Volumetric study of l-valine in aqueous sodium acetate at different concentration and temperature through ultrasonic technique

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ABSTRACT

The ultrasonic velocity (U) and density (ρ) measurements have been carried out for L-valine in aqueous sodium acetate at different concentration and different temperature hence the experimental data is used to find the Lennard-Jones potential (V_{LJ}), Van der Waals constant (a) and molar volume (Vm). L-valine helps to muscle growth and tissue repair. The results are discussed in terms of structure making or structure breaking effects of amino acids in the mixture.

Keywords: L-valine, sodium acetate, Lennard-Jones potential, van der waals constant, molar volume.

1. INTRODUCTION

Ultrasonic is a non-destructive technique. Ultrasonic velocity is used for characterization of structure and properties of solution. There are two methods to produce ultrasonic wave that is piezoelectric and magnetostriction oscillator. Ultrasonic is a type of technique which is used to determine the physical properties of a structure. Electrolyte solution is a type of solution in which atoms, ions or molecules contains which have tendency to lose or gain electrons and which are electrically conductive. Amino acids are the primarily building block of proteins. Aqueous solution of amino acid acts as acid or base because of ionization. Study of acid-base properties can help to understand the properties of proteins [1].

The behavior of liquid system intermolecular interaction, intramolecular association, complex formation, structural changes and specific ion-ion and ion-solvent interaction in solution given by the ultrasonic study of amino acid in aqueous electrolyte and non-electrolytes. There is strong hydrogen bond formed in between sodium acetate and water therefore volumetric compressibility is inadequate in aqueous mixture of L-valine so it is important to understand its behavior in sodium acetate solution at various molarities and temperatures[2]. Hence the derived parameters are Lennard-Jones potential (VLJ), van der Waals constant (a), molar volume (Vm).

2. METHODOLOGY

The AR grade chemicals, such as Amino acid (L-valine) having molecular weight 117.15 g/mol and the salt sodium acetate having molecular weight 82.0343 g/mol are supplied from HIMEDIA Pvt. Ltd Mumbai. Distilled water is used for the preparation of different concentration of amino acid and stock solution of sodium acetate.

The velocity of given solution is obtained from ultrasonic interferometer (Vi microsystems Pvt. Ltd Chennai) by adding some amount of solution in doubly walled measuring cell. Density of solution and distilled water at different concentration and temperature is measured by using weighing machine and the electronically digital thermostat has been used to circulate water through measuring cell. By using these data of velocity and density, we can find out the various thermo-acoustic parameters.

3. DEFINING RELATIONS

Thermo-acoustic parameters were calculated by using some standard relations:

Molar volume: $Vm = \frac{Meff}{\rho}$ ----------- (1)

Van der Waals constant: $a = \left\{ \frac{U^2 V_m{}^2 \rho}{\frac{B}{A}+1} \right\}$ ------------ (2),

where $M_{eff} = \Sigma x_i m_i$

Available volume: $V_a = V_m\{1 - \frac{U}{U_\infty}\}$ ------------ (3)

and Lennard-Jones potential: $V_{LJ} = \{6 \times (\frac{V_m}{V_a}) - 13\}$ ------- (4)

Where ρ, U is density and velocity of solution respectively. B/A is non linear constant obtain from Hartman Relation and U_∞ is constant and has value 1600 m/s.

4. RESULTS AND DISCUSSION

The experimental value of density and velocity for different concentration and different temperature of L-valine in aqueous sodium acetate solution are tabulated in table (1).

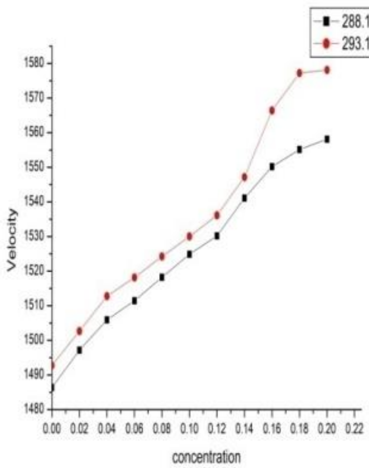
From fig (a) it is observed that the velocity increases as increase in concentration and temperature this shows that, molecular association is being taking place in these liquid mixtures.

Table (1): velocity and density of L-valine in aqueous sodium acetate.

Concentration ($mol\text{-}kg^{-1}$)	Velocity (m/s)		Density (kg/m^3)	
	288.15K	**293.15K**	**288.15K**	**293.15K**
0.00	1486.382	1492.760	975.9404	995.166
0.02	1497.173	1502.668	977.251	1000.353
0.04	1505.932	1512.785	978.228	1003.128
0.06	1511.441	1518.145	986.783	1011.08
0.08	1518.225	1524.233	987.702	1021.995
0.10	1524.876	1530.009	992.601	1041.187
0.12	1530.175	1536.137	994.576	1067.986
0.14	1541.120	1547.135	997.832	1076.352
0.16	1550.186	1566.419	1030.41	1082.917
0.18	1555.128	1577.220	1054.87	1103.575
0.20	1558.118	1578.119	1074.05	1112.344

Table (2): Molar volume, Lennard-Jones potential and van der waals constant of L-valine in aqueous sodium acetate.

