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Thermodynamic and Viscous Properties of Cerium Chloride with Aqueous Formic Acid

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ABSTRACT
The thermodynamic and viscous properties of cerium chloride in aqueous formic acid studied with the help of ultrasound sound velocity, density and viscosity. The data obtained during the study used for determining other parameters like adiabatic compressibility, intermolecular free length, specific acoustic impedance and relative association. These parameters are used to discuss the ion solvent interaction of cerium chloride in aqueous formic acid at 30^{o}C, 35^{o}C and 40^o C temperatures.
Keywords: Ultrasonic velocity, Density, Cerium chloride, Aqueous Formic acid.

INTRODUCTION

The thermodynamic properties of molecules and their solutions are important to understand the molecular interactions and the visometric behavior of solutes have been useful in the solute- solute and solute- solvent interactions occurring in mixed solvents [1,5-8,13,16-19]. Ultrasonic techniques have been used for studying ion solvent interactions in aqueous formic acid and cerium chloride. When aqueous formic acid is brought in contact with cerium chloride, they adhere strongly to the surface the nature of variation of derived acoustic and volumetric properties such as adiabatic compressibility, intermolecular free length, specific acoustic impedance and relative association from ultrasonic measurements at 30^{o}C, 35^{o}C and 40^{o}C [10]. These parameters explore ion solvent interactions in different concentration solution mixture of cerium chloride with aqueous formic acid. The explosive rate of development in high frequency digital and computer techniques has been opened new avenues for laboratory study and industrial purpose. The present paper deals the study of ion solvent interaction of cerium chloride in aqueous formic acid at different temperature.

MATERIALS AND METHODS

All used chemicals in the experiment are of analytical reagent (AR) grade. Comparing with their densities with literature values checked the purity of chemicals [23-25]. The ultrasonic measurements of the solutions of cerium chloride in aqueous formic acid were carried out with a single crystal ultrasonic interferometer (Model –18 Mittal enterprises, New Delhi) at a frequency of 2 MHz [3, 9]. The solutions of various concentrations were prepared by adding weighing quantity of solute in known volume of solvent. Liquid mixtures of different known compositions were prepared in airtight- stoppered measuring flask to minimize the leakage of volatile liquids. Density and viscosity measurements were carried out using thermostat to maintain temperature, which was measured with a digital thermometer. Densities of pure liquid and liquid mixtures can be determined by the doubled walled bicapillary pycknometer [14-15]. And viscosity was determined by suspended level canon unbehlande type viscometer [12].

Theory and calculations-

Many thermodynamic and acoustic properties like Isentropic compressibility (β_s), intermolecular free length (L_f), specific acoustic impedance (Z), apparent molal compressibility (ϕ_K), solvation number (Sn), and relative association (Ra) have been calculated at 30, 35, 40^{o}C. Using ultrasound velocity (U), Density (ρ) and viscosity (η) of these solutions the help of following equations [11]-

$$\text{Isentropic Compressibility } (\beta_s) = \frac{1}{U^2\rho} \quad (1)$$

$$\text{Specific Acoustic Impedance (Z)} = U.\rho \quad (2)$$

$$\text{Intermolecular Free Length } (L_f) = K\sqrt{\beta_s} \quad (3)$$

Relative Association (R_A) = $\frac{\rho}{\rho_o}\left[\frac{U_o}{U}\right]^{1/3}$ (4)

Solvation Number (S_n) = $\frac{n_1}{n_2}\frac{(1-\beta_s)}{\beta_{so}}$ (5)

Apparent Molal Compressibility (ϕ_K) = $\frac{1000\,(\rho_o\beta_s - \beta_{so}\rho)}{C.\,\rho_o} + \frac{\beta_{so}\,M}{\rho_o}$ (6)

Whereρ, ρ_o and Uo are the densities and ultrasonic velocities of solution and solvent respectively, K is Jacobson constant, M molecular weight of solute, β_{so} the isentropic compressibility of solvent, C is concentration in mole/litre $n_1$and n_2 are the number of moles of solvent and solute respectively.

Table-1: Experimental data of Cerium chloride in Formic acid at 30^o C

C Mol/lit	U M/sec	ρ g/cm^3	η c.p.	$\beta_S\times10^{12}$ cm^2/dyne	L_f A	Z $\times 10^5$ g/s.cm	$\phi_K \times 10^9$ cm^2/dyne	Sn	Ra
0.0493	1251	1.3245	1.2826	48.24	0.0152	0.0166	-2579.92	31.6069	0.3610
0.0986	1255	1.3268	1.2845	47.85	0.0151	0.0167	-1310.93	15.2364	0.3605
0.1479	1258	1.3286	1.2863	47.56	0.0150	0.0167	-875.94	9.7616	0.3601
0.1972	1261	1.3308	1.2884	47.26	0.0149	0.0168	-660.64	7.0072	0.3599
0.2465	1265	1.3316	1.2908	46.93	0.0148	0.0168	-529.15	5.3438	0.3589
0.2958	1268	1.3332	1.2926	46.65	0.0147	0.0169	-440.78	4.2256	0.3585
0.3451	1271	1.3356	1.2945	46.35	0.0146	0.0170	-380.25	3.4158	0.3583
0.3944	1274	1.3378	1.2967	46.05	0.0145	0.0170	-334.17	2.8016	0.3581
0.4437	1278	1.3395	1.2984	45.71	0.0144	0.0171	-299.35	2.3161	0.3574
0.4930	1281	1.3408	1.3012	45.45	0.0143	0.0172	-268.31	1.9253	0.3569

