Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 10, No.1, October : 2024

# ULTRASONIC EVALUATION OF A DOXYCYCLINE AQUEOUS SOLUTION AT MULTIPLE TEMPERATURES AND VARYING CONCENTRATIONS

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## Abstract
These days, understanding molecular interactions in solutions greatly depends on ultrasonic velocity. Compounds used to cure illnesses are known as medicines. Doxycycline is a medication that fights malaria. At various concentrations and temperatures, the Doxycycline aqueous solution's acceleration, density, and ultrasonic viscosity were determined. The thermodynamic characteristics, such as specific the computed values of adiabatic compressibility, intermolecular, free length, and acoustic impedance, as well as velocity, density, and viscosity. It foresaw how molecules will interact.

**Key words:**
molecular interaction, ultrasonic, Doxycycline, antimalarial.

## Introduction
Ultrasound, sometimes referred to as medical ultrasonics creates non-invasive pictures of inside body structures using high-frequency sound waves. Originally created in the middle of the 20th century, it is now an essential tool in contemporary medicine, especially for diagnostics. Ultrasound works by transferring with a transducer, sound waves enter the body, which then collects the echoes returned back by different tissues. Without requiring surgery or radiation, these echoes are transformed into real-time visual pictures that let medical professionals assess organs, tissues, and blood flow. Commonly used in pregnancies for monitoring embryonic development, ultrasonography is also crucial in cardiovascular disease, abdominal imaging, and directing certain medical treatments. It is a favoured option for many diagnostic applications due to its affordability, safety, and quick turnaround times[1-3].

The pharmaceutical sector has made extensive use of ultrasonics, applying them to a variety of procedures that improve medication formulation, manufacture, and delivery. One of the main applications is in the high-frequency sound waves used in ultrasonic-assisted integrating and emulsion, which helps to create stable emulsions and homogeneous combinations of medicinal ingredients, guaranteeing uniformity in product quality. In order to increase productivity and efficiency, ultrasound is also used in the method of extraction of bioactive chemicals from natural sources. It also contributes to the creation of nanoparticles, which helps create sophisticated medication delivery techniques that can target certain body parts. Even in the tablet coating process, ultrasonic methods are employed to ensure uniform and regulated coating layers that improve the retention and release characteristics of pharmaceuticals. This technology offers improved productivity and product optimization in pharmaceutical manufacturing because of its accuracy and adaptability to varying environmental conditions[3-6].

A popular antibiotic in the tetracycline class, doxycycline has a broad spectrum of action against a variety of bacterial illnesses. It is frequently given to treat diseases of the skin, urinary tract infections, respiratory tract infections, and several STDs. Additionally, doxycycline is used as a first-line therapy for Lyme disease in patients and as a preventative medication for malaria in visitors to areas where the disease is endemic. It works well for treating rosacea, acne, and some types of periodontitis. Doxycycline is helpful in treating some inflammatory diseases since it also possesses anti-inflammatory qualities. It functions by preventing the synthesis of proteins by bacteria, hence stopping their growth and multiplication. Its flexibility, high oral absorption, and good side-effect pattern make doxycycline an essential tool in contemporary medicine[7-8].

Doxycycline is commonly utilized as an antimalarial medicine, notably for preventing the spread of malaria in tourists visiting locations where the illness is endemic. It works well against Plasmodium falciparum blood-stage parasites, which are among the deadliest malaria parasite types. Doxycycline, in contrast to several other antimalarials, prevents the parasite from replicating inside red blood cells by dealing with the creation of proteins. To provide total protection, doxycycline is usually taken every day beginning a few days prior to traveling to an area where malaria is likely to occur and extending for a few weeks afterward leaving the area. People who are resistant to other medicines prefer it since it has less adverse effects when compared to other antimalarial drugs like mefloquine. However, It is not advised to use it on children younger than eight years old or in pregnant women due to the possibility that it may disrupt the growth of teeth and bones[9-10].

