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Intermolecular free-length and their correlation with molecular interaction in aqueous amino acids at 303.15 K

A.T.Shende[1]*, P.V.Tabhane[2], O.P.Chimankar[2], V.A.Tabhane[3]

[1]Department of Physics, Institute of Science, Nagpur 440 001, (INDIA)

[2]Department of Physics, R.T.M. Nagpur University, Nagpur 440 033, (INDIA)

[3]Department of Physics, University of Pune, Ganeshkhind, Pune 411 007, (INDIA)

E-mail: priyanka1485@gmail.com

ABSTRACT

Ultrasonic Velocity and Density were measured in six aqueous amino acids namely, L-Alanine, L-Aspartic Acid, L-Glutamic Acid, L-Glutamine, L-Phenylalanine and L-Valine of different concentration at 303.15 K. The intermolecular free length and adiabatic compressibility are determined with experimentally measured ultrasonic velocity, and density and correlate them with molecular interaction in aqueous amino acids at 303.15K. The intermolecular free length is discussed in terms of weak interaction between unlike molecules.

KEYWORDS

Intermolecular free length;
Adiabatic compressibility;
Ultrasonic velocity;
Density.

INTRODUCTION

Intermolecular free length is one of the significance thermodynamic properties of liquid which is derived from ultrasonic velocity and density. This property can be used to study the molecular interaction in any liquid system. In the present study an attempt has been made to calculate the free length using ultrasonic velocity and density and the concept of intermolecular free length has also been used to study the intermolecular interaction in aqueous amino acid at 303.15K.

THEORETICAL

Thermodynamically, the internal intermolecular free length (L_f) can be calculated using formula as

$$L_f = K_j (\beta_a)^{1/2} \quad (1)$$

Where, K_j = Jacobson's constant=4.2 x 10^{-9} and

β_a is adiabatic compressibility $\left(\beta_a = \frac{1}{u^2 \times \rho}\right)$ (2)

Where u=ultrasonic velocity and ρ= density

From this relation, the value of L_f for liquid system is obtained.

EXPERIMENTAL

All the given sample L-Alanine, L-Aspartic Acid, L-Glutamic Acid, L-Glutamine, L-Phenylalanine and L-Valine were in pure form (E- Merck grade). Different concentration (0.0075M, 0.008M, 0.0085M,0.009M, 0.0095M, 0.01M) of each sample of were made with doubled distilled water. Densities, and ultrasonic velocities were measured at 303.15 K. Densities were determine with Density

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Bottle with plunger method and Ultrasonic Velocities with Pluse Echo Overlap Method using Innovative Instrument-102 Interferometer along with Ultrasonometer (4 MHz) and Universal Time & Frequency Counter.

