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Ultrasonic Investigation of Aqueous L-Alanine

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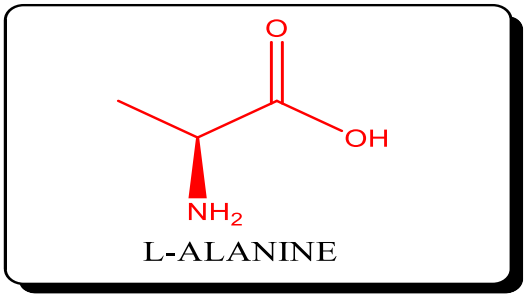
ABSTRACT

Ultrasonic are mechanical waves finds many applications in recent research. The ultrasonic velocity (u), density (ρ), and viscosity (η) of a given material can be used to determine various significant thermo acoustical parameters which can be used for various studies. This paper is deal with acoustical investigation of L-Alanine in water solution by Pulse Echo Overlap (PEO) technique and reporting the value adiabatic (β_a) and isothermal compressibility (β_i) of L-Alanine at different molar concentrations (0.0 to 0.01M) and temperature (283.15K to 323.15K). These values of compressibility may be use for modeling of protein synthesis using Molecular Dynamic Simulation.

Keywords: Adiabatic Compressibility, L-Alanine, Density, Isothermal Compressibility, Ultrasonic velocity.

I. INTRODUCTION

L-Alanine ($C_3H_7NO_2$) is one of the 20 basic amino acids [1]. It is color less , odorless, sweet taste [2,3] with ionization potential of 10.95eV and dissociation constant pKa = 2.34 at 25 ºC[4] occurs in high level in its free states in plasma and found in most proteins and particularly abundant in fibroin, the protein in silk. It is involved in sugar and acid metabolism, increases immunity and provides energy for muscle tissue, brain and the central nervous system [5-8]. It is used as a dietary supplement [9]. It is an important constituent of the vitamin pantothenic acid and is used for its synthesis. It is also used in therapeutic [11] (therapy of acute water diarrhea), pharmaceutical preparation of injection or infusion and flavor compounds in maillard reaction product, stimulant of glucagon secretion [10]. It is used in biochemical research, electroplating, and organic synthesis. The chemical structure of L-Alanine is [1]



A recent study reported L –Alanine had number of applications in pharmaceuticals, biochemistry, biotechnology, medicine, etc. [1-11]. In this study an ultrasonic investigation is carried out to find out various acoustical parameter of L-Alanine at different molar concentrations and temperatures. As L-Alanine is basic amino acids and is biologically active compound in all living organisms, it is important to know their basic physical properties. Knowledge of apparent elastic properties such as adiabatic compressibility (β_a), isothermal compressibility (β_i) and

elastic modulus of biological materials are important for the prediction of their deformation behavior. These elastic properties could be used to compare the relative strengths of biomaterials and investigation of these technological characteristics could aid in the process of protein synthesis [12], bio engineering, drugs making and testing in pharmaceutical industries. This has led several investigators to study the elastic modulus of biological materials. [13,14]

Theoretically value of adiabatic compressibility and isothermal compressibility can be calculated using following formula

$$\beta_a = \frac{1}{u^2 \times \rho} \quad m^2/N \quad \text{----------(1)}$$

$$\beta_i = \gamma\, \beta_a \quad m^2/N \quad \text{----------(2)}$$

where, β_a and β_i are adiabatic and isothermal compressibility ,u is ultrasonic velocity, ρ is density and **γ** is adiabatic constant.

II. MATERIALS AND METHODS

L-Alanine was of AR grade (E- Merck). Different concentrations of L-Alanine (0.0 to 0.01M) were prepared by using triple distilled water (Grade I). Densities, viscosities, ultrasonic velocities and attenuation by absorption were measured at different temperatures (278.15K-323.15K) and molar concentrations (0.0 to 0.01 M). Densities were determined by using density bottle with plunger method whereas viscosities with Oswald Viscometer. Ultrasonic velocities and attenuation were measured with Pulse Echo Overlap method by using AUAR-102 (Automatic Ultrasonic Attenuation Recorder). The corresponding observations and calculations are presented in Tables 1-5. The values in tables are reported in SI system.

