

THE SOLVOLYTIC STUDY OF LANTHANUM CHLORIDE IN AQUEOUS ACETIC ACID

Neha Shakya^{1*}, Neelam Shakya¹, R.S. Gangwar² and S.S.Yadav²

¹Department of Chemistry, Kr. R.C.M.P.G.College, Mainpuri (U.P.) India

²Department of Chemistry, Ganjdundwara P.G. College Ganjdundwara, Etah (U.P.) India

*E-mail: neha27.koyal@gmail.com

ABSTRACT

The ion solvent interaction between lanthanum chloride and aqueous acetic acid was studied with the help of ultrasonic velocity and other parameters (like isentropic compressibility, specific acoustic impedance, inter molecular free length, specific acoustic impedance and relative association) determined by using a single crystal interferometer at a frequency of 2 MHz at 30, 35, and 40°C. The results indicate that there is a significant interaction between solute and solvent.

Keywords: Ultrasound velocity, Density, Lanthanum chloride, Aqueous acetic acid.

© 2012 RASAYAN. All rights reserved

INTRODUCTION

Ultrasonic velocity measurements are used in knowing the molecular interactions in pure, aqueous liquids, binary and ternary mixtures¹⁻⁴. Ultrasonic technique has been used for studying ion solvent interaction in aqueous acetic acid and lanthanum chloride. When lanthanum chloride is dissolved in aqueous acetic acid the ion solvent interaction may be occur. The rapid development of ultrasonic techniques and the introduction of new materials for producing powerful ultrasonic vibrations have been opened up wide field of research and technical applications in physics, chemistry, biology, medicines, and industry. Recently, such study has been extended to different liquid mixtures and attempts have been made to correlate the theoretical predictions with the experimental finding⁵⁻⁷. The present paper is an investigation of the behavior of mixture of lanthanum chloride in aqueous acetic acid with respect to adiabatic compressibility, intermolecular free length, specific acoustic impedance, and relative association from ultrasonic measurements at 30, 35 and 40°C. The sign and magnitude of these parameters have been used to interpret the experimental results in terms of ion solvent interactions between the components of the mixture.

EXPERIMENTAL

All used chemicals are of analytical reagent (AR) grade. Comparing with their densities with literature value checked the purity of chemicals⁸⁻¹⁰. The weighing was done using electronic balance with precision ± 0.01 mg. Density and viscosity measurements were carried out using thermostatically controlled well-stirred water bath to maintain temperature, which was measured with a thermometer. Liquid mixtures of different known compositions were prepared in airtight- stoppered measuring flask to minimize the leakage of volatile liquids. The ultrasonic measurements of the solutions of lanthanum chloride in aqueous acetic acid were carried out with a multifrequency ultrasonic interferometer (model F-81 Mittal Enterprises, New Delhi) at a frequency of 2 MHz the accuracy of velocity measurements is $\pm 0.05\%$ ¹¹⁻¹³. Densities of pure liquid and liquid mixtures can be determined from the double walled bicapillary pycknometer¹⁴⁻¹⁵. and viscosity was determined by suspended level canon unbehlande type viscometer¹⁶.

Theory and calculations

Various acoustic and thermodynamic parameters 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°C. Using ultrasound velocity (U), Density (ρ) and viscosity (η) of these solutions the help of following equations-

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

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

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

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

$$\text{Solvation Number (S}_n\text{)} = \frac{n_1}{n_2} \frac{(1-\beta_s)}{\beta_{so}} \quad (5)$$

$$\text{Apparent Molal Compressibility } (\phi_K) = \frac{1000 (\rho_o \beta_s - \beta_{so} \rho) + \beta_{so} M}{C \cdot \rho_o \rho_o} \quad (6)$$

Where ρ , ρ_o and U_o 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 Lanthanum chloride in acetic acid at 30° C

C Mol/lit	U M/sec	ρ g/cm ³	η c.p.	$\beta_s \times 10^{12}$ cm ² /dyne	L_f Å	$Z \times 10^5$ g/s.cm	$\phi_K \times 10^9$ cm ² /dyne	Sn	Ra
0.0491	1496	1.0598	2.2011	42.16	0.0133	0.0159	-1115.45	80.4261	0.3369
0.0981	1499	1.0621	2.2026	41.90	0.0132	0.0159	-541.20	39.6851	0.3369
0.1472	1502	1.0642	2.2036	41.65	0.0131	0.0160	-352.43	26.0305	0.3367
0.1962	1505	1.0668	2.2048	41.39	0.0130	0.0161	-251.76	19.2327	0.3364
0.2453	1508	1.0697	2.2055	41.11	0.0129	0.0161	-196.41	15.0477	0.3361
0.2943	1511	1.0733	2.2068	40.81	0.0129	0.0162	-160.61	12.1818	0.3364
0.3434	1515	1.0769	2.2073	40.46	0.0128	0.0163	-134.51	10.1019	0.3366
0.3924	1518	1.0795	2.2088	40.20	0.0127	0.0164	-112.34	8.5688	0.3365
0.4415	1522	1.0832	2.2095	39.85	0.0126	0.0164	-96.81	7.3040	0.3362
0.4905	1525	1.0869	2.2118	39.56	0.0125	0.0165	-83.67	6.2777	0.3358

