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Research Article

THERMO-ACOUSTICAL PARAMETERS IN BINARY LIQUID MIXTURE CONTAINING QUINOLINE AND TOLUENE AT TEMPERATURES T=(303.15,308.15,313.15 AND 318.15)K

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ABSTRACT
Densities, Ultrasonic velocities and viscosities have been measured in binary liquid mixture containing quinoline and toluene over the entire mole fraction range of quinoline at temperatures T=(303.15,308.15,313.15 and 318.15)K. Thermo-acoustical parameters such as adiabatic compressibility (β), intermolecular free length (L_f), acoustical impedance (Z) and internal pressure (π) have been calculated from the experimentally measured data. These results have been explained in terms of molecular interactions between the components of liquid mixture.

Keywords: *Density, Ultrasonic Velocity, Adiabatic Compressibility, Intermolecular Free Length, Internal Pressure*

INTRODUCTION
Thermo-acoustical parameters in binary liquid mixture are useful in elucidating the structural interactions between the components of liquid mixture (Sharma and Kanwar, 2012; Ali *et al.,* 1998; Fakruddin *et al.*, 2012; Narendra *et al.*, 2011; Fakruddin *et al.*, 2012). The recent investigations (Kavitha *et al.*, 2016; Chandrakant *et al.*, 2014; Sharma, 2013) on ultrasonic velocity and their derived parameters are available in this technology with variation of composition and temperature. The temperature dependence of the parameters give important information about the molecular interaction between the components of the mixtures. Study of thermo-acoustical parameters are useful to understand different kinds of association, the molecular packing, physico-chemical behaviour and various types of intermolecular interactions in the liquid mixtures (Fakruddin *et al.*, 2013). In the present paper, values of thermo-acoustical parameters and their variations with mole fraction of quinoline in binary liquid mixtures containing quinoline and toluene at temperatures T=(303.15,308.15, 313.15 and 318.15)K have been reported.

MATERIALS AND METHODS
In the present investigation the chemicals used are of AnalaR grade and are obtained from SDFCL chemicals (quinoline) and MERCK chemicals (toluene). The chemicals are purified by standard procedure (Perrin and Armarego, 1980).The different concentrations of the liquid mixture are prepared by varying mole fractions with respect to Job's method of continuous variation. Stoppard conical flasks are used for preserving the prepared mixtures and the flasks are left undisturbed to attain thermal equilibrium. Ultrasonic pulse echo interferometer (Mittal enterprises, India) is used for ultrasonic velocities measurements and all these measurements are done at a fixed frequency of 3MHz. The temperature of the pure liquids or liquid mixtures is done by using temperature controlled water bath by circulating water around the liquid cell which is present in interferometer. Specific gravity bottle is used for the measurement of densities of pure liquids and liquid mixtures. An electronic weighing balance (Shimadzu AUY220, Japan), with a precision of + or - 0.1 mg is used for the measurements of mass of pure liquids or liquid mixtures. Average of 4 to 5 measurements is taken for each sample. Ostwald's viscometer is used for the measurement of viscosity of pure liquids or liquid mixtures. The time of flow of liquid in the viscometer is measured with an electronic stopwatch with a precision of 0.01s.

Theory and Calculations

From the experimentally measured values of ultrasonic velocities, viscosities and densities, thermo-acoustical parameters such as adiabatic compressibility (β),intermolecular free length (**L_f**), acoustical impedance (Z) and internal pressure (π) have been calculated by using following relations

(a) Adiabatic Compressibility (β):

Adiabatic compressibility is a measure of intermolecular association ordissociation or repulsion. It also determines the orientation of the solvent molecules around the liquid molecules.It can be calculated using the equation (Dass *et al.*, 1994)

$$\beta = \frac{1}{\rho . U^2} \quad N^{-1}.m^2 \qquad \text{------(1)}$$

where, U is the ultrasonic velocity and ρ is the density of the solution.

