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Comparative study of acoustic and thermodynamic property of aqueous solution of cefotaxime sodium and ampicillin sodium by using ultrasonic interferometer.

Hajare RS[1], Aswale SS[2] and Aswale SR[3]

[1]Nilkanthrao Shinde College, Bhadrawati, Dist. Chandrapur, Maharashtra.
[2]Lokmanya Tilak Mahavidyalaya, Wani, Dist. Yavatmal, Maharashtra.
[3]Mahatma Gandhi College of Science, Gadchandur, Dist. Chandrapur,Maharashtra.
Email: rajeshhajare34@yahoo.com

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ABSTRACT
Ultrasonic velocity, density and viscosity have been measured for antibiotic cefotaxime sodium and ampicillin sodium in water at different concentrations, temperatures and frequency at 2MHz. From the experimental data, ultrasonic parameters such relative association, specific acoustic relaxation time and free volume have been computed. The results have been interpreted to elucidate molecular interactions in the aqueous solution of cefotaxime sodium and ampicillin sodium.

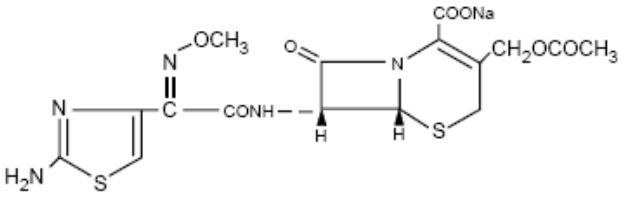
Keywords: Ultrasonic velocity, hydrogen bonding, molecular interactions, cefotaxime sodium, ampicillin sodium.

INTRODUCTION

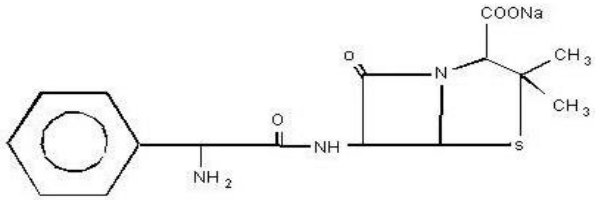
The ultrasonic velocity of liquid is fundamentally related to binding force between the atoms or molecules. When acoustic waves propagated through a liquid, dissipation of energy in sound waves takes place; the study of molecular interactions in various organic liquid and liquid mixtures is of considerable importance in recent years. Ultrasonic studies are used for understanding thermodynamic properties of liquid mixtures and solutions. These studies are also useful in understanding the nature and strength of molecular interactions. The measurement of ultrasonic velocity in pure liquids and mixtures is an important tool to study the physico-chemical properties and also explains the nature of molecular interactions.

A number of researchers [1-4] have investigated molecular interaction in aqueous solution of different antibiotics. Cefotaxime sodium and Ampicillin sodium is used as an antibiotic in pharmaceuticals.

Cefotaxime sodium -



Ampicillin sodium -



Literature survey reveals that no work has been reported on ultrasonic interferometric study of aqueous solution of cefotaxime sodium and ampicillin sodium to investigate the exact nature of molecular interactions. In continuation of our earlier work [5-15] in the present investigation, the comparative study of drugs cefotaxime sodium and ampicillin sodium was studied at different concentration, temperature and at 2MHz frequency. The main purpose of investigation is to study molecular interaction, drug absorption, transmission activity of aqueous solution of cefotaxime sodium and ampicillin sodium.

METHODOLOGY

Antibiotic drug cefotaxime sodium obtained from Alkem laboratories Limited whereas ampicillin sodium obtained from Aristo Pharmaceuticals Private Limited was used. The chemicals used were of analytical grade. Double distilled water was used for preparation of solutions. A special thermostatic water bath arrangement was made for density and ultrasonic velocity measurement and temperature variation was maintained within ±0.01^{0}C multi frequency interferometer (Mittal Enterprises, Model F-83) with accuracy of ±0.03% and frequency 2 MHz was used in the present work for measurement of ultrasonic velocities of solutions. Densities of solutions were measured using specific gravity bottle. These values were accurate up to ± 0.1 kg/m^3. Viscosities of solutions were measured using Ostwald's viscometer. The accuracy of viscometer was 0.001Nsm^{-2}. All the weighing was made on CA-124 (CB/CA/CT series, Contech) digital electronic balance having an accuracy of ± 0.0001g.

RESULTS AND DISCUSSION

In the present investigation, measurements of densities, viscosities and ultrasonic velocities of solvent water and aqueous solution of cefotaxime sodium and ampicillin sodium have been made.

Relative association is a function of ultrasonic velocity and is calculated by the equation,

$$R_A = \frac{d_s}{d_0}\left(\frac{v_0}{v_s}\right)^{1/3} \quad \text{.....(1)}$$

Where, v_0 and v_s are ultrasonic velocities in solvent and solution respectively.

Relaxation time is evaluated by equation

$$\tau = 4/3\beta.\eta \quad \text{..... (2)}$$

Where, β=adiabatic compressibility **η** =viscosity of experimental liquid.

Free volume is calculated by following equation

$$V_f = [Meffv/K\,\eta]^{3/2} \quad \text{..... (3)}$$

Where, M_{eff} is effective molecular weight, K is a temperature independent constant which is equal to 4.28 x 10^9 for all liquids.

Viscosity of Solution is calculated by equation

$$\eta_2 = \eta_1.t_2.ds/t_1.d_0 \quad \text{..... (4)}$$

Where, η_1=viscosity of water, η_2= viscosity of experimental liquid, t_1=time flow of water, t_2=time

flow of experimental liquid, d_0=density of water and ds=density of experimental liquid.

