# **PVT Properties of Liquid** *n*-Alkane Mixtures

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Four liquid-phase isotherms are measured for two binary and one ternary mixture made from four straight-chain hydrocarbons. The accuracy is estimated at  $\pm 0.06\%$  in the volume. A brief description of the modified Bridgmantype sylphon-bellows piezometer used is given, followed by the results of the four isotherms between 25.00° and 85.00°C for equimolar binary mixtures of *n*-decane with *n*-tetradecane and *n*-dodecane with *n*-hexadecane. The ternary mixture is 0.6000 mole fraction *n*-decane with 0.2000 mole fraction *n*-tetradecane and 0.2000 mole fraction *n*-hexadecane. Excess volumes are calculated for the three mixtures at five representative pressures.

Liquid PVT properties of the three mixtures were determined by use of a modified Bridgman-type (5) sylphonbellows piezometer. The data taken in this study represent the first high-accuracy mixture PVT data taken in which the pressure range extends from atmospheric pressure to just below the freezing pressure on all isotherms for liquid mixtures. The unsmoothed PVT data are tabulated as a function of temperature and pressure for the three mixtures. Pure component data over the same ranges of temperature and pressure have been reported elsewhere (24). However, the molecular weight of *n*-tetradecane was incorrectly taken as 196.37 g/g-mol. Thus, molar volume values must be multiplied by 198.40/ 196.37 to obtain the correct molar volumes for *n*-tetradecane.

## Experimental

Apparatus. The operation of the PVT cell can be described with the aid of Figure 1. The two main components of the PVT cell are the bellows, marked B on the drawing, and the slide wire. S. The slide wire is a section of Karma wire approximately 1 in. in length and 0.010 in. in diameter. Karma is a trademark of the Driver-Harris Co., Harrison, N.J., and is an alloy of nickel, chromium, and aluminum. Karma wire was used as the slide wire because of its low-temperature coefficient of resistivity (0  $\pm$  10 ppm/°C), its precision drawn diameter, and its highly uniform linear conductivity (experimentally determined as  $3.87800 \pm 0.00002$  cm/ohm for the 0.010-in. diameter Karma wire) (23). There are three electrical contacts. labeled  $E_1$ ,  $E_2$ , and  $E_3$  on Figure 1, made to the Karma slide wire. The slide wire is held against the edge of contact C by a Teflon plunger-spring arrangement. Contact C is a piece of 0.010-in. diameter Karma wire soldered to a brass plate. The retainer. R, supports the bellows and the associated electrical components. The bellows is held in the retainer by three screws, marked P on the drawing.

As the bellows and sample compress longitudinally under hydrostatic load, the Karma slide wire is drawn past the fixed contact C of Figure 1. The change in length of the bellows is calculated from the change in

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electrical resistance across  $E_1$ ,  $E_2$ , and  $E_3$  after thermal equilibrium is attained.

A Leeds and Northrup Model G-2 Mueller bridge and a Model 2284d galvanometer and scale were used in conjunction with a four-position mercury contact commutator to make the necessary resistance measurements. The bridge had been calibrated by Leeds and Northrup using National Bureau of Standards calibrated reference resistors, and a set of correctional constants was provided with the bridge. The measuring circuit was wired to eliminate lead wire and contact resistance (23).

The pressure-generating system consisted of three hydraulic handjacks and a piston intensifier. The system is capable of pressures to 200,000 psi with a maximum temperature limit on the PVT cell of 150°C. Two Heise gages, one 0-1500-psi gage and one 0-50,000-psi gage, were used for pressure measurements below 50,000 psi. These were temperature compensated and accurate to 0.1% of full scale. The two Heise gages were calibrated by the Heise Bourdon Tube Co. using a National Bureau of Standards approved dead weight tester. A report of the calibration was supplied with each gage. In addition, the calibration of the two gages was rechecked in this laboratory with a Ruska dead weight tester for the 0-1500psi gage and an Aminco 100,000-psi dead weight tester for the 0-50,000-psi gage. For pressures above 50.000 psi, a Manganin cell pressure transducer was used in conjunction with the Mueller G-2 bridge. The Manganin cell, calibrated at 25.00°C with the Aminco 100,000-psi dead weight tester, was maintained at 25.00  $\pm$  0.01°C during each isotherm by an Aminco constant-temperature bath.

A Hallikainen constant-temperature bath and Hallikainen Thermitrol controller were used to control the temperature of the PVT cell. A Sola constant voltage transformer was used as the Thermitrol's power supply. The temperature of the bath was measured to  $\pm 0.01^{\circ}$ C with a platinum resistance thermometer previously calibrated by the National Bureau of Standards on the 1948 International Practical Temperature Scale. All isotherms were run at the set point temperature with measured variations of  $\pm 0.003^{\circ}$ C about the set point.

**Data reduction.** The change in volume of the sample in the bellows relative to the volume at atmospheric pressure as pressure is applied to the system is a function of the following: The vacuum corrected weight of the sample in the bellows,  $W_{vc}$ , the atmospheric pressure density



Figure 1. Detail of bellows-slide wire arrangement

of the sample,  $\rho_{o,T}$ , the temperature and pressure corrected cross-sectional area of the bellows,  $A_{P,T}$ , and the change in length of the bellows with pressure.  $\Delta L_B$ . Appropriate temperature and pressure corrections were applied to  $\Delta L_B$  and  $A_{P,T}$  to obtain the true compression of the sample as represented by Equation 1

$$\left(v_{o} - v_{i}\right)/v_{o} = \left(\Delta L_{B} \cdot A_{P,T} \cdot \rho_{o,T}\right)/W_{vc} \tag{1}$$

The quantity  $(v_o - v_i)/v_o$  is the compression of the sample where  $v_i$  is the specific volume at temperature T and pressure  $P_i$ , and  $v_o$  is the specific volume at temperature T and atmospheric pressure  $P_o$ .

With the exception of the atmospheric pressure density.  $\rho_{o,T}$ , all terms on the right-hand side of Equation 1 were obtained during the course of this study. The atmospheric pressure density,  $\rho_{o,T}$ , for the mixtures were determined from pycnometric measurements (12, 15, 22). For the binary system at temperatures from 25° to 65°C, inclusively, and the ternary system at 25° and 45°C, the experimental excess volume at each temperature for each exact mole fraction was estimated from a curve fit to the data. This value was then used in combination with the pure component densities reported (12, 15, 22) to determine the mixture density. For isotherms at other temperatures, pure component densities and mixture excess volume were obtained by linear temperature interpolation or extrapolation of experimental results for each system. The mixture densities were then calculated as above. The estimated maximum error introduced was  $0.0001 \text{ g/cm}^3$  in the density at 85°C.

An error analysis technique used by the National Bu-

reau of Standards and detailed by Mickley et al. (18), indicates that the errors in the PVT measurements made with this system are no greater than  $0.0006 \text{ cm}^3/\text{cm}^3$ .

A direct comparison of these results with those previously reported for some of the pure components (4, 6, 8, 9) was not possible since the investigations were not conducted at the same temperatures. However, Snyder and Winnick (24) have fitted the isothermal compressibilities of Boelhouwer (4), Bridgman (6), and Cutler et al. (8, 9) with temperature and then interpolated to the temperature of the present study. The relative volume of decane, dodecane, and hexadecane then calculated as a function of pressure agrees with our results within the precision allowed by the temperature interpolation, generally to  $\pm 0.2\%$  at the highest pressure.

