Physico-Chemical Properties of Aqueous Alendronate Sodium through Ultrasonic Investigation at 300K and 303K

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Abstract: *The ultrasonic wave propagation behaviour in solid, liquid, liquid mixtures, suspensions, polymers etc. is nowadays an effective means for examining the physical properties of materials or medium. Thermo-acoustical parameters such as acoustic impedance, adiabatic compressibility, free length, free volume and internal pressure etc. pave way to study the nature, type and strength of intermolecular interactions present in solutions. Therefore systematic investigation of aqueous Alendronate sodium has been undertaken here at 300K and 303K. Thermo-acoustical parameters using density, viscosity and ultrasonic velocity at these temperatures are evaluated and molecular interactions in terms of these parameters are discussed.*

Keywords: Alendronate sodium, Ultrasonic velocity, thermo-acoustical parameters, molecular interactions

1. Introduction

The study of intermolecular interactions plays an important role in the development of molecular sciences. For proper use of liquids, liquid mixtures and solutions in various industries, the study of molecular interactions in them is very essential. The measurement of ultrasonic velocity, density, viscosity and related thermodynamic parameters such as acoustic impedance, adiabatic compressibility, free length, free volume and internal pressure etc. are used to explain the nature, strength and order of molecular interactions. Survey of literature revels that there are five broad divisions of acoustical studies [1-2]. An important information regarding Physico-chemical behaviour of liquid and liquid mixture can be obtained from the knowledge of ultrasonic study [3-6]. Drug macromolecular interactions involved in drug transport, protein binding anesthesia are an important phenomenon in physiological media [7]. Ultrasonic velocity and allied acoustical parameters plays very important role in the study of nature and type of molecular interactions in liquids and liquid mixtures[8-12]. In continuation of our earlier work[13-15] we report the ultrasonic velocity of aqueous Alendronate sodium at 300K and 303K and discuss the nature and type of molecular interactions in the present work. The drug Alendronate($C_4H_{12}NNaO_7P_2 3H_2O$) is in the group of medicine called biophosphonates. It alters the cycle of bone formation and breakdown in the body. It shows bone loss while increasing bone mass, which may prevent bone fractures. It is used in men and women to treat or prevent Osteoporosis that is caused by menopause

2. Experimental

The drug Alendronate sodium has been employed in the present study. Double distilled water is taken as solvent. An aqueous stock solution of an Alendronate sodium drug was prepared and then by dilution method solution of different concentration in the step of 0.01M was prepared. The densities of pure solvent and their solutions were measured with high accuracy ± 0.001g/cm^3. The viscosity of pure solvent and solutions were measured with high accuracy of 0.05 %. Ultrasonic velocity was measured by using digital ultrasonic pulse-echo meter for liquids and solids model (VCT 70A) operating at 2 MHz. The interferometer was filled with test liquid and water was circulated around the measuring cell from a thermostat. The experimental data of concentration in molarity (c,M) ultrasonic velocity (U), density and viscosity at 300K and 303K are tabulated in table 1 and table 2.

3. Result and Discussion

By using experimental data of density, viscosity and ultrasonic velocity of pure solvent and solutions, various acoustical parameters were calculated using following standard equations and are given in table 1.1 and table 2.1.

Adiabatic compressibility (β)
$\beta = 1/U^2\rho$
Where U is ultrasonic velocity and ρ is the density of solution

Free length (L$_f$)
$L_f = K_1 \beta^{1/2}$
Where K_1 is temperature dependent constant ($K_1 = (93.875 + 0.375T) \times 10^{-8}$)

Free Volume
$V_f = [M_{eff} U / k n_s]$
Where M_{eff} is effective molecular weight which is constant equal to 4.28×10^9 independent of temperature for all types of liquids

Internal pressure (π$_i$)
$\pi_i = bRT(k\eta_s/U)^{1/2} (\rho^{2/3} / M_{eff}^{7/6})$
Where b stands for the cubic packing factor which is assumed to be 2 for all liquids and solutions. k is temperature independent constant, R is gas constant, T is the absolute temperature and η_s is the viscosity of the solution

International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064, Impact Factor (2013): 4.438
www.ijsr.net

Acoustic impendence (Z)

$Z = U \rho$ Where U is ultrasonic velocity and ρ is density of solution

Table1: Ultrasonic velocity, density, viscosity of aqueous **Alendronate sodium at 300K**

