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**ResearchArticle**

# EXPERIMENTAL STUDY OF THE THERMO PHYSICAL AND ACOUSTICAL PROPERTIES OF BINARY MIXTURES

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**ABSTRACT**

Ultrasonic velocity (U), Density (ρ) and Viscosity (η) have been measured in binary liquid mixtures of Propylene glycol mono propyl ether (PGPE) + Aniline (ANI) and PGPE + 1-Amino-2-propanol (MIPA) at 303.15 K and 313.15 K. From these values, acoustical parameters such as Adiabatic compressibility (β), Free length (Lf), Acoustical impedance (Z) and Molar volume (V) were calculated using standard relations. Excess values such as ZE, LfE, ηE, UE and VE were also determined. The results are interpreted in terms of molecular interaction such as dipole - dipole interaction or hydrogen bonding between the components of mixture.



## INTRODUCTION

Ultrasonic investigation of liquid mixtures containing polar solvent and weakly interacting components are of considerable interest to researchers in order to understand the intermolecular interaction and binary forces prevailing between the atoms or molecules (1–3). Knowledge about the intermolecular interaction between the components is very much important in several industrial and technological processes (4–7). Ultrasonic velocity and its related parameterslike Adiabatic compressibility (β), Free length ($L_f$), Acoustical impedance (Z) and Molar volume (V) helps in characterizing thermodynamic and physico – chemical aspects of binary liquid mixtures such as molecular association and dissociation (8-9). Hence, the intermolecular interaction existing between the components of these binaries has to be revealed in order to understand any physico- chemical process in these mixtures.

The present work deals with the study of ultrasonic velocity and its related parameter like Adiabatic compressibility(β), Free length ($L_f$), Acoustical impedance (Z), Molar volume (V) and their excess values like $Z^E$ ,$L_f^E$, $\eta^E$, $U^E$ and $V^E$ in the binary system of propylene glycol mono propyl ether (PGPE) + aniline (ANI) and propylene glycol mono propyl ether (PGPE) + 1-Amino-2-propanol (MIPA) at two different temperatures viz., 303.15K and 313.15K.ANI is a popular industrial organic solvent and hence its interaction with neighbouring components in a mixture has to be exposed to know the significance of its compositional behaviour (10). PGPE is a polar solvent and the hydroxyl group of PGPE forms hydrogen bonding with the hydrogen atom of weak base components such as amino group of 1-Amino-2-propanol and aniline. The –OH group of PGPE forms hydrogen bonding with the –OH group of 1-Amino-2-propanol. PGPE is soluble in ANI and MIPA due to the presence of electronegative force between the components.

### *Experimental details*

PGPE, ANI and MIPA were obtained from Sigma Aldrich Chemicals Ltd. Various concentration of the binary mixtures were prepared in terms of mole fractions. The ultrasonic velocities in liquid mixtures were measured using an Mittal type ultrasonic interferometer model M-84 at 2 MHz frequency with an accuracy of ±0.1 $ms^{-1}$. Densities and Viscosities were determined using specific gravity bottle and Ostwald's

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viscometer with an accuracy of ± 0.1Kgm$^{-3}$& ± 0.001NSm$^{-2}$ respectively. All the measurements were made at two different temperatures (303.15K and 313.15K) with the help of an electronically operated digital constant temperature bath (Guna make model) having the operating temperature range from 1$^{o}$C to100$^{o}$C with an accuracy of ± 0.1K.Each observation is repeated for five times and the average is taken as final value. Using the measured data, the acoustical parameter such as Acoustical impedance (Z), Adiabatic compressibility (β), Molar volume (V) and Free length ($L_f$) were calculated from the following standard thermophysical expressions

$Z = U.\rho 1$

Where U = Ultrasonic velocity
ρ = Density of liquid

$\beta = 1/U^2\rho$ 2

$V = M_{eff}/\rho_{mix}$ 3

Where $M_{eff}$is effective molecular weight given as

$M_{eff} = \sum M_i x_i$

In the above expression, $M_i$& $x_i$ are the molecularweight and mole fraction of individual constituents respectively.

$L_f = K_T\sqrt{\beta}$ 4

Where $K_T$ is a Jacobson's constant.