RESULTS AND DISCUSSION

The measured parameters like ultrasound velocity (U), density (ρ), viscosity (η) are given in table (1), (2) and (3). These tables show that these three parameters increases with increase in the concentration of lanthanum chloride in solution. This indicates that strong interaction observed at higher concentrations of lanthanum 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. On the basis of a model of sound propagation proposed by Eyring and Kincaid, the results indicate that the ultrasonic velocity increases on decrease of intermolecular free length and vice versa¹⁷. Intermolecular free length, which is expected to decrease as a result of mixing of the two components decreases with the increase in lanthanum chloride concentration. Rise in temperature generally increase in internal energy of the system by distorting the local structure, resulting in an increase in intermolecular free length. In the present paper, the elevation of temperature from 30° to 40°C

shows the same trend (table 2 and table 3). The isentropic compressibility (β_s) for the solution of lanthanum chloride decreases with increase in solute concentration (table 1,2,3). The decrease with increase in isentropic compressibility is attributed to the fact that the solute molecules in dilute solution ionize in simple metal cation and anions. These ionic particles are 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 solution. The specific acoustic impedance, a product of the density of the solution and velocity has shown the reverse trends to that of intermolecular free length. Thus the fact that increase of specific acoustic impedance with increase in molar concentration at all temperatures (table 1,2and 3) is an indicative of 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 which structural arrangement is affected.

Relative association (Ra) is affected by two factors first is the breaking up of the solvent molecules on addition of electrolyte to it and other is solvation of ion, relative association decreases with the increase of concentration of cerium chloride in the present investigation, it has been observed that relative association value decreases with the increase of concentration of lanthanum chloride but it is increases with the elevation of temperature indicating close association between solute and solvent¹⁸. Solvation number (Sn) are listed in table1, 2and 3 the results show that the solvation number values are found to decrease in solute but it is increases with elevation of temperature which also showed close association between solute and solvent. Apparent molal compressibility (ϕ_K) in each system at 30, 35 and 40°C shows in table 1,2and 3. It is found that apparent molal compressibility has increase with increasing molar concentration the result shows that solvent effect is more dominating than the electrolyte.

Table-2: Experimental data of Lanthanum chloride in acetic acid at 35°C

C Mol/lit	U M/sec	ρ g/cm ³	η c.p.	$\beta_s \times 10^{12}$ cm ² /dyne	L_f Å	$Z \times 10^5$ g/s.cm	$\phi_K \times 10^9$ cm ² /dyne	Sn	Ra
0.0491	1465	1.0584	2.1504	44.02	0.0140	0.0155	-1083.27	80.3867	0.3367
0.0981	1468	1.0608	2.1526	43.74	0.0139	0.0156	-528.10	39.6864	0.3368
0.1472	1472	1.0626	2.1545	43.43	0.0138	0.0156	-343.36	26.0637	0.3365
0.1962	1475	1.0649	2.1568	43.16	0.0137	0.0157	-249.99	19.1992	0.3365
0.2453	1478	1.0665	2.1587	42.92	0.0137	0.0158	-191.14	15.0907	0.3363
0.2943	1481	1.0686	2.1606	42.67	0.0136	0.0158	-153.46	12.2915	0.3363
0.3434	1484	1.0703	2.1627	42.43	0.0135	0.0159	-125.38	10.2887	0.3362
0.3924	1488	1.0725	2.1648	42.11	0.0134	0.0160	-107.05	8.6861	0.3359
0.4415	1491	1.0741	2.1668	41.88	0.0133	0.0160	-90.05	7.4800	0.3358
0.4905	1495	1.0768	2.1686	41.55	0.0132	0.0161	-79.76	6.3787	0.3357

Table-3: Experimental data of Lanthanum chloride in acetic acid at 40°C

C Mol/lit	U M/sec	ρ g/cm ³	η c.p.	$\beta_s \times 10^{12}$ cm ² /dyne	L_f Å	$Z \times 10^5$ g/s.cm	$\phi_K \times 10^9$ cm ² /dyne	Sn	Ra
0.0491	1424	1.0580	2.1078	46.61	0.0150	0.0151	-1152.74	80.2115	0.3367
0.0981	1427	1.0599	2.1086	46.33	0.0149	0.0151	-557.32	39.5466	0.3366
0.1472	1431	1.0621	2.1095	45.98	0.0148	0.0152	-365.53	25.8820	0.3363
0.1962	1435	1.0638	2.1108	45.65	0.0147	0.0153	-266.86	19.0233	0.3359
0.2453	1438	1.0668	2.1116	45.33	0.0146	0.0153	-210.04	14.8141	0.3362
0.2943	1442	1.0693	2.1128	44.97	0.0144	0.0154	-172.67	11.9579	0.3360
0.3434	1445	1.0716	2.1136	44.69	0.0143	0.0155	-143.31	9.9204	0.3361
0.3924	1448	1.0739	2.1148	44.41	0.0143	0.0156	-121.22	8.3610	0.3361
0.4415	1452	1.0770	2.1155	44.04	0.0141	0.0156	-107.28	7.0434	0.3361
0.4905	1456	1.0803	2.1164	43.66	0.0140	0.0157	-96.44	5.9449	0.3362

