# **Biointerface Research in Applied Chemistry**

www.BiointerfaceResearch.com

## **Original Research Article**

**Open Access Journal** 

Received: 09.12.2016 / Revised: 20.01.2017 / Accepted: 29.01.2017 / Published on-line: 15.02.2017

\*corresponding author e-mail address: palani physics06@yahoo.co.in

# Molecular interaction studies of some amino acids with aqueous amoxicillin solution at 308.15K

### R. Palani<sup>1,\*</sup>, J.Selvarasi<sup>2</sup>

<sup>1</sup> Department of physics, DDE Annamalai University, Annamalai Nagar, Tamil Nadu, India

<sup>2</sup> Department of physics, Annamalai University, Annamalai Nagar, Tamil Nadu, India

#### ABSTRACT

Apparent molar compressibilities ( $\varphi_{\mathbf{k}}$ ) and apparent molar volumes ( $\varphi_{\mathbf{v}}$ ), of L-threonine, L-asparagine and L-arginine in aqueous and aqueous amoxicillin solutions (0.0005, and 0.001 mol.dm<sup>-3</sup>) at 308.15K have been determined from precise density and ultrasonic velocity measurements. Limiting apparent molar compressibilities ( $\varphi_{\mathbf{k}}^{\mathbf{0}}$ ) and limiting apparent molar volumes ( $\varphi_{\mathbf{v}}^{\mathbf{0}}$ ) and their constants ( $\mathbf{S}_{\mathbf{k}}, \mathbf{S}_{\mathbf{v}}$ ) of these amino acids at infinite dilution is evaluated. Transfer adiabatic compressibilities ( $\Delta \varphi_{\mathbf{k}}^{\mathbf{0}}$ ), transfer volumes ( $\Delta \varphi_{\mathbf{v}}^{\mathbf{0}}$ ) at infinite dilution from water to aqueous amoxicillin solutions and molar hydration number ( $n_{\rm H}$ ) have been calculated. Viscosity A and B coefficients of Jones-Dole equation have been determined from viscosity measurements. These parameters have been interpreted in terms of ion-solvent and ion-ion interactions are exist in the studied solutions.

Keywords: Amino acids, amoxicillin, ultrasonic velocity, apparent molar volume and molar hydration number.

#### **1. INTRODUCTION**

Most biochemical processes occur in aqueous medium; therefore studies on physicochemical properties of biomolecules like amino acids, sugars and drugs in aqueous solution provide useful information which help in understanding the complex mechanism of molecular interactions [1]. The stabilization of native conformations of biological macromolecules (proteins) is related to several non-covalent interactions including hydrogenbonding, electrostatic and hydrophobic interactions [2,3]. These interactions are important in understanding the stability of proteins, and are implicated in several biochemical and physiological processes in a living cell [4,5]. The protein-drug interactions are important for immunology, biosynthesis, pharmacology, medicine, and cosmetic industry [6]. In biophysical chemistry drug-macromolecular interaction is an important phenomenon involving a complex mechanism [7].Drugmacromolecule interactions are an important phenomenon in physiological media such as blood, membranes and intra-and extra-cellular fluids. Processes of drug transport, protein-binding, anaesthesia are some of the examples where drug biomacromolecules interact in an important and vitally significant manner (Iqbal & Siddiquah, 2006).

Amoxicillin, an antibacterial drug is a part of aminopenicillin family, which is called as broad-spectrum penicillin. In addition to many therapeutic activities, these drugs have several side effects like rash and anaphylaxis. The drug interactions occurring outside the body are categorized as physical or chemical and may occur during formulation, storage as well as while mixing ingredients[8]. L-threonine is an essential amino acid, as it must be provided by dietary which are mostly found in plant and animal proteins. L-asparagine is a non-essential amino acid which is manufactured from other amino acids in the liver. It participates in the functioning of brain and nervous system and helps to maintain equilibrium as well as transformation of amino acid in the liver. It is commonly found in poultry, dairy, eggs, fish, meat, nuts, seafood and whole grains. L-arginine is an essential amino acids that help to synthesize nitric oxide, which plays a critical role in blood circulation throughout the body [9]. Larginine stimulates HGH (Human Growth Harmone) production by blocking the secretion of some natural inhibits, several clinical studies have shown that L-arginine can increase natural HGH production by over 300%. It lowers the blood pressure, helps to regulate healthy immune system, heal and repair soft tissues. Thus, the properties of amino acids in aqueous-drug solutions are essential for understanding the chemistry of biological systems. Despite the importance of the subject, only a few physicochemical studies of amino acids in aqueous-drug solutions have been reported [10]. Therefore, an attempt has been made to carry out the volumetric, ultrasonic and viscometric studies of L-threonine, L-asparagine, and L-arginine in aqueous solutions of antibacterial drug amoxicillin to investigate interactions in these systems.