**Materials.** Decane. dodecane, tetradecane, and hexadecane were obtained from Humphrey Chemical Co., North Haven, Conn. They were manufactured from naturally occurring. even-numbered, straight-chain fatty alcohols. Their purity was at least 99%, as determined from a chromatographic analysis. The most probable impurities would be the adjacent even-numbered *n*-alkanes. The sample was degassed before the bellows was filled. These were the same materials as used in the atmospheric pressure density determinations (*12, 15, 22*).

## **Results and Discussion**

**Experimental data.** The relative volumes for each of the three mixtures studied as a function of pressure at 25.00°, 45.00°, 65.00°, and 85.00°C are presented in Table I. The relative volume,  $\bar{v}_i$ , is defined as 1.0000 –

25.00°C		45.00	°C	65.00°C		85.00°C	
,	Rel vol,		Rel vol,		Rel vol,		Rei vol,
Press, atm	cc/cc	Press, atm	cc/cc	Press, atm	cc/cc	Press, atm	cc/cc
		0.5000 Mole fra	ction mixture	of n-decane n-tetr	adecane		
$\rho_{o,T} = 0.744$	188 g/cm³	$\rho_{o,T} = 0.73$	052 g/cm³	$\rho_{o,T} = 0.71$	560 g/cm³	$\rho_{o,T} = 0.70$	067 g/cm³
1.0	1,0000	1.0	1.0000	1.0	1.0000	1.0	1.0000
17.3	0.9992	17.0	0.9984	17.9	0.9980	9.9	0.9991
70.5	0.9949	33.3	0.9962	32.6	0.9960	15.4	0.9985
99.1	0.9920	68.1	0.9926	70.2	0.9916	18.1	0.9977
137.1	0.9894	98.4	0.9892	101.4	0.9879	20,9	0.9976
176.1	0.9858	137.8	0.9854	135.1	0.9849	26.9	0.9963
208.6	0.9838	210.6	0.9792	214.0	0.9764	35.4	0.9954
239.5	0.9808	304.5	0.9718	518.8	0.9510	42.0	0.9940
273.9	0.9790	411.3	0.9630	614.1	0.9441	48.8	0.9930
312.7	0.9752	504.5	0.9568	722.3	0.9373	55.7	0.9922
377.3	0.9712	612.7	0.9492	823.0	0.9306	63.9	0.9907
514.1	0.9623	723.7	0.9431	927.8	0.9255	70.9	0.9903
585.5	0.9572	823.0	0.9370	1026.5	0.9198	71.0	0.9900
646.1	0.9546	932.6	0.9316	1131.2	0.9151	86.3	0.9876
717.5	0.9497	1018.3	0.9269	1234.7	0.9092	101.4	0.9857
786.9	0.9467	1130.6	0.9219	1500.7	0.8976	137.1	0.9822
852.3	0.9427	1230.6	0.9169	1720.5	0.8901	208.5	0.9739
921.0	0.9398	1431.3	0.9090	1901.5	0.8830	307.9	0.9638
991.1	0.9357	1632.7	0.9009	2322.7	0.8692	417.4	0.9528
1058.4	0.9331	1838.2	0.8942	2725.6	0.8585	613.4	0.9379
1131.2	0.9294	2047.8	0.8862	2927.0	0.8539	728.4	0.9303
1183.0	0.9271			3131.1	0.8481	824.4	0.9235
1257.8	0.9241					926.4	0.9175
						1031.9	0.9114
						1226.5	0.9014
						1373.5	0.8953
						1510.3	0.8882
						1635.5	0.8842
						1770.9	0.8781
						1990.0	0.8714

