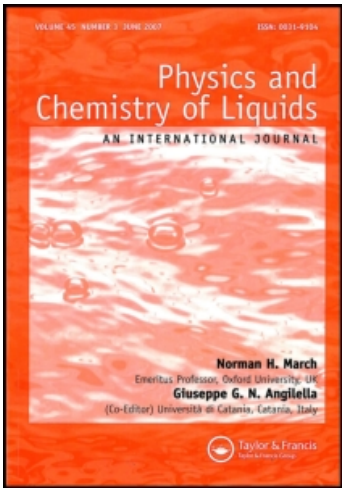


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# Ultrasonic Studies of Binary Mixtures of Trichloroethylene and Tetrachloroethylene with some Aliphatic and Alicyclic Ketones at 303.15 K

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# Ultrasonic Studies of Binary Mixtures of Trichloroethylene and Tetrachloroethylene with some Aliphatic and Alicyclic Ketones at 303.15 K

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Ultrasonic sound velocities and densities were measured for the binary mixtures of trichloroethylene and tetrachloroethylene with some aliphatic and alicyclic ketones namely, methylethylketone, methylpropylketone, diethylketone, cyclopentanone, and cyclohexanone at 303.5 K. Isentropic compressibilities $k_s$ and deviation in isentropic compressibility from ideal behaviour have been calculated from the results. All the mixtures formed by trichloroethylene and tetrachloroethylene with ketones at 303.15 K exhibit negative deviation from ideal behaviour over the entire range of composition.



## 1 INTRODUCTION

In continuation of earlier work on excess volumes, $V^E$, of binary mixtures of trichloroethylene + ketones,[1] and tetrachloroethylene + ketones,[2] sound velocities and isentropic compressibilities ($k_s$) of trichloroethylene and tetrachloroethylene with some aliphatic and alicyclic ketones at 303.15 are reported here.

## 2 EXPERIMENTAL

### Apparatus

Ultrasonic sound velocities were measured with a single crystal interferometer working at a fixed frequency of 1 MHz and were accurate to $\pm 0.075\%$. The temperature of the experimental liquid in the cell was maintained by

circulating water from a thermostatic bath through the double walled liquid container. All the measurements were made at a constant temperature that could be maintained to $\pm 0.01$ K. Densities in respect of mixtures are computed from experimental excess volumes data reported previously,[1,2] using the relation

$$\rho = \frac{X_A M_A + X_B M_B}{V + V^E} \tag{1}$$

$X_A$, $X_B$ denote the mole fractions of the two components, and $M_A$ and $M_B$ stands for the molecular weights. $V$ represents the ideal molar volume of the mixture. $V^E$ denotes the excess molar volume.

## Materials

Analytical reagent grade tetrachloroethylene was dried over sodium carbonate and fractionally distilled. Trichloroethylene (BDH), methylpropylketone (Fluka), and cyclohexanone (BDH) were purified by standard method described by Riddick and Bunger.[3] Methylethylketone (BDH) and diethylketone (BDH) were dried over potassium carbonate for 3 days, then boiled for 2 hours and distilled as reported in literature.[4] Cyclopentanone (Fluka) was dried over anhydrous sodium sulphate for 2 days and then fractionally distilled. The purity of the compounds was checked by measuring densities and boiling points. The boiling points at 760 mm Hg were measured using a Swietoslawski-type ebulliometer which gave an accuracy of $\pm 0.2$°C. The densities of pure compounds were measured using a bi-capillary pycnometer with an accuracy of 5 parts in $10^5$. The measured values are reported in Table I along with the literature values.[3,5]

TABLE I

Boiling points and densities of the pure compound at 303.15 K

| Compound | Boiling point K | | Density, $\rho$ g cm$^{-3}$ | |
|---|---|---|---|---|
| | Expt. | Lit.[3,5] | Expt. | Lit.[3,5] |
| Trichloroethylene | 360.20 | 360.34 | 1.45134 | 1.4514 |
| Tetrachloroethylene | 394.28 | 394.4 | 1.60634 | 1.60640 |
| Methylethylketone | 352.60 | 352.79 | 0.79448 | 0.79452 |
| Methylpropylketone | 373.40 | 373.55 | 0.79661 | 0.79656 |
| Diethylketone | 375.00 | 375.15 | 0.80460 | 0.80461 |
| Cyclopentanone | 403.70 | 403.80 | 0.93898 | 0.93902 |
| Cyclohexanone | 428.70 | 428.80 | 0.93760 | 0.93761 |

