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Acoustic and volumetric properties of ciprofloxacin hydrochloride in dioxane-water mixture at 303.3 K

[1]Prakash Chandra Pal and [2]Smruti Prava Das
[1,2]*Department of Chemistry Ravenshaw University, Cuttack Odisha, India*

Subject: Medicinal Chemistry

Abstract

The acoustical properties have been investigated from the ultrasonic velocity and density measurements of substituted heterocyclic drug (ciprofloxacin hydrochloride) in 1, 4-dioxane-water at 303.3K. The measurements have been performed to evaluate acoustical parameters such as adiabatic compressibility (β_s), Partial molar volume (φ_v), intermolecular free length (L_f), apparent molar compressibility (φ_K), specific acoustic impedance (Z), relative association (R_A), and solvation number (Sn).

Key word: *Ultrasonic velocity, ciprofloxacin hydrochloride, apparent molar volume*

Introduction

In the recent years, measurements of the Ultrasonic velocity are helpful to interpret solute-solvent and ion-solvent interaction in aqueous and non aqueous medium [1-2]. Ultrasonic is a versatile non-destructive technique and highly useful for the investigation of various physical properties [5-7]. Recent developments have found use of ultrasonic energy in medicine, engineering and agriculture. Drug-macromolecular interactions are an important phenomenon in physiological media, such as blood, membranes, intra- and extracellular fluids. Physicochemical investigations play an important role in understanding the nature and the extent of the patterns of molecular aggregation that exist in binary liquid mixtures and their sensitivities to variations in composition and the molecular structure of the pure components. The drug–solvent molecular interaction play an important role in the understanding of drug action [7]. Viscometric properties provide valuable clues for solute–solvent interactions in the solution phase [8].

Ciprofloxacin hydrochloride (Sip-roh-flox-ass-in hi-droh-clor-ride) is a medicine which is used in bacterial infections. Ciprofloxacin hydrochloride (HCl) is a fluoroquinolone antibiotic. It is effective against a wide range of gram positive and gram negative bacteria, and is most well known for its effectiveness against mycoplasma. Ciprofloxacin HCl works by interfering with the bacterial enzyme DNA gyrase, an enzyme necessary for bacterial synthesis, replication, and transcription in both the active and non-active growth phases of the bacterial life cycle [9].The effective concentration for Ciprofloxacin HCl, as with many antibiotics varies with the organism or the cell type, environmental conditions, and stage of growth cycle. However, a concentration of 10 μg/mL is active against most strains of gram

negative and gram positive bacteria, as well as several species of mycoplasma. In comparison to other antibiotics, Ciprofloxacin HCl has many advantages, including lack of known resistant strains, minimal side effects, a lower effective working concentration, non-cytotoxicity, a low reoccurrence rate for contamination, and the ability to kill bacteria in both the active and non-active growth phases [9,10].

In this, the present research Acoustical and volumetric properties have been measured for Ciprofloxacin hydrochloride drug in dioxane-water mixture at 303.3K and different parameters such as adiabatic compressibility (β_s), Partial molar volume (φ_v), intermolecular free length (L_f), apparent molar compressibility (φ_K), specific acoustic impedance (Z), relative association (R_A), solvation number (Sn).limiting apparent molar compressibility ($\varphi^0\kappa$), limiting apparent molar volume(φ^0v) and their constant (Sk, Sv). Viscosity coefficient (A, B)were studied [12-15].

Material and Method

Ciprofloxacin hydrochloride (HCl) and dioxane were purchased from Sigma Aldrich. The double distilled dioxane was used for preparation of different concentration of drug solution.

Preparation of Ciprofloxacin hydrochloride (HCl) in water-Dioxane

The drug Ciprofloxacin hydrochloride (HCl) was used. Dioxane was purified by Vogel's standard method. The double distilled dioxane was used for preparation of different concentration of drugs solution. The densities were determined by using specific gravity bottle by relative measurement method with accuracy ± 1x10-5 gm/cm^3.

