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Ultrasonic, Volumetric and Viscometric Studies of substituted antibiotic Streptomycin in various percentage of aqueous ethanol

M. M. Chaudhari
Maharashtra Mahavidyalaya,
Nilanga, Dist. Latur

S. G. Kulkarni
Maharashtra Mahavidyalaya,
Nilanga, Dist. Latur

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ABSTRACT

Ultrasonic, volumetric, and viscometric studies on antibiotic streptomycin have been carried out in 10%, 20% and 30% aqueous ethanol at 303oK. Various thermodynamic parameters such as adiabatic compressibility, apparent molal volume, apparent molal compressibility and intermolecular free length have been determined. Results are discussed in terms of solute solvent interaction. Study indicates maximum interaction at lower concentration of the solvent.

Introduction:

In recent years, measurement of ultrasonic velocity have been adequately employed in understanding the nature of molecular interactions in pure liquid mixtures. Ultrasonic propagation parameters result valuable information regarding the behaviour of binary liquid systems, because intramolecular and intermolecular association, dipolar interactions, complex formation and related structural changes affect the compressibility of the system which in turn produces corresponding variations in the ultrasonic velocity. Ultrasonic velocities, densities, viscosities and derived thermodynamic and acoustical parameters are of considerable interest in understanding the molecular interactions in

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binary [1-3] and ternary [4-7] liquid mixtures. Various thermodynamic and acoustical parameters of polar liquid mixtures are reported in the literature [8-12].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 [13-14]. Hedaoo et al [15] 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 [16-17] reported thermodynamic and acoustic parameters of substituted ampicillin and ciprofloxacin 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 lengthof the mixture of substituted streptomycin in aqueous ethanol at 303 oK is reported.

Experimental :

All the chemicals used are of analytical grade. Different compositions were made using double distilled water having specific conductance of less than 1X10-6 S cm-1.Solutions of different concentrations were prepared by dissolving known weights of solutes. Density measurements were performed using 10 ml specific gravity bottle. All the weighing were done on a single pan digital balance with an accuracy of ±0.001 gm. Ultrasonic velocities of the solutions were measured using multi frequency ultrasonic interferometer at a frequency of 2 MHz obtained from Mittal Enterprises-Model M81. The accuracy in the measurement of ultrasonic velocity was within ±0.01 ms-1.

Theory :

Sound speeds can be measured by using single frequency ultrasonic interferometer. The ultrasonic waves of known frequency produced by a quartz crystal are reflected by a movable metallic plate kept parallel to the quartz plate. When the state of acoustic resonance is reached due to formation of standing waves, an electrical reaction occurs on the generator driving the quartz plate and its anode current becomes maximum. Micrometer is slowly moved until the anode current meter on high frequency generator shows a maximum. The distance D thus moved by the micrometer between 2 consecutive maxima gives the value of the wavelength [18] by the relation ? = 2 D.

Knowing wavelength ?, ultrasonic velocity U can be determined by the relation U = n ? where n is the frequency of the generator. Various formulas used for calculation are as follows.

Adiabatic compressibility [19-20] of the solution (?s) = 1/(US X X do)

Adiabatic compressibility of the solvent (?o) = 1/(Uo X do)

Apparent molal volume (?v) and Apparent molal compressibility (?k) [21-22] are given by the following equations.

Apparent molal volume (?v) = M/ds+((do - ds) X ?10?^3)/((mdo ds))

Apparent molal compressibility (?k) = (1000(?sdo-?ods))/((mdo ds))+?sM/ds

Wheredo and ds 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 (Lf) [23] is given by

Intermolecular free length (Lf) = K??s

Where K is Jacobson's constant and is given by

K = (93.875 + 0.375 X T) X 10-8

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

Result and discussion:

Streptomycin is soluble in water and insoluble in ethanol.Ethanol is a polar molecule. From the computed properties, streptomycin has 15 hydrogen bond acceptor count, 12 hydrogen bond donor count and 9 rotatable bond count. This shows high probability of formation of hydrogen bond with water molecule. Formation of the bond gives a packed structure to the solution. This certainly should increase the density (ds)of the solution and there by increase the ultrasonic velocity (Us). The data for increase in density and ultrasonic velocity with the increase in the concentration of the solute and solvent is presented in table 1. 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. Figures 1 and 2 shows the graphs of variation of density and ultrasonic velocity with concentration respectively.

