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Research Article

ULTRASONIC BEHAVIOUR OF 1-BUTANETHIOL IN BENZENE, CARBON TETRACHLORIDE, CYCLOHEXANE AND N-HEXANE

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ABSTRACT

Ultrasonic velocity (U) and density (ρ) for the binary liquid mixtures of 1-Butanethiol with Benzene, Carbon tetrachloride, Cyclo hexane, n-Hexane have been measured for 2MHz ultrasonic frequency at 30^0C. The experimental data have been used to calculate acoustic parameters such as adiabatic comperessibility (β_{ad}), acoustic impedance (z), relative association (R_A) and intermolecular free length (L_f). The results are interpreted in terms of molecular interaction between the components of the mixture.

Key Words: *1-Butanethiol, ultrasonic velocity, adiabatic compressibility, intermolecular free length, acoustic impedance, relative association*

INTRODUCTION

During the last six decades ultrasonic studies on liquid mixtures becomes popular and one of the important and reliable tool in the assessment of the nature of molecular interaction within the liquid system. The measurement of ultrasonic velocity in solutions can provide useful information regarding molecular association in solutions and important correlations with various acoustical parameters (Ezhil *et al*., 2011).

Owing to these considerations, an attempt has been made to elucidate the molecular association / molecular interactions of binary mixtures of 1-butanethiol with Benzene, carbon tetrachloride, cyclohexane and n-hexane by measuring density and ultrasonic velocity. The acoustical parameters such as adiabatic compressibility (β_{ad}), intermolecular free length (L_f), acoustic impedance (Z), and relative association (R_A) have been computed from the experimental data with a view to investigate the nature of molecular interactions between the components of a liquid mixtures (Palani *et al*., 2010).

1-Butanethiol, also known as butyl mercaptan ($C_4H_{10}S$) is a volatile liquid with extremely foul smell.

1-Butanethiol is used as industrial solvent and as an intermediate for cotton defoliants. It is sometimes placed in 'stink bombs' and 'stink perfumes' for pranksters.

In the present paper, the authors reported densities and ultrasonic speeds of pure liquids and those of their binary mixtures with 1-Butanethiol as a common component over the entire composition range at 2MHz frequency for 30^0C. Using the experimental values of ρ and U, the value of adiabatic compressibility (β_{ad}) intermolecular free length (L_f), acoustic impedance Z, and molecular association (R_A) are calculated for all the four binary mixtures.

MATERIALS AND METHODS

1-Butanethiol and Benzene, Carbon tetrachloride, Cyclohexane and n-Hexane all are of AR grade were procured from Across, Qualigen, Merck and S.D. fine chemical, Mumbai respectively and were used without further purification. Samples of solution with different mole fractions of 1-Butanethiol in (Benzene, Carbon tetrachloride, Cyclohexane and n-Hexane) were prepared. The density (ρ) and ultrasonic velocity (U) of pure components and their mixtures were measured by using pycknometer and ultrasonic multi frequency interferometer model No. M-83 provided by Mittal Enterprises, New Delhi India, respectively.

RESULTS AND DISCUSSIONS

The experimental values of density (ρ) and ultrasonic velocity (U) were used to calculate the values of adiabatic compressibility (β_{ad}), intermolecular free length (L_f), Acoustic impedance (Z) and relative association (R_A) with the help of following relations.

$$\beta_{ad} = \frac{1}{\rho U^2} \quad \ldots (1)$$

$$L_f = K\,(\beta_{ad})^{1/2} \quad \ldots (2)$$

$$Z = U\rho \quad \ldots (3)$$

$$R_A = \frac{\rho_s}{\rho_0}\left(\frac{U_0}{U_s}\right)^{1/3} \quad \ldots (4)$$

Where, K is temperature – dependent constant (=93.875 + 0.375 x T) x 10^{-8}; T is the absolute temperature; ρ_0 , ρ_s , U_0 and U_s are the densities and ultrasonic velocities of the solvent and solution respectively (Thirumaran ; Isht Vibhu *et al.*, 2004).

