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# ULTRASONIC STUDIES ON INTERIONIC INTERACTIONS OF POTASSIUM CHLORIDE IN AQUEOUS POTASSIUM SULPHATE SOLUTION AT 308.15K

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**Abstract**

*The present study was carried out in order to explore the possible molecular interionic interactions of potassium chloride in aqueous potassium sulphate solution at 308.15K. Experimental values of density (ρ) and ultrasonic velocities (U) were carried out on the liquid ternary mixtures of water + potassium sulphate + potassium chloride. The binary solvent mixture of water + potassium sulphate was prepared under molarity (M) basis. Potassium chloride was added under different molarities with these binary solvent mixtures. The related and relevant parameters correlated to our present study such as adiabatic compressibility, change and relative change in adiabatic compressibility, acoustic impedance (Z), relative association (R.A.) were determined. The present investigation has exploited the possible molecular associations such as ion-ion, ion- solvent, solute-solvent, solute-solute etc., which are identified and eventually discussed about the behavior of solute (potassiumchloride) in the solvent mixture.*

*Key words: adiabatic compressibility, potassium sulphate, acoustic impedance, relative association, solute-solvent.*

## 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[1-5]. 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. In engineering it is used to study the structure of materials. 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 further 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.

The present paper deals the study of interaction between molecules of KCl, $K_2SO_4$ and water at different molarities for various concentrations of KCl.

### Theory and Calculations

Using the measured data, some acoustical parameters such as adiabatic compressibility (β), change (Δβ) and relative change in adiabatic compressibility (Δβ/βo), acoustic impedance (Z), were studied and evaluated by using the standard equations:

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

Change in adiabatic compressibility $(\Delta\beta) = (\beta - \beta_o)$ (2)

Relative change in adiabatic compressibility = $(\Delta\beta/\beta_o)$ (3)

Acoustic impedance $(Z) = U\rho$ (4)

Relative association (R.A) = $\frac{\rho}{\rho_0}\left(\frac{U}{U_0}\right)^{1/3}$ (5)

## Result and Disscussion

The experimental values of density (ρ), and ultrasonic wave velocity (U) for different molarities (M) of the potassium chloride in aqueous potassium sulphate solution at 308.15K are tabulated in Table 1. The values of adiabatic compressibility (β), change in adiabatic compressibility (Δβ) are listed in Table 2. The values relative change in adiabatic compressibility (Δβ/β0) and acoustic impedance (Z) are listed in Table 3. Similarly, the values of relative association (R.A) are tabulated in Table 4.

Figs 1 and 2 shows the variations of density, and ultrasonic wave velocity with molarity (M) of potassium chloride. The variation of adiabatic compressibility (β), change in adiabatic compressibility (Δβ), relative change in adiabatic compressibility (Δβ/β0), relative association (R.A) with Molarity (M) of the same are depicted between 4 – 6 and 7.

In the pottasium chloride liquid system studied, (from Tables 1) one can observe the elevation of density values with increase in molar concentration of pottasium chloride (solutes) as well as of aqueous potassium sulphate content (solvent). The other measured parameter ultrasonic wave velocity (U) which is also found (from Tables 1) to be elevated with increase in same molar concentration of solutes (pottasium chlorides) as well solvent (aqueous potassium sulphate). The elevated behaviour of ultrasonic wave velocity in these solutions may be attributed to the cohesion brought about by the ionic hydration, which may due to the overall increase of cohesion brought about by solute-solute and solute-solvent interaction in the solution.

**Table – 1 Values of Density (ρ) and Ultrasonic Velocity (U) of Potassium Sulfate in aqueousPotassium Chloride Mixture at 308.15K temperature**

| Molarity M/(mol.dm$^{-3}$) | Density ρ/(kg/m$^3$) | | | Ultrasonic Velocity U/(m/s) | | |
|---|---|---|---|---|---|---|
| | SYSTEM :I WATER + $K_2SO_4$ + KCL | | | | | |
| | **0.0 M** | **0.2 M** | **0.4 M** | **0.0 M** | **0.2 M** | **0.4 M** |
| 0.0 | 995.64 | 1080.15 | 1110.41 | 1583.34 | 1590.57 | 1594.03 |
| 0.05 | 1072.31 | 1082.31 | 1113.43 | 1593.13 | 1592.97 | 1597.27 |
| 0.10 | 1082.42 | 1092.39 | 1123.78 | 1594.53 | 1595.23 | 1596.80 |
| 0.15 | 1092.74 | 1103.45 | 1128.40 | 1595.42 | 1594.44 | 1596.00 |
| 0.20 | 1103.07 | 1113.73 | 1134.23 | 1594.65 | 1594.66 | 1595.62 |
| 0.25 | 1113.43 | 1216.09 | 1164.14 | 1595.29 | 1592.23 | 1594.59 |

