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# Molecular Interactions in Binary Mixture of Propylamine with Non-polar Solvents

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Ultrasonic velocity and density measurements for binary mixture: **I.** propylamine + benzene **II.** propylamine + toluene **III.** propylamine + *o*-xylene at 301.15 K have been utilized to compute excess adiabatic compressibility, excess molar volume, free length and available volume. These values are reported as a function of mole fraction X1 of propylamine $\beta_s^E$ *vs.* X1 and $V_m^E$ *vs.* $X_1$ plots are explained in terms of dipole-dipole interactions between two like and unlike molecules.

**Key Words: Molecular interactions, Binary mixtures, Propylamine.**

## INTRODUCTION

Ultrasonic velocity and density measurements proved to be useful tools for gaining informations on the dynamics of liquid systems[1-5]. Rao and Regovramane[6] have explained the nature and strength of molecular interactions for the binary mixtures of triethyl amine with benzene, toluene and *o*-xylene at 308.15 K. Prakash *et al.*[7] also measured ultrasound velocity, density and viscosity of the binary mixtures of triethyl amine with *o*-cresol, *m*-cresol, *o*-chlorophenol and benzyl alcohol at 308.15 K. Recently, an increasing number of thermodynamic studies in binary and ternary mixtures containing electrolytes and/or non-electrolytes are being performed which permit investigation in a wide range of solutions with suitable properties[8-11].

In the present study, the ultrasound velocity and density measurements have been made at 301.15 K in binary mixtures: **I.** propylamine + benzene, **II.** propylamine + toluene, **III.** propylamine + *o*-xylene. The parameters *viz.*, $\beta_s$, $\beta_s^E$, $L_f$, $V_m^E$, $V_a$ derived from experimental data have been presented and discussed.

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## EXPERIMENTAL

Ultrasonic velocity at 2 MHz has been measured by single crystal ultrasonic interferometer manufactured by M/s Mittal Enterprises. The accuracy of the velocity is ± 0.05 %.

Density measurements has been carried out using pyknometer having well-fitted glass cap inorder to prevent changes in composition due to evaporation of volatile liquids. The accuracy in density measurements is within the range ± 0.005 g/mL. All the chemicals used in the present work are from BDH (AR grade).

## RESULTS AND DISCUSSION

Ultrasonic velocity (u) and density (d) have been experimentally determined for binary mixtures of propyl amine alongwith benzene, toluene and *o*-xylene at 301.15 K.

The various acoustic parameters *viz.*, adiabatic compressibility, molar volume, intermolecular free length and available volume were calculated using the following relations[12]

$$\beta_s = 1/u^2d$$

$$V_m = M/d$$

$$L_f = k\sqrt{\beta_s}$$

$$V_a = V_m(1-u/u_\infty)$$

where symbols have their usual meanings. The excess parameters $\beta_s^E$ and $V_m^E$ was calculated as:

$$\beta_s^E = \beta_s \text{ (mix.)} - \beta_s\text{(ideal)}$$

$$V_m^E = V_m \text{ (mix.)} - V_m \text{ (ideal)}$$

The experimentally determined ultrasonic velocity and density along with the calculated parameters are given in Table-1 and Fig. 1. Both the experimentally determined ultrasonic velocity as well as density have been found to decrease with increasing mole fraction (X1) of propylamine.

The adiabatic compressibility values ($\beta_s$) have been found to increase with the increase in mole fraction (X1) of propyl amine. An increase in $\beta_s$ values with increasing X1 may be ascribed to two effects: *viz.*, (i) the decrease in density of the system and (ii) the dipole-dipole interaction between propylamine molecules.

The dependence of excess adiabatic compressibility upon the mole fraction of propylamine has been examined by least square fitting the $\beta_s^E$ values to a polynomial equation