Sr. no	Con.	Density(ρ) Kg/m^3	Ultrasonic velocity(U)(m/s)	Viscosity(η) (N s m^{-2})
1	0.01	997.98	1495.331	8.532549716E-4
2	0.02	999.03	1497.127	8.613350237E-4
3	0.03	1000.03	1498.326	8.723152447E-4
4	0.04	1001.06	1499.528	8.881015898E-4
5	0.05	1002.08	1500.129	8.924753831E-4
6	0.06	1003.64	1501.334	8.997520994E-4
7	0.07	1004.96	1502.540	9.120714028E-4
8	0.08	1006.39	1503.748	9.225646719E-4

Table 1.1 Variation of acoustical parameters with different concentration of aqueous Alendronate sodium at 300K

Sr. no	c.M	β (N^{-1}m^2)	Lf (m)	Vf (m^3/mole)	Z (kg/m^2/s)	πi (N/m^2)
1	0.01	4.48129E-10	4.22E-11	1.54E-06	1492310	91317075
2	0.02	4.46585E-10	4.22E-11	1.52E-06	1495675	91757683
3	0.03	4.45425E-10	4.21E-11	1.49E-06	1498371	92365322
4	0.04	4.44253E-10	4.20E-11	1.45E-06	1501117	93223942
5	0.05	4.43446E-10	4.20E-11	1.44E-06	1503249	93497953
6	0.06	4.42046E-10	4.19E-11	1.43E-06	1506799	93938028
7	0.07	4.40757E-10	4.19E-11	1.40E-06	1509993	94623848
8	0.08	4.39424E-10	4.18E-11	1.38E-06	1513357	95218596

Table 2: Ultrasonic velocity, density, viscosity of aqueous **Alendronate sodium at 303K**

Sr No.	c.M	Density(ρ) Kg/m^3	UltrasonicVelocity (U)(m/s)	Viscosity(η)(N s m^{-2})
1	0.01	996.98	1501.334	8.37615299E-4
2	0.02	997.54	1502.144	8.48355122E-4
3	0.03	998.63	1504.353	8.60193226E-4
4	0.04	999.67	1505.564	8.74366750E-4
5	0.05	1000.78	1506.171	8.86702679E-4
6	0.06	1001.83	1507.385	8.98342441E-4
7	0.07	1002.88	1508.601	9.15387801E-4
8	0.08	1003.92	1509.819	9.37638855E-4

Table 2.1: Variation of acoustical parameters with different concentration of aqueous Alendronate sodium at 303K

| Sr. no	c. M	β (N^{-1}m^2)	Lf (m)	Vf (m^3/mole)	Z (kg/m^2/s)	πi (N/m^2)
1	0.01	4.44999E-10	4.21E-11	1.59E-06	1496800	90234918
2	0.02	4.4427E-10	4.21E-11	1.56E-06	1498449	90821073
3	0.03	4.42482E-10	4.20E-11	1.53E-06	1502292	91451933
4	0.04	4.41311E-10	4.19E-11	1.50E-06	1505067	92229177
5	0.05	4.40466E-10	4.19E-11	1.47E-06	1507346	92927511
6	0.06	4.39296E-10	4.18E-11	1.44E-06	1510144	93563166
7	0.07	4.38129E-10	4.18E-11	1.40E-06	1512946	94474521
8	0.08	4.36969E-10	4.17E-11	1.35E-06	1515737	95643350

