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Study of Acoustical and Thermodynamic Properties of Aqueous Solution of NaI at Different Temperatures

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Abstract: ***Sodium salt is important to human as well as plant. Sodium maintains the normal distribution of water and the osmotic pressure in the various fluid components. The ultrasonic velocity, density and viscosity have been measured for aqueous solutions of NaI at different temperatures and concentrations. From these values, the parameters like adiabatic compressibility, acoustic impedance, isothermal compressibility and surface tension were calculated. The experimental results were correlations with intermolecular interactions between solvent and solute.***

Keyword: Ultrasonic velocity, adiabatic compressibility, acoustic impedance, isothermal compressibility

1. Introduction

Ultrasonic is versatile and non destructive techniques and provides an extensive application in characterizing thermodynamic and physiochemical behavior of liquid mixtures [1–3]. Sodium, potassium level in human blood is of considerable importance for several reasons. Sodium maintains the normal distribution of water and osmotic pressure in the various fluid components. In recent years ultrasonic technique has become a powerful tool in providing information regarding the molecular behavior of liquids and solids owing to its ability of characterizing physiochemical behavior of the binary and ternary mixtures [2–5]. The nature and extent of the patterns of molecular association and dissociation that exist in solutions have been investigated by ultrasonic techniques. The dependence of acoustical parameters on composition and temperature resulting from molecular interaction between components of liquid mixture were of considerable importance [6–8].

Therefore, the present work mainly deals with velocity studies pertaining to aqueous solutions of sodium iodide. Many physiological processes depend upon concentration of electrolyte [9]. This salt is of significant importance in physiological processes of life. Hence, this electrolyte is chosen for the present investigation.

2. Materials and Method

All the chemicals used in this present work are analytical reagent (AR) grades; doubly distilled water has been used for preparing the solution of 0.125M to 2M aqueous electrolytic solutions. Higher concentration solutions prepared by weight and remaining solutions were prepared by dilution method. Densities were determined using specific gravity bottle by relative measurement method with accuracy of ±0.1 $kg.m^{-3.}$ An Ostwald's viscometer was used for viscosity measurement. An ultrasonic interferometer having the frequency 2MHz (VI Microsystems Pvt Ltd, Perungudi, Chennai) with an accuracy of ±0.1% was used for velocity measurement. Constant digital temperature water bath was used to maintain the constant temperature with an accuracy of ±0.1K. Viscosity of solution are measured using an Ostwald viscometer

3. Results and Discussions:

The parameters are calculated on the basis of theory as given below:

Adiabatic compressibility can be calculated from speed of sound (U) and density (ρ) of the measurement.

$$\beta = 1/U^2\rho$$

The acoustic impedance is the product of the velocity of ultrasound in a medium and its density can be calculated[10].

$$Z = U\rho$$

Surface tension $\sigma = (6.3 * 10^{-4})\ \rho\ C^{3/2}$

Many researchers have determined the isothermal compressibility values of aqueous solutions of amino acids and have made an attempt by making the use of an ultrasonic technique to explore the behavior of some amino acids.[11-12]

Isothermal Compressibility: $k_{T2} = 17.1 * 10^{-4}/(T^{4/9} C^2\ \rho^{1/3})$

The ultrasonic studies of liquid mixture are important to investigate the molecular interaction in the solution. The values of ultrasonic velocity, compressibility, and acoustic impedance may be affected by factors like specific forces, intermolecular forces and structural characteristics.

In our present system, water molecules are used as solvent having hydrogen bonding which get affected due to the addition of electrolytes. All types of molecular interactions present in this system.

The values of ultrasonic velocity, density and viscosity of 0 to 2M concentrations of NaI at 298.15K and 303.15K temperatures are presented in Tables 1 to 2. The acoustic parameters such as adiabatic compressibility, acoustic impedance, isothermal compressibility and surface tension are presented in Tables-3 to 6

Table 1: Molarity, ultrasonic velocity, density and viscosity for NaI at 303.15K and at 298.15K

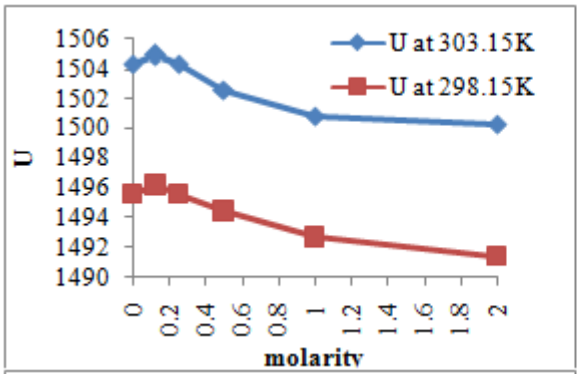
	Temperature					
	303.15K			298.15K		
m	U(m/s)	ρ(Kg/m^3)	η (Nm^{-2}s)	U(m/s)	ρ(Kg/m^3)	η (Nm^{-2}s)
0.0	1504.35	995.54	797.5	1495.59	994.24	890.4
0.125	1504.93	1002.35	808.95	1496.18	1005.64	887.74
0.25	1504.35	1013.35	811.77	1495.59	1011.71	880.16
0.5	1502.59	1033.51	821.74	1494.44	1033.5	892.5
1.0	1500.85	1128.89	857.08	1492.71	1115.12	955.86
2.0	1500.26	1167.01	872.07	1491.42	1164.75	983.5

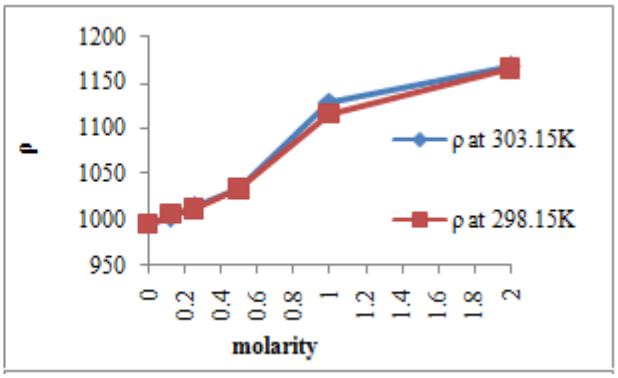
Table 2: Molarity, Adiabatic compressibility, , acoustic impedance, isothermal compressibility and surface tension for NaI at 303.15K.

