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Solute-solvent Interaction In The Solution Of 1,4-dihydroxy Benzene In Methanol And Ethanol

DR. SHIV NANDAN

Associate Professor- Department of Chemistry, N.D. College, Shikohabad-Firozabad (U.P), India

Received- 21.02.2021, Revised- 25.02.2021, Accepted - 28.02.2021 E-mail: aaryvart2013@gmail.com

Abstract: ***Ultrasound velocity measurement of 1, 4-dihydroxy 1-4-benzene in Methanol and ethanol have been correct out for the study of solute-solvent interaction. Various acoustic impedance, Molar sound velocity, apparent molal adiabatic compressibility, relative association and solution number have been evaluation using ultrasonic velocity data. The result was discussed in the light of solute-solvent interaction between the molecules.***

Key words- Solute-Solvent Interaction, Acoustic parameters, Intermolecular free length, compressibility.

Introduction

Several techniques such as IR, NMR, Raman spectrocopy and Ultrasound have been used for the determination of molecular and ion-solvent interaction[1-6]. The present work deals with the study of solute-solvent interaction in the solution of 1, 4-dihydroxy benzene in methanol and ethanol using ultrasound velocity data. The values of ultrasound velocity, specific acoustic impedence, apparent molal adiabatic compressibility. Relative association and solvation number increases while the isentropic compressibility, intermoleculer free length and molar sound velocity decrease with increasing 1, 4-dihydroxy benzene concentration.

Experimental

All the chemicals used in the present study are of AR/BDH quality. A known amount of 1, 4-dihydroxy benzene is dissolved in methanol and ethanol so as to obtain various concentration solutions. The ultrasound velocity in these solutions was measured using a multifrequency ultrasound interferometer (F-81 Mittal Enterprises, New Delhi) at a fixed frequency of 2 MHz and a constant of the solvent and solutions are measured using a specific gravity bottle.

The various acoustic parameters, viz isentropic compressibility (β_s), inter molecular free length (L_f)[7], specific acoustic impedance (Z)[8], molar sound velocity (R), relative association (R_A)[9] Solvation number (S_n)[10] and apparent molal adiabatic compressibility (ϕ_k) have been evaluated by using the following relationships :

1. $\beta_s = 1/u^2\rho$
2. $L_f = K\sqrt{\beta_s}$
3. $Z = u.\rho$
4. $R = M/\rho.V^{1/3}$

   Where [$M = n_1m_1 + n_2m_2/n_1 + n_2$]
5. $R_A = (\rho/\rho_0)(V_0/V)^{1/3}$
6. $S_n = n_1/n_2\left(1\beta_S/\beta_{S_0}\right)$ and
7. $\phi_k = \dfrac{100}{C.\rho_0} = \left(\rho_0\beta_S - \beta_{S_0} + \beta_S.M/\rho_0\right)$

Where $u_0, u; \rho_0, \rho; \beta_{S_0}, \beta_S$ are the ultrasonic velocity density and isentropic compressibility of the solvent and solution respectively, n_1, n_2 and m_1, m_2 are the number of moles and molecular weight of the solvent and solute respectively and K and C are the temperature dependent Jacobson's constant and concentration respectively.

Results and Discussion

Ultrasound velocity (u) in the solution of 1, 4-dihydroxy benzene in methanol and ethanol increases with increasing concentration of 1, 4-dihydroxy benzene. The variation of velocity with concentration (c) can be expressed by the following relationship.

$$du/dc = -u/2\left[1/\rho\left(d\rho/dc\right) + 1/\beta_S\left(d\beta_S/dc\right)\right]$$

In general results show that while the density increase, the isentropic compressibility decrease with increasing concentration of solute and the quantity $\left(d\rho/dc\right)$ is positive while $\left(d\beta_S/dc\right)$ is negative. Since the values of $\left[1/\beta_S\left(d\beta_S/dc\right)\right]$ are larger than the values of $\left[1/\rho\left(d\rho/dc\right)\right]$ for 1, 4 dihydroxy benzene solutions in methanol and ethanol, the concentration derivative of velocity, $\left(du/dc\right)$ is positive i.e. the ultrasonic velocity increases with increasing the concentration of solute.[11-13]

The isentropic compressibility $\left(\beta_S\right)$ of 1, 4-dihydroxy benzene solutions decreases with increase in the molar concentration of solute. The complimentary use of isentropic compressibility data can provide interesting information on solute solvent interaction. The results of isentropic compressibility have been explained in terms of Bachem's equation.[14]

$$\beta_S = \beta_{S_0} + AC + BC^{3/2}$$

Where β_{S_0} is the compressibility of the solvent, C is the molar concentration and A & B are constants. The values of constants A (-15.34 and -14.3) and B (1.455 and 2.551) were obtained from the intercept and slope of the plots, $\left[\left(\beta_S - \beta_{S_0}\right)/C\right]$ versus $C^{1/2}$ for the solutions of alcohols.

Apparent molal adiabatic compressibility $\left(\phi_k\right)$ varies linearly as the square root of concentration $\left(C^{1/2}\right)$. The values of apparent molal adiabatic compressibility are negative with the increase in molar concentration. The values of limiting apparent molal adiabatic compressibility $\left(\phi_k^0\right)$ were evaluated by extra polating the graph of ϕ_k versus $C^{1/2}$ (as shown in figure). The values of ϕ_k [-28.90 and -26.80 cm^2/dyne.10]^9 for the solutions of 1, 4-dihydroxy benzene in methanol and ethanol respectively. These results are in agreement with the results reported by Masson[15] for electrolytic solutions.

The intermolecular free length (L_f) decreases while the specific impedance (Z) increases with an increase in the solute Concentration. This indicates that there is a significant interaction between the solute and solvent molecules. The increase in the values of specific impedance (Z) with increasing 1, 4-dihydroxy benzene concentration can be explained on the basis of lyophobic interaction between solute and solvent molecules which increases the inter molecular distance making relatively under gaps between the molecules and becoming the main cause of impedance in the propagation of ultrasound waves. The values of molar sound velocity (R) solvation number (S_n) and relative association (R_A) vary linearly with the concentration suggest a significant interaction between the solute-solvent molecules and the values are in agreement with the reported for solution of cobalt carboxylates[16].

The results of ultrasound velocity show that the 1, 4-dihydroxy benzene behaves as a weak electrolyte and there is a significant interaction between the 1, 4-dihydroxyy benzene solvent molecules.

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