Values of density (ρ), Ultrasonic velicity (U), adiabatic compressibility (β_{ad}), intermolecular free length (L_f), acoustic impedance (Z) and relative association (R_A) along with mole fraction of 1-Butanethiol in Benzene, carbon tetrachloride, cyclohexane and n-hexane are listed in table No. 1, 2, 3 and 4 respectively. Also the graphical representation for above said parameters against mole fraction (X) of 1-butanethiol is depicted in Figure 1, 2, 3, 4 and 5 respectively (Ali *et al*., 2002).

BENZENE+1-BUTANETHIOL

Table 1: The values of density (ρ), ultrasonic velocity (U), adiabatic compressibility (β_{ad}), intermolecular free length (L_f), Acoustic impedance (Z) and relative association (R_A) of the binary liquid mixture of Benzene + 1-butanethiol at 30^0C

X	ρ	v	ß$_{ad}$	L$_f$	z	R$_A$
0	877	1309.6	6.64849	5.34065	1148519	1
0.04356	875.15	1320.8	6.55003	5.30096	1155898	0.99506
0.08772	873.3	1352	6.26445	5.18411	1180702	0.98526
0.13256	871.45	1300.8	6.78167	5.39387	1133582	0.99590
0.17795	869.6	1300.8	6.79609	5.39961	1131176	0.99379
0.36604	862.2	1285.6	7.01746	5.48684	1108444	0.98920
0.56510	854.8	1272.8	7.2213	5.56596	1087989	0.98399
0.77604	847.4	1270.4	7.31191	5.60077	1076537	0.97608
1	840	1273.6	7.3393	5.61125	1069824	-

CTC +1-BUTANETHIOL

Table 2: The values of density (ρ), ultrasonic velocity (U), adiabatic compressibility (β_{ad}), intermolecular free length (L_f), Acoustic impedance (Z) and relative association (R_A) of the binary liquid mixture of Carbon tetrachloride + 1-butanethiol at 30^0C

X	ρ	v	ß$_{ad}$	L$_f$	z	R$_A$
0	1592	914.4	7.5125	5.67708	1455725	1
0.04515	1554.4	969.6	6.84309	5.41824	1507146	0.95628
0.4997	1516.8	966.4	7.05924	5.50315	1465836	0.93418
0.13706	1479.2	969.6	7.19098	5.55426	1434232	0.91002
0.18361	1441.6	987.2	7.11779	5.52593	1423148	0.88159
0.37497	1291.2	1020	7.444	5.65113	1317024	0.78105
0.57448	1140.8	1075.2	7.528249	5.70346	1226588	0.67806
0.78266	990.4	1159.2	7.51402	5.67765	1148072	0.57409
1	840	1273.6	7.3393	5.61125	1069824	-

CYCLOHEXANE+1-BUTANETHIOL

Table 3: The values of density (ρ), ultrasonic velocity (U), adiabatic compressibility (β_{ad}), intermolecular free length (L_f), Acoustic impedance (Z) and relative association (R_A) of the binary liquid mixture of Cyclo-hexane + 1-butanethiol at 30^0C

X	ρ	v	ß$_{ad}$	L$_f$	z	R$_A$
0	777	1282	7.83074	5.79607	996114	1
0.05035	780.15	1244	8.28288	5.96105	970506.6	1.01417
0.10075	783.3	1234.4	8.37838	5.99532	966905.5	1.02090
0.15112	786.45	1189	8.99425	6.21177	935089.1	1.03789
0.20136	789.6	1300	7.49387	5.67003	1026480	1.01150
0.40209	802.2	1240.8	8.09681	5.89372	995369.8	1.04373
0.60215	814.8	1227.2	8.14926	5.91278	999922.6	1.06403
0.80144	827.4	1220.8	8.10953	5.89835	1010090	1.08236
1	840	1273.6	7.3393	5.61125	1069824	-

N-HEXANE+1-BUTANETHIOL

Table 4: The values of density (ρ), ultrasonic velocity (U), adiabatic compressibility (β_{ad}), intermolecular free length (L_f), Acoustic impedance (Z) and relative association (R_A) of the binary liquid mixture of n-hexane + 1-butanethiol at 30^0C

