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Review Of Research

ULTRASONIC STUDIES OF BINARY LIQUID SYSTEM OF ANILINE + 1-PENTANOL

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ABSTRACT:
The variation of ultrasonic velocity (U), density and viscosity with different concentrations of aniline +1-pentanol binary system at different temperatures were measured. The measured values were used to evaluate the various acoustic and thermodynamic properties like adiabatic compressibility (β) and specific acoustic impedance (Z). It is observed that acoustic impedance (Z) increases with increase in concentration of aniline while the decreasing trend observed in adiabatic compressibility (β).

KEYWORDS : *Ultrasonic velocity, adiabatic compressibility, specific acoustic impedance.*

INTRODUCTION :

In recent years, many attempts have been made [1-5] to study molecular interactions in pure and binary liquid mixtures. These studies are important because of their use in various fields such as textile industry, leather industry, pharmaceutical industry, cosmetic industry etc. Measurement of ultrasonic velocity in liquids give information about physico-chemical behaviour of liquid mixtures such as molecular association and dissociation. Ultrasonic velocity measurements of aqueous solution provides useful information on the structural, physical aspects of solutions. Density and ultrasonic velocity measurements provide systematic information regarding ion-ion, ion-solvent, solvent-solvent interactions and also structural effects of solute and solvent in solution.

The addition of an organic solvent to water brings about a sharp change in solvation of the ions. Survey of literature showed that deviations in adiabatic compressibility for the four mixtures of n-butyl amine with 1-proponol, 1-butanol, 1-pentanol and 1-hexanol were negative over the whole range of composition. The results were used to point out that strong H-bond interactions lead to decrease in intermolecular free length (L_f) between the molecules in the mixture [6]. In the study of binary system of aniline with benzene, toluene, carbon tetrachloride, chlorobenzene, dioxane and acetone, the density and ultrasonic velocity measurements have been carried out to evaluate adiabatic compressibilities of binary systems that are under investigation. Anwar Ali *et. al.* have been studied the molecular interactions in binary mixtures of terahydro furan with alkanols (C_6, C_8, C_{10}) with the help of ultrasonic and volumetric study. They measured the density and ultrasonic speeds in binary mixtures of tetrahydrofuran (THF) with 1-hexanol, 1-octanol and 1-decanol over the whole composition range at 35^{0}C to evaluate isentropic compressibility (β), intermolecular free length (L_f), acoustic impedance (Z) etc. They proved that there is disruption of associated structure of alkanols on addition of tetrahydrofuran (THF), which dominates over the weak interaction between unlike molecules in all the three systems investigated [7]. The another study, i.e. ultrasonic behaviour of the systems, water+1-pentanol and water +1-hexanol, the effect of alcohols on the temperatures corresponding to adiabatic compressibility minimum (TACM), sound velocity maximum (TSVM) and specific acoustic impedance maximum (TSAIM) of pure water has been studied by experimentally determining the sound velocity in the density of aqueous solutions at different concentrations over the temperature range 25-80^{0}C. In this study, the template method has been employed to fix experimental values of TACM, TSVM and TSAIM to evaluate the structural contribution to the shift in TACM, TSVM and TSAIM and also, it is represented graphically. The shifts indicate the interactions between solute-solvent molecules in the mixtures, to be feebly hydrophilic in the given temperature range [7]. The effect of molecular size shape and molecular association of alcohols on volumetric and acoustic properties of binary mixtures containing aniline and 1-alkanols (C_1-C_4) has been also reported [8].

To the best of our knowledge, the systematic investigations of ultrasonic velocity, density and viscosity and other associated parameters of binary mixtures containing aniline as common component with 1-alkanols (C_5-C_8), has not been reported.

Therefore, in the present study, the effect of Aniline + 1-pentanol mixture on ultrasonic velocity and other associated parameters have been reported.

