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# Density and Ultrasonic Velocity Study of 1, 2-Dichloroethane with Nitrobenzene Binary Liquid Mixture at 303.15K and 308.15K Two Temperatures at 4MHz

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***Abstract:*** ***Theoretical values of ultrasonic velocity and density in the binary mixture of 1, 2-Dichloroethane with Nitrobenzene have been evaluated at two temperatures 303.15 K and 308.15 K at fixed frequency 4MHz have been measured. From the experimental data acoustical parameters such like acoustic impedance(Z),Adiabatic compressibility(βad), available volume (Va), intermolecular free length ($L_f$), ), molar volume (Vm), free volume ($V_f$), ), internal pressure($\pi_i$), relaxation (τ) and Gibb's free energy (ΔG*) have been completed. These results are interpreted in terms of molecular interaction between the components of the mixture using Ideal mixture relation collegian factor theory tomato's relation junjies method and free length theory ($L_f$). A good agreement has been found between theoretical and experimental values $U^2_{exp}$ /$U^2_{mix}$ has also been computed for binary liquid mixtures system.***

***Keywords****: Ultrasonic velocity, density, binary liquid mixture, 1, 2-Dichloroethane, Nitrobenzene.*

## I. INTRODUCTION

Measurement of ultrasonic speed has been adequately utilized in understanding the molecular interaction in pure, binary and higher order multi component liquid mixture [1-3]. The propagation of inaudible speed throughout the medium could also be a thermo dynamical property and has come to be recognized as terribly specific and distinctive tool for predicting and estimating various physic-chemical properties of the liquid mixture into consideration [4-10]. Ultrasonic speed measuring data proves to be a really easy and convenient too to work out varied thermodynamic properties of liquid and liquid mixtures. Within the present paper the theoretical values of ultrasonic speed in binary liquid mixtures containing 1, 2-Dichloroethane and Nitrobenzene at 2 temperatures 303.15 K and 308.15 K over the entire mole fraction vary of 1, 2-Dichloroethane are evaluated by using nomotos [11], impedance relation [12],van deal and vangeel Ideal mix relation[13], junjies method[14], are compared with the experimental values 1,2-Dichloroethane is a commonly known as ethylene dichloride is a chlorinated hydrocarbon. Chemical formula $CH_4Cl_2$. It is a colours less liquid with a chloroform- like odour. The chemical 1, 2-Dichloroethane is most common use of the production of vinyl chloride, which is used to take polyvinyl chloride pipes, furniture and automobile upholstery, wall coverings, housewares, and automobile parts. Nitrobenzene is a water-insoluble pale yellow oil with an almond-like order with the chemical formulaC6H5No2 it is a freezes to give greenish-yellow crystal. It is also used to mask unpleasant odours in shoe and floor polish, leather dressings, paints solvents and other materials redistilled, soil of membrane nitrobenzene has been used as an in expensive perfume for soaps a significant merchant for nitrobenzene is use in the production of the analgesic paracetamol comparison of theoretical values of ultrasonic velocities with the experimentally measured value in the present binary liquid mixtures is expected to reveal the nature of interactions between the component molecules of the liquid mixtures. The deviation of unity has been evaluated for explaining the non ideality in the liquid mixture for the variation of $U^2_{exp}$ /$U^2_{imx.}$

## II. MATERIALS AND METHODS

The chemical used in the present investigation are of Analar grade (with purity>0.995) and are obtained from SDFCL chemicals (1, 2-dichloroethane) and MERCK chemicals (Nitrobenzene).The chemicals are purified by standard procedure [16]. The different concentration of the liquid mixture are prepared by varying mole fraction with respect to Jacobs's method of continuous variation. Stoppered conical flasks are used for preserving the prepared mixture and the flasks are left undisturbed to attain thermal equilibrium. The chemicals used in the present investigation are of Analar grade (with purity>0.995) and are further purified by employing the standard methods mentioned in literature [14-15]. Ultrasonic velocity (U) was measured using an ultrasonic

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interferometer working at 4MHz with an accuracy of ±0.05 % (Model F-81, Mittal enterprises, India). The measured speeds of sound have a precision of 0.8 $m.sec^{-1}$ .The temperature stability was maintained with ±0.01 K. By circulating water bath around the measuring cell through a pump. The density (ρ) of the pure liquids and their mixtures are determined using a $10^{-5}$ $m^3$ double-arm pycnometer, and the values from triplicate replication at each temperature are reproducible within 2 x $10^{-1}$ $kg{\cdot}m^3$ and the uncertainty in the measurement of density is found to be 2 parts in $10^4$ parts. The reproducibility in mole fractions was within ±0.0002

## III. THEORY AND CALCULATION

Using the measured data, the acoustical parameters have been calculated. The experimental values of density (ρ), ultrasonic sound velocity (u) and viscosity (η) of pure liquids and their mixtures as function of mole fraction of 1, 2-Dichloroethane at 303.15 and 308.15K were used to calculate the parameters such as $V_E$, $K_s$, $\Delta\kappa_s$ and $\Delta\eta$ from experimental data using the following expressions Volumetric, ultrasonic and viscometric studies of binary liquid mixtures of 1, 2-Dichloroethane

$$K_s = u^{-2}\rho^{-1} \quad (1)$$

$$L_f = K/u\ (\rho^{1/2} \quad (2)$$

$$Z = u\ \rho \quad (3)$$

$$\Delta_L = L_f - [x_1 L_{f1} + x_2 L_{f2}] \quad (4)$$

$$\Delta Z = Z - [x_1 Z_1 + x_2 Z_2] \quad (5)$$

$$Ve = [x_1M_1 + x_2M_2/\rho_1] - [x_1M_1 + x_2M_2/\rho_2] \quad (6)$$

$$\Delta\kappa s = \kappa_s - [x_1 \kappa_{s1} + x_2\ \kappa_{s2z}] \quad (7)$$

$$\Delta\eta = \eta - [x_1\ \eta_1 + x_2\ \eta_2] \quad (8)$$

$$\Delta u = u - [x_1\ u_1 + x_2\ u_2] \quad (9)$$

where $\kappa_{s1}$, $L_{f1}$, $Z_1$, $\rho_1$, $u_1$, $\eta_1$, $M_1$, $x_1$, $V_1$, $\kappa_{s2}$, $L_{f2}$, $Z_2$, $\rho_2$, $u_2$, $\eta_2$, $x_2$, $M_2$, $V_2$, $\kappa_s$, $L_f$ , Z, ρ, u, and η, are isentropic compressibility, intermolecular free length, acoustic impedance, density, ultrasonic speed, viscosity, molecular weight, mole fraction and volume of the components1, components 2, and mixtures, respectively