(b) Intermolecular Free Length (L_f)

The free length is the distance between the surfaces of the neighbouring molecules. The intermolecular free length has been calculated using the following formula given by Jacobson (1952)

$$L_f = k.\beta^{1/2} \quad Å \qquad \text{-------(2)}$$

where, k is Jacobson's constant.

(c) Acoustical Impedance (Z):

Acoustic impedance is important in the determination of acoustictransmission and reflection at the boundary of two materials having different acoustic impedance. It is also useful in the designing of ultrasonictransducers and for assessing absorption of sound in a medium. It is given by the relation

$$Z = U.\rho \quad Kg.m^{-2}.s^{-1} \qquad \text{-------(3)}$$

(d) Internal Pressure (π):

Internal pressure is a fundamental property of a liquid, which provides an excellent basis for examining the solution phenomenon and studying various properties of the liquid state. The internal pressure (Suryanarayana and Kuppusamy, 1976) of the liquid mixture is obtained from the experimental values of ultrasonic velocity, density and viscosity given by

$$\pi = bRT\left[\frac{K\eta}{U}\right]^{1/2} . \left[\frac{\rho^{2/3}}{M_{eff}^{\;7/6}}\right] N.m^{-2} \text{-------(4)}$$

RESULTS AND DISCUSSION

The experimentally measured values of densities, ultrasonic velocities and viscosities of pure liquids together with the literature values are given in Table-1.

Table 1: The Values of Densities (ρ), Ultrasonic Velocities (u) and Viscosities (η) of Pure Liquids together with Literature Values at Temperature T=303.15K

Liquid	Density ρ($Kg.m^{-3}$)		Ultrasonic velocity U($m.s^{-1}$)		Viscosity η (m.Pa.S)	
	Exp	Lit	Exp	Lit	Exp	Lit
quinoline	1085.45	1085.79[14]	1553.68	1547.00[14]	2.9320	2.9280[14]
toluene	861.12	856.30[15]	1273.23	1278.40[15]	0.5900	0.5890[15]

The evaluated values of thermo-acoustical parameters such as adiabatic compressibility (β), intermolecular freelength (**L_f**), acoustical impedance (Z) and internal pressure **(π)** for the above binary liquid mixture over the entire mole fraction range of quinoline at temperatures T=(303.15,308.15,313.15and 318.15) K are given in the Table2.

Table 2:The Values of Thermo-Acoustical Parameters such as Adiabatic Compressibility (β), Intermolecular Free length (L_f), Acoustical Impedance(Z) and Internal Pressure (π) for the above Binary Liquid Mixture over the Entire Molefraction Range of Quinoline at Temperatures T=(303.15,308.15, 313.15 and 318.15)K

Mole fraction (X_1)	Adiabatic Compressibility(β) x10^{-11} $N^{-1}.m^2$ T=303.15K	T=308.15K	T=313.15K	T=318.15K
0.0000	71.63	75.21	78.77	83.08
0.0904	66.11	69.32	72.51	76.35
0.1828	61.15	64.03	66.90	70.34
0.2772	56.67	59.27	61.85	64.94
0.3737	52.61	54.97	57.31	60.09
0.4723	48.94	51.08	53.20	55.70
0.5731	45.61	47.55	49.47	51.74
0.6762	42.57	44.34	46.09	48.14
0.7817	40.23	41.81	43.29	45.02
0.8896	38.50	39.73	40.93	42.07
1.0000	38.17	38.43	38.72	39.17
	Intermolecular Free length (L_f) Å			
0.0000	0.1678	0.1732	0.1785	0.1846
0.0904	0.1612	0.1663	0.1713	0.1770
0.1828	0.1550	0.1598	0.1645	0.1699
0.2772	0.1493	0.1537	0.1582	0.1632
0.3737	0.1438	0.1481	0.1523	0.1570
0.4723	0.1387	0.1427	0.1467	0.1512
0.5731	0.1339	0.1377	0.1415	0.1457
0.6762	0.1294	0.1330	0.1365	0.1405
0.7817	0.1258	0.1291	0.1323	0.1359
0.8896	0.1230	0.1259	0.1287	0.1314
1.0000	0.1225	0.1238	0.1252	0.1268
	Acoustical Impedance (Z) x 10^6 $Kg.m^{-2}.s^{-1}$			
0.0000	1.0964	1.0595	1.0269	0.9900
0.0904	1.1598	1.1218	1.0882	1.0504
0.1828	1.2249	1.1859	1.1514	1.1126
0.2772	1.2917	1.2517	1.2162	1.1765
0.3737	1.3603	1.3193	1.2828	1.2422
0.4723	1.4306	1.3886	1.3512	1.3096
0.5731	1.5027	1.4596	1.4213	1.3788
0.6762	1.5765	1.5324	1.4931	1.4497
0.7817	1.6310	1.5871	1.5511	1.5103
0.8896	1.6735	1.6368	1.6059	1.5776
1.0000	1.6864	1.6780	1.6690	1.6566
	Internal pressure(π)x 10^6 $N.m^{-2}$			
0.0000	102.32	87.67	73.66	60.46

