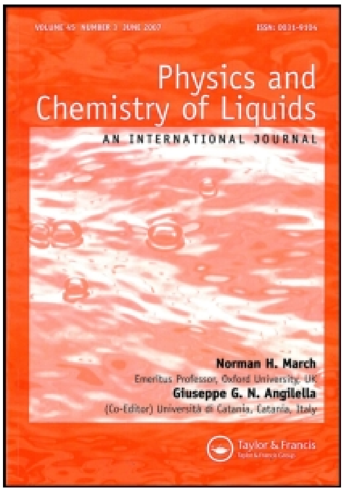

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# ISOBARIC VLE DATA FOR THE BINARY SYSTEMS 1,3-DICHLOROPROPANE WITH ISOMERIC BUTANOLS

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*(Received 3 April 1994)*

Isobaric vapour-liquid equilibrium data at 40.0 and 101.3 kPa for the binary systems 1,3-dichloropropane with 1-butanol, 2-butanol, 2-methyl-1-propanol and 2-methyl-2-propanol are reported. Some of the studied systems present azeotropes. The activity coefficients were found to be thermodynamically consist- ent, and they were satisfactorily correlated with the Margules, Van Laar, Wilson, NRTL and UNIQUAC equations.

KEY WORDS: Isobaric vapour-liquid equilibrium, 1,3-dichloropropane, butanols

## INTRODUCTION

The knowledge of vapour–liquid equilibrium provides information about thermodynamic behaviour of the liquid mixtures. With this objective and following a research program involving haloalkanes and butanols[1–11] we report here new isobaric vapour–liquid equilibrium measurements for the binary systens 1,3-dichloropropane with isomeric butanols at 40.0 and 101.3 kPa.

## EXPERIMENTAL

The apparatus used for the present study was a still (Labodest model) manufactured by Fischer and Verfahrenstechnik (Germany). The equilibrium temperatures were measured to an accuracy of ±0.01 K by means of a thermometer (model F25) from Automatic Systems Laboratories, and the pressure in the still was measured with a pressure transducer Druck PDCR 110/W (pressure indicator DPI201) with an accuracy of ±0.1 kPa. The composition of the liquid and vapour samples were determined by measuring their densities at 298.15 K. The experimental procedure was checked and described in an earlier paper[12].

The liquids used, 1-butanol (better than 99.8 mol%), 2-methyl-1-propanol and 2-methyl-2-propanol (better than 99.5 mol%), and 2-butanol and 1,3-dichloropropane (better than 99 mol%) were obtained from Aldrich. The purity of the materials was checked by GLC chromatography and by measuring their physical properties. The

**Table 1** Physical properties (densities at 298.15 K and normal boiling points) of the pure compounds.

| *Compound* | $\rho/kg\,m^{-3}$ *exptl.* | $\rho/kg\,m^{-3}$ *lit.*[14] | $T_b/K$ *exptl.* | $T_b/K$ *lit.*[14] |
|---|---|---|---|---|
| 1,3-dichloropropane[a] | 1180.25 | 1180.0 | 394.10 | 393.95 |
| 1-butanol | 805.85 | 806.0 | 390.84 | 390.81 |
| 2-butanol | 802.40 | 802.6 | 372.65 | 372.70 |
| 2-methyl-1-propanol | 797.98 | 797.8 | 380.72 | 380.81 |
| 2-methyl-2-propanol | 781.00 | 781.2 | 355.50 | 355.57 |

[a] Reference 13

comparison of measured physical properties, density and normal boiling point, with literature values[13,14] are shown in Table 1.

## RESULTS AND DISCUSSION

Table 2 shows the vapour-liquid equilibrium data $(T, x_1, y_1)$, the activity coefficients and excess free energies at 40.0 and 101.3 kPa. In Figures 1–4 the $T - x_1 - y_1$ diagrams

**Table 2** Experimental vapour–liquid equilibrium data for 1,3-dichloropropane(1) with isomeric butanols (2) at indicated pressure.