Table 1: Comparison of experimental Ultrasonic Velocity (U), Density (ρ), Viscosity (η), of pure liquid with literature value at 303.15K.

| Components | Velocity (U) | | Density (ρ) | | Viscosity (η) | |
|---|---|---|---|---|---|---|
| | Exp | Lit | Exp | Lit | Exp | Lit |
| 1,2-Dichloroethane | 1270.4 | 1272(34) | 1.2400 | 1.2408(35) | .7350 | .7350(36) |
| Nitrobenzene | 1432 | 1432 | 1.2020 | 1.2026 | 1.6061 | 1.6060 |

Table 2. Values of Ultrasonic Velocity (U), Density (ρ), Adiabatic Compressibility ($\beta_{ad}$), Intermolecular Free Length ($L_f$), Acoustical Impedance (Z), Molar Volume ($V_m$), Rao's Constant (R),Wada's constant (W), Available Volume ($V_a$), Degree of Molecular Interaction ($\chi_u$) at temperatures 303.15 and 308.15 K with frequency 4MHz for molefraction 1,2-dichloroethane with Nitrobenzene.

| $X_1$ | $U$ $m.s^{-1}$ | $\rho$ $Kg.m^{-2}$ | $\beta_{ad}.10^{-10}$ $m^2.N^{-1}$ | $L_f$ x $10^{-10}$ m | $Z\ x10^6$ $Kg.m^2.s^{-1}$ | R $\times10^{-3}$ $m^{10/3}\ s^{-1/3}\ mol^{-1}$ | W$\times10^{-1}$ $(m^3/mol^{-1})$ $(N/m^2)^{1/7}$ | $V_m \times10^{-6}$ $m^3/mol^{-1}$ | $V_a \times10^{-6}$ $m^3/mol^{-1}$ | $\chi_u \times10^{-2}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 303.15 K | | | | | | | | | | |
| 0.0000 | 1443.70 | 1196.51 | 4.0099 | 0.4155 | 1.7274 | 5.3977 | 8.4376 | 102.8921 | 1.0051 | 0.0000 |
| 0.2050 | 1410.90 | 1206.29 | 4.1644 | 0.4234 | 1.7020 | 5.0993 | 7.9892 | 97.9519 | 1.1577 | 0.0039 |
| 0.3920 | 1379.90 | 1214.71 | 4.3235 | 0.4315 | 1.6762 | 4.8345 | 7.5898 | 93.5546 | 1.2870 | 0.0060 |
| 0.5632 | 1350.40 | 1221.98 | 4.4876 | 0.4396 | 1.6502 | 4.5975 | 7.2315 | 89.6132 | 1.3980 | 0.0064 |
| 0.7206 | 1322.50 | 1228.57 | 4.6538 | 0.4476 | 1.6248 | 4.3835 | 6.9070 | 86.0382 | 1.4922 | 0.0056 |
| 0.8657 | 1295.90 | 1234.46 | 4.8237 | 0.4557 | 1.5997 | 4.1894 | 6.6121 | 82.7875 | 1.5735 | 0.0034 |
| 1.0000 | 1270.40 | 1240.08 | 4.9966 | 0.4638 | 1.5754 | 4.0114 | 6.3413 | 79.7968 | 1.6438 | 0.0000 |
| 308.15 K | | | | | | | | | | |
| 0.0000 | 1421.18 | 1187.50 | 4.1693 | 0.4278 | 1.6877 | 5.4102 | 8.4544 | 103.6724 | 1.1587 | 0.0000 |
| 0.2050 | 1391.70 | 1197.08 | 4.3131 | 0.4351 | 1.6660 | 5.1148 | 8.0100 | 98.7001 | 1.2850 | 0.0035 |
| 0.3920 | 1364.00 | 1206.20 | 4.4561 | 0.4422 | 1.6453 | 4.8494 | 7.6098 | 94.2066 | 1.3895 | 0.0057 |
| 0.5632 | 1337.60 | 1213.98 | 4.6040 | 0.4495 | 1.6238 | 4.6128 | 7.2519 | 90.1956 | 1.4792 | 0.0062 |
| 0.7206 | 1312.40 | 1220.97 | 4.7551 | 0.4568 | 1.6024 | 4.3992 | 6.9281 | 86.5673 | 1.5560 | 0.0052 |
| 0.8657 | 1288.40 | 1227.18 | 4.9090 | 0.4642 | 1.5811 | 4.2060 | 6.6344 | 83.2749 | 1.6218 | 0.0030 |
| 1.0000 | 1265.60 | 1232.80 | 5.0642 | 0.4715 | 1.5602 | 4.0300 | 6.3664 | 80.2678 | 1.6776 | 0.0000 |

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Table 3. Values of Viscosity ($\eta$), Free Volume ($V_f$), Relaxation Time ($\tau$), Internal Pressure ($\pi$), Gibb's Free Energy ($\Delta G$), Enthalpy ($H$), Classical Absorption coefficient ($\alpha/f^2$), Ultrasonic Attenuation ($\alpha$) at temperatures 303.15 and 308.15 K with frequency 4MHz for molefraction 1,2-dichloroethane with Nitrobenzene.

