

**Table 3.** Chemical composition of the distillate fractions obtained by the hydrogenation of tar (5 MPa, 400°C,  $\tau = 15$  min, and a laboratory high-pressure setup)

Characteristic	Distillate fraction with bp, °C		
	80–180	180–250	250–320
With no catalyst			
Density at 20°C, g/cm <sup>3</sup>	1.0106	1.0812	1.2350
Iodine number, (g I <sub>2</sub> )/(100 g of product)	43.50	42.35	40.47
Group hydrocarbon composition, wt %:			
<i>n</i> -paraffins	55.40	16.02	16.42
isoparaffins	10.14	14.65	13.75
aromatic hydrocarbons	17.20	55.40	56.41
naphthenes	14.48	10.85	11.98
olefins	2.30	3.08	1.44
cycloolefins	0.48	–	–
Sulfur content, wt %	0.07	0.09	0.11
In the presence of a Mo catalyst (0.025% Mo + 0.03% S)			
Density at 20°C, g/cm <sup>3</sup>	0.9013	1.0004	1.1206
Iodine number, (g I <sub>2</sub> )/(100 g of product)	38.42	36.57	32.51
Group hydrocarbon composition, wt %:			
<i>n</i> -paraffins	51.54	25.73	21.61
isoparaffins	8.67	26.23	24.62
aromatic hydrocarbons	22.95	28.37	38.40
naphthenes	14.04	18.25	14.23
olefins	1.28	1.42	1.14
cycloolefins	0.01	0.03	0.08

## EXPERIMENTAL

Tar without preliminary dehydration (water content, 3.4%) and distillation in a mixture with a prepared catalyst and oil distillation residue with bp above 320°C (oil from the Kumkol field in the Republic of Kazakhstan) taken in a ratio of 1 : 1 was used as the feedstock. Table 1 characterizes the tar, and the oil residue had the following characteristics: density at 20°C, 0.8077 g/cm<sup>3</sup>; viscosity, 9.69 mm<sup>2</sup>/s; paraffin content, 14.73 wt %; asphaltene content, 1.52 wt %; and tar content, 8.2 wt %. The elemental composition of the oil residue was as follows (wt %): C, 83.85; H, 11.27; S, 1.81; N, 0.80; and O, 2.27.

The catalyst was prepared by the addition of an aqueous solution of ammonium paramolybdate (3.0 wt % on a raw material basis) and elemental sulfur (in a powdered form) as a sulfidizing additive in an amount of 0.03–0.09 wt % on a catalyst basis to the tar. The resulting mixture was dispersed in a homogenizer at a temperature of 130°C and a plate rotation speed of

1500 rpm. The metal concentrations were 0.025, 0.05, and 0.12% on a raw material basis.

The experiments were carried out in a high-pressure laboratory setup with a 0.25-dm<sup>3</sup> hollow reactor and a stirrer. The mixture of tar with a catalyst and a sulfur additive heated to 70–80°C was loaded into a reactor, which was preliminarily purged with argon and filled with hydrogen at an initial pressure of 2–3 MPa. The reactor heating was turned on, and the stirrer was turned on upon reaching a temperature of 150°C. The temperature was measured with a thermocouple and automatically maintained with an accuracy of  $\pm 2^\circ\text{C}$ . The working pressure of hydrogen was 5.0 MPa, the temperature was 350–450°C, and the reaction time was 15 min. The hydrogen pressure of 5.0 MPa was chosen as effective based on experimental data [11] and the results obtained previously [12, 13].

The group hydrocarbon composition of the obtained tar distillate fractions was determined on a CHROMATEK chromatograph (Germany), and the sulfur content was measured by energy-dispersive X-ray fluo-