OBSERVATIONS AND GRAPHS

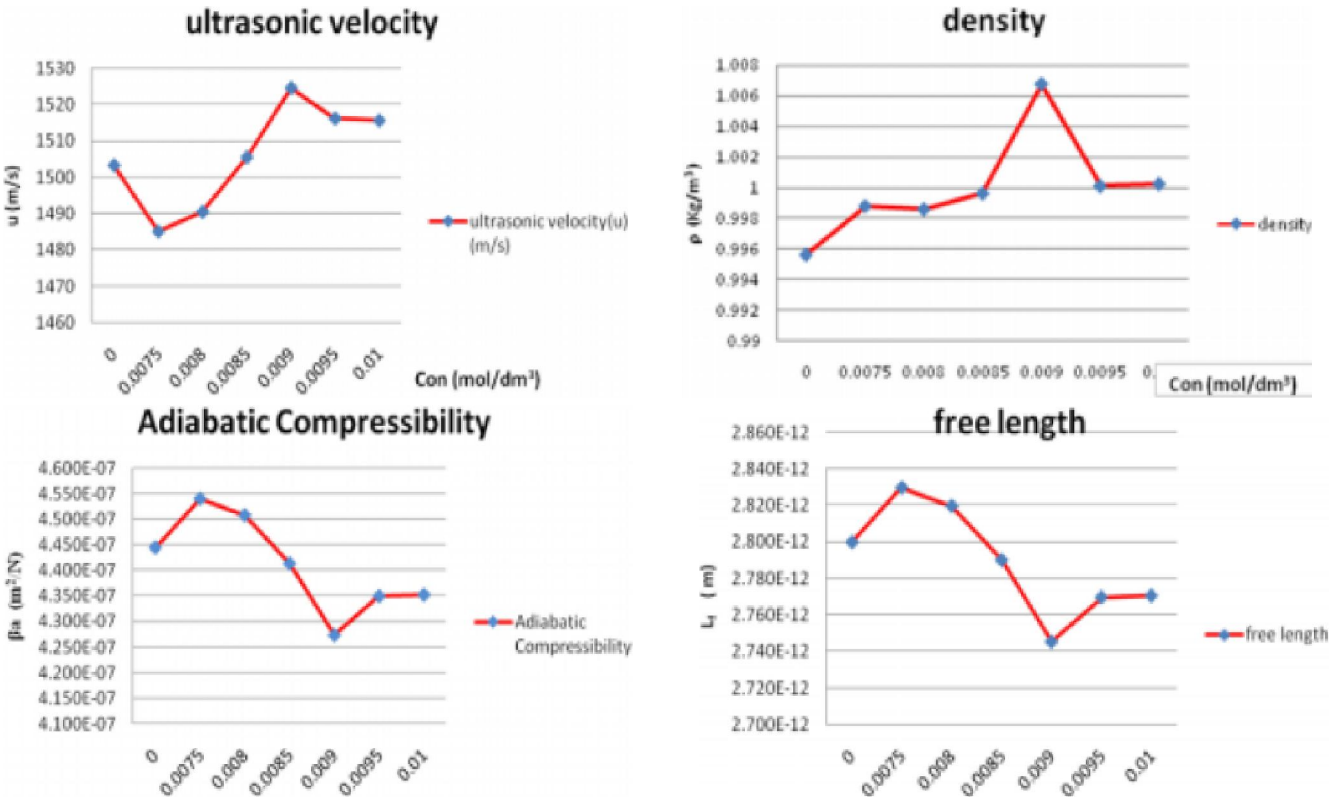

Figure 1 : Ultrasonic velocity, density, adiabatic compressibility and free length for aqueous L-Alanine at 303.15K