| X | $\eta\times10^{-3}$ $NSm^{-2}$ | $V_f\times10^{-7}$ $m^3mol^{-1}$ | $\tau \times 10^{-12}$ sec | $\pi \times10^{6}$ $Nm^{-2}$ | $\Delta G \times 10^{-20}$ K J $mol^{-1}$ | H x $10^{-3}$ J $mol^{-1}$ | $\alpha/f^2 \times 10^{14}$ $m^{-1}s^2$ | $\alpha$ Neper/m |
|---|---|---|---|---|---|---|---|---|
| 303.15 K | | | | | | | | |
| 0.0000 | 1.6475 | 1.2650 | 0.8808 | 457.3247 | 0.4734 | 47.0551 | 15.6239 | 48.2123 |
| 0.2050 | 1.4159 | 1.4424 | 0.7862 | 452.3563 | 0.4715 | 44.3092 | 12.6355 | 44.0322 |
| 0.3920 | 1.2235 | 1.6382 | 0.7053 | 447.0468 | 0.4698 | 41.8233 | 10.2858 | 40.3893 |
| 0.5632 | 1.0640 | 1.8498 | 0.6366 | 441.7971 | 0.4681 | 39.5909 | 8.4334 | 37.2529 |
| 0.7206 | 0.9349 | 2.0643 | 0.5801 | 437.6551 | 0.4666 | 37.6550 | 6.9979 | 34.6622 |
| 0.8657 | 0.8269 | 2.2883 | 0.5318 | 433.8743 | 0.4652 | 35.9193 | 5.8514 | 32.4294 |
| 1.0000 | 0.7350 | 2.5253 | 0.4897 | 430.2823 | 0.4639 | 34.3351 | 4.9224 | 30.4576 |
| 308.15 K | | | | | | | | |
| 0.0000 | 1.5279 | 1.3834 | 0.8494 | 448.9423 | 0.4808 | 46.5429 | 13.7181 | 47.2272 |
| 0.2050 | 1.3119 | 1.5842 | 0.7544 | 443.4083 | 0.4789 | 43.7644 | 11.1501 | 42.8370 |
| 0.3920 | 1.1328 | 1.8069 | 0.6730 | 437.7803 | 0.4770 | 41.2418 | 9.1334 | 38.9914 |
| 0.5632 | 0.9836 | 2.0513 | 0.6038 | 431.9987 | 0.4752 | 38.9644 | 7.5271 | 35.6703 |
| 0.7206 | 0.8632 | 2.2999 | 0.5473 | 427.3819 | 0.4736 | 36.9973 | 6.2753 | 32.9524 |
| 0.8657 | 0.7614 | 2.5673 | 0.4984 | 422.7846 | 0.4721 | 35.2073 | 5.2637 | 30.5655 |
| 1.0000 | 0.6739 | 2.8601 | 0.4550 | 417.9557 | 0.4706 | 33.5484 | 4.4360 | 28.4114 |

Table 4. Excess Acoustic and Thermodynamic parameters of Ultrasonic Velocity ($U^E$), Adiabatic Compressibility ($\beta_{ad}^E$), Intermolecular Free Length ($L_f^E$), Acoustical Impedance ($Z^E$), Molar Volume ($V_m^E$), Available Volume ($V_a^E$), Viscosity ($\Delta\eta$), Free Volume ($V_f^E$), Internal Pressure ($\pi^E$), Enthalpy ($H^E$), Gibb's F
ree Energy ($\boldsymbol{\Delta G^E}$) at temperatures 303.15, 308.15 K with frequency 4MHz for mole fraction 1,2-dichloroethane with Nitrobenzene.

| X | $U^E$ m/sec | $\beta_{ad}^E$ $X10^{-10}$ $N^{-1}ms^2$ | $L_f^E$ $X10^{-10}$ m | $Z^E$ $X10^6$ $Kgm^2s^{-1}$ | $V_m^E$ $X10^{-6}$ $m^3/mol^{-1}$ | $V_a^E$ $X10^{-6}$ $m^3/mol^{-1}$ | $\Delta\eta$ X $10^{-3}$ $NSm^{-2}$ | $V_f^E$ $X10^{-7}$ $m^3/mol^{-1}$ | $\pi^E$ $X10^6$ $N/m^2$ | $H^E$ $X10^{-3}$ J/mol | $\Delta G^E$ $X10^{-20}$ J/mol |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 303.15K | | | | | | | | | | | |
| 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.2050 | 2.7291 | -0.0477 | -0.0020 | 0.0053 | -0.1733 | 0.0216 | -0.0445 | -0.0810 | 0.5757 | -0.1381 | 0.0004 |
| 0.3920 | 4.1321 | -0.0732 | -0.0030 | 0.0080 | -0.2644 | 0.0315 | -0.0663 | -0.1209 | 0.8025 | -0.2457 | 0.0006 |
| 0.5632 | 4.3042 | -0.0780 | -0.0032 | 0.0084 | -0.2714 | 0.0331 | -0.0696 | -0.1250 | 0.8370 | -0.3002 | 0.0006 |
| 0.7206 | 3.6767 | -0.0671 | -0.0027 | 0.0069 | -0.2119 | 0.0269 | -0.0551 | -0.1089 | 0.7234 | -0.2343 | 0.0005 |
| 0.8657 | 2.2293 | -0.0404 | -0.0016 | 0.0039 | -0.1106 | 0.0154 | -0.0306 | -0.0677 | 0.4127 | -0.1238 | 0.0003 |
| 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 308.15K | | | | | | | | | | | |
| 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.2050 | 2.4586 | -0.0400 | -0.0017 | 0.0045 | -0.1877 | 0.0198 | -0.0407 | -0.1024 | 0.6272 | -0.1109 | 0.0005 |
| 0.3920 | 3.8680 | -0.0644 | -0.0027 | 0.0076 | -0.2820 | 0.0273 | -0.0600 | -0.1560 | 0.8468 | -0.2022 | 0.0007 |
| 0.5632 | 4.1080 | -0.0697 | -0.0029 | 0.0080 | -0.2855 | 0.0281 | -0.0630 | -0.1644 | 0.8811 | -0.2546 | 0.0007 |
| 0.7206 | 3.3803 | -0.0594 | -0.0024 | 0.0066 | -0.2323 | 0.0233 | -0.0490 | -0.1481 | 0.7784 | -0.1776 | 0.0006 |
| 0.8657 | 1.9389 | -0.0353 | -0.0014 | 0.0038 | -0.1311 | 0.0138 | -0.0270 | -0.0948 | 0.4741 | -0.0834 | 0.0004 |
| 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

