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

An Analysis of Specific Acoustic Impedance, Apparent Molal Volume and Transport Properties of Non-Aqueous Solutions of Peptides

R.Padmavathy[1], K.Dhanalakshmi[2], E.Jasmine Vasantha Rani[3], S.Sujatha[4]

[1, 3]Associate Professor, Department of Physics, Seethalakshmi Ramaswami College,

[2] Research Scholar, Department of Physics, Seethalakshmi Ramaswami College,

[4]Assistant Professor, Department of Physics, Srimati Indira Ganthi college, Tiruchirappalli-620002, Tamilnadu, India

Abstract: ***Ultrasonic investigations in non-aqueous solutions of peptides provide useful information in understanding the Physico-chemical properties of the interacting components. Peptides and amino acids are used as probe molecule to understand the complex nature of protein. It is recognized that the study of the behavior of model compounds of proteins like amino acids and peptides as solutions help in understanding the factors governing the thermodynamic stability of the native structure of proteins. The analysis of ultrasonic and thermodynamic properties of proteins in non-aqueous solvent has been the area of interest. In the present investigation ultrasonic velocity, transport properties and other related parameters were successfully employed at different temperatures and concentrations to understand the structural changes occurring in the solutions.***

Keywords: Ultrasonic velocity, transport properties, molecular interactions.

1. Introduction

Ultrasonic studies are extensively used to estimate the thermodynamic properties and to predict the intermolecular interactions in liquids [1].It is most preferred in many fields such as pharmaceutical industry, biomedical research, chemical industry, water research and scattering spectroscopy, etc., [2]. Proteins are complex molecules, their behavior in solutions are governed by a combination of many specific interactions; it is a good approach to study simpler model compounds such as amino acids and peptides which are basic building blocks of the proteins [3]. Internal pressure and free volume which are the fundamental properties of the liquid state has been studied initially by Hildebrand et al [4-5] and subsequently by several workers [6-11]. The study of transport properties of liquid system has gained much importance during recent years [12] the molecular interaction in liquid solution can be studied by transport properties. The ultrasonic velocity and its derived parameters provide fruitful information regarding the nature of intermolecular interactions. In the present work an attempt has been made to investigate the behavior of peptide solution to study the molecular interaction through specific acoustic impedance, apparent molal volume and internal pressure and free volume at different temperatures (5°C to 55°C) & at various concentrations.

2. Material and methods

Ultrasonic investigations of peptide salt in formamide are carried out for five different concentrations from a low temperature to a high temperature. Basic parameters such as density, viscosity, ultrasonic velocity are determined with the help of constant temperature bath. Densities of the solutions are measured through 25ml specific gravity bottle. Cannon Fenske viscometer is used to measure the time flow of the solution in order to calculate viscosity. Ultrasonic velocity is measured through ultrasonic interferometer of frequency 2MHz. the derived parameters such as transport properties (π_i, v_f,) specific acoustic impedance (z), apparent molal volume ($\boldsymbol{\varphi_v}$) are determined using the basic parameters. The formulae used to calculate them are given below

$$\pi_i = bRT\,[K\eta/u]^{1/2}\,[\rho^{2/3}/M_{eff}^{7/6}] \quad \text{----------(1)}$$

$$V_f = [Meff\ U/K\eta]^{3/2} cc \quad \text{----------(2)}$$

$$z = \rho u\ (Rayl \quad \text{----------(3)}$$

$$\varphi_v = 1000/C_1\,\rho^0\,(\rho^0 - \rho) + M/\rho^0\ (ml/moI) \quad \text{----------(4)}$$

3. Results And Discussion

3.1 Transport properties

Cohesive energy is the measure of internal pressure. In peptide salt, the internal pressure exhibits an increasing trend with respect to increasing molalities as shown in table and figure (1). The increase in cohesive energy indicates that there is a strong interaction prevails between the solute and solvent. Hence, this increase may be attributed to the structure making nature of the solute in the solvent [13-15].

Free volume is the free space available for the molecules to move [16]. The structure making and breaking effects of the samples are also confirmed by decreasing and increasing values of free volume with respect to molalities and temperatures as expected[17,18].The variations of free volume with respect to molalites and temperatures are also confirm that there is strong solute-solvent interaction in peptide solutions[19].

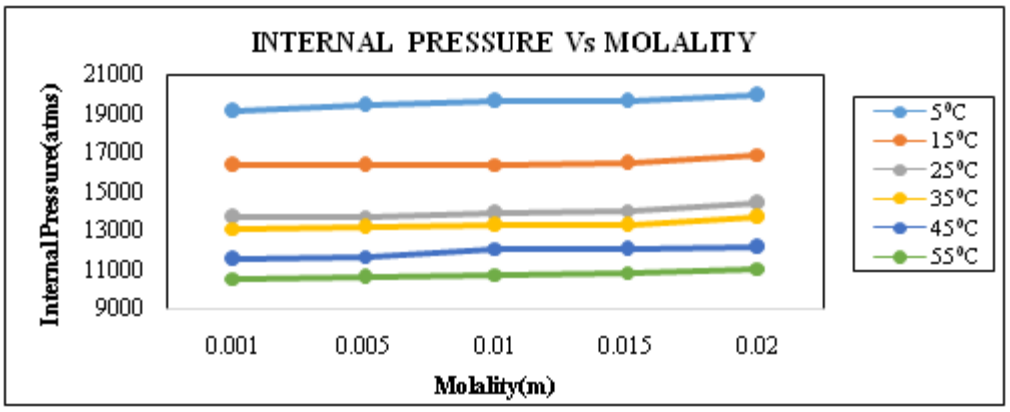

Figure 1: Internal Pressure (atms)

Table 1: Internal Pressure (atms)