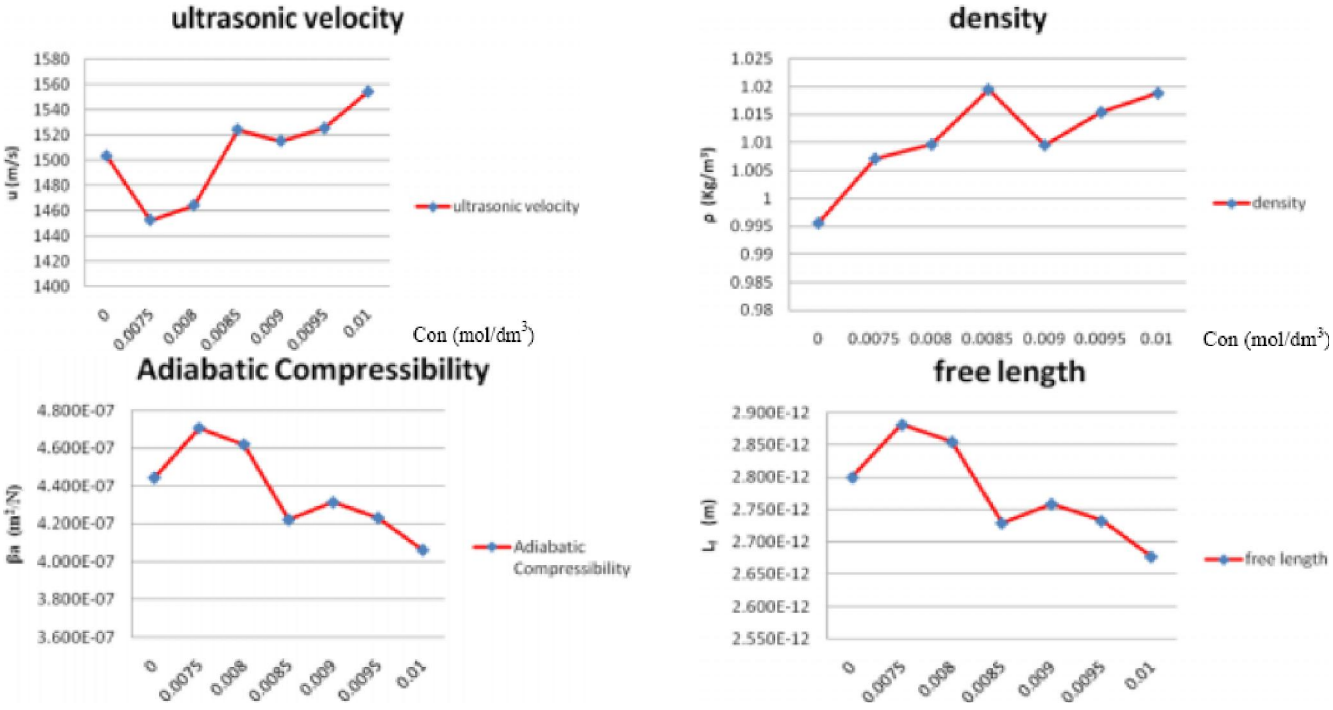

Figure 2 : Ultrasonic velocity, density, adiabatic compressibility and free length for aqueous L-Aspartic Acid at 303.15 K

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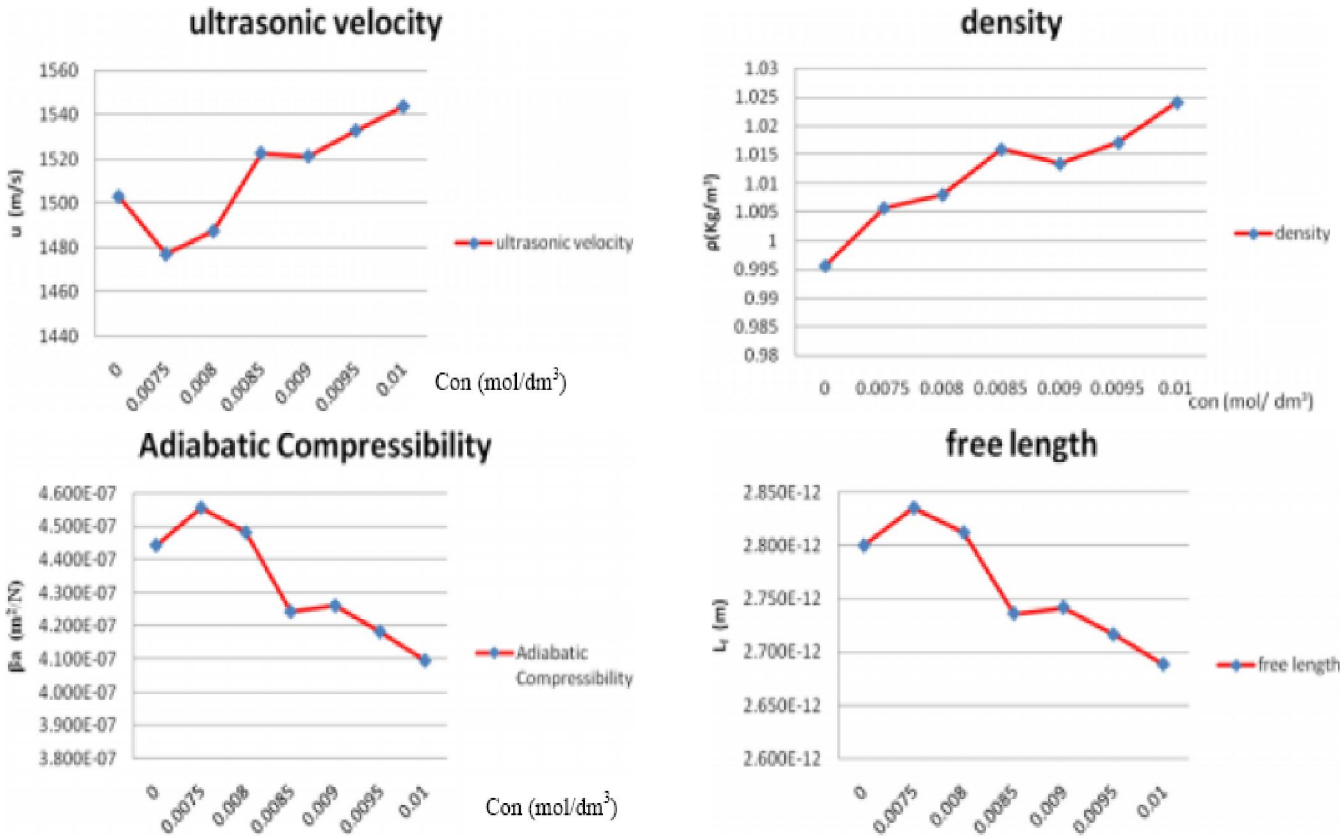

