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Study of thermo-acoustical parameters in binary liquid mixture containing aniline and mesitylene at temperatures T= (303.15, 308.15, 313.15 and 318.15) K.

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ABSTRACT

Ultrasonic velocities, densities and viscosities have been measured in binary liquid mixture containing aniline and mesitylene over the entire mole fraction range of aniline at temperatures T= (303.15, 308.15, 313.15 and 318.15) K. From experimentally measured data of ultrasonic velocity, density and viscosity, thermo-acoustical parameters such as adiabatic compressibility (β), intermolecular free length (L_f), acoustical impedance (Z) and internal pressure (π) have been calculated. These results have been explained in terms of molecular interactions between the components of liquid mixture.
Keywords: Ultrasonic velocity, density, viscosity, adiabatic compressibility, internal pressure.

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INTRODUCTION

The study of thermo-acoustical parameters in binary liquid mixture has proved to be useful in elucidating the structural interactions between the components of liquid mixture **[**1-6**]**.There are considerable number of recent investigations **[**7-9**]** 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 **[**10**]**. In the present paper, values of thermo-acoustical parameters and their variations with mole fraction of aniline in binary liquid mixtures containing aniline and mesitylene at temperatures T=(303.15,308.15,313.15 and 318.15)K have been reported**[**11**]**.

MATERIALS AND METHODS

In the present investigation the chemicals used are of AnalaR grade and are obtained from SDFCL chemicals (aniline) and MERCK chemicals (mesitylene). The chemicals are purified by standard procedure [12].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

ADIABATIC COMPRESSIBILITY (β):

Adiabatic compressibility is a measure of intermolecular association or dissociation or repulsion. It also determines the orientation of the solvent molecules around the liquid molecules. It can be calculated using the equation [13]

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

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

INTERMOLECULAR FREE LENGTH (L_f)

The free length is the distance between the surfaces of the neighboring molecules. The intermolecular free length has been calculated using the following formula given by Jacobson [14]

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

Where, k is Jacobson's constant.

ACOUSTICAL IMPEDANCE (Z):

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

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

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 [15] of the liquid mixture is obtained from the experimental values of ultrasonic velocity, density and viscosity given by

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

RESULTS AND DISCUSSION

The evaluated values of thermo-acoustical parameters such as adiabatic compressibility (β), intermolecular free length (L_f), acoustical impedance (Z) and internal pressure for the above binary liquid mixture over the entire mole fraction range of aniline at temperatures T= (303.15, 308.15, 313.15 and 318.15) K are given in the **Table-1**. The variations of these thermo-acoustical values with respect to the mole fraction of aniline at temperatures T= (303.15, 308.15, 313.15 and 318.15) K are represented in the figures from Fig-**1** to **Fig-4**.

Table 1: 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 mole fraction range of aniline at temperatures T= (303.15, 308.15, 313.15 and 318.15) K.

Mole fraction (X)	Adiabatic compressibility(β) x10^{-11} $N^{-1}.m^2$			
	T=303.15K	T=308.15K	T=313.15K	T=318.15K
0.0000	67.62	70.02	72.74	75.66
0.0166	63.33	67.07	69.55	72.77
0.0367	59.86	64.49	67.02	70.21
0.0613	55.91	60.05	62.63	65.50
0.0922	52.41	55.96	58.43	61.09
0.1322	49.18	52.33	54.61	57.07
0.1860	46.61	49.23	51.11	53.39
0.2622	44.00	46.23	47.91	50.02
0.3786	41.68	43.58	45.10	46.88
0.5782	39.60	41.22	42.55	44.14
1.0000	37.62	39.16	40.74	42.31
	Intermolecular free length(L_f) Å			
0.0000	0.1630	0.1671	0.1715	0.1762
0.0166	0.1578	0.1635	0.1677	0.1728
0.0367	0.1534	0.1604	0.1647	0.1697
0.0613	0.1483	0.1547	0.1592	0.1639
0.0922	0.1435	0.1494	0.1537	0.1583
0.1322	0.1391	0.1445	0.1486	0.1530
0.1860	0.1354	0.1401	0.1438	0.1480
0.2622	0.1315	0.1358	0.1392	0.1433

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0.3786	0.1280	0.1318	0.1351	0.1387
0.5782	0.1248	0.1282	0.1312	0.1346
1.0000	0.1216	0.1250	0.1284	0.1317
	Acoustical impedance(Z) x 10^6 Kg.m^{-2}.s^{-1}			
0.0000	1.13	1.10	1.07	1.04
0.0166	1.18	1.14	1.11	1.08
0.0367	1.22	1.17	1.14	1.10
0.0613	1.28	1.23	1.19	1.16
0.0922	1.34	1.29	1.25	1.21
0.1322	1.40	1.34	1.30	1.27
0.1860	1.44	1.40	1.36	1.32
0.2622	1.50	1.45	1.42	1.38
0.3786	1.55	1.51	1.48	1.44
0.5782	1.60	1.56	1.53	1.49
1.0000	1.65	1.60	1.56	1.52
	Internal pressure(π) x 10^6 N.m^{-2}			
0.0000	105.75	97.62	87.16	73.02
0.0166	108.48	100.58	89.65	76.12
0.0367	117.43	110.43	100.23	88.63
0.0613	123.75	117.03	107.52	97.22
0.0922	128.42	121.82	112.81	103.50
0.1322	131.55	125.12	116.46	107.96
0.1860	133.62	127.16	118.65	110.82
0.2622	134.01	127.63	119.40	112.16
0.3786	132.88	126.61	118.71	111.87
0.5782	129.78	123.68	116.12	109.77
1.0000	129.38	120.74	113.32	106.45

