Asian Journal of Chemistry Vol. 22, No. 7 (2010), 5419-5422

Ultrasonic Studies of Dextrin in Aqueous Media at 298 K

S. NITHIYANANTHAM* and L. PALANIAPPAN†
Department of Physics (Ultrasonics Division), SRM University, Kattankulathur-603 203, India
E-mail: s_nithu59@rediffmail.com

The ultrasonic velocity, density and viscosity of dextrin in aqueous medium were measured at 298 K. The acoustical parameters such as adiabatic compressibility, free length, free volume, internal pressure, acoustical impedance, relative association, Rao's constant and Wada's constant are calculated. The results are interpreted in terms of molecular interaction between the components of the mixtures.

Key Words: Ultrasonic velocity, Acoustical parameters, Dextrin.

INTRODUCTION

Ultrasonic analysis of biological specimen had their beginning at the end of first world war. There has been substantial work on tissue studies in recent past, especially by Dunn and his group[1]. Survey of literature[2-4] reveals that there has been five broad divisions of bio-acoustical studies of which the present work deals with the characterization of the specimen (dextrin) using the sound velocity. The magnitude of density as well as the velocity of sound in human body fluids or constituents is of vital importance for carrying out acoustical analysis of human system or organs[5-9] since sudden excess or reduction of velocity of the wave indicates some abnormality[10,11].

EXPERIMENTAL

1-6 % Standard solution of dextrin, in steps of 1 % was prepared initially. All the solutions are left for 2 h and complete solubility is noted[12]. The ultrasonic velocity in the liquid mixtures have been measured using an ultrasonic interferometer (Mittal type-82) working at 2 MHz frequency with accuracy 0.1 ms^{-1}. The density and viscosity are measured using a Pycknometer and an Ostwald's viscometer of accuracy of 0.1 kgm^{-3} and 0.001 $mNsm^{-2}$, respectively.

Using the measured data, the acoustical parameters such as adiabatic compressibility, free length, free volume, internal pressure, acoustic impedance, relative association, Rao's constant and Wada's constant have been calculated using the following expressions (1-8).

$$\beta = 1/U^2\rho \qquad (1)$$

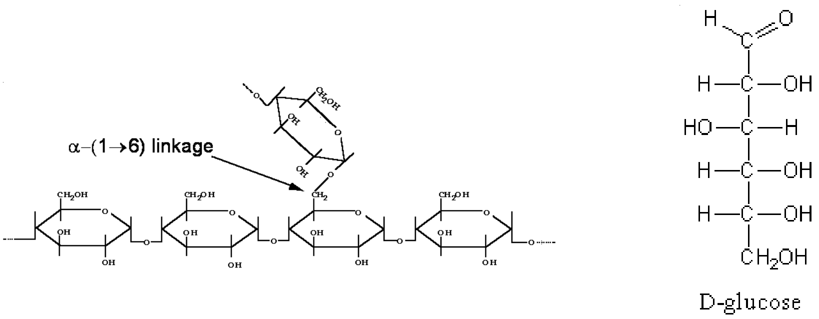
†Department of Physics (DDE), Annamalai University, Annamalai Nagar-608 002, India.

$$L_f = k_T(\beta)^{1/2} \quad (2)$$
$$V_f = (M_{eff}\, U/\eta k)^{3/2} \quad (3)$$
$$\pi_i = bRT(k\eta/U)^{1/2}/(\rho^{2/3}/M^{7/6}) \quad (4)$$
$$Z = U_\rho \quad (5)$$
$$R_A = \rho/\rho_o(U_o/U)^{1/3} \quad (6)$$
$$R = U^{1/3}V \quad (7)$$
$$W = \beta^{-1/7}V \quad (8)$$

Dextrin supplied by SD fine Chem. have been taken in the forms of solutions. Double distilled water is used throughout the work.

RESULTS AND DISCUSSION

The perusal of the Table-1, clearly reveals that the measured parameters *viz.*, sound velocity, density and viscosity increases with increase in concentration of dextrin. As dextrin increases, the number of molecules in the medium increases, making the medium to be denser, which leads lesser compressibility and hence sound velocity increases. Further, the increase in the number of particles simply increases the frictional resistance between the layers of medium and that leads to increase the coefficient of viscosity. Moreover, the existing particle-particle frictional resistance expects some interaction and this expectation is further supported by the non-linear increasing trend of the measured parameters. The same trend observed by Nithiyanantham *et al.*[13] in some aqueous carbohydrates system.



Structure of dextrin and glucose

To explore the nature and type of existing interactions some thermoacoustical parameters have been determine and their extremities and trends are analyzed in the light of existing structural variations. The calculated values of chosen thermoacoustical parameters are presented (Table-1). Referring that table, it is observed that the trend shown by adiabatic compressibility (β) is in general decrease with increase with dextrin (branched chain units of glucose, bond with 1, 6 linkages). The compressibility is the ease with which a medium can be compressed. The higher compressibility values are higher. It implies that the medium is loosely packed whereas the lower compressibility is an indication of maximum interaction. The

TABLE-1
MEASURED VALUES OF ULTRASONIC VELOCITY (U), DENSITY (ρ) AND VISCOSITY (η) AND CALCULATED VALUES SUCH AS ADIABATIC COMPRESSIBILITY (β), FREE LENGTH (L_f), FREE VOLUME (V_f), INTERNAL PRESSURE (π_i), ACOUSTICAL IMPEDANCE (Z), RELATIVE ASSOCIATION (R_A), RAO'S CONSTANT (R) AND WADA'S CONSTANT (W) FOR VARIOUS PERCENTAGE (%) OF DEXTRIN IN WATER AT 298 K

