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ULTRASONIC STUDIES OF $Co(NO_3)_2$ IN ISOPROPANOL WATER SOLVENT AT 303.15 K

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Various acoustic parameters such as isentropic compressibility (β_s), intermolecular free length (L_f), apparent molar volume (ϕ), apparent molar compressibility (ϕ_k), molar compressibility (w), molar sound velocity (R), acoustic impedance (z) of $Co(NO_3)_2$ in 10%, 20%, 30% and Isopropanol water at 303.15 K have been determined from ultrasonic velocity (V), density (ρ) and relative viscosity (η_r) of the solution. These parameters are related with the molar concentration of the solution and reflects the distortion of the structure of the solvent (*i.e.*, Isopropanol-water) when the solute is added to it.

INTRODUCTION

Studies on the solution of structure of aqueous electrolytes are numerous. Viscometry [1, 2] is an important tool in order to elucidate the solute-solvent interaction and the nature of a solute as a structure maker or a structure breaker. Viscosity and density data provide an insight into the state of association of the solute and the extent of its interaction with solvent. Moreover, ultrasonic studies [3,4] leading to several acoustic parameters provide necessary information regarding structural effects of the solute and solvent in solution. Nomoto *et al.* [5], made successful attempts to evaluate sound velocity in binary liquid mixtures. The nature and degree of molecular interactions in different solutions depend upon several factors, *i.e.*, the nature of the solvent, the structure of the solute and also the extend of salvation taking place in the solution. Some earlier works [6, 7] dealt with the study of solute-solvent interaction from viscosity and ultrasonic measurements in both aqueous and non-aqueous media. The present work reflects the molecular interaction studies of $Co(NO_3)_2$ in Isopropanol-Water solvent at 303.15 K. An attempt has also been made to evaluate the ultrasonic velocities and other acoustic parameters in $Co(NO_3)_2$ and Isopropanol-Water mixture using Nomoto and ideal mixing relations.

RESULTS AND DISCUSSION :

Table 1 shows that the relative viscosity (η_r) increases with the increasing % volume of Isopropanol. It may be due to increase degree of *H*-bonding between CH_2OHCH_2OH and H_2O. The relative viscosity increases with increasing concentration of solute. This fact follows the work of Widemann [8] *et al*.

The apparent molar volume (ϕ) was determined from the following equation

$$\phi = \frac{M}{\rho_0} . \frac{(\rho - \rho_0)}{\rho_0} \frac{10^3}{c}$$

and the results are noted in Table-1.

where *M* = molecular mass of the solute'

ρ_0 = density of the solvent,

ρ = density of the solution and

c = molar concentration of the solution.

The data follows Masson's equation [9] (plot of ϕ vs $c^{1/2}$ is linear $\phi = \phi_0 + s_v c^{1/2}$)

Table 1 : Physical properties of $Co(NO_3)_2$ in Isopropanol-water at 303.15 K

Concentration mol Cm^{-3}	η_r kg.$m^{-1}s^{-1}$	ρ gm mL^{-1}	ϕ cm^3 mol^{-1}
(i) 10% Iso-Propanol in water			
0.1000	1.088119	1.04233	265.9077
0.0750	1.067263	1.03508	273.1583
0.0500	1.046155	1.02783	280.4085
0.0250	1.024559	1.02057	287.6589
0.0100	1.011000	1.01629	292.0092
0.0075	1.008621	0.01554	292.7342
0.0050	1.006167	0.01477	293.4593
0.0025	1.003550	1.01404	294.1843
0.0010	1.001791	1.01361	294.6193
0.0000	1.000653	1.03329	-
(ii) 20% Iso-Propanol in water			
0.1000	1.092249	1.05654	270.0449
0.0750	1.070592	1.04929	277.2950
0.0500	1.004842	1.04204	284.5450
0.0250	1.025749	1.04204	291.7941
0.0100	1.001152	1.03479	296.1451
0.0075	1.009025	1.03044	296.8701

0.0050	1.006447	1.02971	297.5951
0.0025	1.003710	1.02899	298.3202
0.0010	1.001869	1.02783	298.7552
0.0000	1.000765	1.02754	-
(iii) 30% Iso-Propanol in water			
0.1000	1.100656	1.06955	273.834
0.0750	1.076729	1.06230	281.083
0.0500	1.052535	1.05504	288.333
0.0250	1.027828	1.04785	295.583
0.0100	1.012370	1.03044	296.145
0.0075	1.009668	1.02976	296.870
0.0050	1.006882	1.02899	297.595
0.0025	1.003935	1.02826	298.322
0.0010	1.001965	1.02783	298.755
0.0000	1.000872	1.02754	-

The values of the limiting apparent molar volume (ϕ_0) and slope (s_v) calculate J from the plots are recorded in Table 2. The positive value of s_v indicates the ion-ion interaction. The increase of ϕ_0 with increasing concentration of Isopropanol may be attributed to low surface charge density.

As a result the electrostatic attraction is more in a medium of low dielectric constant. The plot of $(\eta_r\text{-}1)/c^{1/2}$ is linear, which is in good agreement with the Jones-Dole equation [10].

$$\eta_r = 1 + A\sqrt{C} + BC$$

$$\frac{\eta_r - 1}{c^{1/2}} = A + BC^{1/2}$$

The value of A and B obtained from the plot are recorded in Table 2.

