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Ultrasonic Velocity and allied parameters of drug Colimax in aqueous 1-propanol at 298.15K

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ABSTRACT

Ultrasonic velocity (U) and density (ρ) have been measured at 298.15K for drug colimax in binary mixture of 1-propanol(PrOH)+water(H_2O). Various acoustical parameters such as acoustical impedance (Z), adiabatic compressibility (β), intermolecular free length (L_f), relative association (R.A.), molar volume (V_m) and molar sound velocity (R_m) have been calculated from ultrasonic velocity & density data. The results have been discussed from the view point of drug-solvent and intermolecular interactions.

Key words: Density, drug, 1-propanol, ultrasonic velocity and water.

INTRODUCTION

It stems from the observation that there has not been much research carried out in the measurements of density and ultrasonic velocity of narcotic analgesic drugs for understanding their physico-chemical behaviour in terms of drug-solvent interactions in aqueous alcoholic systems.

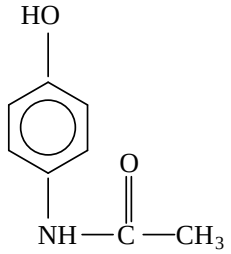
Drug molecules in general are characterized by large hydrophobic groups, and are insoluble in water, they are administered mostly in their salt form. The solution behaviour therefore, depends upon the nature of solvent, functional groups, nature of drug and combination of different constituents forming the drug.

In the view of the above, an attempt has been made to study the density and ultrasonic velocity measurements of narcotic analgesic drug in aqueous-alcoholic systems in order to investigate various kinds of interactions that govern the solution behavior of drug.

EXPERIMENTAL SECTION

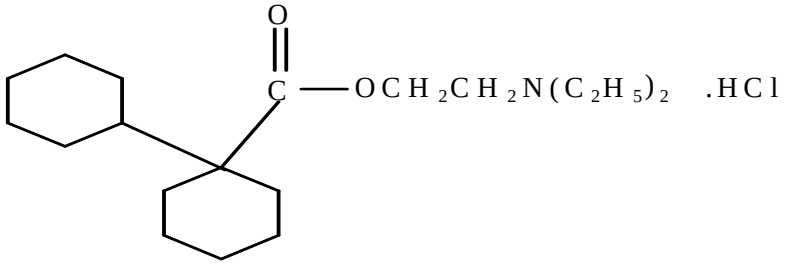
1. 1-Propanol (extra pure, AR grade, SRL Pvt. Ltd Mumbai) was kept overnight in the vacuum oven dried 4A^o molecular sieves. After decantation, solvent was refluxed for 2-3 hours and then distilled slowly through a long fractionating column.
2. PrOH+H_2O mixtures of compositions (0,10,20,-------90 and 100 mol%) have been prepared by mixing measured amounts of pure liquids in cleaned and dried flasks. A fixed amount of drug (0.250 g in 40 ml of a solvent /solvent system) has been prepared for the measurements.
3. The densities of pure solvent and various mixtures have been measured with specially designed sealable type pycnometer of 20 cm^3 capacity. The pycnometer filled with air-free experimental liquids was kept in a transparent walled water thermostat maintained at 25±0.05^{0}C.
4. The ultrasonic velocities in pure solvents as well as various mixtures were measured using ultrasonic interferometer (Model-81, supplied by Mittal Enterprises, New Delhi) operating at frequency 1 MHz. The temperature of the solution placed in the double-walled interferometer cell (attached with a quartz plate fixed at the bottom) was maintained constant from a thermostat with the help of toulu pump.
5. The drug Colimax (Wallace Pharmaceuticals Pvt. Ltd., Goa-403409) was used as such after drying in the vacuum oven. The various components of drug in a tablet are paracetamol- 500 mg and dicyclomine hydrochloride-20 mg having the following structures [1].

[1] Paracetamol [$C_8H_9NO_2$] Mol. wt. 151



N-(4-hydroxyphenyl) acetamide

[2] Dicyclomine hydrochloride [$C_{19}H_{35}NO_2HCl$] Mol. wt. 345.5



2- (diethylamino)ethyl[bicyclohexyl]-1-carboxylate hydrochloride

6. The experimental values of density and ultrasonic velocity were compared with literature values [2]. The accuracy of both density and ultrasonic velocity measurements was estimated to be ±0.2% and ±0.5% respectively.
7. The sources of error may be purity of the drug supplied and measurement of data. The measured data presented in the various tables for density and ultrasonic velocities are the average values of 3-4 determinations.