EXPERIMENTAL:

The aniline AR grade (s.d. fine chemicals, purity > 99.5%) and 1-pentanol (Merck-Schuchardt, purity > 99.0%) were used without their further purification, for preparation of binary mixtures of aniline and 1-pentanol. The binary solutions were of 0%, 20%, 40%, 60%, 80% and 100% concentrations of aniline on wt. in gm basis. The ultrasonic study of aniline+ 1-pentanol binary liquid systems was carried out as a function of different temperature and concentrations. All aniline + 1-pentanol mixture were prepared by mass using mettler balance (Switzerland Model AE-240) with a precision of ± 0.0001 gm in air-tight stopered glass bottles to measure the experimental properties namely ultrasonic velocity, density and viscosity. The ultrasonic velocity of frequency 2MHz in aniline + 1-pentanol mixtures were measured by the interferometer method using Mittal's F-81 instrument at different temperatures viz. 298.15, 303.15, 308.15, 313.15 and 318.15K with the error in measurements ±15%. The desired temperature of mixture during measurements ultrasonic velocity is maintained by using thermostatically controlled water bath with thermal stability of ± 0.05^0C for 15 min. to attain thermal equilibrium at the desired temperature. The densities of pure liquids and their mixtures were measured by using specific gravity bottle i.e. density bottle. The error in the measurements of density of solution that were under investigations in present study is ± 0.0001 gm.
Viscosity measurements of the solutions were carried out as a function of concentration and temperature using Ostwald's viscometer .All the measurements of experimental properties i.e. ultrasonic velocity, density and viscosity of the solutions of different concentrations were carried out at temperature 298.15, 303.15, 308.15, 313.15 and 318.15K. All the measurements of ultrasonic velocity (U), density (ρ) and viscosity (η) are repeated thrice and average reading is considered.

Table: 1 A- Ultrasonic velocity (U), density (ρ) and viscosity (η) of aniline+1-Pentanol system at 298.15 K

Sr. No	Mole fraction	U m/sec	ρ kg/m^3	η Pas. $X10^{-3}$
1	0.0000	1323	856.2	3.05
2	0.1914	1375	888.3	3.08
3	0.3869	1419	914.7	3.14
4	0.5867	1474	943.3	3.20
5	0.7911	1535	975.9	3.58
6	1.0000	1622	1010.0	4.15

Table: 2 A- Ultrasonic velocity (U), density (ρ) and viscosity (η) of aniline+1-Pentanol system at 303.15 K

Sr. No	Mole fraction	U m/sec	ρ kg/m^3	η Pas. $X10^{-3}$
1	0.0000	1305	855.6	2.79
2	0.1914	1357	879.6	2.81
3	0.3869	1405	906.4	2.85
4	0.5867	1462	938.7	2.93
5	0.7911	1528	972.2	3.24
6	1.0000	1616	1006.2	3.82

Table: 3 A- Ultrasonic velocity (U), density (ρ) and viscosity (η) of aniline+1-Pentanol system at 308.15 K

Sr. No	Mole fraction	U m/sec	ρ kg/m^3	η Pas. X10^{-3}
1	0.0000	1294	851.4	2.51
2	0.1914	1344	875.5	2.52
3	0.3869	1387	901.8	2.53
4	0.5867	1450	933.3	2.68
5	0.7911	1521	968.0	2.93
6	1.0000	1595	1002.4	3.44

Table: 4 A- Ultrasonic velocity (U), density (ρ) and viscosity (η) of aniline+1-Pentanol system at 313.15 K

Sr. No	Mole fraction	U m/sec	ρ kg/m^3	η Pas. X10^{-3}
1	0.0000	1280	846.6	2.3
2	0.1914	1332	871.1	2.3
3	0.3869	1377	897.9	2.2
4	0.5867	1440	928.9	2.4
5	0.7911	1505	964.5	2.6
6	1.0000	1575	997.5	3.0

Table: 5 A- Ultrasonic velocity (U), density (ρ) and viscosity (η) of aniline+1-Pentanol system at 318.15 K