A minute observation of the Table1 suggests that the experimentally calculated values of ultrasonic velocity of aqueous solution of cefotaxime sodium increases with increases in concentration and temperature at 2MHZ frequency. Addition of solute is indicative of greater association of molecules due to effective solute-solvent interaction which results increase in ultrasonic velocity. The increase in concentration weakens the molecular forces and hence change in velocity is observed. Ultrasonic velocity increases on increasing the concentration of solute may be attributed to cohesion brought about by the association among the molecule and greater solute - solvent interaction due to formation of hydrogen bond between molecule of cefotaxime sodium and water. The values of density and viscosity increase with increase in concentration and the same deceases with increase of temperature. The decrease in values of density and viscosity with increase in temperature shows decrease in intermolecular forces due to increasing the thermal energy of the system. The increasing values of density, viscosity and ultrasonic velocity show that there is moderate attraction between solute and solvent molecules. Relaxation time and relative association increases with increase in concentration and same decreases with rise in temperature. This suggests strong intermolecular interaction between solute and solvent molecules. With increasing concentration and temperature free volume increase suggests increase in molecular packing in medium and also supports strengthening of molecular interaction among the components of aqueous solution.

Table 1: Acoustic parameters of aqueous solution of Cefotaxime sodium at 2MHz.

Temperature (K)	Concentration (M)	Ultrasonic Velocity (m/s)	Density (Kg/m^3)	Viscosity $\eta x10^3$ (NSm^{-2})	Acoustic relaxation time $\tau x10^{-10}$sec	Relative association (R_A)	Free Volume $V_f x10^{-8}$ (m3/mole)
303.15	0.001	1489.33	1016.16	0.8699	5.13	1.0225	1.27
	0.01	1491.21	1025.55	0.9301	4.19	1.0315	1.41
	0.1	1524.10	1043.55	1.1765	6.46	1.0420	2.20
308.15	0.001	1526.54	1006.14	0.7598	4.32	1.0143	1.43
	0.01	1527.13	1016.52	0.9833	5.5	1.0246	1.46
	0.1	1564.90	1039.00	1.0050	5.26	1.0388	1.66
313.15	0.001	1563.38	999.53	0.7054	3.85	1.0004	1.11
	0.01	1528.29	1010.52	0.7303	4.12	1.0191	1.10
	0.1	1637.99	1038.66	0.8477	4.05	1.0235	1.34

Table 2: Acoustic parameters of aqueous solution of Ampicillin sodium at 2MHz

Temperature (K)	Concentration (M)	Ultrasonic Velocity (m/s)	Density (Kg/m^3)	Viscosity $\eta x10^3$ (NSm^{-2})	Acoustic relaxation time $\tau x10^{-10}$ (sec)	Relative association (R_A)	Free Volume $V_f x10^{-8}$ (m3/mole)
303.15	0.001	1456.63	1024.94	0.8514	5.2203	1.0390	1.1920
	0.01	1528.85	1028.97	0.8896	4.9321	1.0264	1.3770
	0.1	1598.42	1033.77	0.9639	4.8660	1.0160	1.7567
308.15	0.001	1526.69	1019.55	0.7252	4.0695	1.0278	1.0100
	0.01	1526.79	1022.23	0.7517	4.2061	1.0304	1.0700
	0.1	1598.55	1027.55	0.8049	4.0872	1.0201	1.3400
313.15	0.001	1492.82	1017.30	0.6651	3.9122	1.0340	0.8540
	0.01	1563.28	1018.65	0.6821	3.6534	1.0196	0.9560
	0.1	1601.06	1025.79	0.7353	3.7289	1.0186	1.1700

A minute observation of the Table 2 suggests that in the aqueous solution of ampicillin sodium the ultrasonic velocity increases with increase of concentration and same is non-linear with increase of temperature at 2MHZ frequency. As concentration increases number of molecules in the medium increases, making the medium to be denser, this leads to lesser compressibility resulting in quick transfer of sound velocity which indicates maximum association among the molecules of aqueous ampicillin sodium solution due to effective solute-solvent interaction. Relaxation time decreases with increase in temperature and increases with increase of concentration. Increase in relaxation time indicates that degree of co-operation for relaxation of the molecules increases which increases the bulk of cluster when solute is added to solvent which indicates the presence of specific molecular interaction among ampicillin sodium and water.

Relative association shows variation with increase of concentration and temperature suggest the specific molecular interactions among the components. Free volume increases with increase in concentration and same decreases with increase in temperature. Increase of free volume with concentration suggest structure breaking nature whereas opposite trend of free volume with increase of temperature suggest structure promoting nature.

On comparing the acoustic and thermodynamic parameters of aqueous solution of cefotaxime sodium and ampicillin sodium, ampicillin sodium has high value of ultrasonic velocity. It indicates that strong solute-solvent interaction exists in aqueous solution of ampicillin sodium. ampicillin sodium has low relaxation time which shows that ampicillin sodium get rearranged in such a way that it forms the closely pack structure when it is added to water molecules. Comparatively ampicillin sodium has low value of relative association than cefotaxime sodium. This indicates that breaking of solvent structure is more in ampicillin sodium than cefotaxime sodium. Ampicillin sodium shows low value of free volume than cefotaxime sodium. This suggests close packing of molecules inside the shield is higher in aqueous solution of ampicillin sodium rather than cefotaxime sodium. Thus all the acoustic parameters favor strong intermolecular interaction in aqueous solution of ampicillin sodium than cefotaxime sodium.

CONCLUSION

From all the acoustic and thermodynamic parameters it can be concluded that in aqueous solution of ampicillin sodium strong solute- solvent interaction exist than cefotaxime sodium solution. Hence ampicillin sodium may be thought as more powerful and potent antibiotic than cefotaxime sodium.

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Conflicts of interest: The authors stated that no conflicts of interest.

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