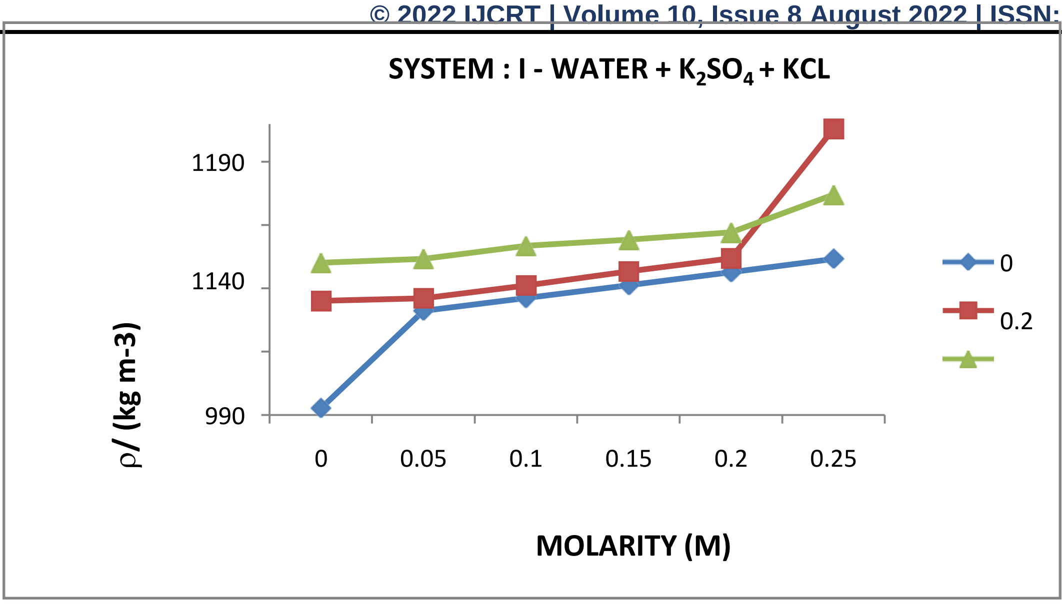



**Fig- 1 Variation of Density (ρ) Vs Molarity (M)**

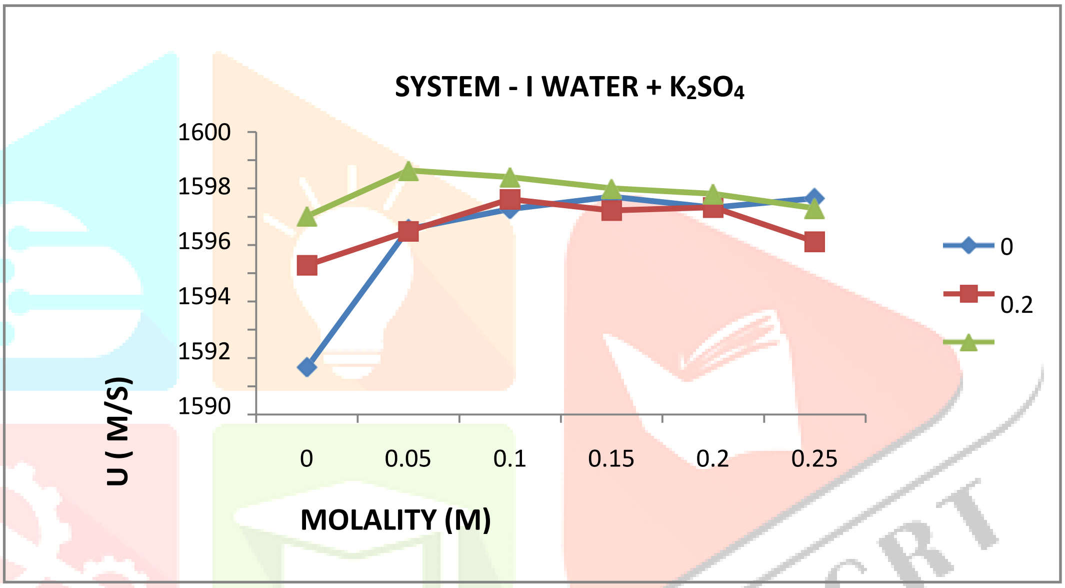



**Fig- 2 Variation of Ultrasonic wave Velocity (U) Vs Molarity (M)**

The adiabatic compressibility (β) of the solute can be expressed as the extent to which hydration around the solute molecule can be expressed. The perusal of Table-2 exhibits the values of adiabatic compressibility (β), which are found to be decreased with increase in molar concentration of solute (potassium chloride) as well as potassium sulphate content. Such a decrease in adiabatic compressibility observed in solvent (aqueous potassium chloride solution) may be attributed to weakening of hydrogen bond in the solution. It is well known fact that when a solute dissolves in a solvent, some of the solvent molecules are attached to the ions (produced from the solutes), because of ion- solvent interaction. Since, the solvent molecules are oriented in the ionic field; these molecules are more compactly packed in the primary salvation shells as compared to the packing in the absence of the ions. This is the reason, why the solvent is compressed by the introduction of the ions. Thus, the electrostatic field of the ions causes the compression of the medium giving rise to a phenomenon called ‘Electrostriction’. Since the water molecules are compressed, they do not respond to a further application of pressure. So the solutions become harder to