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Ultrasonic Characterization of Some Nitrogenous Bases in Aqueous Solution

P. D. Bageshwar[1], N. R. Pawar[2], O. P. Chimankar[3] R. D. Chavhan[4] and D. V. Nandanwar[5]

[1]Department of Physics, M. M. College, Darwha - 445 202, India

[2, 4]Department of Physics, Arts, Commerce & Science College, Maregaon - 445 303, India

[3]Department of Physics, RTM Nagpur university, Nagpur - 440 033, Maharashtra, India

[5]Department of Physics, M. M. Science College, Nagpur, Maharashtra, India

Abstract: ***The present paper reports the ultrasonic characterization of some nitrogenous bases like adenine and guanine in aqueous solution at different concentration and at different temperature. Ultrasonic velocity and density measurement were carried out by Multi frequency Interferometer technique operated at 1 MHz - 10 MHz. It helps in finding Thermo acoustic parameters such as adiabatic compressibility, acoustic impedance, etc. The main aim of this study is to obtain information on the nature & strength of molecular interaction and molecular relaxation guanine and adenine in aqueous solution. The thermo acoustic study of nitrogenous bases provides the information regarding molecular interactions in the solution. These studies have application in pure as well as applied research in the field of bio-medical and industrial process. The non linear ultrasonic characterization of aqueous nitrogenous bases would play a very important role in diagnostic procedure for more complete investigation of normal and diseased state. This study will also lead to better understanding of nitrogenous bases for possible application to be used as life saving medicine. Therefore the proposed study is worthwhile and interesting from number of aspects. Thermo-acoustic parameters were successfully employed to explain different types of molecular interactions such as strong, weak, complex formation, hydrogen bonding interactions, structure making and breaking properties of the interacting components.***

Keywords: Ultrasonic velocity; thermo-acoustic parameters; guanine; adenine

1. Introduction

Ultrasonic wave velocity in a medium provides valuable information about the physical properties of the medium. It also provides important information about various inter and intra-molecular processes such as relaxation of the medium or the existence of isomeric states or the exchange of energy between various molecular degrees of freedom. Ultrasonic parameters are extensively being used to study molecular interactions in pure liquids binary liquid mixtures[1-4]and ionic interactions in single and mixed salt solutions of bio-liquids[5-10]. The experimental investigations have shown that derived parameters such as the adiabatic compressibility (βa), acoustic impedance and their deviation from the additive rule provide a better insight into molecular processes[11-13]. In the present paper ultrasonic velocity and density have been measured. From these data other thermo acoustic parameters have been computed using standard formulae.

2. Materials and Methods

The liquids used were of BDH analar grade and were redistilled in the laboratory. In this study the measurements have been made in the temperature range 293 K-313 K. The temperature of the liquid mixture was kept constant by the use of thermostat U-10 with ± 0.01 K accuracy. Density measurement was carried out by using hydrostatic sinker method with an accuracy ±0.01%. A monopan electrical balance of least count as 0.0001 gm was used to record change in plunger weight dipped in the solutions correct to fourth place of decimal. Ultrasonic velocity measurements were made with an ultrasonic multi-frequency interferometer (Mittal enterprises, New Delhi) in the frequency range 1 MHz to 10 MHz with an accuracy of ±0.1%.

3. Results and Discussion

Fig.1& 2 contains the plot of ultrasonic velocity versus molar concentration at different temperatures. It is observed that ultrasonic velocity increases with increase in molar concentration of guanine in aqueous solution, indicating association in the molecules of the component. The association in the constituent molecules may involve due to hydrogen bonding or due to dipole-induced dipole interaction between the constituent molecules. Amino group in guanine and adenine are act as hydrogen bond acceptor or donor, hence association may be possible through hydrogen bonding. The peak at molar concentration 0.6 in fig1 is due to the formation strong hydrogen bond. This interaction leads to the complex formation on these molar concentration.