Theory

Sound-velocity is given by: $U = (\varphi\kappa.d)^{-1/2}$

Apparent molar compressibility ($\varphi\kappa$) has been calculated by using the relation,

$$\varphi\kappa = 1000\beta_s C^{-1} - \beta_s d_0^{-1}(1000C^{-1}dM)$$

Where, β_s, d and d_0 are the adiabatic compressibility and density of solution and solvent respectively. C is molar concentration of solute; M is molecular weight of solute.

Apparent molar volume

$(v_\varphi) = 1000(Cd_0)^{-1}(d_0 - d) + M_2 d_0^{-1}$

Specific acoustic impedance (Z) = Us ds

Intermolecular free length (L_f) = $K\sqrt{\beta_s}$

Relative association (R_A) = (ds / d0) x (U0 /Us) $^{1/3}$

The entire viscosity data have been analyzed by using

Jones-Dole equation

$\eta_r - 1 / \sqrt{c} = A + B\sqrt{c}$

Result and Discussion

In the present investigation, different acoustical properties such as Relative viscosity(η_r), Density(ds), Apparent molar volume(vφ), Solvation number(Sn) are listed in table-1. limiting apparent molar volume(φ_0v), Limiting apparent molar compressibility ($\varphi_0\kappa$), their constant (Sk, Sv) and viscosity coefficient (A, B) are listed in table-2. Ultrasonic velocity (Us), apparent molar compressibility ($\varphi\kappa$), relative association (R_A), adiabatic compressibility(Ks), Intermolecular free length (L_f),specific acoustic impedance (Z) are listed in table-3. It was found that the ultrasonic velocity decreased with the increase in concentration for dioxane-water system. Variation of ultrasonic velocity in solution depends upon the increase or decrease of molecular free length after mixing the component. Intermolecular free length increased linearly on increase in concentration of Ciprofloxacin hydrochloride in 1,4dioxane. .It is happened because there was significant interaction between ions and solvent molecules suggesting a structure promoting behavior of the added electrolyte. The specific acoustic impedance (Z) decreased with the increase in concentration. When concentration of electrolyte was increased, the thickness of oppositely charged ionic atmosphere increases due to decrease in ionic strength. This is suggested by decrease in acoustic impedance with increase in concentration. It was seen that the intermolecular free length increased very little with the increase in concentration in dioxane-water system.This intermolecular free length variation is due to greater force of attraction between solute and solvent by forming hydrogen bonding. The adiabatic compressibility increased with the increase in concentration of solution. It is happened due to collection of solvent molecule around ions, this supporting weak ion-solvent interaction.This indicates that there is significant solute-solvent interaction. It was observed that apparent molar volume increased with concentration. It indicates the existence of strong ion-solvent interaction. It was found that the value of adiabatic compressibility was increased with the increase in concentration of Ciprofloxacin hydrochloride in dioxane-water system. It shows strong electrostatic attractive force in the vicinity of ions. From the data, we were concluded that strong molecular association was found in dioxane-water system. The value of relative association increased with the increase in concentration the solvation number in Ciprofloxacin hydrochloride –dioxane system is increased with concentration, it indicates the solvent molecule forms strong coordination bond in primary layer. The limiting molar compressibility was positive. The value of S_k exhibits positive. It indicates the existence of ion-ion or solute-solute interactions in system.

From table-2, it was found that the value of limiting apparent molar volume was positive in systems. It indicates that the ion-dipolar interaction in Ciprofloxacin hydrochloride in 1,4-dioxane-water mixture. The positive value of S_v indicates the strong solute-solvent interaction. These value indicates an induced effect of 1, 4- dioxane on solute-solvent interaction. The value of S_k and S_v have been determined in table-2.