Sr.No	Mole fraction	U m/sec	ρ kg/m^3	η Pas. X10^{-3}
1	0.0000	1263	843.3	2.05
2	0.1914	1310	865.4	2.04
3	0.3869	1366	894.6	2.04
4	0.5867	1434	923.3	2.20
5	0.7911	1493	961.4	2.35
6	1.0000	1563	994.4	2.75

RESULT AND DISCUSSION:

The data of measured values of ultrasonic velocity (U), density (ρ) and viscosity (η) of Aniline + 1-pentanol mixture of different concentrations at temperature 298.15, 303.15, 308.15, 313.15 and 318.15K are given in Table 1A, 2A, 3A, 4A and 5A respectively.

The variation of experimentally determined properties such as ultrasonic velocity, density and viscosity as a function of concentrations at temperature 298.15, 303.15, 308.15, 313.15 and 318.15K are graphically represented in Fig. 1A, 2A and 3A respectively.

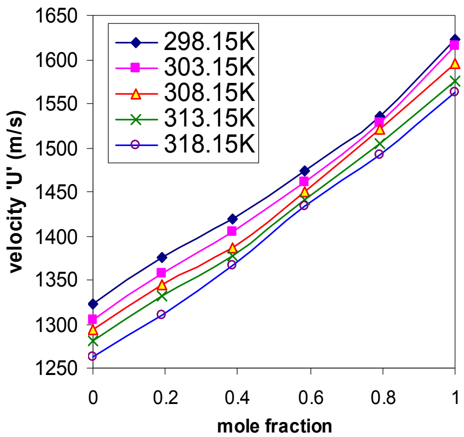

Fig. 1A: Variation of Ultrasonic velocity with concentration of aniline + 1-pentanol

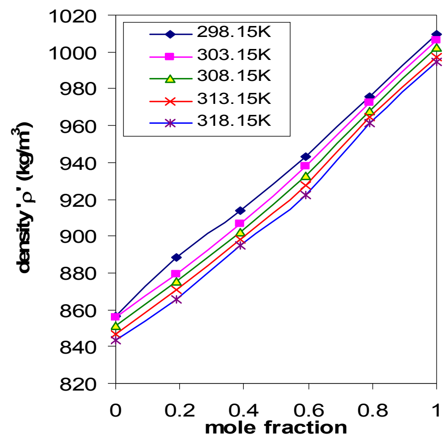

Fig. 2A: Variation of density with mole fraction of aniline + 1-pentanol

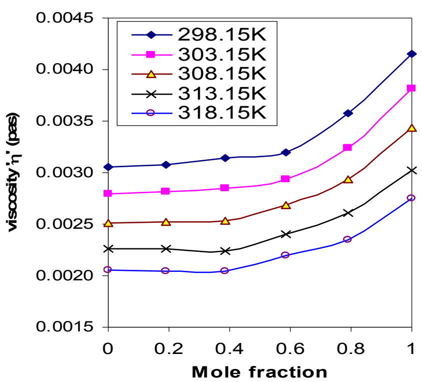

Fig. 3A: Variation of viscosity with mole fraction of aniline + 1-pentanol

The experimentally measured properties viz. ultrasonic velocity (U), density (ρ) and viscosity (η) of aniline + 1-pentanol solutions of different concentrations at temperature 298.15, 303.15, 308.15, 313.15 and 318.15K are used to evaluate the various acoustic and thermodynamic properties like adiabatic compressibility (β), specific acoustic impedance (Z), using the relations the data obtained of these parameters at temperatures 298.15, 303.15, 308.15, 313.15 and 318.15K are given in Table 6A, 7A, 8A, 9A, and 10A respectively.