Table 2 : Limiting apparent molar volume (), Limiting slope (s_v), A & B of $Co(NO_3)_2$ in Isopropanol-water 303.15 K

Parameter	**10%**	**20%**	**30%**
ϕ_0 ($cm^3\ mol^{-1}$)	37.56	38.71	40.47
s_v($cm^{9/2}\ mol^{-3/2}$)	25.30	26.01	27.70
$A \times 10^2$ ($mol^{-1/2}\ L^{1/2}$)	3.31	3.34	3.45
B (mol^{-1} L)	0.78	0.82	0.90

The increasing value of A with Isopropanol contents supports the increase in electrostatic attraction as well as in ion-solvent interactions while the increase in s_v values attribute to large size of solvent molecules and strong association between water and organic solvent through H-bonding.

Table 3 : Variation of acoustic parameters of $Co(NO_3)_2$ in Isopropanol and water at 303.15 K.

Concentration mole dm^{-3}	U m/sec	$\beta_s \times 10^{-11}$ $cm^2 dyne^{-1}$	W	R	$Z \times 10^{-5}$ $cm^2 dyne^{-1}$	$L_f \times$ 10^{-11} m	$\phi_k \times 10^{-8}$
10% Isopropanol in water							
0.1000	1574	3.87244	8577.545	15075.34	1.640628	1.24234	-2.1361
0.0750	1570	3.87244	8622.748	15168.07	1.625076	1.24986	-2.2225
0.0500	1568	3.95719	8671.699	15268.58	1.611637	1.25586	-2.5813
0.0250	1565	4.00060	8719.705	15367.24	1.597206	1.26273	-3.4306
0.0100	1561	4.03834	8745.293	15419.86	1.586333	1.26867	-3.8083
0.0075	1560	4.04640	8749.043	15841.86	1.584186	1.26994	-5.3370
0.0050	1559	4.05449	8752.797	15435.30	1.582040	1.27121	-5.3901
0.0025	1556	4.07305	8753.342	15436.42	1.577868	1.27411	-5.3606
0.0010	1555	4.08004	8754.954	15439.74	1.576177	1.27520	-6.4170
0.0000	1554	4.08646	8755.492	15440.84	1.574713	1.27621	-
20% Isopropanol in water							
0.1000	1589	3.74857	8501.567	14919.67	1.678844	1.22231	-2.9573
0.0750	1585	3.79355	8545.736	15010.14	1.663127	1.22962	-3.3448
0.0500	1583	3.82960	8593.573	15108.22	1.649551	1.23540	-4.2982
0.0250	1580	3.87109	8640.471	15240.44	1.634970	1.24212	-6.9408
0.0100	1572	3.92210	8659.159	15242.82	1.619853	1.25108	-.11757
0.0075	1570	3.93988	8661.234	15247.08	1.616654	1.25311	-.13973
0.0050	1569	3.94768	8664.887	15254.59	1.614487	1.25435	-.19401
0.0025	1566	3.96562	8665.384	15255.61	1.610265	1.25720	-3.1632
0.0010	1564	3.97745	8665.362	15255.56	1.607528	1.25907	-.67256
0.0000	1562	3.98877	8664.290	15253.36	1.605019	1.26086	-
30% Isopropanol in water							
0.1000	1598	3.66137	8426.421	14765.93	1.709147	1.20801	-3.6744
0.0750	1595	3.70024	8471.139	14857.39	1.694375	1.21440	-4.3823
0.0500	1593	3.73503	8517.954	14953.23	1.680701	1.22010	-5.8798
0.0250	1590	3.77507	8563.831	15047.23	1.666009	1.22010	-.10161
0.0100	1583	3.82441	8583.595	15087.75	1.651789	1.22662	-.20476
0.0075	1580	3.84162	8584.056	1508.870	1.647513	1.23461	-.25009
0.0050	1578	3.85404	8586.067	15092.82	1.644283	1.23738	-.35031

0.0025	1575	3.87143	8586.521	15093.75	1.640016	1.24128	-.63111
0.0010	1570	3.89776	8591.797	15084.06	1.634126	1.24639	-.01314
0.0000	1565	3.92380	8576.027	15072.23	1.628468	1.25055	-

The ultrasonic [11,12] velocity (*U*), isentropic compressibility (β_s) [13], Molar compressibilities (w), Molar sound velocity (R), Accoustic impedance (Z) [14], inter molecular free length (L_f) and Apparent molar compressibility (ϕ_k) of $Co(NO_3)_2$ in 10%, 20% and 30% Isopropanol H_2O at 303.15 K are recorded in the Table 3.

U, W, R, ϕ_k increases while β_s, Z, L_f decreases with increasing contents of Isopropanol in the solvent, suggest the powerful interaction between Isopropanol and water.

The increase in U, Z, ϕ_k while decrease β_s, w, R, L_f with increasing concentration of the solute represents the decease in cohesive force. The decrease in cohesive force is responsible for the structure breaking nature of the solute. The H-bond exists between Isopropanol and Water is disrupted by the solute molecule and there by formation of new bonding between solute and solvent molecules has occurred.

EXPERIMENTAL

The solvents used were purified by appropriate method. Isopropanol and water were triple distilled. Purity was about 99.9% which was in good agreement with the standard values [15] of density, viscosity etc. The solvents of different Isopropanol contents were prepared by taking required volume of Isopropanol in distilled water.

The ultrasonic velocity was measured (with an accuracy ± 0.5 ms^{-1}) by single crystal variable path ultrasonic interferometer (Mittal Enterprise, Model F-81) operating at a frequency of 5 MHz. Water from a thermo statically regulated bath (Toshniwal, India) equipped with Jumo D.B.P. temperature sensor was circulated with a single holder (with double wall) to maintain the temperature of liquid constant at 303.15 K with a precision of ± 0.01 K. The viscosity of the solutions was measured by a calibrated Ostwald viscometer. The viscometer was immersed in a constant temperature water bath and a time of flow was measured with the help of a cathetometer. Ten observations were taken for each measurement.

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