#### Table I. Mole Fraction Mixtures

Ret vol, cc/cc         Ret vol, cc/cc         Ret vol, cc/cc         Ret vol, ress, atm         Ret vol, cc/cc         Ret vol, ress, atm         Ret vol, cc/cc           ss, atm         cc/cc         Press, atm         cc/cc         Press, atm         cc/cc           ss, atm         cc/cc         Press, atm         cc/cc $\rho_{x,r} = 0.70067$ $\rho_{x,r} = 0.70067$ status         cc/cc $\rho_{x,r} = 0.75931$ $\rho_{x,r} = 0.74902$ $\rho_{x,r} = 0.75931$ $\rho_{x,r} = 0.71928$	25.00°C		45.00°C		65.00°C		85.00°C	
is, atm         cc/cc         Press, atm         cc/cc         Press, atm         cc/cc         Press, atm         cc/cc $p_{n,\tau} = 0.7002$ $p_{n,\tau} = 0.7492$ $p_{n,\tau} = 0.71628$		Rel vol,	<u> </u>	Rel vol,		Rei vol,		Rel vol
$ \begin{array}{c} \mu_{nr} = 0.70067 \ g/cm \\ 2786. 0 & 0.85 \\ 2786. 0 & 0.85 \\ 2786. 0 & 0.85 \\ 2786. 0 & 0.85 \\ 2880. 0 & 0.85 \\ 2795. 0 & 0.82 \\ 3009. 9 & 0.82 \\ 4000. 3 & 0.81 \\ 4244. 8 & 0.81 \\ 4244. 8 & 0.81 \\ 4244. 8 & 0.81 \\ 4244. 8 & 0.81 \\ 4244. 8 & 0.81 \\ 4244. 8 & 0.81 \\ 4244. 8 & 0.81 \\ 4244. 8 & 0.81 \\ 4244. 8 & 0.81 \\ 4244. 8 & 0.81 \\ 4244. 8 & 0.81 \\ 4244. 8 & 0.81 \\ 4244. 8 & 0.81 \\ 4244. 8 & 0.81 \\ 4244. 8 & 0.81 \\ 4244. 8 & 0.81 \\ 4244. 8 & 0.97 \\ 1.0 & 1.000 & 1.0 & 1.000 & 1.0 & 1.00 \\ 1.0 & 1.000 & 1.0 & 1.000 \\ 1.0 & 1.000 & 1.0 & 1.000 \\ 1.0 & 0.9984 & 18.1 & 0.9977 & 17.2 & 0.9395 & 36.4 & 0.99 \\ 3.7 & 0.9985 & 135.1 & 0.9961 & 97.1 & 0.4988 & 403.8 & 0.95 \\ 5.1 & 0.9981 & 275.2 & 0.9766 & 137.1 & 0.4988 & 403.8 & 0.95 \\ 5.1 & 0.9981 & 275.2 & 0.9766 & 137.1 & 0.4988 & 403.8 & 0.95 \\ 5.1 & 0.9981 & 275.2 & 0.9766 & 137.1 & 0.4988 & 403.8 & 0.95 \\ 9.2 & 0.9988 & 410.0 & 0.9552 & 307.9 & 0.7700 & 616.8 & 0.94 \\ 9.2 & 0.9988 & 410.0 & 0.9561 & 515.4 & 0.9541 & 825.0 & 0.973 \\ 44.6 & 0.9775 & 548.8 & 0.9561 & 515.4 & 0.9541 & 825.0 & 0.973 \\ 44.6 & 0.9775 & 548.8 & 0.9961 & 612.1 & 0.3334 & 1018.3 & 0.914 \\ 45.7 & 0.9664 & 82.2 & 0.9373 & 1248.0 & 0.9228 & 1227.9 & 0.98 \\ 11.3 & 0.9664 & 82.3 & 0.9400 & 1018.3 & 0.9248 & 1227.9 & 0.98 \\ 102.0 & 0.9625 & 95.4 & 0.9373 & 1248.0 & 0.9032 & 1770.2 & 0.88 \\ 102.0 & 0.9625 & 95.4 & 0.9373 & 1248.0 & 0.9032 & 1770.2 & 0.88 \\ 102.8 & 0.9273 & 1498.0 & 0.9032 & 170.8 & 0.987 \\ 125.8 & 0.9273 & 1498.0 & 0.9032 & 170.8 & 0.987 \\ 125.8 & 0.9273 & 1498.0 & 0.9032 & 170.0 & 0.8 \\ 102.9 & 0.7593 & 2249.2 & 0.86 \\ 2168.9 & 0.7593 & 2249.2 & 0.86 \\ 208.9 & 0.7593 & 2249.2 & 0.86 \\ 208.9 & 0.7593 & 2249.2 & 0.86 \\ 30.65 & 0.9973 & 124.5 & 0.9943 & 17.8 & 0.9974 & 17.1 & 0.375 \\ 1.0 & 0.9664 & 82.0 & 0.9273 & 1498.0 & 0.9373 & 2249.2 & 0.86 \\ 30.65 & 0.9973 & 127.7 & 0.9434 & 3269.7 & 0.944 \\ 3269.7 & 0.944 & 3269.7 & 0.944 \\ 3269.7 & 0.944 & 3269.7 & 0.944 \\ 3269.7 & 0.944 & 3269.7 & 0.943 \\ 326.0 & 0.9973 & 127.7 & 0.9453 & 31.6 & 0.9433 & 727.7 & 0.318 \\ 35.6 & 0.9$	ress, atm	cc/cc	Press, atm	cc/cc	Press, atm	cc/cc	Press, atm	cc/cc
$\begin{array}{c c c c c c c c c c c c c c c c c c c $							$\rho_{o,T}=0.70$	067 g/cm³
$\begin{array}{c} & \begin{array}{c} & & & & & & & & & & & & & & & & & & &$							2178.5	0.8642
$ \begin{array}{c} & 2795, 6 & 0.84 \\ 3135, 1 & 0.83 \\ 3397, 5 & 0.82 \\ 3000, 9 & 0.82 \\ 4000, 3 & 0.81 \\ 4244, 8 & 0.997 \\ 41, 2 & 0.9985 & 36, 4 & 0.99 \\ 84, 7 & 0.9996 & 98, 7 & 0.9901 & 68, 7 & 0.9965 \\ 84, 7 & 0.9962 & 98, 7 & 0.9901 & 68, 7 & 0.9955 & 137, 8 & 0.98 \\ 85, 7 & 0.9865 & 127, 2 & 0.9756 & 137, 1 & 0.8968 & 403, 8 & 0.95 \\ 95, 1 & 0.9861 & 275, 2 & 0.9756 & 137, 1 & 0.8968 & 403, 8 & 0.95 \\ 91, 1 & 0.9893 & 410, 0 & 0.9552 & 307, 9 & 0.9700 & 615, 8 & 0.97 \\ 91, 1 & 0.9793 & 484, 1 & 0.9566 & 409, 3 & 0.961 & 718, 9 & 0.93 \\ 86, 6 & 0.9757 & 544, 8 & 0.9561 & 515, 4 & 0.9541 & 825, 0 & 0.926 \\ 91, 1 & 0.9702 & 613, 9 & 0.9611 & 517, 5 & 0.944 & 0.870 \\ 91, 1 & 0.964 & 784, 3 & 0.9439 & 244, 4 & 0.297 & 1134, 0 & 0.91 \\ 91, 0 & 0.964 & 784, 3 & 0.9439 & 244, 4 & 0.297 & 1134, 0 & 0.91 \\ 91, 0 & 0.964 & 784, 3 & 0.9437 & 1120, 6 & 0.1818 & 13694 & 0.93 \\ 102, 0 & 0.964 & 784, 3 & 0.9437 & 1120, 6 & 0.1818 & 13694 & 0.93 \\ 112, 0 & 0.964 & 754, 3 & 0.932 & 1386, 7 & 0.9033 & 1664, 0 & 0.89 \\ 120, 0 & 0.962 & 1016, 6 & 0.932 & 1386, 7 & 0.9033 & 1664, 0 & 0.8 \\ 160, 1 & 0.9664 & 75, 0 & 0.933 & 114, 0 & 0.977 & 2045, 1 & 0.77 \\ 122, 8 & 0.926 & 1120, 6 & 0.973 & 2045, 1 & 0.77 \\ 122, 8 & 0.926 & 1120, 6 & 0.937 & 104, 4 & 0.997 \\ 122, 8 & 0.9961 & 17, 8 & 0.997 & 104, 1 & 0.957 \\ 122, 8 & 0.9961 & 17, 8 & 0.997 & 104, 1 & 0.957 \\ 124, 8 & 0.9961 & 17, 8 & 0.9961 & 17, 8 & 0.997 & 104, 1 & 0.957 \\ 125, 8 & 0.9933 & 31, 6 & 0.957 & 204, 1 & 0.977 & 217, 1 & 0.957 \\ 125, 8 & 0.9933 & 31, 6 & 0.957 & 204, 1 & 0.957 \\ 125, 8 & 0.9933 & 31, 6 & 0.957 & 204, 1 & 0.957 \\ 125, 8 & 0.9933 & 31, 6 & 0.957 & 204, 1 & 0.$							2388.0	0.8589
$\begin{array}{c} 3357, 1 & 0.83\\ 3357, 5 & 0.82\\ 3359, 9 & 0.82\\ 424.8 & 0.81\\ 424.4 & 0.996\\ 1.0 & 1.0000 & 1.0 & 1.0000 & 1.0 & 1.0000 & 1.0 & 1.00\\ 1.0 & 1.0000 & 1.0 & 1.0000 & 1.0 & 1.0000\\ 1.0 & 1.0000 & 1.0 & 1.0000 & 1.0 & 1.0000\\ 1.0 & 0.9964 & 97.1 & 0.9965 & 97.6 & 0.99\\ 35.7 & 0.9885 & 135.1 & 0.9964 & 97.1 & 0.9896 & 403.8 & 0.95\\ 95.1 & 0.9831 & 339.2 & 0.9707 & 208.5 & 0.9786 & 517.5 & 0.94\\ 97.1 & 0.9733 & 484.1 & 0.9965 & 407.9 & 0.9700 & 616.8 & 0.92\\ 97.1 & 0.9733 & 484.1 & 0.9964 & 409.3 & 0.9617 & 718.9 & 0.93\\ 90.5 & 0.9737 & 618.9 & 0.9318 & 617.5 & 0.9470 & 299.1 & 0.22\\ 44.6 & 0.9737 & 618.9 & 0.9367 & 1130.6 & 0.9470 & 299.1 & 0.22\\ 44.7 & 0.9644 & 822.3 & 0.9401 & 108.3 & 0.9642 & 1018.3 & 0.92\\ 44.7 & 0.9644 & 824.3 & 0.9357 & 1130.6 & 0.9188 & 139.4 & 0.91\\ 11.3 & 0.9684 & 754.3 & 0.9327 & 1488.7 & 0.9033 & 166.4 & 0.88\\ 159.8 & 0.9212 & 153.2 & 0.8372 & 206.1 & 0.88\\ 159.8 & 0.9212 & 153.2 & 0.8372 & 206.1 & 0.88\\ 159.8 & 0.9212 & 153.2 & 0.8372 & 206.1 & 0.87\\ 1225.8 & 0.9212 & 153.2 & 0.8372 & 206.1 & 0.87\\ 150.1 & 0.9662 & 1019.6 & 0.9302 & 166.2 & 0.879\\ 115.8 & 0.924 & 163.2 & 0.897\\ 125.8 & 0.9212 & 153.2 & 0.897\\ 125.8 & 0.9212 & 153.2 & 0.8372 & 206.1 & 0.97\\ 37.1 & 0.9968 & 97.5 & 0.9933 & 1.6 & 0.997\\ 37.1 & 0.9968 & 97.5 & 0.9933 & 1.6 & 0.997\\ 37.1 & 0.9968 & 97.5 & 0.9933 & 1.6 & 0.997\\ 37.1 & 0.9968 & 97.5 & 0.9833 & 1.6 & 0.997\\ 37.1 & 0.9968 & 97.5 & 0.9833 & 1.6 & 0.997\\ 37.1 & 0.9968 & 97.5 & 0.9833 & 1.6 & 0.997\\ 37.1 & 0.9968 & 97.5 & 0.9833 & 1.6 & 0.997\\ 37.1 & 0.9968 & 97.5 & 0.9833 & 1.6 & 0.997\\ 37.1 & 0.9968 & 97.5 & 0.9833 & 1.6 & 0.9975 &$							2795.6	0.8477
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $							3195.1	0.8377
$ \begin{array}{c} 0.500 \mbox{ mole fraction mixture of $n$-dodecane and $n$-hexadecane $$n$, $r$, $r$ = 0.75691 g/cm^3$ $$\rho_{s,r} = 0.75692 g/cm^1$ $$\rho_{s,r} = 0.7571 g/cm^3$ $$\rho_{s,r} = 0.75692 g/cm^1$ $$\rho_{s,r} = 0.7571 g/cm^3$ $$\rho_{s,r} = 0.7571 g/cm^3$ $$\rho_{s,r} = 0.7571 g/cm^3$ $$\rho_{s,r} = 0.7570 g/cm^2$ $$\rho_{s,r} = 0.7571 g/cm^3$ $$\rho_{s,r} = 0.7570 g/cm^2$ $$\rho_{s,r} = 0.7571 g/cm^3$ $$\rho_{s,r} = 0.75929 g/cm^3$ $$\rho_{s,r} = 0.7571 g/cm^3$ $$\rho_{s,r} = 0.75929 g/cm^3$ $$\rho_{s,r} = $							3597.5	0.8288