In the present paper, we report the densities, ultrasonic velocities, and viscosities of solutions of L-threonine, L-asparagine, and L-arginine in aqueous and aqueous amoxicillin (0.0005 and 0.001 mol.dm<sup>-3</sup>) solutions at 308.15K. Various physicochemical parameters, viz., the adiabatic compressibility, molar hydration number, apparent molar compressibility, apparent molar volume, limiting apparent molar compressibility, limiting apparent molar volume, and their constants (Sk,Sv) transfer limiting apparent molar volume, and viscosity A and B coefficients of Jones-Dole equation have been calculated using the experimental data. The results have been interpreted in terms of ion-solvent and ion-ion interactions in these systems.

#### 2. EXPERIMENTAL SECTION

L-threonine, L-asparagine, and L-arginine with purities > 0.99 procured from Sd Fine chemicals and amoxicillin with purities > 0.99 purchased from Siscon Biomedicals, India, were used, as supplied. All the chemicals were stored in special airtight bottles to avoid the exposure of solutions to air and evaporations. Doubly distilled, degassed water was used for the preparation of all solutions. The solutions were prepared by weighing on a electronic digital balance (Model: SHIMADZU AUX 220) with a precision of  $\pm 0.1$ mg. The density was determined using 5ml specific gravity bottle by relative measurement method. An ultrasonic interferometer having fixed the frequency of 2MHz (MITTAL ENTERPRISES, New Delhi model F-81) has been used for ultrasonic velocity measurement. The viscosity was measured by Ostwald's type capillary viscometer and time measurements were performed using digital chronometer within  $\pm 0.01$ s (model: CASIO HS-10W). The sensitivity of the instrument corresponds to a precision in density, viscosity and ultrasonic velocity measurements of  $1.10^{-1}$  kgm<sup>-3</sup>,  $1.10^{-4}$  Nsm<sup>-2</sup> and  $1.10^{-1}$  ms<sup>-1</sup>. The uncertainty of the density, viscosity and velocity estimates was found to be within  $\pm 1.$ kgm<sup>-3</sup>,  $\pm 0.001$ Nsm<sup>-2</sup> and  $\pm 5$  ms<sup>-1</sup> respectively. The accuracy in the temperature measurement is ±0.1K.

Using the measured data, the following volumetric, compressibility and transport parameter have been calculated using the standard relations. Adiabatic compressibility.

$$\beta = \frac{1}{\mathbf{V}^2 \rho} \tag{1}$$

Molar hydration number has been computed using the relation

$$n_{\rm H} = \left(\frac{n_1}{n_2}\right) \left(1 - \frac{\beta}{\beta_a}\right) \tag{2}$$

where,  $\beta$  and  $\beta$ o are adiabatic compressibilities of solution and solvent respectively,  $n_{\pm}$  and  $n_{\mp}$  are number of moles of solvent and solute respectively.

The apparent molar compressibility has been calculated from relation.

$$\varphi_{k} = \frac{1000}{M\rho_{o}} (\rho_{o}\beta - \rho \beta_{o}) + (\frac{Ms\beta_{o}}{\rho_{o}})$$
(3)

#### **3. RESULTS SECTION**

The experimental values of density ( $\rho$ ), viscosity ( $\eta$ ) and ultrasonic velocity (U) for different molar composition of each of the three amino acids viz., L-threonine, L-asparagine and Larginine in aqueous and aqueous amoxicillin solutions (0.0005, and 0.001 mol.dm<sup>-3</sup>) at 308.15K are shown in Table 1. The values of adiabatic compressibility ( $\beta$ ),molar hydration number ( $n_H$ ), apparent molar compressibility ( $\phi_R$ ), apparent molar volume ( $\phi_{\Psi}$ ), limiting apparent molar compressibility ( $\phi_R$ ), limiting apparent molar volume ( $\phi_{\Psi}^{0}$ ), and their constants ( $\mathbb{S}_{IR},\mathbb{S}_{\Psi}$ ), transfer adiabatic compressibility ( $\Delta \phi_R^{0}$ ), transfer volume ( $\Delta \phi_{\Psi}^{0}$ ) and viscosity A and B coefficient of Jones-Dole equation were calculated and the results are given in Tables 2 and 3. Further, the variation of these parameters of studied systems have been drawn using principle of least square fitting. where,  $\beta$ ,  $\rho$  and  $\beta_0$ ,  $\rho_0$  are the adiabatic compressibility and density of solution and solvent, respectively, M is the molar concentration of the solute and M<sub>s</sub> the molecular weight of the solute.  $\varphi_k$  is the function of M as obtained by Gucker(1993) [11] from Debye Huckel [12] and is given by

$$\varphi_{\rm R} = \varphi_{\rm R}^{\sharp} + \mathbb{S}_{\rm R} M^{1/2} \tag{4}$$

where,  $\varphi_{\mathbf{k}}^{\mathbb{D}}$  is the limiting apparent molar compressibility at infinite dilution and  $\mathbb{S}_{\mathbf{k}}$  is a constant.  $\varphi_{\mathbf{k}}^{\mathbb{D}}$  and  $\mathbb{S}_{\mathbf{k}}$  of equation (4) have been evaluated by least square method.