DISCUSSION

Various thermodynamic parameters such as acoustical impedance (Z), adiabatic compressibility (β), intermolecular free length (L_f), relative association (R.A.), molar volume (V_m), and molar sound velocity (R_m) have been calculated at 298.15K, using ultrasonic velocity (U) and density (ρ) of these solutions with the help of following equations [3-5] to have an insight on drug-solvent and intermolecular interactions.

$Z = U\rho$ (1)

$\beta = 1/(U^2 \rho)$ (2)

$L_f = K/(U_{exp}\, \rho^{½}_{exp})^{½} = K \beta^{½}$ (3)

R. A. $= (\rho/\rho_0)\,(U/U_0)^{1/3}$ (4)

$V_m = M/\rho$ (in case of pure solvent)

$= \bar{M}/\bar{\rho}$ (where $M = x_1M_1 + x_2M_2$) (5)

$R_m = U^{1/3} V_m$ (6)

where U, ρ and U_0, ρ_0 are velocities and densities of the studied solution or solvent system and those of the pure solvent system, respectively, K is a temperature-dependent constant ($K = \{93.875 + 0.375T\} \times 10^{-8}$; T is absolute temperature), V_m is the molar volume of the solvent, solvent mixture, or solution and M is the molecular weight of the drug taken.

Density (ρ): From Tables (1-2) and Fig. (1), it is evident that the density values decreases with the increase of the PrOH content for the studied solvent system. However, these values increases with the addition of drug. This behaviour has been found to be similar as reported by Maity et al. for EtOH+H_2O and MeOH+H_2O solvent systems [6] and Syal et al.[2] for aqueous solution of MeOH, EtOH and PrOH for drug Parvon-spas and also for drug Colimax in EtOH+H_2O solvent systems[7].

Ultrasonic velocity (U): From perusal of Tables and Fig (2), it is evident that ultrasonic velocity value increases with the addition of PrOH in PrOH+H_2O mixture up to 10 mol% of PrOH, and then decreases with further addition of PrOH. Such maxima in the ultrasonic velocity value has also been reported[6] at 16 wt% MeOH and 25 wt% EtOH in MeOH+H_2O and EtOH+H_2O mixtures which shows a close agreement between the experimental values with the literature values. Also, in acetonitrile (AN)+H_2O mixtures[8] there occurs a maximum at 10 mol % of AN which has been described by the fact that in higher water region of these solvent mixtures, the extent of hydrogen bonding is considerably affected by the addition of co-solvent AN and AN acts as structure breaker.

The addition of drug increases the value of ultrasonic velocity but general behaviour remains the same as for all studied pure solvent systems. A similar effect has been reported by Syal et al. in case of sucrose in AN+H_2O[8], DMSO+H_2O[9], for drug Parvon-spas in different alcohols and for drug Colimax in EtOH+H_2O solvent systems. This shows that solute-solvent interactions, though present, do not alter the solvent-solvent interactions already present in the binary mixtures. However, increase in velocity in any solution with addition of solute is indicative of greater association of molecules due to effective solute-solvent interactions[9].

Acoustic impedence (Z): From the Tables it is evident that Z values show linear variation for the studied solvent system with the addition of alcohol to water. However with the addition of dug Colimax, Z values shows maxima at 0.1 mol% of alcohol (PrOH+H_2O).

Adiabatic Compressibility (β): Compressibility is an important parameter as its low value gives the data of a compact structure characterized by a greater strength of bonding. These β-values have been evaluated as per the above given equation and have been presented in Tables (1-2) and in Figure (3). In PrOH+H_2O system, there is regular increase in β-values. However with the addition of drug, β-values shows minima at 10 mol% of PrOH and then increases with further addition of PrOH. Anomalous behavior of alcohol-water mixtures has also been reported in the literature[10], whereby small additions of an alcohol to water cause a decrease in compressibility, due to the making and breaking of hydrogen bonds. The general pattern for the compressibility behavior on adding alcohol in the presence of drug remains the same in all studied solvent systems. However, the difference in compressibility values of different alcohols in the studied aqueous alcoholic mixtures can be attributed to different chain lengths of the alcohol molecule, the molecular volume, inter/intramolecular interactions of these alcohols nature and amount of constituents of studied drugs.

Intermolecular free length (L_f): The Intermolecular free length depends upon the Intermolecular attractive and repulsive forces. Eyring and Kincaid[11] have proposed that L_f is a predominating factor in determining the variation of ultrasonic velocity of solutions. The change in free length also indicates that there is significant interaction between the solute and solvent molecules due to which structural arrangement is also affected. From Tables, it is clear that L_f shows minima at 10 mol% of PrOH in PrOH+H_2O system. Since L_f is directly proportional to compressibility, it shows similar behaviour as obtained for β and opposite to that of U.