Table 2 shows the computed values of intermolecular free length (Lf) and adiabatic compressibility (?s) 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.

The values of apparent molal volume ?v and apparent molal compressibility ?k at different concentration of Streptomycin in 10%, 20% and 30% of ethanol in water are presented in table 3. Figures 5 and 6 shows the graphs of their variation with concentration respectively. All the values of ?v and ?k are negative for the concentration range under study. Both ?v and ?k increases with the concentration of the solution, at fixed concentration of the solvent. But they decrease as the concentration of the solvent is increased.

Limiting values of ?v and ?k are shown table 4. The nature of ?v and ?k as obtained from the data in table 3, together with the positive values of Sv obtained from Masson's equation [24] support the structure making tendency of the solution. The values of limiting parameters, Øov and Øok for different concentration of ethanol in water show the following order. 30% ethanol water < 20% ethanol water < 10% ethanol water. Hence solute solvent interactions are higher in 10% ethanol-water solvent than in the other 2 cosolvents.

Viscosity data were analysed using Jones-Dole equation [25]

$$\frac{\eta}{\eta_0} - 1 = Am^{1/2} + Bm$$

A and B are Falkenhagen and Jones-Dole coefficients respectively, and the other terms have their usual meaning. Positive values of B for all the concentrations of ethanol in water under consideration suggest strong ion solvent interaction.

Acknowledgements :

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

concentration C (moles/Ltr)	Density d_s			Ultrasonic velocity U_s		
	10% Ethanol + Streptomycin	20% Ethanol + Streptomycin	30% Ethanol + Streptomycin	10% Ethanol + Streptomycin	20% Ethanol + Streptomycin	30% Ethanol + Streptomycin
0.002	0.99692	1.00112	1.00309	1449	1590	1614
0.004	0.99806	1.00233	1.00362	1460	1604	1630
0.005	0.99834	1.00261	1.00395	1471	1614	1660
0.006	0.99885	1.00305	1.00407	1480	1621	1680
0.008	1.00004	1.00329	1.00436	1490	1634	1698
0.01	1.00040	1.00365	1.00464	1521	1650	1715

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

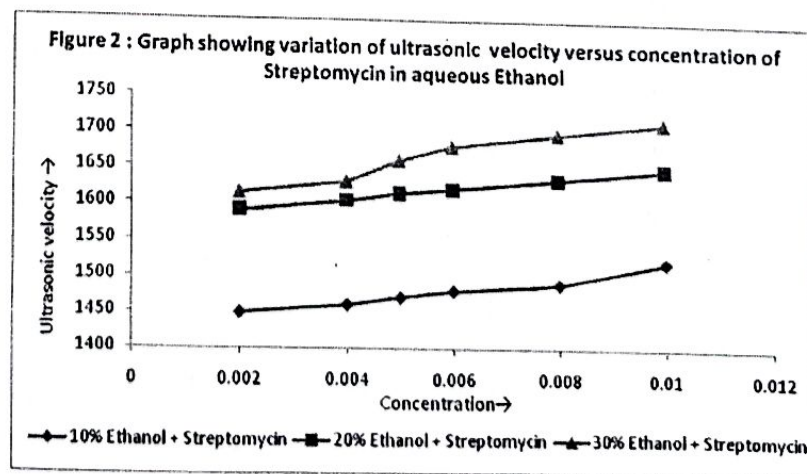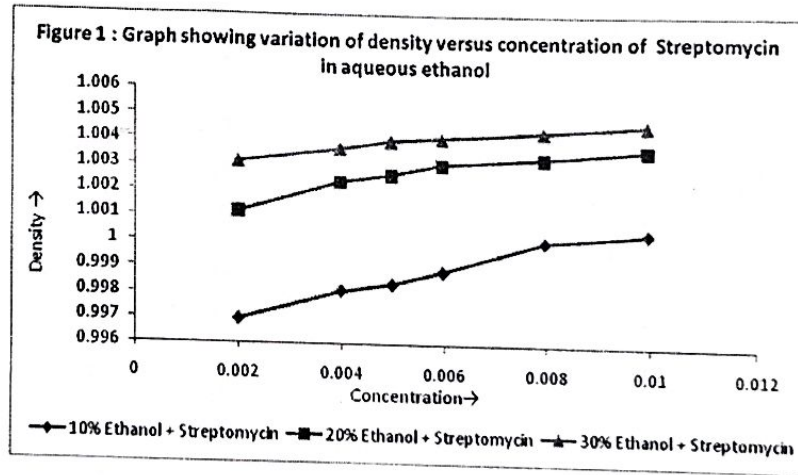| concentration C (moles/Ltr)	Intermolecular free length L_f			Adiabatic compressibility β_s		
	10% Ethanol + Streptomycin	20% Ethanol + Streptomycin	30% Ethanol + Streptomycin	10% Ethanol + Streptomycin	20% Ethanol + Streptomycin	30% Ethanol + Streptomycin
0.002	1.4340E-09	1.3039E-09	1.2835E-09	4.78E-07	3.95E-07	3.83E-07
0.004	1.4224E-09	1.2920E-09	1.2705E-09	4.70E-07	3.88E-07	3.75E-07
0.005	1.4122E-09	1.2837E-09	1.2474E-09	4.63E-07	3.83E-07	3.61E-07
0.006	1.4025E-09	1.2783E-09	1.2323E-09	4.57E-07	3.80E-07	3.53E-07
0.008	1.3924E-09	1.2676E-09	1.2195E-09	4.50E-07	3.73E-07	3.45E-07
0.01	1.3639E-09	1.2550E-09	1.2075E-09	4.32E-07	3.66E-07	3.39E-07

