

DENSITY OF DIHEPTYL ETHER IN THE LIQUID PHASE

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The results of an experimental investigation of the P-ρ-T-dependence of liquid diheptyl ether in the ranges of temperatures 293-553 K and pressures 0.1-98 MPa are presented.

Diheptyl ether in the liquid phase is used widely in organic synthesis and in the chemical industry for extracting aqueous solutions of salts as well as solvents of grease and varnish. It should be noted that the efficiency of large industrial installations producing ethers and using them as a raw material and a solvent as well as the efficiency of technological processes increase sharply if the process develops at high temperatures and elevated pressures. Therefore, scientifically justified designs of such economically feasible large-tonnage installations require the knowledge of reliable data on a complex of thermophysical properties of the original substances in wide temperature and pressure ranges.

Despite the extended application of diheptyl ether, its density has not received sufficient study. We investigated the P-ρ-T-dependence of liquid diheptyl ether in the temperature range from 293 to 553 K and the pressure range from 0.1 to 98 MPa.

Measurements were carried out on an improved experimental setup by the method of hydrostatic weighing [1]. The temperature was determined by a PTS-10 type standard resistance thermometer of the 1st category with application of a U309 potentiometric installation; the pressure was determined by an MP-2500 type manometer with the accuracy rating 0.05.

Special attention was paid to finding the constants of the elements of a suspending system [2]. The overall relative error in measuring the density with the confidence coefficient $\alpha = 0.95$ amounts to 0.1%. The density was measured from the isotherms with a step in pressure of 5-10 MPa and in temperature of 20-25 K. Earlier the diheptyl ether density was investigated only at room temperature [3]. Our data coincide with the data of [3] within uncertainty of the experiment (Table 1).

According to the results of analysis, to analytically describe the data obtained for the density use is made of the equation of state in the form of the Tait equation

$$\frac{\rho - \rho_0}{\rho} = A \ln \left[\frac{B + P}{B + P_0} \right], \quad (1)$$

where ρ_0 is the density at $P = 4.91$ MPa and different temperatures; ρ is the density at the pressure and temperature of the experiment; P is the pressure of the experiment; A and B are coefficients of the equation, which are the functions of temperature:

$$A = \sum_{i=0}^2 a_i T^i \quad \text{and} \quad B = \sum_{i=0}^2 b_i T^i. \quad (2)$$

Moreover, we generalized the equation of state for the object investigated. This equation will be given below.

Using the experimental data obtained at different temperatures and pressures, we plotted the lines $T = \text{const}$ in the plane $(P/\rho^2, \rho^6)$. These lines turned out to be straight in the entire range of pressures (see Fig. 1). The equation of these straight lines has the form [4, 5]

$$P = C\rho^2 + D\rho^8. \quad (3)$$

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TABLE 1. Density ρ , kg/m^3 , of Diheptyl Ether as a Function of the Temperature T, K, and Pressure P, MPa

T, K	Pressure P, MPa											
	0.101	4.91	9.81	19.62	29.43	39.24	49.05	58.86	68.81	78.48	88.29	98.10
293	798.5	802.9	807.8	811.4	814.2	817.3	823.4	827.6	835.2	839.9	848.2	854.2
313	782.3	788.5	793.2	798.1	801.2	805.1	812.4	816.8	829.3	831.2	839.2	844.5
333	765.4	774.4	778.3	783.4	786.4	792.3	800.0	805.6	819.2	820.0	828.9	835.1
353	748.3	758.2	763.5	769.2	773.9	780.2	787.9	795.1	809.4	811.1	820.3	825.2
373	731.3	734.4	748.9	755.1	760.2	767.6	776.9	784.8	793.8	801.2	810.8	835.4
393	714.2	729.3	733.4	740.2	746.5	755.5	764.3	773.5	782.6	790.9	800.7	806.6
413	697.6	715.2	719.0	726.2	733.4	749.2	752.4	762.8	772.4	781.2	790.4	796.5
433	680.5	700.0	704.5	711.5	720.3	730.6	740.6	751.4	761.9	771.2	780.8	787.2
453	663.9	685.2	689.6	697.3	707.6	718.5	729.2	740.6	751.2	761.5	771.3	777.8
473	646.4	670.5	684.7	682.4	693.4	706.3	717.4	730.0	740.4	751.9	761.5	767.9
493	630.1	656.2	660.1	668.9	680.2	693.2	705.4	719.4	730.0	742.2	751.8	758.9
513	613.4	641.5	645.0	654.6	666.6	681.4	693.8	709.2	719.2	731.4	741.4	749.1
533	596.2	627.6	680.0	639.2	652.3	669.1	682.1	698.4	708.5	722.1	731.3	739.5
553	578.9	613.3	615.0	625.4	639.4	657.9	670.2	688.2	698.2	712.4	721.5	730.1