The excess values of the parameter are computed from the following expressions

$\eta^E = \eta_{mix} - (x_1\eta_1 + x_2\eta_2)$ 5

$Z^E = (\rho_{mix}U_{mix}) - (X_1\rho_1U_1 + X_2\rho_2U_2)$ 6

$V^E = (X_1M_1 + X_2M_2/\rho_{mix}) - (X_1M_1/\rho_1 + X_2M_2/\rho_2)$ 7

Where
$\boldsymbol{\rho_{mix}}$ = Density mixtures
$\boldsymbol{\rho_1}$ = Density of first components
$\boldsymbol{\rho_2}$ = Density of second components
$\mathbf{M_1}$= Molecular weight of first components
$\mathbf{M_2}$ = Molecular weight of second components

$L_f^E = K/(U^2_{mix}\rho_{mix})^{1/2} - (X_1 K/(U^2_1\rho_1)^{1/2} + (X_2 K/(U^2_2\rho_2)^{1/2})$ 8

Where

Z K = Jacobson's constant = $200\times10^{-8}$ at 303.15K
$=203\times10^{-8}$ at 313.15K

$U^E = U - (X_1U_1 + X_2U_2)$ 9

From the review of literature, the values for the Density and Speed of MIPA, ANI and PGPE are given in table 1 (11).

**Table 1** Density and Speed of MIPA, ANI and PGPE

| T (K) | P (Kgm$^{-3}$) | U (Ms$^{-1}$) |
|---|---|---|
| | MIPA | |
| 303.15 | 951 | 1526 |
| | 952.39 | ------ |
| 313.15 | 944 | 1493 |
| | 944.30 | ---------- |
| | ANILINE | |
| 303.15 | 1011 | 1612 |
| | 1010.9 | 1614 |
| 313.15 | 1006 | 1581 |
| | --------- | ---------- |
| | PGPE | |
| 303.15 | 879 | 1215 |
| | --------- | --------- |
| 313.15 | 872 | 1186 |
| | --------- | --------- |

## RESULTS AND DISCUSSION

The experimental density (ρ), viscosity (η), and Ultrasonic velocity (U) values and computed parameters β,Z, V & $L_f$of PGPE in ANI and PGPE in MIPA at 303.15K & 313.15K are given in Table 2 and 3 respectively. All the excess values of the parameter $V^E$, $L_f^E$, $Z^E$, $\eta^E$ and $U^E$ at 303.15K & 313.15K are given in Table 4 and 5.

**Table 2**Experimental Density(ρ),Viscosity(η) and Ultrasonic velocity(U) Data and Computed Parameters (β, Z, V and $L_f$)values for thePGPE + ANI binary mixture

| Mole fraction$X_1$ | ρ Kgm$^{-3}$ | η×10$^{-3}$ Nsm$^{-1}$ | Ums$^{-1}$ | β× 10$^{-10}$ | Z×10$^3$ | V×10$^6$ M$^3$mol$^{-1}$ | $L_f$× 10 $^{-11}$ |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | | | | 303.15K | | | |
| 1.0000 | 879 | 1.5587 | 1215 | 7.7065 | 1067.9 | 134.448 | 5.5521 |
| 0.9196 | 893 | 1.5835 | 1254 | 7.1212 | 1119.8 | 130.0335 | 5.3371 |
| 0.8371 | 906 | 1.6468 | 1293 | 6.6019 | 1171.4 | 126.0816 | 5.1388 |
| 0.7470 | 918 | 1.7093 | 1335 | 6.1121 | 1225.5 | 121.5359 | 4.9445 |
| 0.6549 | 933 | 1.7786 | 1374 | 5.6773 | 1281.9 | 117.3311 | 4.7654 |
| 0.5592 | 946 | 1.8453 | 1416 | 5.2720 | 1339.5 | 106.8816 | 4.5921 |
| 0.4580 | 958 | 1.9536 | 1455 | 4.9306 | 1393.5 | 109.1022 | 4.4409 |
| 0.3522 | 972 | 2.0253 | 1494 | 4.6092 | 1452.1 | 104.9588 | 4.2938 |
| 0.2402 | 987 | 2.0565 | 1537 | 4.2887 | 1517.0 | 100.4660 | 4.1418 |
| 0.1235 | 1000 | 2.1280 | 1577 | 4.0210 | 1577.0 | 96.1771 | 4.0104 |
| 0.0000 | 1011 | 2.1984 | 1612 | 3.8064 | 1629.7 | 92.1167 | 3.9019 |
| | | | | 313.15K | | | |
| 1.0000 | 872 | 1.3917 | 1186 | 8.1529 | 1034.1 | 135.5275 | 5.7960 |
| 0.9196 | 885 | 1.5301 | 1223 | 7.5544 | 1082.3 | 131.2090 | 5.5795 |
| 0.8371 | 898 | 1.5924 | 1261 | 7.0031 | 1132.3 | 127.2048 | 5.3720 |
| 0.7470 | 913 | 1.6595 | 1300 | 6.4810 | 1186.9 | 122.2015 | 5.1679 |
| 0.6549 | 926 | 1.6831 | 1338 | 6.0322 | 1238.9 | 118.2181 | 4.9857 |
| 0.5592 | 948 | 1.7651 | 1379 | 5.5470 | 1307.2 | 106.6561 | 4.7810 |
| 0.4580 | 953 | 1.8167 | 1418 | 5.2186 | 1351.3 | 109.6747 | 4.6373 |
| 0.3522 | 967 | 1.9291 | 1458 | 4.8647 | 1409.8 | 105.5015 | 4.4773 |
| 0.2402 | 982 | 2.0026 | 1501 | 4.5198 | 1473.9 | 100.9775 | 4.3157 |
| 0.1235 | 995 | 2.0732 | 1542 | 4.2267 | 1534.2 | 96.6532 | 4.1734 |
| 0.0000 | 1006 | 2.0961 | 1581 | 3.9768 | 1590.4 | 92.5754 | 4.0482 |

