocity rises, suggesting a definite rise in solute-solvent interactions and a larger degree of molecular connection among the solution's constituents through hydrogen bonding[22].

The crucial characteristic that allows us to comprehend the solid influence of molecular interactions is relative association. The fact that the relative association value drops as concentration rises and is displayed in tables 1, 2, and 3 as well as in figures (a, b, and c) indicates that the solute molecule's structure has an impact on this attribute. An increase in solute-solvent interactions is indicated by a greater relative association with concentration. Figure c displays the variance in the relaxation time of aqueous clindamycin solutions at various temperatures. The relaxation time rises with concentration and falls with temperature, as this picture indicates. The structure-breaking effect brought on by thermal vibrations and the weakening of intermolecular hydrogen bonds are the causes of this phenomenon.

**Conclusion**

Experimental observations of clindamycin aqueous solutions' density, viscosity, and ultrasonic velocity at various concentrations and temperatures show that these factors have a major influence on ultrasonic velocity, a crucial indicator of molecular interaction. As concentration rises, the relative association value decreases, indicate solute-solvent interaction. Because of thermal vibrations and decreasing intermolecular hydrogen bonds, the relaxation time of aqueous clindamycin solutions varies with concentration, rising with concentration and dropping with temperature. Tables 1, 2, and 3 as well as Figures a, b, and c all show that there is a significant molecular interaction in the clindamycin aqueous solution at a temperature of 308.15 K and a concentration of 0.1 M.

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