| $T/K$ | $x_1$ | $y_1$ | $\gamma_1$ | $\gamma_2$ | $G^E/J\,mol^{-1}$ |
|---|---|---|---|---|---|
| | | 1,3-dichloropropane(1) + 1-butanol(2) at 40.0 kPa | | | |
| 364.76 | 0.0526 | 0.1320 | 2.427 | 0.998 | 136.2 |
| 362.57 | 0.1144 | 0.2542 | 2.313 | 1.006 | 306.0 |
| 360.84 | 0.1971 | 0.3555 | 1.992 | 1.033 | 485.7 |
| 359.73 | 0.2789 | 0.4298 | 1.768 | 1.068 | 616.9 |
| 358.86 | 0.3613 | 0.4864 | 1.592 | 1.128 | 730.8 |
| 358.27 | 0.4490 | 0.5296 | 1.424 | 1.229 | 811.2 |
| 358.16 | 0.4971 | 0.5529 | 1.348 | 1.286 | 818.8 |
| 358.05 | 0.6090 | 0.6077 | 1.214 | 1.459 | 790.9 |
| 358.48 | 0.7590 | 0.6849 | 1.081 | 1.866 | 624.4 |
| 359.25 | 0.8497 | 0.7495 | 1.029 | 2.300 | 445.6 |
| 359.95 | 0.8927 | 0.7944 | 1.013 | 2.565 | 336.3 |
| 361.04 | 0.9386 | 0.8620 | 1.007 | 2.870 | 212.7 |
| | | 1,3-dichloropropane(1) + 1-butanol(2) at 101.3 kPa | | | |
| 389.26 | 0.0504 | 0.0961 | 2.181 | 1.006 | 146.6 |
| 388.07 | 0.1028 | 0.1721 | 1.979 | 1.017 | 274.3 |
| 386.97 | 0.1491 | 0.2368 | 1.936 | 1.027 | 389.9 |
| 385.75 | 0.2385 | 0.3262 | 1.726 | 1.058 | 554.5 |
| 385.16 | 0.3195 | 0.3889 | 1.562 | 1.096 | 656.3 |
| 384.74 | 0.4205 | 0.4513 | 1.393 | 1.173 | 742.6 |
| 384.65 | 0.5399 | 0.5171 | 1.246 | 1.305 | 772.1 |
| 385.16 | 0.6290 | 0.5748 | 1.172 | 1.400 | 719.0 |
| 385.57 | 0.7060 | 0.6147 | 1.104 | 1.577 | 652.7 |
| 385.93 | 0.7356 | 0.6333 | 1.080 | 1.648 | 605.9 |
| 386.53 | 0.8030 | 0.6884 | 1.057 | 1.840 | 530.2 |
| 389.55 | 0.9041 | 0.8211 | 1.030 | 1.954 | 293.3 |