$$\beta_s^E = A0 + A1X_1 + A2X_1^2$$

TABLE-1

| Mole fraction propylamine ($X_1$) | Ultrasonic velocity (u) ($ms^{-1}$) | Density (d) (g/mL) | Isentropic compressibility ($\beta_s \times 10^{12}$) ($cm^2$/dyne) | Intermolecular free length ($L_f$) | Molar volume ($V_m^E$) (mL/mol) | Available volume ($V_a$) (mL/mol) |
|---|---|---|---|---|---|---|
| (I) Propylamine + benzene | | | | | | |
| 0.0000 | 1297.3 | 0.8597 | 69.11 | 0.5229 | 0.00 | 17.19 |
| 0.1316 | 1268.2 | 0.8463 | 73.47 | 0.5391 | -0.93 | 18.50 |
| 0.2613 | 1250.6 | 0.8215 | 77.83 | 0.5549 | -0.54 | 19.41 |
| 0.3890 | 1230.0 | 0.7921 | 83.45 | 0.5746 | 0.42 | 20.61 |
| 0.5148 | 1219.8 | 0.7765 | 86.55 | 0.5852 | -0.21 | 20.88 |
| 0.6388 | 1204.8 | 0.7478 | 92.13 | 0.6037 | 0.72 | 21.75 |
| 0.7610 | 1188.3 | 0.7254 | 97.63 | 0.6215 | 0.91 | 22.66 |
| 0.8813 | 1171.4 | 0.7170 | 101.64 | 0.6341 | -0.60 | 23.46 |
| 1.0000 | 1157.5 | 0.6911 | 108.00 | 0.6537 | 0.00 | 23.61 |
| (II) Propylamine + toluene | | | | | | |
| 0.0000 | 1286.3 | 0.8510 | 71.02 | 0.5300 | 0.00 | 21.22 |
| 0.1535 | 1266.7 | 0.8348 | 74.66 | 0.5435 | -0.49 | 21.74 |
| 0.2973 | 1244.3 | 0.8113 | 79.61 | 0.5612 | -0.04 | 22.52 |
| 0.4323 | 1217.5 | 0.7912 | 85.27 | 0.5808 | -0.40 | 23.48 |
| 0.5593 | 1210.3 | 0.7639 | 89.37 | 0.5946 | 0.88 | 23.45 |
| 0.6790 | 1193.7 | 0.7508 | 93.47 | 0.6081 | 0.02 | 23.58 |
| 0.7920 | 1179.0 | 0.7368 | 97.64 | 0.6215 | -0.71 | 23.52 |
| 0.8988 | 1167.1 | 0.7152 | 102.65 | 0.6373 | -0.51 | 23.59 |
| 1.0000 | 1157.5 | 0.6911 | 108.00 | 0.6537 | 0.00 | 23.61 |
| (III) Propylamine + *o*-xylene | | | | | | |
| 0.0000 | 1342.5 | 0.8792 | 63.11 | 0.4997 | 0.00 | 19.40 |
| 0.1703 | 1314.2 | 0.8582 | 67.47 | 0.5167 | -0.39 | 20.39 |
| 0.3239 | 1271.3 | 0.8310 | 74.46 | 0.5428 | 0.08 | 22.44 |
| 0.4630 | 1247.0 | 0.8122 | 79.18 | 0.5597 | -0.55 | 22.88 |
| 0.5897 | 1240.3 | 0.7803 | 83.31 | 0.5741 | 0.51 | 22.55 |
| 0.7055 | 1216.8 | 0.7690 | 87.83 | 0.5895 | -1.01 | 22.69 |
| 0.8117 | 1191.7 | 0.7423 | 94.86 | 0.6126 | -0.60 | 23.32 |
| 0.9095 | 1173.2 | 0.7207 | 100.81 | 0.6315 | -0.79 | 23.41 |
| 1.0000 | 1157.5 | 0.6911 | 108.00 | 0.6537 | 0.00 | 23.61 |

The curve fit parameters along with standard deviations are listed in Table-2 and Fig. 2. The excess adiabatic compressibiilty values are found to be negative, although smaller in magnitude. The negative values, however, suggests dipole-dipole interaction between the molecules of binary mixtures. The strength of interaction is much weaker in propyl amine and benzene system, which may be attributed to the non-polar nature of benzene.