Relative association (R.A.): The values of relative association (R.A.) for studied solvent mixtures, in the Tables suggests that these go on decreasing with the increase of alcohol content. Whereas no appreciable variation is noted in R.A. values has been noted with the addition of drug.

Molar volume (V_m): From Tables and Fig. (4) it is evident that value of molar volume (V_m) decreases with the increase of water content to studied aqueous alcoholic systems. But there is no appreciable change in V_m values in drug solution with the addition of fixed amount of studied drug from that of the pure solvent system. This supports the decrease of R.A. value for studied solvent systems.

Molar sound velocity (R_m): Molar sound velocity is also called Rao's constant. Molar sound velocity (R_m) in general shows linear increase with the addition of alcohol in the studied solvent mixtures, as presented in Tables. No change in R_m value has been noted with the addition of drug to solvent systems. A similar effect has been reported by Syal et al. for drug Parvon-spas in various alcohols and for drug Colimax in EtOH+H_2O[2,7].

It is thus concluded that alcohol water system is characterized by structural changes which is associated with the different extent of hydrophobic hydration of alcohol molecules. The studied drug is structure promoter and enhances the presence of interaction in the aqueous alcohol system.

Acknowledgement
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Table 1: Density (ρ), Ultrasonic Velocity (U), Specific Acoustic Impedance (Z), Relative Association (R. A.), Adiabatic Compressibility(β), Intermolecular Free Length (L_f), Molar Volume (V_m) and Molar Sound Velocity (R_m) for PrOH+H_2O Solvent System at 25°C.

Mol. Frac. of PrOH	ρx10^{-3} ($kg.m^{-3}$)	U ($m.s^{-1}$)	Z X 10^{-6} $Kg.m^{-2}.s^{-1}$	R.A.	βx10^{5} (Bar^{-1})	L_f x 10^{11} (m)	V_m ($cm^3.mol^{-1}$)	R_m x 10^4 $(m.s^{-1}).^{1/3}$ m^3mol^{-1}
0.0	0.9970	1501.0	1.496	1.0000	4.45	4.34	18.0	2.067
0.1	0.9403	1506.0	1.416	0.9420	4.68	4.45	23.6	2.706
0.2	0.9196	1437.0	1.321	0.9358	5.26	4.72	28.7	3.239
0.3	0.8876	1383.0	1.227	0.9149	5.89	4.99	34.4	3.841
0.4	0.8668	1343.0	1.164	0.9024	6.39	5.20	40.1	4.429
0.5	0.8502	1313.0	1.116	0.8916	6.81	5.37	45.8	5.023
0.6	0.8366	1285.0	1.075	0.8837	7.23	5.53	51.6	5.613
0.7	0.8273	1269.0	1.049	0.8775	7.50	5.63	57.2	6.203
0.8	0.8168	1248.0	1.019	0.8712	7.85	5.77	63.1	6.801
0.9	0.8078	1232.0	0.995	0.8653	8.15	5.87	69.0	7.402
1.0	0.8000	1201.0	0.960	0.8643	8.66	6.05	75.0	7.972

Table 2: Density (ρ), Ultrasonic Velocity (U), Specific Acoustic Impedance (Z), Relative Association (R. A.), Adiabatic Compressibility (β), Intermolecular Free Length (L_f), Molar Volume (V_m) and Molar Sound Velocity (R_m) for Drug Colimax with Concentration 4.05 × 10^{-2} mol. dm^{-3} in PrOH+H_2O Solvent System at 25°C.

Mol. Frac. of PrOH	ρx10^{-3} ($kg.m^{-3}$)	U ($m.s^{-1}$)	Z X 10^{-6} $Kg.m^{-2}.s^{-1}$	R.A.	βx10^{5} (Bar^{-1})	L_f x 10^{11} (m)	V_m ($cm^3.mol^{-1}$)	R_m x 10^4 $(m.s^{-1}).^{1/3}$ m^3mol^{-1}
0.0	0.9974	1503.0	1.499	1.0000	4.50	4.33	18.0	2.067
0.1	0.9974	1545.0	1.541	0.9908	4.25	4.21	22.3	2.573
0.2	0.9199	1446.0	1.330	0.9343	5.27	4.69	28.7	3.245
0.3	0.8895	1389.0	1.235	0.9156	5.90	4.96	34.4	3.838
0.4	0.8695	1355.0	1.178	0.9024	6.34	5.15	40.0	4.429
0.5	0.8570	1320.0	1.131	0.8972	6.78	5.32	45.5	4.992
0.6	0.8380	1298.0	1.088	0.8823	7.17	5.47	51.5	5.623
0.7	0.8291	1279.0	1.060	0.8772	7.47	5.58	57.2	6.206
0.8	0.8188	1256.0	1.028	0.8716	7.84	5.72	63.0	6.799
0.9	0.8089	1243.0	1.005	0.8640	8.10	5.82	69.0	7.417
1.0	0.8021	1210.0	0.970	0.8645	8.63	6.00	74.8	7.971