compress. Consequently, this will lead to in decrease in compressibility values. It may also be inferred that weakening of hydrogen bond strength formed by the solute and solvent molecules may also be the reason for decrease in compressibility. The negative values of change in adiabatic compressibility (Δβ) and relative change in adiabatic compressibility (-Δβ/β0) are due to solute-solvent interactions[6,7].Such an increase in (Δβ) and (-Δβ/β0) values with increase in concentration may be attributed to an overall increase in the cohesive forces in the solution. Thesecohesive forces may be due to the interactions in the solution[8].

**Table – 2 Values of Adiabatic Compressibility (β) and change in Adiabatic Compressibility (Δβ) of Potassium Sulfate in aqueous Potassium Chloride mixture at 308.15K**

| Molarity M/(mol.dm$^{-3}$) | Adiabatic Compressibility β x ($10^{-10}$ $m^2$ $N^{-1}$) | | | Change in Adiabatic Compressibility (Δβ) $pa^{-1}$ | | |
|---|---|---|---|---|---|---|
| | SYSTEM : I WATER + $K_2SO_4$ + KCL | | | | | |
| | **0.0 M** | **0.2 M** | **0.4 M** | **0.0 M** | **0.2 M** | **0.4 M** |
| 0.0 | 3.9482 | 4.2695 | 4.3689 | - | - | - |
| 0.05 | 3.6756 | 3.6424 | 3.5219 | 0.2478 | 0.6146 | 0.8416 |
| 0.10 | 3.6360 | 3.5987 | 3.4923 | 0.2825 | 0.6469 | 0.9128 |
| 0.15 | 3.5954 | 3.5663 | 3.5023 | 0.3162 | 0.6827 | 0.9422 |
| 0.20 | 3.5655 | 3.5334 | 3.4638 | 0.2606 | 0.7145 | 0.9901 |
| 0.25 | 3.5295 | 3.4439 | 3.3790 | 0.3861 | 1.0168 | 1.1992 |