The apparent molar volume has been calculated using the relation.

$$\varphi_{\nabla} = \left(\frac{M_{\text{B}}}{\rho}\right) - \left[\frac{1000}{Mp\rho_{0}}(\rho - \rho_{0})\right]$$
(5)

The apparent molar volume  $\varphi_{\psi}$  has been found to differ with concentration according to [13] empirical relation as:

$$\boldsymbol{\varphi}_{\boldsymbol{\nabla}} = \boldsymbol{\varphi}_{\boldsymbol{\nabla}}^{\boldsymbol{0}} + \mathbb{S}_{\boldsymbol{\nabla}} \mathbf{M}^{1/2} \tag{6}$$

where,  $\varphi_{V}^{0}$  is the limiting apparent molar volume at infinite dilution and  $\mathbb{S}_{V}$  a constant and these values were determined by least square method.

Transfer volumes, and transfer adiabatic compressibility of each amino acid,  $\Delta \varphi_{\mathbb{V}}^{\mathbb{D}}$  and  $\Delta \varphi_{\mathbb{R}}^{\mathbb{D}}$  from water to aqueous amoxicillin were calculated using the equation.

 $\Delta \varphi_{y}^{0} = \varphi_{y}^{0} \text{ (in aqueous amoxicillin solution)} - \varphi_{y}^{0} \text{ (in water)}$ (7) where,  $\varphi_{y}^{0}$  denotes limiting apparent molar volume  $\varphi_{v}^{0}$ , and limiting apparent molar adiabatic compressibility  $\varphi_{v}^{0}$ .

The viscosity A and B coefficient for the amino acids in aqueous amoxicillin solution were calculated from the Jones-Dole equation [14].

$$\frac{\Pi}{\pi_{ee}} = 1 + A M^{1/2} + BM$$
 (8)

where,  $\eta$  and  $\eta_o$  are the viscosities of the solution and solvent respectively and M are the molar concentration of the solute. A is known as the Falkenhagen coefficient which characterizes the ionic interaction and B is the Jones-Dole or viscosity B coefficient which depends on the size of the solute and the nature of solutesolvent interaction.

Density is a measure of ion-solvent interactions. The values of density are increases (Fig 1) with concentration of amino acids and aqueous amoxicillin which shows that the increase in ionsolvent interactions and this may be due to contraction in volume owing to the presence of solute molecules. This can be attributed to the structure-forming ability of the solute in the presence of the solvent. The change in structure of the solvent or solution is a result of hydrogen bond formation, dissociation and the hydrophobic or hydrophilic character of the solute. From the Fig 2 it is found that the ultrasonic velocity for the three systems were increased with the increase in concentrations of amino acids and amoxicillin content. The increase in velocity may be attributed to strong ion- solvent interactions. This may probably be due to

Molecular interaction studies of some amino acids with aqueous amoxicillin solution at 308.15K

molecular association and complex formation through hydrogen bonding [15].

The values of  $\beta$  (Fig 4) in the studied system show a decreasing trend due to (i) an increase in number of dipolar ions in solution, and/or (ii) the formation of a compact structure of dipolar ions-water dipoles and a dipolar-ion structure in solution. This shows that molecular association is greater for amino acid molecules, which exists in dipolar form in neutral solution and have stronger interaction with the surrounding water molecules[16]. An increase in electrostrictive compression of water around the molecules results in larger decrease in the compressibility of the solution. The magnitudes of  $\beta$  values are larger in L-threenine than other two amino acids. The larger  $\beta$ values which shows molecular association/interactions is greater in L-threonine than other two amino acids. The hydration number is the number of water molecules rigidly bound to the ions. From the Fig 5 it reveals that the positive  $n_{\rm H}$  values get decreased with increasing the concentration of amino acid, but a reverse trend occurs when amoxicillin contents are increased. This indicates the existence of ion-solvent interaction. The hydration numbers mainly come from the electrostriction effect of the charged end/polar groups of amino acid on water. Further, in the present study the decreasing behaviour which shows amoxicillin has a dehydration effect on the amino acid and vice-versa [17].



**Figure 1.** Variation of density of some amino acids in aqueous amoxicillin solutions for various concentration at 308.15K

Further insight into the type and extent of the amino acids interactions in an aqueous solution of drug was obtained from the behaviour of the apparent molar volume and the apparent molar adiabatic compressibility. The variation of apparent molar volume  $\varphi_{\rm F}$  and apparent molar adiabatic compressibility  $\varphi_{\rm k}$  of amino acid and in an aqueous solution of amoxicillin are shown in Fig 6-7.



**Figure 2.** Variation of velocity of some amino acids in aqueous amoxicillin solutions for various concentration at 308.15K.