Figure 3 : Ultrasonic velocity, density, adiabatic compressibility and free length for aqueous L-Glutamic Acid at 303.15K

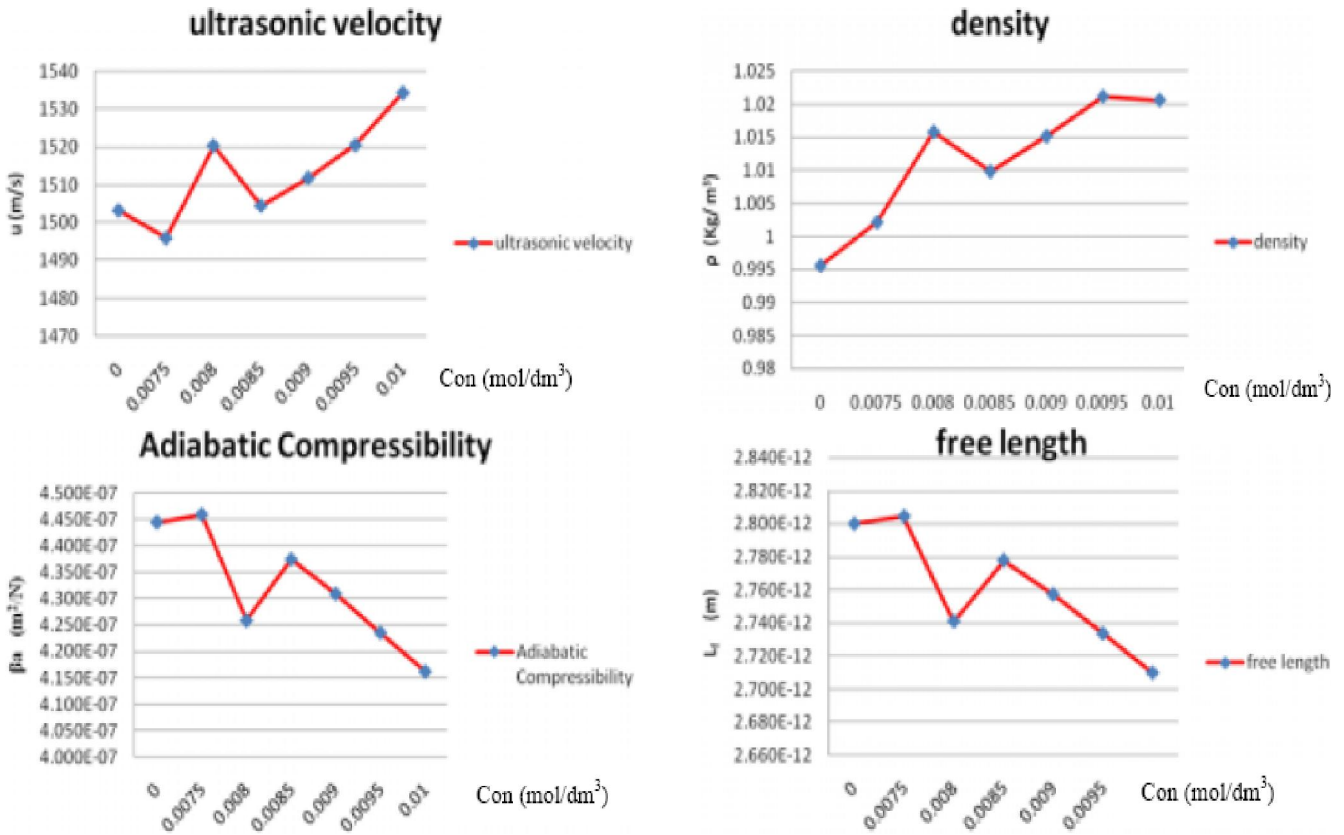

Figure 4 : Ultrasonic velocity, density, adiabatic compressibility and free length for aqueous L-Glutamine at 303.15K

