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MOLECULAR INTERACTION IN IONIC LIQUIDS AT DIFFERENT TEMPERATURES

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Abstract - *The electrical conductivity (σ), ultrasonic velocity (U) and density (ρ) have been measured for the aqueous potassium chloride solutions at different temperatures and at frequency 4 MHz for different concentration of KCl. The experimental data's have been used to study of the molecular interaction in the aqueous solutions by calculating parameters such as adiabatic compressibility, free length and acoustic impedance. Variation of the above parameters for the various solutions at different temperature is indicative of the nature of interaction between them.*

Key Words: **Ultrasonic velocity, free length, acoustic impedance.**

1. INTRODUCTION

Ultrasonic method finds extensive application in investigating various physicochemical parameters involving molecular interactions in liquid solutions. Now a day, ultrasonic studies are extensively used for characterizing the thermodynamic properties of liquid solutions [1-8]. This method plays an important role in understanding the nature of molecular interactions. This technique has also been used in biomedical engineering, agriculture and medicine. Ultrasonic pulses can speed up certain chemical reactions and act as a catalytic agent in wheat germination. Velocity of sound waves in a medium is fundamentally related to the binding forces between the molecules.

Human body needs many minerals known as essential minerals. These are divided in two groups, major minerals (like Na, K ...) and micro minerals (like Fe, Si,...). The latter is required in small amounts than the former. Potassium is a very significant body mineral, important to both cellular and electrical function. It is one of the main blood minerals called "electrolytes" (the others are sodium and chloride). This means it carries a tiny electrical charge (potential). Potassium is the primary positive ion found within the cells, where 98 percent of the 120 grams of potassium contained in the body is found. The blood serum contains about 4-5 mg. (per 100 ml.) of the total potassium; the red blood cells contain 420 mg. This is why a red-blood-cell level is a better indication of an individual's potassium status than the commonly used serum level.

Conductivity is the ability of an aqueous solution to carry an electrical current. Conductivity measurement is an extremely widespread and useful method for quality control purposes. Surveillance of feed water purity, control of drinking water quality, estimation of total number of ions in a solution can all be performed using conductivity measurements. The measurement of conductivity is a rapid and inexpensive way of determining the ionic strength of a solution.

The present paper deals the study of interaction between molecules of KCl and water at different temperatures for various concentrations of KCl

2. MATERIALS AND METHODS

The chemicals used in the present work were analytical reagent (AR). Water used was prepared by distilling ordinary water thrice over alkaline KMnO4 in all glass apparatus. Conductivity measurements are carried out using Conductivity meter. Before and after measurements, the instrument was calibrated with NaCl solution. Each measurement was repeated three times and the average values were calculated. Ultrasonic velocity at different temperatures were measured by using an ultrasonic interferometer (Model M-84) with the accuracy of ±0.1ms^{-1}. The densities of the mixtures were measured using a 10ml specific gravity bottle by relative measurement method with an accuracy of ±0.01 kgm^{-3}. An Oswald viscometer (10 ml) was used for the viscosity measurement with an accuracy of ±0.001 Nsm^{-2}. Standard equations are used for calculation of density and viscosity. The electrical conductivity, density, viscosity, and ultrasonic velocity were measured as a function of concentration of KCl at 288K, 298K and 308K.

3. THEORY

Using the experimental values, the following thermodynamic parameters were calculated.

i. Adiabatic compressibility: $\beta = \frac{1}{U^2.\rho}$ ………… (1)

ii. Intermolecular free length: $L_f = K_T.\beta^{1/2}$ ………. (2)

Where, K_T =(93.875 + 0.375.T) x 10-8 is Jacobson's temperature dependent constant .

iii. Acoustic impedance: $Z = \rho.U$ ……….. (3)

4. RESULT AND DISCUSSION

The experimental data of electrical conductivity, ultrasonic velocity and density of aqueous solution of potassium chloride at different temperatures are shown in tables 1 and 2. The calculated values of adiabatic compressibility, free length, and acoustic impedance are presented in tables 2 and 3.