$\begin{array}{c c c c c c c c c c c c c c c c c c c $							3809.9	0.8236
$\begin{array}{c c c c c c c c c c c c c c c c c c c $							4000 3	0.8199
$p_{\mu,\tau} = 0.75891 g/cm^3 \qquad p_{\mu,\tau} = 0.7490 g/cm^3 \qquad p_{\mu,\tau} = 0.73062 g/cm^3 \qquad p_{\mu,\tau} = 0.71628 g/cm^3 \\ 1.0 1.0000 1.0 1.0000 1.0 1.0000 1.0 1.$							4000.3	0.015
$p_{p,\tau} = 0.75891 g/cm^3 \qquad p_{p,\tau} = 0.7362 g/cm^3 \qquad p_{p,\tau} = 0.7363 g/cm^3 \qquad p_{p,\tau} = 0.7363 g/cm^3 \qquad p_{p,\tau} = 0.7364 g/c^3 \qquad 0.865 \qquad 0.8973 \qquad 0.486 \qquad 0.865 \qquad 0.8973 \qquad 0.9960 \qquad 0.65 \qquad 0.8973 \qquad 0.9960 \qquad 0.65 \qquad 0.8973 \qquad 0.9960 \qquad 0.65$			0.5000 1 6 1				4244.0	0.8150
$ p_{a,T} = 0.7937 g(-m)^{-1} p_{a,T} = 0.7908 g(-m)^{-1}$	0 759	$201  \mathrm{g/cm^3}$		n mixture of n	-dodecane and n-	nexadecane	o = - 0 71	528 g/cm <sup>3</sup>
1,0       1.0000       1.0       1.0000       1.0       1.0000       1.0       1.00       1.00         17.6       0.9994       18.1       0.9977       17.2       0.9985       36.4       0.99         17.6       0.9925       137.8       0.98       0.9901       66.7       0.9925       137.8       0.98         13.7       0.9885       135.1       0.9664       97.1       0.9968       403.8       0.57         13.9       0.9831       339.2       0.9707       268.5       0.9790       616.8       0.94         23.2       0.9608       410.0       0.9562       307.9       0.9700       616.8       0.94         23.2       0.9608       410.0       0.9561       617.5       0.9470       92.1       0.92         24.6       0.9772       618.8       0.9966       409.3       0.9470       92.1       0.92         11.3       0.9664       784.3       0.9439       924.4       0.9297       113.4       0.91         11.3       0.9664       784.3       0.9439       924.4       0.9297       113.4       0.91         16.7       0.9964       79.3       0.9671       130.6       0.9	$\rho_{o,T} = 0.756$	par B\cius	$\rho_{o,T} = 0.74$	490 g/ciri*	$\rho_{o,T} \simeq 0.75$		$p_{o,T} = 0.71$	1 0000
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	1.0	1.0000	1.0	1.0000	1.0	1.0000	1.0	1.0000
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	17.6	0.9984	18.1	0.9977	17.2	0.9985	36.4	0.9953
84,7 0.9926 93.7 0.9901 66.7 0.9925 137.8 0.990 135,7 0.9885 135.1 0.9864 97.1 0.9895 205.8 0.97 175.9 0.9851 275.2 0.9756 137.1 0.9858 403.8 0.95 105.1 0.9831 333.2 0.9707 205.5 0.9786 517.5 0.94 171.1 0.9783 448.1 0.9596 409.3 0.9617 718.9 0.93 180.6 0.9757 548.8 0.9661 515.4 0.9541 825.0 0.92 180.6 0.9707 648.9 0.9476 812.1 0.9354 1018.3 0.92 181.3 0.9664 754.3 0.9439 924.4 0.9297 1134.0 0.91 146.7 0.9664 822.3 0.9407 1018.3 0.9297 1134.0 0.91 146.7 0.9664 822.3 0.9400 1013.3 0.9247 1018.3 0.929 180.0 0.9707 648.9 0.9367 1130.6 0.9188 1365.4 0.98 180.7 0.9664 822.3 0.9400 1013.3 0.9224 1227.9 0.90 180.7 0.9664 829.0 0.9367 1130.6 0.9188 1365.4 0.98 180.7 0.9664 829.0 0.9322 1221.7 0.9146 1497.3 0.89 150.1 0.9662 958.4 0.9332 1221.7 0.9146 1497.3 0.89 150.1 0.9662 958.4 0.9332 1261.7 0.9033 1646.4 0.88 1802.9 0.9273 1489.0 0.9032 1770.2 0.88 1802.9 0.9273 1489.0 0.9032 1770.2 0.88 1805.9 0.933 2046 1640.2 0.8937 2045.1 0.87 1255.8 0.9242 1640.2 0.8937 2045.1 0.87 2664.3 0.65 2166.9 0.8798 2443.8 0.68 2664.3 0.65 2166.9 0.8798 2443.8 0.68 2664.3 0.65 2057 0.48 Mixture of 0.6000 mole fraction κ-decane and 0.2000 mole fraction each κ-tetradecane and <i>n</i> -hexadecane $\rho_{n.7} = 0.74503 g/cm^3 \rho_{n.7} = 0.73048 g/cm^3 \rho_{n.7} = 0.71571 g/cm^3 \rho_{n.7} = 0.70085 g/cm 10 1.0 1.0000 1.0 1.0000 1.0 1.0000 1.0 1.$	72.6	0.9934	85.9	0.9912	35.0	0.9961	97.6	0.9879
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	84.7	0.9926	98.7	0.9901	68.7	0.9925	137.8	0.9835
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	135.7	0.9885	135.1	0.9864	97.1	0.9896	205.8	0.9763
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	175 9	0.0000	275.2	0 9756	127 1	0 9858	403.8	0.9579
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	205 1	0.3031	220 2	0.0707	200 5	0.0000	50.0 517 5	n 0/90
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	205.1	0.9831	559.2	0.9/0/	208.0	0.9760	517.5	0.9403
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	239.2	0.9808	410.0	0.9652	307.9	0.9/00	610.8	0.9414
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	271.1	0.9783	484.1	0.9596	409.3	0.9617	718.9	0.9347
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	308.6	0.9757	548.8	0.9561	515.4	0.9541	825.0	0.9281
	344.6	0.9732	618.9	0.9518	617.5	0.9470	929.1	0.9222
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	380.0	0.9707	684.9	0,9476	812.1	0.9354	1018.3	0.9173
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	411 3	0 9684	754 3	0 9439	924 4	0 9297	1134.0	0.9118
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	116 7	0.0664	822.3	0.0400	1018 3	0.0248	1227 0	0 9069
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	490.7	0.9004	022.3	0.0007	1120 0	0.0240	1260.4	0.000
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	480.7	0.9641	889.0	0.9307	1130.6	0.9188	1309.4	0.9000
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	512.0	0.9625	958.4	0.9332	1221.7	0.9146	1497.3	0.8952
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	550.1	0.9602	1019.6	0.9302	1368.7	0.9083	1646.4	0.8891
$\begin{array}{cccccccccccccccccccccccccccccccccccc$			1082.9	0.9273	1498.0	0.9032	1770.2	0.8844
$\begin{array}{cccccccccccccccccccccccccccccccccccc$			1159.8	0.9240	1640.2	0,8979	1913.8	0.8796
$\begin{array}{c c c c c c c c c c c c c c c c c c c $			1225.8	0.9212	1753.2	0.8937	2045.1	0.8751
$\begin{array}{c c c c c c c c c c c c c c c c c c c $					1971.6	0.8862	2249.2	0.8686
$\begin{array}{c c c c c c c c c c c c c c c c c c c $					2168 9	0 8798	2443 8	0 8628
$\begin{array}{cccccccccccccccccccccccccccccccccccc$					2100.5	0,0750	2661 2	0.8571
$\begin{array}{c c c c c c c c c c c c c c c c c c c $							2004.5	0.00/1
3269.70.84Mixture of 0.6000 mole fraction a-decane and 0.2000 mole fraction each a-tetradecane and n-hexadecane $\rho_{o.T} = 0.74503 \text{ g/cm}^3$ $\rho_{o.T} = 0.73048 \text{ g/cm}^3$ $\rho_{o.T} = 0.71571 \text{ g/cm}^3$ $\rho_{o.T} = 0.7085 \text{ g/cm}^3$ 1.01.00001.01.00001.01.000016.70.998218.60.998117.80.997417.10.99735.00.9996897.50.989331.60.999740.40.99900.30.9910210.60.9793201.10.9767201.70.97437.10.9876308.60.9704308.60.9672318.80.96606.50.9819518.20.9487497.70.9513517.50.94452.10.9711723.70.9419616.10.9432624.30.93210.60.9662817.60.9369717.50.9363720.90.92272.60.9631931.90.9305926.40.9242824.40.92250.80.95731021.70.92631021.70.91331021.70.90316.80.95381130.60.92061130.60.91391129.20.90352.20.94631499.40.90521372.80.90271368.70.89263.40.93301899.50.89121763.40.88731771.90.87776.10.93022041.70.88721919.90.88171913.3<							30/6.7	0.8464