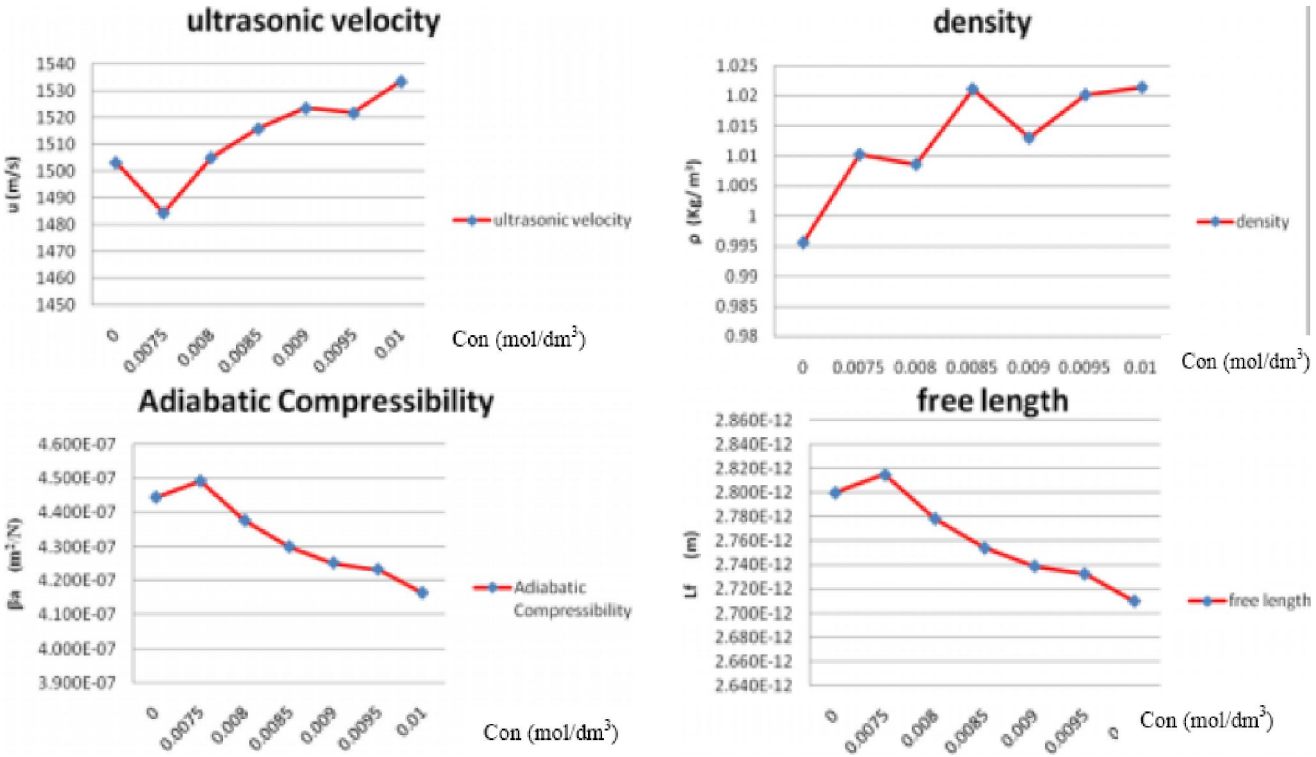

Figure 5 : Ultrasonic velocity, density, adiabatic compressibility and free length for aqueous L-Phenylalanine at 303.15K