CONCLUSION

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

ACKNOWLEDGEMENTS

Authors thanks to Dr. Sushila Tyagi, Director, Kr. R.C.M.P.G. College, Mainpuri for the providing lab facility.

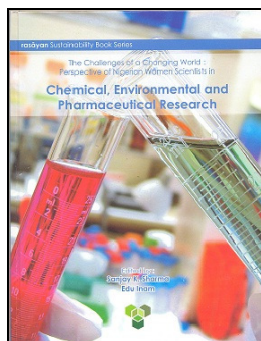
REFERENCES

1. V.Kannapan, Xavier Jesu, S. Raja and R. Jaya Santhi, *Ind. J. Pure and Appl. Phys.*, **41**, 690, (2003).
2. R. Mehra and M. Pancholi, *J. Ind.Chem. Soc.*, **82**, 791, (2005).
3. A. Dhanalaxmi and S.Sekar, *J. Pure Appl. Ultrason*, **21**, 97, (1990).
4. R.D. Rai, R.K. Shukla and J.D. Pandey, *J. Chem. Thermodynamics*, **21**,125, (1989).
5. M.S. Khanwalkar, *Acoustics Lett.* **14**, 229, (1991).
6. J.D. Pandey, V.N. Shrivastava, V. Vyas and N. Panta, *Indian J. Pure Appl. Phys.*, **25**, 467, (1987).
7. A.N. Kannapan and V. Rajendran, *Acoustica*, **75**, 192, (1991).
8. J.Timmermann, *Physico – Chemical constant of pure organic compounds*, Elsevier Publishing Co. Inc. New York (1950).
9. A.Wiessberger, *Techniques of the organic Chemistry Vol. 7*, Interscience publishers, New York (1959).
10. R.C. Weist, *C.R.C. Handbook of Chemistry Physics 58 ed.* C.R.C. Press Inc. 18901, (1977-78).
11. G.L. Goober, *Ultrasonics, Theory and Applications*, The English University Press, London, (1968).
12. A.K. Gupta C.K. Yadav and K.Krishna, *J. Ind. Council Chem.*, **17**, 32, (2004).
13. R.B. Yadav, A.K. Gupta and C.K. Yadav, *J. Ind. Council Chem.*, **14**, (1997).
14. P.S.Nikam and A.B. Sawant, *J. Chem. Engg. Data*, **42**, 585, (1997).
15. P.S.Nikam and A.B. Sawant *J. Mol. Liq.*, **75**, 199, (1998).
16. A.R. Mahajan, S.R. Mirgane, S.B. Deshmukh, *Material Science Research India*, **4**, 345, (2007).
17. P.S.Nikam and M. Hasan, *J. Chem. Engg. Data*, **33**, 165, (1988).
18. P.B. Agrawal, M. Idrees, M. Siddiqui and M.L. Narwade, *Indian J. Chem.*, **42A**, 42, (2003).

[RJC-875/2012]

Absolutely FREE*

[For New life Members]



**The Challenges of a Changing World:
Perspective of Nigerian Women
Scientists in Chemical, Environmental
and Pharmaceutical Research**

[ISBN: 978-81-921149-0-3]

Print Price: Rs. 990/- only

Be a Proud Life Member of

RASĀYAN J. Chem.

Life Membership for Individuals: Rs.8000/- for Indians and USD 1000 for others.

Life Membership for Institutional: Rs.10000/- for Indians and USD 1500 for others.

BENEFITS OF LIFEMEMBERSHIP:

1. You will receive the journal and all its special issues regularly lifelong.
2. If you are a LIFE MEMBER, you need not to pay subscription fee every time for publication of your paper in RJC.
3. You'll be a Reviewer for RJC manuscripts of your Field Interest and we'll publish your name in our journal.
4. You will be exempted from Registration Fee of any National or International future events (i.e. workshop, seminars, Conferences etc.) organized by RJC.
5. You may be elected as Editorial Member of RJC (Note: It'll depend upon your publication and scientific achievements).
6. New Life members shall have a **BOOK*** absolutely **FREE** from RJC with Complements.

For being a **Life Membership**, just mail to editor-in-Chief with your detailed Resume.