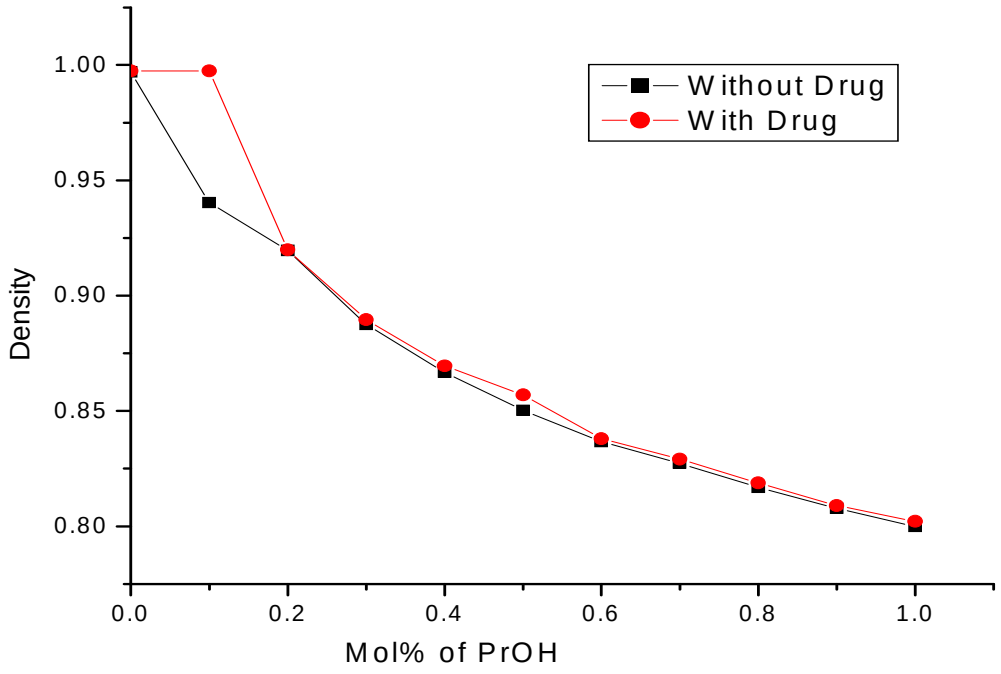

Fig. 1 Plot of Density Vs composition of PrOH+H_2O with and without drug.

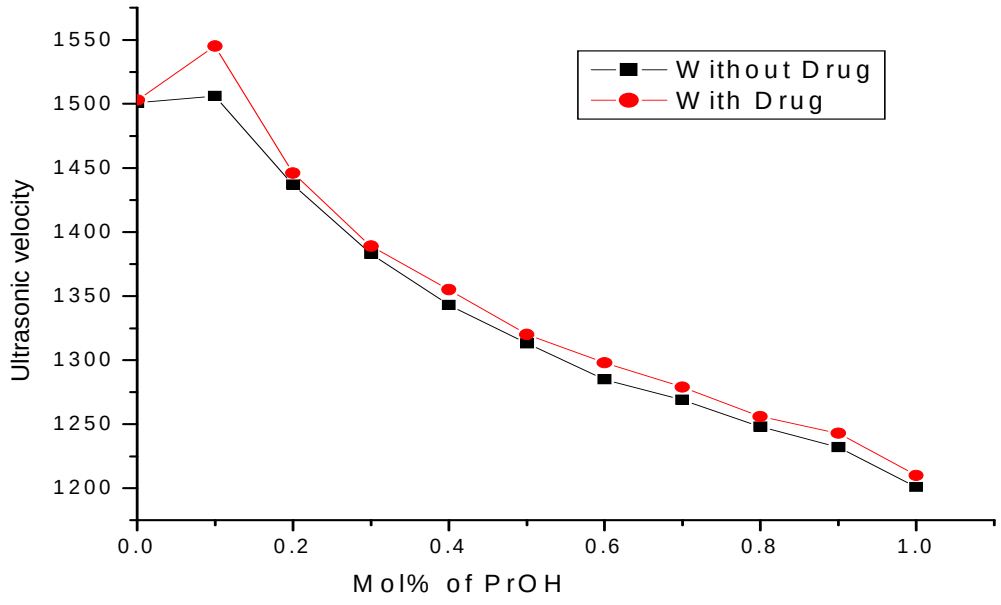

Fig. 2 Plot of Ultrasonic velocity Vs composition of PrOH+H_2O with and without drug.

