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Effect of Addition of Antibiotic Drug Ciprofloxacin on Binary Solvent Aqueous Ethanol at 303 °K

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ABSTRACT

Ultrasonic and density measurements on Ciprofloxacin in various percentages of ethanol and water are carried out at 303 °K. Parameters such as adiabatic compressibility, apparent molal volume, apparent molal compressibility and intermolecular free length of the solution have been computed from these data. Results show that molecular interactions are more at lower concentrations of Ciprofloxacin in aqueous ethanol.

Introduction:

Considerable scientific and practical interest has been stimulated by the investigation of organic liquids by ultrasonic measurements [1-3]. Studies involving density and viscosity measurements are important for the elucidation of ion-solvent, ion-ion, solvent-solvent interactions in mixed solvent systems. The nature and degree of molecular interactions in the solution depend upon the nature of medium, the structure of solute molecule and also the extent of solvation [4-5] taking place in the solution. Various thermodynamic and acoustical parameters have been reported by the study of aqueous,

non-aqueous, pure and mixed electrolytic and non-electrolytic solutions [6-11].Ultrasonic, viscometric and volumetric studies of some substituted acetophenons and acetic acid in THF water, DMF water and dioxane water at 303.15 oK are reported by Aswar et al [12-13]. Hedaoo et al [14] reported adiabatic compressibility, apparent molal volume, apparent molal compressibility and solvation number of 2,3-Dihydroquinazolin-4 (1H)-one derivatives in 27% DMF water. Chaudhari et al [15] reported thermodynamic and acoustic parameters of substituted ampicillin in aqueous ethanol at 303 oK. In the present paper thermodynamic and acoustic parameters such as adiabatic compressibility, apparent molal volume, apparent molal compressibility and intermolecular free length of the mixture of substituted Ciprofloxacin in aqueous ethanol at 303 oK is reported.

Experimental:

All the chemicals used for the experiment are of analytical grade. Water was distilled thrice. 0.2 gm KMnO4 and 0.5 gm NaOH was added to each litre of distillate to deionise it. Solution was distilled again and was used for the preparation of different composition of Ciprofloxacin in aqueous ethanol. Solvent ethanol was purified by standard procedure [16]. Purity of solvents was checked by comparing density and viscosity values with literature values.

Density measurements were performed using specific gravity bottle. All the weighing were done on a single pan digital balance with an accuracy of ±0.001 gm.

For ultrasonic measurements M-81 interferometer supplied by Mittal Enterprises was used with measuring frequency of 2 MHz and frequency tolerance of ±20%.

Formulae used for determining acoustical parameters:

1. $\lambda = 2D$
   where λ is wavelength and D is the distance travelled by micrometer screw between 2 consecutive maxima in ammeter.
2. Ultrasonic velocity (U) = $n \times \lambda$.
   Where n = frequency of the generator
3. Adiabatic compressibility [17-18] of the solution (β_s) = $1/(U_s \times \times d_o)$
4. Adiabatic compressibility of the solvent (β_o) = $1/(U_o \times d_o)$
   Apparent molal volume (ϕ_v) and Apparent molal compressibility (ϕ_k) [19-20] are given by the following equations.

5. Apparent molal volume $(\phi_v) = \frac{M}{ds} + \frac{(do - ds)\ X\ 10^3}{(mdo\ ds)}$

6. Apparent molal compressibility $(\phi_k) = \frac{1000(\beta s do - \beta o ds)}{(mdo\ ds)} + \frac{\beta s M}{ds}$

Where d_o and d_s are the densities of the pure solvent and the solution respectively. M is the molality and M is the molecular weight of the solute.

According to studies, intermolecular free length (L_f) [21] is given by

7. Intermolecular free length $(L_f) = K\sqrt{\beta_s}$

Where K is Jacobson's constant and is given by

8. $K = (93.875 + 0.375\ X\ T)\ X\ 10^{-8}$

Where T is the temperature at which the experiment is carried out.