**Table 2** (*Continued.*)

| $T/K$ | $x_1$ | $y_1$ | $\gamma_1$ | $\gamma_2$ | $G^E/\text{J mol}^{-1}$ |
|---|---|---|---|---|---|
| 1,3-dichloropropane(1) + 2-butanol(2) at 40.0 kPa | | | | | |
| 348.96 | 0.0853 | 0.1183 | 2.354 | 0.999 | 209.5 |
| 348.37 | 0.1585 | 0.1896 | 2.076 | 1.024 | 393.9 |
| 348.16 | 0.2323 | 0.2451 | 1.846 | 1.056 | 532.4 |
| 347.95 | 0.2898 | 0.2789 | 1.697 | 1.100 | 639.4 |
| 347.95 | 0.4082 | 0.3447 | 1.489 | 1.200 | 781.9 |
| 348.16 | 0.5004 | 0.3852 | 1.346 | 1.321 | 833.6 |
| 348.88 | 0.6087 | 0.4356 | 1.218 | 1.501 | 808.4 |
| 350.35 | 0.7054 | 0.4870 | 1.111 | 1.700 | 672.0 |
| 351.53 | 0.7706 | 0.5384 | 1.076 | 1.867 | 583.8 |
| 353.77 | 0.8512 | 0.6184 | 1.030 | 2.165 | 412.7 |
| 359.76 | 0.9600 | 0.8437 | 1.007 | 2.583 | 133.0 |
| 1,3-dichloropropane(1) + 2-butanol(2) at 101.3 kPa | | | | | |
| 372.36 | 0.0620 | 0.0691 | 2.099 | 1.003 | 151.9 |
| 372.15 | 0.1639 | 0.1565 | 1.809 | 1.028 | 371.2 |
| 372.15 | 0.2200 | 0.1954 | 1.683 | 1.051 | 473.8 |
| 372.25 | 0.3046 | 0.2463 | 1.527 | 1.100 | 604.5 |
| 372.47 | 0.3578 | 0.2780 | 1.457 | 1.132 | 664.2 |
| 373.15 | 0.4966 | 0.3500 | 1.294 | 1.269 | 769.5 |
| 374.16 | 0.5874 | 0.3970 | 1.202 | 1.387 | 756.1 |
| 376.70 | 0.6935 | 0.4627 | 1.098 | 1.523 | 606.1 |
| 379.76 | 0.7798 | 0.5345 | 1.029 | 1.654 | 419.5 |
| 383.82 | 0.8844 | 0.6830 | 1.029 | 1.876 | 313.0 |
| 387.76 | 0.9450 | 0.7920 | 0.999 | 2.280 | 141.6 |
| 1,3-dichloropropane(1) + 2-methyl-1-propanol(2) at 40.0 kPa | | | | | |
| 355.75 | 0.0697 | 0.1410 | 2.673 | 1.002 | 209.3 |
| 355.00 | 0.1069 | 0.1911 | 2.426 | 1.016 | 320.5 |
| 354.15 | 0.1636 | 0.2544 | 2.176 | 1.037 | 464.5 |
| 353.63 | 0.2233 | 0.3093 | 1.975 | 1.058 | 576.8 |
| 353.27 | 0.3034 | 0.3636 | 1.732 | 1.105 | 693.1 |
| 353.05 | 0.3674 | 0.3994 | 1.583 | 1.159 | 770.0 |
| 352.90 | 0.4667 | 0.4441 | 1.394 | 1.281 | 842.2 |
| 352.95 | 0.5310 | 0.4719 | 1.299 | 1.381 | 852.0 |
| 353.33 | 0.6257 | 0.5148 | 1.186 | 1.564 | 804.9 |
| 353.67 | 0.6656 | 0.5352 | 1.145 | 1.652 | 757.9 |
| 355.15 | 0.8034 | 0.6245 | 1.049 | 2.129 | 551.0 |
| 357.14 | 0.8768 | 0.7066 | 1.012 | 2.438 | 357.7 |
| 358.86 | 0.9163 | 0.7729 | 0.997 | 2.583 | 229.1 |
| 1,3-dichloropropane(1) + 2-methyl-1-propanol(2) at 101.3 kPa | | | | | |
| 380.46 | 0.0340 | 0.0538 | 2.328 | 1.000 | 90.1 |
| 380.15 | 0.0562 | 0.0849 | 2.243 | 1.001 | 145.0 |
| 379.32 | 0.1194 | 0.1585 | 2.020 | 1.015 | 307.3 |
| 378.67 | 0.2056 | 0.2358 | 1.779 | 1.046 | 485.8 |
| 378.55 | 0.2991 | 0.2985 | 1.553 | 1.093 | 611.1 |
| 378.66 | 0.3675 | 0.3397 | 1.434 | 1.136 | 670.6 |
| 378.86 | 0.4693 | 0.3925 | 1.290 | 1.237 | 731.0 |
| 378.94 | 0.5351 | 0.4278 | 1.230 | 1.326 | 761.8 |
| 379.85 | 0.6285 | 0.4790 | 1.141 | 1.463 | 707.8 |
| 380.86 | 0.7116 | 0.5312 | 1.084 | 1.637 | 632.5 |
| 382.27 | 0.8023 | 0.6098 | 1.059 | 1.892 | 547.7 |
| 384.00 | 0.8650 | 0.6900 | 1.057 | 2.074 | 468.6 |
| 387.07 | 0.9118 | 0.7485 | 0.997 | 2.321 | 230.7 |

