EXAMINATION OF TEMPERATURE DEPENDENCE DENSITIES OF ENERGY CARRIERS - NARROW FRACTIONS ALKYL BENZENE AT TEMPERATURES 217.15-473.150K AND ATMOSPHERIC PRESSURE

F.Q. ABDULLAEV, D.A. AGAEVA, Ju.A. DZHABIEV, D.A. DZHAFAROVA
The Azerbaijan State Oil Academy
Baku, Az . 1010, Azadliq ave., 20

Выполнено экспериментальное исследование плотности четырех удельных фракций концентратов алкилированного бензола в интервале температур от 273,15 до 473,15К при атмосферном давлении. Предлагаются четыре уравнения, показывающие температурные зависимости плотности фракций во всем исследуемом интервале температур с учетом ошибки экспериментов

The experimental research of density of four narrow fractions of concentrates alkyl benzene within the limits of temperatures from 273,15 up to 473,15K at atmospheric pressure is carried out. Four equations featuring temperature dependences of density of fraction in all explored interval of temperatures are offered in the uniform shape with a margin error experiment.

Benzene, its monoalkylas, their intermixtures and concentrates are widely used in the oil refining, petrochemical, chemical industries and power system.

In the present stage of a civilization development of the heavy industry and, first of all, its such basic economic branches as fuel and energy, chemical, oil refining, that is one of unconditional backgrounds of the solution of all economic problems is very important.

Very actually also improvement of structure of energy balance of the countries, decrease in it of a share of the naphtha used as fuel and replacement by its gas and coal, the accelerated atomic engineering.

For the successful solution of the specified problems wide introduction in manufacture of new machines and devices of major individual power and productivity, dismantle and reconstruction of the out-of-date inventory, making and introduction in manufacture of more effective technique and technology, development of manufacture of the pure and superpure substances, new polymeric and composite materials, and also products from them, essential expansion of the nomenclature of used substances and materials, and also working bodies and a gamut of change of their parameters is necessary.

For a scientific substantiation of designing most economically effective processes and kettles in the chemical, oil refining, petrochemical industries and power engineering it is necessary to have a reliable information about thermophysical properties initial, intermediate and end-products, and also working bodies in a wide gamut of change of basic parameters of state.

From this point of view studying of properties and making of engineering computational methods can be carried to the primary goals of the modern scientific researches.

Density is one of the most important thermophysical properties of gases, fluids and their intermixtures. Data about density are used for making new and perfection existing technological and heat exchange processes, the automated control systems, and also at operation of machines and apparatuses in power engineering.

Measuring of density of petroleum, mineral oil, i.e. narrow fractions of concentrates of various classes of hydrocarbons now is carried out on the standard procedures providing also an opportunity of recalculation of density on other temperature. According to these standards the density of mineral oil is measured at atmospheric pressure and the particular temperatures (it is usual 20°C). The error of measuring of density, as a rule, does not exceed ± (0.03 ÷ 0.05) %.

Recalculation of density on other temperature is carried out by the simple interpolation equations, tables or nomographic charts. Errors of recalculation reach ± (2 ÷ 3) % at low temperatures and ± (5 ÷ 10) % at high ones.

It is possible to explain an irregularity of the modern computational methods of density of petroleum to that they are developed on a restricted material.

The purpose of the present work is the experimental research and the analytical description of temperature dependence of density for four narrow fractions of concentrates alkyl benzenes at temperatures 273.15÷473.15K and at atmospheric pressure.

Measuring of density higher boiling monoalkyl benzenes is carried out by means of two pycnometers, specially created for this purpose.

The first pycnometer of a special construction, with a narrow neck and supplied by an agitator, is made of a glass, second - from stainless steel of mark 1X18H9T, with diameter 28 mm, height of a cylindrical part 70 mm, with the spherical bottoms.

Thickness of a wall of the second pycnometer is 0.1 mm. Capillaries are soldered to the bottoms of this pycnometer from stainless steel of mark 1X18H9T in diameter $d_{в}/d_{н}$ = 1/1.5 mm by silver solder. The mass of an empty steel pycnometer makes 14.8148×10^{-3} kg. The volume of pycnometers was determined by control measurements according to values of density of water and a toluene [1,2].

The pycnometers were filled with a fluid (usual water and a toluene) and were located in liquid a thermostat of mark ITI- 3/84 in which constancy of temperatures was maintained automatically with precision ±0.01K. The temperature in experience was measured and checked by means of model platinum thermometer PTS-10 with application of the potentiometer У-309, with the error ±0.01K. As thermostatic liquid are applied ethylene glycol, water and glycerin.

