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Ultrasonic Absorption and Relaxation Studies in Aqueous Arginine and Methionine using PEO Technique

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ABSTRACT

Ultrasonic absorption studies may throw more light on the molecular interactions to know the behavior of biological macromolecules in aqueous solution. It is the key to solve the critical problems with the role and interaction of these substances in living organisms. In this paper, the ultrasonic velocity and absorption measurements were made using Pulse Echo Overlap (PEO) technique at 2 MHz at 298 K in aqueous Arginine and aqueous Methionine. The related parameters relaxation time, classical absorption, excess absorption, volume viscosity has been evaluated. The observed ultrasonic absorption is much higher than the classical absorption. These studies show that the nature of molecular interaction in aqueous solution of biological molecules is complex in nature.

Keywords: Ultrasonic velocity, Classical absorption, Relaxation time, volume viscosity,

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INTRODUCTION

Ultrasonic wave propagation studies in a medium provide important tools for evaluation of the structural, physical and chemical properties of medium. The nature of ultrasonic absorption properties of aqueous protein solution shed more light on many chemical analyses as well as an idea about the complexity of protein molecules. The ultrasonic properties of liquid and biological media have been studies in detail by many researchers [1-17]. Limited information available particularly on the ultrasonic absorption of aqueous biomaterials in the literature.

In the view of extensive applications of ultrasound in biomedical technology, in the present study, absorption measurements were undertaken in aqueous arginine and methionine solutions at a frequency of 5 MHz and at a temperature of 298 K.

MATERIALS AND METHODS

Arginine and Methionine used were of E Merck /AR BDH grade.Water was used as a solvent. Triple distilled water was used for preparation of solutions. Different compositions of Arginine and methionine were prepared with water. The ultrasonic velocity and absorption measurements were carried out using highly versatile accurate pulse echo overlap technique by using automatic ultrasonic attenuation recorder (AUAR-102) supplied by innovative instrument Hyderabad (India). The frequency of the pulses is kept at 2 MHz. The accuracy in the measurement of absorption is about 2 %. The density of the solutions was determined using hydrostatic plunger method. The viscosity of liquid was measured by Oswald's viscometer. Thermostatically controlled water circulation system is used to maintain the temperature at 298K with an accuracy of 0.05^0C. The measured ultrasonic velocity, density, viscosity, absorption and various other parameters were calculated by using the standard formulae.

RESULTS AND DISCUSSION

The observed variation in the velocity, absorption and other calculated parameters are shown in table 1& 2.The graphical representation are shown in fig.1.1 to 1.6 and 2.1 to 2.6 for aqueous arginine and aqueous methionine respectively.

The observed ultrasonic velocity (fig.1.1,2.1), ultrasonic absorption (fig.1.3,2.3), classical absorption (fig.1.4,2.4), relaxation time(fig.1.2,2.2) and other parameters shows nonlinear trend with increase in molar concentration. This may be attributed to molecular association and complex formation. This may be brought about through a hydrogen bonding possible between the molecules [3].

