Research Paper Physics

# Dielectric and Ultrasonic Studies of the Drug Oxytetracycline Hydrochloride in Ethanol at 303 K

* Beena T ** Ramya Rajan M.P *** Sudha L

*, *** Department of Physics,SRM University, Ramapuram, Chennai-600089

** Department of Physics, Saveetha School of Engineering, Saveetha University, Thandalam,Chennai-602105

**ABSTRACT**

*The dielectric parameters such as static dielectric constant, microwave and optical dielectric constant, relaxation time have been measured by Higasi's method for the drug Oxytetracycline hydrochloride in ethanol for various mole fractions at 303 K. The thermodynamic parameters such as molar free energy of activation and viscous flow have been calculated. For the same system, ultrasonic velocity at 2 MHz has been measured using ultrasonic interferometer. Acoustical parameters like adiabatic compressibility, molar volume, inter molecular free length, acoustical impedance, Rao's constant have been calculated. In both the cases, a weak interaction is observed between the drug and ethanol.*

**Keywords : Dielectric Constant, Ultrasonic Velocity, Oxytetracycline Hydrochloride, Ethanol**

## INTRODUCTION

Dielectric and ultrasonic studies of liquids leads to the useful information about the fluid structure of the molecules [1]. This helps in better understanding the nature and kinds of solute-solvent interactions. Drug macromolecular interactions are an important phenomenon in physiological media such as blood, membrane, intra and extracellular fluids [2]. The dielectric properties show the influence of the drugs in the organic solvent which finds its applications in the pharmaceutical industries and medicinal physics. The ultrasonic studies of the drug shows the structural changes associated with them in terms of acoustic properties.

The present study is focused on dielectric and ultrasonic studies of the drug Oxytetracycline hydrochloride in the solvent ethanol at 303 K. The drug is soluble in the polar solvent ethanol and they are readily suitable to explore solute-solvent interactions.

Oxytetracyclines are a family of broad-spectrum antibiotics of known prophylactic and therapeutic values. They contain electron-donor groups likely to bind metal ions occurring in-vivo. So, tetracycline antibiotic behave as relatively efficient chelating agents [3]. It is found that no reports has been made in dielectric and ultrasonic investigation of Oxytetracycline hydrochloride (OXTH) in ethanol for different molecular fractions.

## Materials and methods

Oxytetracycline hydrochloride is obtained from M/s. Swasthik Pharma Distributors, Chennai. The dielectric constant (ε') and dielectric loss (ε") at microwave frequency were determined by X-Band microwave bench and the dielectric constant ($\varepsilon_\infty$) at optical frequency was determined by Abbe's refractometer equipped by M/s.Vidyut Yantra,India. The static dielectric constant ($\varepsilon_0$) was measured by LCR meter supplied by M/s.Wissenschaijftlich Technische, Werkstatter, Germany.

The velocity of ultrasonic wave has been measured using Ultrasonic Interferometer at the frequency of 2 MHz supplied by PICO (Model BL-02), Chennai. The dielectric and acoustical parameters were calculated from the following equations :

**Dielectric constant**

$$\varepsilon' = \left(\frac{\lambda_0}{\lambda_c}\right)^2 + \left(\frac{\lambda_0}{\lambda_d}\right)^2$$

**Dielectric loss**

$$\varepsilon'' = \frac{2}{\pi}\left(\frac{\lambda_g}{\lambda_d}\right)\left(\frac{\lambda_0}{\lambda_d}\right)^2 \frac{\partial_\rho}{\partial_n}$$

where, $l_c$ is the cutoff wavelength, $l_0$ the free-space wavelength, $l_g$ the guide wavelength and $l_d$ the wavelength in the dielectric-filled waveguide cell. r represents for the inverse standing wave ratio and n is an integer.

