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SOLVOLYTIC STUDY OF BINARY MIXTURE OF IRON PENTACARBONYL IN CLORO BENZENE AT 35°C

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ABSTRACT

Viscosity (η), density (ρ), and ultrasonic velocity (U) are reported for binary mixtures of iron pentacarbonyl with chlorobenzene over entire range of composition at 35°C and atmospheric pressure from the experimental data, various acoustical parameters such as adiabatic compressibility (β), intermolecular free length (L_f), specific acoustic impedance (Z), apparent molal compressility (ϕ_k), solvation number (S_n) and relative association (Ra) were calculated and found close association between solute and solvent interactions.

Keywords: Ultrasonic velocity, Iron penta carbonyl,Adiabatic comppressibility.

INTRODUCTION

In recent years, ultrasonic velocity studies in many of the aqueous[1-2], pure non-aqueous[3-4] and mixed[5-10] electrolytic solutions have led to new insights into the process of ion-ion and ion-solvent interactions. Mixed[11-13] liquids rather than single pure liquids in varying proportions are of almost practical importance in most chemical and industrial processes. In the present work an attempt has been made to investigate the behavior of almost practical importance in most chemical and industrial processes. In the present work an attempt has been made to investigate the behavior of binary solutions of $Fe(CO)_5$ in chlorobenzene with regard to adiabatic compressibility, intermolecular free length, specific acoustic impedance and relative association from ultrasonic measurements at 35°C. Iran pentacarbonyl is used as an antiknocking agent in the molar fuels and as a catalyst in organic reactions. It is also used in the manufacture of powdered iron cores for high frequency coils used in the radio and television industries.

EXPERIMENTAL

All chemicals used in the research work are of analytical reagent (AR) grade obtained from E.Merk and Riedal. The purity of the used chemicals was checked by density determination at 35°C. The values of density obtained tally with the literature values. Binary liquids mixtures of different known compositions were prepared in airtight-stoppered measuring flask to minimize the leakage of volatile liquids. Weights of the samples were measured using electronic balance with an accuracy of ±0.01mg. The double walled bicapillary pyknometer was used for the measurement of densities of solvents and solutions[14-15]. Uncertainty in density measurement is within the range of ±0.0005gm/cm^3. An ubbelohde viscometer, having frequency of 2 MHz (Mittal Enterprises, New Delhi, Model: F-81) with an accuracy of ±0.05%[16-17]. All measurements were made in a thermostatically controlled water bath with temperature accuracy of ±1°C. Detailed of experimental techniques are given elsewhere[18].

Theory and calculations

Different thermodynamic parameters such as adiabatic compressibility (β), intermolecular free length (L_f), specific acoustic impedance (Z), apparent molal compressibility (ϕ_k), solvation number (S_n) and relative association (Ra), have been calculated at 35°C, using ultrasonic velocity (U), density (ρ) and viscosity (η) of these solutions with the help of the following equations.

$$\beta = U^{-2} \times \rho^{-1} \quad (1)$$

$$L_f = K \times \beta^{-1/2} \quad (2)$$

$$Z = U \times \rho \quad (3)$$

$$\phi_k = 1000 (\rho^\circ \beta - \beta^\circ \rho) / C \rho^\circ + (\beta^\circ \times M) / \rho^\circ \quad (4)$$

$$S_n = n_1/n_2 (1- \beta / \beta^\circ) \quad (5)$$

$$Ra = (\rho/ \rho^\circ) (U^\circ/ U)^{1/3} \quad (6)$$

Where ρ, ρ°and U, U° are the densities and ultrasonic velocities of solution and solvent, respectively; K is Jacobson constant; M molecular weight of solute; β° and β the adiabatic compressibility of solvent and solution, C is concentration in mole/litre; n_1 and n_2 are the number of moles of solvent and solute, respectively.

Table-1: Measured parameters of Fe $(CO)_5$ in chlorobenzene at 35°C.

C mol/lit	ρ g/cm^3	η c.p.	U m/sec	β× 10^{12} cm^2/dyne	$\phi_k \times 10^9$ cm^2/dyne	Z × 10^5 g/s.cm	L_f A	R_a	S_n
0.0590	1.0191	0.7726	1395	49.21	-4.7671	0.1457	0.4465	0.0567	5.9505
0.1179	1.0250	0.7785	1397	48.79	-4.0665	0.1467	0.4446	0.1134	10.9761
0.1769	1.0309	0.7844	1399	48.38	-3.8011	0.1477	0.4427	0.1701	15.9383
0.2359	1.0368	0.7903	1401	47.97	-3.6448	0.1488	0.4409	0.2267	20.8383
0.2948	1.0427	0.7962	1403	47.57	-3.5325	0.1498	0.4390	0.2832	25.6772
0.3538	1.0486	0.8021	1405	47.18	-3.4424	0.1509	0.4372	0.3397	30.4560
0.4128	1.0545	0.8080	1407	46.79	-3.3653	0.1519	0.4354	0.3961	35.1756
0.4717	1.0604	0.8139	1409	46.40	-3.2965	0.1530	0.4336	0.4524	39.8372
0.5307	1.0663	0.8196	1411	46.02	-3.2333	0.1540	0.4318	0.5088	44.4417
0.5897	1.0722	0.8257	1413	45.64	-3.1743	0.1551	0.4300	0.5650	48.9901

RESULTS AND DISCUSSION

The measured parameters viz. ultrasonic velocity (U), density (ρ), viscosity (η) are given in the table (1). The table shows these three parameters increase with concentration of $Fe(CO)_5$. This indicates that strong interaction observed at higher concentrations of $Fe(CO)_5$ and suggests more association between solute and solvent molecules in the system. The variation of ultrasonic velocity in a solution depends on the intermolecular free length on mixing. On the basis of a model for sound propagation proposed by Eyring and Kincaid[6], ultrasonic velocity increases on decrease of free length and vise versa. Intermolecular free length is a predominant factor in determining the variation of ultrasonic velocity in fluids and their solutions. In the present investigation, it has been observed that intermolecular free length decreases linearly on increasing concentration of $Fe(CO)_5$ in chlorobenzene. This indicates significant interaction between solute and solvent, suggesting a structure promoting behavior on the addition of $Fe(CO)_5$. As expected, adiabatic compressibility (β) decreases with increase of concentration of $Fe(CO)_5$ indicating that the molecules are nearer in the system. Table (1) shows the acoustic impedance (Z) increases with the increase in concentration of $Fe(CO)_5$. The increase in ultrasonic velocity, acoustic impedance and decrease in adiabatic compressibility, intermolecular free length with the addition of $Fe(CO)_5$ indicates the intermolecular forces are increases with addition of $Fe(CO)_5$.

Relative association is influence by two factors[19] (i) the breaking up of the solvent molecules on addition of electrolyte to it and (ii) the salvation of ion that are simultaneously present; the former resulting in a decrease and later increase of relative association. In the present investigation, it has been observed that relative association value increases with the concentration of $Fe(CO)_5$ indicating close association between solute and solvent. Solvation number (S_n) are calculated and listed in table (1). The S_n values are found to increase with the increase in solute, which also suggested close association between solute and solvent.

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