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Table 5. Experimental and Theoretical values of Ultrasonic velocity at temperatures 303.15, 308.15K for mole fraction 1,2-dichloroethane with Nitrobenzene.

| Mole Fraction X | $U_{EXP}$ $ms^{-1}$ | $U_J$ $ms^{-1}$ | $U_{NOM}$ $ms^{-1}$ | $U_{FLT}$ $ms^{-1}$ | $U_{IDR}$ $ms^{-1}$ | $U_{IMR}$ $ms^{-1}$ | $U_{RAO}$ $ms^{-1}$ |
|---|---|---|---|---|---|---|---|
| 303.15 K | | | | | | | |
| 0.0000 | 1443.70 | 1443.70 | 1443.70 | 1443.70 | 1443.70 | 1443.70 | 1443.70 |
| 0.2050 | 1410.90 | 1410.70 | 1413.79 | 1419.05 | 1407.15 | 1389.75 | 1411.86 |
| 0.3920 | 1379.90 | 1379.56 | 1384.29 | 1387.67 | 1374.29 | 1350.60 | 1380.58 |
| 0.5632 | 1350.40 | 1350.09 | 1355.20 | 1354.57 | 1344.57 | 1321.54 | 1350.17 |
| 0.7206 | 1322.50 | 1322.16 | 1326.53 | 1323.92 | 1317.59 | 1299.64 | 1321.75 |
| 0.8657 | 1295.90 | 1295.64 | 1298.26 | 1295.30 | 1292.96 | 1283.03 | 1294.84 |
| 1.0000 | 1270.40 | 1270.40 | 1270.40 | 1270.40 | 1270.40 | 1270.40 | 1270.40 |
| 308.15 K | | | | | | | |
| 0.0000 | 1421.18 | 1421.18 | 1421.18 | 1421.18 | 1421.18 | 1421.18 | 1421.18 |
| 0.2050 | 1391.70 | 1392.00 | 1394.41 | 1398.32 | 1388.28 | 1372.76 | 1391.15 |
| 0.3920 | 1364.00 | 1364.27 | 1367.98 | 1375.47 | 1358.74 | 1337.52 | 1364.59 |
| 0.5632 | 1337.60 | 1337.86 | 1341.89 | 1347.25 | 1332.06 | 1311.34 | 1337.96 |
| 0.7206 | 1312.40 | 1312.67 | 1316.13 | 1319.11 | 1307.86 | 1291.66 | 1312.70 |
| 0.8657 | 1288.40 | 1288.61 | 1290.70 | 1291.54 | 1285.79 | 1276.80 | 1288.49 |
| 1.0000 | 1265.60 | 1265.60 | 1265.60 | 1265.60 | 1265.60 | 1265.60 | 1265.60 |

Table 5. Percentage deviation between Experimental and Theoretical values of Ultrasonic velocity at temperatures 303.15, 308.15K for mole fraction 1,2-dichloroethane with Nitrobenzene.

| Mole Fraction *X* | $\%U_{NOM}$ | $\%U_J$ | $\%U_{IDR}$ | $\%U_{FLT}$ | $\%U_{IMR}$ | $\%U_{RAO}$ | $U^2_{exp}/U^2_{imx}$ |
|---|---|---|---|---|---|---|---|
| 303.15 K | | | | | | | |
| 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 - 1.4993 | 0.0000 | 1.0000 |
| 0.2050 | 0.2046 | -1.3972 | -0.2658 | 0.5775 | - 2.1232 | 0.0679 | 1.0307 |
| 0.3920 | 0.3180 | -0.0249 | -0.4069 | 0.5634 | - | 0.0495 | 1.0439 |
| 0.5632 | 0.3557 | -0.0229 | -0.4314 | 0.3089 | 2.1374 - | -0.0170 | 1.0442 |
| 0.7206 | 0.3047 | -0.0257 | -0.3716 | 0.1073 | 1.7283 - | -0.0565 | 1.0355 |
| 0.8657 | 0.1823 | -0.0204 | -0.2269 | -0.0461 | 0.9934 | -0.0817 | 1.0202 |
| 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 |
| 308.15 K | | | | | | | |
| 0.0000 | 1421.18 | 1421.18 | 1421.18 | 1421.18 | 1421.18 | 1421.18 | 1421.18 |
| 0.2050 | 1391.70 | 1392.00 | 1394.41 | 1398.32 | 1388.28 | 1372.76 | 1391.15 |
| 0.3920 | 1364.00 | 1364.27 | 1367.98 | 1375.47 | 1358.74 | 1337.52 | 1364.59 |
| 0.5632 | 1337.60 | 1337.86 | 1341.89 | 1347.25 | 1332.06 | 1311.34 | 1337.96 |
| 0.7206 | 1312.40 | 1312.67 | 1316.13 | 1319.11 | 1307.86 | 1291.66 | 1312.70 |
| 0.8657 | 1288.40 | 1288.61 | 1290.70 | 1291.54 | 1285.79 | 1276.80 | 1288.49 |
| 1.0000 | 1265.60 | 1265.60 | 1265.60 | 1265.60 | 1265.60 | 1265.60 | 1265.60 |