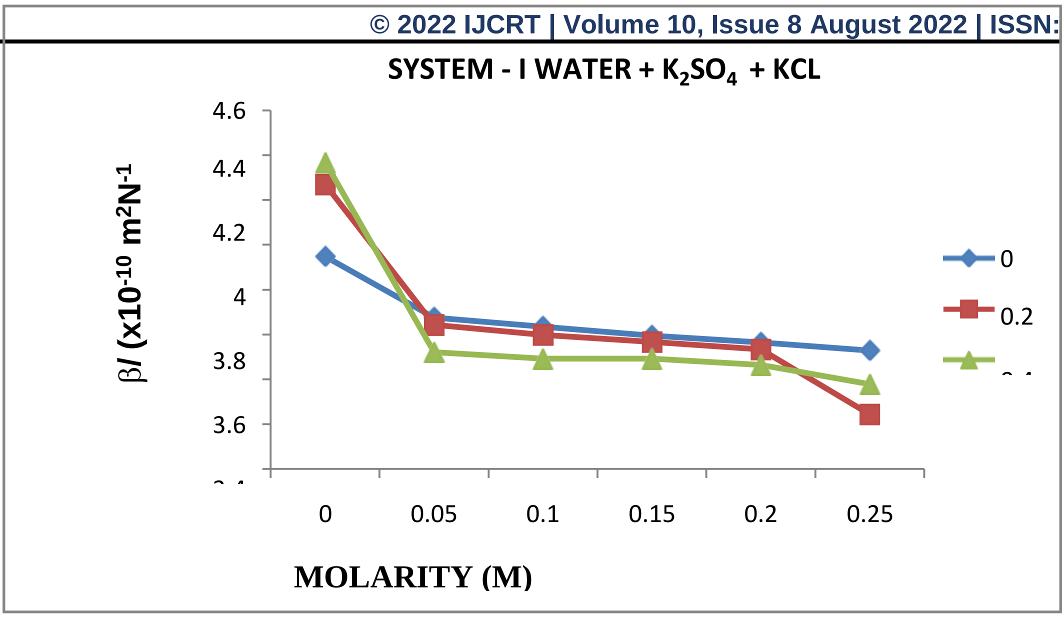



**Fig- 4 Variation of Adiabatic Compressibility (β) Vs Molarity (M)**

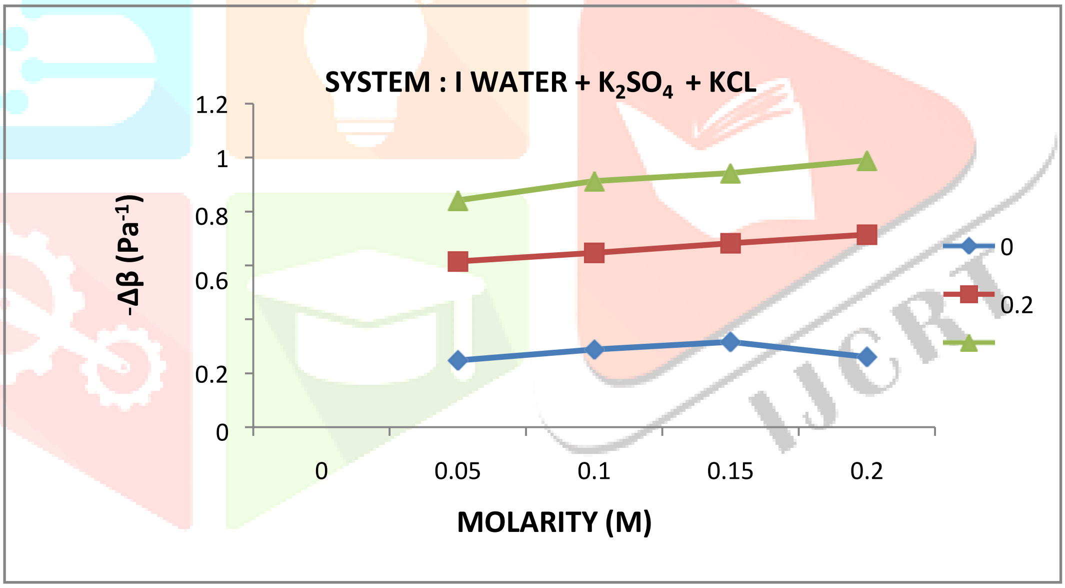



**Fig – 4 Variation of change in adiabatic compressibility (-Δβ)Vs Molarity (M)**

**Table – 3 Values of Relative Change in Adiabatic Compressibility ($\Delta\beta/\beta_0$) and Acoustic Impedance (Z) of aqueous Potassium Chloride mixture at 308.15K**

| Molarity M/(mol.dm$^{-3}$) | Relative Change in Adiabatic Compressibility $-\Delta\beta/\beta_0 \times 10^3$ | | | Acoustic Impidance Z X $10^{-6}$ (kg $m^{-2}$ $s^{-1}$) | | |
|---|---|---|---|---|---|---|
| | SYSTEM : I WATER + K2SO4 + KCL | | | | | |
| | **0.0 M** | **0.2 M** | **0.4 M** | **0.0 M** | **0.2 M** | **0.4 M** |
| 0.0 | - | - | - | - | - | - |
| 0.05 | 0.6276 | 1.4395 | 1.9250 | 1.7078 | 1.7235 | 1.7776 |
| 0.10 | 0.7155 | 1.5130 | 2.0874 | 1.7253 | 1.741 | 1.793 |
| 0.15 | 0.8008 | 1.5990 | 2.1874 | 1.7432 | 1.7586 | 1.800 |
| 0.20 | 0.660 | 1.673 | 2.2667 | 1.7588 | 1.774 | 1.809 |
| 0.25 | 0.9703 | 2.3810 | 2.7448 | 1.7760 | 1.9361 | 1.8559 |