Table: 6 A- Adiabatic compressibility (β) and acoustic impedance (Z) of aniline+1-Pentanol system at 298.15 K

Sr. No	Mole fraction	β $(m^2/N) \times 10^{-10}$	Z $(Kg/m^2s) \times 10^5$
1	0.0000	6.6707	11.32
2	0.1914	5.9931	12.13
3	0.3869	5.4638	12.89
4	0.5867	4.9178	13.79
5	0.7911	4.3012	14.94
6	1.0000	3.7630	16.37

Table: 7 A- Adiabatic compressibility (β) and acoustic impedance (Z) of aniline+1-Pentanol system at 303.15 K.

Sr. No	Mole fraction	β $(m^2/N) \times 10^{-10}$	Z $(Kg/m^2s) \times 10^5$
1	0.0000	6.8616	11.16
2	0.1914	6.1767	11.93
3	0.3869	5.5905	12.73
4	0.5867	4.9800	13.65
5	0.7911	4.3725	14.83
6	1.0000	3.8061	16.25

Table: 8 A- Adiabatic compressibility (β) and acoustic impedance (Z) of aniline+1-Pentanol system at 308.15 K

Sr. No	Mole fraction	β $(m^2/N) \times 10^{-10}$	Z $(Kg/m^2s) \times 10^5$
1	0.0000	6.9645	11.05
2	0.1914	6.3909	11.70
3	0.3869	5.7658	12.50
4	0.5867	5.0800	13.49
5	0.7911	4.4631	14.72
6	1.0000	3.9229	15.98

Table: 9 A- Adiabatic compressibility (β) and acoustic impedance (Z) of aniline+1-Pentanol system at 313.15 K

Sr. No	Mole fraction	β $(m^2/N) \times 10^{-10}$	Z $(Kg/m^2s) \times 10^5$
1	0.0000	7.2085	10.83
2	0.1914	6.4660	11.60
3	0.3869	5.8712	12.36
4	0.5867	5.1873	13.40
5	0.7911	4.5748	14.51
6	1.0000	4.0428	15.70

Table: 10 A- Adiabatic compressibility (β) and acoustic impedance (Z)of aniline+1-Pentanol system at 318.15 K

Sr. No	Mole fraction	β $(m^2/N) \times 10^{-10}$	Z $(Kg/m^2s) \times 10^5$
1	0.0000	7.4300	10.65
2	0.1914	6.7298	11.33
3	0.3869	5.9938	12.21
4	0.5867	5.2383	13.31
5	0.7911	4.6698	14.34
6	1.0000	4.1177	15.54

The graphical representation of variation of acoustic and thermodynamic parameters such as adiabatic compressibility (β) and specific acoustic impedance (Z) as a function of concentration are shown in Fig. 4A and 5A.

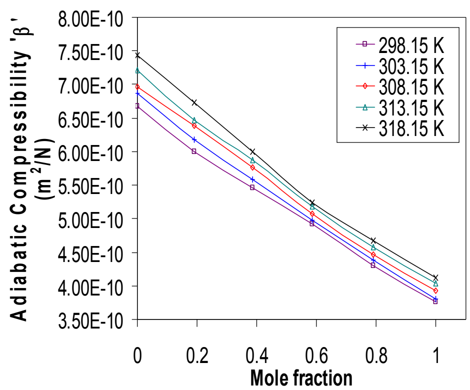

Fig. 4A: Variation of adiabatic compressibility with mole fraction of aniline + 1-pentanol

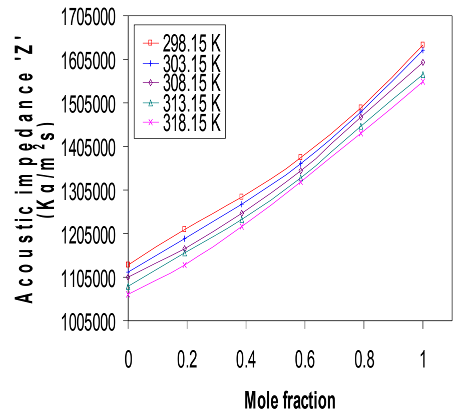

Fig. 5A: Variation of acoustic impedance with mole fraction of aniline + 1-pentanol

The variation of ultrasonic velocity (U) with different concentration of aniline +1-pentanol binary system at different temperature is shown in Fig. 1A. The figure shows a linear increase of ultrasonic velocity with increase in concentration of aniline, attaining a highest value of ultrasonic velocity for 1 mole fraction value of concentration of solution in case of each plot for given temperature. It is also clear from the Tables 1A to 5A and evident from Fig. 1A that for a given concentration of solutions of aniline + 1-pentanol, the ultrasonic velocity decreases as the temperature increases.