**Table 3**Experimental Density(ρ),Viscosity(η) and Ultrasonic velocity(U) Data and Computed Parameters (β, Z, V and $L_f$) values for the PGPE + MIPA binary mixture

| Mole fraction $X_1$ | ρKgm$^{-3}$ | η×10$^{-3}$ Nsm$^{-1}$ | U ms$^{-1}$ | β× 10$^{-10}$ | Z×10$^3$ | V×10$^6$ M$^3$mol$^{-1}$ | $L_f$×$^{10-11}$ |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | | | | 303.15K | | | |
| 1.0000 | 879 | 1.5587 | 1215 | 7.7065 | 1067.9 | 134.4482 | 5.5521 |
| 0.9338 | 885 | 1.8048 | 1232 | 7.4444 | 1090.3 | 130.2259 | 5.4568 |
| 0.8626 | 892 | 2.1354 | 1250 | 7.1748 | 1115.0 | 125.8632 | 5.3571 |
| 0.7853 | 899 | 2.6703 | 1270 | 6.8965 | 1141.7 | 121.0789 | 5.2522 |
| 0.7018 | 905 | 2.7683 | 1308 | 6.4585 | 1183.7 | 116.2872 | 5.0827 |
| 0.6114 | 912 | 3.3558 | 1343 | 6.0792 | 1224.8 | 111.2280 | 4.9312 |
| 0.5171 | 919 | 4.5223 | 1380 | 5.7138 | 1268.2 | 106.5832 | 4.7807 |
| 0.4043 | 927 | 5.5480 | 1418 | 5.3649 | 1314.4 | 99.8489 | 4.6324 |
| 0.3161 | 934 | 7.0806 | 1455 | 5.0573 | 1358.9 | 94.9464 | 4.4976 |
| 0.1485 | 942 | 9.0206 | 1490 | 4.7816 | 1403.5 | 86.4755 | 4.3733 |
| 0.0000 | 951 | 11.7207 | 1526 | 4.5155 | 1451.2 | 78.9800 | 4.2499 |
| | | | | 315.15K | | | |
| 1.0000 | 872 | 1.3917 | 1186 | 8.1529 | 1034.1 | 135.5275 | 5.7963 |
| 0.9338 | 879 | 1.4808 | 1213 | 7.7319 | 1066.2 | 131.1149 | 5.6446 |
| 0.8626 | 885 | 1.9617 | 1242 | 7.3250 | 1099.1 | 126.8587 | 5.4941 |
| 0.7853 | 892 | 2.5704 | 1271 | 6.9397 | 1133.7 | 122.0291 | 5.3476 |
| 0.7018 | 898 | 2.6275 | 1302 | 6.5690 | 1169.1 | 117.1937 | 5.2029 |
| 0.6114 | 905 | 3.0893 | 1331 | 6.2372 | 1204.5 | 112.0883 | 5.0698 |
| 0.5171 | 912 | 3.8814 | 1361 | 5.9195 | 1241.2 | 107.4013 | 4.9389 |
| 0.4043 | 920 | 4.8944 | 1394 | 5.5935 | 1282.4 | 100.6086 | 4.8010 |
| 0.3161 | 928 | 6.2946 | 1425 | 5.3066 | 1322.4 | 95.5603 | 4.6763 |
| 0.1485 | 935 | 7.8758 | 1457 | 5.0381 | 1362.2 | 87.1229 | 4.5564 |
| 0.0000 | 944 | 10.6300 | 1493 | 4.7523 | 1409.3 | 79.5656 | 4.4253 |