**Figure 3.** Variation of viscosity of some amino acids in aqueous amoxicillin solutions for various concentration at 308.15K.

The  $\varphi_{\mathbb{R}}$  and  $\varphi_{\Psi}$  values are negative and varies non-linearly in all studied systems. Negative  $\varphi_{\mathbb{R}}$  and  $\varphi_{\Psi}$  values indicate the presence of electrostatic, hydrophilic or ionic interactions and solute-solvent (syal et al., 2005b: Chauhan et al., 2012) shows that water molecules around the solute are less compressible than those in the enlarge which attributed to strong attractive interactions (Kumar and Kaur 2012) [18]. Different types of interactions which could occur in an amino acid-drug system is (i) hydrophilic or

#### Molecular interaction studies of some amino acids with aqueous amoxicillin solution at 308.15K

ionic interactions between the polar group of the drug and the zwitterion of the amino acid and (ii) hydrophilic or hydrophilic interactions between the polar group of the drug and the polar group of the amino acid. These electrostatic types of interaction, i.e. (i) and (ii) result in the reduction of the electrostriction effect and in enhanced overall structure of water. The magnitude of  $\varphi_{k}$  and  $\varphi_{\psi}$  is in the order: L-threonine > L-asparagine > L-arginine.



**Figure 4.** Variation of adiabatic compressibility of some amino acids in aqueous amoxicillin solutions for various concentration at 308.15K.



**Figure 5.** Variation of hydration number of some amino acids in aqueous amoxicillin solutions for various concentration at 308.15K.

Further, the limiting apparent molar compressibility  $\varphi_k^{\mathbb{Q}}$ measures the ion-solvent interactions and the constant  $\mathbb{S}_k$  affords information regarding ion-ion interaction. The values  $\varphi_k^{\mathbb{Q}}$  of and  $\mathbb{S}_k$  for various concentration of amoxicillin along with different amino acid have been indexed in Table 3. The negative values  $\varphi_{\mathbb{R}}^{\mathbb{Q}}$  showing the presence of strong solute-solvent interactions result in less compressible solution [19].



Figure 6. Variation of apparent molar compressibility of some amino acids in aqueous amoxicillin solutions for various concentration at 308.15K.



**Figure 7.** Variation of apparent molar volume of some amino acids in aqueous amoxicillin solutions for various concentration at 308.15K

The increase in  $\varphi_k^{\oplus}$  values with different concentration of amoxicillin may be due to the release of large water molecules from the secondary solvation layer of zwitterions of amino acid into the bulk of water, which makes the solutions more compressible [20]. However, the magnitudes of different types of ionic interactions seem to be in direct relation with increase in

#### Molecular interaction studies of some amino acids with aqueous amoxicillin solution at 308.15K

amoxicillin concentration in the system which in turn results in more negative  $\varphi_{k}^{0}$  values. These results further substantiate the fact that hydrophilic-ionic/hydrophilic-hydrophilic interactions exceed hydrophilic- hydrophobic interaction. The magnitude of  $\varphi_{k}^{0}$  is in the order: L-threonine > L-asparagine > L-arginine. Relatively, lesser  $S_{k}$  values for all the studied system suggests very weak ion-ion interactions. As ion-ion interactions are insignificant at endless dilution, which indicate that ion-solvent interactions are predominanting in the mixtures [21].

The limiting apparent molar volume  $\varphi_{V}^{0}$  by definition is free from ion-ion interactions and therefore provides a measure of ion-solvent interactions whereas the experimental slope  $S_{w}$ provides information regarding ion-ion interaction. The values of  $\varphi_v^{\mathbb{Q}}$  and  $\mathbb{S}_v$  are reported in Table 3. The negative  $\varphi_v^{\mathbb{Q}}$  values indicate the presence of ion-solvent interactions, which increase with increase in the amoxicillin concentration in all amino acids. As per co-sphere overlap model [22,23] an overlap of co-spheres of two ionic species causes an increase in volume, whereas overlap of hydrophobic-hydrophobic groups and ion-hydrophobic groups result in volume decrease. From Table 3, it is also observed that the magnitude of  $S_{u}$  is both positive and negative values at different concentrations of amoxicillin for the studied system. Though not a regular trend has been observed, this clearly indicates that number of effects influence the (solute + solute) interactions[24].

In all three systems, the variation of  $\Delta \varphi_{k}^{\oplus}$  and  $\Delta \varphi_{v}^{\oplus}$  (Fig8&9) are all positive and increase with increase in the concentration of amoxicillin for each amino acid.



**Figure 8.** Variation of transfer adiabatic compressibility of some amino acids with molarity of aqueous amoxicillin solutions at 308.15K



**Figure 9.** Variation of transfer volume of some amino acids with molarity of aqueous amoxicillin solutions at 308.15K.