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

concentration C (moles/Ltr)	Apparent molal volume			Apparent molal compressibility		
	10% Ethanol + Streptomycin	20% Ethanol + Streptomycin	30% Ethanol + Streptomycin	10% Ethanol + Streptomycin	20% Ethanol + Streptomycin	30% Ethanol + Streptomycin
0.002	-5202	-15519	-23740	-5.14E-3	-13.34E-3	-28.00E-3
0.004	-2598	-7770	-11712	-4.51E-3	-8.48E-3	-15.86E-3
0.005	-2017	-6156	-9318	-4.93E-3	-7.75E-3	-15.37E-3
0.006	-1670	-5106	-7689	-5.16E-3	-6.98E-3	-14.22E-3
0.008	-1256	-3715	-5657	-4.70E-3	-5.99E-3	-11.54E-3
0.01	-924	-2892	-4438	-5.55E-3	-5.50E-3	-9.88E-3

Table 4: Limiting values of ?v and ?k for Streptomycin in various percentage of ethanol in water

Medium	$\emptyset^{\circ}_{v}$	$\emptyset^{\circ}_{k}$	S_v	S_k
10% E A + Amp	-7771.5	-0.1061	73976	0.0005
20% E A + Amp	-23144	-0.3044	219286	0.0238
30% E A + Amp	-35265	-0.3534	334483	0.0275

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

Figure 2 : Graph showing variation of ultrasonic velocity versus concentration of Streptomycin in aqueous Ethanol

Figure 3 : Graph showing variation of Intermolecular free length versus concentration of Streptomycin in aqueous ethanol

Figure 4 : Graph showing variation of adiabatic compressibility versus concentration of Streptomycin in aqueous ethanol