Table-2: Experimental data of Cerium chloride in Formic acid at 35^{o}C

C Mol/lit	U M/sec	ρ g/cm^3	η c.p.	$\beta_S\times10^{12}$ cm^2/dyne	L_f A	Z $\times 10^5$ g/s.cm	$\phi_K \times 10^9$ cm^2/dyne	Sn	Ra
0.0493	1225	1.2886	1.1516	51.71	0.0165	0.0158	-2742.93	31.5726	0.3637
0.0986	1229	1.3006	1.1534	50.90	0.0162	0.0160	-1508.36	15.1660	0.3659
0.1479	1232	1.3024	1.1556	50.59	0.0161	0.0160	-1004.38	9.6967	0.3655
0.1972	1235	1.3048	1.3578	50.25	0.0160	0.0161	-755.86	6.9474	0.3653
0.2465	1239	1.3065	1.3592	49.86	0.0159	0.0162	-607.73	5.2864	0.3646
0.2958	1242	1.3088	1.3415	49.53	0.0158	0.0163	-507.45	4.1711	0.3644
0.3451	1245	1.3106	1.3436	49.23	0.0157	0.0163	-433.98	3.3684	0.3640
0.3944	1249	1.3125	1.3454	48.84	0.0155	0.0164	-381.85	2.7576	0.3633
0.4437	1252	1.3142	1.3476	48.54	0.0154	0.0165	-338.22	2.2793	0.3629
0.4930	1256	1.3168	1.3495	48.14	0.0153	0.0165	-307.56	1.8880	0.3625

Table-3: Experimental data of Cerium chloride in Formic acid at 40^{o}C

C Mol/lit	U M/sec	ρ g/cm^3	η c.p.	$\beta_S\times10^{12}$ cm^2/dyne	L_f A	Z $\times 10^5$ g/s.cm	$\phi_K \times 10^9$ cm^2/dyne	Sn	Ra
0.0493	1205	1.2526	1.1235	54.98	0.0176	0.0151	-2709.71	31.5793	0.3622
0.0986	1208	1.2548	1.1258	54.61	0.0175	0.0152	-1355.57	15.2187	0.3619
0.1479	1212	1.2569	1.1276	54.16	0.0174	0.0152	-911.04	9.7420	0.3613
0.1972	1216	1.2585	1.1293	53.74	0.0172	0.0153	-685.25	6.9901	0.3606
0.2465	1219	1.2602	1.1315	53.40	0.0171	0.0154	-545.35	5.3306	0.3602

0.2958	1223	1.2623	1.1336	52.96	0.0170	0.0154	-457.52	4.2104	0.3596
0.3451	1226	1.2647	1.1354	52.61	0.0169	0.0155	-392.39	3.4040	0.3594
0.3944	1230	1.2664	1.1378	52.19	0.0168	0.0156	-344.09	2.7914	0.3587
0.4437	1234	1.2685	1.1386	51.77	0.0166	0.0157	-307.50	2.3076	0.3581
0.4930	1237	1.2704	1.1393	51.44	0.0165	0.0157	-275.37	1.9178	0.3578

RESULTS AND DISCUSSION

The measured properties in experiment like ultrasonic velocity (U), Density (ρ), Viscosity (η) are shown in table 1,2 and 3. These data show that these three parameters increases with increase in concentration of cerium chloride in solution. This indicates that strong interaction observed at higher concentrations of cerium chloride and suggests more association between solute and solvent molecules in the system. The variations of ultrasound velocity with concentration depend upon the concentration derivatives of density and compressibility the results indicates that the ultrasonic velocity increases with decrease of intermolecular free length (Table-1) and vice versa. Intermolecular free length (L_f), which is expected to decrease with mixing of two components, decreases with the increase in cerium chloride concentration. Rise in temperature generally increases the internal energy of the system by distorting the local structure, resulting in an increasing in intermolecular free length. The isentropic compressibility of lanthanum chloride solution decreases with increase in solute concentration the decrease in isentropic compressibility is based on the fact that the solute molecules in dilute solution ionize in metal cation and anions, these ionic particles mare surrounded by a layer of solvent molecules, firmly bound and oriented towards the ions. The orientation of solvent molecules around the ions is attributed to the influence of electrostatic field of ions and thus the internal pressure increases, which lowers the compressibility of the solutions [20]. The elevation of temperature from 30 to 40 shows the same trend (Table 1,2 and 3).

Apparent molal compressibility (ϕ_K) in each system shown in table (1,2 and 3), It is clear that apparent molal compressibility has increases with increasing molar concentration. The result shows that solvent effect is more dominating than the electrolyte. The specific acoustic impedance is a product of the density of the solution and the velocity has shown the reverse tends to that of intermolecular free length [4]. Thus the fact that increases in molar concentration at these three temperatures. The results indicate that the increase in intermolecular forces with the addition of solute forming aggregates of solvent molecules around solute ions and supports the strong solute- solvent interactions due to structural arrangement affected. Relative association [2] is affected by two factors (i) the breaking of the solvent molecules, (ii) the solvation of ion, the relative association decreases with increase of concentration in the present investigation. It has been observed that relative association decrease with the concentration of cerium chloride but it is increases with the elevation in temperature indicating close association between solute and solvent. Solvation numbers (Sn) are calculated by Passynsky equation [21-22]. and the results show that the solvation numbers are found to decrease in solute but it is increases with the elevation of temperature, which also showed close association between solute and solvent.

CONCLUSION

Based on the experimental data, it may be concluded that the ion solvent interaction in the liquid mixture of cerium chloride with aqueous formic acid is significant and this interaction increases with increase the temperature and concentration.

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