**Table 4** Excess acoustic impedance ($Z^E$),excess viscosity($\eta^E$ ), excess Molar volume($V^E$), excess free lenth($L_f^E$) and excess Ultrasonic velocity($U^E$) values of the PGPE + ANI binary mixture

| 303.15 K | | | | | |
|---|---|---|---|---|---|
| **Mole fraction $X_1$** | **$Z^E$ X10$^3$** | **$\eta^E$ X10$^{-3}$** | **$V^E$ X10$^6$ m$^3$ mol$^{-1}$** | **$L_f^E$ X10$^{-9}$m** | **$U^E$ ms$^{-1}$** |
| 1.0000 | 0 | 0 | 0 | 0 | 0 |
| 0.9196 | 6.510 | -0.0267 | -1.0200 | -0.0261 | 6.920 |
| 0.8371 | 9.521 | -0.0193 | -1.6088 | -0.0475 | 10.912 |
| 0.7470 | 20.151 | -0.0048 | -1.9351 | -0.0565 | 24.234 |
| 0.6549 | 21.240 | 0.0008 | -2.4438 | -0.0678 | 23.125 |
| 0.5592 | 24.423 | 0.0054 | -2.5471 | -0.0732 | 26.486 |
| 0.4580 | 22.743 | 0.0501 | -2.3285 | -0.0676 | 26.118 |
| 0.3522 | 18.980 | 0.0506 | -2.1405 | -0.0608 | 20.534 |
| 0.2402 | 22.557 | 0.0122 | -1.8419 | -0.0498 | 20.598 |
| 0.1235 | 17.459 | 0.0099 | -1.1213 | -0.0295 | 14.836 |
| 0.0000 | 0 | 0 | 0 | 0 | 0 |
| | | 313.15K | | | |
| 1.0000 | 0 | 0 | 0 | 0 | 0 |
| 0.9196 | 3.279 | 0.0816 | -0.8117 | -0.0241 | 5.085 |
| 0.8371 | 5.181 | 0.0836 | -1.4543 | -0.0459 | 8.283 |
| 0.7470 | 16.579 | 0.0958 | -2.1878 | -0.0551 | 18.649 |
| 0.6549 | 13.933 | 0.0499 | -2.4214 | -0.0646 | 16.792 |
| 0.5592 | 28.363 | 0.0636 | -3.3524 | -0.0769 | 19.358 |
| 0.4580 | 16.924 | 0.0450 | -2.4893 | -0.0659 | 19.174 |
| 0.3522 | 14.055 | 0.0795 | -2.2676 | -0.0600 | 14.854 |
| 0.2402 | 17.456 | 0.0762 | -1.9378 | -0.0485 | 15.116 |
| 0.1235 | 13.305 | 0.0653 | -1.1724 | -0.0280 | 10.573 |
| 0.0000 | 0 | 0 | 0 | 0 | 0 |

**Table 5**Excess acoustic impedance ($Z^E$),excess viscosity($\eta^E$ ), excess Molar volume($V^E$), excess free lenth($L_f^E$) and excess Ultrasonic velocity($U^E$) values of the PGPE + MIPA binary mixture