		$\rho / (kgm^{-3})$		r	$/(x \ 10^{-3} \ \text{Nsm}^{-2})$	)	U / (m.s <sup>-1</sup> )							
M / (mol.dm <sup>-3</sup> )	water + amoxicillin													
	0.0 M	0.0005M	0.001M	0.0M	0.0005M	0.001M	<b>0.0M</b>	0.0005M	0.001M					
	System - I : water + amoxicillin +L-threonine													
0.00	994.0	995.1	997.7	0.7190	0.7295	0.7320	1517.2	1520.2	1524.6					
0.02	995.9	996.9	999.6	0.7254	0.7309	0.7325	1519.6	1524.3	1527.6					
0.04	997.9	1000.3	1001.7	0.7313	0.7371	0.7390	1521.6	1526.8	1530.4					
0.06	999.8	1004.0	1006.7	0.7424	0.7437	0.7501	1523.2	1532.3	1538.4					
0.08	1001.8	1005.9	1008.5	0.7506	0.7498	0.7532	1525.3	1538.9	1542.8					
0.10	1002.9	1009.0	1011.6	0.7566	0.7570	0.7593	1527.6	1540.0	1544.4					
System – II : water + amoxicillin +L-asparagine														
0.00	994.0	995.1	997.7	0.7190	0.7295	0.7320	1517.2	1520.2	1524.6					
0.02	996.9	998.4	1000.9	0.7261	0.7318	0.7361	1520.4	1526.2	1528.8					
0.04	998.7	999.6	1002.3	0.7332	0.7397	0.7448	1522.3	1530.4	1538.4					
0.06	1000.7	1002.1	1004.5	0.7484	0.7475	0.7511	1524.2	1538.3	1546.8					
0.08	1002.2	1004.0	1006.5	0.7514	0.7533	0.7569	1526.4	1546.2	1568.1					
0.10	1003.4	1008.4	1011.2	0.7589	0.7632	0.7649	1529.2	1554.1	1580.5					
			System ·	- III :water + an	noxicillin +L-arg	ginine								
0.00	994.0	995.1	997.7	0.7190	0.7295	0.7320	1517.2	1520.2	1524.6					
0.02	997.4	999.5	1002.2	0.7276	0.7348	0.7380	1521.6	1528.0	1531.6					
0.04	1000.3	1002.7	1005.2	0.7335	0.7449	0.7481	1523.6	1536.6	1550.2					
0.06	1002.0	1008.2	1010.8	0.7562	0.7535	0.7570	1526.2	1544.5	1558.8					
0.08	1003.6	1012.7	1014.9	0.7585	0.7612	0.7646	1528.4	1552.8	1575.6					
0.10	1005.8	1016.9	1019.5	0.7631	0.7684	0.7776	1530.6	1566.2	1589.2					
The po	The positive values of $\Delta m^2$ indicate the dominance of electrostriction decreases and structure making tendency of jons													

Table 1. Values of density (p), viscosity (n) and ultrasonic velocity (U) of amino acids in aqueous amoxicillin solutions at 308.15K for

The positive values of  $\Delta \varphi_{k}^{p}$  indicate the dominance of interactions between the dipolar ions centre of amino acid and drug indicating the structure forming tendency of the ions. However, with the increase in concentration of amoxicillin,

electrostriction decreases and structure making tendency of ions increase. As a result, the electrostricted water is much less compressible than bulk water and leads to large decrease in the compressibility with increase in amoxicillin concentration. The

#### Molecular interaction studies of some amino acids with aqueous amoxicillin solution at 308.15K

positive values of  $\Delta \varphi_{\mathbb{V}}^{\mathbb{P}}$  indicates strong ion-ion interactions of amoxicillin with amino acids. The observed positive values of transfer volume suggests structure promoter nature of these solutes which is due to their solvophobic salvation as well as the structural interaction for two co-spheres according to co-sphere overlap model [22,23]. The types of interaction that occurs between amino acids and amoxicillin molecules can be classified as: (i) ion hydrophilic interactions (ii) hydrophilic - hydrophilic interactions (iii) ion-hydrophobic interactions and (iv) hydrophobic hydrophobic interactions. Ion-hydrophobic interactions and hydrophobic-hydrophobic interactions contribute negatively based on co-sphere overlap model whereas ion - hydrophilic and hydrophilic - hydrophilic interactions contribute positively to the  $\Delta \varphi_k^{\mathbb{D}}$  and  $\Delta \varphi_k^{\mathbb{D}}$  values. Therefore, it is concluded that ion hydrophilic and hydrophilic - hydrophilic interactions are dominating in the mixtures.

From Fig 3, it is observed that the viscosity values have been found to be increasing with an increase in concentration of amino acids as well as increase in solutions. This may be attributed to an increase in the solute-solvent interactions.