**Table 2** (*Continued.*)

| $T/K$ | $x_1$ | $y_1$ | $\gamma_1$ | $\gamma_2$ | $G^E/\mathrm{J\,mol^{-1}}$ |
|---|---|---|---|---|---|
| | 1,3-dichloropropane(1) + 2-methyl-2-propanol(2) at 40.0 kPa | | | | |
| 334.05 | 0.0954 | 0.0765 | 2.488 | 1.014 | 276.5 |
| 334.37 | 0.1434 | 0.1044 | 2.228 | 1.023 | 374.6 |
| 334.73 | 0.2288 | 0.1469 | 1.934 | 1.065 | 555.9 |
| 335.45 | 0.3237 | 0.1845 | 1.665 | 1.124 | 680.9 |
| 336.16 | 0.4130 | 0.2109 | 1.447 | 1.214 | 744.7 |
| 337.60 | 0.5362 | 0.2564 | 1.275 | 1.358 | 764.5 |
| 339.25 | 0.6413 | 0.2961 | 1.150 | 1.546 | 693.5 |
| 342.34 | 0.7686 | 0.3628 | 1.037 | 1.900 | 501.4 |
| 345.65 | 0.8306 | 0.4381 | 1.016 | 1.992 | 373.7 |
| 352.47 | 0.9322 | 0.6323 | 1.009 | 2.479 | 204.2 |
| 357.65 | 0.9700 | 0.7910 | 1.006 | 2.614 | 102.6 |
| | 1,3-dichloropropane(1) + 2-methyl-2-propanol(2) at 101.3 kPa | | | | |
| 355.86 | 0.0616 | 0.0422 | 2.242 | 1.007 | 166.6 |
| 356.48 | 0.1266 | 0.0764 | 1.932 | 1.020 | 297.1 |
| 347.35 | 0.2045 | 0.1158 | 1.757 | 1.038 | 429.9 |
| 358.07 | 0.2749 | 0.1429 | 1.573 | 1.075 | 526.0 |
| 359.16 | 0.3526 | 0.1748 | 1.444 | 1.114 | 594.6 |
| 360.37 | 0.4451 | 0.2082 | 1.306 | 1.193 | 649.9 |
| 362.39 | 0.5461 | 0.2508 | 1.197 | 1.284 | 637.4 |
| 364.18 | 0.6114 | 0.2797 | 1.122 | 1.345 | 570.0 |
| 366.63 | 0.7080 | 0.3366 | 1.075 | 1.525 | 531.8 |
| 369.97 | 0.7832 | 0.4033 | 1.045 | 1.650 | 439.8 |
| 374.65 | 0.8493 | 0.4929 | 1.016 | 1.731 | 300.9 |
| 379.36 | 0.9063 | 0.6054 | 1.014 | 1.867 | 225.0 |
| 383.19 | 0.9383 | 0.6942 | 1.004 | 1.955 | 143.4 |

are represented. Mixtures containing 2-methyl-2-propanol at 40.0 kPa and 1-butanol, 2-butanol and 2-methyl-1-propanol at both pressures 40.0 and 101.3 kPa present minimum temperature azeotropes, furthermore when pressure increases the composition of the azeotropic mixture becomes richer in isomeric butanol, the composition and the boiling temperature of the azeotropes are gathered in Table 3.

The activity coefficients $\gamma_i$ were calculated, taking into account the non-ideality of the vapour phase, from following equations:

$$\gamma_1 = \frac{y_i P}{x_i p_i^0} \exp\left[\frac{(B_{ii} - V_i^0)(p - p_i^0) + (1 - y_i)^2 P \delta_{ij}}{RT}\right] \tag{1}$$

$$\delta_{ij} = 2B_{ij} - B_{ii} - B_{jj} \tag{2}$$

here $x_i$ and $y_i$ are the liquid and vapour phase compositions, $P$ is the total pressure, $p_i^0$ are the vapour-pressures of the pure compounds calculated by using the Antoine equation, where the constants appear in Table 4, $B_{ij}$ are the second virial coefficients and $B_{ij}$ are the cross second virial coefficients calculated using the Amdur-Mason equation[15], and $V_i^0$ are the molar volumes of the saturated liquids estimated by the