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Result and discussion:

Table 1 and 2 shows the density and ultrasonic velocity measurement data for various concentration of ciprofloxacin in 10% , 20% and 30% ethanol water mixture. Figure 1 and 2 shows the graphs of variation of density and ultrasonic velocity with concentration respectively. Ciprofloxacin is insoluble in water and slightly soluble in ethanol. Keeping the concentration of ethanol fixed in water, density increases with the concentration of the solution. As the concentration of the solvent is increased, density further increases with concentration. Ethanol is a polar molecule. From the computed properties, Ciprofloxacin has 7 hydrogen bond acceptor count, 2 hydrogen bond donor count and 3 rotatable bond count. Increase in the concentration increase the formation of hydrogen bonding between solute-solute molecules. This gives a packed structure. Packing further increases with increase in concentration of the solvent, thereby increasing the density and ultrasonic velocity with the increase in concentration of the solvent.

Table 2 shows the computed values of intermolecular free length and adiabatic compressibility with the concentration of the solution. Figures 3 and 4 shows the graphs of their variation with concentration respectively. Both show decreasing trend. Intermolecular free length decreases with increase in concentration of the solution. It further decreases with increase in concentration of the solvent. This can be attributed to

the fact that, as the concentration of the solution and the solvent increases formation of hydrogen bond between solute-solute molecules increases.

Table 3 shows the values of apparent molal volume (?v) and apparent molal compressibility (?k) calculated from the formulas 5 and 6 respectively, presented in this paper. Figure 5 and 6 shows the graphs of their variation with concentration respectively. Both ?v and ?k are negative for the concentration range of the solution studied. Both ?v and ?k show increasing trend with increase in the concentration of the solution for a fixed concentration of the solvent. This indicates that the solution is more compressible at the lower end of the concentration. Positive Sv values obtained from Masson's equation [22] support the structure making tendency of the solution i.e. hydrophobic nature [23].

Conclusion :

Increase in the trends of density, ultrasonic velocity, ?v and ?k with increase concentration and decreasing trends of adiabatic compressibility and intermolecular free length with increase in concentration, indicates that hydrogen bonding takes place in the solution and it shows structure making tendency.

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Table 1 : Density and ultrasonic velocity at different concentration of Ciprofloxacin in various percentage of ethanol in water

concentration C (moles/ Ltr)	Density d_s			Ultrasonic velocity U_s		
	10% ethanol + Ciprofloxacin	20% ethanol + Ciprofloxacin	30% ethanol + Ciprofloxacin	10% ethanol + Ciprofloxacin	20% ethanol + Ciprofloxacin	30% ethanol + Ciprofloxacin
0.002	0.99814	1.00149	1.00240	1550	1562	1576
0.004	0.99830	1.00193	1.00261	1556	1590	1594
0.005	0.99838	1.00221	1.00330	1571	1600	1612
0.006	0.99846	1.00237	1.00358	1591	1602	1616
0.008	0.99878	1.00289	1.00419	1612	1616	1636
0.01	0.99909	1.00301	1.00472	1632	1642	1684

Table 2 : Intermolecular free length Lf and Adiabatic compressibility ?s at different concentration of Ciprofloxacin in various percentage of ethanol in water

concentration C (moles/Ltr)	Intermolecular free length L_f			Adiabatic compressibility β_s		
	10% ethanol + Ciprofloxacin	20% ethanol + Ciprofloxacin	30% ethanol + Ciprofloxacin	10% ethanol + Ciprofloxacin	20% ethanol + Ciprofloxacin	30% ethanol + Ciprofloxacin
0.002	1.34E-09	1.33E-09	1.31E-09	4.17E-07	4.09E-07	4.02E-07
0.004	1.33E-09	1.30E-09	1.30E-09	4.14E-07	3.95E-07	3.93E-07
0.005	1.32E-09	1.30E-09	1.28E-09	4.06E-07	3.90E-07	3.83E-07
0.006	1.31E-09	1.29E-09	1.28E-09	3.96E-07	3.89E-07	3.81E-07
0.008	1.29E-09	1.28E-09	1.27E-09	3.85E-07	3.82E-07	3.72E-07
0.01	1.27E-09	1.26E-09	1.23E-09	3.76E-07	3.70E-07	3.51E-07

Table 3 : Apparent molal volume ?v and Apparent molal compressibility ?k at different concentration of Ciprofloxacin in various percentage of ethanol in water

