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# THE EQUATION OF STATE FOR SOLUTIONS OF THE SUNFLOWER OIL + ISOMERHEXANE SYSTEM

**M. M. Safarov and Z. Abdukhamidova** UDC 531.756

*The article presents the results of an experimental investigation into the density of solutions of the sunflower oil + isomerhexane system (from 23 to 75%) at temperatures of from 293 to 450 K and pressures of from 0.101 to 98.1 MPa. An equation of state is obtained.*

We investigated the density of the solutions of the sunflower oil + isomerhexane system at temperatures of from 293 to 450 K and pressures of from 0.101 to 98.1 MPa. The concentration of the solvent (isomerhexane) in the solutions was varied from 25 to 75 wt.%. The purity of the sunflower oil and isomerhexane was 96.9%; the error in the measured composition of the prepared mixture was 0.01%.

Measurements were conducted on an experimental setup by the method of hydrostatic weighing [1]. The test temperature was measured by a first-grade PTS-10-type resistance thermometer with a U309 potentiometric device; the pressure was measured by an MP-2500-type dead-weight pressure gauge.

The suspension system was calibrated by the method of hydrostatic weighing in water and hexane using a VLA-200 G-M-type analytical balance according to the procedure of [2-4]. Attention was particularly given to determining the constants of the elements of the suspension system [3].

The setup, proposed by K. D. Guseinov, is convenient and easy to use. When density is measured, all of the components have high temperatures. The total relative error in the density measurements for a confidence coefficient $\alpha = 0.95$ is 0.1%.

It is a well-known fact that density decreases with a rise in temperature, whereas it increases with a rise in pressure. As the temperature rises, the pressure effect on the density of the objects under investigation increases. Investigations have shown that, depending on the solvent concentration, the density of solutions decreases according to a linear law.

To obtain an equation of state for solutions with the use of experimental data at different temperatures and pressures, we plotted the lines $T = \text{const}$ in the $(P/\rho^2, \rho^6)$ plane. Over the entire range of pressures the lines $T = \text{const}$ appeared to be straight (Fig. 1) [5]. The equation of these straight lines has the form

$$P = A\rho^2 + B\rho^8, \tag{1}$$

where $P$ is the external pressure, MPa; $\rho$ is the density, kg/m$^3$; $A$ and $B$ are coefficients.

Analysis of the coefficients $A$ and $B$ has shown that they are functions of temperature, i.e., $A = f_1(T)$ and $B = f_2(T)$. Knowing the functions $f_1(T)$ and $f_2(T)$, we can use Eq. (1) to calculate the density of the investigated solutions in a wide range of temperatures and pressures.

Figure 2 shows coefficients $A$ and $B$ versus temperature. From this figure we can see that this dependence is described by a secon-degree equation:

$$A = \sum_{i=0}^{2} a_i T^i; \quad B = \sum_{i=0}^{2} b_i T^i. \tag{2}$$

The values of the coefficients $a$ and $b$, found by the least-squares method on a computer, are presented in Table 1.

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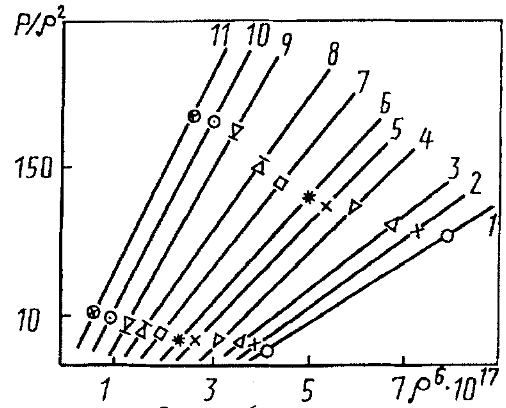


Fig. 1. Dependence of $P/\rho^2$ on $\rho^6$ of 24.36% sunflower oil + 75.64% isomerhexane solution at: 1) 292.3 K; 2) 313.7; 3) 325.4; 4) 354.3; 5) 373; 6) 390.4; 7) 418.4; 8) 443; 9) 464.2; 10) 494.9; 11) 524 K. $P/\rho^2$, Pa·$\mu^6$/kg$^2$; $\rho$, kg$^6$/m$^{18}$.

