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Research Article

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Ultrasonic studies of molecular interactions of certain Zinc electrolytes in Poly (Ethylene Glycol)

A. Sherif[1*], N. Afsar[2] and S. Narayanan[3]

[1]Post Graduate and Research Department of Chemistry, The New College, Chennai, Tamil Nadu, India
[2]Department of Chemistry, Govt. Arts College, Ponneri, Chennai, Tamil Nadu, India
[3]Post Graduate and Research Department of Chemistry, Presidency College, Chennai, Tamil Nadu, India

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ABSTRACT

The present investigation was carried out in order to explore the possible molecular interactions of various zinc electrolytes in polyethylene glycol. Measurement of ultrasonic velocity (u), density (ρ) and viscosity (η) have been carried out for the various systems of zinc sulphate+ PEG, zinc acetate+ PEG and zinc nitrate+ PEG in different concentrations at 303K. From the experimental data acoustical parameters such as adiabatic compressibility (βa), acoustic impedance (z) and intermolecular free length (Lf) have been calculated. These parameters are used to interprete the molecular interactions in terms of ion-solvent, ion-ion and solute-solvent of the electrolytic solutions.

Keywords: Ultrasonic velocity, Density, Viscosity, Acoustical parameters, Molecular interactions.

INTRODUCTION

In recent years, Ultrasonic investigation is an important tool in understanding acoustical and thermodynamic behaviour of electrolytic and non-electrolyte mixtures. The measurements of ultrasonic velocity, density, viscosity and derived parameters have been used to determine ion-solvent interactions in electrolytic solutions [1-4]. The molecular interactions depend on the solubility, salt concentration and polymer-substrate interactions. Ultrasonic energy is used in medicine, engineering agriculture, defence and industry. Using densities, viscosities and ultrasonic velocities, the acoustical parameters such as adiabatic compressibility (β), acoustic impedance and free length (Lf) have been calculated. These parameters have been used to study the molecular interactions in electrolytic solutions. A number of researchers have been studied acoustical properties of solution containing transition metal ions [5-7] .Ultrasonic studies are also used in the ionic interaction using different transition metals with polypropylene glycol and poly vinyl alcohol [8,9]. However the ultrasonic studies of the same metal with other ligands are having not been received using poly ethylene glycol. In the present paper, we have been studied to determine the densities, viscosities and ultrasonic velocities of zinc sulphate, zinc acetate and zinc nitrate with poly ethylene glycol (PEG) at 303K. The polyethylene glycol is used to prepare the nano particle. The zinc metal salts are inorganic compounds are used in the laboratory. From the experimental data adiabatic compressibility (β), acoustic impedance (z) and intermolecular free length (Lf) have been calculated. These parameters have utilized to study of various interactions taking place in the solution of electrolyte in polyethylene glycol. The interactions between the ions and the molecules of the solvent in electrolytic solutions are very strong. In solution of ionic solute the attraction between the solute and solvent is ion-dipole type. When electrolyte is dissolved in solvent it causes volume contraction due to interaction between the ion and solvent molecule.

EXPERIMENTAL SECTION

Materials

All the chemicals were used of AR grade of minimum assay 99.9% of zinc sulphate, zinc acetate and zinc nitrate. These chemicals were used to prepare the salt solution. All the chemicals were prepared using with distilled water. Aqueous solutions of all the salt (0.2M to 0.16M) were prepared. To this various concentrated solutions mixed with poly ethylene glycol.

Methods

Chemicals were weighed in an electronic balance (Model: SHIMADZU AX 200). An Ostwald's viscometer (10ml capacity) is used for the viscosity measurements. The flow of time was measured with a digital stop watch capable of registering time accurate to ±0.1s. The density measurements were performed using recalibrated specific gravity bottle. Ultrasonic velocity was measured with a single crystal interferometer(F81, Mittal Enterprises, New Delhi) at 2 MHz The interferometer was calibrated against the ultrasonic velocity of water used at T=303K. The temperature of the solution was maintained by an electronically controlled thermostatic water bath. The accuracy in the temperature measurement is ± 0.1K.

Theory and calculations

Using the measured values ultrasonic velocity (u), density (ρ) and viscosity (η) various acoustical parameters such as adiabatic compressibility (βa), acoustic impedance (z) and intermolecular free length (Lf) were calculated by using the following relations.

Ultrasonic velocity (u) = υ x λ --------- (1)
Adiabatic compressibility (βa) = $1/ u^2\rho$-------- (2)
Acoustic impedance (z) = u. ρ---------- (3)
Intermolecular free length (Lf) = $K/u.\rho^{1/2}$-------(4)

Where K is the temperature dependant Jacobson constant

u and ρ are the ultrasonic velocity and density of solutions respectively.