**Table 2.** Values of adiabatic compressibility ( $\beta$ ), molar hydration number ( $n_H$ ), apparent molar compressibility ( $\phi_k$ ), and apparent molar volume ( $\phi_v$ ) of amino acids in aqueous amoxicillin solutions at 308.15K for

M/	$\beta / (\times 10^{-10} \text{m}^2 \text{N}^{-1})$			n <sub>H</sub>			$-\frac{\varphi_{k}}{(m^{2}m^{2}m^{2}m^{2})}$			$-\phi_{\star}/(x^{10^{-3}}m^{3}mol^{-1})$		
water + amoxicillin												
	0 0 M	0 0005M	0 001 M	0 0M	0 0005M	0 001M	0 0M	0 0005M	0 001M	0 0M	0 0005M	0.001M
System - I : water + amoxicillin + L-threonine												0.001111
0.00	4.3704	4.3484	4.3120	-	-	-	-	-	-	-	-	-
0.02	4.3483	4.3172	4.2870	14.16	19.94	16.11	1.5225	1.9529	1.6604	95.78	90.60	95.08
0.04	4.3282	4.2885	4.2412	13.46	18.44	21.97	1.4835	2.0652	2.2020	98.08	130.48	99.94
0.06	4.3109	4.2420	4.1972	12.67	22.64	24.64	1.4165	2.4212	2.5614	97.08	148.34	149.22
0.08	4.2905	4.1978	4.1658	12.69	24.03	23.53	1.4272	2.4722	2.4108	97.79	123.62	134.05
0.10	4.2729	4.1789	4.1444	12.43	21.63	21.57	1.3661	2.3023	2.2760	89.08	138.31	137.60
System – II : water + amoxicillin + L-asparagine												
0.00	4.3704	4.3484	4.3120	-	-	-	-	-	-	-	-	-
0.02	4.3394	4.3013	4.2747	19.72	30.27	24.16	2.1874	2.3548	2.5839	146.16	165.91	160.07
0.04	4.3225	4.2713	4.2156	15.82	24.71	31.09	1.7565	2.4190	2.9068	118.20	112.93	114.85
0.06	4.3014	4.2170	4.1608	14.62	28.03	32.47	1.6408	2.6996	3.0096	112.10	116.84	112.93
0.08	4.2826	4.1661	4.0405	13.94	29.14	43.71	1.5480	2.7646	3.8690	102.74	111.20	109.39
0.10	4.2618	4.1059	3.9588	13.82	30.98	45.52	1.4991	3.0061	4.1152	94.09	132.39	133.66
		11		Systen	n - III : water	+ amoxicil	lin + L-arg	ginine	1			
0.00	4.3704	4.3484	4.3120	-	-	-	-	-	-	-	-	-
0.02	4.3304	4.2851	4.2535	25.54	40.53	37.75	2.7473	4.1262	3.8973	171.29	221.01	224.84
0.04	4.3065	4.2238	4.1397	20.40	39.83	55.52	2.2898	3.9449	5.1176	158.22	190.24	186.78
0.06	4.2845	4.1579	4.0714	18.22	40.61	51.62	2.0176	4.1289	4.9534	133.69	217.44	216.31
0.08	4.2654	4.0953	3.9720	16.72	40.74	55.14	1.8399	4.1249	5.1790	120.11	218.13	212.15
0.10	4.2438	4.0089	3.8837	16.09	43.34	55.17	1.7846	4.3474	5.2249	117.84	215.25	214.14
T1	C					· · · · · · · · · · · ·		1 	· · · · · · · · · · · · · · · · · · ·	· · · · · · · · · · · ·		

The variations of viscosity for amino acids in aqueous amoxicillin solutions can be represented by Jones- Dole equation [14] in which A and B are the constants characteristics of ion-ion and ionsolvent interactions, respectively. These values of A coefficient and B coefficient are reported in Table 3. It is observed from the Table 3 that the values of A coefficients are negative for all amino acids in all concentration of amoxicillin solutions. These values of A coefficient over the entire composition range of amoxicillin indicates the presence of weak ion-ion interactions. Further, the values of B coefficient have been observed to be positive and of higher magnitude for all the amino acids in the present study in all different concentration of aqueous amoxicillin solutions. Large and positive B coefficient values as compared with A coefficient values indicate the dominance of ion-solvent interactions over ion-ion interactions [25].

**Table 3.** Values of limiting apparent molar compressibility  $(\varphi_k^{e})$ , limiting apparent molar volume  $(\varphi_k^{e})$ , and their constants  $S_k$  and  $S_v$ , transfer adiabatic compressibility  $(\Delta \varphi_k^{e})$ , transfer volume  $(\Delta \varphi_k^{e})$ , and A and B co- efficient of Jones-Dole equation of the amino acids in aqueous amoxicillin solutions at 308.15 K