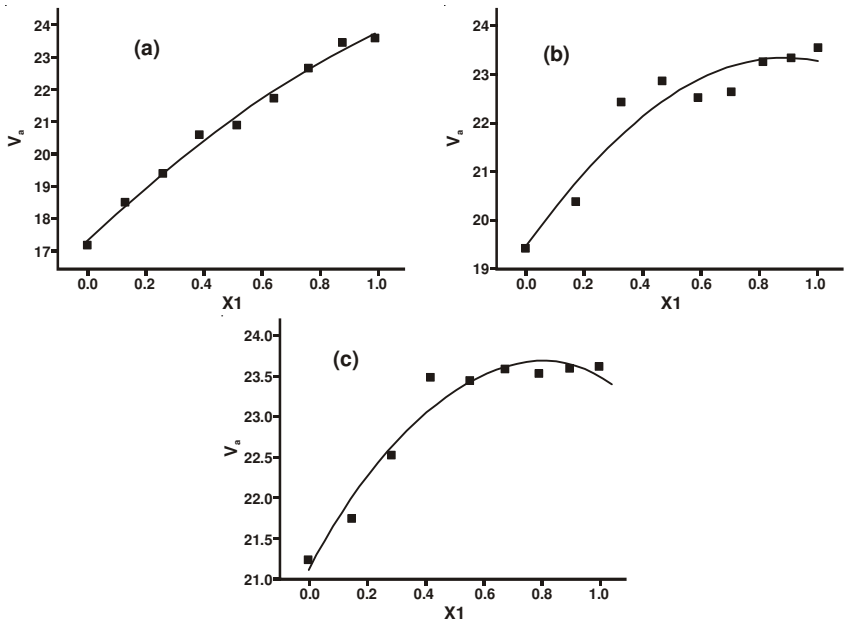


Fig. 1. Available volume ($V_a$) *vs.* mole fraction ($X_1$); (a) propylamine + benzene (b) propylamine + toluene (c) propylamine + *o*-xylene

TABLE-2
CURVE FIT PARAMETERS FOR $\beta_s^E$

| | | |
|---|---|---|
| (I) Propylamine + benzene | | |
| A0 | 0.081256427 | 0.50766 |
| A1 | -7.114539200 | 2.34730 |
| A2 | 6.714295500 | 2.25219 |
| (II) Propylamine + toluene | | |
| A0 | -0.20674678 | 0.50854 |
| A1 | -9.57536420 | 2.29862 |
| A2 | 9.96202410 | 2.18703 |
| (III) Propylamine + *o*-xylene | | |
| A0 | 0.52959338 | 1.06476 |
| A1 | -23.73502100 | 4.72729 |
| A2 | 22.02892300 | 4.47285 |

The increase in free-length values with decreasing ultrasonic velocity seems to be due to solute-solute interaction.

The plots of available volume *vs.* mole fraction of propylamine also indicates the least interaction in the system containing benzene.

In the light of the above results, it seems that the interactions present in the systems under investigation is due to electron releasing nature of propylamine.

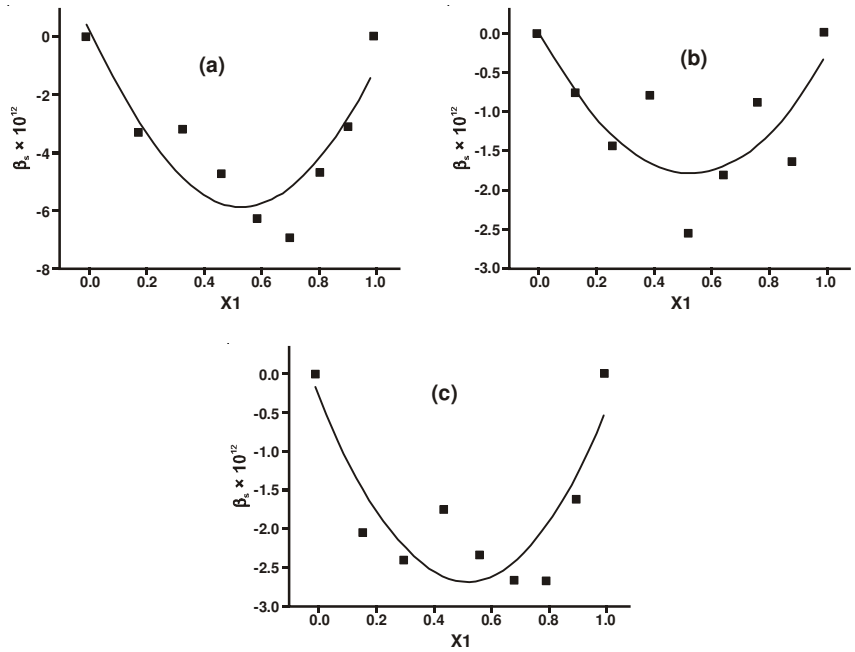


Fig. 2. Excess adiabatic compressibility ($\beta_s^E$) *vs.* mole fraction (X1); (a) propylamine + benzene (b) propylamine + toluene (c) propylamine + *o*-xylene

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