Table -1: Measured Values of ultrasonic velocity and Density

Conc. of KCl	**U / m.s^{-1}**			**ρ / Kg.m-3**		
	288 K	298 K	308 K	288 K	298 K	308 K
5 %	1501.2	1506.2	1510.4	1007.2	1004.2	1000.2
10 %	1513.3	1518.2	1523.2	1010.3	1007.1	1003.5
15 %	1516.4	1521.3	1527.4	1014.2	1011.3	1007.4
20 %	1521.7	1527.1	1532.1	1018.1	1015.4	1011.3
25 %	1525.3	1530.2	1535.2	1022.2	1019.1	1014.3

Velocity increases, when concentration of KCl increases at a particular temperature and also increases when temperature increases at a particular concentration. The increase in the ultrasonic velocity usually indicates a greater association of the component molecules. The greater association is due to ionic hydration of the solute. KCl is strong electrolytes which dissolve in water to form K+, Cl- ions respectively.

Table-2: Measured Values of electrical conductivity and calculated values of adiabatic compressibility.

Conc. of KCl	**σ / mS.cm^{-1}**			**β x 10^{-10} / N^{-1}m^2**		
	288 K	298 K	308 K	288 K	298 K	308 K
5 %	57.6	64.4	71.7	4.404	4.389	4.383
10 %	109.1	116.3	123.4	4.322	4.307	4.292
15 %	149.2	156.4	163.5	4.285	4.264	4.254
20 %	183.1	190.2	198.1	4.238	4.223	4.214
25 %	213.4	220.3	227.4	4.204	4.189	4.183

Table-3: Calculated values of free length and acoustic impedance

Conc. of KCl	**L_f x 10^{-10} / m**			**Z x 10^6 / Kg.m^{-2}sec^{-1}**		
	288 K	298 K	308 K	288 K	298 K	308 K
5 %	0.4114	0.4149	0.4232	1.5126	1.5125	1.5109
10 %	0.4075	0.4110	0.4187	1.5290	1.5292	1.5294
15 %	0.4054	0.4090	0.4167	1.5395	1.5397	1.5400

20 %	0.4036	0.4069	0.4149	1.5504	1.5505	1.5490
25 %	0.4019	0.4053	0.4134	1.5596	1.5598	1.5570

A greater cohesion in the solution is introduced as water molecules are attached to the ions strongly by electrostatic forces of interaction [9]. Variation of ultrasonic velocity with concentration of KCl is presented in figure 1.