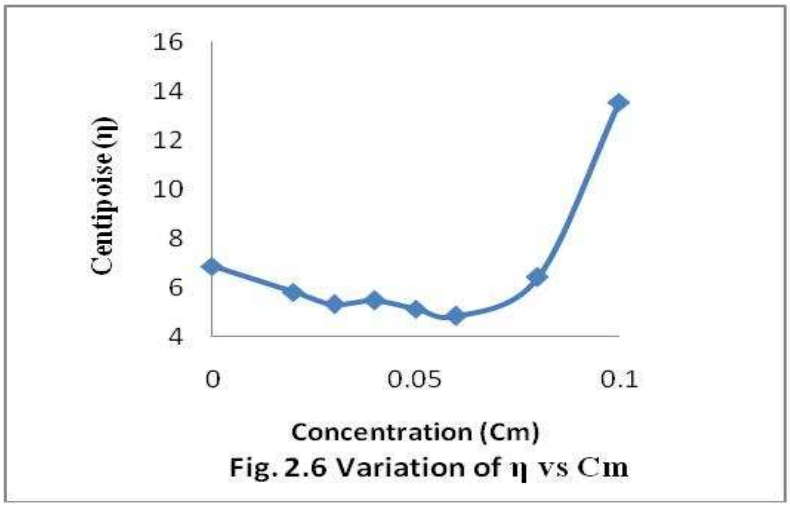

Fig. 2.6 Variation of η vs Cm

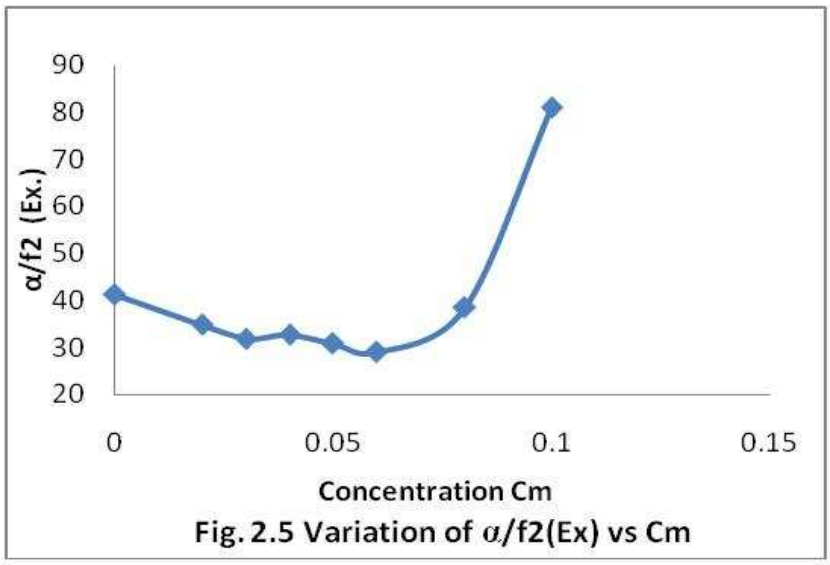

Fig. 2.5 Variation of α/f2(Ex) vs Cm