X	ρ	v	ß$_{ad}$	L$_f$	z	R$_A$
0	658	1086	1.28859	7.43515	714588	1
0.0596	667.1	1108	1.22104	7.23765	739147	1.00707
0.11932	676.2	1104.8	1.2116	7.2096	747066	1.02179
0.17714	685.3	1122.4	1.15831	7.04928	769181	1.03010
0.23362	694.4	1129.6	1.1286	6.9583	784394	1.04156
0.44847	730.8	1158.4	1.01973	6.61416	846559	1.08700
0.64660	767.2	1176.8	9.41209	6.35441	902841	1.13516
0.82991	803.6	1201.6	8.61867	6.08069	965606	1.18078
1	840	1273.6	7.3393	5.61125	1069824	-

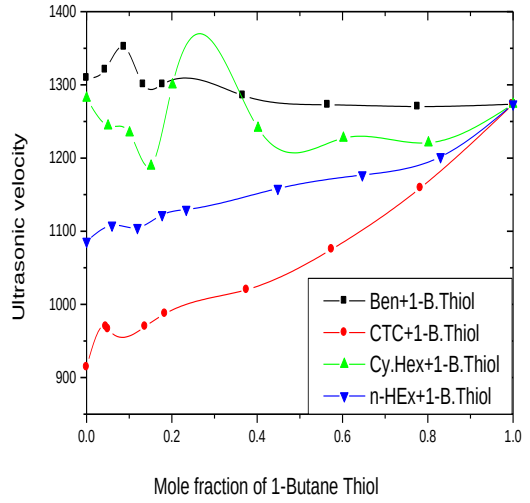

Figure 1: The ultrasonic velocity for binary mixtures of 1-butanethiol with benzene, carbon tetrachloride, cyclohexane and n-hexane

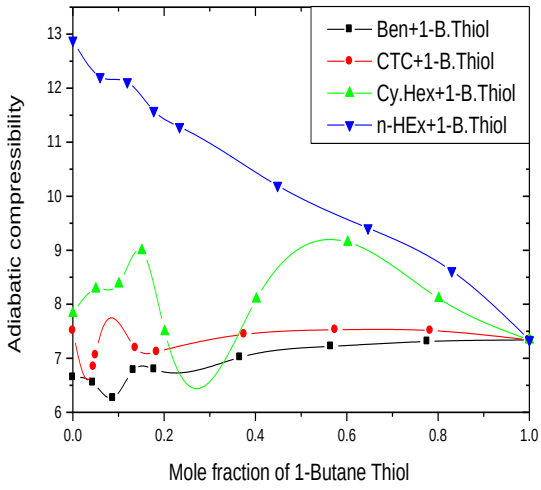

Figure 2: The Adiabatic compressibility for binary mixtures of 1-butanethiol with benzene, carbon tetrachloride, cyclohexane and n-hexane

From the above values it is clear that ultrasonic velocity increases with mole fraction of 1-butanethiol in (Carbon tetrachloride + 1-butanethiol) and (n-hexane + 1-butanethiol) systems. This increase with concentration indicates that there is inter molecular interaction exists within the mixture. On the basis of the model for sound propagation proposed by Eyring and Kincaid, ultrasonic velocity increases on decrease of intermolecular free length (L_f) and vice versa (Bedare *et al*., 2012) as shown n figure (1) and figure (2).

In case of Benzene + 1-Butanethiol the ultrasonic velocity (figure 1) increases and reaches to maxima near mole fraction 0.1 (figure 1) and at the same mole fraction adiabatic compressibility figure (2) And inter molecular free length figure (3) decreases and reaches to minima indicate complex formation amongst the constituent of the liquid mixture (Shahane, 2004). Further ultrasonic velocity (U) decreases with increasing mole fraction (X) of 1-butanethiol where as the β_{ad} and L_f increases correspondingly. The increase in free length is due to lose packing of the molecules inside the shield which may be brought by weakening of molecular interactions (Ezhil *et al*., 2011). Increase in the compressibility values (Ravichandran, 2011) supports the above statement.