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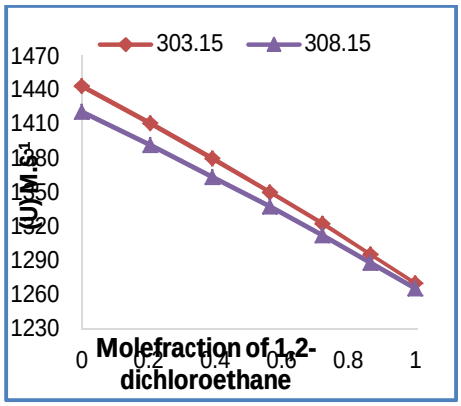


Fig.3.1.1 Variation of Ultrasonic Velocity with mole fraction of 1,2-dichloroethane + Nitrobenzene

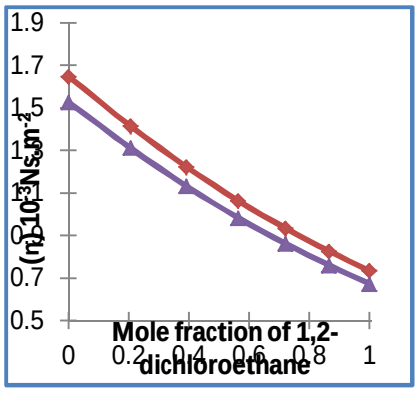


Fig.3.1.2 Variation of Viscosity with mole fraction of 1,2-dichloroethane + Nitrobenzene

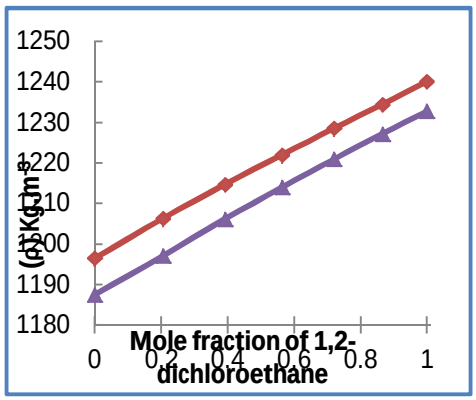


Fig.3.1.3 Variation of Density with mole fraction of 1,2-dichloroethane + Nitrobenzene

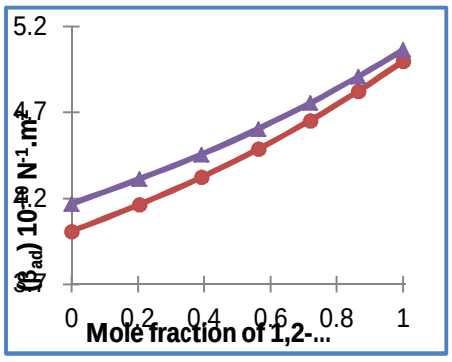


Fig.3.1.4 Variation of Adiabatic compressibility with mole fraction of 1,2-dichloroethane + Nitrobenzene

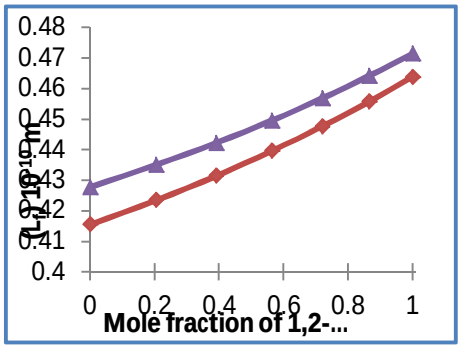


Fig.3.1.5 Variation of Intermolecular free length with mole fraction of 1,2-dichloroethane + Nitrobenzene

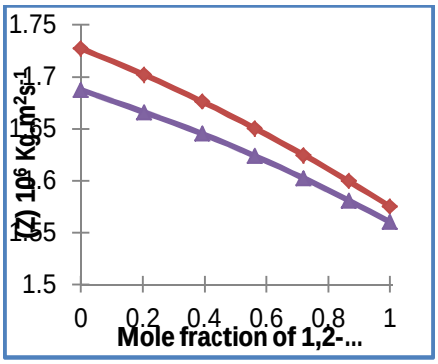


Fig.3.1.6 Variation of Acoustic impedance with mole fraction of 1,2-dichloroethane + Nitrobenzene


Fig.3.1.7 Variation of Molar Volume with mole fraction of 1,2-dichloroethane + Nitrobenzene

Fig.3.1.8 Variation of Available Volume with mole fraction of 1,2-dichloroethane + Nitrobenzene

Fig.3.1.9 Variation of Free Volume with mole fraction of 1,2-dichloroethane + Nitrobenzene

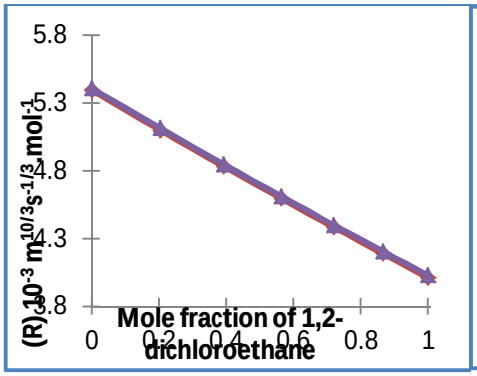


Fig.3.1.10 Variation of Rao's Constant with mole fraction of 1,2-dichloroethane + Nitrobenzene

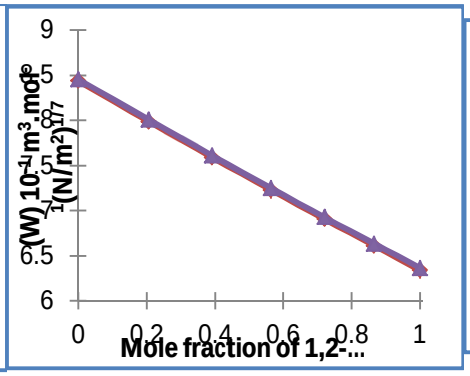


Fig.3.1.11 Variation of Wada's Constant with mole fraction of 1,2-dichloroethane + Nitrobenzene