Concentration C (moles/Ltr)	Apparent molal volume ϕ_v			Apparent molal compressibility ϕ_k		
	10% ethanol + Ciprofloxacin	20% ethanol + Ciprofloxacin	30% ethanol + Ciprofloxacin	10% ethanol + Ciprofloxacin	20% ethanol + Ciprofloxacin	30% ethanol + Ciprofloxacin
0.002	-6014	-15895	-23591	-20.39E-3	-11.02E-3	-15.17E-3
0.004	-2854	-7865	-11654	-10.93E-3	-9.18E-3	-9.73E-3
0.005	-2221	-6271	-9384	-10.30E-3	-8.35E-3	-9.67E-3
0.006	-1800	-5188	-7803	-10.25E-3	-7.11E-3	-8.37E-3
0.008	-1293	-3860	-5832	-8.95E-3	-6.19E-3	-7.46E-3
0.01	-989	-3023	-4641	-8.10E-3	-6.09E-3	-8.07E-3

Figure 1 : Graph showing variation of density versus concentration of Ciprofloxacin in aqueous ethanol

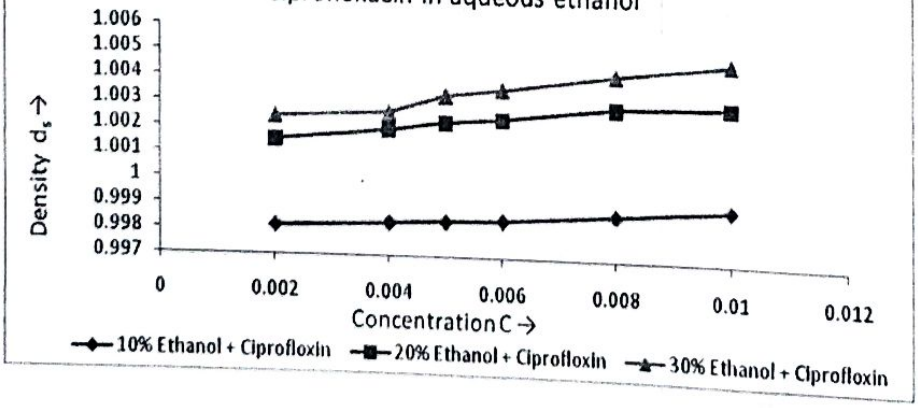


Figure 2 : Graph showing variation of ultrasonic velocity U_s versus concentration C of Ciprofloxacin in aqueous ethanol

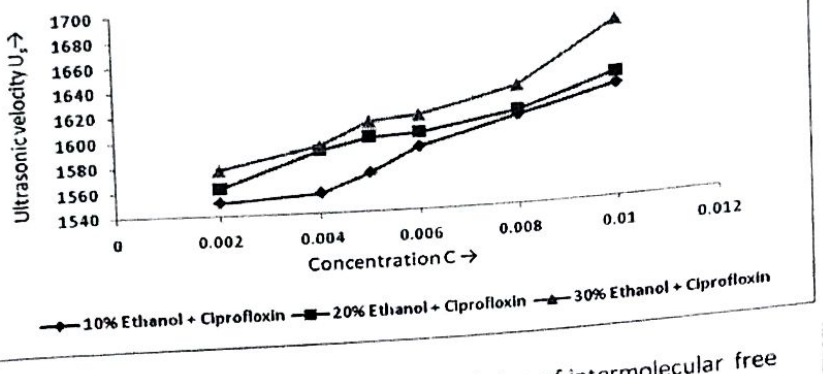


Figure 3 : Graph showing variation of intermolecular free length L_f versus concentration C of Ciprofloxacin in aqueous ethanol

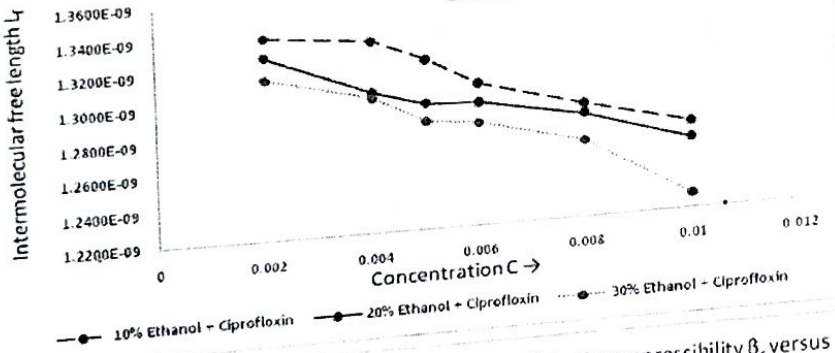


Figure 4 : Graph showing variation of Adiabatic compressibility β_s versus concentration of Ciprofloxacin in aqueous ethanol