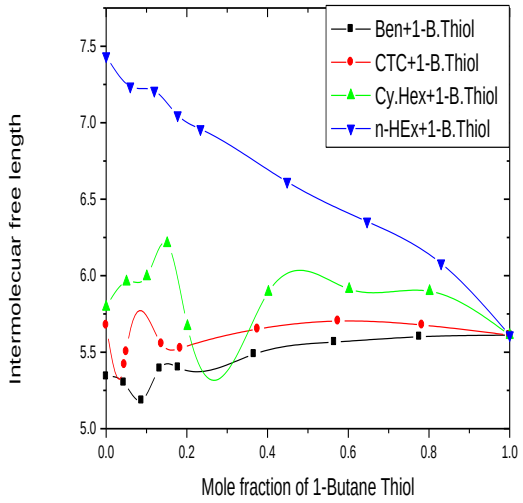

Figure 3: The intermolecular free length for binary mixtures of 1-butanethiol with benzene, carbon tetrachloride, cyclohexane and n-hexane

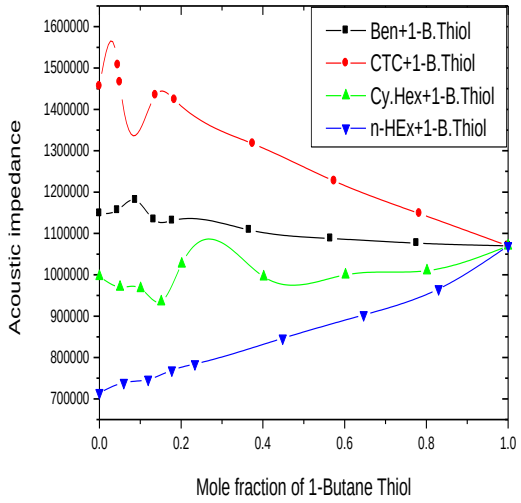

Figure 4: The Acoustic impedance for binary mixtures of 1-butanethiol with benzene, carbon tetrachloride, cyclohexane and n-hexane

On the contrary, in case of Cyclohexane + 1-Butanethiol the ultrasonic velocity (figure 1) decreases and reaches to minima near mole fraction 0.2 (figure 1) and at the same mole fraction adiabatic compressibility (figure2) and intermolecular free length (figure3) increases and reaches to maxima may be due to weak association between the molecules.

An increasing values of acoustic impedance (Z) (figure4) in Carbon tetrachloride + 1-Butanethiol, Cyclohexane + 1-Butanethiol, n-Hexane + 1-Butanethiol further supports the possibility of molecular interaction between unlike molecules (Thirumaran *et al.*) where as in case of Benzene + 1-Butanethiol the acoustic impedance decreases indicating significant interaction between the mixing components (Ezhil *et al*., 2011).

Relative association (figure5) in case of Cyclohexane + 1-Butanethiol and n-Hexane +1-Butanethiol increases with increase in mole fraction of 1-Butanethiol prove stronger dipole – induced dipole interaction between unlike molecules which results in contraction of volume which supports decrease in compressibility and free length (Harish Kumar *et al*., 2012). The decrease of R_A in the systems Benzene + 1-butanethiol and Carbon tetrachloride + 1-Butanethiol suggests that breaking of solvent structures

predominates over the solvation of solute due to non-polar nature of Benzene and Carbon tetrachloride (Zade, 2011).

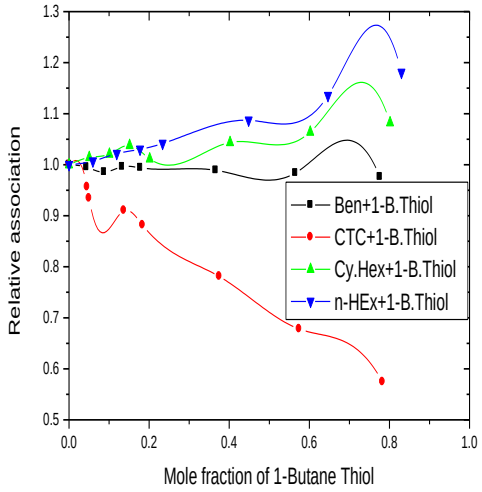

Figure 5: The relative association for binary mixtures of 1-butanethiol with benzene, carbon tetrachloride, cyclohexane and n-hexane

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