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ULTRASONIC INVESTIGATION ON AQUEOUS α-AMYLASE AT 298 K

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ABSTRACT
The ultrasonic velocity, density and viscosity at 298 K have been measured in the binary system of with α-amylase in aqueous medium. The acoustical parameters such as adiabatic compressibility, free length, free volume and 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.
Keywords: Ultrasonic velocity, acoustic parameters, α-amylase.

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 Floyd Dunn[1]and his group. 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 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].

The carbohydrate splitting enzymes must break down the linkages in order to form simple products[12], these are mostly α-amylases, found both in the salivary and in the pancreatic juice[13]. It is also activated by chloride with the help of Ca^{++} ions. Another type of amylase recognized as β amylase, acts only at the terminal reducing end of a polyglucan chain found in plants. Animal amylases including those present in human tissues are α-amylases. They attack α-1, 4 linkages in a random manner anywhere along the polyglucan chain[14].

EXPERIMENTAL

Sample preparation and experimental techniques

A 1 to 6% standard solution of amylase, in steps of 1% was prepared initially. All the solutions are left for 2 hours and complete solubility is found[15].

The ultrasonic velocity in the liquid mixtures have been measured using an Ultrasonic interferometer (Mittal type) 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 ± 0.1kgm^{-3} and ± 0.001$mNsm^{-2}$ respectively.

Using the measured data, the acoustical parameters such as adiabatic compressibility (β), free length (L_f), free volume (V_f) and internal pressure (π_i) , acoustical impedance (Z), relative association (R_A), Rao's constant (R) and Wada's constant have (W) been calculated using the following expressions.

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

$L_f = k_T (\beta)^{1/2}$ (2)
$V_f = (M_{eff} U/\eta k)^{3/2}$ (3)

$\pi_i = bRT (k\eta /U)^{1/2} /(\rho^{2/3}/M^{7/6})$ (4)
$Z = U\rho$ (5)
$R_A = \rho/\rho_o(U_o/U)^{1/3}$ (6)
$R = U^{1/3}V$ (7)
and
$W = \beta^{1/7}V$ (8)

The α-amylase, supplied by S.D. 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 amylase. As amylase 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 in Nithiyanantham et al[16] in some aqueous carbohydrates system.

To explore the nature and type of existing interactions some thermoacoustical parameters have been determine and their extremities and trends are analysed in the light of exising structural variations. The calculated values of chosen thermoacoustical parameters are presented in the same Table1. Referring that table, it is observed that the trend shown by adiabatic compressibility (β) is in general decrease with increase with amylase. 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 gradual decreases in adiabatic compressibility with amylase 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. Analysing 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 (πi). From the Table 1, (V_f) is in decreasing trend with increasing the concentration of amylase. 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 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 amylase 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 in Nithiyanantham et al[17].

CONCLUSIONS

1. Presence of molecular interactions are confirmed.
2. Solute-solute interactions are more favoured.
3. Number concentration of molecules available in the system over rules the strength of interaction.

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Table-1: Measured values of Ultrasonic velocity (U), density (ρ) and viscosity (η) and calculated values adiabaticcompressibility (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 amylase in water at 298

%	U ms^{-1}	ρ Kgm^{-3}	η X10^3 Nsm^{-2}	β X 10^{10} $N^{-1}m^2$	L_f X 10^{11} m	V_f X 10^8 m^3mol^{-1}	π_i X 10^{-9} Nm^{-2}	Z X 10^{-6} kgm^{-2} s^{-1}	R_A	R X10^1 $m^{10/3}$ $s^{-1/3}mol^{-1}$	W X 10^1 m^3 mol^{-1} $(N/m^2)^{1/7}$
1	1516.8	1009.8	0.918	4.304	4.140	1.532	2.068	1.861	3.9206	2.7314	1.0084
2	1520.2	1011.4	0.941	4.278	4.127	1.538	2.087	1.824	3.9569	2.7358	1.0091
3	1523.2	1012.9	0.964	4.255	4.116	1.543	2.106	1.790	3.9924	2.7391	1.0101
4	1525.8	1014.2	0.994	4.235	4.106	1.547	2.125	1.739	4.0290	2.7513	1.0107
5	1528.5	1019.2	1.013	4.199	4.089	1.558	2.136	1.720	4.0525	2.7574	1.0151
6	1531.0	1022.7	1.036	4.172	4.075	1.566	2.150	1.691	4.0812	2.7654	1.0180

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