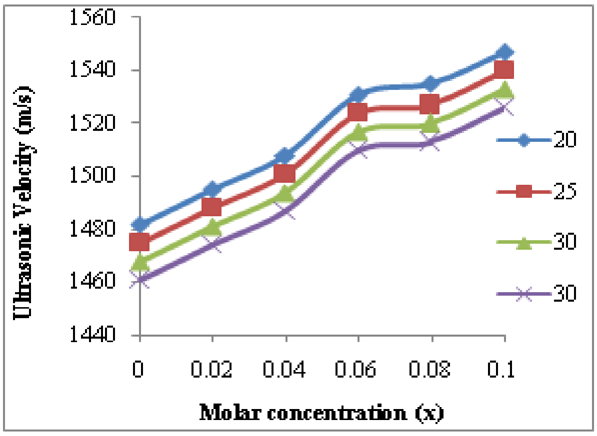

Figure 1: Variation of Ultrasonic velocity vs. Molar conc.

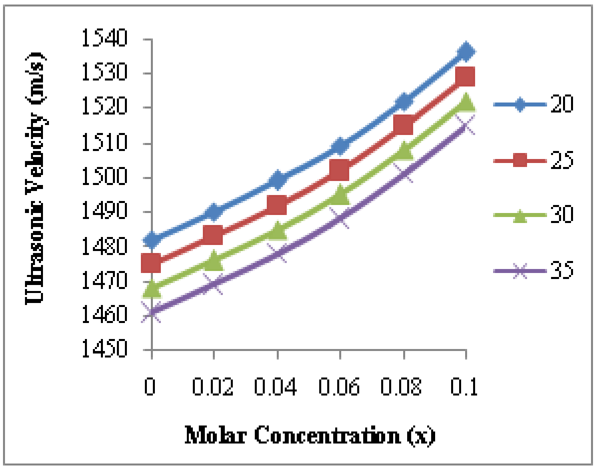

Figure 2: Variation of Ultrasonic velocity vs. Molar conc.

Fig.3 & 4 contains the plot of density versus molar concentration. It is observed that density increases with increase in concentration of guanine and adenine in aqueous solution. Increase in density decreases the volume indicating association in component molecules of guanine and adenine. The density of molecules of guanine and adenine in aqueous solution may be increase due to structural reorganization indicating the closed packed structure of components, hence molecular cluster increases. This makes the liquid medium less compressive. Density is an important concept regarding buoyancy, purity and packaging. It varies with temperature and pressure. Increasing the pressure on an object decreases the volume of the object and therefore increases its density, increasing the temperature of a substance decreases its density.

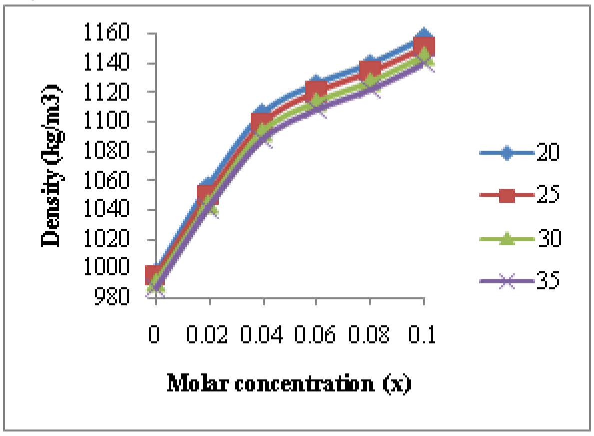

Figure 3: Variation of Density vs. Molar conc.

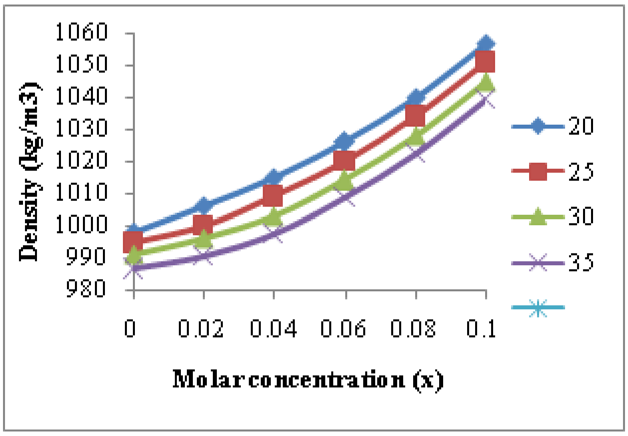

Figure 4: Variation of Density vs. Molar conc.

