EXPERIMENTAL STUDY OF THE THERMAL CONDUCTIVITY OF DIHEPTYL ADIPINATE AT HIGH TEMPERATURES AND PRESSURES

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Experimental data is presented on the thermal conductivity of diheptyl adipinate in a broad range of temperatures and pressures.

Reliable data on the thermal conductivity of organic acid esters in a broad range of state parameters is needed to develop technical specifications and to design equipment for the petrochemical industry for the production of these substances and their derivatives.

Experimental studies of the thermal conductivity of liquids at high temperatures and pressures involve technical difficulties: the development of complicated special equipment is need to conduct such experiments.

The present article, being a continuation of the studies [1-4], reports results of an experimental study of the thermal conductivity of diheptyl adipinate at temperatures from room temperature to 600°K and pressures up to 98 MPa. The main characteristics of diheptyl adipinate are as follows: content of the main component 98.2%; molecular weight 342; density 928.8 kg/m^3; boiling point 595°K. Measurements were made by the method of monotonic heating [5] on a new design of cylindrical bicalorimeter.

The theory behind the method and the method itself are explained in detail in [6-8].

TABLE 1. Experimental Values of the Thermal Conductivity $\lambda \cdot 10^4$, W/(m·K), of Diheptyl Adipinate in Relation to Temperature and Pressure

T, °K	P, MPa					
	0,098	19,6	39,2	58,8	78,4	98,0
295,1	1538	1626	1699	1763	1829	1891
305,0	1526	1615	1690	1756	1822	1886
315,9	1503	1591	1672	1735	1807	1875
326,5	1484	1577	1660	1728	1794	1860
337,6	1471	1566	1637	1709	1787	1852
348,2	1452	1543	1622	1695	1774	1839
360,0	1431	1520	1606	1687	1768	1828
372,3	1412	1511	1594	1672	1740	1818
384,8	1387	1486	1569	1651	1738	1811
394,9	1370	1474	1562	1645	1718	1792
404,5	1359	1462	1540	1624	1714	1792
414,0	1340	1439	1533	1611	1698	1774
425,4	1317	1426	1512	1604	1692	1761
436,9	1306	1402	1503	1580	1673	1750
448,1	1280	1393	1481	1574	1671	1749
458,8	1258	1369	1470	1556	1648	1831
470,3	1243	1356	1447	1549	1645	1726
482,6	1228	1331	1435	1526	1624	1707
493,1	1204	1320	1414	1517	1618	1704
503,5	1185	1296	1406	1499	1600	1688
514,7	1173	1289	1383	1482	1594	1688
524,4	1149	1264	1376	1478	1575	1669
534,8	1132	1257	1350	1454	1571	1665
545,3	1116	1234	1344	1452	1554	1649
556,6	1104	1225	1320	1428	1550	1638
567,5	1075	1198	1314	1421	1535	1627
577,4	1060	1186	1295	1408	1524	1623
587,9	1048	1174	1284	1396	1515	1616
602,8	—	1147	1256	1372	1493	1595

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The bicalorimeter consists of two coaxially positioned cylinders. The gap between the cylinders is filled with the test liquid. The inside cylinder (core) is made of M1 copper. The working surfaces of the core were carefully ground, chrome-plated, and polished. The outside cylinder is a massive copper block into which a tube of 1Kh18N9T stainless steel has been pressed. In contrast to the previous design [7], a lens-type seal was used to maintain high pressure. The main dimensions of the bicalorimeter: inside diameter of the copper block 10.160 ± 0.005 mm, diameter of the copper core 9.130 ± 0.002 mm, length of the measurement section 80 mm.

Experimental determination of thermal conductivity amounts to measurement of the time lag of the temperature of the core relative to the temperature of the block. To determine this we used an R-345 potentiometer of the 0.001 class and a 51-SD stopwatch. The pressure was created and measured with an MP-2500 piston gauge of the 0.05 class and standard reference gauges. In calculating thermal conductivity, we introduced all of the corrections appropriate to this method [5]. No correction was made for radiation due to the lack of data on the absorption spectra of the substances measured. The calculated maximum measurement error was 2%. The reproducibility of the experimental results obtained with the same state parameters was within the 1% range. The possible effect of convection was checked by conducting a series of experiments with different core heating rates (temperature gradients). The good agreement between the measurement results was evidence of the absence of an effect of convection on the measurements.

