REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1S (2024)
http://www.veterinaria.org
Received: 20/04/2024 Revised: 28/04/2024 Accepted: 14/05/2024

Molecular Interaction Of Potassium Salts In Aqueous And Alcoholic Solution At 298K

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Abstract
The Ultrasonic velocity measurement technique created a great impact on measuring thermodynamic parameters of materials and evaluating the molecular interactions taken place between dissolved substances and solvent molecules. More often, by employing the ultrasound waves and determining the velocity through the solutions, values of internal energy, enthalpy, free energy, and entropy of those solutions can be estimated. In addition, the variation in the ultrasonic velocity can predict the solute-solvent interactions at the molecular level as well as the extent of the same. This makes the possibility to draw some conclusions about the structures and behaviors of dissolved species in the given solvent conditions. The density, velocity, and viscosity of potassium salt KCl in water and ethanol as solvent are measured in the present investigation at 298 K of different concentrations. Experimental data are used to calculate different acoustic parameters to investigate the molecular relationship of potassium in aqueous and alcoholic solutions.

Key Words: Potassium aqueous solution, Potassium alcoholic solution Ultrasonic, acoustic parameter Molecular interaction.

Introduction
Supramolecular chemistry is a section of molecular science in which the following of the interactions between molecules is crucial. In the recent past, ultrasonic techniques have been employed effectively, as a training tool in understanding the molecular behavior of substances such as liquids and solids, since such techniques are capable of describing the physicochemical characteristics of a given substance. The techniques of ultrasonics have been applied widely to investigate molecular processes occurring in liquid-phase systems. The current investigation focuses on using ultrasonics to examine the intermolecular interactions in two binary liquid mixtures: The systems under study were an aqueous potassium chloride (KCl) solution and a potassium chloride-ethanoic acid solution. These arrangements are viewed at room temperature (298 K) to investigate the extent of interaction of KCl with molecules of the two solvents. In general, this is a work involving the use of ultrasonic techniques to investigate the intermolecular forces in KCl – water and KCl – ethanol at normal temperatures.

The researchers have investigated the variations in ultrasonic velocity along with other related parameters of liquid mixtures concerning the concentration of the component liquids. That is, they relate these changes to other structural transformations that may be taking place within the liquids.

The researchers adopted quantitative techniques to explain the quantitative behavior of adiabatic compressibility which is a property of solutions dependent actual concentration of dissolved solute particles in the solution. These phenomena give information about solute-solvent hydrogen bonding. Types of attractions comprising intermolecular forces include forces of attraction that operate at a distance, hydrogen bonding, and van der Waals whilst the types of repulsions involving electron clouds carry limited distances. The electrostatic induction and dispersion forces are the long-range forces and they are caused by the overlap of electro clouds of the molecules when they get close enough to each other and are often highly directional. There are two categories of intermolecular forces, long and short-range.

We have evaluated in this report the acoustic parameters: The thermodynamic properties reachable at 298K to water include adiabatic compressibility directly proportional to intermolecular interaction of the molecules of water, the free length of water, and the acoustic impedance.

Experimental techniques
1 Adiabatic compressibility (β)
The equation of Newton Laplace gives us the acceleration of slow as a function of the speed of sound (U), its density (ρ) is noted as

$$\beta = (U^2\rho)^{-1}$$

2 Free Length between Molecules
The distance between the nearer surfaces of neighbor molecules in a liquid and the intermolecular free length can be obtained from the adiabatic compressibility of the liquid. It is not the transfer of heat but the amount of volume that changes when pressure is applied. It is noteworthy that these two liquid attributes are tied by a certain mathematical formula.

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$Lf = KT \beta a^{1/2}$

3 Relaxation Duration (τ)

One of the parameters is the relaxation time describing how long it is taking to transfer the energy of excited particles. This time varies with temperature and means of purification of the material. The relation allows us to calculate the relaxation time (τ).

$\tau = 4/3 \beta\eta$

4 Impedance of Acoustics (Z)

The impedance of Acoustics is defined as the resulting velocity of liquid U joining hand with the density of liquid ρ. This quantity defines the capacity for the transfer of sound waves from one fluid medium to another or a fluid medium to a solid medium.