Fig.5 & 6 contains the plot of acoustic impedence (Z) versus molar concentration. It is observed that, the values of acoustic impedance increases with increase in the molar concentration of component molecules in aqueous solution. It is in good agreement with the theoretical requirements because ultrasonic velocity increases with increase in molar concentration. The increase in acoustic impedance (Z) with molar concentration can be explained on the basis of intermolecular interactions between the component molecules, which decreases the intermolecular distance, making relative fewer gap between the molecules. This also indicates significant interactions in the component molecules of the binary liquid system.

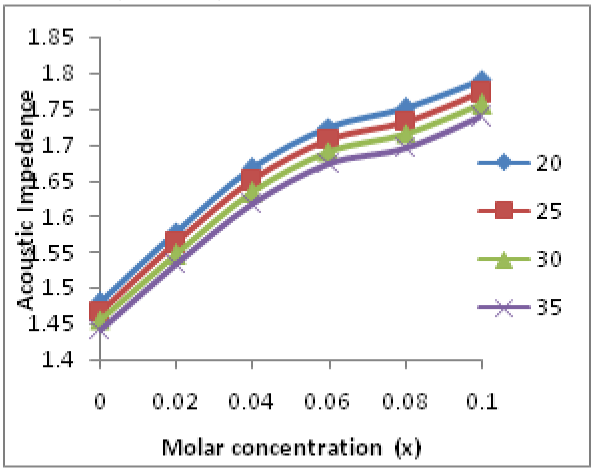

Figure 5: Variation of Acoustic impedance vs. Molar conc.

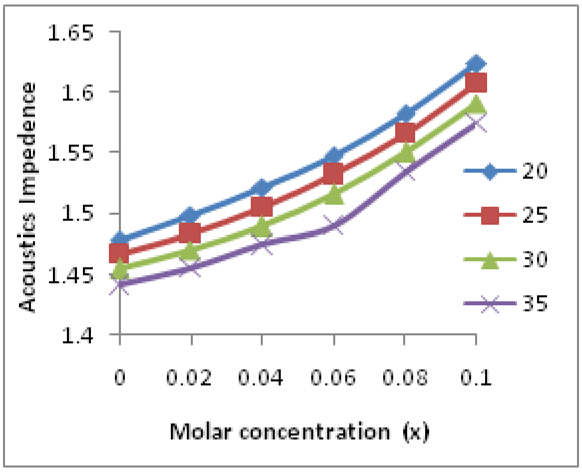

Figure 6: Variation of Acoustic impedance vs. Molar conc.

Fig.7 & 8 contains the plots of adiabatic compressibility (β_a) versus molar concentration. It is observed that adiabatic compressibility decreases with increase in molar concentration indicating strong molecular interaction in the component molecules of guanine and adenine in aqueous solution, shows associating tendency of component molecules.

The observed decrease of adiabatic compressibility with molar concentration indicates the enhancement of degree of association in the molecules of the components. Hence the intermolecular distance decreases with increase in molar concentration. It is primarily the compressibility that changes with structure which leads to change in ultrasonic velocity. Decrease in adiabatic compressibility indicated there is definite contraction in the components molecules. This clearly shows that there is significant interaction between the component molecules. The decrease in adiabatic compressibility brings the molecules to a closer packing resulting into a decrease of intermolecular free length. The decrease in the values of adiabatic compressibility strengthens the strong molecular association between the unlike molecules through hydrogen bonding.