Analysis of the experimental results obtained (Table 1) shows that the thermal conductivity of diheptyl adipinate decreases with an increase in temperature. Conversely, it increases with an increase in pressure.

Meissner's formula [9] is widely used to determine the effect of pressure on the thermal conductivity of liquids. Analysis shows [6] that it is suitable only in a limited range of state parameters. It is most expedient to describe thermal conductivity through parameters measured directly in tests, i.e., through pressure and temperature.

Analysis of the experimental data led us to the following formula for calculating the thermal conductivity of diheptyl adipinate at high pressures and temperatures:

$$\lambda = (0{,}1052 + 56{,}76\cdot 10^{-5}P) + (17{,}1\cdot 10^{-5} - 7\cdot 10^{-7}P)(T_{\mathrm{boi}} - T).$$

It is accurate to within ±1.5% in describing the experimental data within a broad range of temperatures and pressures.

NOTATION

P, pressure, MPa; T, absolute temperature, °K; T_{boi}, boiling point; λ, thermal conductivity, W/m·K.

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THERMAL DIFFUSION IN BINARY GAS MIXTURES

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The temperature dependence and the pressure dependence of the thermal diffusion coefficient as well as its dependence on the concentrations of interdiffusing components is evaluated with the aid of the (12—7, δ) model potential. The results of calculations are found to agree with experimental data within the accuracy of measurements.

Study of thermal diffusion is known to be an important way to study intermolecular interactions [1, 2]. That possibility is seriously limited, however, because of a lack of reliable experimental data. Systematic measurements of thermal diffusion in binary gas mixtures were begun only during the past five years [3-11]. The mean difference between generalized data in one such study [4] and the results of another study [5] pertaining to equimolar mixtures of monoatomic gases at 300°K temperature is ±4%, the maximum difference being ±10%. These figures must evidently be accepted as objective estimates of the error of experimental data. It therefore is not worthwhile to use for calculations the extremely unwieldy expression [12] for higher-order approximations in the Chapman—Cowling method.

In this study the thermal diffusion coefficient for binary mixtures of nonpolar gases will be calculated in the first Chapman—Cowling approximation [1, 2]. Only the results for mixtures containing helium are reported here. Those mixtures were also studied experimentally in the most systematic and thorough manner. Calculations were made using the paired model potential (12—7, δ) [13] and the Kong combining rules [14]. It has been demonstrated in earlier studies [13, 15-17] that the (12—7, δ) potential consistently describes experimental data on the second virial coefficient, the viscosity, and the thermal conductivity of nonpolar gases as well as of their mixtures at low density levels.

Since the thermal diffusion coefficient is an intricate function of concentrations, temperatures, pressures, and molecular masses of the components, the dependence on each of these influencing factors was evaluated separately.

Theoretical values and experimental values [5-7] of the thermal diffusion coefficient for molar mixtures with helium concentrations of 0.2-0.8 are compared in Table 1. The agreement is close, the mean difference being 4.7% and the maximum difference being 10.6%.

TABLE 1. Concentration Dependence of Thermal Diffusion Coefficient. Comparison of Calculations with Experimental Data [5, 6, 7] (T = 300°K, P = 0.03 MPa, x_1 — molar concentration of helium)

x_1	He—Ne		He—Ar		He—Kr		He—Xe		He—N_2		He—CH_4	
	[5]	calc.	[5]	calc.	[5]	calc.	[5]	calc.	[6]	calc.	[7]	calc.
0,20	0,277	0,290	0,316	0,320	0,344	0,332	0,355	0,340	0,293	0,262	0,246	0,250
0,50	0,316	0,336	0,396	0,411	0,442	0,440	0,471	0,462	0,370	0,363	0,311	0,317
0,80	0,367	0,405	0,531	0,577	0,620	0,650	0,699	0,723	0,503	0,554	0,423	0,440

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