RESULTS AND DISCUSSION

The experimentally measured values of ultrasonic velocity(u), density(ρ) and viscosity(η) of the electrolytic solutions and calculated values of acoustical parameters such as adiabatic compressibility(βa), acoustic impedance(z) and intermolecular free length(Lf) are reported in Table1,Table 2 and Table 3 for the systems of zinc sulphate + PEG, zinc acetate+ PEG and zinc nitrate+ PEG respectively. The graphs are plotted for ultrasonic velocity (u), adiabatic compressibility (βa), acoustic impedance (z) and intermolecular free length (Lf) in various concentrations are shown in fig.1 to fig 4.

Table-1 Ultrasonic velocities(U), densities(ρ), viscosities(η), adiabatic compressibility(β), acoustic impedance(Z) and intermolecular free length(Lf) of Zinc sulphate with PEG at303K

Conc(M)	Velocity(U) ms^{-1}	Density (ρ) kgm^{-3}	Viscosity (η)$x10^{-3}Nsm^{-2}$	Adiabatic compressibility (β)/$10^{-10}Kg^{-1}ms^{-2}$	Acoustic impedance (Z) /$10^{6}Kgm^{-2}S^{-1}$	Int. mole. free length (Lf)/10^{-11}m
0.02	1626	1043	1.5162	3.6264	1.6959	3.77815
0.04	1628	1044	1.5248	3.6140	1.6996	3.7717
0.06	1632	1045	1.5263	3.5929	1.7054	3.76065
0.08	1636	1047	1.5364	3.5685	1.7129	3.74787
0.1	1632	1049	1.5537	3.5792	1.712	3.75348
0.12	1623	1051	1.5639	3.6121	1.7058	3.7707
0.14	1616	1053	1.5957	3.6365	1.7016	3.78343
0.16	1615	1057	1.6235	3.6273	1.7071	3.77861

The ultrasonic velocity (u) for the zinc electrolytic solutions at 2MHz frequency at various concentration have been determined using Eq.(1).and experimental values of u have been presented in Table 1 ,Table 2 and Table 3.These observed values showed that ultrasonic velocity increases with increase in concentration of electrolytic solution. The variation of ultrasonic velocity in a solution depends on the intermolecular free length (Lf).It determines the sound of velocity in fluid state. The increase in ultrasonic velocity the decrease in intermolecular free length and vice versa .The increase in ultrasonic velocity with increase in concentration clearly shows that the molecular association in zinc sulphate +PEG zinc acetate + PEG and zinc nitrate + PEG systems. A sudden decrease of velocity at concentration of 0.1M for zinc sulphate+ PEG system, at 0.14M for zinc acetate + PEG system and at 0.06M for zinc nitrate + PEG system. The sudden decrease in velocity may be due to the complex formation or molecular

interactions. In zinc acetate + PEG system the molecular interaction occur only at higher concentration of 0.14M than another two systems. This is due to weak electrolytic solution.

Table-2 Ultrasonic velocities (U), densities (ρ), viscosities (η), adiabatic compressibility (β), acoustic impedance (Z) and intermolecular free length (Lf) of Zinc acetate with PEG at 303K

Conc(M)	Velocity(U) ms^{-1}	Density (ρ) kgm^{-3}	Viscosity (η $x10^{-3}Nsm^{-2}$)	Adiabatic compressibility (β)/$10^{-10}Kg^{-1}ms^{-2}$	Acoustic impedance (Z) /10^{6} $Kgm^{-2}S^{-1}$	Int. mole. free length (Lf)/10^{-11}m
0.02	1616	1039	1.5674	3.6855	1.679	3.8088
0.04	1618	1040	1.5808	3.6729	1.6827	3.8023
0.06	1619	1041	1.5987	3.6648	1.6854	3.7981
0.08	1620	1046	1.5282	3.6428	1.6945	3.7867
0.1	1622	1047	1.7147	3.6303	1.6982	3.7802
0.12	1624	1050	1.6704	3.6111	1.7052	3.7702
0.14	1621	1051	1.6936	3.621	1.7037	3.7753
0.16	1617	1054	1.7105	3.6286	1.7043	3.7793

Table-3 Ultrasonic velocities (U), densities (ρ), viscosities (η), adiabatic compressibility (β), acoustic impedance (Z) and intermolecular free length (Lf) of Zinc nitrate with PEG at 303K