From Table-2 it was observed that the value of 'A' (Falkenhagen coefficient) was positive. 'A' measures of ionic interaction. It indicates that there is a strong solute-solute interaction in solute molecules. The Jones–Dole coefficient measures solute –solvent interaction. The value of "B"coefficient was negative in which measures the solute-solvent interactions. But with the increase in concentration of dioxane-water,the B value becomes less negative indicating stronger ion-solvent interaction.The value of A and B are determined.figure.1 and Table 2

Table-2: Physical properties of ciprofloxacin hydrochloride in dioxane-water mixture at 303.3 K

Concentration (mole.lit^{-1})	Relative viscosity (ηr)	Density (ds) kg m^{-3}	Apparent molarvolume (vφ) m^{3}mole^{-1}	Solvation number (S_n)
10% dioxane-water mixture at 303.3 K				
0.00	1.512	1021.11	0.5072	0.32743
1x10^{-3}	1.444	1021.23	0.5166	0.32975
2x10^{-3}	1.382	1021.32	0.5264	0.33256
3x10^{-3}	1.303	1021.46	0.5356	0.33451
4x10^{-3}	1.232	1021.58	0.5392	0.33696
5x10^{-3}	1.221	1021.62	0.5458	0.33936
6x10^{-3}	1.206	1021.67	0.5506	0.34239
7x10^{-3}	1.189	1021.70	0.5544	0.34461
8x10^{-3}	1.172	1021.77	0.5586	0.34714
9x10^{-3}	1.159	1021.81	0.5618	0.34925
20% dioxane-water mixture at 303.3 K				
0.00	1.521	1021.32	0.5297	0.32806
1x10^{-3}	1.461	1021.41	0.5335	0.33017
2x10^{-3}	1.404	1021.49	0.5366	0.33206
3x10^{-3}	1.345	1021.54	0.5405	0.33402
4x10^{-3}	1.295	1021.59	0.5441	0.33697
5x10^{-3}	1.232	1021.66	0.5480	0.33986
6x10^{-3}	1.212	1021.69	0.5512	0.34249
7x10^{-3}	1.195	1021.73	0.5548	0.34499
8x10^{-3}	1.181	1021.76	0.5589	0.34736
9x10^{-3}	1.166	1021.82	0.5677	0.35034
30% dioxane-water mixture at 303.3 K				
0.00	1.531	1021.47	0.5302	**0.32840**
1x10^{-3}	1.468	1021.54	0.5339	**0.34042**
2x10^{-3}	1.412	1021.59	0.5373	**0.34183**
3x10^{-3}	1.355	1021.62	0.5409	**0.34314**
4x10^{-3}	1.304	1021.68	0.5449	**0.34520**
5x10^{-3}	1.243	1021.72	0.5483	**0.34713**
6x10^{-3}	1.218	1021.75	0.5514	0.34985
7x10^{-3}	1.207	1021.79	0.5552	**0.35120**
8x10^{-3}	1.189	1021.81	0.5589	**0.35366**
9x10^{-3}	1.173	1021.89	0.5087	**0.35517**

Table-2: Limiting Apparent molar compressibility (φκ), Limiting Apparent molar volume (vφ), S_v,S_k, A and B.

Parameter	10%	20%	30%
Limiting Apparent molar volume (φ_v)m^3mole	0.5053	0.5056	0.5058
Limiting Apparent molar compressibility (φ0κ)x 10^{-9} m^2 N^{-1}	1.0425	1.0427	1.0428
S_v $m^3kg^{1/2}$ $mole^{-3/2}$	6.322	6.327	6.329
S_k M^3mole-2kg. N^{-1}	51.885	51.886	51.889
A	10.501	10.504	10.506
B	-55.453	-55.451	-55.449

Table-3:

Ultrasonic velocity (Us) m s^{-1}, Apparent molar compressibility (φk x10^{-9}) m^2 N^{-1}, Relative association (R_A), Adiabatic compressibility (K_S) x10^{-10} m^2N^{-1}, Intermolecular free length (L_f) x10^{-11} m, Specific acoustic impedance (Zx10^6) kg m^{-2} s^{-1}

