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

Ultrasonic Velocity and Absorption in Aqueous Lactose Solution

Sunita T Hiwarkar[1], S P Dange[1], O P Chimankar[2], S A Ghosh, V A Tabhane

Department of Physics, Sindhu Mahavidyalaya, Nagpur

Department of Physics, RTM Nagpur University, Campus, Nagpur

Ex. Director, Government Vidharbha Institute of Science and Humanity, Amravati, India

Department of Physics, SP Pune University, Ganeshkhind, Pune, India

Abstract: ***The ultrasonic velocity and absorption measurements were carried out in aqueous solution oflactose over the entire range of concentration from 0.00 M to 0.1M and temperature range between 293 K to 313 K*** at frequen***icy1MHz,4MHz,5MHz and10 MHz***. The Pulse ***e***cho ***overlap technique has been used for the measurement of velocity and echo-amplitudes. These values are utilised to evaluate the non-linear properties such as adiabatic compressibility((β_a),relaxation time(τ), classical and observed absorption(α/f^2)***, etc***.These parameters show nonlinear increase or decrease with various concentration and temperatures. These parameters are interpreted as due to the formation of intermolecular hydrogen bonding between the hydroxyl groups of lactose and water molecules.***

Keywords: Ultrasonic velocity, adiabatic compressibility, absorption, relaxation time, hydrogen bonding

1. Introduction

Number of studies has been focused on the ultrasonic properties of biomaterial solution. The object of those studies is to identify the molecular interaction between biomaterials and solvent. Understanding the behaviour of aqueous carbohydrates solution is of almost important in biology, medicine and the taste quality exhibited by them[1].Carbohydrates play an important role in animal and plant life. The study of carbohydrates/saccharides has become a subject of increasing interest because of multidimensional physical, biochemical and industrially useful properties of this compound[2].

Carbohydrate in water is of fundamental importance for biological reasons, lactose and their strong interaction with water .The various thermodynamics and ultrasonic studies have been shown that the hydrogen of saccharides depends upon the number of hydroxyl groups.In this paper an attempt has been made to understand the molecular interaction of lactose with water by evaluating various acoustic parameters based on the ultrasonic velocity and echo amplitude measurements in aqueous solutions of lactose at various concentration and temperatures.

2. Sample Preparation and Experimental Techniques

Aqueous solutions of lactose (AR grade) in the concentration range of0.00Mto 0.1M, under theinvestigation are prepared by dissolving known amount of lactose in the doubled distilled water. The ultrasonic velocities andamplitude ofechoes in aqueous lactose at various concentration range of0.00N to 0.1Nand temperature between 293K and 313Kwith interval of 5Kare measured by a MHF-400 high frequency pulser-receiver (Roop telesonic ultrasonix limited Mumbai)atfrequencies of 1MHz,4MHz,5MHz and 10 MHz .The density (ρ), viscosity (η) and are measured by pyknometer method and Oswald viscometer respectively. Using the measured data, acoustic parameters namely adiabatic compressibility(βa) relaxation time (τ),classical and observed absorption (α/f^2) etc . are calculatedby using the standard formulae[4].Thebehaviour of various acoustical parameters were represented graphically at different concentrations and temperature.