The Fig. 2A shows the variation of density with concentration at temperature 298.15, 303.15, 308.15, 313.15 and 318.15K for a binary system that was under investigation. The figure indicates that for a given temperature; the density of solution increases as the concentration of solution increases. The Fig. 2A also indicates that the density (ρ) of solution at given concentration decreases as the temperature increases.

The plots of variation of viscosity with concentration for temperature 298.15, 303.15, 308.15, 313.15 and 318.15K are shown in Fig. 3A. Though a increasing trend for a viscosity with concentration is observed, the increase in viscosity (η) is comparatively slow for concentrations from 0.0000 up to 0.3869% mole fraction. From 40% to 100% concentration, the increase in values of viscosity is comparatively higher for a given temperature.

The variation of adiabatic compressibility (β) with concentration for different temperature is plotted in Fig. 4A. The plots indicates linear decrease in the values of adiabatic compressibility (β) with the increase in concentration of aniline + 1-pentanol binary liquid system for a given temperature. This observed trend is same for different temperatures i.e. 298.15, 303.15, 308.15, 313.15 and 318.15. It is also seen that at a given concentration value, the adiabatic compressibility (β) is least for temperature 318.15K and it increases with decrease in temperature.

The Fig. 5A indicates the change in acoustic impedance (Z) with increase in concentration of aniline in the binary mixture of it with 1-pentanol. This variation is studied at different temperature viz. 298.15, 303.15, 308.15, 313.15 and 318.15K. The plots show a linear increase in acoustic impedance (Z) as the concentration goes on increasing. For a given concentration the value of acoustic impedance (Z) is found to be maximum at temperature 298.15K and minimum at temperature 318.15K.

CONCLUSION:

From the values listed in Tables 1A to 5A and the graphical presentation of the variation of ultrasonic velocity (U) in Fig. 1A, it is observed that the ultrasonic velocity (U) is in increasing trend with an increase in aniline concentration. This change in velocity with the mole concentration of aniline is indication of existence of interaction between components of liquid mixture i.e. aniline and 1-pentanol molecules at all compositions. In this system, two different types of interaction may be present. They are attraction between similar molecules or the attraction between dissimilar molecules.

The values of density and viscosity are given in Tables 1A to 5A. The increase in the density values with the increase in the concentration of aniline indicates strong intermolecular attraction between dissimilar molecules even at low concentration Fig. 3A display the variation of viscosity with concentration. It is noticed that the values of viscosity (η) increase slowly at lower concentration and beyond 80% concentration the increase is faster. The increasing values of viscosity indicate an increase of frictional resistance forces that may be due to change in

1. Effective molecular area or
2. The cohesive / adhesive forces or
3. Relative random velocity between the components of mix or combination of these three.

The data from Tables 6A to 10A and the Fig. 4A shows the variation of adiabatic compressibility as a function of concentration. It indicates exactly reverse trend to that of velocity variation as expected. The ease with which a medium can be compressed is given by adiabatic compressibility (β). The decreasing trend observed in adiabatic compressibility (β) values suggest that the medium is not easily compressible with the increasing concentration. The values of acoustic impedance (Z) from Tables 6A to 10A and its variation as a function of concentration as seen from Fig. 5A. It is observed that acoustic impedance (Z) increases with increase in concentration of aniline. This is in agreement with the theoretical requirements because ultrasonic velocity (U) and density (ρ) both increase with increase in concentration as seen in the present study.

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