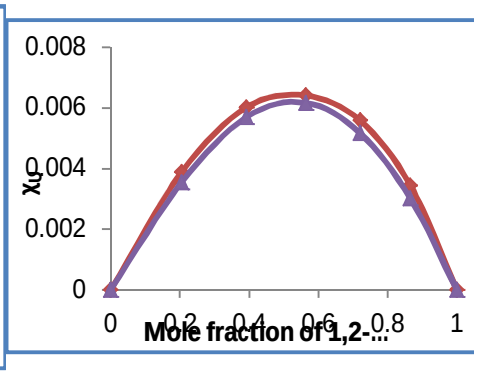


Fig.3.1.12 Variation of Degree of molecular interaction with mole fraction of 1,2-dichloroethane + Nitrobenzene

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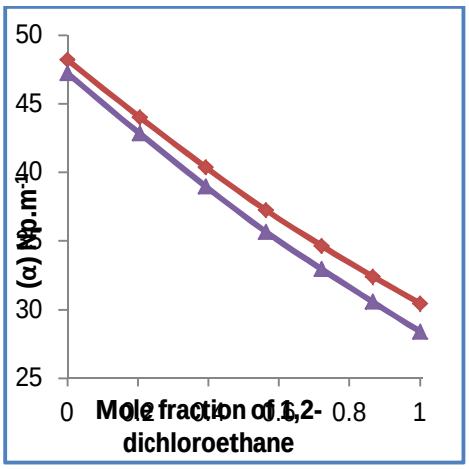



Fig.3.1.13 Variation of Ultrasonic Attenuation with mole fraction of 1,2-dichloroethane + Nitrobenzene

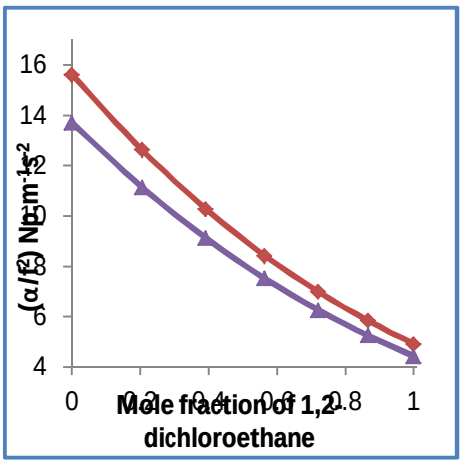



Fig.3.1.14 Variation of Classical Absorption Coefficient with mole fraction of 1,2-dichloroethane + Nitrobenzene

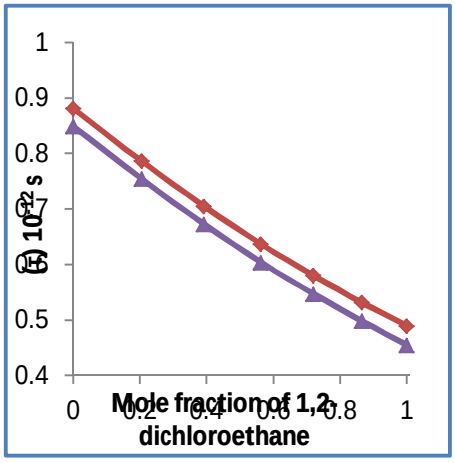
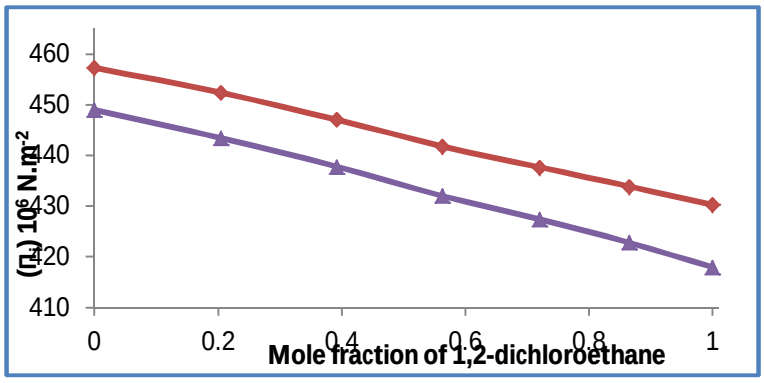



Fig.3.1.15 Variation of Relaxation Time with mole fraction of 1,2-dichloroethane + Nitrobenzene




Variation of Internal Pressure with mole fraction of 1,2-dichloroethane + Nitrobenzene

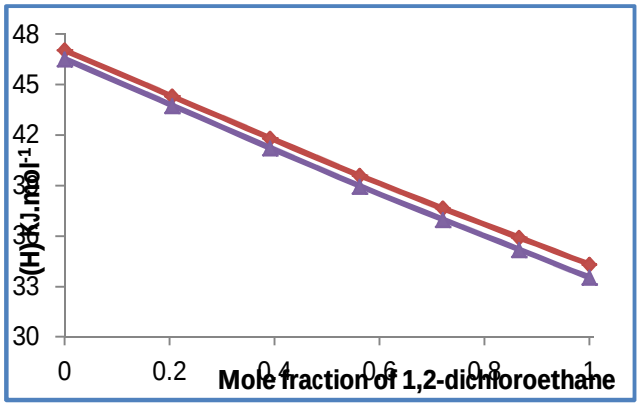



Fig.3.1.17 Variation of Enthalpy with mole fraction of 1,2-dichloroethane + Nitrobenzene

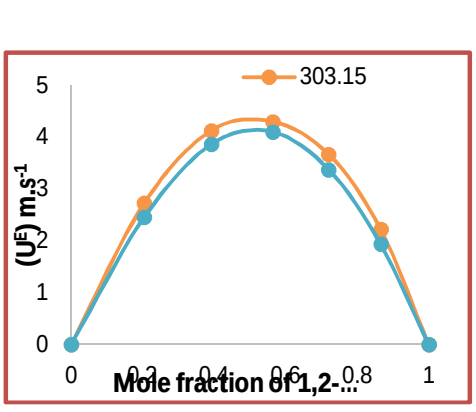



Fig.1 Variation of Excess Ultrasonic Velocity with molefraction of 1,2-dichloroethane + Nitrobenzene