Amino acids	Amoxicillin M /(mol. dm <sup>-3</sup> )	φ <sup>*</sup> /(10 <sup>-7</sup> m <sup>2</sup> N <sup>-1</sup> )	φ <sup>•</sup> / 10 <sup>-3</sup> m <sup>3</sup> mol <sup>-1</sup> )	S <sub>k</sub> /( 10 <sup>-7</sup> N <sup>-1</sup> m <sup>-1</sup> mol <sup>-1</sup> )	$\frac{S_v}{m^3 L^{1/2} mol^{-3/2}}$	$\Delta \frac{\phi}{k} (10^{-7} \text{ m}^2 \text{N}^{-1})$	Δ <mark>φ</mark> , / 10 <sup>-3</sup> m <sup>3</sup> mol <sup>-1</sup> )	A / $(dm^{3/2}mol^{-1/2})$	B / (dm <sup>3/2</sup> mol <sup>-1</sup> )
	0.00	1.6461	101.96	0.8561	27.38	-	-	-0.0250	0.6130
L-threonine	0.0005	1.6111	73.14	-2.6643	-224.09	0.035	28.82	-0.0706	0.5526
	0.001	1.3528	55.95	-3.6670	-283.58	0.2933	46.01	-0.0785	0.6451
L-asparagine	0.00	2.6272	181.21	3.8003	280.75	-	-	-0.0134	0.6207
	0.0005	1.7703	172.44	-3.7055	188.11	0.8569	8.77	-0.0656	0.6665

Molecular interaction studies of some amino acids with aqueous amoxicillin solution at 308.15K											
Amino acids	Amoxicillin M /(mol. dm <sup>-3</sup> )	$\frac{\phi_{k}^{*}}{m^{2}N^{-1}}$	φ <sup>•</sup> , / 10 <sup>-3</sup> m <sup>3</sup> mol <sup>-1</sup> )	S <sub>k</sub> /( 10 <sup>-7</sup> N <sup>-1</sup> m <sup>-1</sup> mol <sup>-1</sup> )	$\frac{S_v / (10^{-3})}{m^3 L^{1/2} mol^{-3/2}}$	$\Delta \varphi_{k}^{2}/(10^{-7} m^{2} N^{-1})$	Δφ <sup>•</sup> / 10 <sup>-3</sup> m <sup>3</sup> mol <sup>-1</sup> )	A / (dm <sup>3/2</sup> mol <sup>-</sup> 1/2)	B / (dm <sup>3/2</sup> mol <sup>-1</sup> )		
	0.001	1.1749	165.09	-8.9510	164.16	1.4523	16.12	-0.0756	0.7080		
L-arginine	0.00	3.4672	219.79	5.6168	335.64	-	-	-0.0145	0.7226		
	0.0005	3.3361	205.87	-1.2583	-27.59	0.1311	13.92	-0.0305	0.6454		
	0.001	3.2968	211.88	-6.6548	4.40	0.1704	7.91	-0.0487	0.7539		

#### 4. CONCLUSIONS

Density, viscosity and ultrasonic velocity measurement for L-threonine, L-asparagine and L-arginine in aqueous amoxicillin solutions are reported in this study. Apparent molar properties, partial molar properties of transfer and transport properties were computed from experimental values. The interaction between amino acids and drug molecules are evident from the interpretation of the data. The results indicate that there exist strong ion-solvent interactions over ion-ion interactions in these systems. Further, from the magnitude of  $\beta$ ,  $\boldsymbol{\phi}_k$  and  $\boldsymbol{\phi}_k^{\boldsymbol{\varphi}}$  it is concluded that L-threeonine shows strong ion-solvent interaction

#### **5. REFERENCES**

[1] Anil kumar Nain, Monika Lather ., Solute-solute and solute-solvent interactions of L- histidine and L-arginine in aqueous – streptomycin sulphate solutions at different temperatures; A physicochemical study, J.Mol.Liq., 211,178-186, **2015.** 

[2] P.H.Von Hippel, T.Schleich, Ion effects on the solution structure of biological macromoleculesAccounts chem.Res. 2,9,257-265, **1969**.

[3] F. Franks, Protein stability: the value of 'old literature'Biophys. Chem. 96,2-3, 117–127,**2002.** 

[4] A.M.Ronero, E. Moreno.J.L. Rojas, Apparent molal volumes and viscosities of  $DL-\alpha$ -alanine in water–alcohol mixtures, Thermochim.Acta., 328,1-2,33-38, **1999.** 

[5] A. Taravati, M. Shokrzadeh, A.G. Ebadi, P. Valipour, A.T.M. Hassan, F. Farrokhi, Various effects of sugar and polyols on the protein structure and function: role as osmolyte on protein stability World Appl. Sci. J. 2, 353–362,**2007.** 

[6] S. Li, W. Sang, R. Lin, Partial molar volumes of glycine, L-alanine, and L-serine in aqueous glucose solutions at T=298.15 K, J. Chem. Thermodyn. 34,11,1761-1768,2002.

[7] M.J.Iqbal, S.Mahrukh, Partial molar volume of mefenamic acid in alcohol at temperatures between T=293.15 and T=313.15K, Journal of the Brazilian Chemical Society 17,5,851-858,**2006**.