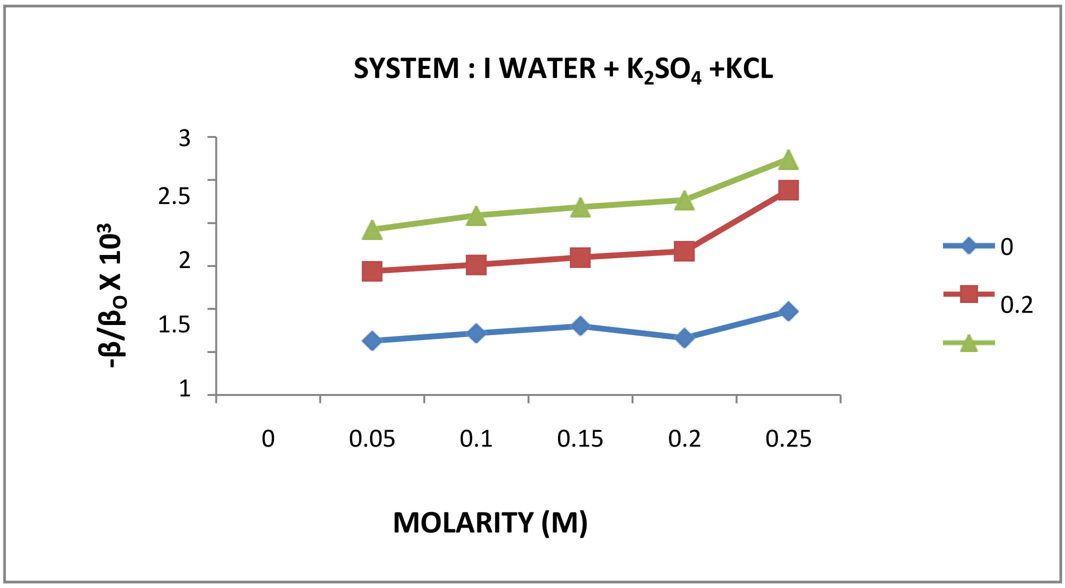



Fig –5 Variation of relative change in adiabatic compressibility ($-\Delta\beta/\beta_0$) Vs Molarity (M)