Values of volume of the pycnometer, determined by two fluids (water and a toluene) up to 350K, were agreed among themselves with a margin error ± (0,01 ÷ 0,02) %. At other temperatures the volume of pycnometers was determined by the formula:

$$V_T = V_{293,15} \cdot \left[1 + 3\alpha(T - 293.15)\right] \qquad (1)$$

where V_t - volumes of pycnometers at temperature of experience; $V_{293,15}$ = 107.9089×10^{-6} м^3 for glass and $V_{293,15}$ = 45.7691×10^{-6} м^3 for a steel pycnometer; - a linear expansion coefficient, which medial value it is equal 8.5·10^{-6} hailstones-1 for a glass and 16.1·10-6 hailstones-1 for steel 1X18H9T [3].

All operations of weighing were carried out on assay balances of first class ADV-200.

After scooping pycnometers on measuring density of four narrow fractions alkyl benzene the basic examinations were carried out in an interval of temperatures 217.15-473.15K and atmospheric pressure. An error of the gained data on density has not exceeded ± (0,01 ÷ 0,03) %.

The data obtained by various pycnometers, were very well agreed, and discrepancies did not exceed specified above an error of experience.

All the experimental results of density of narrow fractions alkyl benzene are given in table 1. The straggling of skilled points concerning averaging lines of temperature dependence of density does not exceed ± (0.01 ÷ 0.02) %.

Table 1

Experimental values of density of four narrow fractions of alkyl benzene at atmospheric pressure ant various temperatures

T, K	Density, ρ, г/см^3			
	№1	№2	№3	№4
273.15	0.8946	0.8585	0.8703	0.8905
298.15	0.8767	0.8402	0.8537	0.8735
323.15	0.8585	0.8217	0.8371	0.8566
348.15	0.8403	0.8031	0.8207	0.8399
373.15	0.8220	0.7844	0.8043	0.8232
398.15	0.8035	0.7658	0.7877	0.8066
423.15	0.7851	0.7471	0.7713	0.7900
448.15	0.7667	0.7286	0.7548	0.7734
473.15	0.7492	0.7101	0.7386	0.7565

*

Fraction	With temperature of boil
№1	473.15 ÷ 633.15K
№2	553.15 ÷ 573.15K
№3	633.15 ÷ 653.15K
№4	T > 653K

Grafoanalitycs by processing it is erected, that temperature dependences of all four explored narrow fractions alkyl benzene within the limits of temperatures 217.15 – 473.15K and atmospheric pressure can be describing by the uniform equation:

$$\rho_T = a + b\cdot(T_i - T_0) + C\cdot(T_i - T_0)^2, \qquad (2)$$

Where *a, b, c* are constants for various fractions; $T0$ = 273.15K - reference temperature; T_i - varies from 273.15 up to 473.15K.

Having solved for each fraction the equation (2) by method of the least quadrates in view of all skilled points, had been certain{spotted} values of coefficients a, b, c which are given in table 2.

Comparison calculated on the equation (2) and the found values of coefficients *a, b, c*, with skilled results has shown data, that in all explored interval of temperatures for all four fractions alkyl benzene the medial discrepancy makes ± (0.01 ÷ 0.02) %, and peak does not exceed ± 0.07 %.

Table 2

Values of coefficients of the equation (2) for various narrow fractions of concentrates alkyl benzene

Fraction	*a*	*в*	*c*
№1	0.895133	-7.31329·10^{-4}	-5.53293·10^{-9}
№2	0.858642	-7.40740·10-^{4}	-1.26338·10^{-8}
№3	0.870279	-6.63133·10^{-4}	2.19976·10^{-8}
№4	0.8903889	-6.74350·10^{-4}	2.87501·10^{-8}

Equation (2) allows getting next generalized formulas for first derivative of density by temperature at atmospheric pressure for narrow fractions of alkyl benzene at liquid state:

$$\rho_T^{/} = \left(\frac{\partial\rho}{\partial T}\right)_p = b + 2\cdot C\cdot(T_i - T_0) \qquad (3)$$

Values of $\rho_T^{/}$ for all investigated narrow fractions of alkyl benzene calculated by equation (3) are shown in table 3.

Table 3

Temperature dependence of first derivative of density by temperature at atmospheric pressure $\left(\frac{\partial\rho}{\partial T}\right)_p$ for narrow fractions of alkyl benzene

T, K	$\rho_T^{/}$			
	№1	№2	№3	№4
273.15	-731.3290·10^{-6}	-740.7399·10^{-6}	-663.1328·10^{-6}	-674.3502·10^{-6}
298.15	-731.6060·10^{-6}	-741.3716·10^{-6}	-662.0330·10^{-6}	672.9126·10^{-6}
323.15	-731.8820·10^{-6}	-742.0033·10^{-6}	-660.9331·10^{-6}	-671.4751·10^{-6}
348.15	-732.1592·10^{-6}	-742.6350·10^{-6}	659.8332·10^{-6}	-670.0376·10^{-6}
373.15	-732.4351·10^{-6}	-743.2667·10^{-6}	-658.7333·10^{-6}	-668.6000·10^{-6}
398.15	-732.7119·10^{-6}	-743.8983·10^{-6}	-657.6334·10^{-6}	-667.1624·10^{-6}
423.15	-732.9889·10^{-6}	-744.5300·10^{-6}	-656.5336·10^{-6}	-665.7249·10^{-6}
448.15	-733.2649·10^{-6}	-745.1617·10^{-6}	-655.4337·10^{-6}	-664.2874·10^{-6}
473.15	-733.5420·10^{-6}	-745.7934·10^{-6}	-654.3338·10^{-6}	-662.8498·10^{-6}

The analysis shows the dependence of $\rho^{/}$ of temperature is linear and changes a little with temperature.