Concentration (mol-kg^{-1})	Molar volume (m^3/mol)		Lennard-Jones potential (J mol^{-1})		Van der Waals constant	
	288.15K	**293.15K**	**288.15K**	**293.15K**	**288.15K**	**293.15K**
0.00	0.064834	0.063582	71.4944	76.5205	8772987.0	938985.2
0.02	0.064748	0.063253	80.3640	85.6273	8867695.4	1047967.8
0.04	0.064685	0.063079	89.0536	97.0855	8949431.9	1064392.9
0.06	0.064125	0.062584	95.4108	104.5654	8933648.2	1077407.5
0.08	0.064067	0.061917	104.4105	113.7060	9002634.8	1086645.7
0.10	0.063752	0.060777	114.8022	124.1425	9028585.0	1085817.6
0.12	0.063626	0.059252	124.4706	137.3221	9036883.7	1085583.4
0.14	0.063419	0.058793	150.0308	168.5532	9152748.8	1101098.6
0.16	0.061415	0.058438	179.7248	272.7603	8968288.7	1132007.8
0.18	0.059992	0.057344	201.0023	419.7849	8811506.8	1133334.5
0.20	0.058921	0.056893	216.2645	425.7634	8680068.2	1135408.5



(a)

(b)

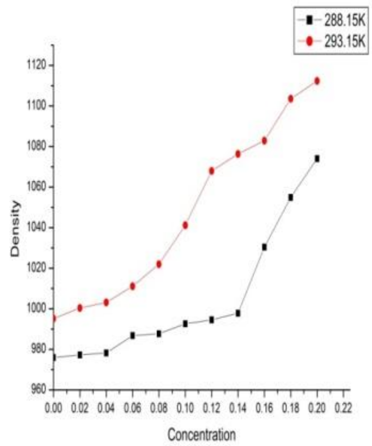
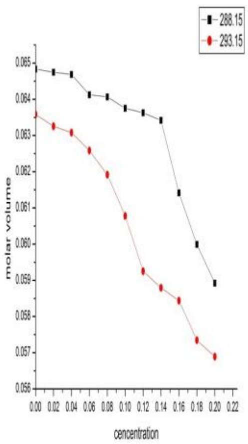
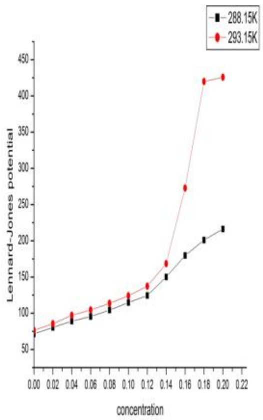
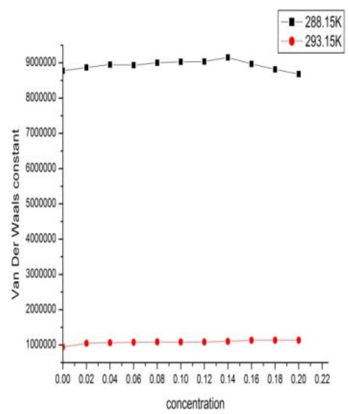


Figure (a) and (b): shows the variation of velocity and density with concentration







(c) (d) (e)

Figure (c), (d) and (e): shows the variation molar volume, Lennard-Jones potential, Van Der Waals constant with concentration

Density is increases with increasing temperature and concentration show in fig (b), indicates that the greater interaction in solute-solvent and solvent-solvent. The increase in density may be interpreted to the structure-maker of the solvent due to the added solute. Hydrogen bond formation or dissociation or hydrophobic or hydrophilic character of solute gives the change in structure of solvent and solution. That is change in density is correlated to property of hydrogen bond formation and dissociation [3].

By using the experimental data of velocity and density the other parameters are calculated like molar volume, Van der Waals constant, Lennard-Jones potential. Table (2) shows the order of other parameters of L-valine in aqueous sodium acetate solution at varying temperature.

Molar volume is directly proportional to effective mass and inversely proportional to density of solution. From figure (4) It happened because of solvent-solvent and ion-solvent interaction. We observed that molar volume decreases with increase in concentration. Further, decreases with rise in temperature [4].

In figure (5) The atoms are increases with respect to temperature at given pressure and hence radius also increases therefore the value of Lennard-Jones potential is increases as increase in concentration and increasing temperature[5].

From figure (6) it is observed that the van der waals constant having almost linear trend with respect to concentration and at low temperature van der waals constant is high and vice versa because particle kinetic energy is more significant than the potential energy due to intermolecular forces[6].

5. CONCLUSION

The ultrasonic study of aqueous solution of sodium acetate and L-valine. The ultrasonic velocity, density and viscosity studies were carried out on the solution of sodium acetate in L-valine at two different temperatures. Using these parameters, another coefficient values are determined.

From experimental result we conclude that there is interaction between solute and solvent molecule results in formation of attractive forces. Which promotes the structure making tendency. Due to weak intermolecular force and thermal energy of system, we noticed that strength of molecular interaction weakens with rise in temperature. And hence the biological and biochemical relation is formed when we studied the ultrasonic velocity, density and viscosity of L-valine in aqueous solution at two different temperatures.

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

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