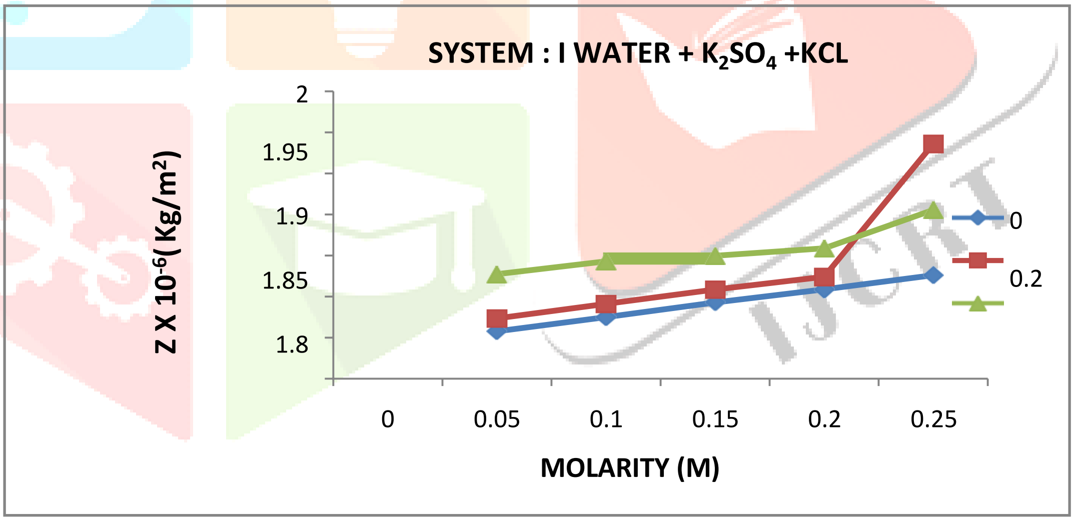
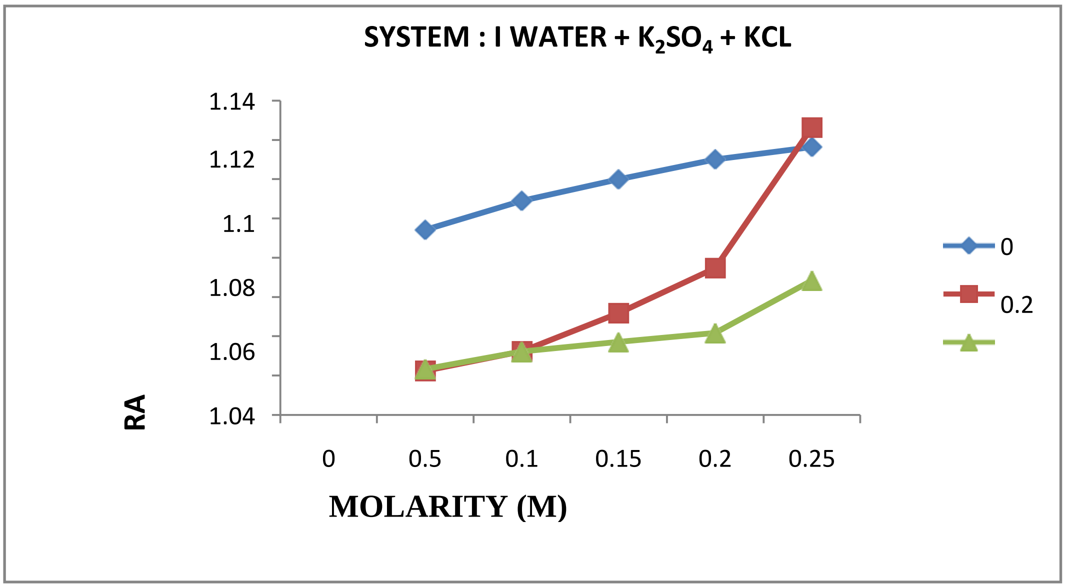



Fig –6 Variation of Acoustic impedance (Z) Vs Molarity (M)

The examination of Table-2 and 3 exhibits the values of acoustic impedance (Z) and relative association (R.A) which are found to be increased with increase in molar concentration of solute (potassium chloride) as well as potassium sulphate content. Acoustic impedance (Z) is the impedance offered to the sound wave by the components of the mixture whereas the relative association (RA) is the measure of extent of association of the components in the medium. The increasing trend in these parameters suggests the strengthening of interaction among the components[9]. The interaction may be solute–solute or solute–solvent or solvent– solvent type. To ascertain the exact type, the trend of these two parameters may also be used. It is peculiar to note that these two parameters depend on density. Increase in density of the mixture clearly reveals that more mass is accumulated in the components. This reveals the significant characteristics of the medium, i.e., though the density and velocity apparently seem to be independent of each other, in actual case, it is not so. For a single particle of a component in the mixture, the sound velocity depends on the size and mass of the particle. Size is important in offering cohesion effects whereas mass is important regarding the inertial effects. If the propagated sound energy is of enough strength, then only it can lift that mass and transfer the energy to the next particle. If the nearby particles are close, then the transfer speed will be more. If the addition of solute increases the density (mass appreciably) of the mixture the medium is made more inertial and to enhancement of the acoustic impedance. But in this case nothing can be revealed about the interactions. However, in most cases, the size will develop that increases the cohesion effects and so the components tend to move fast. This increase in particle movement is restricted by the surrounding particle that increases the net acoustic impedance. This shows the existence of specific interactions among the components, in particular solute–solute or solute–solvent. To have a much more deeper insight into this process, relative association may be used as a supporting parameter. If the increase in velocity is due to size enlargement of the component in the mixture, cohesion will increase and thus it may lead to solvent–solvent interaction and in this case relative association will decrease with increasing molarity. On the other hand, if the increase in velocity is due to mass accumulation, it may lead to either solute–solute interaction or solute–solvent interaction that depends on the magnitude of velocity variation. Larger variation is characterized by solute–solute, whereas a small variation indicates solute–solvent interaction. Such things can be best studied by relative association. If relative association increases but negligibly, after mixing the solute, then there will be poor association and this belongs to solute–solvent type[10]. But if the variation of relative association is appreciable then it is to be taken as solute–solute type. The observed trend of acoustic impedance and the relative association of the pottasium chloride with molarity are in general increasing, indicating two facts that the specific interactions are not solvent–solvent type and also the chances for complexation are enhanced with increasing molarity.