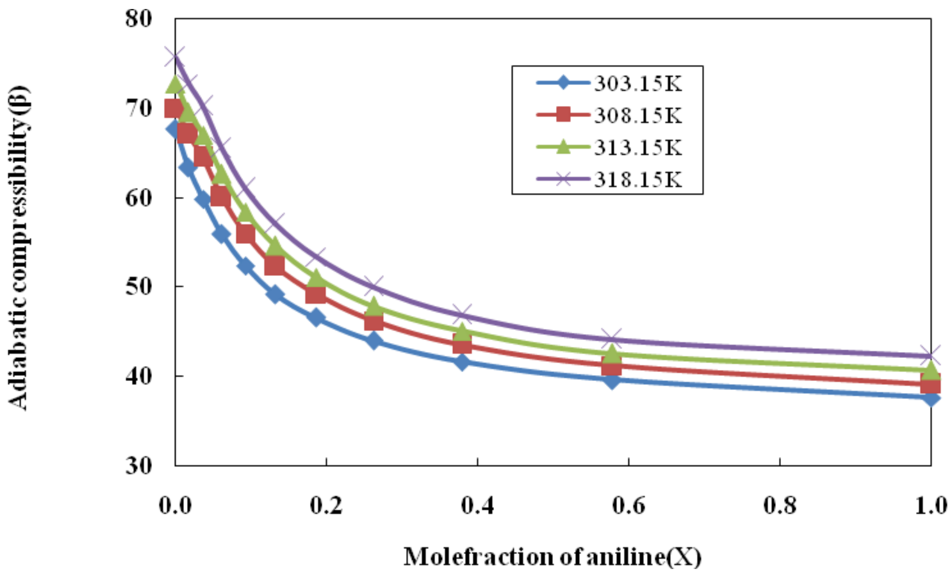

Fig1: Variation of adiabatic compressibility (β) with mole fraction of aniline(X)

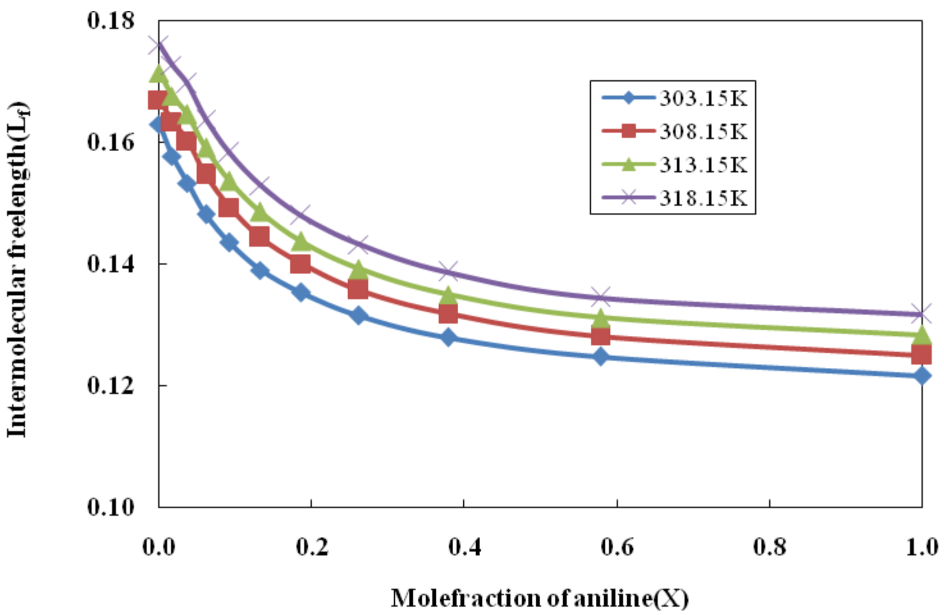

Fig 2: Variation of intermolecular free length (L_f) with mole fraction of aniline(X)