Conc(M)	Velocity(U) ms^{-1}	Density (ρ) kgm^{-3}	Viscosity (η $x10^{-3}Nsm^{-2}$)	Adiabatic compressibility (β)/$10^{-10}Kg^{-1}ms^{-2}$	Acoustic impedance (Z) /10^{6} $Kgm^{-2}S^{-1}$	Int. mole. free length (Lf)/10^{-11}m
0.02	1621	1039	1.5460	3.66284	1.6842	3.79709
0.04	1628	1040	1.5475	3.62792	1.6931	3.77895
0.06	1627	1042	1.5505	3.62541	1.6953	3.77764
0.08	1625	1045	1.5549	3.62391	1.6981	3.77685
0.1	1622	1049	1.5601	3.62345	1.7015	3.77662
0.12	1621	1053	1.5741	3.61415	1.7069	3.77176
0.14	1621	1057	1.6012	3.60047	1.7134	3.76462
0.16	1620	1058	1.6541	3.60151	1.714	3.76516

Density is a measure of solvent-solvent and ion-solvent interactions. It is observed that for all the three systems, the values of density increases when increase in concentration suggesting thereby solute –solvent and solvent –solvent interactions. Increase in density is due the presence of solute molecules.

Viscosity is also an important factor in understanding the molecular interaction in electrolytic solutions. The calculated viscosity values for all the three systems are presented in Table -1, Table -2 and Table- 3. It is observed that viscosity exhibits a non-linear variation with increase in concentration of solute of zinc salts content and this indicate the presence of ion-solvent interaction.

Acoustical parameters such as Acoustic impedance are calculated using Eq. 3. From Table- 1.Table -2 and Table- 3 and fig.3 clearly show that the same trend with velocity for all the three systems.