**Table –4 Values of Relative Association (R.A) of Potassium Sulfate in aqueous PotassiumChloride mixture at 308.15K**

| Molarity M/(mol.dm$^{-3}$) | SYSTEM :I WATER + $K_2SO_4$ + KCL | | |
|---|---|---|---|
| | Relative Association (R.A) | | |
| | 0.0 M | 0.2 M | 0.4 M |
| 0.0 | - | - | - |
| 0.05 | 1.0741 | 1.0024 | 1.0033 |
| 0.10 | 1.0890 | 1.0124 | 1.0122 |
| 0.15 | 1.0999 | 1.0318 | 1.0172 |
| 0.20 | 1.1100 | 1.0548 | 1.0217 |
| 0.25 | 1.1163 | 1.1263 | 1.0484 |




**Fig–7 Variation of Relative association (R.A) Vs Molarity (M)**

## Conclusion

The ultrasonic studies on interionic interactions of pottasium chlorides in aqueous potassium sulphate at 308.15K have been investigated and are consolidated as,

In the light of the above discussion, it may be concluded that there are existence of powerful molecular interactions in the systems studied. Both the solute-solute interactions and solute-solvent interactions arepossible in the systems.

**REFERENCES**


1. Dash, A.K.,Paikaray, R. 2014. Studies on Acoustic Parameters of Ternary Mixture of Dimethyl Acetamide in Acetone and Isobutyl Methyl Ketone using Ultrasonic and Viscosity Probes, Int. J. of Chem. &Phy Sc., 3: 69-79.
2. Praharaj, M.K., Satapathy, A., Mishra, P., Mishra S. 2013a. Ultrasonic analysis of intermolecular interaction in the mixtures of benzene with n, ndimethylformamide and cyclohexane at different temperatures", J of Chem.& Phar. Res.,5: 49-56.
3. Praharaj, M.K., Mishra S. 2014a. Study of acoustic and thermodynamic parameters for binary mixture containing cyclohexane and the substituted benzenes at different temperatures, J Chem. Bio.&Phy. Sc., Section C, 5: 686-699.
4. Praharaj, M.K., Mishra S. 2015. Molecular interaction in ternary liquid mixtures at different temperatures, World journal of pharmacy and pharmaceutical sciences, 5: 1597-1607.
5. Praharaj, M.K., Mishra S. 2016. Ultrasonic Study of Certain Binary Mixtures In Terms of the Excess Values of Thermodynamic Parameters. Int. J Recent Sci. Res. 7: 9125-9128. Nath, G.,Paikaray, R. 2009. Effect of frequency on acoustic parameters in a binary mixture of polar liquids, Indian J. of Phys., 83: 1567-15.
6. Riyazudden and Khan Imran, Interactions in L-alanine–/L-proline–/L-valine–/L-leucine–aqueous KCl/KNO3 systems at different temperatures: An isentropic compressibility study, J. ThermochimicaActa, 2009, 483, 45.
7. Aswar A. S., Interaction studies on biomolecules in aqueous medium, *J. Pure Appl. Ultrason*ics, 1998, **20,** 82.
8. Ali A., Nain A.K., Kumar N. and Ibrahim M., Study of molecular interactions in binary mixtures of acetonitrile with amides through ultrasonic speed measurements, J. *Pure Appl. Ultrasonics*, 2002, 24**,** 27-35.
9. PandeyD. and Akhtar Y., Ultrasonic studies of aqueous concentrated electrolytic solutions at 298.15 K, J.Pure Appl. Ultrasonics, 1996, 18, 108-113.
10. Syal V.K., Lal G., Bisht P., Chauhan S., Ultrasonic measurements of some 1:1 electrolytes inchlorobenzene + methanol mixtures, J. Mol. Liquids, 1995, 63, 317-328.