4. Result and Discussion
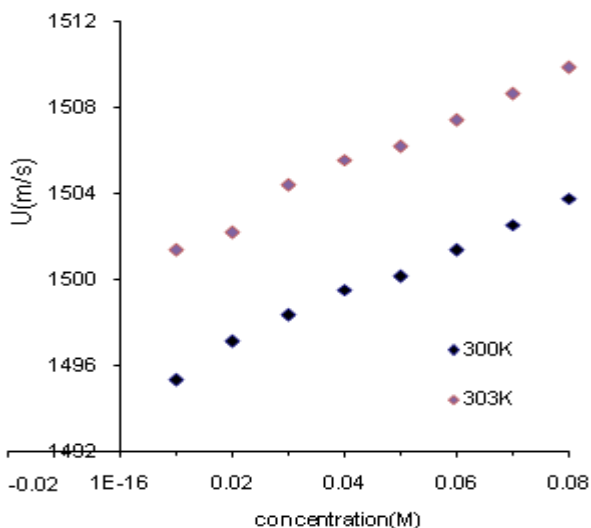
Fig1.Ultrasonic velocity vs concentratiion

It is observed that ultrasonic velocity of aqueous Alendronate sodium increases with rise in concentration and decreases with rise in temperature as shown in **fig.1** which indicates the association of molecular bonding and confirms the strengthening of magnitude of molecular interactions whereas decrease in ultrasonic velocity with rise in temperature shows opposite trend. The change in adiabatic compressibility with concentration and temperature occurs due to structural arrangement of the molecules. The variation in adiabatic compressibility is as shown in **fig.2**. Decrease in adiabatic compressibility with concentration indicates strong m molecular interactions which may be of type solute-solvent. The same is supported by variation in ultrasonic velocity
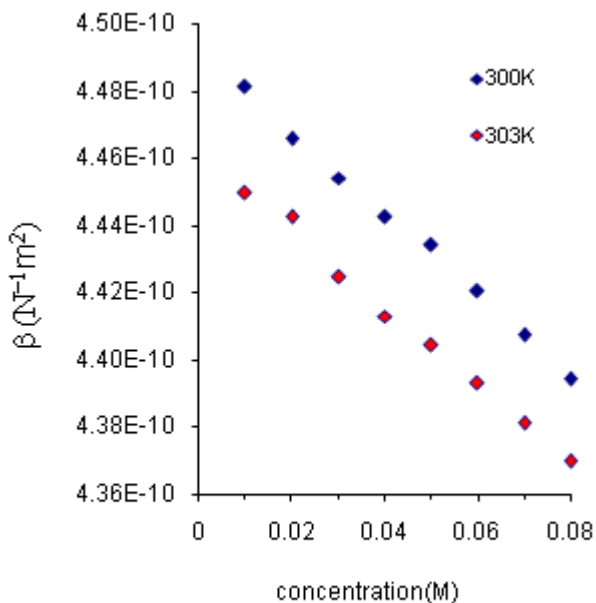
Fig2.Adiabatic compressibility vs concentratiion