Molality	5°C	15°C	25°C	35°C	45°C	55°C
.001	19130	16330	13669	13147	11562	10586
.005	19393	16371	13736	13174	11720	10625
.01	19642	16389	13905	13254	12101	10787
.015	19647	16426	14044	13296	12029	10886
.02	19929	16911	14391	13691	12151	11085

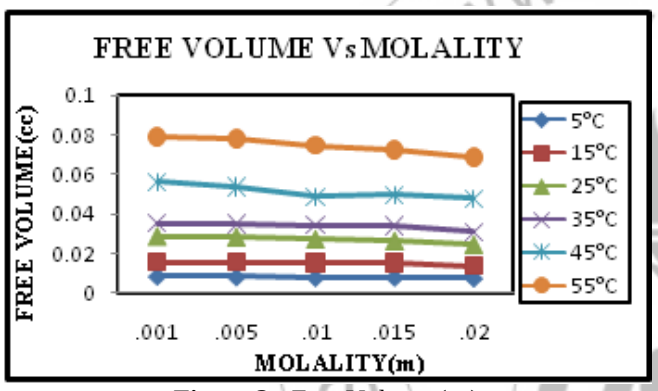

Figure 2: Free Volume (cc)

Table 2: Free Volume (cc)

Molality	5°C	15°C	25°C	35°C	45°C	55°C
.001	0.0087	0.0154	0.0288	0.0353	0.0562	0.0791
.005	0.0083	0.0153	0.0284	0.0351	0.0539	0.0782
.01	0.008	0.0152	0.0274	0.0344	0.0489	0.0747
.015	0.0081	0.0151	0.0265	0.0341	0.0497	0.0726
.02	0.0077	0.0139	0.0246	0.0311	0.0482	0.0687

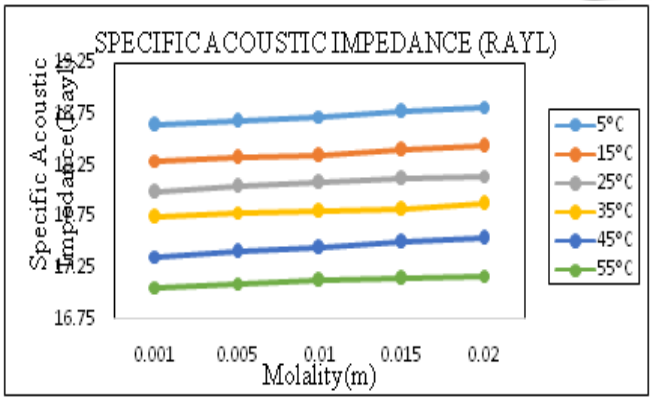

Figure 3: Specific Acoustic Impedance (RAYL)

Table 3: Specific Acoustic Impedance (RAYL)

Molality	5°C	15°C	25°C	35°C	45°C	55°C
.001	18.64	18.30	17.99	17.74	17.36	17.06
.005	18.68	18.33	18.05	17.79	17.41	17.10
.01	18.73	18.35	18.08	17.80	17.44	17.12
.015	18.77	18.40	18.12	17.82	17.50	17.14
.02	18.82	18.44	18.15	17.88	17.54	17.17

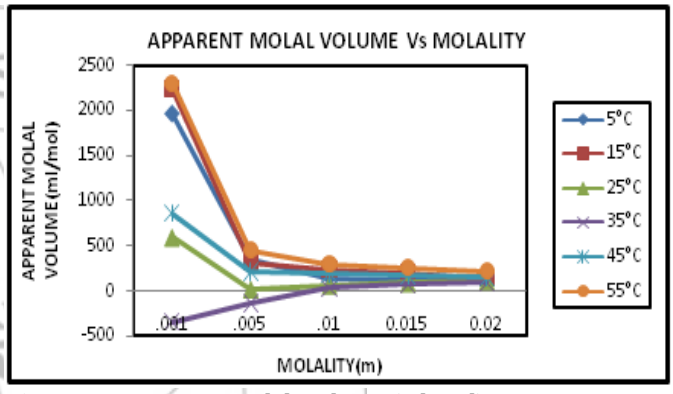

Figure 4: Apparent Molal Volume (ml/mol)

Table 4: Apparent Molal Volume (ml/mol)

Molality	5°C	15°C	25°C	35°C	45°C	55°C
.001	1965.67	2231.57	596.97	-340.40	861.10	2306.06
.005	353.11	318.75	19.28	-133	221.68	453.17
.01	153.47	233.70	65.95	26.46	199.86	302.53
.015	125.12	201.97	88.39	66.48	182.23	257.14
.02	141.21	144.44	114.38	91.32	160.14	225.34

3.2 Specific Acoustic Impedance

The variations of specific acoustic impedance with respect to the molality are given in table and in figure (1.3).The linear variations of specific acoustic impedance with concentrations and temperature may be due to the effect of solute-solvent interactions [19].

3.3 Apparent Molal Volume

The decrease in apparent molal volume with an increase in molality is observed in both the solutions which suggest that the strong ion-ion interaction [20] taking place in the solutions. The higher values of φv suggest that there is strong solute-solvent interaction and lower values support the strong ion-ion interactions [21,22].

4. Conclusion

Ultrasonic technique is very useful in finding out the existence of interactions between the components of solutions. Dipeptides have been used in study of protein

structure and functions. Peptides and proteins are the most characteristic chemical compounds found in the living cells. Phynylalanine is an essential amino acids,it contains an aromatic side chain. Which contribute to ultraviolet absorbance and fluorescence properties. It is used in the manufacture of food &dring products and sold as nutritional supplement for its reputed analgesic& antidepressant effects. In the present work π_i,,v_f, Z, φ_v study have been carried out. The behavior of the solute in the solvent reveals that the salt act as structure maker.

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