Figure -1 Variation of ultrasonic velocity Vs concentration

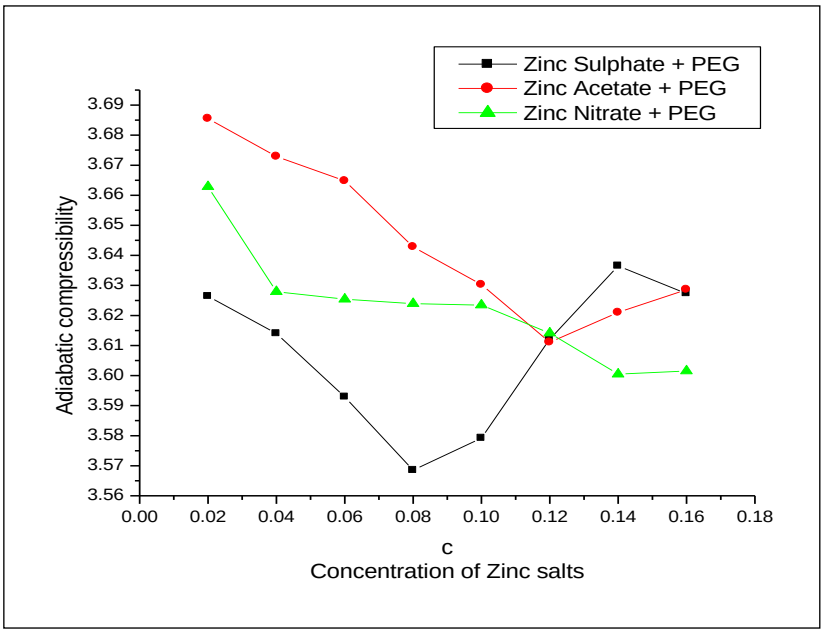


Figure-2 Variation of adiabatic compressibility Vs Concentration

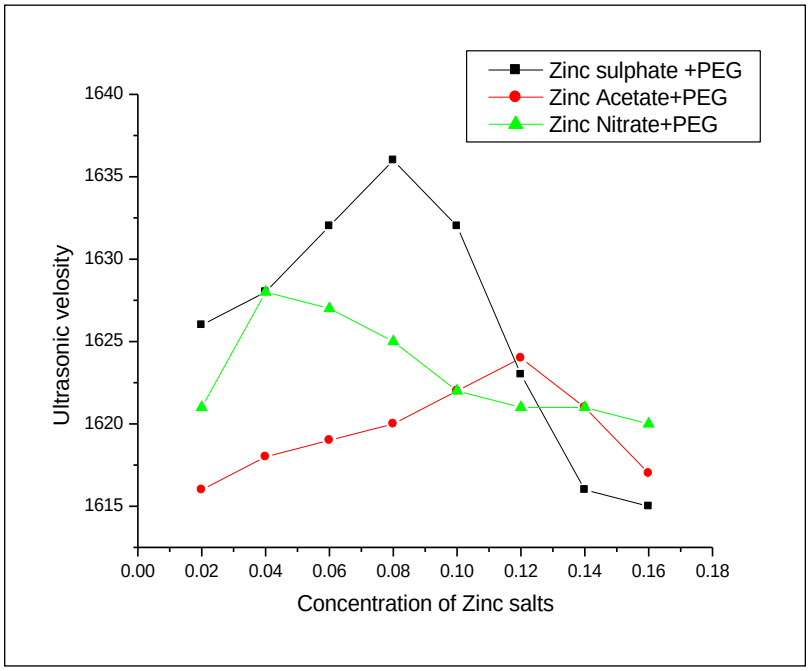


Figure -3 Variation of acoustic impedance Vs Concentration

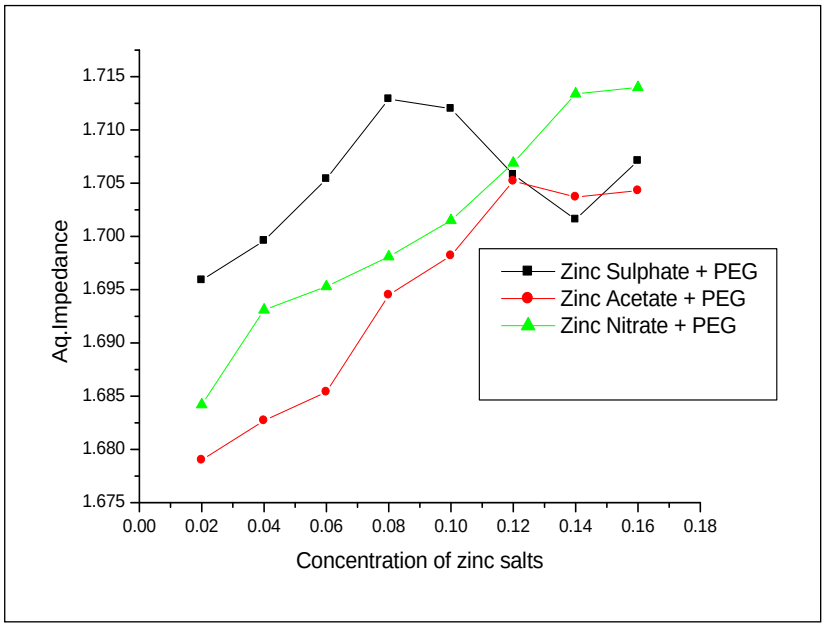
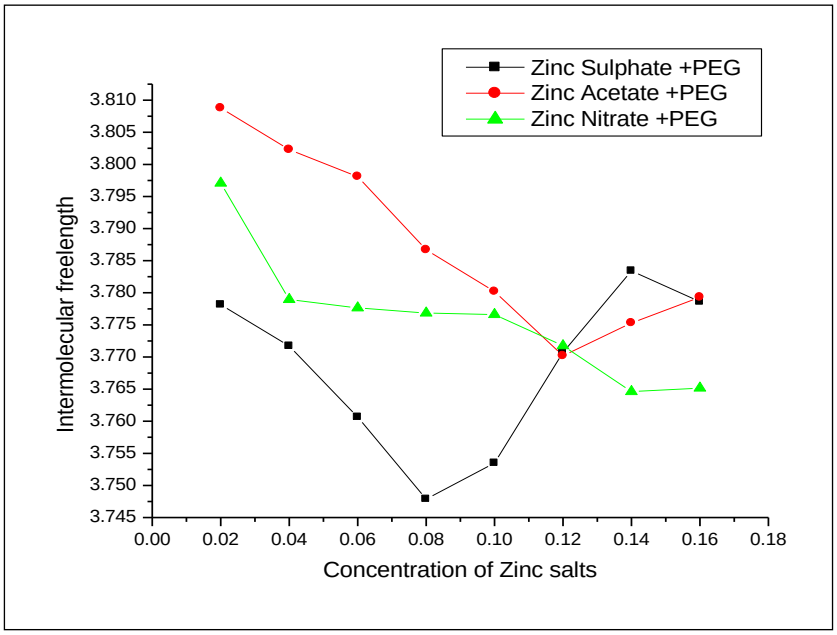


Figure- 4. Variation of intermolecular free length Vs Concentration



CONCLUSION

Ultrasonic velocity (u), density(ρ) and viscosity(η) and acoustical parameters such as adiabatic compressibility(βa), acoustic impedance(z) and intermolecular free length(Lf) of zinc sulphate+ PEG, zinc acetate+ PEG and zinc nitrate+ PEG have been measured at various concentration at 303K.Based on the three systems shows non-linear, increase and decrease behaviour. The trends indicate ion-solvent, ion-ion and solute-solvent interactions. These interactions occur at low concentration for the systems with strong electrolyte solutions such as zinc sulphate+ PEG and zinc nitrate+ PEG. In weak electrolyte solution such as zinc acetate+ PEG the interaction occur at higher concentration. The ultrasonic technique provides comprehensive investigations between ion-solvent, ion-ion and solute-solvent interactions.

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