CALCULATION OF THE DENSITY OF SOLUTIONS (SUNFLOWER OIL + *n*-HEXANE) OVER A WIDE RANGE OF TEMPERATURES AND PRESSURE

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We present the results from an experimental investigation of the density of the sunflower oil system as a function of the mass concentration of n-hexane in the ranges of temperatures $T = 290-520$ K and pressures $P = 0.101-98.1$ MPa. A method of hydrostatic weighing was used to measure the density of the solutions under study.

Previously, the density of sunflower oil and *n*-hexane at room temperature and atmospheric pressure was investigated in [1, 2]. We studied the density of sunflower oil as a function of the mass concentration of *n*-hexane (24.75; 50.3; 75.33%) in the ranges of temperatures $T = 290-520$ K and pressures $P = 0.101-98.1$ MPa for the first time. Within the limits of experimental error, our data coincide with those obtained by the authors of [2, 3].

The density of the solutions studied was measured by a method of hydrostatic weighing on a setup developed by K. D. Guseinov and his pupils [4]. The setup consists of the following units: a measuring instrument that is filled with a studied liquid, an air thermostat with a VLA-200 M-G-type analytical balance, an electroservo system, a system for creating and measuring pressure, a temperature measurement system, and a pumping and filling system.

The measuring instrument, consisting of two high-pressure vessels, is placed in the air thermostat. The total relative error in measuring the density for a confidence coefficient $\alpha = 0.95$ is 0.1%. We investigated experimentally the $P-\rho-T$-dependence of pure subflower oil, *n*-hexane, and solutions of the systems. We found that the density of the investigated objects decreases with and increase in temperature, but increases with a decrease of pressure.

The concentration of the sunflower oil and *n*-hexane in the solutions was determined by measuring their density in a pycnometer, as was the concentration of the initial oil and *n*-hexane. The density was measured 3 to 5 times, and the average result was adopted. The density of the solutions was determined with an error of less than 0.01%, thus making it possible to calculate the concentration of the solutions with an accuracy of from 0.03 to 0.05%.

The differential form of the Tate equation is:

$$-\left(\frac{\partial\rho}{\partial P}\right)_T = \frac{B}{A+P}. \tag{1}$$

Upon integration, Eq. (1) has the form:

$$\frac{\rho - \rho_0}{\rho} = B \ln\left[\frac{A+P}{B+P_0}\right], \tag{2}$$

where ρ_0 is the d ensity of the investigated solution at 4.91 MPa; ρ is the density of the solution at pressure P, MPa; A and B are the coefficients of the equation.

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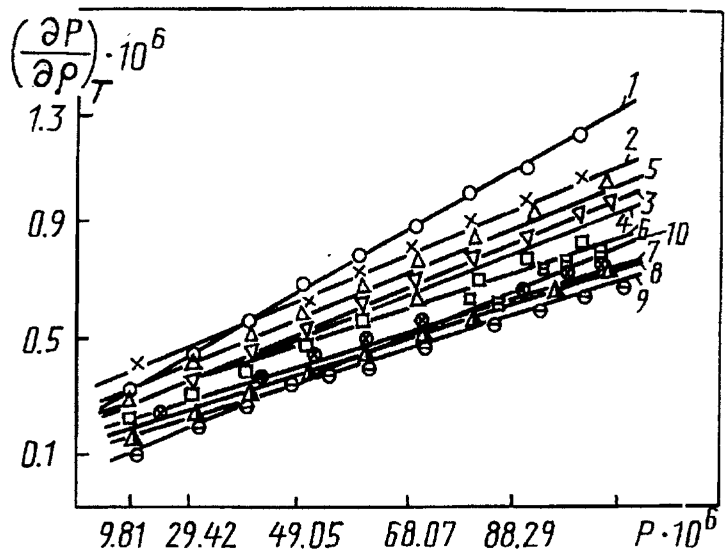

Fig. 1. Graph of $(\partial P/\partial \rho)_T = f(P)$ for a solution of 75.33% oil + 24.67% *n*-hexane: 1) 293.6 K; 2) 313.46; 3) 333.7; 4) 353.15; 5) 374.28; 6) 415.4; 7) 434.27; 8) 453.08; 9) 474.16; 10) 495.6 K. *P*, Pa.

To obtain a formula for solutions of sunflower oil + *n*-hexane, we used experimental data at different temperatures and pressures and plotted the lines T = const in the plane $[P - (\partial P/\partial \rho)_T]$:

$$\left(\frac{\partial P}{\partial \rho}\right)_T = f(P) . \tag{3}$$

The satisfaction of relation (3) for a solution of 75.33% oil + 24.67% *n*-hexane is shown in Fig. 1. As is seen from the figure, the lines T = const are straight lines and are described by the equation

$$-\left(\frac{\partial P}{\partial \rho}\right)_T = \frac{A}{B} + \frac{P}{B} , \tag{4}$$

where P is the external pressure, MPa; and ρ is the density, kg/m^3. Analysis of the coefficients A and B has shown that they are functions of temperature.

The data obtained can be represented as:

$$\frac{A}{A_1} = f\left(\frac{T}{T_1}\right) , \tag{5}$$

$$\frac{B}{B_1} = f\left(\frac{T}{T_1}\right) , \tag{6}$$

where A and B are the coefficients of the equations at T_1:T_1 = 380 K.