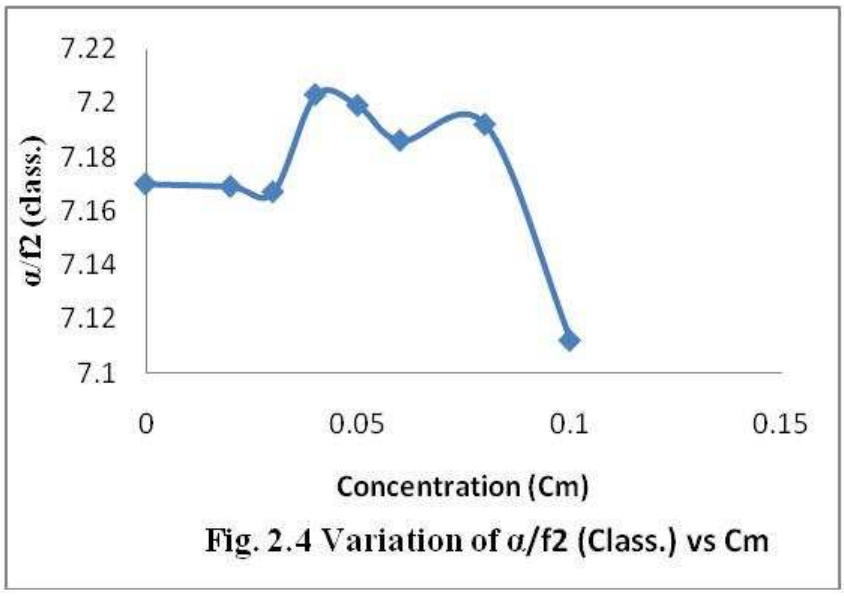

Fig. 2.4 Variation of α/f2 (Class.) vs Cm

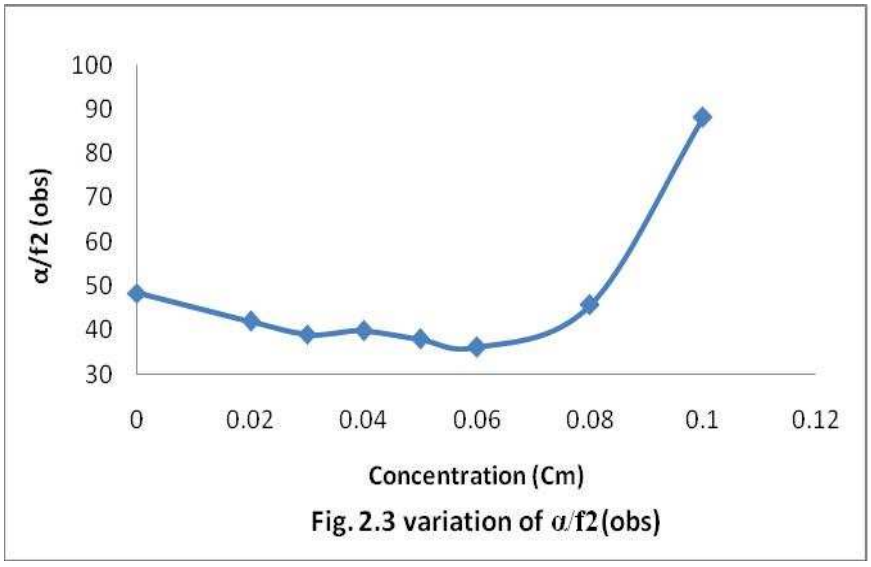

Fig. 2.3 variation of α/f2(obs)