Mixture of 0.6000 mole fraction n-decane and 0.2000 mole fraction each n-tetradecane and n-hexadecane $\rho_{o,T} = 0.74503 \text{ g/cm}^3$ $\rho_{o,T} = 0.73048 \text{ g/cm}^3$ $\rho_{o,T} = 0.71571 \text{ g/cm}^3$ $\rho_{o,T} = 0.70085 \text{ g/cm}$ 1.01.00001.01.00001.01.00001.016.70.998218.60.998117.80.997417.10.99735.00.996897.50.989331.60.995740.40.99668.90.99910210.60.9793201.10.9767201.70.97437.10.9876308.60.9704308.60.9672318.80.96606.50.9819518.20.9487497.70.9513517.50.94452.10.9762618.20.9487497.70.9513517.50.94452.10.9711723.70.9419616.10.9432624.30.93210.60.9662817.60.9369717.50.9363720.90.92272.60.95331130.60.92061130.60.91391129.20.90312.20.94631499.40.90521372.80.90271368.70.88220.30.94201636.80.89981497.30.89741502.80.88221.10.93301289.50.89121763.40.88731771.90.87721.30.9305926.40.9242824.40.92252.20.94631499.40.9252 <t< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td>3269.7</td><td>0.8423</td></t<>							3269.7	0.8423
$\rho_{o.T} = 0.74303$ g/cm² $\rho_{o.T} = 0.7343$ g/cm² $\rho_{o.T} = 0.71371$ g/cm² $\rho_{o.T} = 0.7033$ g/cm²1.01.00001.01.00001.01.00001.016.70.998218.60.998117.80.997417.10.99735.00.996897.50.989331.60.995740.40.99468.90.9910210.60.9793201.10.9767201.70.9737.10.9876308.60.9704308.60.9672318.80.96506.50.9819518.20.9547411.30.9588410.60.95310.60.9762618.20.9487497.70.9513517.50.94452.10.9711723.70.9419616.10.9432624.30.93610.60.9662817.60.9369717.50.9363720.90.92272.60.9631931.90.9305926.40.9242824.40.92250.80.95731021.70.92631021.70.91331021.70.91316.80.95381130.60.92061130.60.91391129.20.90052.20.94631499.40.90521372.80.90271368.70.89420.30.94401636.80.89981497.30.89741502.80.88353.60.93561779.70.89551645.00.88171991.30.87754.40.93022041.70.8972	Mixtu 0.745	re of 0.6000 mo	le fraction n-decane	e and 0.2000 m	ole fraction each	n-tetradecane	and n-hexadecan	e 195 g /om³
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$\rho_{o,T} \equiv 0.745$	1 0000	$\rho_{o,T} \equiv 0.73$	1 0000	$\rho_{o,T} \equiv 0.713$	1 0000	$\rho_{o,T} = 0.700$	1 0000
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	1.0	T.0000	1.0	1.0000	1.0	1,0000	1.U	1.0000
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	10./	0.9982	18.6	0.9981	1/.8	0.99/4	1/.1	0.99/6
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	35.0	0.9968	97.5	0.9893	31.6	0.9957	40.4	0.9944
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	68.9	0.9931	137.8	0.9860	68.2	0.9912	67.8	0.9906
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	100.3	0.9910	210.6	0.9793	201.1	0.9767	201.7	0.9745
106.5       0.9819       518.2       0.9547       411.3       0.9588       410.6       0.955         175.9       0.9762       618.2       0.9487       497.7       0.9513       517.5       0.944         152.1       0.9711       723.7       0.9419       616.1       0.9432       624.3       0.936         10.6       0.9662       817.6       0.9369       717.5       0.9363       720.9       0.922         10.6       0.9631       931.9       0.9305       926.4       0.9242       824.4       0.923         10.8       0.9573       1021.7       0.9263       1021.7       0.9193       1021.7       0.9193         16.8       0.9538       1130.6       0.9206       1130.6       0.9139       1129.2       0.903         16.8       0.9494       1225.8       0.9169       1223.1       0.9093       1232.6       0.900         52.2       0.9463       1499.4       0.9052       1372.8       0.9027       1368.7       0.894         20.3       0.9420       1636.8       0.8998       1497.3       0.8974       1502.8       0.887         125.8       0.9330       1899.5       0.8912       1763.4       <	137.1	0.9876	308.6	0.9704	308.6	0.9672	318.8	0.9622
175.9       0.9762       618.2       0.9487       497.7       0.9513       517.5       0.94         10.6       0.9662       817.6       0.9369       717.5       0.9363       720.9       0.922         10.6       0.9662       817.6       0.9305       926.4       0.9242       824.4       0.923         10.6       0.9631       931.9       0.9263       1021.7       0.9193       1021.7       0.9193         16.8       0.9573       1021.7       0.9263       1021.7       0.9193       1021.7       0.913         16.8       0.9538       1130.6       0.9206       1130.6       0.9139       1129.2       0.903         188.3       0.9494       1225.8       0.9169       1223.1       0.9093       1232.6       0.900         52.2       0.9463       1499.4       0.9052       1372.8       0.9027       1368.7       0.894         20.3       0.9420       1636.8       0.8998       1497.3       0.8974       1502.8       0.887         53.6       0.9356       1779.7       0.8955       1645.0       0.8913       1644.3       0.887         25.8       0.9330       1899.5       0.8912       1763.4	206.5	0.9819	518.2	0.9547	411.3	0.9588	410.6	0.9537
52.1       0.9711       723.7       0.9419       616.1       0.9432       624.3       0.931         10.6       0.9662       817.6       0.9369       717.5       0.9363       720.9       0.929         72.6       0.9631       931.9       0.9305       926.4       0.9242       824.4       0.921         50.8       0.9573       1021.7       0.9263       1021.7       0.9193       1021.7       0.9193         i16.8       0.9538       1130.6       0.9206       1130.6       0.9139       1129.2       0.901         i88.3       0.9494       1225.8       0.9169       1223.1       0.9093       1232.6       0.900         52.2       0.9463       1499.4       0.9052       1372.8       0.9027       1368.7       0.894         20.3       0.9420       1636.8       0.8998       1497.3       0.8974       1502.8       0.886         53.6       0.9356       1779.7       0.8955       1645.0       0.8913       1644.3       0.887         25.8       0.9330       1899.5       0.8912       1763.4       0.8873       1771.9       0.877         76.1       0.9302       2041.7       0.8872       1919.9	275 9	0 9762	618.2	0 9487	497 7	0 9513	517 5	n 9447
5.2.1       0.3711       7.2.7       0.3415       0.10.1       0.9422       0.24.3       0.931         110.6       0.9662       817.6       0.9369       717.5       0.9363       720.9       0.929         172.6       0.9631       931.9       0.9305       926.4       0.9242       824.4       0.921         150.8       0.9573       1021.7       0.9263       1021.7       0.9193       1021.7       0.9193         166.8       0.9538       1130.6       0.9206       1130.6       0.9139       1129.2       0.901         188.3       0.9494       1225.8       0.9169       1223.1       0.9093       1232.6       0.900         52.2       0.9463       1499.4       0.9052       1372.8       0.9027       1368.7       0.894         20.3       0.9420       1636.8       0.8998       1497.3       0.8974       1502.8       0.884         53.6       0.9330       1899.5       0.8912       1763.4       0.8873       1771.9       0.877         76.1       0.9302       2041.7       0.8872       1919.9       0.8817       191.3       0.877         54.4       0.9266       2039.7       0.8708       2584.0 <td>252 1</td> <td>0.5702</td> <td>722 7</td> <td>0.040</td> <td>- J/ ./ 616 1</td> <td>0.0010</td> <td>EDV 2</td> <td>0,394/</td>	252 1	0.5702	722 7	0.040	- J/ ./ 616 1	0.0010	EDV 2	0,394/