Figure 4: Internal Pressure vs concentratiion

The intermolecular free length (L_f) is again a predominant factor in determining the existing interactions among the components of the mixture. Analyzing the respective tables, it is noticed that free length (L_f) reflects a similar trend as that of adiabatic compressibility (β).The variation of free length with concentration and temperature is as shown in **fig.3** As regards aqueous solution of Alendronate sodium, the adiabatic compressibility (β) and hence free length (L_f) values are initially maximum, that conveys more available free space between the molecules. It may be taken as a consequence of lesser molecular size. It is observed that as concentration increases, free space between the molecules decreases with rise in concentration.
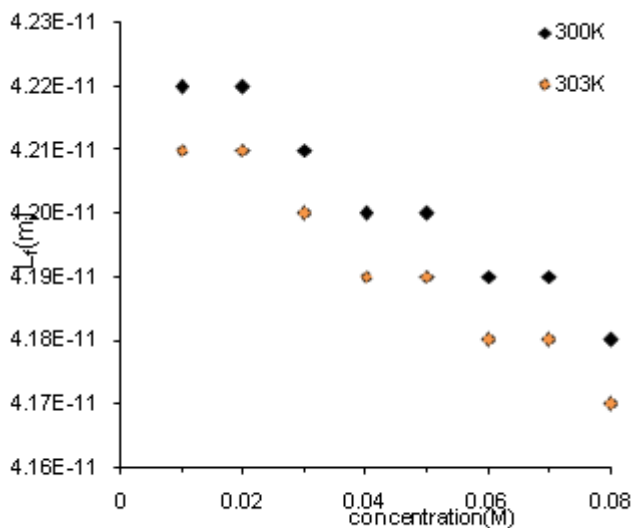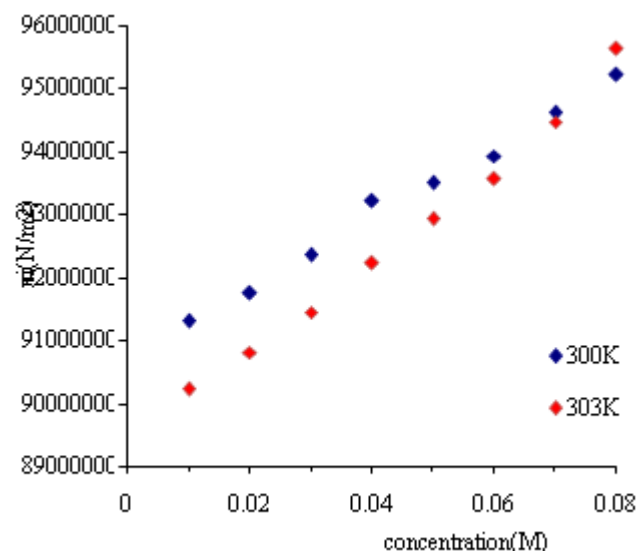
The variation in internal pressure of aqueous Alendronate sodium is as shown in **fig.4**. Increase in internal pressure with concentration indicates that attracting forces are becoming more dominant thereby decreasing the space between solute-solvent molecules. Therefore the strength of the molecular interactions increases.
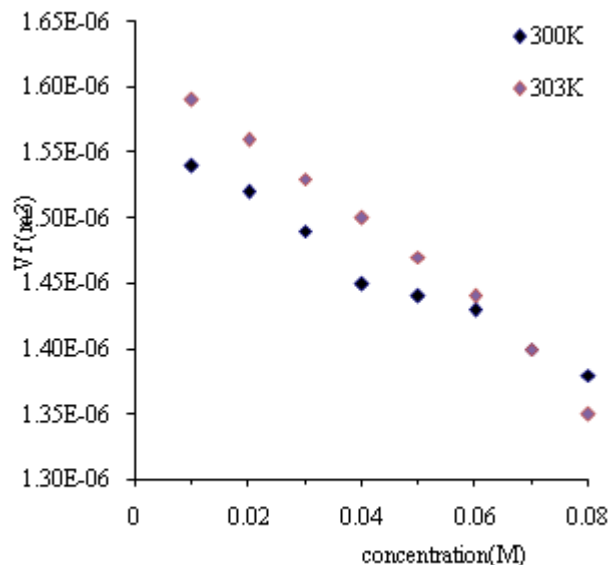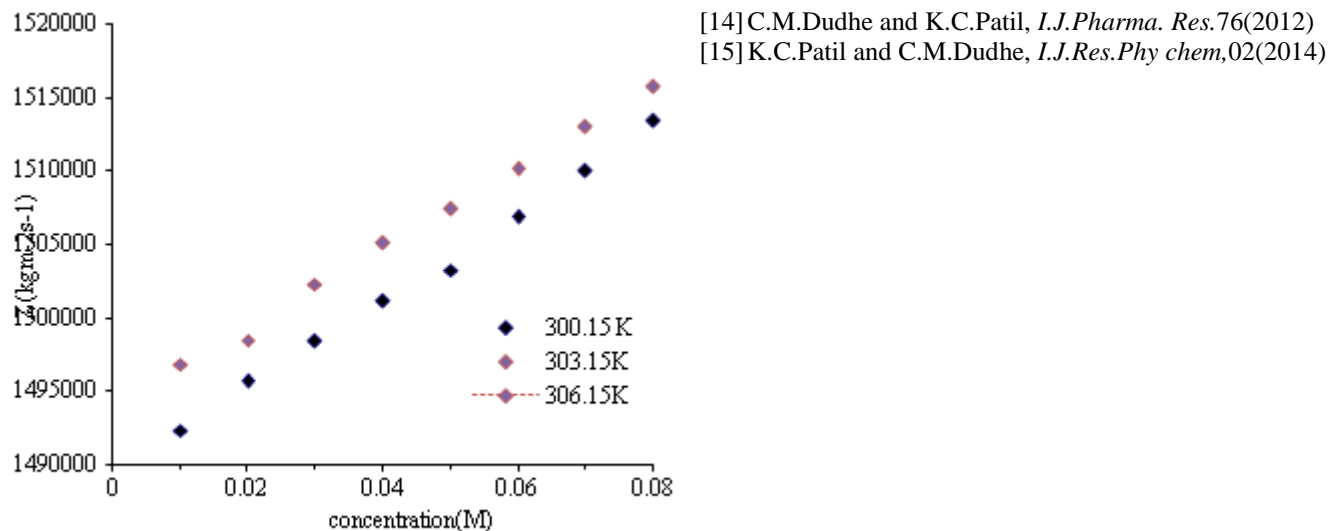

Fig5.Free volume vs concentratiion

Fig3.Free length vs concentratiion

424

Fig6.Acoustic impedence vs concentratiion

[14] C.M.Dudhe and K.C.Patil, *I.J.Pharma. Res.*76(2012)
[15] K.C.Patil and C.M.Dudhe, *I.J.Res.Phy chem,*02(2014)

Free volume as in **fig.5** has shown exactly opposite trend with concentration to that of internal pressure. This indicates that the spacing between the components of solution decreases with concentration which confirms the increase in association of solute with water molecules and strengthening of molecular interactions.

Acoustic impedance offered by the components of solution to the propagation of sound wave through it. Variation in acoustic impedance with concentration and temperature as shown in **fig.6** clearly indicates rise in strength of molecular interactions which is also supported by other acoustical parameters.

5. Acknowledgements

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