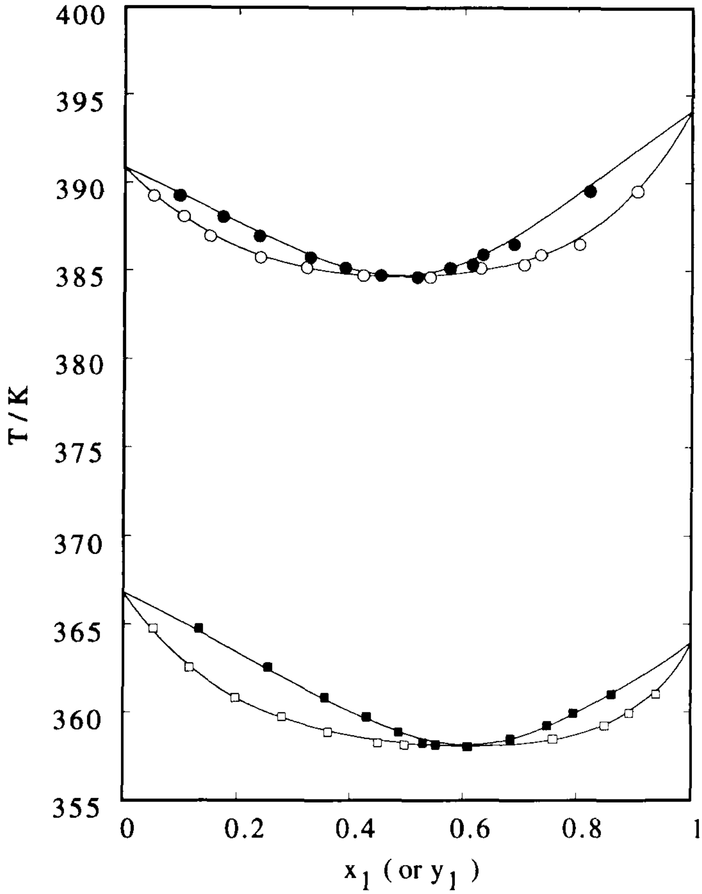

**Figure 1** $T-x_1-y_1$ diagrams for 1,3-dichloropropane(1) + 1-butanol(2): (□, ■) exptl. data at 40.0 kPa; (○, ●) exptl. data at 101.3 kPa; (———) Wilson equation.

**Table 3** Composition ($x_{1(az)}$) and boiling temperature ($T_{(az)}$) of the azeotropic mixtures.

| *System* | *P/kPa* | $x_{1(az)}$ | $T_{(az)}/K$ |
|---|---|---|---|
| 1,3-dichloropropane + | | | |
| 1-butanol | 40.0 | 0.6077 | 358.01 |
| | 101.3 | 0.4887 | 384.65 |
| 2-butanol | 40.0 | 0.2826 | 347.93 |
| | 101.3 | 0.1652 | 371.89 |
| 2-methyl-1-propanol | 40.0 | 0.4246 | 352.96 |
| | 101.3 | 0.3297 | 378.59 |
| 2-methyl-2-propanol | 40.0 | 0.0248 | 333.87 |

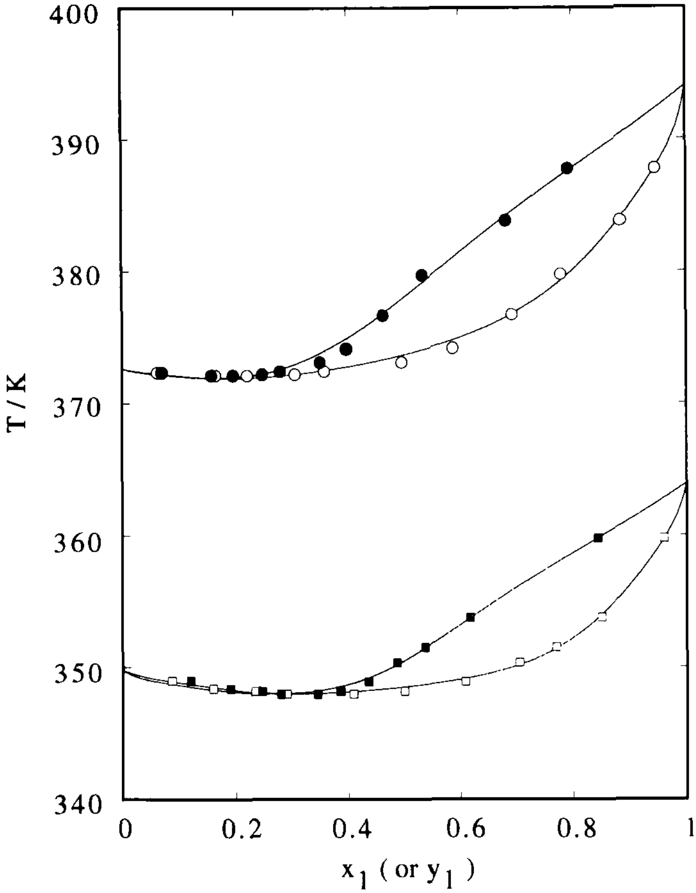

**Figure 2** $T - x_1 - y_1$ diagrams for 1,3-dichloropropane(1) + 2-butanol(2): (□, ■) exptl. data at 40.0 kPa; (○, ●) exptl. data at 101.3 kPa; (———) Wilson equation.