| 303.15K | | | | | |
|---|---|---|---|---|---|
| **Mole fraction $X_1$** | **$Z^E$ X10$^3$** | **$\eta^E$ X10$^{-3}$** | **$V^E$ X10$^6$ m$^3$ mol$^{-1}$** | **$L_f^E$ X10$^{-9}$m** | **$U^E$ ms$^{-1}$** |
| 1.0000 | 0 | 0 | 0 | 0 | 0 |
| 0.9338 | -1.726 | -0.4160 | -0.4665 | -0.0016 | -2.214 |
| 0.8626 | -5.931 | -0.8218 | -0.9714 | -0.0053 | -8.036 |
| 0.7853 | -7.084 | -1.0584 | -1.3726 | -0.0050 | -10.245 |
| 0.7018 | 3.070 | -1.8077 | -1.5186 | -0.0240 | 1.938 |
| 0.6114 | 7.759 | -2.1529 | -1.6615 | -0.0364 | 6.992 |
| 0.5171 | 3.994 | -2.0338 | -1.6768 | -0.0555 | 3.067 |
| 0.4043 | 17.334 | -2.0711 | -1.5952 | -0.0463 | 16.821 |
| 0.3161 | 29.468 | -1.4231 | -1.5200 | -0.0512 | 27.917 |
| 0.1485 | 9.847 | -1.1863 | -0.6927 | -0.0216 | 10.793 |
| 0.0000 | 0 | 0 | 0 | 0 | 0 |
| | | 313.15K | | | |
| 1.0000 | 0 | 0 | 0 | 0 | 0 |
| 0.9338 | 8.466 | -0.5128 | -0.6236 | -0.0179 | 8.020 |
| 0.8626 | 13.144 | -0.7013 | -0.9873 | -0.0362 | 13.519 |
| 0.7853 | 20.395 | -0.7941 | -1.5011 | -0.1641 | 20.580 |
| 0.7018 | 24.671 | -1.5072 | -1.5428 | -0.0567 | 26.094 |
| 0.6114 | 24.421 | -1.8933 | -1.6887 | -0.0613 | 25.550 |
| 0.5171 | 15.005 | -2.0532 | -1.7040 | -0.0725 | 16.253 |
| 0.4043 | 23.937 | -2.0068 | -1.6063 | -0.0573 | 24.224 |
| 0.3161 | 32.173 | -1.4109 | -1.6475 | -0.0571 | 29.639 |
| 0.1485 | 9.185 | -1.3779 | -0.7043 | -0.0223 | 10.186 |
| 0.0000 | 0 | 0 | 0 | 0 | 0 |
| | | | | - | |

From the tables 2 and 3, it is found that the ultrasonic velocity (U), density (ρ) and viscosity (η) are increasing with increasing in mole fraction of ANI and MIPA. The increase in velocity perhaps is due to structural changes occurring in the mixture, resulting in weakening of intermolecular forces (12). However, in both the binary systems, ultrasonic velocity (U) decreases with increase of temperature at all noted concentration. This is because of the increase in spacing between molecules and increase in enthalpy of its structural arrangement. Other parameters such as density (ρ) and viscosity (η) decreases with increase of temperature. This indicates that the intermolecular forces decreases due to increases in thermal vibrations of the system, which also causes an increase in volume expansion and hence increase in free path length.

In PGPE + ANI system, when mole fraction of aniline is increased, an increasing trend is observed in density, viscosity and velocity. It reveals that the addition of aniline increases the effective molecular space. This can be attributed to both relatively higher dielectric constant of aniline (13,14) and its electron donor nature. When ANI is mixed with PGPE, ANI exhibits significant interactions such as dipole – dipole interaction and hydrogen bonding in the liquid mixture.

However, Adiabatic compressibility (β) and Free length ($L_f$) of PGPE + MIPA decreases with increase in concentration of MIPA. This shows significantinteraction between solute and solvent molecules and is found also in other binary system. Acoustic impedance (Z) is the ratio of the effective sound pressure at a point to the effective particular velocity at that point. In both the binary systems, on increasing the mole fraction of ANI and MIPA, the acoustic impedance (Z) also increases. This shows the weakening of intermolecular forces (15).

The decrease in molar volume (V), adiabatic compressibility (β) and free length ($L_f$) and increase in acoustic impedance (Z) with the mole concentration of both binary systems reveals the presence of specific interactions between the components in these mixtures.