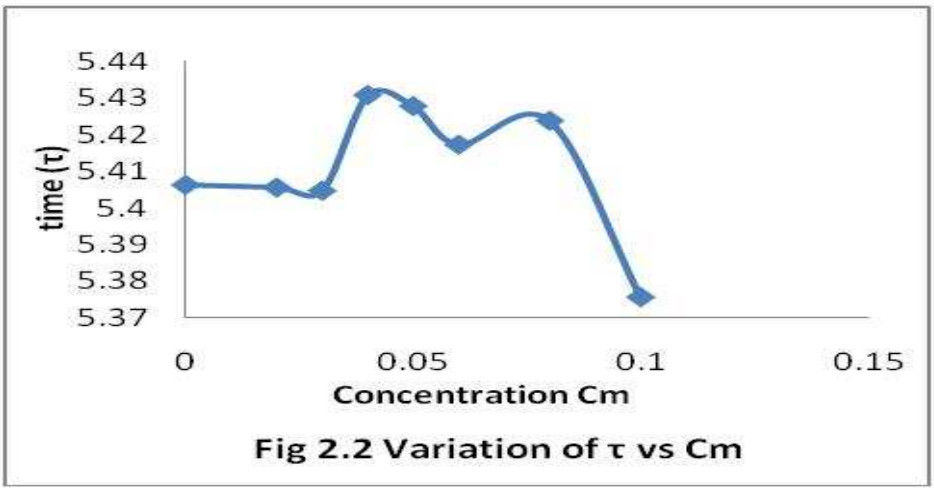

Fig 2.2 Variation of τ vs Cm

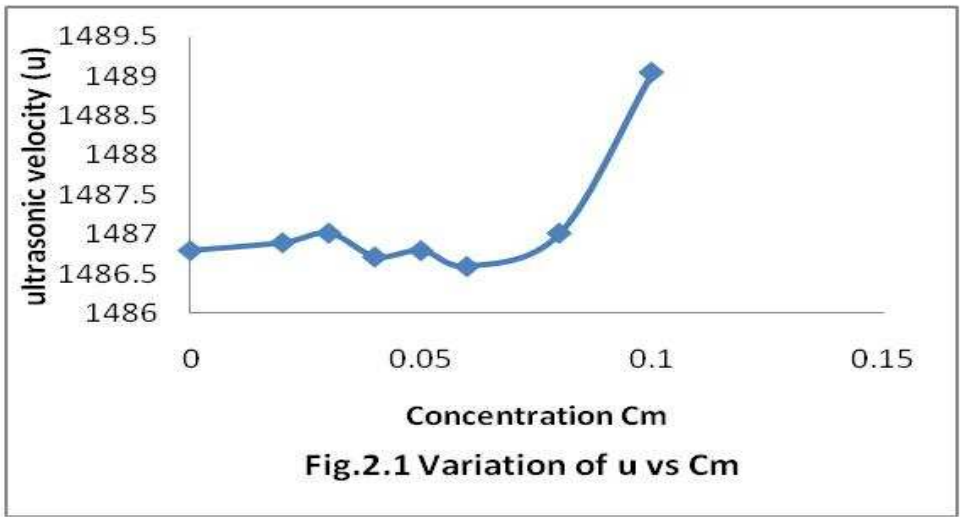

Fig.2.1 Variation of u vs Cm

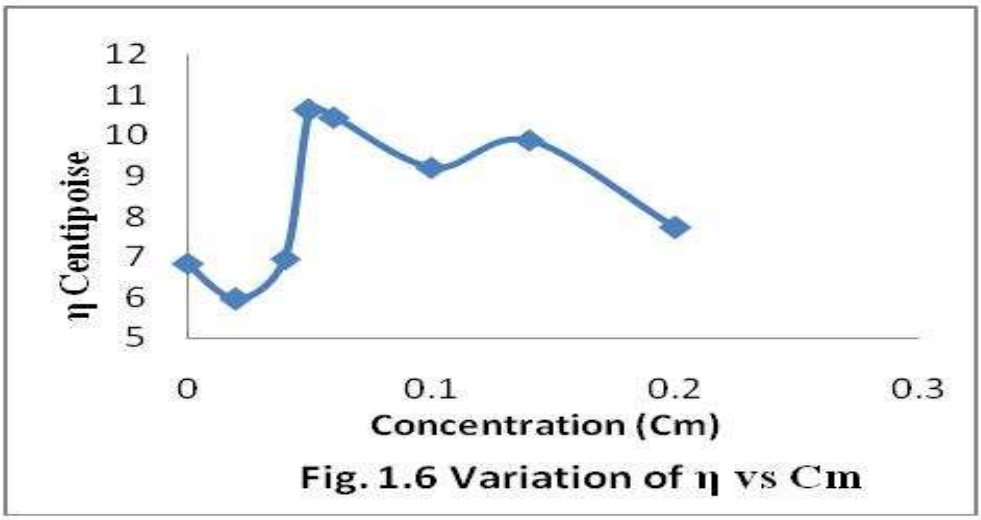

Fig. 1.6 Variation of η vs Cm

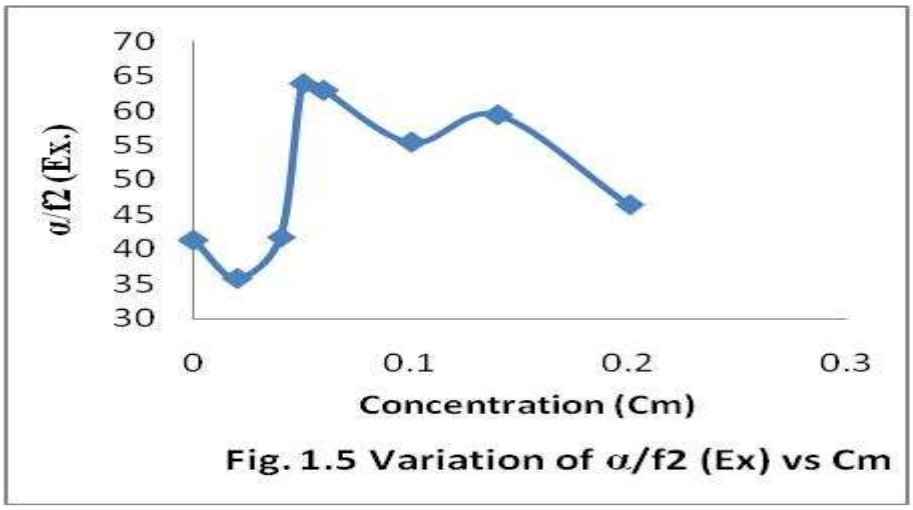

Fig. 1.5 Variation of α/f2 (Ex) vs Cm

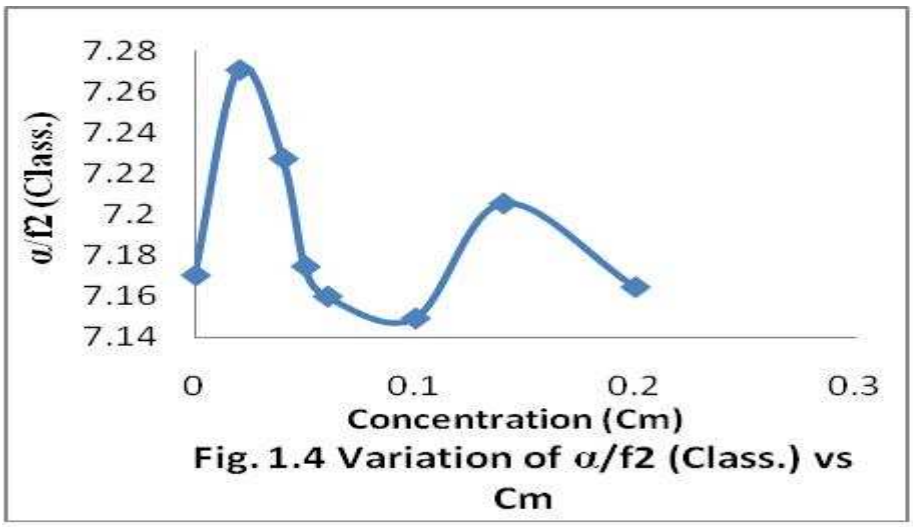