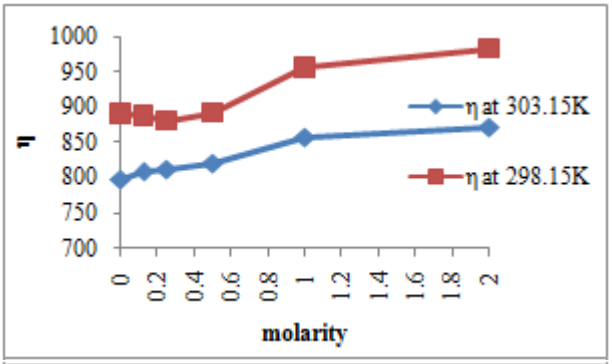
M	βx10^{-10} (m^{2}N^{-1})	Zx10^6 (Kgs^{-1}m^{-2})	k_T*10^{-12} (m^{2}N^{-1})	σ (kg/m^{2}sec)
0	4.4386	1.497	59.70	36595.07
0.125	4.405	1.508	59.52	36866.71
0.25	4.36	1.524	59.35	37249.75
0.5	4.285	1.553	59.09	37924.16
1.0	3.933	1.694	57.52	41352.15
2.0	3.807	1.751	56.93	42733.31

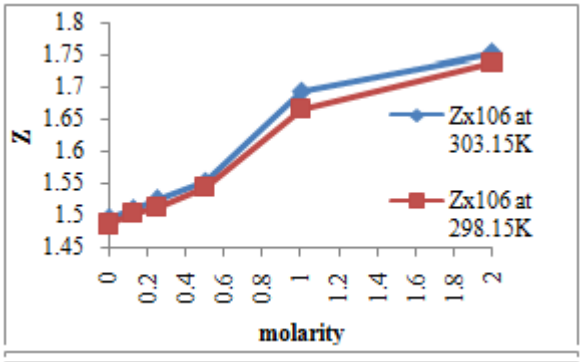
Table 3: Molarity, Adiabatic compressibility, acoustic impedance, isothermal compressibility and surface tension for NaI at 298.15K.

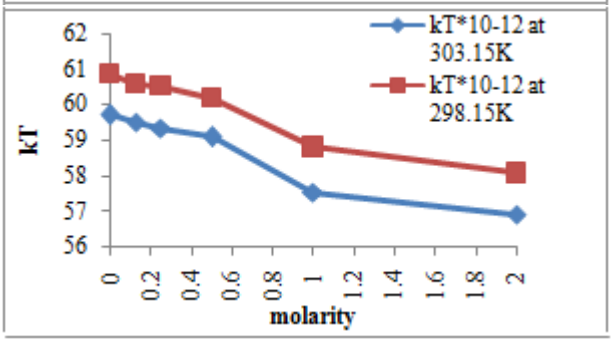
M	βx10^{-10} (m^{2}N^{-1})	Zx10^6 (Kgs^{-1}m^{-2})	k_T*10^{-12} (m^{2}N^{-1})	σ (kg/m^{2}sec)
0	4.496	1.4869	60.87	36228.52
0.125	4.442	1.5046	60.59	36665.60
0.25	4.418	1.5131	60.52	36865.10
0.5	4.332	1.5445	60.18	37615.66
1.0	4.024	1.6645	58.81	40515.88
2.0	3.859	1.7371	58.07	42264.25

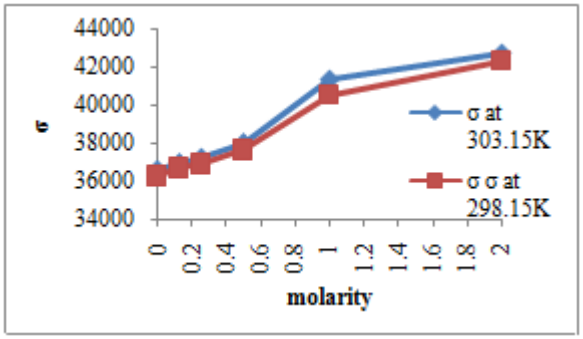












From the above Tables -1, it is observed that ultrasonic velocity, density and viscosity decreased as concentration increased in case of NaI. With respect to temperature, ultrasonic velocity is greater at high temperature and vice versa in both cases. Viscosity is lower at high temperature and vice versa.

On the basis of above graphs and data of table 2 and table 3, it is found that adiabatic compressibility goes on decreasing as concentration increase and this indicates that strong solute-solvent interaction operating which is nothing but an ion-dipole interactions. It is observed that the isothermal compressibility is showing decreasing trend with increase in molarities. Also as the molarities of the solute increases there is found increase in surface tension. The increase variation of surface tension with concentration of solute also indicates the significant associative interaction in the solution.

4. Conclusions

It is general observed that ultrasonic velocity increased, as concentration increased. But in case of NaI the situation is reversed, it may be due to I^- ions. Iodide ion having greater size than chloride hence iodide ions break the structure of aqueous medium and affect stiffness of medium. Medium stiffness decides the velocity of medium.

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