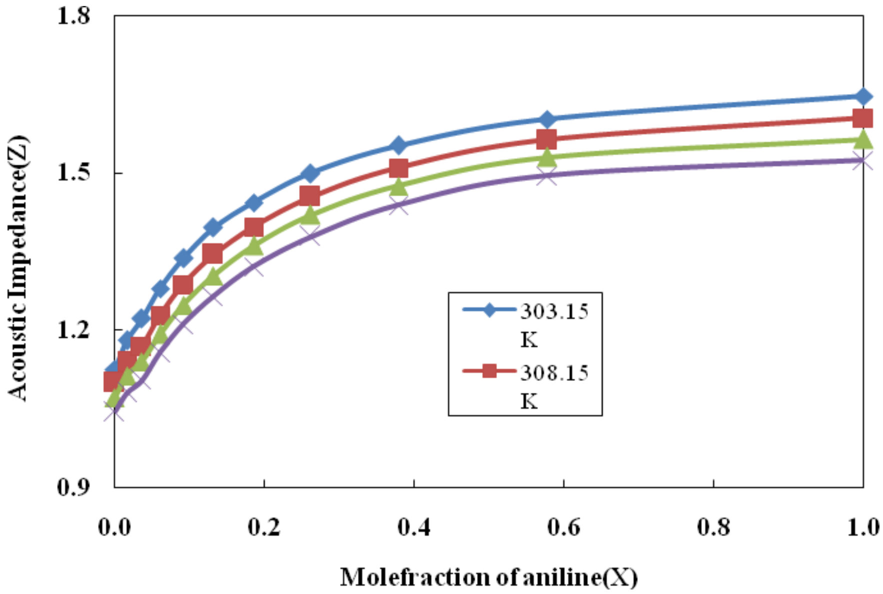

Fig 3: Variation of acoustical impedance (Z) with mole fraction of aniline(X)

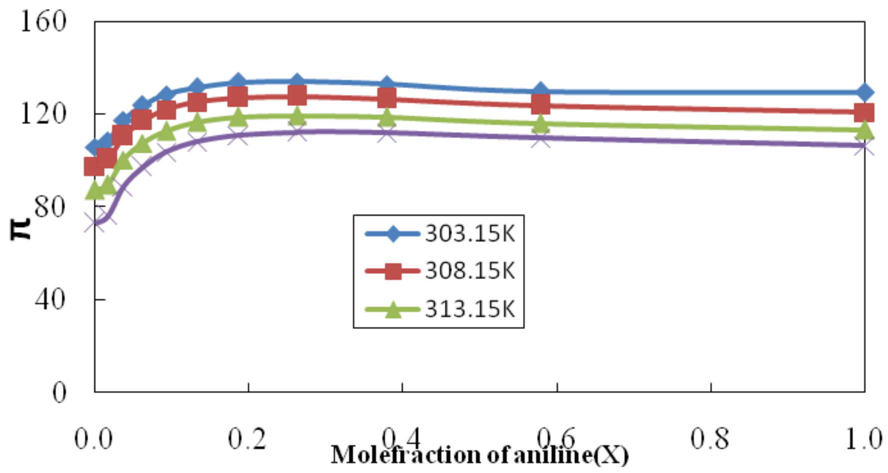

Fig 4: Variation of internal pressure (π) with mole fraction of aniline(X)

The variation of adiabatic compressibility(β) with respect to the mole fraction of aniline ranging from 0 to 1 at temperatures T=(303.15,308.15,313.15 and 318.15)K is as shown in **Fig-1**. From **Fig-1**, it is observed that the value of adiabatic compressibility decreases with increase in mole fraction of aniline. Also from **Fig-1**, it is 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[18] in their binary mixtures and reported that the interactions become weaker with increase of temperature. The variation of intermolecular free length (L_f) with respect to the mole fraction of aniline ranging from 0 to 1 at temperatures T= (303.15, 308.15, 313.15 and 318.15) K is as shown in **Fig-2.** From **Fig-2**, it is observed that the value of intermolecular free length decreases with increase in mole fraction of aniline. The decrease in intermolecular free length (L_f) indicates strong intermolecular interactions[19] between the components of the liquid mixture. Also intermolecular free length increases with the increase of temperature. According to a model proposed by Eyring Kincaid, ultrasonic velocity should increase if the intermolecular free length decreases as a result of mixing components[20]. In the present study, similar results are observed. **Fig-3** represents the variation of acoustical impedance (Z) with respect to the mole fraction of aniline at temperatures T= (303.15, 308.15, 313.15 and 318.15) K. From **Fig-3**, it is cleared that the value of acoustical impedance increases with the mole fraction of aniline. This supports the strong molecular interactions as suggested by Garcia et al. [21], Oswald et al. [22]. 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 mole fraction of aniline ranging from 0 to 1 at temperatures T=(303.15,308.15,313.15 and 318.15)K is as shown in **Fig-4.** From **Fig-4**, it is observed that internal pressure value increases with the increase of mole fraction of aniline. The above from Fig-4 results tell that the interactions are increasing [23] with mole fraction of aniline and decreasing with temperature.

CONCLUSIONS

Ultrasonic velocity, density and viscosity values are measured in the binary liquid mixture containing aniline and mesitylene 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 mole fraction range of aniline. 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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