5 Relative association (Ra)

$$RA = \frac{ds}{Do} \cdot \left(\frac{v_0}{v_s} \right)^{1/3}$$

Experimental

Density Measurement

A 25-milliliter specific gravity bottle which is placed in a water bath maintained at a known temperature containing experimental liquid is used to determine the density of pure liquids and mixtures.

$\rho_2 = (W_2 / W_1)\ \rho_1$

W_1 is the weight of the distilled water.
W_2 is the weight of the solution.
ρ_1 is the density of distilled water.
ρ_2 is the density of the solution.

Viscosity Measurement

A calibrated Ostwald Viscometer with doubly distilled water is utilized for measuring the viscosity of pure liquids as well as liquid mixtures. During the experiment, Brigg's burette is covered with a water bath to keep it at a constant temperature. The Ostwald Viscometer is then immersed in the experimental liquid some doubly distilled water is also taken as a reference. The whole apparatus including the arm of Ostwald Viscometer filled with the experimental liquid as well as the doubly distilled water is placed in the constant temperature water bath. This makes it possible to complete the viscosity measurement at the required and thus constant temperature. It can be measured by timed flow through the capillary tube of a calibrated Ostwald Viscometer to which the proper relation must then be applied to obtain the viscosity. The objective here is to measure and estimate the real viscosities of both neat fluids and mixtures of these neat fluids.

$\eta 2 = (\rho 2\ t2 / \rho 1\ t1)\ \eta 1$

Where,
η2 = solution viscosity
η1 = water coefficient viscosity
ρ2 = solution densities
ρ1 = water density

Velocity Measurement

An interferometer purchased from Mittal Enterprises was employed to determine the magnitude of the velocity of the ultrasonic wave in a particular liquid mixture. The interferometer operates at a carrier frequency of 2 megahertz nominally, although this can vary from plus or minus 0.005 percent. Normally to make the measurements, a double-walled vessel of special design was utilized as the measurement cell. This vessel enabled the tests to be conducted at a specific temperature for the liquid being tested. From the interferometer, ultrasonic wave velocity passing through a mixture of liquid is determined to be [velocity measurement].
$U=\lambda f$
f is the frequency and $\lambda = 2d/n$ (wavelength of the ultrasonic waves).

Results and discussion

The data on solutions of KCl in water and 20% ethanol are given in Tables I and II respectively. The values of the speed of sound waves, mass density, and viscosity determined from the experiment of KCl in water solutions for different

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concentrations of 0.01 mf to 0.09 mf are presented in Table I. Based on these measured values, some other acoustic parameters are determined. The same experimentally obtained and calculated solution properties are presented in Table II but for the KCl dissolved in 20% ethanol aqueous solution instead of distilled water. All kinetic measurements were done at 298 K and different molar concentrations of KCl.

The data in Figure 1 verifies that an increase of potassium chloride (KCl) concentration in both water and alcohol solutions leads to the higher velocities of the ultrasound waves at 298 K constant temperature level. At higher solute concentrations excess intermolecular interactions exist between solute and solvent molecules. But sound velocity is proved to be higher in the aqueous solution than in the alcoholic solution. In essence, what this means is the dense packing of the aqueous solution allows for more interaction of the solute, in this case, the KCl, and the solvent, water.

With the increase in the concentration of the KCl in both water as well as in the alcohol the results on the aqueous solution decreased gradually. In this, it is further shown that there is a more considerable amount of hydrogen bonding than in the other cases, and therefore potassium ions are closer to the water. Nevertheless, the study shows that the impedance is higher in the aqueous solutions than in the alcoholic solutions at all concentrations. This once more suggests that water had a stronger interaction with the KCl solute than with alcohol, and that water aids more effectively in dissolving the salt. In conclusion, the finding reveals that KCl has higher solubility and better molecular interaction with water than alcohol.

Table I: “Ultrasonic velocity (U), Density(ρ), Adiabatic compressibility(β), Acoustic Impendence(z), Relative Association RA, Intermolecular Free length (Lf) Viscosity(η) and Relaxation time τ in aqueous solution KCl at 298 K.”