**Methodology**

**2. Ultrasonic velocity**

Ultrasonic sound waves through liquids may be measured with a device called A high-frequency interferometer (Mittal Enterprises, The model F-81). This approach uses three concentrations of Doxycycline the solution (0.001, 0.01, and 0.1 M) to create ultrasonic waves at a frequency of 2 MHz the water-soluble solution of Doxycycline is positioned between the quartz crystal and a parallel, moveable reflector to allow the waves to flow through. Standing waves are created in the aqueous solution as a result of the waves' interference with the incident waves as they reflect off the reflector. Points of the greatest and lowest sound intensity corresponding to positive and negative interference, respectively were detected by varying the reflector's location. The distance that exists between two sequential peaks has been measured, which equated half a wavelength of the ultrasound waves[11-12].

$v = 2df$………………. (1)

where (d) is the distance that exists between subsequent maxima and (f) is the frequency, was used to compute the velocity of the sound in the aqueous medium using this distance and the ultrasonic waves' known frequency. Specific density was measured using a gravity bottle, and
Ostwald viscometer was used to measured viscosity. Based on these measurements, several computation of thermodynamic parameters included intermolecular free length, acoustic impedance, and adiabatic compressibility.

**2. Isentropic compressibility**

Adiabatic compressibility is a fractional decrease in volume for every unit increase in pressure in the absence of heat exchange. These modifications have to do with the medium's compressibility. Adiabatic compressibility is mathematically inversely related to the ultrasonic velocity and exhibits an ultrasonic velocity reversal trend. Laplace's equation may be used to calculate the adiabatic compressibility[13].

$\beta = 1 / v2.d$ …………………. (2)

where, d is density and v is the ultrasonic wave velocity.

**3. Intermolecular free length.**

The free length between molecules is dependent upon adiabatic compressibility and exhibits behaviour inversely related to ultrasonic velocity and akin to adiabatic compressibility. The distance that exists between the surfaces of neighbouring molecules, or the intermolecular free length, can be used to represent the adiabatic compressibility of a solution of molecules. The association between both solvent and solute molecules, which modifies the molecular structural arrangement, is shown by an alteration in free length. By applying the Jacobson's formula equation to adiabatic compressibility, the intermolecular free lengths may be determined[14].

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$L_f = K\sqrt{\beta_s}$ …………………. (3)

where K, which is dependent of the liquid's characteristics, is the temperature dependency constant sometimes referred to as Jacobson's constant. Β is a adiabatic compressibility.

**4. Specific acoustic impedance**

Specific acoustic impedance contributes to a knowledge of molecular interactions. The complex ratio of the effectiveness particle velocity at a location to the effective pressure of sound at that location is known as the certain impedance of sound. Specific acoustic impedance can be computed using the formula using ultrasonic velocity and density[15].

$Z = v_s.d_s$ …………………… (4)

Where, vs is velocity and ds are density of solution.

**Result and Discussion**

| Sr. no | Concentration (M) | Acoustic velocity | Concentration | Viscosity | Isentropic compressibility | Intermolecular distance | Specific acoustic impedance |
|---|---|---|---|---|---|---|---|
| **1** | 0.001 | 1380.00 | 1049.6 | 1.15 | 5.00 | 0.0140 | 144.84 |
| **2** | 0.01 | 1410.00 | 1051.2 | 1.17 | 4.78 | 0.0137 | 148.21 |
| **3** | 0.1 | 1436.93 | 1063.6 | 1.27 | 4.55 | 0.0133 | 152.83 |

**Table no 1. Measured value of doxycycline aqueous solution are ultrasonic speed, velocity and density at 298.15K temperature and calculated value are, adiabatic compressibility, intermolecular free length, and acoustic impedance.**

| Sr. no | Concentration (M) | Ultrasonic wave speed | Concentration | Viscosity | Adiabatic compressibility | Intermolecular free length | Specific acoustic impedance |
|---|---|---|---|---|---|---|---|
| **1** | 0.001 | 1395.00 | 1048.8 | 0.93 | 4.89 | 0.0138 | 146.30 |
| **2** | 0.01 | 1440.75 | 1050.4 | 0.95 | 4.52 | 0.0133 | 152.38 |
| **3** | 0.1 | 1468.76 | 1062.4 | 1.00 | 4.36 | 0.0130 | 156.04 |