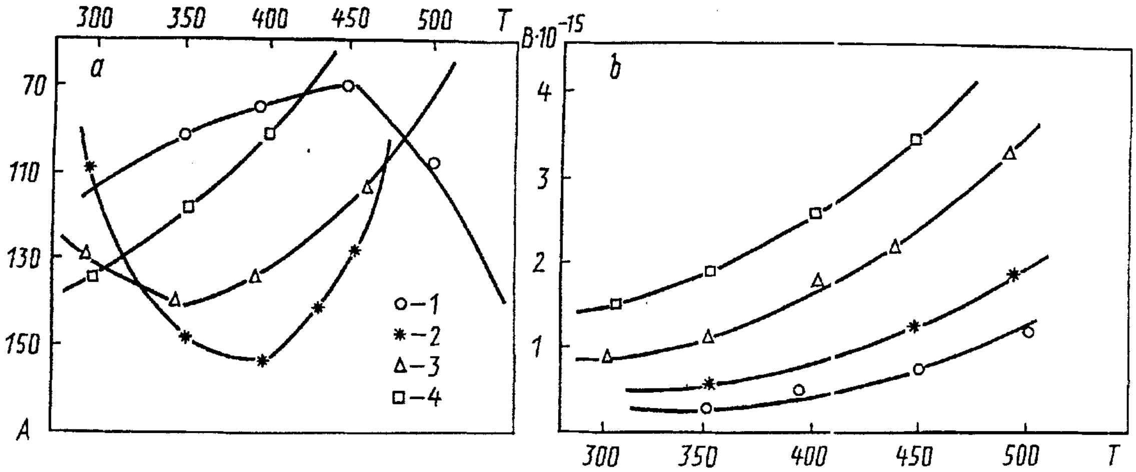


Fig. 2. Dependence of coefficients $A$ (a) and $B$ (b) on $T$: 1) 24.36% sunflower oil + 75.64% isomerhexane; 2) 76.46% sunflower oil + 23.5% isomerhexane; 3) 50.21% sunflower oil + 49.79% isomerhexane; 4) 100% isomerhexane. $A$, $B$, Pa·m$^6$/kg$^6$; $T$, K.

From relations (1) and (2) we obtain a final generalized equation of state for the solutions investigated:

$$P = \sum_{i=0}^{2} a_i T^i \rho^2 + \sum_{i=0}^{2} b_i T^i \rho^8 , \tag{3}$$

with the help of which the experimental $P$-$\rho$-$T$ data of the solutions are described with an arithmetic mean error of 0.20%.

In processing the experimental data on the density of the objects under investigation, we also employed the Tate equation. The results of calculations by this equation show that the error attains 1–5%. Thus, the resulting Eq. (3) reproduces the experimental data rather well.

Using equation of state (3), we calculated the values of the thermal properties of the solutions whose coefficient of volumetric expansion is defined by the expression:

$$\alpha_p = -\frac{1}{\rho}\left(\frac{\partial \rho}{\partial T}\right)_p = \frac{A'(T) + B'(T)\rho^6}{2A(T) + 8B(T)\rho^6} . \tag{4}$$

We now write the value of isothermal compressibility:

TABLE 1

| Coefficients | Solutions | | | |
|---|---|---|---|---|
| | Isomerhexane, 100% | Sunflower oil + 29.54% isomerhexane | Sunflower oil + 49.74% isomerhexane | Sunflower oil + 75.64% isomerhexane |

$$\beta_T = \frac{1}{P}\left(\frac{\partial \rho}{\partial T}\right)_P = \frac{1}{2\rho^2 A(T) + 8B(T)\rho^6}. \qquad (5)$$

Next, we calculate the internal pressure and the difference between heat capacities ($C_P - C_V$):

$$P_i = \frac{\alpha_P}{\beta_T} T - P, \qquad (6)$$

$$C_P - C_V = \frac{\alpha_P^2 T}{\beta_T \rho}. \qquad (7)$$

The value of the thermal pressure of the solutions is determined from the formula:

$$\gamma = \frac{1}{P}[A'(T)\rho^2 + B'(T)\rho^2]. \qquad (8)$$

The results of the investigation show that the coefficients $\alpha_p$, $\beta_T$, $C_P - C_V$ increase with a rise in temperature, and the coefficients $\alpha_p$ and $\beta_T$ increase with a rise in pressure, while $C_P - C_V$ decreases.

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