3. Result and Discussion

In the present work water is used as solvent which is essential constituent of multi-living and non-living bodies of the universe and universal solvent. In figure 1, Ultrasonic velocity is found to increase with the increase in lactose concentration as well as with temperature ultrasonic velocity shows peak at 0.04 and dip at 0.08 while adiabatic compressibility shows revers trend in binary system of lactose with water. The variation of ultrasonic velocity shows that there is strong solute–solvent interaction in any solution indicates the maximum association among the molecules of solution[9].The maximum association is due to the hydrogen bonding between the solute and solvent molecules[6]. Adiabatic compressibility (β_a), relaxation time (τ)values as functions of concentration and temperature for lactose have been plotted in figure 2, and 3 at10MHz respectively .It shows that adiabatic compressibility values decreases with increase in the concentration of lactose as well as with temperature. This confirms the presence of solute solvent interaction of the-OH groups of lactose concentration[3] .Velosity increases with increasing concentration at 313K adiabatic compressibility are higher than of solution and it decrease with concentration of solution. Adiabatic compressibility ((β_a) is the measure of intermolecular association or dissociation. The structural arrangement of molecule affects the compressibility. The decrease in adiabatic compressibility with increase in molar concentration indicates enhancement of degree of association among the liquid molecules due to hydrogen bonding. Hence the intermolecular distance decreases with increase in molar concentration[10]. The conductivity studies of sucrose solution and acoustical properties of fructose and

maltose in water and in aqueous NH_4Cl solutions also confirm the formations of hydrogen bonds between the solute and water molecules.[3]Figure 3,shows that relaxation time slightlydecreases. Decrease in relaxation time decreases the ultrasonic absorption in this binary liquid system.Decrease in relaxation time with temperature is due to supply of thermal energy[13].The non-linear variation of ultrasonic absorption in each curve figure 4 to figure8 with molar concentration strongly supports the presence of dipole-induced dipole interaction in the constituent molecules in this binary liquid system.

The stronger homo molecular interaction in the molecules of lactose may be responsible for non –linear variation of absorption in this binary liquid system. The relaxation time increases with increase in temperature .The variation of observed ultrasonic absorption shows a peak at particular concentration in the binary liquid system lactose+water. At the peak absorption is maximum. The molar concentration corresponding to the maximum absorption may be called as the critical concentration .This indicate that the solution is highly structured .The formation of hydrogen bonds is likely to make the solution highly structured and such a solution generally absorbs more ultrasonic energy[11], as the ultrasonic wave passes through it.

The classical absorption,relaxation time shows variation non linear and observed ultrasonic absorption shows peak at particular concentration in binary liquid system .This indicate that the solution is highly structured .The formation of the hydrogen bonds is likely to make the solution highly structured and such a solution generaly absorb more ultrasound energy.As the ultrasonic wave passes through the medium, part of its energy is utilised in the weakening or a breaking up of O-H bonds. This explanation finds some support from the NMR studies, in which the hydrogen bonds tends to weaken when the protons are brought closer[11].Thepeak in sound absorption coefficient indicates a remote possibility of formation of an aggregate containing one molecule of carbohydrate and one molecule of water. The molecules are aggregate and forms large clusters. This aggression of many small molecules are bound together by cohesive forces or secondary bonds called Micll. As the number of aggregate molecules are more at critical Micll concentration (CMC), the observed ultrasonic absorption, classical absorption, relaxation time, excess absorption and volume viscosity are more at CMC[12].The observed ultrasonic absorption is very much higher than the classical absorption in aqueous lactose. It is characteristics feature of solutions in which strong association due to molecular interaction. Classical absorption is much smaller than the observed absorption. This indicate that the absorption in these liquid system is not mainly due to shear viscosity alone but may due to some other effects .The excess absorption has same trend as that of observed absorption .