An examination of data in tables 4 & 5 suggests that the excess acoustic impedance ($Z^E$) of PGPE + MIPA was initially negative and increases with increase in the mole fraction of MIPA and finally becomes positive. When temperature is increased, the entire range of excess acoustic impedance ($Z^E$) becomes positive. Meanwhile the excess acoustic impedance ($Z^E$) of PGPE + ANI is positive in the entire range of composition. Positive value of $Z^E$ in mole concentration of both binary systems reveals the possibility of the presence of strong attractive force between the components. The $\eta^E$ value of PGPE + ANI was initially negative and on increasing the mole fraction of ANI, the value of $\eta^E$ becomes positive. This reveals the presence of both strong attraction forces between the molecules and specific interaction such as formation of hydrogen bonding between OH and N. The negative value of $\eta^E$of PGPE + MIPA suggest the mutual loss of specific interactions between unlike molecules (16,17). Negative deviation in viscosity may also occur where dispersion forces are dominant, particularly for the system having different molecular sizes (17,18). It reveals the presence of weak interaction between the molecules.

It is noticed from Table 4 and 5 that the behaviour of excess acoustic impedance ($Z^E$) is similar to excess ultrasonic velocity $U^E$. The positive value of $U^E$also indicates strong attraction among the components of a mixture (22).

The behaviour of excess values of $Z^E$, $L_f^E$, $V^E$, $\eta^E$and $U^E$ with mole fraction of binary system at 303.15K and 313.15K were shown in figure 1to10.