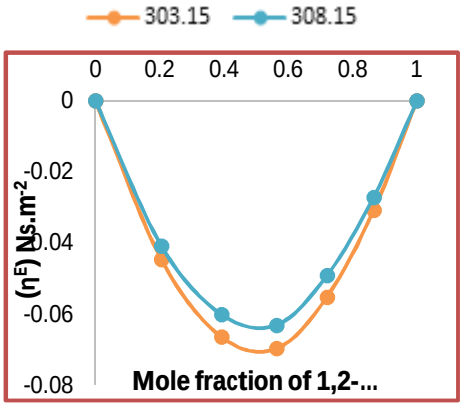



Fig.4.2 Variation of Viscosity with molefraction of 1,2-dichloroethane + Nitrobenzene

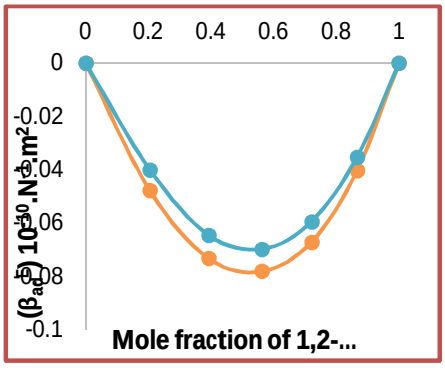



Fig.4.1.3 Variation of Excess Adiabatic Compressibility with molefraction of 1,2-dichloroethane + Nitrobenzene

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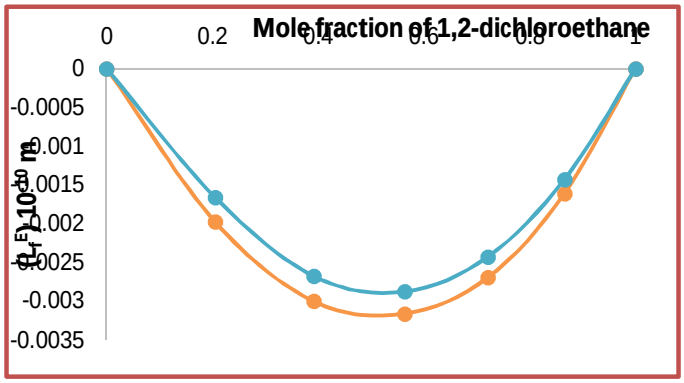


Fig.4.1.4 Variation of Excess Intermolecular free length with molefraction of 1,2-dichloroethane + Nitrobenzene

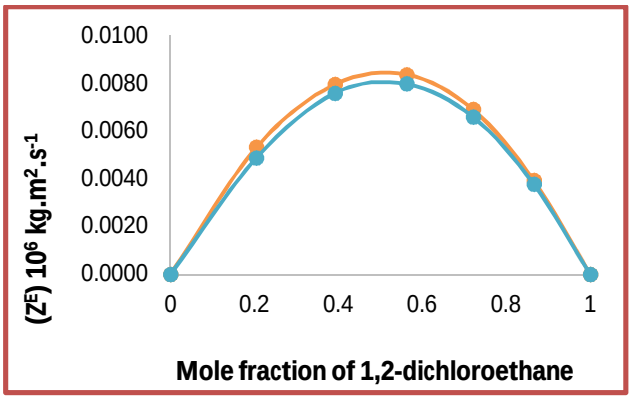


Fig.4.1.5 Variation of Excess Acoustic impedance with molefraction
of 1,2-dichloroethane + Nitrobenzene

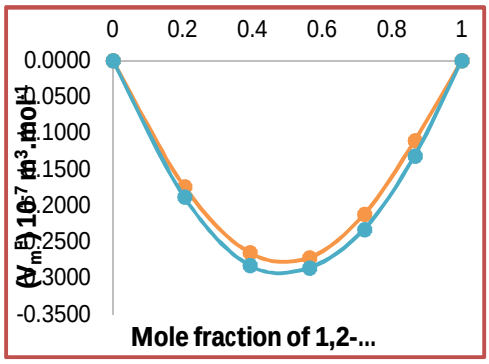


Fig.4.1.6 Variation of Excess Molar Volume with molefraction of
1,2-dichloroethane + Nitrobenzene

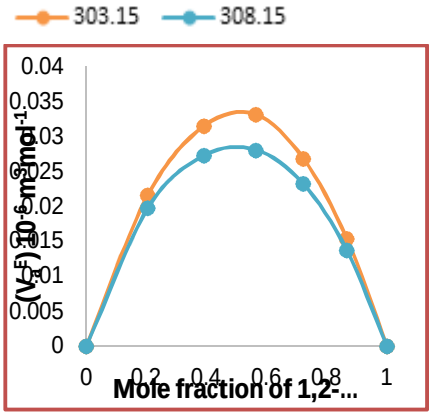


Fig.4.1.7 Variation of Excess Available Volume with molefraction of 1,2-dichloroethane + Nitrobenzene

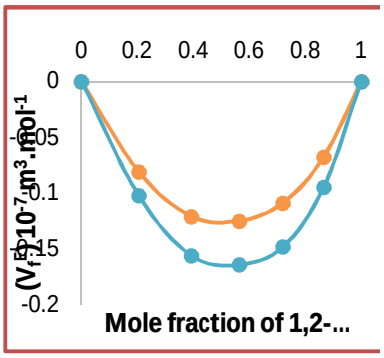


Fig.4.1.8 Variation of Excess Free Volume with molefraction of
1,2-dichloroethane + Nitrobenzene