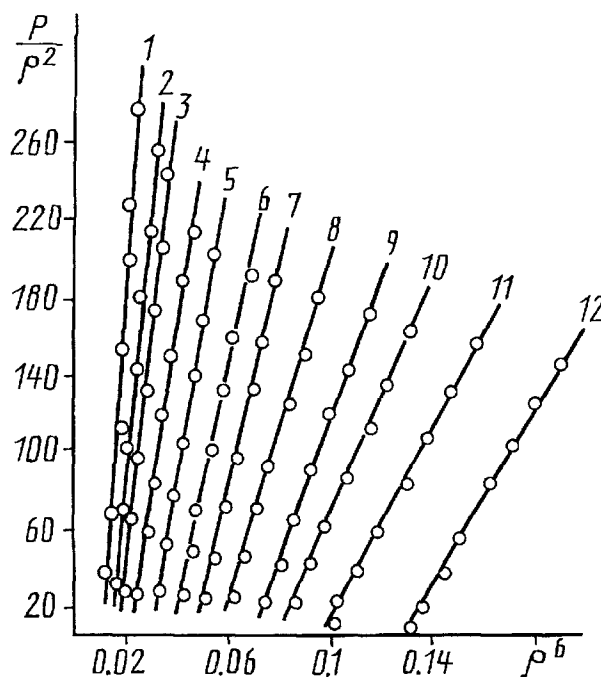


Fig. 1. P/ρ^2 vs ρ^6 for diheptyl ether at the values of T, K: 1) 293; 2) 313; 3) 335; 4) 373; 5) 393; 6) 413; 7) 433; 8) 453; 9) 473; 10) 513; 11) 533; 12) 553.

Analysis of the coefficients C and D showed that they are functions of temperature, i.e., $C = f_1(T)$, $D = f_2(T)$. Knowing the functions $f_1(T)$ and $f_2(T)$, it is possible to calculate from Eq. (3) the density of diheptyl ether in wide temperature and pressure ranges. The coefficients C, D and T are third-degree polynomials:

$$C = \sum_{i=0}^3 c_i T^i; \quad D = \sum_{i=0}^3 d_i T^i. \quad (4)$$

The values of the coefficients c_i and d_i were found by the least-squares method (see Table 2). From Eqs. (1)-(4) we obtain the final generalized equations for the state of liquid diheptyl ether

TABLE 2. Values of the Coefficients a_i , b_i , c_i and d_i of Eqs. (5) and (6) for Liquid Diheptyl Ether

$a_i(T)$	$b_i(T)$	$c_i(T)$	$d_i(T)$
0.0604	5.46	7.639	$-2.799 \cdot 10^{-16}$
-2.28	-17600	-0.0403	$2.424 \cdot 10^{-18}$
2.30	15.0	$-2.745 \cdot 10^{-5}$	$-7.1667 \cdot 10^{-21}$
		$9.2126 \cdot 10^{-8}$	$-8.009 \cdot 10^{-24}$

$$\rho = \frac{\rho_0}{1 - \sum_{i=0}^2 a_i T^i \ln \left[\frac{\sum_{i=0}^2 b_i T^i + P}{\sum_{i=0}^2 b_i T^i + P_0} \right]}, \quad (5)$$

$$P = \sum_{i=0}^3 c_i T^i \rho^2 + \sum_{i=0}^3 d_i T^i \rho^8. \quad (6)$$

The temperature dependence of a_i , b_i , c_i and d_i is given in Table 2. The mean relative difference between experimental data and those calculated from Eqs. (5) and (6) amounts to 0.14% at a maximum discrepancy of 0.36%.

Using equation of state (6), we calculated the coefficients of volumetric expansion, isothermal compressibility and internal pressure as well as the difference of heat capacities, the thermal pressure and the speed of sound propagation in diheptyl ether.

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