Percentage (%)	U (ms^{-1})	ρ (Kg^{-3})	$\eta \times 10^3$ (Nsm^{-2})	$\beta \times 10^{10}$ ($N^{-1}m^2$)	$L_f \times 10^{11}$ (m)	$V_f \times 10^8$ (m^3mol^{-1})	$\pi_i \times 10^{-9}$ (Nm^{-2})	$Z \times 10^{-6}$ ($kg^{-2} s^{-1}$)	R_A	$R \times 10^1$ ($m^{10/3} s^{-1/3}mol^{-1}$)	$W \times 10^1$ ($m^3 mol^{-1}$) $(N/m^2)^{1/7}$
1	1516.5	1003.4	0.923	4.334	4.154	1.844	2.719	1.522	1.0020	2.0817	3.9421
2	1519.3	1008.8	0.945	4.294	4.135	1.811	2.727	1.533	1.0068	2.0922	3.9647
3	1522.5	1013.5	0.964	4.257	4.117	1.790	2.728	1.543	1.0107	2.1045	3.9902
4	1524.9	1017.7	1.001	4.226	4.102	1.720	2.754	1.552	1.0144	2.1171	4.0163
5	1528.3	1020.7	1.070	4.194	4.086	1.583	2.820	1.560	1.0167	2.1327	4.0472
6	1532.6	1024.3	1.185	4.156	4.068	1.384	2.937	1.570	1.0193	2.1476	4.0769

gradual decreases in adiabatic compressibility with dextrin suggest that the medium become more and more less compressibile. The intermolecular free length (L_f) is again a predominant factor in determining the existing interactions among the components of the mixture. Analyzing the respective table, (L_f) reflects a similar trend as that of (β).

The average available volume between the molecules of mixture is referred as free volume (V_f) whereas the resultant force per unit area between the components as the internal pressure (π_i). Free volume (V_f) is in decreasing trend with increasing the concentration of dextrin. Internal pressure is in general expected to show a reverse trend to that of (V_f).

Acoustic impedance (Z) is the impedance offered to the sound wave by the components of the mixture whereas the relative association (R_A) is the measure of extent of association of the components (the dextrin decomposes to maltose and glucose under hydrolysis) in the medium. Increasing trend in these parameters suggest the strengthening of interaction among the components. The interaction may be solute-solute or solute-solvent or solvent-solvent type.

The molar sound velocity (R) indicates the cube root of sound velocity through one molar volume of solutions, called as Rao's constant and is also a measure of interaction existing in the solution. Further, the trend of molar adiabatic compressibility (W), called as Wada's constant, which depends on the adiabatic compressibility of one molar volume solutions, may be taken as a confirmation for existing interactions. The observed values of molar sound velocity and molar compressibility in all the monosaccharides are of increasing trend with amylase, indicating that the magnitude of interaction are enhanced. The increasing trend of molar compressibility or molar sound velocity with increasing dextrin indicates the availability of more number of components in a given region, thus leads to a tight packing of the medium and thereby increase the interactions. This confirms the predictions obtained from relative association and acoustic impedance that the specific interactions are of solute-solute and solute-solvent type. This is however seems to be peculiar as the components of the medium is enhanced that outweighs the degree of interactions. Same results are observed by Nithiyanantham *et al.*[14].

Conclusion

• Cohesion plays a key role in deciding the nature and strength of interaction in dextrin.

• Solute-solute as well as solute-solvent interactions are existing in the solution.

• Presence of hydrated hydroxyl group has almost no effect in solute-solvent interaction in starch and dextrin.

REFERENCES

1. F. Dunn, Ultrasonic Biophysics (Downden, Hutchinson & Ross Inc. Stroundsberg Pennysyloanic, USA, Bench Mark Oapers in Acoustics, Sep. 7 (1976).
2. R. Pholman, *Phys. Z.*, **40**, 160 (1939).
3. I.E.E.E. Pioneer Ultrasound, Physical Chemical and Biophysical effects-Translation from Russian-Consultant Bureau, New York (1964).
4. T.F. Hueter, *Nature*, **35**, 285 (1948).
5. G.D. Ludwig, *J. Acoust. Soc. Am*., **22**, 862 (1950).
6. J. Singh and S.S. Bhatti, *Indian J. Pure Appl. Phys.*, **36**, 43 (1998).
7. A.K. Singh and J. Behari, *Indian J. Pure Appl. Phys.*, **32**, 528 (1994).
8. K.G. Bhatia, V.R. Singh, M.C. Bansal and S. Bhatia, *Indian J. Pure Appl. Phys.*, **40**, 515 (2002).
9. L. Palaniappan and V. Velusamy, *Indian J. Pure Appl. Phys.*, **42**, 591 (2004).
10. K. Jerie, A. Baranowski, J. Przybylski and J. Glinski, *J. Mol. Liquids*, **111**, 25 (2004).
11. J.D. Panday, R. Dev and B.D. Bhatt, *J. Mol. Liquids*, **111**, 67 (2004).
12. J.W. Moore, Physical Chemistry, Longmans Greens and Co. Lts., London, edn. 4 (1962).
13. S. Nithiyanantham and L. Palaniappan, *Acta Cienc. Ind.*, **31C**, 533 (2005).
14. S. Nithiyanantham and L. Palaniappan, *Acta Cienc. Ind.*, **32C**, 392 (2006).

(*Received*: 12 October 2009; *Accepted*: 26 March 2010) AJC-8569