## Results and Discussion

Isentropic compressibility ($k_s$) was derived from the expression

$$k_s = u^{-2}\rho^{-1} \tag{2}$$

where $u$ and $\rho$ denotes sound velocity and density respectively. The $k_s$ values were accurate to $\pm 1$ $TPa^{-1}$. The deviation in isentropic compressibility ($K_s$) has been calculated from the equation

$$K_s = k_s - \phi_1 k_{s,1} - \phi_2 k_{s,2} \tag{3}$$

where $k_s$, $k_{s,1}$ and $k_{s,2}$ are the isentropic compressibilities of the pure components and $\phi_1$ and $\phi_2$ are volume fractions. Densities, sound velocities, isentropic compressibilities, deviations in isentropic compressibility for all the binary systems are listed in Tables II and III. The plots of $K_s$ against volume fraction of trichloroethylene and tetrachloroethylene are presented in Figures 1 and 2. The experimental $K_s$ values against volume fraction $\phi_1$

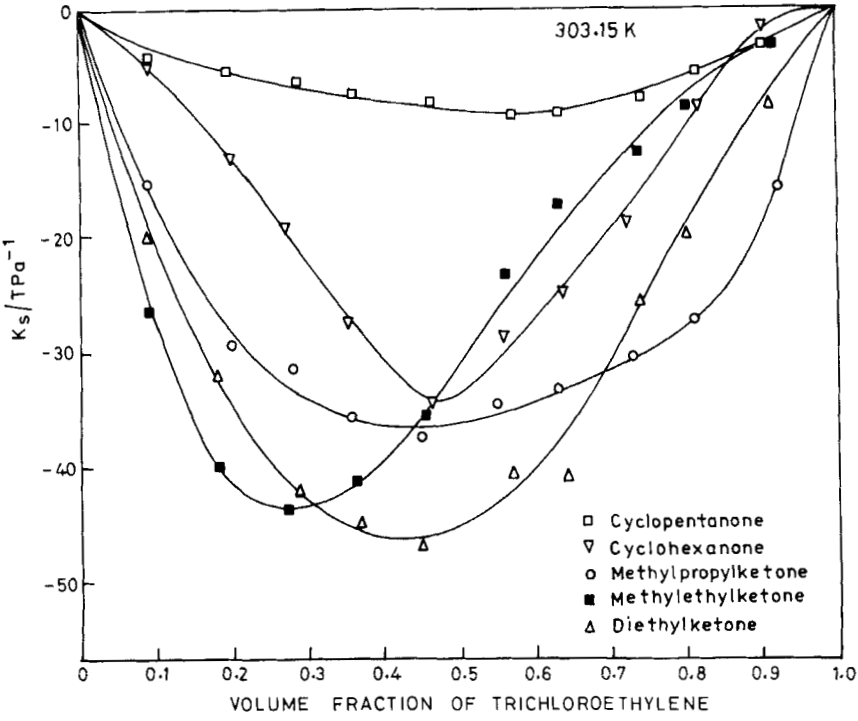


FIGURE 1 Parameter $K_s$ versus volume fraction curves for trichloroethylene with ketones at 303.15 K.

TABLE II

Volume fraction $\phi_1$ of trichloroethylene, density $\rho$, sound velocity $u$, isentropic compressibility $K_s$ from Eq. (2) and $K_s$ from Eq. (3) for trichloroethylene + ketones at 303.15 K