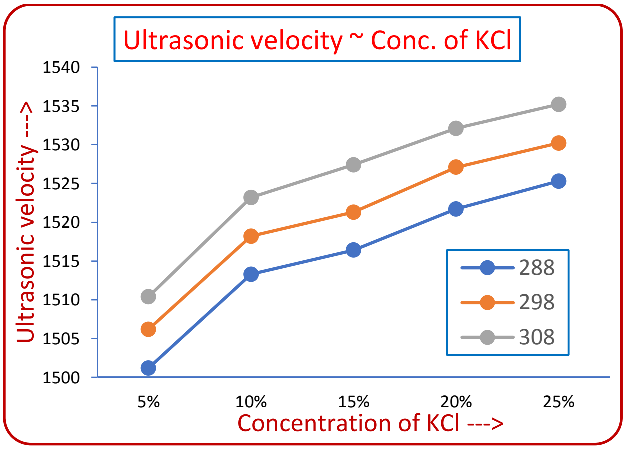

Fig.-1: Variation of ultrasonic velocity with conc. of KCl

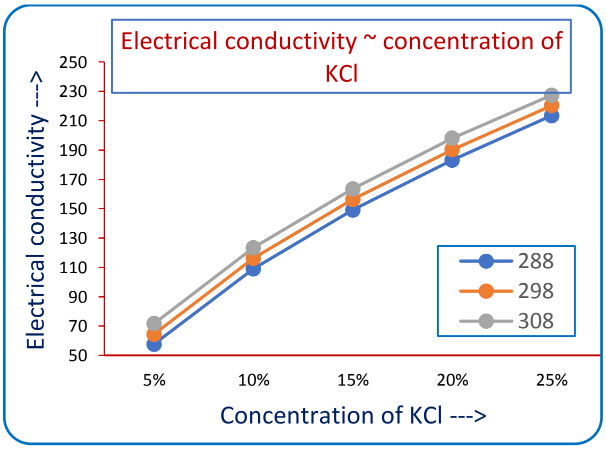

Fig.-2: Variation of Electrical cond. with conc. Of KCl

As presented in table 1, the increase of density with increase in concentration of KCl, suggests a strong electrolytic interaction between solute and solvent molecules. With increase in temperature, there is a decrease in intermolecular force due to increase in thermal energy of the system which results in decrease in density. The value of adiabatic compressibility (β) decreases with increase in concentration of KCl and also with increase in temperature due to structural changes of molecules in the mixture. This also confirms the increase in intermolecular forces.

The free length decrease with increasing solute concentration indicates a significant interaction between solute and solvent molecules and hence a structure promoting behavior on the addition of solute.

Acoustical impedance (Z) increases with increase in concentration of KCl. This behavior becomes accountable for the transmission of ultrasonic waves.

The conductivity may provide information regarding the nature and strength of forces existing between the ions. Variation of conductivity with concentration of KCl at different temperatures is shown in figure 2. The conductivity increases with increase in concentration of KCl. The increase in conductivity depends on the solvent added and the extent to which the ions are dissociated. Electrical conductivity also increases as temperature increases for a particular concentration of KCl. Conductivity of ionic liquids increases due to the presence of water-rich regions. With increase in temperature, water evaporates and thus the conductivity increases.

5. CONCLUSION

The trends in the variation of parameters derived from ultrasonic velocity and density at temperatures 288K, 298K, 308K and 318K over the entire composition range suggests existence of molecular interaction in the chosen ternary mixture.

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REFERENCES

[1] A. Ali, S. Hyder, A. K. Nain, 2000. Indian J Phys., 74(B), 63.

[2] M. K. Praharaj, A. Satapathy, P. Mishra, S. Mishra, 2013, J of Chem.& Phar. Res., 5, 49-56.

[3] A. Ali, A. K. Nain, 1996. Acoust. Lett., 19, 181.

[4] A. K. Dash, R. Paikaray, 2014. Int. J. of Chem. &Phy Sc., 3, 69-79.

[5] V. Gupta, A. K. Sharma, M. Sharma, 2014. Chemical Science Transactions, 3(2), 736-744.

[6] L. E. Kinsler, A. R. Rray, 2000. Fundamentals of Acoustics, Wiley Eastern, New Delhi,1989.

[7] M. K. Praharaj, A. Satapathy, P. Mishra, S. Mishra, 2012. Journal of Theoretical and Applied Physics (Springer open Journal), 7(23), 1-6.

[8] M. K. Praharaj, S. Mishra, 2018, Journal of Thermal Analysis and Calorimetry, 132(2), 1089-1094.

[9] V. Gupta, A. K. Sharma, M. Sharma, 2014. Comparative Ultrasonic and Conductometric Studies of Aqueous Sodium Chloride and Potassium Chloride Solutions, Chemical Science Transactions, 3(2), 736-744.

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Dr. Manoj Kumar Praharaj, presently working as Assistant Professor in Department of Physics at Ajay Binay Institute of Technology, Cuttack, Odisha, with 20 years of teaching and ten years of research experiences. He was published about 30 research papers in Journals of National and International repute and presented 15 papers in National and International conference.