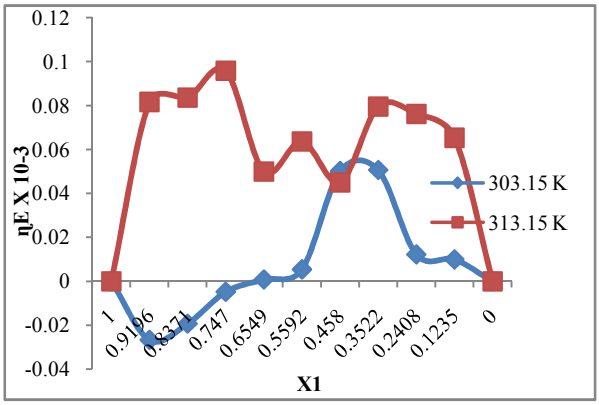


**Fig 1** Excess viscosity $\eta^E$ - mole fraction of PGPE + Aniline

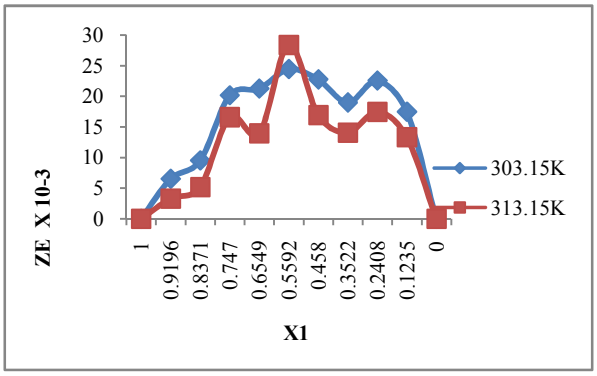


**Fig 2** Excess Acoustic Impedance $Z^E$ - mole fraction of PGPE + Aniline

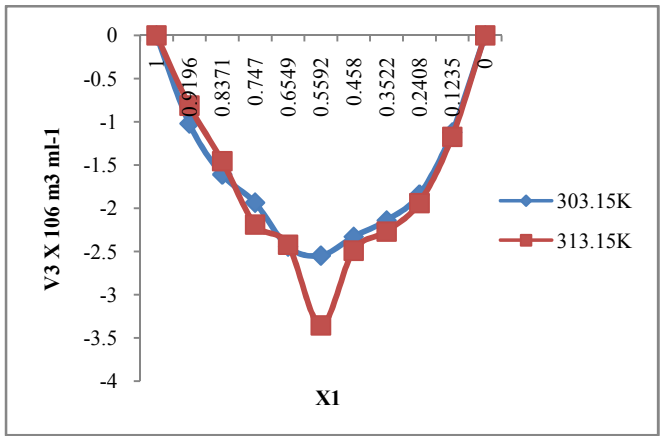


**Fig 3** molar volume $V^E$ - mole fraction of PGPE + Aniline

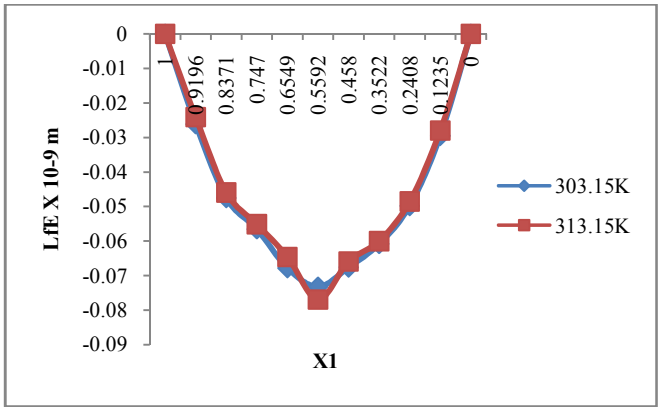


**Fig 4** Free Length $L_f^E$ - mole fraction of PGPE + Aniline

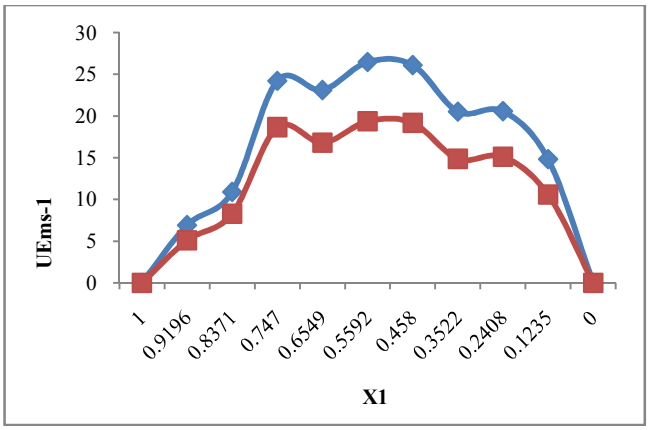


**Fig 5** ultrasonic velocity $U^E$ - mole fraction of PGPE + Aniline

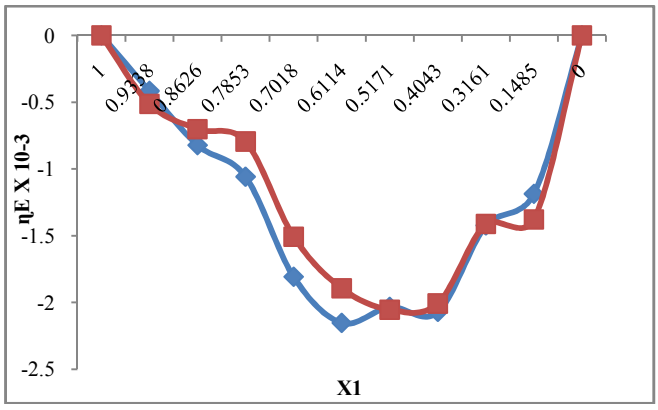


**Fig 7** Excess viscosity $\eta^E$ - mole fraction of PGPE + MIPA

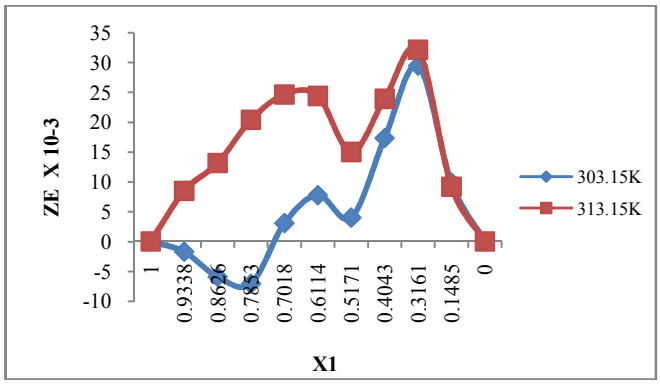


**Fig 6** Excess Acoustic Impedance $Z^E$ - mole fraction of PGPE + MIPA

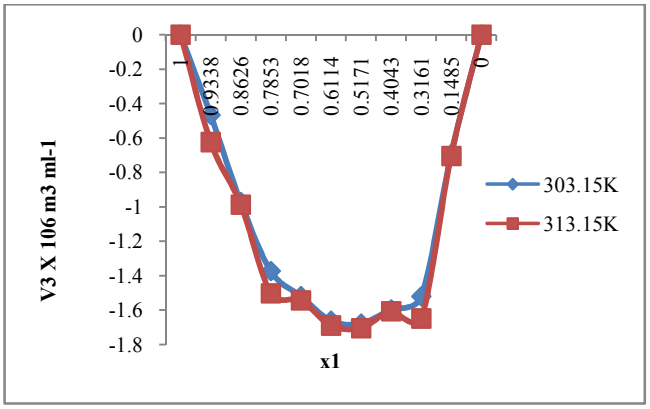


**Fig 8** molar volume$V^E$ - mole fraction of PGPE + MIPA

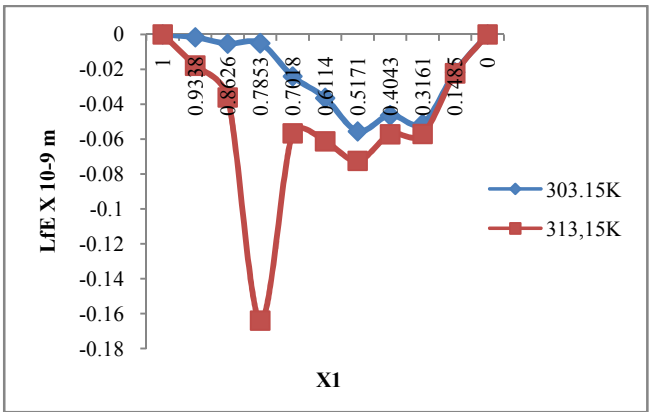


**Fig 9** Free Length $L_f^E$- mole fraction of PGPE + MIPA e

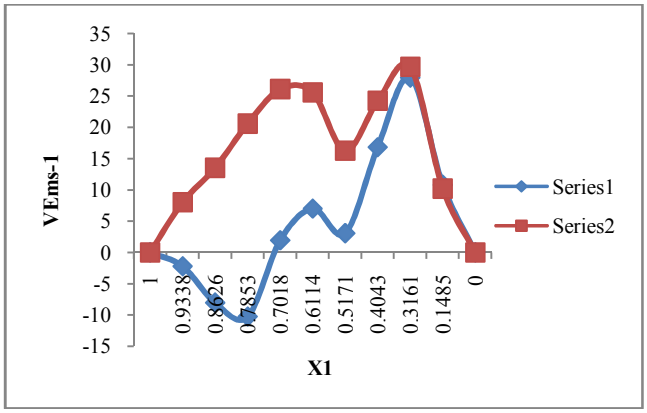


**Fig10** ultrasonic velocity $U^E$ - mole fraction of PGPE + MIPA

The value of $V^E$ is the resultant contribution from several opposing effects namely chemical, physical and structural. The chemical or specific interaction result in volume concentration, leading to negative excess volume and these interactions include charge transfer complexes, dipole – dipole and dipole – induced dipole interaction, proton acceptor interaction and H – bonding between unlike molecules.

The more negative $V^E$ value of both systems viz., PGPE + Aniline and PGPE + MIPA at 303.15K and 313.15K reveals the presence of two $CH_3$ groups increases the electron density at the oxygen atom of hydroxyl group. Hence it may be concluded that the interaction between PGPE with ANI and MIPA under study increases when hydroxyl group is attached to a carbon atom with greater number of $CH_3$ groups.