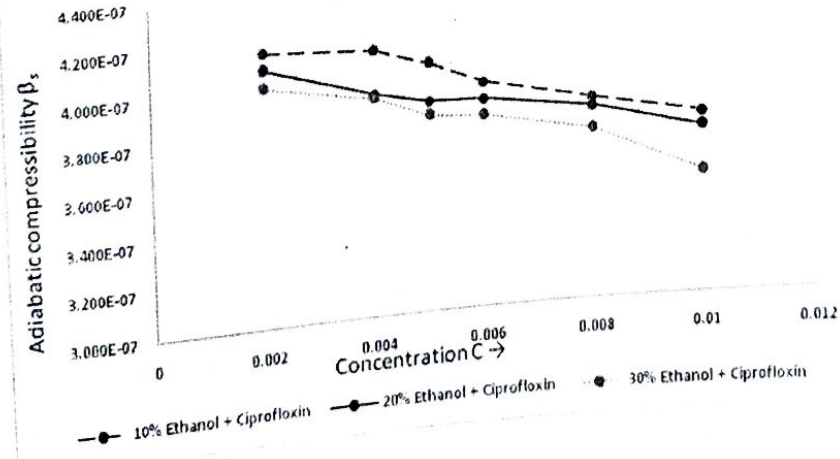


Figure 5 : Graph showing variation of apperant molal volume Φ_v versus concentration C of Ciprofloxacin in aqueous ethanol

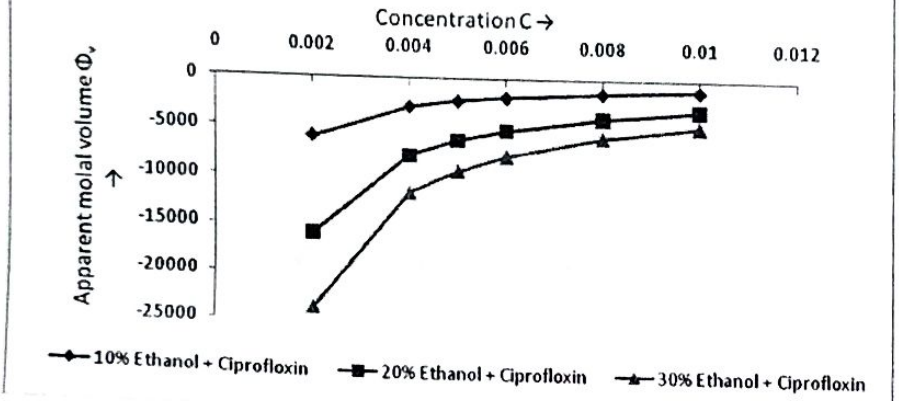
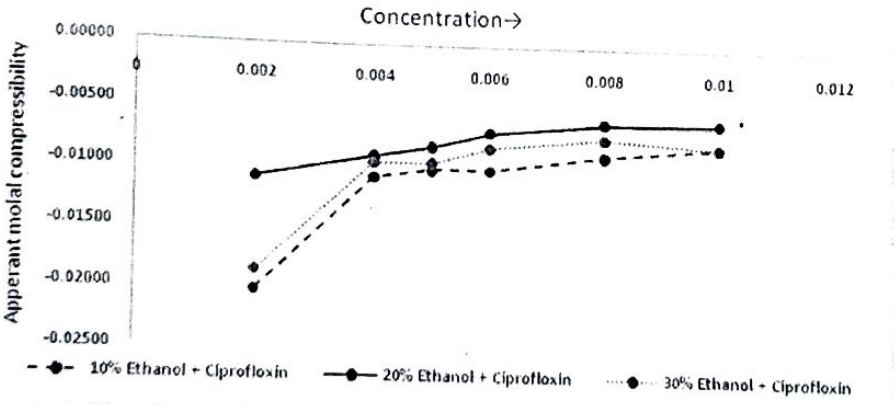


Figure 6: Graph showing the variation of apparent molal compressibility versus concentration of Ciprofloxacin in aqueous ethanol



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