**Table no 2: Measured value of doxycycline aqueous solution are ultrasonic speed, conductivity and density at 303.15K temperature and calculated value are, Acoustic impedance, adiabatic compressibility as well as the free length between molecules.**

| Sr. no | Concentration (M) | Ultrasonic velocity | Concentration | Viscosity | Adiabatic compressibility | Intermolecular free length | Specific acoustic impedance |
|---|---|---|---|---|---|---|---|
| **1** | 0.001 | 1398.23 | 1046.4 | 0.75 | 4.88 | 0.0138 | 146.10 |
| **2** | 0.01 | 1482.48 | 1050.02 | 0.76 | 4.33 | 0.0130 | 155.66 |
| **3** | 0.1 | 1499.87 | 1059.6 | 0.88 | 4.19 | 0.0128 | 158.92 |

**Table no 3: Measured value of doxycycline aqueous solution are ultrasonic speed, fluidity and densities at 308.15K temperature and calculated value are, Acoustic impedance, intermolecular free length, and adiabatic compressibility.**

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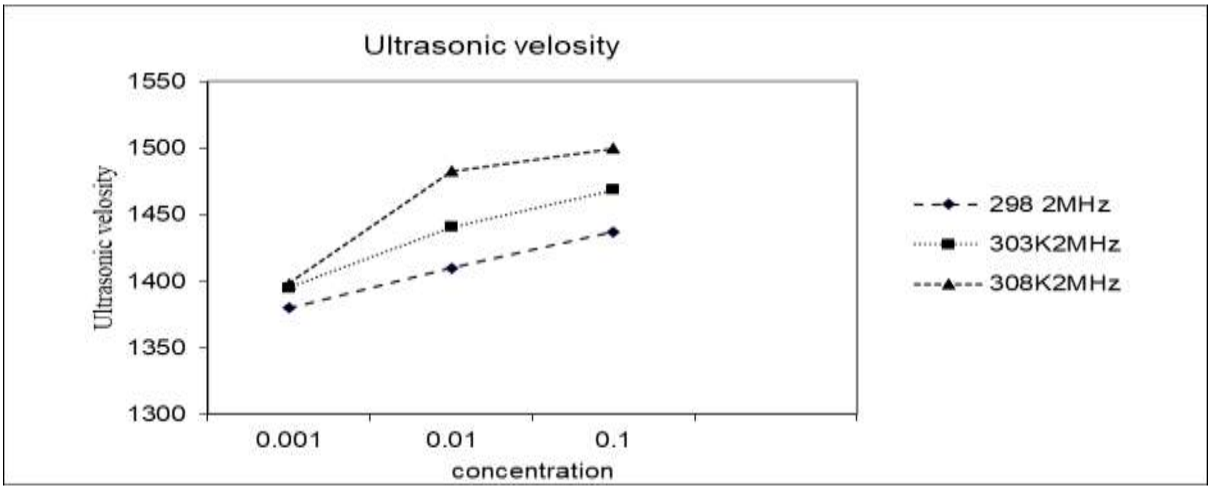