Fig. 1.4 Variation of α/f2 (Class.) vs Cm

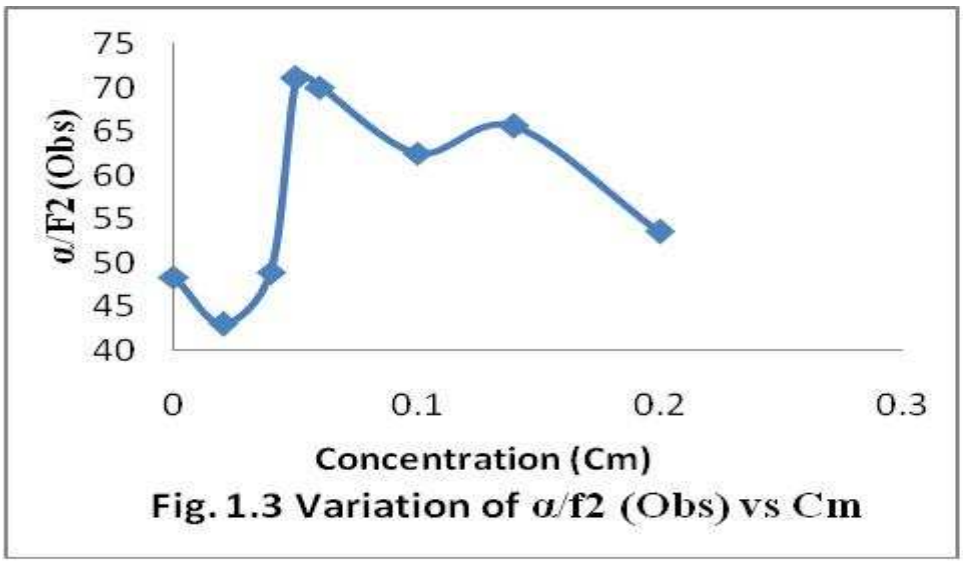

Fig. 1.3 Variation of α/f2 (Obs) vs Cm

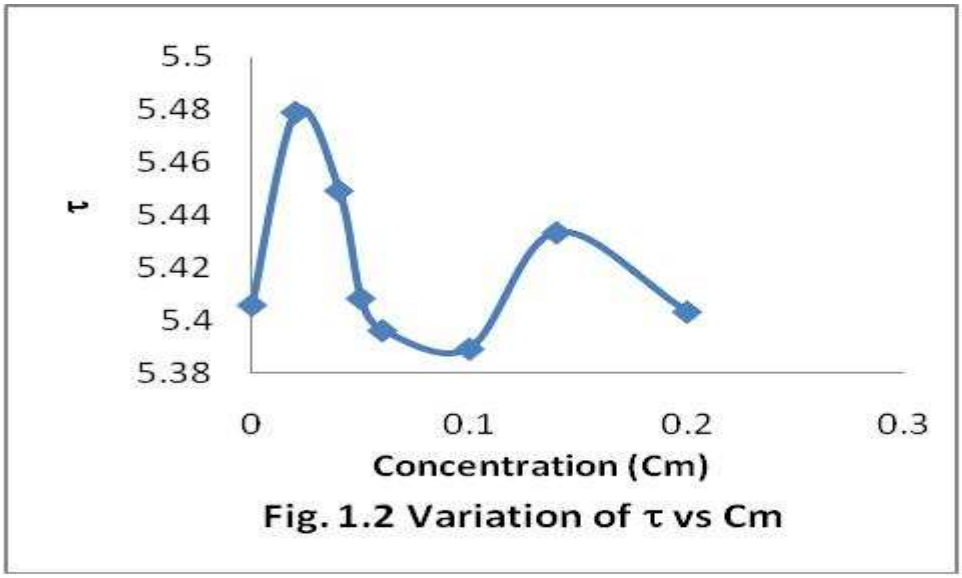

Fig. 1.2 Variation of τ vs Cm

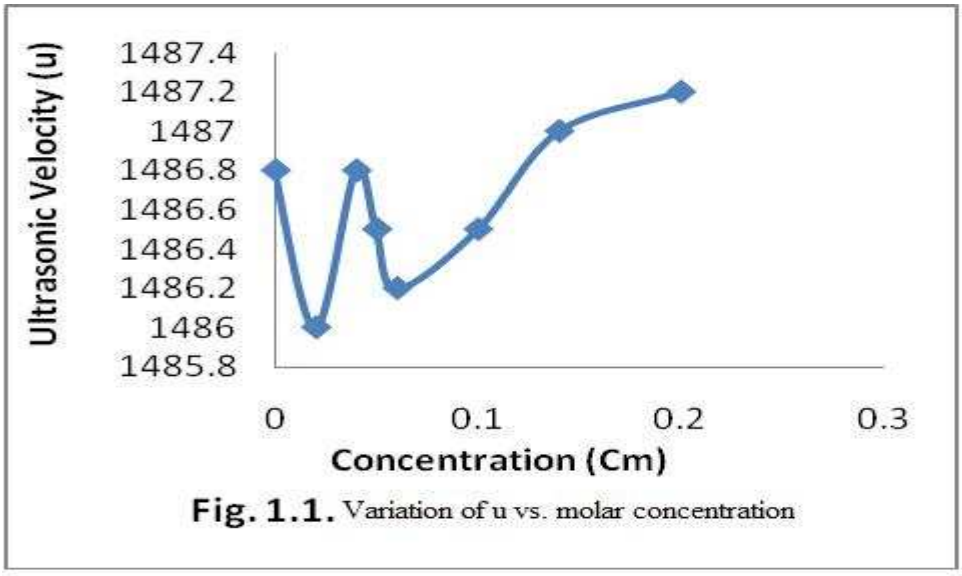

Fig. 1.1. Variation of u vs. molar concentration

The observed ultrasonic absorption (fig.1.3, 2.3) in aqueous Arginine and Methionine initially decreases with molar concentration. This may be attributed due to the formation of strong hydrogen bonds which generally increase the inter proton distance between adjacent hydrogen bonds. This is also due to the weakening of intermolecular forces of bulk solution and the decrease in non-hydrated free water content of the solutions[4].