Concentration	Ultrasonic velocity (Us) m s^{-1}	Apparent molarcompressibiity(φk x10^{-9}) m^2 N^{-1}	Relative association (R_A)	Adiabatic compressibiliy (β_s) x10^{-10} m^2N^{-1}	Intermolecular free length (L_f) x10^{-11} m	Specific acoustic impedance (Zx10^6) kg m^{-2} s^{-1}
10% dioxane-water mixture at 303.3 K						
0.00	1322.21	3.5603	1.00164	5.60432	4.76121	1.3503
1x10^{-3}	1318.24	3.5852	1.00359	5.63804	4.77563	1.3462
2x10^{-3}	1313.62	3.6165	1.00582	5.67706	4.79206	1.3424
3x10^{-3}	1307.85	3.6372	1.00735	5.72666	4.81293	1.3367
4x10^{-3}	1303.93	3.6643	1.00933	5.76068	4.82715	1.3328
5x10^{-3}	1299.19	3.6895	1.01195	5.80314	4.84492	1.3274
6x10^{-3}	1294.54	3.7231	1.01359	5.84395	4.86196	1.3227
7x10^{-3}	1286.67	3.7472	1.01527	5.89693	4.88937	1.3168
8x10^{-3}	1287.43	3.7751	1.01716	5.93554	4.89993	1.3126
9x10^{-3}	1277.91	3.5603	1.00164	5.97965	4.91804	1.3078
20% dioxane-water mixture at 303.3 K						
0.00	1322.28	3.564	1.00168	5.60439	4.76125	1.3504
1x10^{-3}	1318.25	3.5853	1.00357	5.63806	4.77564	1.3463
2x10^{-3}	1313.64	3.6167	1.00583	5.67704	4.79207	1.3425
3x10^{-3}	1307.88	3.6374	1.00734	5.72662	4.81294	1.3368
4x10^{-3}	1303.81	3.6647	1.00938	5.76064	4.82716	1.3329
5x10^{-3}	1299.13	3.6894	1.01192	5.80313	4.84494	1.3275

$6x10^{-3}$	1294.45	3.7237	1.01354	5.84399	4.86195	1.3228
$7x10^{-3}$	1286.61	3.7479	1.01528	5.89696	4.88936	1.3169
$8x10^{-3}$	1287.42	3.7753	1.01712	5.93551	4.89994	1.3127
$9x10^{-3}$	1277.84	3.5602	1.00163	5.97963	4.91805	1.3079
30% dioxane-water mixture at 303.3 K						
0.00	1322.30	3.5606	1.00174	5.60441	4.76125	1.3504
$1x10^{-3}$	1318.29	3.5855	1.00364	5.63807	4.77565	1.3463
$2x10^{-3}$	1313.67	3.6167	1.00589	5.67707	4.79207	1.3425
$3x10^{-3}$	1307.88	3.6378	1.00736	5.72668	4.81295	1.3369
$4x10^{-3}$	1303.97	3.6644	1.00939	5.76069	4.82717	1.3329
$5x10^{-3}$	1299.21	3.6896	1.01198	5.80315	4.84495	1.3278
$6x10^{-3}$	1294.55	3.7235	1.01360	5.84397	4.86197	1.3229
$7x10^{-3}$	1286.68	3.7476	1.01527	5.89698	4.88935	1.3169
$8x10^{-3}$	1287.44	3.7756	1.01717	5.93559	4.89997	1.3129
$9x10^{-3}$	1277.92	3.5606	1.00165	5.97967	4.91808	1.3086