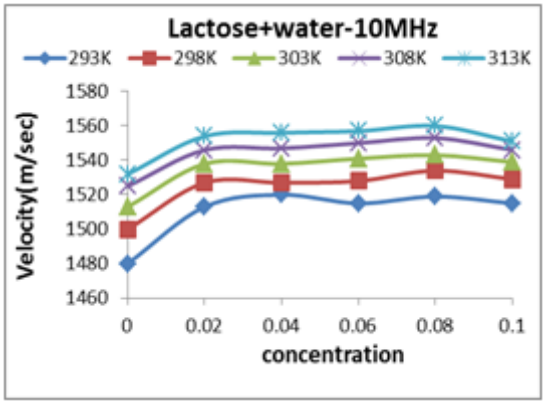

Figure 1: Variation of Ultrasonic velocity with concentration

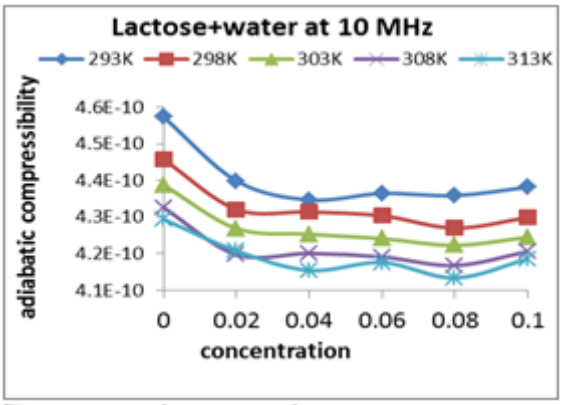

Figure 2: Variation of Adiabatic compressibility with concentration

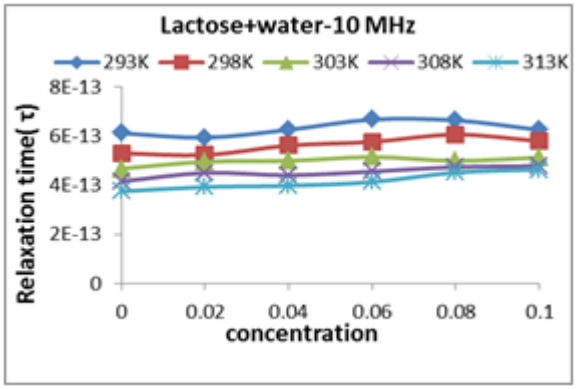

Figure 3: Variation of relaxition time with concentration.

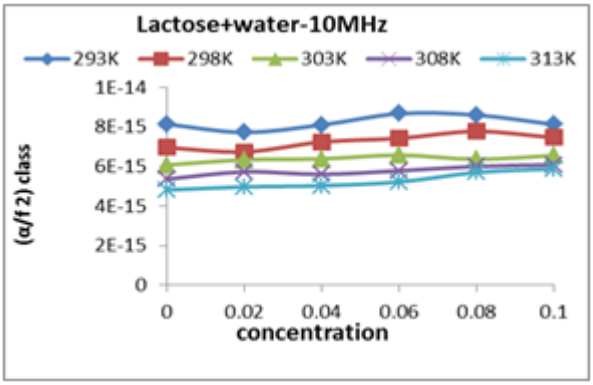

Figure 4: Variation of classical absorption with Concentration

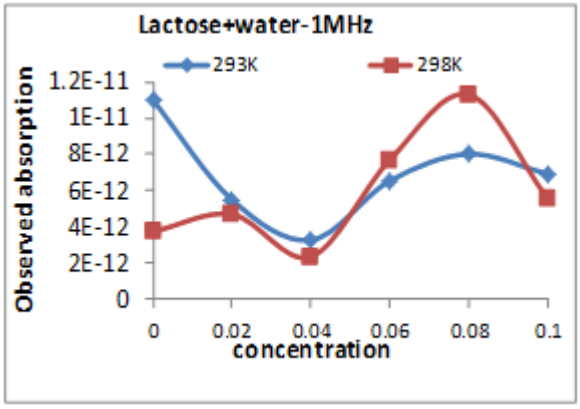

Figure 5: Variation of observed absorption with concentration at 1MHz

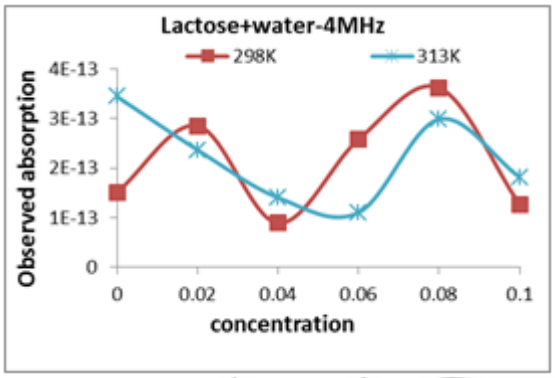

Figure 6: Variation of observed absorptionwith concentration at 4MHz.