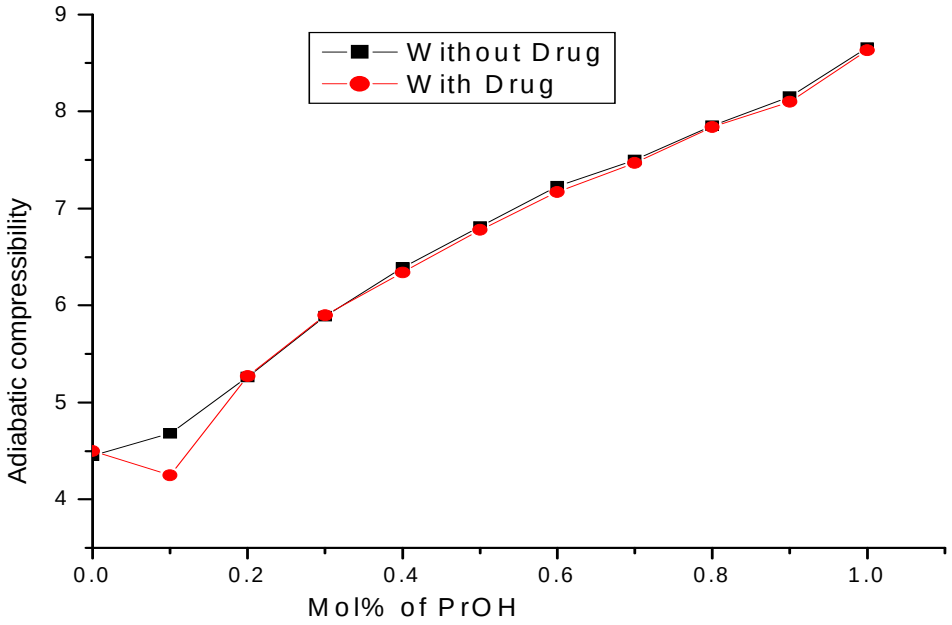

Fig. 3 Plot of Adiabatic compressibility Vs composition of PrOH+H_2O with and without drug.

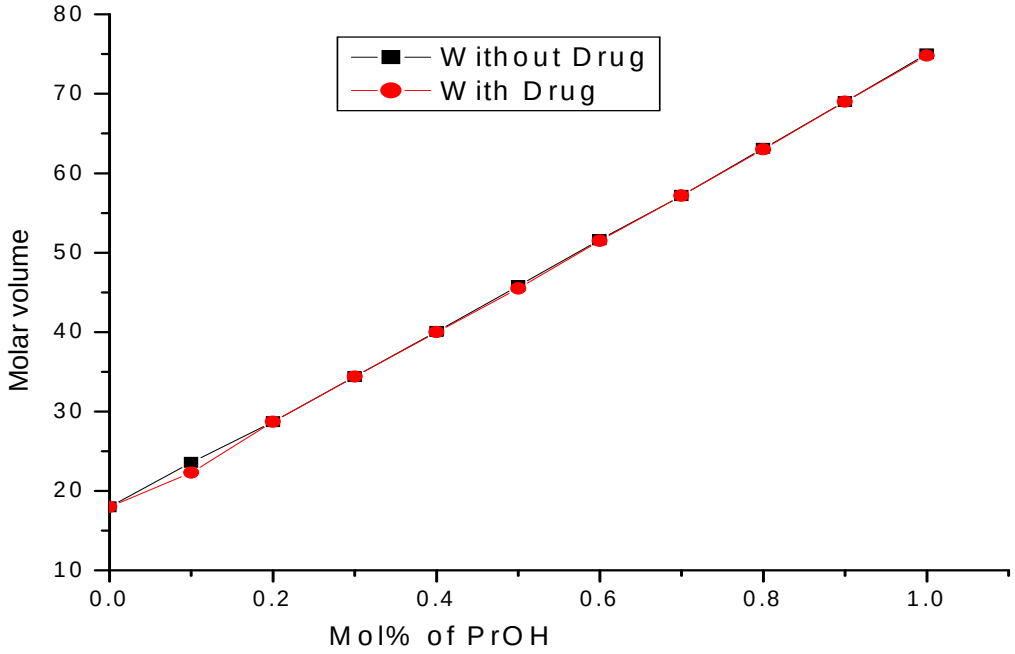

Fig. 4 Plot of Molar volume Vs composition of PrOH+H_2O with and without drug.

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