Mole fraction	ultrasonic velocity U (m/s)	Densityρ (Kg/m^3)	Viscosity η	Adiabatic compressibility B*10^{-10}	Acoustic Impendence z	Free length Lf A^o	Relaxation time τ *10^{-10}	Relative Association Ra
0.01	1452.36	1017.54	0.9986	4.66	1477834	0.013534	6.2	1.030953
0.02	1455.32	1019.00	1.0123	4.63	1482971	0.013497	6.25	1.031732
0.03	1458.63	1020.78	1.0356	4.6	1488940	0.013454	6.36	1.032752
0.04	1463.54	1022.36	1.0432	4.57	1496265	0.013399	6.35	1.033192
0.05	1468.75	1025.65	1.0601	4.52	1506423	0.01333	6.39	1.03529
0.06	1473.61	1026.41	1.0698	4.49	1512528	0.013281	6.4	1.034917
0.07	1477.21	1028.96	1.0745	4.45	1519990	0.013232	6.38	1.036645
0.08	1481.62	1029.31	1.0856	4.43	1525046	0.01319	6.41	1.035967
0.09	1486.16	1030.69	1.0101	4.39	1531770	0.013141	5.92	1.036299

Table II: “Ultrasonic velocity (U), Density(ρ), Viscosity(η), Adiabatic compressibility(β), Acoustic Impendence(z), Mean Free length (Lf), Relaxation time (τ) and Relative Association (R_A) in alcoholic solution KCl at 298 K.”

Mole fraction	ultrasonic velocity U (m/s)	Densityρ (Kg/m^3)	Viscosity η	Adiabatic compressibility B*10^{-10}	Acoustic Impendence z	Free length Lf A^o	Relaxation time τ *10^{-10}	Relative Association Ra
0.01	1210.52	910.23	0.9026	7.50	1101852	0.017168	9.02	1.130137
0.02	1215.62	911.45	0.9082	7.42	1107977	0.017168	8.99	1.130066
0.03	1218.63	913.54	0.9165	7.37	1113267	0.017085	9.01	1.131724
0.04	1222.64	915.02	0.9189	7.31	1118740	0.017023	8.96	1.132317
0.05	1226.37	916.23	0.9236	7.26	1123637	0.016953	8.94	1.132664
0.06	1230.53	918.04	0.9364	7.19	1129676	0.016891	8.98	1.133621
0.07	1235.63	919.65	0.9376	7.12	1136347	0.016817	8.9	1.134045
0.08	1238.63	920.13	0.9402	7.08	1139701	0.016733	8.88	1.13372
0.09	1240.61	921.18	0.9489	7.04	1142605	0.016625	8.86	1.13562

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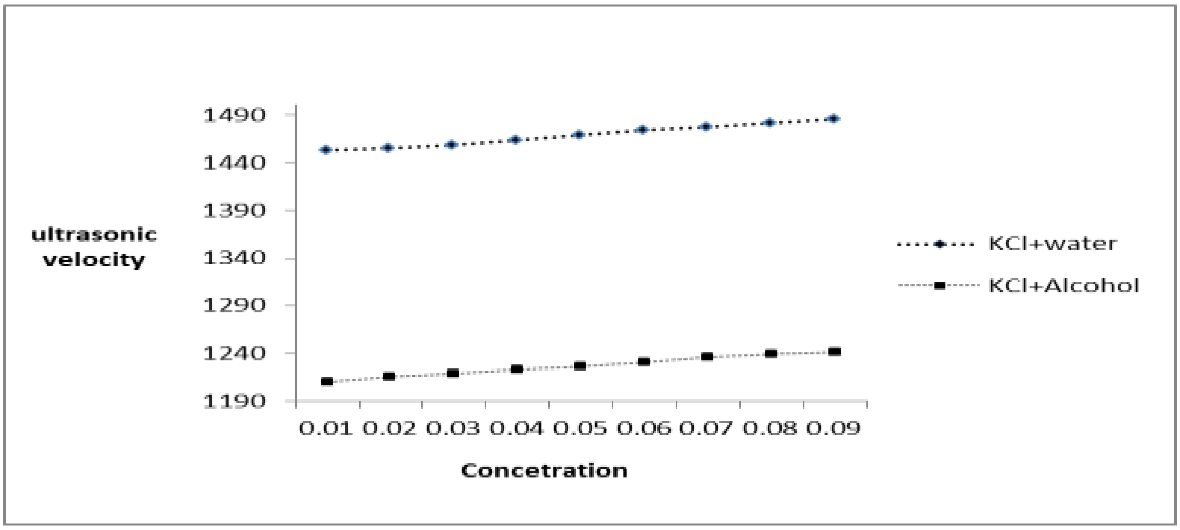