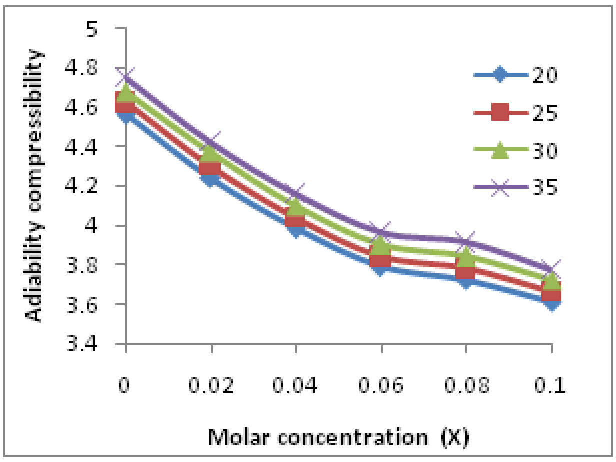

Figure 7: Variation of Adiabatic compressibility vs. Molar conc.

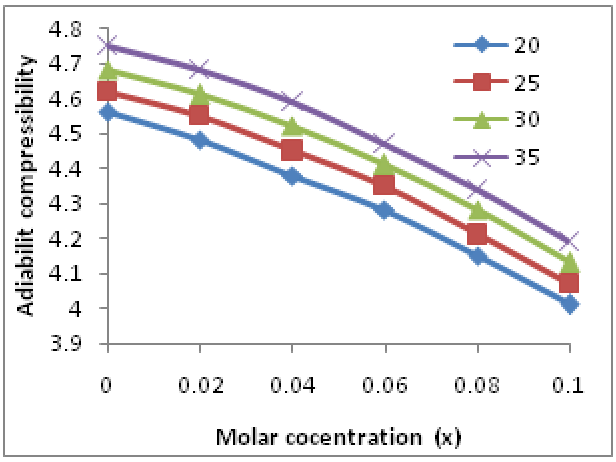

Figure 8: Variation of Adiabatic compressibility vs. Molar conc.

4. Conclusions

1. The observed molecular association in this binary liquid mixture may be due to the formation hydrogen bond or due to interstitial accommodation or due to induction or due to London dispersion forces in the constituents molecules.
2. Decrease in adiabatic compressibility and free length with increase in molar concentration is due to association.
3. Thermo-acoustic parameters such as ultrasonic velocity, acoustic impedance, density, adiabatic compressibility, etc indicates the strength of molecular interactions in the binary liquid mixture.

5. Acknowledgement

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References

[1] Burton C J, J Acoust Am, 20, (1948) 186.
[2] Rao M R, “Current Sci”, 8, (1939) 510.
[3] Wada Y, J Phys Soc Jpn, 4, (1949) 280.
[4] Ravichandran S & Ramanajchan K, J Pure & Appl Ultrason, 28, (2006) 40.
[5] Rath D C & Samal K, J pure Appl Ultrason 16, (1994) 6.
[6] Chimankar O P, Tabhane V A & Baghel G K, J Acoust Soc of India, 34, 4, (2007) 126
[7] Tabhane V A, Chimankar O P, Manja S & Nambinarayanan T K, J Pure & Appl Ultrason, 21 , 3, (1999) 57.
[8] Chimankar O P, Rewatkar K G & Tabhane V A, Indian J of Phys, 75 B, 2, (2001) 141.
[9] Bhandakkar V D Tabhane V A & Ghosh Sharda, Indian J pure & appl Phys, 41, (2003) 849.
[10] Manikiam B & Narasimham A V, Indian J Pure & Appl Phys, 22, (1984) 29.
[11] Chimankar O P, Shriwas Ranjeeta S & Tabhane V A, Arch of appl science res, 2, 6, (2010) 285.
[12] Adgaonkar C S, Deogaonkar V S & Kadu P D, Indian J Pure & Appl Ultrason, 15, (1997)
[13] Chimankar O P, Sangeeta Jajodia , Shriwas Ranjeeta and V A Tabhane, Arch appl sci res, 3, 3, (2011) 252.