0.0904	118.74	107.14	93.94	79.52
0.1828	129.58	119.57	108.58	97.03
0.2772	138.20	129.35	119.84	110.04
0.3737	145.15	137.18	128.76	120.20
0.4723	150.76	143.51	135.94	128.31
0.5731	155.30	148.64	141.76	134.87
0.6762	158.93	152.78	146.48	140.20
0.7817	160.06	154.33	148.71	142.96
0.8896	160.49	155.31	150.38	145.46
1.0000	162.29	155.78	147.94	144.33

From Table-2, it is observed that the value of adiabatic compressibility decreases with increase in molefraction of quinoline and also observed that as the temperature increases the adiabatic compressibility value increases in the present binary liquid mixture. Similar observations are made by Ali and Nain (2000) in their binary mixtures and reported that the interactions become weaker with increase of temperature. The variation of intermolecular freelength(L_f) with respect to the molefraction of quinoline ranging from 0 to 1 at temperatures T=(303.15,308.15,313.15 and 318.15)K is given in Table-2and it is observed that the value of intermolecular free length decreases with increase in mole fraction of quinoline.The decrease in intermolecular freelength (L_f) indicates strong intermolecular interactions (Eyring and Kincaid, 1938)between the components of the liquid mixture. Also intermolecular freelength increases with the increase of temperature. According to a model proposed by Eyring and Kincaid (1938), ultrasonic velocity should increase if the intermolecular freelength decreases as a result of mixing components (Nikkam*et al.*, 2000). In the present study, similar results are observed. The variation of acoustical impedance (Z) with respect to the molefraction of quinoline at temperatures T=(303.15,308.15,313.15 and 318.15)K is given in Table-2 and it is cleared that the value of acoustical impedance increases with the molefraction of quinoline. This supports the strong molecular interactions as suggested by Garcia *et al.*, (1996), Oswal *et al.*, (1998). When an acoustic wave travels in a medium, there is a variation of pressure and instantaneous velocity from particle to particle. This is governed by the inertial and elastic properties of the medium. The variation of internal pressure (π) with respect to molefraction of quinoline ranging from 0 to 1 at temperatures T=(303.15,308.15,313.15 and 318.15) K is as given in Table-2and from table it is observed that internal pressure value increases with the increase of molefraction of quinoline and which results show that the interactions are increasing with molefraction of quinoline and decreasing with temperature in the present binary liquid mixture.

Conclusion

Density, ultrasonic velocity and viscosity values are measured in the binary liquid mixture containing quinoline andtoluene at temperatures T=(303.15, 308.15, 313.15 and 318.15) K. By using these values, thermo-acoustical parameters such as adiabatic compressibility (β), intermolecular free length (L_f), acoustical impedance (Z) and internal pressure (π) have been calculated over the entire molefraction range of quinoline. An analysis of these results suggests the presence of strong intermolecular interactions between the components of liquid mixture. Also the strength of molecular interactions is observed to be decreased with temperature.

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