H10.6       0.9662       817.6       0.9369       717.5       0.9363       720.9       0.924         172.6       0.9631       931.9       0.9305       926.4       0.9242       824.4       0.923         150.8       0.9573       1021.7       0.9263       1021.7       0.9193       1021.7       0.9193         16.8       0.9538       1130.6       0.9206       1130.6       0.9139       1129.2       0.903         188.3       0.9494       1225.8       0.9169       1223.1       0.9093       1232.6       0.906         52.2       0.9463       1499.4       0.9052       1372.8       0.9027       1368.7       0.894         120.3       0.9420       1636.8       0.8998       1497.3       0.8974       1502.8       0.884         53.6       0.9356       1779.7       0.8955       1645.0       0.8913       1644.3       0.882         125.8       0.9300       1899.5       0.8912       1763.4       0.8873       1771.9       0.877         76.1       0.9302       2041.7       0.8872       1919.9       0.8817       191.3       0.877         54.4       0.9266       2265.6       0.8708       2584.0 <td>502.1</td> <td>0.9/11</td> <td>723.7</td> <td>0.9419</td> <td>010.1</td> <td>0.9432</td> <td>024.5</td> <td>0.9507</td>	502.1	0.9/11	723.7	0.9419	010.1	0.9432	024.5	0.9507
4/2.6       0.9631       931.9       0.9305       926.4       0.9242       824.4       0.925         550.8       0.9573       1021.7       0.9263       1021.7       0.9193       1021.7       0.9193         116.8       0.9538       1130.6       0.9206       1130.6       0.9139       1129.2       0.901         188.3       0.9494       1225.8       0.9169       1223.1       0.9093       1232.6       0.900         52.2       0.9463       1499.4       0.9052       1372.8       0.9027       1368.7       0.894         120.3       0.9420       1636.8       0.8998       1497.3       0.8974       1502.8       0.882         153.6       0.9356       1779.7       0.8955       1645.0       0.8913       1644.3       0.887         125.8       0.9330       1899.5       0.8912       1763.4       0.8873       1771.9       0.877         76.1       0.9302       2041.7       0.8872       1919.9       0.8817       1991.3       0.877         54.4       0.9266       2265.6       0.8708       2584.0       0.855	410.6	0.9662	81/.0	0.9369	/1/.5	0.9363	/20.9	0.9296
i50.8       0.9573       1021.7       0.9263       1021.7       0.9193       1021.7       0.9193         i16.8       0.9538       1130.6       0.9206       1130.6       0.9139       1129.2       0.909         i88.3       0.9494       1225.8       0.9169       1223.1       0.9093       1232.6       0.900         i52.2       0.9463       1499.4       0.9052       1372.8       0.9027       1368.7       0.894         i20.3       0.9420       1636.8       0.8998       1497.3       0.8974       1502.8       0.886         i53.6       0.9356       1779.7       0.8955       1645.0       0.8913       1644.3       0.887         i25.8       0.9330       1899.5       0.8912       1763.4       0.8873       1771.9       0.877         i76.1       0.9302       2041.7       0.8872       1919.9       0.8817       1991.3       0.877         i54.4       0.9266       2039.7       0.8708       2584.0       0.855	4/2.0	0.9631	931.9	0.9305	926.4	0.9242	824.4	0.9231
116.8       0.9538       1130.6       0.9206       1130.6       0.9139       1129.2       0.909         188.3       0.9494       1225.8       0.9169       1223.1       0.9093       1232.6       0.909         52.2       0.9463       1499.4       0.9052       1372.8       0.9027       1368.7       0.894         120.3       0.9420       1636.8       0.8998       1497.3       0.8974       1502.8       0.886         153.6       0.9356       1779.7       0.8955       1645.0       0.8913       1644.3       0.887         125.8       0.9330       1899.5       0.8912       1763.4       0.8873       1771.9       0.877         176.1       0.9302       2041.7       0.8872       1919.9       0.8817       1991.3       0.877         54.4       0.9266       2039.7       0.8708       2584.0       0.852	550.8	0.9573	1021.7	0.9263	1021.7	0.9193	1021.7	0.9117
588.3       0.9494       1225.8       0.9169       1223.1       0.9093       1232.6       0.90         '52.2       0.9463       1499.4       0.9052       1372.8       0.9027       1368.7       0.89         '20.3       0.9420       1636.8       0.8998       1497.3       0.8974       1502.8       0.88         '53.6       0.9356       1779.7       0.8955       1645.0       0.8913       1644.3       0.887         '25.8       0.9300       1899.5       0.8912       1763.4       0.8873       1771.9       0.877         '76.1       0.9302       2041.7       0.8872       1919.9       0.8817       1991.3       0.877         '54.4       0.9266       2039.7       0.8708       2584.0       0.857	616.8	0.9538	1130.6	0.9206	1130.6	0.9139	1129.2	0.9058
752.2       0.9463       1499.4       0.9052       1372.8       0.9027       1368.7       0.894         120.3       0.9420       1636.8       0.8998       1497.3       0.8974       1502.8       0.886         153.6       0.9356       1779.7       0.8955       1645.0       0.8913       1644.3       0.887         120.3       0.9330       1899.5       0.8912       1763.4       0.8873       1771.9       0.877         176.1       0.9302       2041.7       0.8872       1919.9       0.8817       1991.3       0.870         54.4       0.9266       2039.7       0.8708       2584.0       0.857	688.3	0.9494	1225.8	0.9169	1223.1	0.9093	1232.6	0.9009
320.3       0.9420       1636.8       0.8998       1497.3       0.8974       1502.8       0.887         553.6       0.9356       1779.7       0.8955       1645.0       0.8913       1644.3       0.887         125.8       0.9330       1899.5       0.8912       1763.4       0.8873       1771.9       0.877         176.1       0.9302       2041.7       0.8872       1919.9       0.8817       1991.3       0.870         54.4       0.9266       2039.7       0.8708       2584.0       0.857	752.2	0.9463	1499.4	0.9052	1372.8	0.9027	1368.7	0.8944
10110         101100         101100         101100	820.3	0.9420	1636.8	0.8998	1497 3	0.8974	1502 8	0.8885
1013         1013         1014 <th< td=""><td>953 6</td><td>0 0356</td><td>1770 7</td><td>0 8055</td><td>16/15 0</td><td>0 2012</td><td>16// 2</td><td>n 2227</td></th<>	953 6	0 0356	1770 7	0 8055	16/15 0	0 2012	16// 2	n 2227
725.0       0.5350       1695.5       0.8912       1765.4       0.8873       1771.9       0.877         176.1       0.9302       2041.7       0.8872       1919.9       0.8817       1991.3       0.870         54.4       0.9266       2039.7       0.8708       2584.0       0.857         2265.6       0.8708       2584.0       0.857	1025.9	0.000	1000 5	0.0500	1762 4	0.0113	1771 0	0.002/
1/6.1         0.9302         2041.7         0.88/2         1919.9         0.8817         1991.3         0.87           .54.4         0.9266         2039.7         0.8777         2178.5         0.86           .2265.6         0.8708         2584.0         0.852	1020.0	0,9330	2011 -	0.8912	1/03.4	0.88/3	1//1.9	0.8//8
.54.4         0.9266         2039.7         0.8777         2178.5         0.860           2265.6         0.8708         2584.0         0.857	10/6.1	0.9302	2041.7	0.8872	1919.9	U.8817	1991.3	0.8700
2265.6 0.8708 2584.0 0.852	1154.4	0.9266			2039.7	0.8777	2178.5	0.8637
					2265.6	0.8708	2584.0	0.8521
2450.7 0.8659 2794.3 0.846					2450.7	0.8659	2794.3	0.8463
2663.0 0.8595 2939.6 0.84					2663.0	0.8595	2939.6	0.8415
2881 4 n.9544 2196 0 n.927					2881 /	0 8544	2126 0	0.0110
					2001.4	0.0044	320C 3	0.0000
					2301.4	0.0010	3360.3	0.0521