**Table 4** Contants of Antoine's equation for vapour pressures of the compounds, (pressure in kPa).

| *Compound* | *A* | *B* | *C* |
|---|---|---|---|
| 1,3-dichloropropane[a] | 5.48790 | 1020.494 | 172.038 |
| 1-butanol | 6.54743 | 1338.769 | 177.042 |
| 1-butanol | 6.35457 | 1171.981 | 169.955 |
| 2-methyl-1-propanol | 6.50091 | 1275.197 | 175.187 |
| 2-methyl-2-propanol | 6.35648 | 1107.060 | 172.102 |

[a] Our own vapour pressure measurements

Yen and Woods method[16]. The Antoine's constants for the 1,3-dichloropropane were obtained from our own vapour-pressure measurements and for the isomeric butanols were taken from Riddick *et al.*[17]. The second virial coefficients for the 1,3-dichloropropane were estimated by the Redlich-Kwong equation[18], and for the

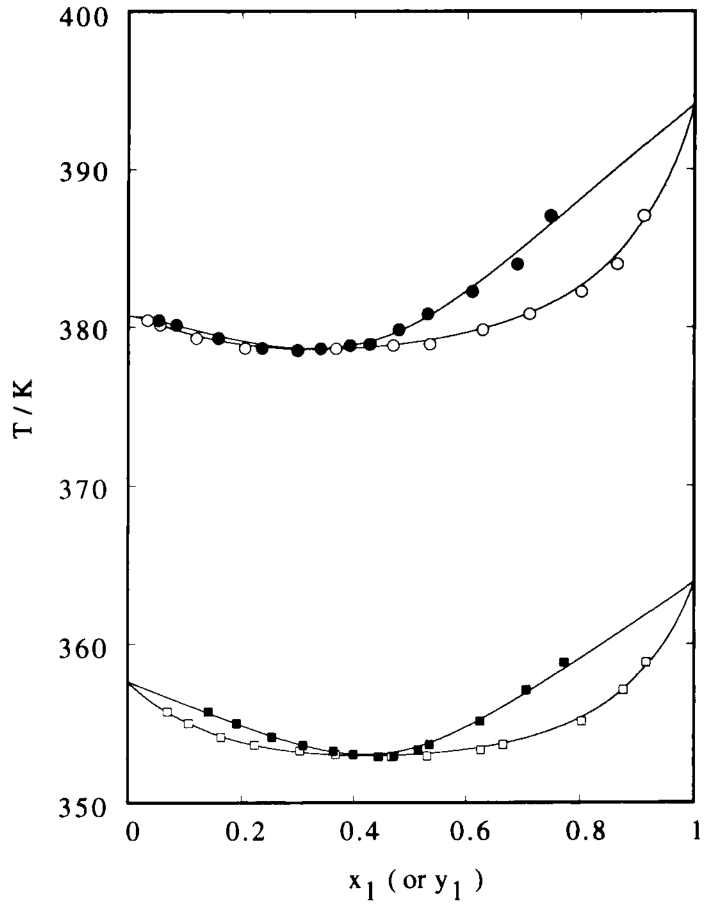

**Figure 3** $T - x_1 - y_1$ diagrams for 1,3-dichloropropane(1) + 2-methyl-1-propanol(2): (□, ■) exptl. data at 40.0 kPa; (○, ●) exptl. data at 101.3 kPa; (———) Wilson equation.

isomeric butanols were obtained from TRC-tables[14]. The correction for the non-ideality of the vapour phase, represented by the exponential term in Eq. 1, was important only at very dilute concentrations.

The thermodynamic consistency of the activity coefficients was tested using the Van Ness method[19], described by Fredeslund *et al.*[20] using a third order Legendre polynomial. According to this test, the experimental activity coefficients are considered consistent if the average deviation in $y(\Delta y)$ is smaller than 0.01, all the present systems satisfy this condition.

The activity coefficients were correlated with the Margules, Van Laar, Wilson, NRTL and UNIQUAC equation. The parameters have been obtained by fitting the reduced excess free energies $G^E/RT$ using the simplex method. These parameters along with the average deviation in $T$ ($\Delta T$), average deviation by $y$ ($\Delta y$) and activity coefficients at infinite dilution are listed in Table 5. All the equations correlated the activity coefficients quite well.