Figure 5 : Graph showing variation of apperant molal volume versus concentration of Streptomycin in aqueous ethanol
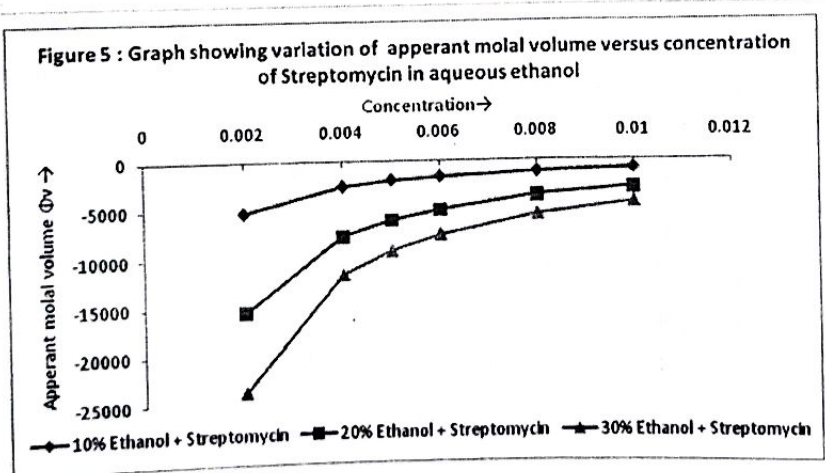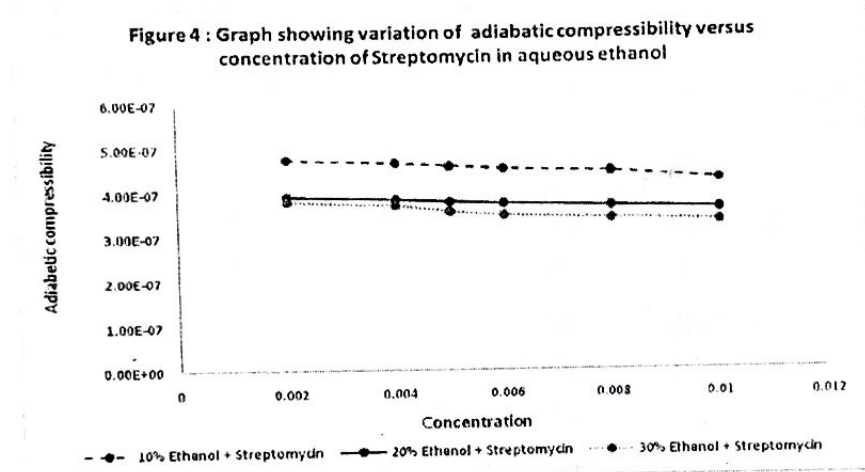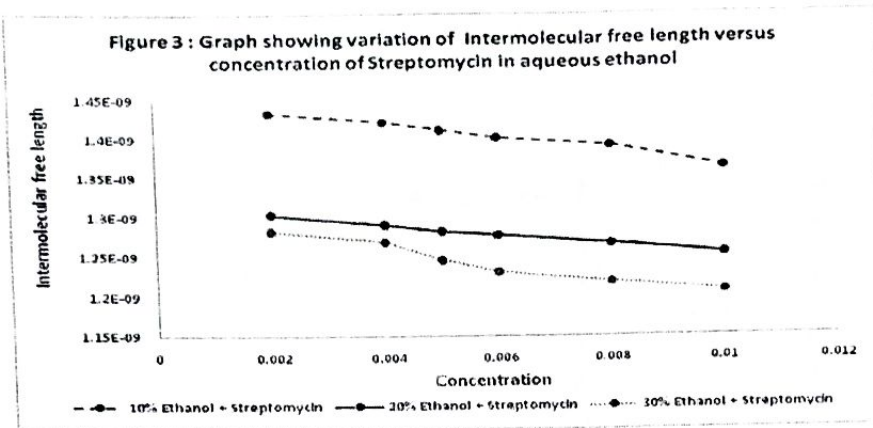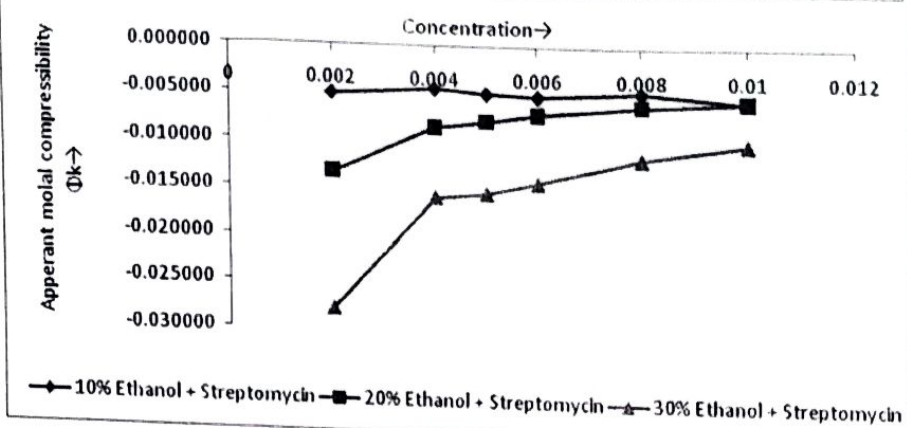
Figure 6 : Graph showing variation of Apperant molal compressibility versus concentration of Streptomycin in aqueous ethanol

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