[8] R.Bhar,J.K.Kaushik, Thermal stability of protein in aqueous polyol solution : Role of the surface tension of water in the stabilizing effect of polyols . J.Phys. Chem., 102, 7058-7066,**1998**.

[9] E.Jasmine Vasantha Rani,K.Kannagi,R.Padmavathy,N.Radha., Solvation effect and thermochemical study of some L-arginine salts in polar solvent using ultrasonic velocity., Indian J. Of Pure&Applied Physics., 52,155-161,**2014.** 

[10] H. Kumar, K. Kaur, Densities and speeds of sound ofL-serine with squeous solutions of antibacterial drugs at different temperatures, J. Chem. Eng. Data., 58,2, 203–208,**2013.** 

[11] Gucker FT. The apparent and molal heat capacity, volume and compressibility of electrolytes. Chem Rev. 13,1,111-130,**1993.** 

[12] Debye P and Huckle E. Theory of electrolytes II. The limiting law of electrical conductivity. Z Phys. 24,305-325,**1923.** 

[13] Masson D O. Solute molecular volumes in relations to salvation and ionization. Philosophical Magazine Series 7,8: 218-224,**1929.** 

than other two amino acids. The positive  $\Delta \phi_k^{o}$ ,  $\Delta \phi_v^{o}$  and B coefficient values are argued of structure making behaviour of amino acids in aqueous amoxicillin solutions. Further, the positive  $\Delta \phi_k^{o}$  and  $\Delta \phi_v^{o}$  values in all the studied systems are indicative of stronger ion-solvent interactions. All these observations collectively show the preeminence of hydrophilic-ionic over hydrophobic-hydrophobic interactions in the present ternary system.

[14] G.Jones, M.Dole,The Viscosity of aqueous solutions of strong electrolytes with special reference to barium chloride. J.Am.Chem.Soc.51, 10,2950-2964,**1929**.

[15] A.Awasthi, M.Rastogi, M.Gupta, J.P.Shukla, Ultrasonic investigation of molecular association in ternary mixtures, J.Mol.Liquids., 80,1,77,**1999**.

[16] Arakawa, K. Sasaki, k.: The structure theory of water. I.Two state theory.Bull.Soc. Jpn. 42,303-308,**1969**.

[17] A.K.Nain, Renu pal, Neetu: Volumetric, Ultrasonic and viscometric studies of solute- solute and solute-solvent interactions of L- threonine in aqueous sucrose solutions at different temperatures. J. Chem. Thermodyn. 64,172-181,2013.

[18] S.Chauhan Poonam Chaudhary.,Kundan Sharma., Kuldeep Kumar. Kiran: Temperature –dependent volumetric and viscometric properties of amino acids n aqueous solutions of an antibiotic drug. Chemical papers. 67,11, 1442-1452,**2013.** 

[19] A.Pal, N.Cuauhan, Volumetric, viscometric, and acoustic behaviour of diglycine in aqueous saccharide solutions at different temperatures, J.Mol.liquids., 149,1-2, 29-36,2009.

[20] M.A.Riyazuddeen, Usmani, Densities, Speeds of Sound, and Viscosities of (L-Proline + Aqueous Glucose) and (L-Proline + Aqueous Sucrose) Solutions in the Temperature Range (298.15 to 323.15) K J.Chem.Eng.Data., 56,9,3504-3509,**2011.** 

[21] C.M.Romero, F.Negrete. Effect of temperature on partial molar volumes and viscosities of aqueous solutions of  $\alpha$ -Di-Amino butyric acid. Di-Norvaline and di-norleucine, Phys.Chem.liq., 42,261-267,**2004.** 

[22] M.J. Iqbal, M.A. Chaudhary, Effect of volumetric and viscometric properties of some non-steroidal anti-inflammatory drugs in aprotic solvents, J. Chem. Thermodyn. 42, 951–956, **2010**.

[23] A.K. Mishra, J.C. Ahluwalia, Apparent molal volumes of amino acids, Nacetylamino acids and dipeptides in aqueous solution, J. Phys. Chem. 88,1,86–92,1984.

[24] Z.Yan, J.J.Wang, H. Zheng, D.Liu, Volumetric properties of some amino acids in aqueous guanidine hydrochloride at 5,15, 25, and 35°C. J.Sol.Chem.27,5,473–477,**1998.** 

[25] T.C Bai, G.B Yan Viscosity B-coefficients and activation parameters for viscous flow of a solution of heptanedioic acid in aqueous sucrose solutioncarbohydr.Res. 338,24,2921-2927,**2003**.

#### 6. ACKNOWLEDGEMENTS

The authors wish to express their grateful thanks to Dr.V.Ramasamy, Professor and Head, Department of Physics, Annamalai University, for his kind help and encouragement which he extended to them throughout the period of this study.

 $\bigcirc$  2017 by the authors. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution license (http://creativecommons.org/licenses/by/4.0/).