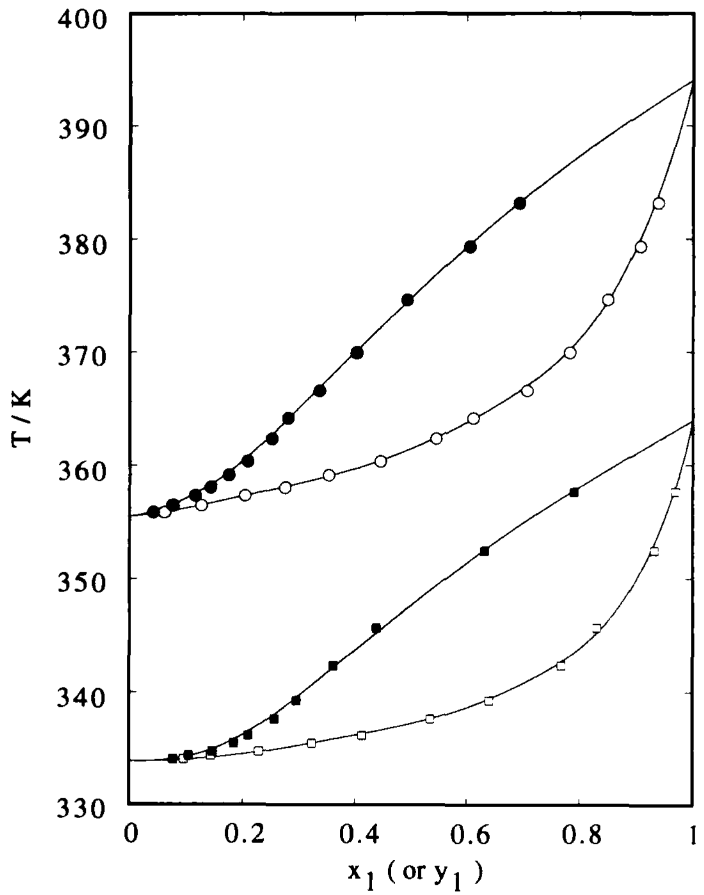

**Figure 4** $T-x_1-y_1$ diagrams for 1,3-dichloropropane(1) + 2-methyl-2-propanol(2): (□, ■) exptl. data at 40.0 kPa; (○, ●) exptl. data at 101.3 kPa; (———) Wilson equation.

The systems deviate positively from ideality and the activity coefficients decrease with increasing pressure, the greatest activity coefficients correspond to the mixture containing 2-methyl-2-propanol. The molecular interactions that govern the thermodynamic behaviour has been previously described in a previous paper[8], and the most important effect in the mixture process are the breaking of the self-association in the butanols and the specific interaction between the Cl-group of the dichloroalkane and the OH-group of the butanol. The excess free energies has been calculated from activity coefficients and they are positive over the entire range of composition and also decrease with increasing pressure. At 40.0 kPa the values of $G^E$ fall in the order 2-methyl-1-propanol > 2-butanol > 1-butanol > 2-methyl-2-propanol while at 101.3 kPa the order is 1-butanol > 2-butanol > 2-methyl-1-propanol > 2-methyl-2-propanol, although the $G^E$ values for the mixtures containing 1-butanol, 2-butanol and 2-methyl-1-propanol are very similar. Furthermore the $G^E$ values at 101.3 kPa

**Table 5** Correlation parameters, average derivative in $T(\Delta T)$, average deviation in $y(\Delta y)$, and activity coefficients at infinite dilution $\gamma_i^{\alpha}$.