Fig.1: Ultrasonic velocity of KCl in water and Alcohol at 298K

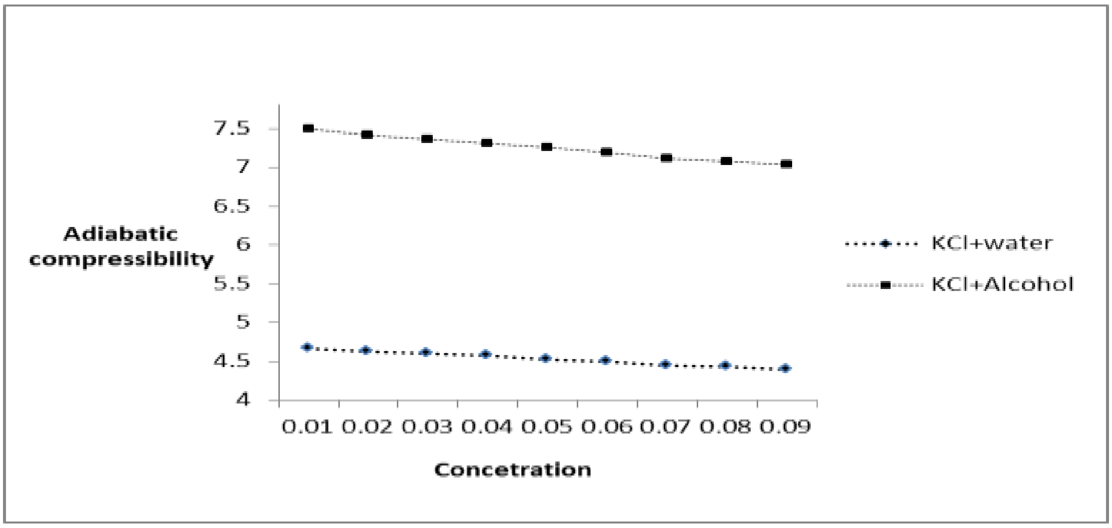

Fig. 2: Various solvents KCl adiabatic compressibility at 298K

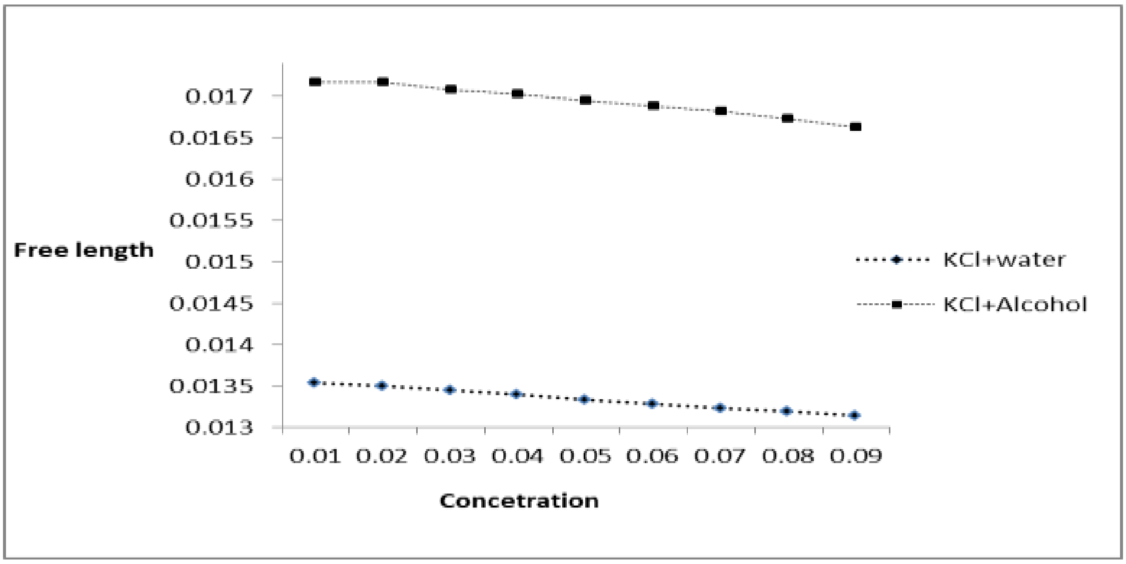

Fig 3: The Length of Free KCl in Water and Alcohol

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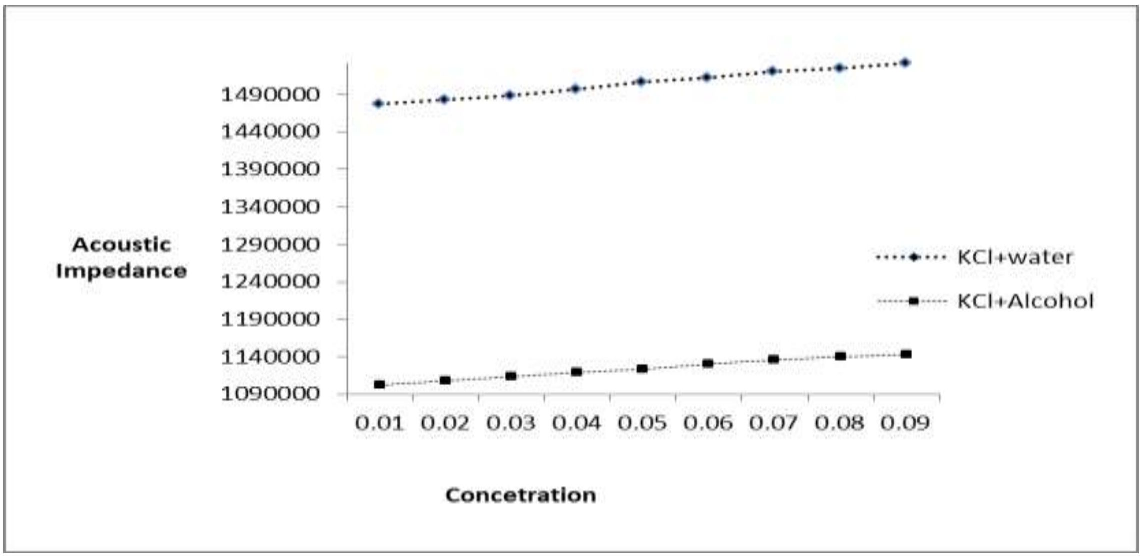

Fig.4: Specific acoustic impedance of KCl in aqueous and alcohol solvents

Conclusion

In this inquiry, several acoustic parameters are evaluated using the velocity, density, and viscosity of KCl in water and alcohol at 298K, including acoustic impendence, adiabatic compressibility, intermolecular free length, relaxation time, and relative association. From this, it is concluded that the values of velocity, viscosity, z, RA, τ are increased gradually with the concentration increase in aqueous and alcoholic KCl solution at the same temperature 298K. More to that, with an increase in the relative proportion of the solute in the solution, solute-solvent encounters increase as well. At the same time, the solvent acoustic parameters beta and Lf, which characterize the solvent structure and density, significantly decrease. Third, this reduction suggests enhancement of interactions between solvent molecules and solute in the solution. From tables I and II and figures of all the acoustic parameters it is concluded that the values of the parameters of U, $R_{A,}$ η, z, and τ of KCl in water are higher than KCl in 20% ethanol at the same temperature 298K. While the values of acoustic parameters β and L_f are lower for KCl in water than KCL in alcohol. This study concludes that KCl solute interacts strongly with water as a solvent as compared to alcohol.

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