The molar concentration that corresponds to the maximum absorption may be called critical concentration. At critical concentration the solution is more structured due to the formation of hydrogen bond. This highly structured solution generally absorbs more ultrasonic energy. The maximum occur at particular concentration may indicate a remote possibility of the formation of an aggregate containing one molecule of amino acid and one molecule of water. These molecular aggregates form large molecular clusters. This aggregation of many small molecules is bound together by cohesive forces [5].

According to some investigators[6-16] the water molecules which surround the electrolyte undergo electrostriction i.e. when the amino acids are dissolved in water, amine and carboxylic groups strongly interact and are present in ionic form (NH_3^+ and COO^-). A more dense packing of water molecules in the vicinity of such ions suggests that cohesion through hydration is more probable. The increased cohesion between the water molecules leads to increase in observed absorption. The increase in observed absorption may also be due to the mobility of the solvent (water) molecules closest to ions should always be less than the mobility of the molecules in pure solvent.

The observed absorption is very much higher than the classical absorption. It is a characteristic feature of the solutions in which strong association effect is present due to molecular interaction [17]. Which may also indicates that the absorption in solution is not mainly due to shear viscosity alone but may be due to some other effects [18].The excess absorption (fig.1.5, 2.5) and volume viscosity (fig.1.6,2.6) has the same trend as that of the observed absorption. This may be due to intermolecular association, which can be explained on the basis of Hall's two- state model owing to the associative nature of the systems[19]. This model assumes the presence of two structures, i.e. Closed packed structure and open packed structure. The probable two states are hydrated amino acids and free water.

Table 1- Aqueous Arginine

C_m(%)	u_*10^2 Cm/Sec	τ_*10^{-11} Sec	$\alpha/f^2_{*10}{}^{-17}$ (Obs) Sec^2/Cm	$\alpha/f^2_{*10}{}^{-17}$ (Cla) Sec^2/Cm	$\alpha/f^2_{*10}{}^{-17}$ (Ex) Sec^2/Cm	η_v Centipoise
0.0	1486.80	5.406	48.39	7.1703	41.22	6.8501
0.02	1486.00	5.4792	43.06	7.2709	35.79	5.9602
0.04	1486.80	5.4494	49.00	7.2274	41.77	6.9489
0.05	1486.50	5.4085	71.02	7.1746	63.84	10.6179
0.06	1486.20	5.3963	70.00	7.1599	62.84	10.4516
0.10	1486.50	5.3893	62.52	7.1492	55.37	9.2161
0.14	1487.00	5.4335	65.59	7.2055	59.38	9.8911
0.20	1487.20	5.4034	53.55	7.1645	46.38	7.7183

Table 2- Aqueous Methionine

C_m(%)	u_*10^2 Cm/Sec	τ_*10^{-11} Sec	$\alpha/f^2_{*10}{}^{-17}$ (Obs) Sec^2/Cm	$\alpha/f^2_{*10}{}^{-17}$ (Cla) Sec^2/Cm	$\alpha/f^2_{*10}{}^{-17}$ (Ex) Sec^2/Cm	η_v Centipoise
0.0	1486.80	5.4063	48.39	7.170	41.22	6.8501
0.02	1486.90	5.4056	42.00	7.169	34.83	5.8075
0.03	1487.02	5.4047	39.02	7.167	31.85	5.3129
0.04	1486.72	5.4308	39.89	7.203	32.68	5.4495
0.05	1486.80	5.4278	38.00	7.199	30.80	5.1308
0.06	1486.60	5.4173	36.18	7.186	28.99	4.8340
0.08	1487.02	5.4238	45.65	7.192	38.45	6.4148
0.10	1489.05	5.3757	88.07	7.112	80.95	13.55

CONCLUSION

The ultrasonic absorption is more in aqueous methionine at higher concentration, which may be due to higher volume viscosity. This indicates the aqueous solution of methionine is more structured than aqueous arginine.

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