| *Equation* | $A_{12}$ | $A_{21}$ | $\Delta T/K$ | $\Delta y$ | $\gamma_1^{\alpha}$ | $\gamma_2^{\alpha}$ |
|---|---|---|---|---|---|---|
| | 1,3-dichloropropane(1) + 1-butanol(2) at 40.0 kPa | | | | | |
| Margules | 0.9752 | 1.2129 | 0.04 | 0.0022 | 2.65 | 3.36 |
| Van Laar | 0.9875 | 1.2213 | 0.05 | 0.0019 | 2.68 | 3.39 |
| Wilson | 0.6604 | 0.3996 | 0.07 | 0.0024 | 2.76 | 3.51 |
| NRTL($\alpha_{12}=0.3$)[b] | 0.9899 | 0.2569 | 0.05 | 0.0019 | 2.70 | 3.41 |
| UNIQUAC[b] | 0.6534 | 1.0275 | 0.05 | 0.0019 | 2.69 | 3.40 |
| | 1,3-dichloropropane(1) + 1-butanol(2) at 101.3 kPa | | | | | |
| Margules | 0.9174 | 1.0144 | 0.08 | 0.0067 | 2.50 | 2.76 |
| Van Laar | 0.9183 | 1.0177 | 0.08 | 0.0066 | 2.51 | 2.77 |
| Wilson | 0.6454 | 0.5029 | 0.07 | 0.0057 | 2.55 | 2.83 |
| NRTL($\alpha_{12}=0.3$) | 0.7072 | 0.3505 | 0.07 | 0.0064 | 2.52 | 2.78 |
| UNIQUAC | 0.7557 | 0.9490 | 0.08 | 0.0065 | 2.51 | 2.77 |
| | 1,3-dichloropropane(1) + 2-butanol(2) at 40.0 kPa | | | | | |
| Margules | 0.0268 | 1.1972 | 0.15 | 0.0071 | 2.79 | 3.31 |
| Van Laar | 1.0362 | 1.1974 | 0.15 | 0.0068 | 2.82 | 3.31 |
| Wilson | 0.6118 | 0.4286 | 0.18 | 0.0059 | 2.89 | 3.44 |
| NRTL($\alpha_{12}=0.3$) | 0.8775 | 0.3670 | 0.16 | 0.0066 | 2.84 | 3.34 |
| UNIQUAC | 0.7014 | 0.9637 | 0.16 | 0.0067 | 2.83 | 3.32 |
| | 1,3-dichloropropane(1) + 2-butanol(2) at 101.3 kPa | | | | | |
| Margules | 0.9390 | 0.9213 | 0.26 | 0.0075 | 2.56 | 2.51 |
| Van Laar | 0.9384 | 0.9222 | 0.26 | 0.0075 | 2.56 | 2.51 |
| Wilson | 0.5750 | 0.5980 | 0.27 | 0.0067 | 2.60 | 2.56 |
| NRTL($\alpha_{12}=0.3$) | 0.4717 | 0.5334 | 0.26 | 0.0073 | 2.57 | 2.53 |
| UNIQUAC | 0.8645 | 0.8455 | 0.26 | 0.0074 | 2.56 | 2.52 |
| | 1,3-dichloropropane(1) + 2-methyl-1-propanol(2) at 40.0 kPa | | | | | |
| Margules | 1.1275 | 1.1676 | 0.09 | 0.0018 | 3.09 | 3.21 |
| Van Laar | 1.1282 | 1.1675 | 0.09 | 0.0018 | 3.09 | 3.21 |
| Wilson | 0.5255 | 0.4821 | 0.12 | 0.0020 | 3.19 | 3.33 |
| NTRL($\alpha_{12}=0.3$) | 0.6947 | 0.5723 | 0.10 | 0.0016 | 3.12 | 3.24 |
| UNIQUAC | 0.7870 | 0.8584 | 0.09 | 0.0017 | 3.10 | 3.22 |
| | 1,3-dichloropropane(1) + 2-methyl-1-propanol(2) at 101.3 kPa | | | | | |
| Margules | 0.8504 | 1.0744 | 0.15 | 0.0083 | 2.34 | 2.93 |
| Van Laar | 0.8557 | 1.0936 | 0.15 | 0.0084 | 2.35 | 2.98 |
| Wilson | 0.7465 | 0.4196 | 0.15 | 0.0082 | 2.39 | 3.07 |
| NRTL($\alpha_{12}=0.3$) | 0.9628 | 0.1378 | 0.15 | 0.0083 | 2.36 | 2.99 |
| UNIQUAC | 0.6448 | 1.0819 | 0.15 | 0.0084 | 2.36 | 2.99 |
| | 1,3-dichloropropane(1) + 2-methyl-2-propanol(2) at 40.0 kPa | | | | | |
| Margules | 1.1816 | 0.9731 | 0.11 | 0.0069 | 3.26 | 2.65 |
| Van Laar | 1.1866 | 0.9841 | 0.12 | 0.0067 | 3.28 | 2.68 |
| Wilson | 0.4176 | 0.6525 | 0.13 | 0.0064 | 3.39 | 2.74 |
| NRTL($\alpha_{12}=0.3$) | 0.2835 | 0.9329 | 0.12 | 0.0066 | 3.30 | 2.69 |
| uniquac | 1.0281 | 0.6662 | 0.12 | 0.0066 | 3.29 | 2.68 |
| | 1,3-dichloropropane(1) + 2-methyl-2-propanol(2) at 101.3 kPa | | | | | |
| Margules | 0.9278 | 0.7792 | 0.10 | 0.0065 | 2.53 | 2.18 |
| Van Laar | 0.9342 | 0.7838 | 0.10 | 0.0065 | 2.55 | 2.19 |
| Wilson | 0.4980 | 0.7459 | 0.10 | 0.0065 | 2.59 | 2.21 |
| NRTL($\alpha_{12}=0.3$) | 0.1735 | 0.7720 | 0.10 | 0.0065 | 2.55 | 2.19 |
| UNIQUAC | 1.0564 | 0.7035 | 0.10 | 0.0065 | 2.55 | 2.19 |

[a] $\Lambda_{12}, \Lambda_{21}$

[b] $\tau_{12}, \tau_{21}$

for the studied mixtures are greater than for the mixtures of 1,2-dichloroethane with isomeric butanols[21].

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