**fig. 1 fluctuation in ultrasonic speed with concentration and temperature.**

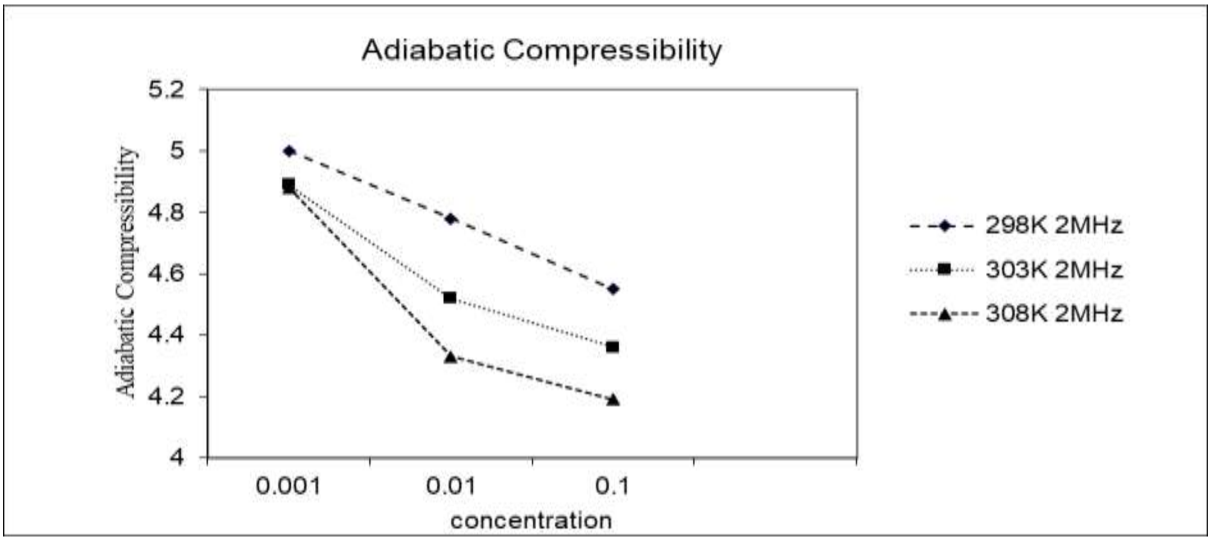


**fig. 2 variation of compressibility adiabatic with concentration and temperature.**

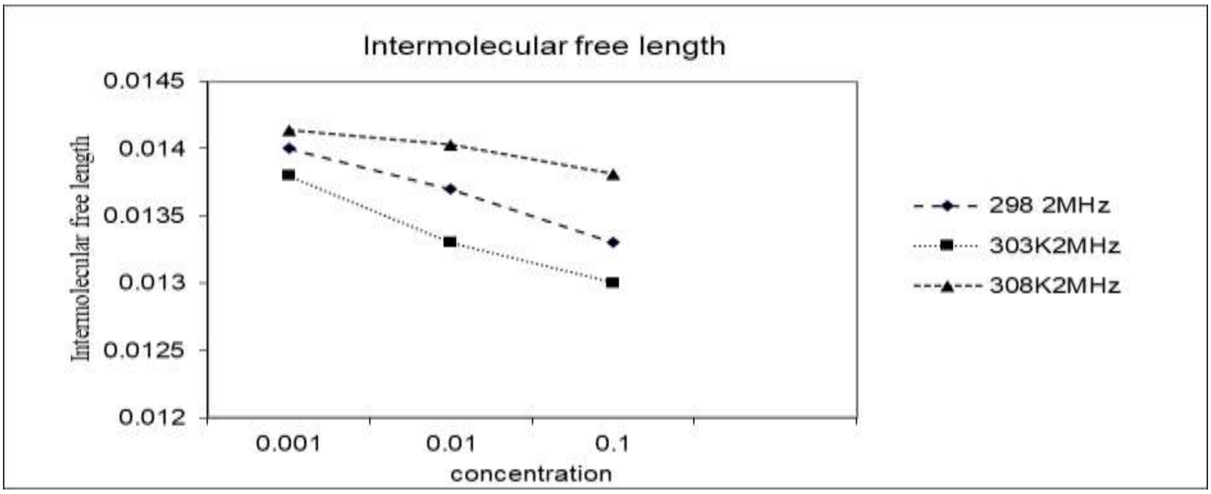


**Fig. 3 Intermolecular free length variation with temperature and concentration.**

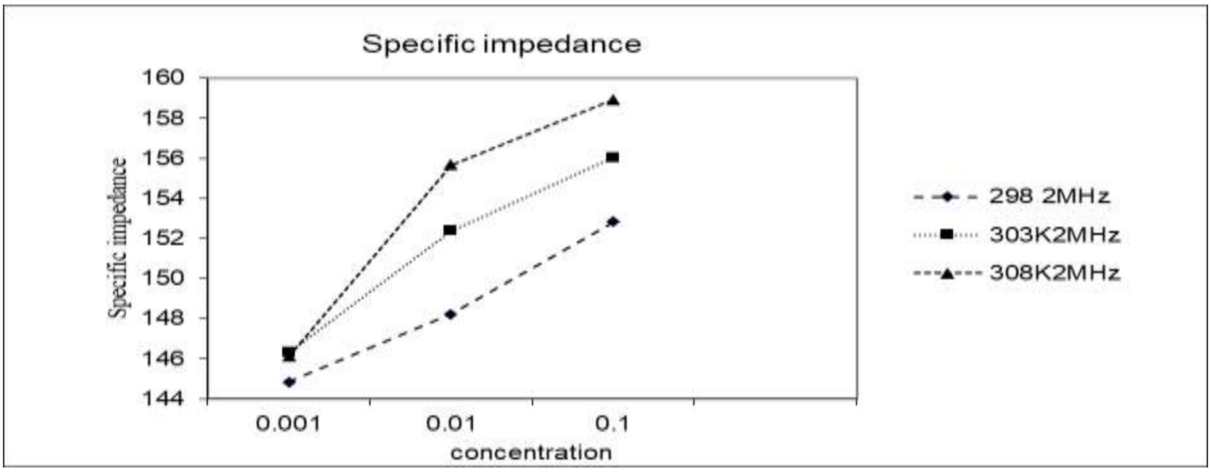


**Fig. 4 variation of Specific impedance with temperature and concentration.**

Tables 1, 2, and 3 show the measured densities, viscosities, and ultrasonic velocities of the Doxycycline aqueous solution at several concentrations (0.001, 0.01 and 0.1) in a range of temperatures 298.15, 303.15, and 308.15 K. In order to get a methodical comprehension of the impact of temperature and concentration on these parameters, graphs have been made and are displayed in Figures 1, 2, 3, and 4.

The kind and degree of molecular contact can be inferred from the ultrasonic velocity fluctuation in solution. The shift in the medium's elastic characteristics determines the alteration in ultrasonic velocity. According to Fig. 1, table 1,2 and 3 the ultrasonic velocity rises as the concentration and temperature does as well. This is because the solution's density increased with concentration, decrease with temperature and viscosity have increased with concentration, decrease with temperatures, which has caused its compressibility to decrease. Weak solute-solvent interactions at lower concentrations are the cause of the first smaller ultrasonic velocity measurements. The solute-solvent interaction and, thus, the ultrasonic velocity increase with concentration[16].

Fig. 3 depicts the difference in free length. This figure shows that when the concentration and temprature rises, the free length of the doxycycline aqueous solution decreases, and This suggests that a sizable solute-solvent interaction exists, which results in behaviour that promotes structure. The decrease in molecular spacing in the water-based solution of doxycycline is the cause of the decreasing pattern of free length with concentration. This kind of variance in the free length is caused by donor-acceptor interactions and dipole-dipole interactions among solute solvent molecule; it also shows the solute's propensity to promote structure[17].

Acoustic impedance is the part of a solution that prevents the propagation of ultrasonic waves. The relationship between temperature and concentration and acoustic impedance is seen in Fig. 4 and table 1,2,3. The current aqueous solution's increasing acoustic impedance as temperature and concentration rise is caused by changes in the solution's elastic and inertial characteristics. This shows how the solute and solvent are molecularly linked by hydrogen bonding[18].

**Conclusion**

Based on the above table (1, 2, 3) and figure (1, 2, 3, 4) which show the measured values of ultrasonic the computed values of the acoustic impedance, free length, intermolecular distance, and adiabatic compressibility, as well as velocity, density, and viscosity. Strong solute-solvate interaction is present in a 0.1M solution of doxycycline at 308.15k temperature.

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