| $\phi_1$ | $\rho$ g cm$^{-3}$ | $U$ m sec$^{-1}$ | $k_s$ TPa$^{-1}$ | $K_s$ Tpa$^{-1}$ |
|---|---|---|---|---|
| | Trichloroethylene + diethylketone | | | |
| 0.0000 | 0.80460 | 1196.6 | 868.0 | — |
| 0.0871 | 0.87359 | 1173.8 | 830.8 | −19.9 |
| 0.1823 | 0.92973 | 1159.7 | 799.8 | −32.1 |
| 0.2911 | 0.99978 | 1141.0 | 768.3 | −42.0 |
| 0.3669 | 1.05238 | 1125.4 | 750.2 | −45.1 |
| 0.4505 | 1.11314 | 1107.7 | 732.1 | −46.7 |
| 0.5710 | 1.18289 | 1087.7 | 714.6 | −40.3 |
| 0.6404 | 1.22953 | 1054.0 | 732.1 | −40.6 |
| 0.7389 | 1.28653 | 1056.7 | 696.1 | −25.5 |
| 0.8008 | 1.32140 | 1047.4 | 689.8 | −19.6 |
| 0.9117 | 1.40528 | 1023.9 | 678.8 | −8.6 |
| 1.0000 | 1.45134 | 1014.2 | 669.9 | — |
| | Trichloroethylene + methylethylketone | | | |
| 0.0000 | 0.79448 | 1171.1 | 917.8 | — |
| 0.0881 | 0.86329 | 1154.2 | 869.5 | −26.5 |
| 0.1823 | 0.92453 | 1139.8 | 832.6 | −40.0 |
| 0.2719 | 0.97930 | 1124.9 | 806.9 | −43.5 |
| 0.3616 | 1.04414 | 1102.9 | 787.3 | −40.9 |
| 0.4555 | 1.10568 | 1084.2 | 769.4 | −35.5 |
| 0.5601 | 1.17027 | 1063.3 | 755.8 | −23.2 |
| 0.6309 | 1.21281 | 1052.5 | 744.3 | −17.1 |
| 0.7299 | 1.26997 | 1042.5 | 724.5 | −12.4 |
| 0.8016 | 1.31938 | 1032.8 | 710.6 | −8.5 |
| 0.9197 | 1.39592 | 1020.3 | 688.1 | −3.2 |
| 1.0000 | 1.45134 | 1014.2 | 669.9 | — |
| | Trichloroethylene + methylpropylketone | | | |
| 0.0000 | 0.79661 | 1200.3 | 871.3 | — |
| 0.0902 | 0.86071 | 1177.7 | 837.7 | −15.4 |
| 0.2010 | 0.93182 | 1157.3 | 801.3 | −29.5 |
| 0.2814 | 0.98198 | 1140.4 | 783.0 | −31.6 |
| 0.3618 | 1.04454 | 1120.3 | 762.8 | −35.6 |
| 0.4519 | 1.10937 | 1101.4 | 743.1 | −37.2 |
| 0.5505 | 1.16829 | 1085.8 | 726.0 | −34.4 |
| 0.6339 | 1.22270 | 1072.7 | 710.7 | −32.9 |
| 0.7314 | 1.28935 | 1057.5 | 693.6 | −30.4 |
| 0.8111 | 1.32997 | 1050.9 | 680.0 | −27.1 |
| 0.9204 | 1.40178 | 1031.7 | 670.2 | −15.7 |
| 1.0000 | 1.45134 | 1014.2 | 669.9 | — |
| | Trichloroethylene + cyclohexanone | | | |
| 0.0000 | 0.93760 | 1388.4 | 553.3 | — |
| 0.0881 | 0.99354 | 1342.1 | 558.8 | −4.8 |
| 0.2019 | 1.04592 | 1302.7 | 563.4 | −13.4 |
| 0.2716 | 1.08257 | 1277.6 | 565.9 | −19.1 |

TABLE II (*continued*)

| $\phi_1$ | $\rho$ g cm$^{-3}$ | $U$ m sec$^{-1}$ | $k_s$ TPa$^{-1}$ | $K_s$ TPa$^{-1}$ |
|---|---|---|---|---|
| 0.3512 | 1.12950 | 1249.6 | 567.1 | −27.2 |
| 0.4593 | 1.18784 | 1212.6 | 572.5 | −34.4 |
| 0.5554 | 1.23107 | 1173.9 | 589.5 | −28.6 |
| 0.6378 | 1.27050 | 1142.4 | 603.1 | −24.6 |
| 0.7219 | 1.31151 | 1109.7 | 619.2 | −18.3 |
| 0.8105 | 1.36409 | 1070.7 | 639.5 | −8.3 |
| 0.8997 | 1.41276 | 1038.4 | 656.5 | −1.7 |
| 1.0000 | 1.45134 | 1014.2 | 669.9 | — |
| | Trichloroethylene + cyclopentanone | | | |
| 0.0000 | 0.93898 | 1373.1 | 564.9 | — |
| 0.0912 | 0.99778 | 1325.9 | 570.1 | −4.4 |
| 0.1947 | 1.04959 | 1281.9 | 579.8 | −5.5 |
| 0.2882 | 1.08654 | 1250.1 | 588.9 | −6.3 |
| 0.3615 | 1.12397 | 1222.5 | 595.3 | −7.6 |
| 0.4612 | 1.18250 | 1182.1 | 605.2 | −8.1 |
| 0.5703 | 1.24117 | 1144.0 | 615.6 | −9.2 |
| 0.6336 | 1.26985 | 1124.8 | 622.4 | −9.0 |
| 0.7409 | 1.33005 | 1088.1 | 635.0 | −7.7 |
| 0.8156 | 1.36668 | 1065.1 | 645.0 | −5.5 |
| 0.9002 | 1.40985 | 1039.6 | 656.3 | −3.1 |
| 1.0000 | 1.45134 | 1014.2 | 669.0 | — |