The satisfaction of relations (5) and (6) is shown in Figs. 2 and 3. We can see from these figures that all values of the coefficients A/A_1 and B/B_1 fall along a common straight line. The equations of these straight lines have the form:

$$A = \left(-0.54\frac{T}{T_1} + 1.49\right) A_1 , \tag{7}$$

$$B = \left(-0.98\frac{T}{T_1} + 3.23\right) B_1 . \tag{8}$$

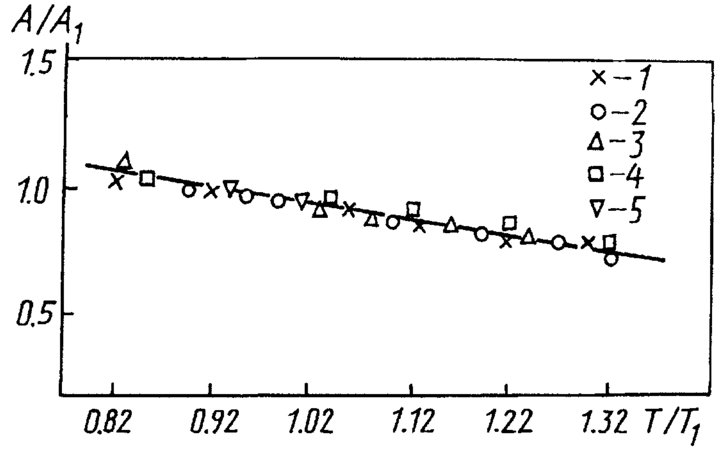

Fig. 2. Graph of $A/A_1 = f(T/T_1)$ for the investigated solutions: 1) 24.75% oil + 75.25% *n*-hexane; 2) 50.32% oil + 49.68% *n*-hexane; 3) 75.33% oil + 24.67% *n*-hexane; 4) 100% oil; 5) 25.11% oil + 74.89% *n*-hexane.

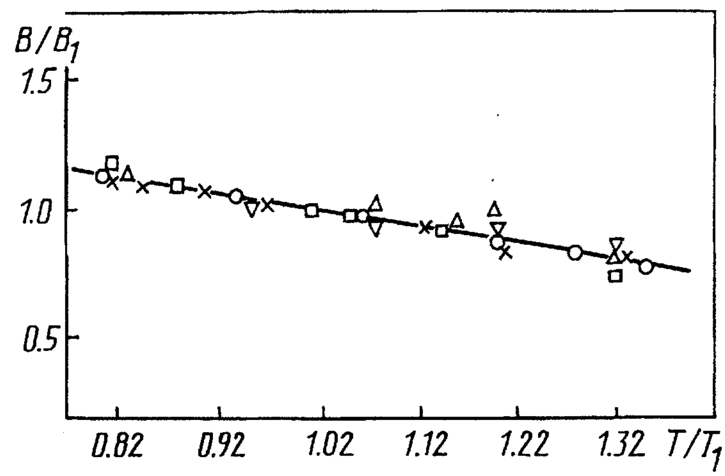

Fig. 3. Graph of $B/B_1 = f(T/T_1)$ for the investigated solutions. The symbols are the same as those of Fig. 2.

Analysis of the coefficients A_1 and B_1 has shown that they are functions of the mass concentration of *n*-hexane and oils. These curves are described by the equations

$$A_1 = (-1.34\cdot 10^2 n_{oil}^2 + 1.46\cdot 10^4 n_{oil}^4 + 2.86\cdot 10^4)\,, \tag{9}$$

$$B_1 = (7.08\cdot 10^{-7} n_{hexane}^2 - 1.02\cdot 10^{-4} n_{hexane} + 7.69\cdot 10^{-3})\,. \tag{10}$$

With allowance for Eqs. (9) and (10), we write Eqs. (7) and (8) in the form:

$$A = \left(-0.54\frac{T}{T_1} + 1.49\right)(-1.34\cdot 10^2 n_{oil}^2 + 1.46\cdot 10^4 n_{oil} + 2.86\cdot 10^4)\,, \tag{11}$$

$$B = \left(-0.98\frac{T}{T_1} + 3.23\right)(7.08\cdot 10^{-7} n_{hexane}^2 - 1.02\cdot 10^{-4} n_{hexane} + 7.69\cdot 10^{-3})\,. \tag{12}$$

Upon solving Eq. (2), we obtain

$$\rho = \frac{\rho_0}{1 - B \ln\left(\frac{P + A}{P_0 + A}\right)}. \qquad (13)$$

With allowance for Eqs. (11) and (12), Eq. (13) can be represented as

$$\rho = \frac{\rho_0}{\left(-0.98\frac{T}{T_1} + 3.23\right)(7.08 \cdot 10^{-7} n_{\text{hexane}}^2 - 1.02 \cdot 10^4 n_{\text{hexane}} + 7.69 \cdot 10^{-3})} \times \frac{1}{\ln\left[(P + D)/(P_0 + D)\right]}, \qquad (14)$$

where

$$D = \left[\left(-0.54\frac{T}{T_1} + 1.49\right)\right]\left(-1.34 \cdot 10^4 n_{\text{oil}} + 1.46 \cdot 10^4 n_{\text{oil}} + 2.86 \cdot 10^4\right).$$

Using Eq. (14), we calculated the density of sunflower oil in the ranges of temperatures T = 290–500 K and pressures P = 4.9–98.1 MPa. The error of calculation was 0.1%.

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