 $(v_o - v_i)/v_o$ . The compression  $(v_o - v_i)/v_o$  is defined by Equation 1. No smoothing of the data has been done in Table 1.

**Representation of experimental data by Tait equation.** An empirical equation usually known as the "Tait" equation has been used to represent the PVT behavior for a number of liquids (2, 3, 8-11, 14, 17, 19-21, 23-25). The "usual" Tait equation has been commonly written as

$$v_i = v_o - J \ln \left[ (P_i + L) / (P_o + L) \right]$$
 (2)

where  $v_o = v_o$  ( $P_o$ ), a reference volume, the parameters J and L are taken pressure-independent. Macdonald (16) suggested that Equation 2 is better written in the form involving two physical quantities,  $K_o$  and  $K_o'$ , where  $K_o$  is the bulk modulus at reference pressure.  $K_o = K|_{P=P(o)}$ , and  $K_o' = (\partial K/\partial P)_T|_{P=P(o)}$ . This form of the UTE may be written in terms of the relative volume as

$$\bar{v}_i = 1 - 1/(K_o' + 1) \ln [1 + (K_o' + 1)(P_i - P_o)/K_o]$$
 (3)

where  $\bar{v}_i$  is the relative volume at pressure  $P_i$ .

The two parameters,  $K_o$  and  $K_o'$ , were evaluated from the experimental PVT data on each of the mixtures for each of the isotherms by a new generalized least-squares regression technique (1, 7). The results are shown in Table II. The pure component data tabulated in ref. 24 were reevaluated by this new technique. The best-fit values for  $K_o$  and  $K_o'$  are also reported in Table II. The worst deviation of any data point from the smooth curve was  $0.0011 \text{ cm}^3/\text{cm}^3$ .

The curves shown in Figure 2 are the results by using Equation 3 with the parameters as given in Table II. The raw experimental data for the 0.5000 mole fraction *n*-decane and *n*-tetradecane mixture are also shown. In order to see the difference in the fit of Equation 3 to the experimental mixture PVT data, it was necessary to plot differences in compression as a function of pressure at constant temperature. Figure 3 presents such a representative plot for the 0.5000 mole fraction *n*-dodecane and *n*-hexadecane mixture at 85.00°C.

The original Tait equation (13),  $(v_o - v)/v_o = AP/(B + P)$ , and the equation referred to by Macdonald as 3BE (16), a series expansion of  $\bar{v}_i$  in terms of  $(P - P_o)$  up to third degree, were also tested. However, neither the pure component nor the mixture data were represented as well as with Equation 3, even though only two parameters are required by Equation 3.