TABLE III

Volume fraction $\phi_1$ of tetrachloroethylene, density $\rho$, sound velocity $u$, isentropic compressibility $k_s$ from Eq. (2) and $K_s$ from Eq. (3) for tetrachloroethylene + ketones at 303.15 K

| $\phi_1$ | $\rho$ g cm$^{-3}$ | $U$ m sec$^{-1}$ | $k_s$ TPa$^{-1}$ | $K_s$ TPa$^{-1}$ |
|---|---|---|---|---|
| | Tetrachloroethylene + diethylketone | | | |
| 0.0000 | 0.80460 | 1196.6 | 868.0 | — |
| 0.0902 | 0.88414 | 1179.3 | 813.3 | −29.1 |
| 0.2019 | 0.97623 | 1161.6 | 759.2 | −51.6 |
| 0.2913 | 1.04114 | 1152.2 | 723.5 | −61.9 |
| 0.3666 | 1.10258 | 1140.6 | 697.2 | −66.8 |
| 0.4518 | 1.17717 | 1125.9 | 670.1 | −69.8 |
| 0.5505 | 1.25535 | 1110.2 | 646.3 | −65.6 |
| 0.6418 | 1.32919 | 1092.0 | 630.9 | −55.1 |
| 0.7299 | 1.39709 | 1078.2 | 615.7 | −45.3 |
| 0.8107 | 1.46403 | 1062.6 | 604.9 | −33.2 |
| 0.9117 | 1.54107 | 1043.9 | 595.5 | −13.9 |
| 1.0000 | 1.60634 | 1032.1 | 584.4 | — |
| | Tetrachloroethylene + methylethylketone | | | |
| 0.0000 | 0.79448 | 1171.1 | 917.8 | — |
| 0.0851 | 0.86401 | 1158.9 | 861.8 | −27.6 |

(*continued over page*)

TABLE III (*continued*)