Higasi's method has been used to evaluate the most probable relaxation time t, employing the following equations :

Average relaxation time t(1) is described by

$$\tau_{(1)} = \frac{a''}{\omega(a' - a_\infty)}$$

while the overall dielectric relaxation t(2) is given by

$$\tau_{(2)} = \frac{a_0 - a'}{\omega a''}$$

where "w" the angular frequency $a_0$, a', a", $a_\infty$ are defined by equation

$e_0 = e_{01} + a_0 w_2$

$e' = e_1' + a' w_2$

$e'' = a'' + w_2$

$e_\infty = e_{1\infty} + a_\infty w_2$

in which subscript 1 refers to the pure solvent 2 to the solute, subscript 0 refers to the static frequency and ∞ to the infinite or optical frequency and $w_2$ is the height fraction of the solute.

The molar free energies have been calculated using the Eyring's equation

 ISSN - 2250-1991

$$\tau = \left(\frac{h}{KT}\right)\exp\left(\frac{\Delta F_{\tau}}{RT}\right)$$

$$\eta = \frac{Nh}{V}\exp\left(\frac{\Delta F_{\eta}}{RT}\right)$$

where h is planck's constant, K is Boltzmann's constant, N is Avogadro number and V is the molar volume

.

Adiabatic compressibility (b), b = $1 / U^2 r$
Intermolecular free length ($L_f$), $L_f = Kb^{1/2}$
Where, K is the Jacobson temperature dependent constant ($4.281 \times 10^9$)
Molar volume ($V_m$)
$V_m = (M_1 f_1 + M_2 f_2) / r_{12}$

where, $M_1$ is the molecular weight of solute, $M_2$ is the molecular weight of solvent, $f_1$ is the mole fraction of solute, $f_2$ is the mole fraction of solvent, $r_{12}$ is the density of the solution system.

Acoustic impedance (Z), Z = U. r

**Results and Discussion :**
Table 1 shows the experimental data of static dielectric constant ($\varepsilon_0$), microwave dielectric constant ($\varepsilon'$) optical dielectric constant ($\varepsilon_\infty$) and relaxation time (t) of OXTH in ethanol in various concentrations at 303 K. It is observed that the static and microwave dielectric constant decreases with increasing solute concentration. Optical dielectric constant and relaxation time increases with increasing solute concentration. The decrease in static and microwave dielectric constant with increase solute shows the formation of solvated sheath[2]. The solvent molecules in this state are under the influence of solute molecules resulting in lowering of the values.

The increase of dielectric constant in optical frequency shows that the interaction between solute and solvent is prominent at high frequency, whereas the decrease of dielectric constant shows that solute-solvent interaction at low frequency is weak. The increase in t with increase in concentration depends upon the shape and size of the rotating molecular entities of the solution[4] The solute-solvent molecular association arises due to the polar nature of the solvent.

The free energy of activation of OXTH in ethanol which is presented in Table 2, shows that the activation of dielectric relaxation ($\Delta F\tau$) involves rotation of molecular entities, whereas activation of viscous flow involves rotational as well as transitional motion of the molecules.

Table 3 shows the experimental data of adiabatic compressibility and intermolecular free length increases with increase in concentration of drug molecules. The adiabatic compressibility is found to be increasing with solute-solvent interaction. The decrease in ultrasonic velocity and in adiabatic compressibility leaves the molecule far apart which is attributed to the weak intermolecular associations between solute and solvent molecules[5]. It may be due to the loose packing of the molecules inside the shield.

**Table 1. Values of dielectric constant ($\varepsilon_0$, $\varepsilon'$, $\varepsilon_\infty$) and relaxation time $\tau$(ps) of Oxytetracycline hydrochloride in ethanol at 303 K.**

| System | Concentration | Static dielectricconstant ($\varepsilon_0$) | Microwave dielectric Constant($\varepsilon'$) | Optical dielectric Constant ($\varepsilon_\infty$) | Relaxation Time t(ps) |
|---|---|---|---|---|---|
| Ethanol + OXTH | 0.00 | 25.25 | 25.5 | 1.8414 | 126.52 |
| | 0.02 | 24.520 | 24.454 | 1.844 | 146.13 |
| | 0.04 | 24.040 | 24.301 | 1.8523 | 143.94 |
| | 0.06 | 23.561 | 23.423 | 1.855 | 149.33' |
| | 0.08 | 23.081 | 23.012 | 1.8577 | 152.09 |