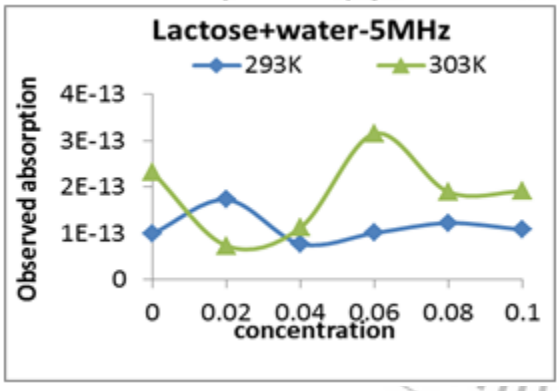

Figure 7: Variation of observed absorption with concentration at 1MHz.

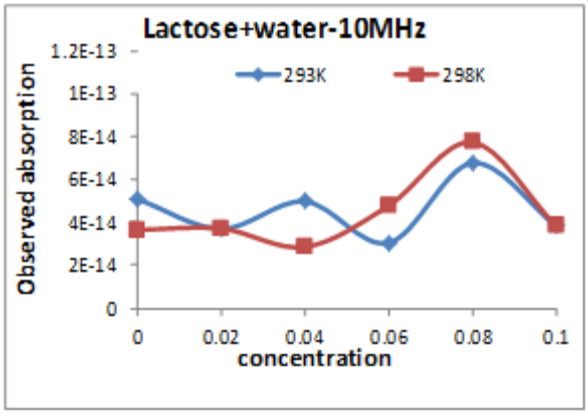

Figure 8: Variation of observed absorption with concentration at 4MHz.

4. Conclusion

1) The nonlinear variation of thermo acoustic properties in aqueous lactose reflects the presence of intermolecular interaction between molecule of lactose and water.
2) Classical absorption slightly increases with increase in concentration. This indicates that solution is highly ordered due to outstanding hydration and such solution generally absorbs more ultrasonic energy[11], this structural relaxation process plays very important role in the study of molecular and structural properties of the component molecules in binary liquid mixture.

5. Acknowledgment

The authors are greatful to University Grants Commision, New Delhi, for providing financial support to this work through research project.

References

[1] Parke S.A. GordhanG.Birah and RoelinaDisk,Chem.Senses. 24,271 (1999)
[2] David O.C.Marten M.H. and Anthony F.B,Ann.Ny.Acad.Sci.204,502(1973)
[3] P.S.Nikam,H.R.Ansari and Mehdi Hasan.J,Mol.Liq.84,169(2000)
[4] O.P.Chimankar,"Thermodynamic in some real fluid mixtures in different environment"Ph.D.Thesis,Nagpur(1998)
[5] Uedaira H,Bull.Chem.Soc.Jpn.53,2451(1980) .
[6] KharatS.J.Journal of Molecular Liquids 140,10-14(2008).
[7] Sethu Raman M.PonnuswamyV.KolandaivelPeruma K I,Journal of Molecular Liquids 142,-16(2008).
[8] Rao,K.Ch., Rajulu,A.V.andNaidu,S.V.Journal Polymer.Mater.,12(1989)149.
[9] Tabtane V A,ChimankarO.P,Manja S and NambinarayananT K,J Pure and and applied Ultrason,21,3 (1999) 57.
[10] Lippincott E R &SrinivasaRao,Pramana, 26(5),1964 3006).
[11] GormallyG,Gettins W J& W).
[12] Back F,OakenfullD,SmithM.B,Biochemistrys 18,519(1979)Chem