| $\phi_1$ | $\rho$ g cm$^{-3}$ | $u$ m sec$^{-1}$ | $k_s$ TPa$^{-1}$ | $K_s$ TPa$^{-1}$ |
|---|---|---|---|---|
| 0.1923 | 0.95889 | 1140.6 | 801.6 | −52.1 |
| 0.2779 | 1.03105 | 1126.9 | 763.8 | −61.3 |
| 0.3665 | 1.11145 | 1110.4 | 729.7 | −65.9 |
| 0.4505 | 1.17205 | 1100.5 | 704.5 | −63.1 |
| 0.5614 | 1.26091 | 1086.2 | 672.2 | −58.4 |
| 0.6689 | 1.34570 | 1073.4 | 645.0 | −49.8 |
| 0.7211 | 1.38012 | 1070.2 | 632.2 | −45.2 |
| 0.8002 | 1.45413 | 1056.9 | 615.6 | −35.4 |
| 0.9213 | 1.55420 | 1041.6 | 593.0 | −17.7 |
| 1.0000 | 1.60634 | 1032.1 | 584.4 | — |
| | Tetrachloroethylene + methylpropylketone | | | |
| 0.0000 | 0.79661 | 1200.3 | 871.3 | — |
| 0.0902 | 0.87491 | 1174.9 | 827.9 | −17.5 |
| 0.1903 | 0.96006 | 1149.3 | 788.5 | −28.2 |
| 0.2844 | 1.03892 | 1126.8 | 758.1 | −31.6 |
| 0.3513 | 1.09028 | 1116.5 | 735.8 | −34.7 |
| 0.4419 | 1.16278 | 1099.0 | 712.0 | −32.5 |
| 0.5782 | 1.27948 | 1076.3 | 674.7 | −30.7 |
| 0.6311 | 1.31200 | 1073.4 | 661.5 | −28.7 |
| 0.7409 | 1.40271 | 1060.4 | 634.0 | −24.7 |
| 0.8111 | 1.46833 | 1050.9 | 616.7 | −21.9 |
| 0.9116 | 1.54742 | 1042.9 | 594.1 | −15.7 |
| 1.0000 | 1.60634 | 1032.1 | 584.4 | — |
| | Tetrachloroethylene + cyclohexanone | | | |
| 0.0000 | 0.93760 | 1388.4 | 553.3 | — |
| 0.0924 | 1.00556 | 1346.6 | 548.4 | −7.8 |
| 0.2112 | 1.08444 | 1301.7 | 544.2 | −15.7 |
| 0.2713 | 1.12407 | 1281.0 | 542.1 | −19.6 |
| 0.3605 | 1.18209 | 1250.9 | 540.6 | −23.9 |
| 0.4500 | 1.24771 | 1218.1 | 540.2 | −27.1 |
| 0.5619 | 1.32408 | 1172.6 | 549.3 | −21.5 |
| 0.6398 | 1.37503 | 1142.9 | 556.8 | −16.4 |
| 0.7288 | 1.43570 | 1111.2 | 564.1 | −11.9 |
| 0.8081 | 1.48516 | 1084.3 | 572.7 | −5.7 |
| 0.9312 | 1.57053 | 1046.7 | 581.2 | −1.1 |
| 1.0000 | 1.60634 | 1032.1 | 584.4 | — |
| | Tetrachloroethylene + cyclopentanone | | | |
| 0.0000 | 0.93898 | 1373.1 | 564.9 | — |
| 0.0862 | 1.00583 | 1329.7 | 562.3 | −4.3 |
| 0.1829 | 1.07291 | 1291.3 | 559.0 | −9.5 |
| 0.2711 | 1.12986 | 1260.5 | 557.0 | −13.2 |
| 0.3660 | 1.19605 | 1224.1 | 557.9 | −14.1 |
| 0.4617 | 1.25051 | 1194.5 | 560.5 | −13.4 |
| 0.5665 | 1.32719 | 1155.7 | 564.1 | −11.8 |
| 0.6309 | 1.37059 | 1134.7 | 566.7 | −10.5 |
| 0.7305 | 1.43480 | 1102.7 | 573.2 | −9.1 |
| 0.8155 | 1.49237 | 1077.7 | 576.9 | −6.9 |
| 0.9214 | 1.56602 | 1051.6 | 577.4 | −3.3 |
| 1.0000 | 1.60634 | 1032.1 | 584.4 | — |