**Table 2. Values of free energy of activation energy ($\Delta F\tau$) and free energy of viscous flow ($\Delta F\eta$) of Oxytetracycline hydrochloride in ethanol at 303 K.**

| System | Concentration | Free energy of activation of dielectric ($\Delta F\tau$) | Free energy of viscous flow ($\Delta F\eta$) |
|---|---|---|---|
| Ethanol + OXTH | 0.00 | 9.70 | 12.80 |
| | 0.02 | 10.34 | 13.036 |
| | 0.04 | 10.58 | 13.598 |
| | 0.06 | 10.89 | 3.754 |
| | 0.08 | 10.90 | 13.90 |

**Table 3. Values of velocity, adiabatic compressibility and molar volume of Oxytetracycline hydrochloride in ethanol at 303 K.**

| System | Concentration (Drug + Ethanol) | Velocity (v) m/s | Adiabatic compressibility ($\beta$) X$10^{-10}$ $N^{-1}$ $m^2$ | Molar volume ($V_m$) $m^3$ $mol^{-1}$ |
|---|---|---|---|---|
| OXTH+ Ethanol | 0.8 + 39.2 | 1400 | 5.85 | 0.0437 |
| | 0.6 + 38.4 | 1280 | 6.56 | 0.0430 |
| | 2.4 + 37.6 | 1200 | 7.361 | 0.0424 |
| | 3.2 + 36.8 | 1160 | 7.96 | 0.04284 |
| | 40 + 0 | 1576 | 3.44 | 0.03420 |
| | 0 + 40 | 1140 | 8.795 | 0.0457 |

**Table 4. Values of Intermolecular free length, acoustic impedance and Rao's constant of Oxytetracycline hydrochloride in ethanol at 303 K.**

| System | Concentration (OXTH + Ethanol) | Intermolecular ($L_f$) free length x $10^{-11}$ m | Acoustic $\tau$ (z) impedance x $10^6$ $Kgm^2s^{-1}$ | Rao's constant (R) |
|---|---|---|---|---|
| OXTH+ Ethanol | 0.08 + 39.2 | 4.715 | 1.278 | 0.4897 |
| | 1.6 + 38.4 | 5.11 | 1.189 | 0.4668 |
| | 2.4 + 37.6 | 5.413 | 1.132 | 0.4505 |
| | 3.2 + 36.8 | 5.6296 | 1.08 | 0.4501 |
| | 40 + 0 | 3.7008 | 1.843 | 0.3980 |
| | 0 + 40 | 5.9176 | 0.997 | 0.4774 |

Table 4 shows the experimental data of molar volume, Acoustic impedance and Rao's constant of OXTH in ethanol. Acoustic impedance decreases with increase in drug concentration indicates significant interaction between the solute and solvent. According to ultrasonic data, it indicates the possibility of weak molecular interaction between components of the mixtures.

**CONCLUSIONS**
From the observed parameters, it is very obvious that there exists a molecular association between the components of the liquid mixtures. In specific, a weak molecular interaction is noticed in the present system of liquid mixtures.

**REFERENCES**

Gupta F.C and Arrawatia M.L (1977), "Dielectric Relaxation Time& Dipole Moment of Some Substituted Benzotrifluorides in Benzene Solutions" Indian Journal of Pure and Applied Physics,16,451-453.. | [2] Ajay Chaudhari, Lnde M.K and Arbad B.R.(2002),"Dielectric study of Pharmacologically important drugs in Ethanol at different temperatures usinf Time Domain Reflectometry" Journal of Molecular Liquids, 100/3, 207-215. | [3] Medani S.M, (1996), "Equilibrium studies of binary and ternary complexes of Oxytetracycline and amino acid or DNA units" Proc.Indian Acad Sci,109,135-146. | [4] Lokhande M.P, Migrane S.R, Arbad B.R, (1997)," Study of interactions between drugs and methanol at microwave frequency by time domain dielectric spectroscopy", Journal of Pure and Applied Physics,36,138-143. | [5] Ramya Rajan M.P,Dhamodharan.S, Udaya Lakshmi K, (2013)," Ultrasonic studies of Molecular interactions of 1,4 Diazabicyclo 2,2,2- Octane in different solvents at 303 K" ,Indian Journal Of Research, 2 41-42. |