Table 1. L-Alanine aqueous solution at 283.15K

Con.	**0**	**0.0075**	**0.008**	**0.0085**	**0.009**	**0.0095**	**0.01**
u	1455	1464	1462	1464	1472	1469	1467
ρ	999.70	995.81	997.98	1003.66	1008.17	1003.48	1005.53
β_a	4.723E-10	4.686E-10	4.690E-10	4.652E-10	4.579E-10	4.618E-10	4.619E-10
β_i	6.612E-10	6.560E-10	6.567E-10	6.512E-10	6.411E-10	6.465E-10	6.467E-10

Con. is reported in Molarity (M)

Table 2. L-Alanine aqueous solution at 293.15K

Con.	**0**	**0.0075**	**0.008**	**0.0085**	**0.009**	**0.0095**	**0.01**
u	1481	1459	1469	1491	1535	1513	1512
ρ	998.21	1001.08	1000.98	1001.39	1009.09	1005.10	1005.53
β_a	4.566E-10	4.690E-10	4.632E-10	4.490E-10	4.205E-10	4.349E-10	4.349E-10
β_i	6.392E-10	6.566E-10	6.485E-10	6.285E-10	5.887E-10	6.089E-10	6.089E-10

Con. is reported in Molarity (M)

Table 3. L-Alanine aqueous solution at T= 303.15K

Con.	0	0.0075	0.008	0.0085	0.009	0.0095	0.01
u	1503	1485	1491	1506	1525	1516	1516
ρ	995.65	998.82	998.61	999.64	1006.73	1000.11	1000.24
β_a	4.444E-10	4.540E-10	4.508E-10	4.413E-10	4.273E-10	4.349E-10	4.352E-10
β_i	6.222E-10	6.356E-10	6.311E-10	6.179E-10	5.982E-10	6.089E-10	6.093E-10

Con. is reported in Molarity (M)

Table 4. L-Alanine aqueous solution at T= 313.15K

Con.	0	0.0075	0.008	0.0085	0.009	0.0095	0.01
u	1522	1514	1520	1530	1544	1539	1540
ρ	992.22	1003.07	1003.98	1005.03	1015.88	1011.58	1011.87
β_a	4.349E-10	4.351E-10	4.312E-10	4.249E-10	4.131E-10	4.173E-10	4.165E-10
β_i	6.089E-10	6.092E-10	6.037E-10	5.949E-10	5.783E-10	5.843E-10	5.831E-10

Con. is reported in Molarity (M)

Table 5. L-Alanine aqueous solution at T= 323.15K

Con.	0	0.0075	0.008	0.0085	0.009	0.0095	0.01
u	1540	1539	1540	1540	1546	1541	1543
ρ	988.03	1011.58	1011.59	1014.42	1027.18	1012.57	1020.67
β_a	4.269E-10	4.174E-10	4.171E-10	4.157E-10	4.072E-10	4.160E-10	4.113E-10
β_i	5.977E-10	5.843E-10	5.839E-10	5.819E-10	5.701E-10	5.824E-10	5.758E-10

Con. is reported in Molarity (M)

III. RESULTS

The aqueous system prepared for the present investigation consists of L-Alanine, in triple distilled water (Grade I). The adiabatic compressibility and isothermal compressibility were calculated by using Equation 1 and 2 respectively and the results are depicted in the Tables 1-5. This was expected as the results are in the order of 10^{-10} and is well in agreement with general defined order of compressibility in SI system.

IV. DISCUSSION

The system used for present paper was L-Alanine +Water. When L-Alanine dissolved in water formation of zwitterions takes place due to transfer of proton from carboxylic group (COOH) to amine group (NH_2) i.e. NH_2 becomes NH_3^+ and COOH becomes COO^-. These zwitterions play crucial role when an ultrasonic wave passes though them. From first two rows of Tables 1-5 shows variation in the values of ultrasonic velocity and density of aqueous L-Alanine This is because of ultrasonic waves modifies the positions of the component particles from the propagation space by performing mechanical work against the internal forces. This modification affects the adiabatic compressibility and isothermal compressibility of aqueous L-Alanine. By introducing this value of adiabatic and isothermal compressibility for the studied aqueous L-Alanine it is possible to estimate changes of longitudinal and transverse dimensions of aqueous L-Alanine and this change is important to design the biological constituents in which L- Alanine is involved such as proteins, cells, tissues etc. Also if we know the value of compressibility then we determine the bulk modulus of a system and hence various mechanical properties. These values of compressibility may be use in Protein bioelectronics [15]. Hence, the reported results can be explored its due significance in number of new researches in biological media.

V. CONCLUSION

From the above table 1-5 the value of adiabatic compressibility and isothermal compressibility are in well agreement with general define value. Hence reporting the same for aqueous L-Alanine. This is the first time the values of adiabatic and isothermal compressibility of L-Alanine are being reported.

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