The numerical values of $V^E$ become more negative as the temperature is increased and they vary in the following order PGPE + Aniline < PGPE + MIPA. The excess intermolecular free length $L_f^E$are negative in both binary systems, at over the entire range of compositions. The negative excess values are due to the associated molecules, which accounts for the existence of strong molecular interaction (19), whereas positive excess values causes weak interaction between unlike molecules. The sign of excess intermolecular free length $L_f^E$ play a vital role in assessing the interaction between the components due to hydrogen bonding, charger transfer, dipole - dipole interaction and dipole–induced dipole interaction, intertial accommodation and orientationalordering (20). Therefore negative value of excess intermolecular free length $L_f^E$ in present work suggest that dipole – dipole interaction are prevailing through H – bonding in the liquid mixtures (21).

## CONCLUSION

The densities, viscosities, speed of sound, acoustic impedance, molar volume, intermolecular free length, and adiabatic compressibility at 303.15 K & 313.15K have been measured for two binary mixtures. From these measured data excess acoustic impedance, excess molar volume, deviation in viscosities, excess ultrasonic velocity and excess intermolecular free length have been calculated. These results have been used to discuss the nature of interaction between unlike molecules in terms of hydrogen bonding, dipole – dipole interaction and proton acceptor interaction of molecules.

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