**Experimental excess volumes.** The excess volume at any temperature, pressure, and composition is defined as

$$V^{E}(T, P, x) = V_{m}(T, P, x) - \sum x_{i}V_{i}(T, P)$$
(4)

where  $V_m$  is the molar volume of the mixture, and  $V_i$  and  $x_i$  are the molar volume and mole fraction of the *i*th component, respectively. The molar volumes of the three mixtures and the four pure components are calculated by

#### Table II. Compression Parameters Ko and Ko'

	Temp, °C				
System	25.00	45.00	65.00	85.00	
$C_{10}$ $K_{o} =$	9161 ± 23	7825 ± 31	6778 ± 27	6002 ± 24	
$\kappa_{o'} =$	$10.4~\pm~0.05$	$10.5~\pm~0.06$	10.4 $\pm$ 0.05	$10.3\pm$ 0.04	
C12	10701 $\pm$ 100	$8885~\pm~26$	$8008~\pm~58$	$6595~\pm~25$	
	$9.3\pm0.2$	10.4 $\pm$ 0.06	$10.1~\pm~0.1$	$10.5~\pm~0.05$	
C14	11114 ± 235	9751 $\pm$ 84	$8632~\pm~22$	7512 $\pm$ 22	
	$9.0~\pm~1.1$	$9.9\pm0.6$	10.0 $\pm$ 0.04	$10.1~\pm~0.04$	
C <sub>16</sub>	(8735 ± 426) <sup>a</sup>	10264 $\pm$ 176	9215 $\pm$ 65	$8058~\pm~65$	
	$(31.0 \pm 6.7)^a$	10.9 $\pm$ 0.6	$10.0~\pm~0.1$	$10.1 \pm 0.1$	
$C_{10} + C_{14}$	11604 $\pm$ 164	8932 ± 75	$7908~\pm~38$	$6703 \pm 42$	
	7.6 $\pm$ 0.4	$10.3 \pm 0.2$	$10.1 \pm 0.07$	$10.5 \pm 0.07$	
$C_{12} + C_{16}$	10781 $\pm$ 88	9140 $\pm$ 87	$8619 \pm 40$	7441 $\pm$ 15	
	$11.0~\pm~0.5$	$10.8\pm0.3$	$10.1~\pm~0.08$	$10.3\pm0.03$	
$C_{10} + C_{14} +$	$10115 \pm 105$	8718 ± 54	$7640 \pm 42$	$6722~\pm~18$	
C <sub>16</sub>	$10.3 \pm 0.3$	10.6 $\pm$ 0.1	$10.5~\pm~0.08$	$10.3\pm0.03$	

<sup>a</sup> Pressure range of data insufficient to accurately determine parameters.



Figure 2. Compression results for decane-tetradecane equimolar mixture curves are calculated from Equation 3 by using parameters listed in Table II

Figure 3. Difference between calculated (Equation 3) and experimental compression for dodecane-hexadecane equimolar mixture at 85°C

Table III.	Experimental	Excess Vo	lumes
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	25°C	45°C					
P, atm	V <sup>E</sup> , cc/mol	P, atm	V <sup>E</sup> , cc/mol				
$C_{10} + C_{14} (x_1 = 0.5000)$							
1	$-0.04 \pm 0.04$	1	$-0.10 \pm 0.04$				
100	$0.16~\pm~0.04$	400	$0.00 \pm 0.05$				
300	$0.42 \pm 0.05$	800	$0.07~\pm~0.06$				
500	$0.54 \pm 0.05$	1200	$0.13 \pm 0.08$				
600	$0.58~\pm~0.06$	1600	$0.18~\pm~0.09$				
	65°C		85°C				
1	$-0.09 \pm 0.04$	1	$-0.09 \pm 0.04$				
700	$0.10 \pm 0.06$	1000	$-0.07 \pm 0.07$				
1300	$0.12 \pm 0.09$	2000	$0.08 \pm 0.09$				
1900	$0.12 \pm 0.09$	3000	$0.21 \pm 0.11$				
2400	$0.11~\pm~0.11$	3600	$0.28 \pm 0.12$				
$C_{12} + C_{16} (x_1 = 0.5000)$							
	45°C		65°C				
1	$-0.03 \pm 0.04$	1	$-0.06 \pm 0.04$				
200	$-0.12 \pm 0.04$	500	$-0.09 \pm 0.05$				
500	$-0.18 \pm 0.05$	1000	$-0.11 \pm 0.07$				
800	$-0.21 \pm 0.06$	1500	$-0.12 \pm 0.09$				
1000	$-0.21 \pm 0.07$	2000	$-0.13 \pm 0.09$				
1	$-0.06 \pm 0.04$						
800	$0.10 \pm 0.06$						
1600	$0.14 \pm 0.09$						
2400	$0.16 \pm 0.10$						
2900	$0.1/\pm 0.11$						
$C_{10} + C_{14} + C_{16}$ (x <sub>1</sub> = 0.6000, x <sub>2</sub> = 0.2000)							
	45°C		65°C				
1	$-0.11\pm0.04$	1	$-0.16 \pm 0.04$				
200	$-0.13 \pm 0.04$	500	$-0.18 \pm 0.05$				
500	$-0.14 \pm 0.05$	1000	$-0.15 \pm 0.07$				
800	$-0.13 \pm 0.06$	1500	$-0.11 \pm 0.09$				
1000	$-0.13 \pm 0.07$	2000	$-0.07 \pm 0.09$				
	85°C						
1	$-0.20 \pm 0.04$						
800	$-0.24 \pm 0.06$						
1600	$-0.22 \pm 0.09$						
2400	$-0.19 \pm 0.10$						
2900	$-0.17 \pm 0.11$						

using Equation 3 with the parameters as given in Table II, the standard molecular weights, and the densities at pressure  $P_o$  (1 atm).

The experimental excess volumes of the two binary mixtures and one ternary mixture at five characteristic pressures are presented in Table III. The experimental uncertainties in the calculated excess volumes are also reported.

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#### Nomenclature

 $A_{P,T}$  = cross-sectional area of the sylphon-bellows, cm<sup>2</sup>

J = coefficient in Equation 2, cm<sup>3</sup>/g

K = isothermal bulk modulus, atm

 $K_o$  = isothermal bulk modulus at  $P = P_o$ , atm

 $K_o' = (\partial K / \partial P)_T |_{P = P(o)}$ , dimensionless

L = coefficient in Equation 2, atm

 $\Delta L_B$  = change in length of the sylphon-bellows as a function of P and T, cm

 $P_o$  = atmospheric pressure. atm

 $P_i$  = pressure. atm

 $t = \text{temperature}, ^{\circ}\text{C}$ 

T = temperature, K

- $v_o = \text{atmospheric pressure specific volume, cm}^3/q$
- $v_i$  = specific volume at *i*th pressure, cm<sup>3</sup>/g

 $\bar{v}_i$  = relative volume at *i*th pressure, dimensionless

 $V_i$  = molar volume of *i*th component, cc/mol

 $V_{\underline{m}}$  = molar volume of mixture, cc/mol

 $V^E$  = excess volume. cc/mol

x = mole fraction

 $W_{vc}$  = vacuum corrected weight of sample in bellows, grams

 $\rho_{o,T}$  = atmospheric pressure density at temperature T, g/cm<sup>3</sup>

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