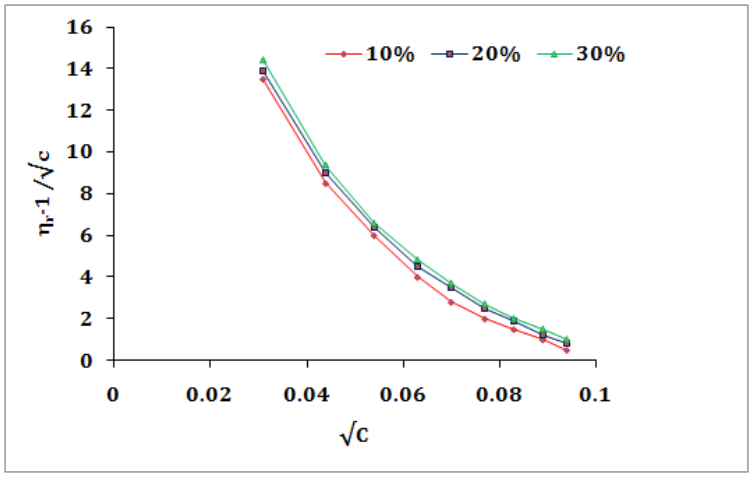

Fig.1: Relative viscosity of drug using Jones-Dole equation

Conclusion

In the present study mentions the experimental data for ultrasonic velocity and density at 303.3K for ciprofloxacin in 1,4-dioxane-water mixture. From experimental data calculated acoustical parameters and studied to explain solute-solvent interaction and ion-ion / solute-solute interaction are existing between drug and organic solvent mixture.

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Reference

1. Harsh Kumar, Meenu Singla, Arjuna Katal Effect of N-acetylglycine on volumetric, acoustic and viscometric behavior of aqueous amoxicillin solutionsThermochimica Acta, Volume 583, 10 May 2014, Pages 49-58
2. Meenu Singla, Rajeev Jindal, Harsh Kumar Volumetric, acoustic, and UV absorption studies on solute–solvent interactions of dipeptides of glycine with aqueous amoxicillin solutionsThermochimica Acta, Volume 591, 10 September 2014, Pages 140-151
3. S. Baluja and S. Oza , Fluid phase equlibria. , **2005**, 200(1): 49-54.
4. M. K. Rawat and Sangeeta, Ind. J. pure Appl. Phy. , **2008**, 46: 187-192.
5. A Ali. and A K Nain, Acoustics Lett. **, 1996,** 19: 53.
6. H. Ogawa and S J Murakami, J. Solution. Chem., **1987**, 16:315.
7. Suresh Ryshetti, Bharath Kumar Chennuri, Raghuram Noothi, Savitha Jyostna Tangeda, Ramesh L. Gardas Volumetric properties of betaine hydrochloride drug in aqueous NaCl and KCl solutions at different temperaturesThermochimica Acta, Volume 597, 10 December 2014, Pages 71-77
8. Muhammad Javed Iqbal, Mansoora Ahmed Chaudhry Effect of temperature on volumetric and viscometric properties of some non-steroidal anti-inflammatory drugs in aproticsolventsThe Journal of Chemical Thermodynamics, Volume 42, Issue 8, August 2010, Pages 951-956
9. Edith Cristina Laignier Cazedey, Hérida Regina Nunes Salgado A novel and rapid microbiological assay for ciprofloxacin hydrochlorideJournal of Pharmaceutical Analysis, Volume 3, Issue 5, October 2013, Pages 382-386
10. Zhengwei Mao, Lie Ma, Changyou Gao, Jiacong ShenPreformed microcapsules for loading and sustained release of ciprofloxacin hydrochlorideJournal of Controlled Release, Volume 104, Issue 1, 5 May 2005, Pages 193-202
11. T. Schöck, M. Hussein, B. Hitzmann, T. Becker **,**Influence of dissolved carbon dioxide on the sound velocity and adiabatic compressibility in aqueous solutions with saccharose and ethanol**,** Journal of Molecular Liquids, Volume 175, November 2012, Pages 111-120
12. A.P. Mishra and D.K. Mishra, J.Chem. Pharm.Res. **2011,** Vol.3 (3):489.
13. M. Arvinthraj , S. Venktesan and D. Meera, J.Chem. Pharm.Res, **2011,** Vol.3 (2):623.
14. S.K. Thakur and S.Chauhan, J.Chem. Pharm.Res., **2011,**Vol.3(2) :657.
15. H Eyring , J.F. Kincaid, *J. Chem. Phys*., **6,** 620-629 (1938).