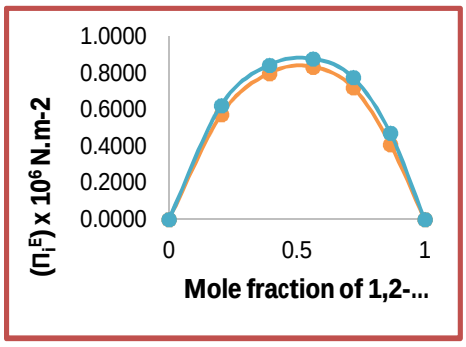


Fig.4.1.9 Variation of Excess Internal Pressure with molefraction of 1,2-dichloroethane + Nitrobenzene

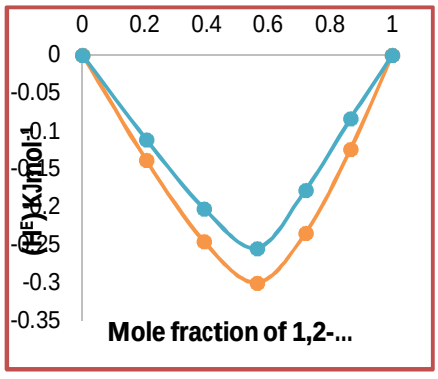


Fig.4.1.10 Variation of Excess Enthalpy with molefraction of
1,2-dichloroethane + Nitrobenzene

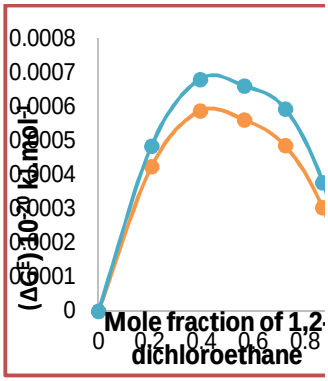


Fig.4.1.11 Variation Excess Gibb's Free Energy with molefraction of 1,2-dichloroethane + Nitrobenzene

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## IV. RESULT AND DISCUSSIONS

The experimentally measured values of Density (ρ), Ultrasonic velocity (U), Viscosity (η) and thermodynamic parameters like adiabatic compressibility (βad), Intermolecular free length ($L_f$),Acoustic impedance (Z), Molar volume ($V_m$), Rao's Constant (R), Wada's constant (W), Internal pressure (π) and Free volume ($V_f$) of 1,2-Dichloroethane with nitrobenzene binary liquid system at different temperatures at a frequency of 4MHz over the whole concentration of 1,2-Dichloroethane with Nitrobenzene are presented in Table-2

The ultrasonic velocity decreases with increase in the concentration of 1, 2-Dichloroethane and decreases with increase in temperature[16-19]. The decrease in velocity is perhaps due to structural changes occurring in the mixtures resulting in weakening of intermolecular forces. Further the ultrasonic velocity decreases with increase in temperature at any concentrations as rise in temperature leads to less disordered structure and more spacing between the molecules.

Density increases with increasing the concentration 1, 2-Dichloroethane of and also it decreases with increasing the temperature. It suggests that a solute-solvent interaction exist between 1, 2-Dichloroethane and Nitrobenzene system. In other words the decrease in density may be interpreted to the structure maker of the solvent due to H-bonding

The induced dipole moment that creates induced dipole–induced dipole force of attraction between pair of atoms. This type of interaction is weaker which is given by the least ultrasonic velocity[20] . From the Table-2, the adiabatic compressibility and free length decreases with increasing mole fraction of the1, 2-Dichloroethane and increases with increasing temperature. Which suggest that making and breaking of H- bonding between molecules of the system[21-23]. The intermolecular free length depends upon the intermolecular attractive and repulsive forces. Eyring and Kincaid have proposed that $L_f$ is a predominating factor in determining the variation of ultrasonic velocity of solution. Hence it can be concluded that there is significant interaction between solute and solvent molecules due to which the structural arrangement is also affected. From the above parameters it is clear that there is a strong association between and Nitrobenzene system.

The acoustic impedance (Z) (which is the product of ultrasonic velocity and density of the solution) increases with increase in concentration of 1, 2-Dichloroethane. It represents that there is strong interaction between the 1, 2-Dichloroethane and Nitrobenzene system. In this system, viscosity increases with increasing molefraction of 1, 2-Dichloroethane and decreases with increasing temperature. The decrease in density and viscosity with temperature indicates that decrease in intermolecular forces due to increase in thermal energy of the system, which cause increase in volume expansion and hence increase in free length.

Viscosity increases with concentration of 1, 2-Dichloroethane confirms that increase of cohesive forces because of strong interaction[24-26].The internal pressure decreases with increasing mole fraction of1, 2-Dichloroethane.The reduction in internal pressure may be due to the loosening of cohesive forces and adhesive force leading to breaking the structure of the solution. This gives the information regarding the nature and strength of forces existing between the molecules. The free volume decreases with increase molefraction of 1, 2-Dichloroethane. The free volume is the space available for the molecules to move in an imaginary unit cell[27-30]. It clearly indicates the existence of intermolecular interaction, due to which the structural arrangement is considerably affected. International Letters of Chemistry, Physics and Astronomy Vol. 52 55These binary systems exhibit non-linear increase/decrease in U, $V_f$, Z and $\pi_i$ values with composition of 1,2-Dichloroethane. This indicates the presence of intermolecular interactions between the component molecules of the mixture[31-33]. In order to substantiate the presence of interactions (either adhesive or cohesive forces) between the molecules.

## V. CONCLUSION

From the data of ultrasonic speed, density and viscosity, various acoustical parameters and their excess values for the binary liquid mixture of 1, 2-dichloroethane with Nitrobenzene was measured at (303.15, 308.15) K, it is obvious that there exist strong molecular interactions between 1, 2-Dichloroethane and Nitrobenzene. The existence of type of molecular interactions in solute-solvent is favoured in the system, confirmed from the U, ρ, βad, Lf, Z, Vm, R, W, η, π and $V_f$ data. Weak dispersive type intermolecular interactions are confirmed in the systems investigated. All the experimental determinations of acoustic parameters are weakly correlated between 1, 2-dichloroethane with Nitrobenzene.

## VI. ACKNOWLEDGEMENT

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