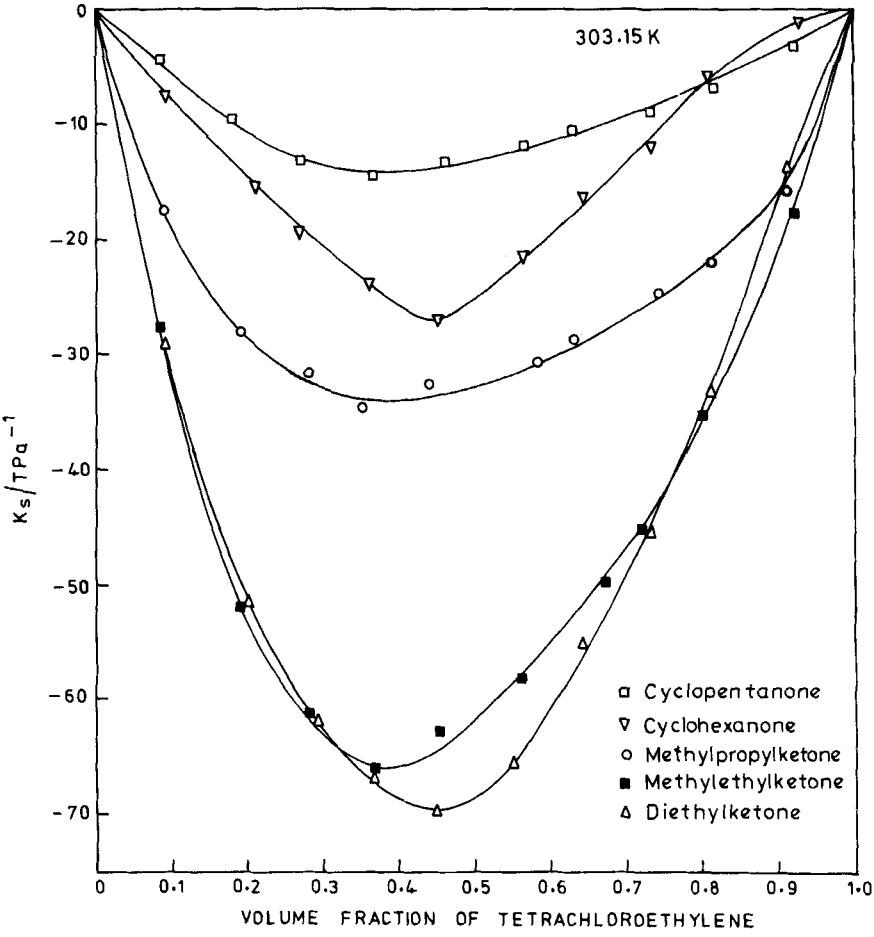


FIGURE 2 Parameter $K_s$ versus volume fraction curves for tetrachloroethylene with ketones at 303.15 K.

may be represented by

$$K_s/\phi_1\phi_2 = a_0 + a_1(\phi_1 - \phi_2) + a_2(\phi_1 - \phi_2)^2 \qquad (4)$$

where $a_0$, $a_1$, $a_2$ are adjustable parameters obtained by the method of least squares and are given in Table IV along with the standard deviation $\sigma(K_s)$. The $K_s$ curves are negative over the entire range of composition for all of the systems formed by trichloroethylene with ketones. This could be due to existence of specific interaction between the dipole of the ketones and polarizable of trichloroethylene.

TABLE IV

Least square parameters in Eq. (4) and the standard deviation $\sigma$ ($TPa^{-1}$) of $K_s$ at 303.15 K

| System | $a_0$ | $a_1$ | $a_2$ | $\sigma(K_s)$ |
|---|---|---|---|---|
| | $TPa^{-1}$ | | | |
| Trichloroethylene + methylethylketone | −119.5279 | 174.7749 | −97.8379 | 2 |
| Trichloroethylene + methylpropylketone | −142.2650 | −2.9802 | −87.4645 | 1 |
| Trichloroethylene + diethylketone | −174.4509 | 81.5326 | 0.8963 | 1 |
| Trichloroethylene + cyclopentanone | −33.7096 | 3.0128 | −13.1836 | 1 |
| Trichloroethylene + cyclohexanone | −124.0364 | 23.4827 | 134.7536 | 2 |
| Tetrachloroethylene + methylethylketone | −256.2268 | 80.0246 | −47.9458 | 2 |
| Tetrachloroethylene + methylpropylketone | −124.7354 | 23.4517 | −111.6879 | 1 |
| Tetrachloroethylene + diethylketone | −269.5398 | 97.4790 | 7.0700 | 1 |
| Tetrachloroethylene + cyclopentanone | −52.3289 | 11.9238 | −2.8449 | 1 |
| Tetrachloroethylene + cyclohexanone | −93.7049 | 43.9993 | 58.7886 | 1 |

The $K_s$ curves for the mixtures of tetrachloroethylene with ketones are also negative over the whole composition range. This may be examined on the basis of the electron donating capacities of the carbonyl group of the ketones which induces dipole interaction between the dipole of the ketones and tetrachloroethylene. The negative values of $K_s$ for all the binary systems with trichloroethylene and tetrachloroethylene fall in the following order:

Diethylketone > methylethylketone > methylpropylketone >

cyclohexanone > cyclopentanone



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## References

1. H. Iloukhani, K. D. Reddy, M. V. P. Rao, *Phys. Chem. Liq.*, In press (1984).
2. H. Iloukhani, K. D. Reddy, M. V. P. Rao, *J. Chem. Eng. Data*. In press (1985).
3. J. A. Riddick, W. S. Bunger, *Organic Solvents in Techniques of Chemistry*, 3rd ed. Vol. II, Wiley Interscience (New York, 1970).
4. P. R. Naidu, *Aus. J. Chem.*, **23**, 967 (1970).
5. J. Timmermans, *Physico-chemical constants of Pure Organic Compounds*, Elsevier Publishing Company (Amsterdam, 1965).