Relation of individual derivative $\left(\frac{\partial v}{\partial T}\right)_p$ to specific volume v_0 (equivalent $\left(\frac{\partial\rho}{\partial T}\right)_p$ to density ρ_0) characterize a rate of change of volume of liquid at heating, if pressure is constant. This relation name coefficient of volume expansion

$$\alpha_p = \frac{1}{\rho_0}\left(\frac{\partial\rho}{\partial T}\right)_p, \qquad (4)$$

where ρ_0 - density at T_0 = 273.15K for all fractions. Calculated by equation (4) the values of α_p for all narrow fractions of alkyl benzene are shown in table 4.

Values of α_p change a little with temperatures for all fractions and have linear character.

In an interval of temperatures from 273.15 up to 473.15K for fractions №1 and №2 values of α_p increases accordingly for 0.30 % and 0.68 %, and for fractions №3 and №4 on the contrary, α_p decreases for 1.33 and 1.70 % accordingly.

Table 4

Temperature dependence of coefficient of thermal expansion α_p for narrow fractions of alkyl benzene at liquid state and at atmospheric pressure

T, K	α_p			
	№1	№2	№3	№4
273.15	$81.7493 \cdot 10^{-5}$	$86.2830 \cdot 10^{-5}$	$76.1959 \cdot 10^{-5}$	$75.7271 \cdot 10^{-5}$
298.15	$81.7809 \cdot 10^{-5}$	$86.3566 \cdot 10^{-5}$	$76.0695 \cdot 10^{-5}$	$75.5657 \cdot 10^{-5}$
323.15	$81.8111 \cdot 10^{-5}$	$86.4302 \cdot 10^{-5}$	$75.9431 \cdot 10^{-5}$	$75.4043 \cdot 10^{-5}$
348.15	$81.8420 \cdot 10^{-5}$	$86.5038 \cdot 10^{-5}$	$75.8168 \cdot 10^{-5}$	$75.2428 \cdot 10^{-5}$
373.15	$81.8729 \cdot 10^{-5}$	$86.5774 \cdot 10^{-5}$	$75.6904 \cdot 10^{-5}$	$75.0814 \cdot 10^{-5}$
398.15	$81.9039 \cdot 10^{-5}$	$86.6509 \cdot 10^{-5}$	$75.5640 \cdot 10^{-5}$	$74.9200 \cdot 10^{-5}$
423.15	$81.9348 \cdot 10^{-5}$	$86.7245 \cdot 10^{-5}$	$75.4376 \cdot 10^{-5}$	$74.7586 \cdot 10^{-5}$
448.15	$81.9657 \cdot 10^{-5}$	$86.7981 \cdot 10^{-5}$	$75.3112 \cdot 10^{-5}$	$74.5971 \cdot 10^{-5}$
473.15	$81.9966 \cdot 10^{-5}$	$86.8717 \cdot 10^{-5}$	$75.1848 \cdot 10^{-5}$	$74.4357 \cdot 10^{-5}$

CONCLUSION

The experimental research of density of four narrow fractions of concentrates alkyl benzene within the limits of temperatures 273.15 ÷ 473.15K and atmospheric pressure is carried out. For this purpose two pycnometers which volumes differed in 2.36 times are made. For the first time for narrow fractions of concentrates alkylbenzene 36 experimental values of density are obtained. The peak relative accuracy of skilled data does not exceed ±0.02 %.

Grafoanalitycs processing erects temperature dependences of density and are featured by the uniform equation of an error of evaluations on which does not exceed ±0.07 % and in the core make ±(0.01÷0.02 %).

The generalized equations of temperature dependence of all narrow fractions of alkyl benzene and coefficients of thermal expansion of volume are calculated.

[1]. *Vukalovich M.P., Rivkin S.L., Alexandrov A.A.* Table of thermophysical properties of water and water a pair. M.: Standards Publishing House, 1969, 408 p.

[2]. *Mamedov A.M., Ахундов T.S.* Table of thermodynamic properties of gases and fluids. Release 5. Hydrocarbons of an aromatic series. M.: Standards Publishing House, 1978, 139 p.

[3]. Thermophysical properties of substances. The manual under. red. Prof. *N.B. Vargaftik.* M.-L. The state energy publishing house, 1956, 367 p.