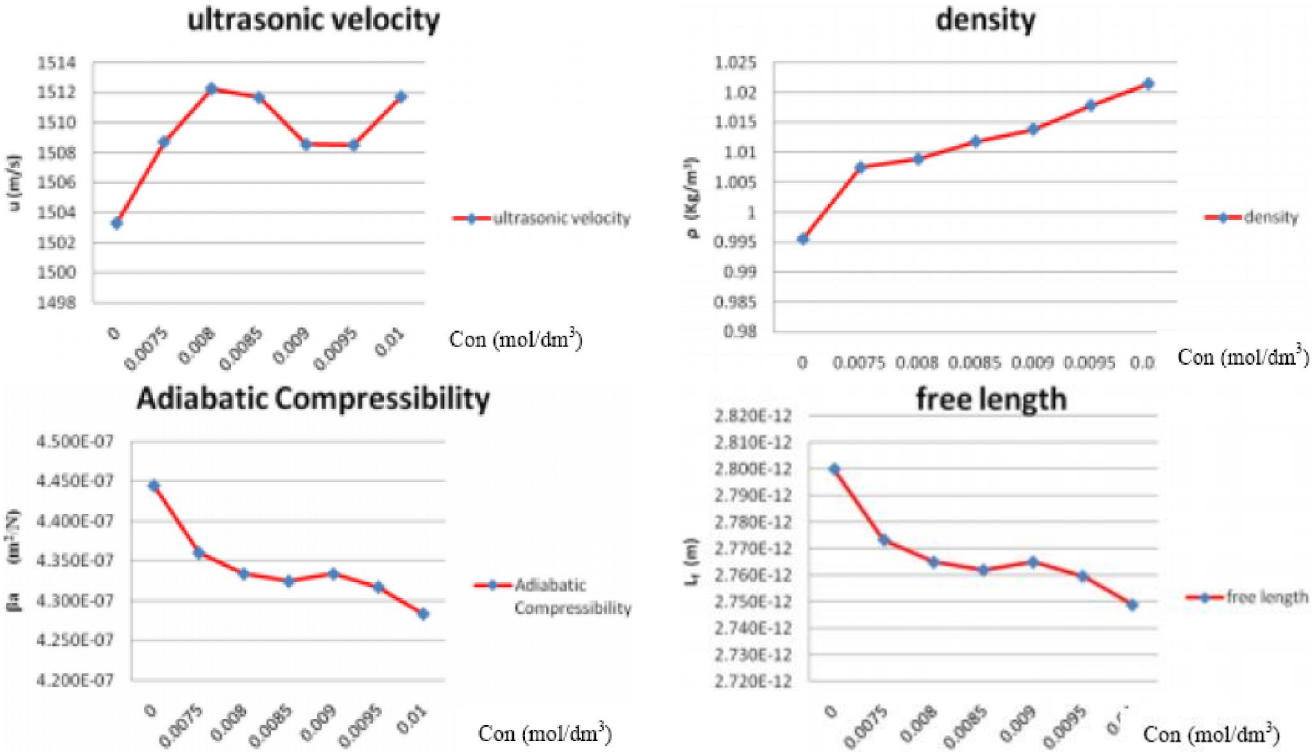

Figure 6 : Ultrasonic velocity, density, adiabatic compressibility and free Volume for aqueous L-Valine at 303.15K

RESULT

The liquid system taken for the present investigation were L-Alanine, L-Aspartic Acid, L-Glutamic Acid, L-Glutamine, L-Phenylalanine and L-Valine having conc. 0.0075M, 0.008M, 0.0085M, 0.009M, 0.0095M, and 0.01M. Experimentally values of densities, viscosities

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and ultrasonic velocities with different concentration at 303.15K

Intermolecular free lengths and Adiabatic Compressibility for all pure liquid system were calculated from Eq. (1) and (2) respectively.

DISCUSSION

From the above Figure it was observed that ultrasonic velocity increases with concentration. This is due to breaking of cluster of water molecule by the amino acid molecule resulting in enhancing the closed packed structure of water (association). The graph of adiabatic compressibility (βa) supports the association. The factor apparently responsible for such behavior may be the presence of interaction caused by the proton transfer reaction of amino acid and hydrophilic nature of solution. The increase in association may be due to water enhancement brought by the increase in electrostriction. The electrostriction effect which causes shrinkage in the volume of solvent is caused by zwitterionic portion of the amino acids. The decrease in adiabatic compressibility supports this interaction. Amino acid molecules in the neutral solution exist in dipolar form and they have stronger interaction with surrounding water molecules. The increasing electrostrictive compression of water around the molecule results in a larger decrease in the adiabatic compressibility of the solution.

Intermolecular free length (L_f) is one the significance thermodynamic property of a any system which can be used to study the molecular interaction in a given system. The decrease in free length with molar concentration may be due to increasing strength of dipolar association or formation of hydrogen bonding or complex formation between the component molecules while the increase in free length with molar concentration may be due to weakening of dipolar association or breaking up of hydrogen bonding. From the above Figure. it was observed that the free length showing decreasing trend for all given sample which shows that dipole-dipole interaction or H-bonding is predominated in aqueous amino acids. The values of ultrasonic velocities, densities and viscosities also support the result. The irregular decreasing trend only shows that at certain concentration the association (or H-Bonding) is more or that concentration is favorable for molecular association.

CONCLUSION

All the above discussion shows that there will be molecular association (or dipole- dipole interaction or dipole-induced dipole interaction) when we add amino acids to pure water. This shows that molecular interaction occur in aqueous amino acids.

Hence intermolecular free length (L_f) can be used to study the molecular interaction in a given system.

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