

**Table 2**

Characteristics of distillate fractions with boiling point up to 180 °C, obtained from the hydrotreated coal tar (5.0 MPa, 400 °C,  $\tau$  = 15 min, ozone feeding rate 0.25 ml/min, coal tar: oil paste-forming agent = 1:1, laboratory unit).

Indicator	Catalyst	
	0,025% Mo + 0,03% S	0,05% Mo without adding S
Ozonation time 0 min		
Density at 20 °C, g/cm <sup>3</sup>	0,7913	0,7533
Content, %:		
Aromatic hydrocarbons	22,9	37,6
Sulphur	0,02	0,07
Iodine number, containment g J <sub>2</sub> /100 g fuel	38,4	42,7
Ozonation time 30 min		
Density at 20 °C, g/cm <sup>3</sup>	0,7443	0,7531
Content, %:		
Aromatic hydrocarbons	17,2	23,4
Sulphur	0,003	0,006
Iodine number, containment g J <sub>2</sub> /100 g fuel	24,9	30,2
Ozonation time 60 min		
Density at 20 °C, g/cm <sup>3</sup>	0,7439	0,7475
Content, %:		
Aromatic hydrocarbons	12,8	19,8
Sulphur	0,001	0,004
Iodine number, containment g J <sub>2</sub> /100 g fuel	23,6	30,3
Ozonation time 90 min		
Density at 20 °C, g/cm <sup>3</sup>	0,7430	0,7226
Content, %:		
Aromatic hydrocarbons	13,9	29,1
Sulphur	0,002	0,002
Iodine number, containment g J <sub>2</sub> /100 g fuel	24,4	35,2

provided with consideration of volumes of each fraction. The hydrocarbon-type content of the received distillate fractions of the coal tar was determined on the Khromatek chromatograph (Germany), the sulfur content - by the POST LEKI P1437 device (Germany) using the method of energy-dispersive X-ray fluorescence spectrometry.

## 2. Findings and discussion

The results of hydrofining of the ozonized coal tar are given in Table 1, which shows that ozonolysis at the ozonation time of 30 min and at the change of hydrofining temperature of from 350 to 450 °C contributes to the increase of formation of light and medium distillates compared to the process under comparable conditions, but without ozonation. The maximum total yield of these distillates (48.2%) was observed at the ozonation time of the coal tar during 60 min and at the temperature of 400 °C, which is probably due to the deepening of the cracking process, as evidenced by the higher formation of gasoline and diesel fractions (14.8% and 33.4%, respectively) compared to the time of ozone exposure to the coal tar during 30 and 90 min at the same temperature. It should be noted that when the resin hydrofining temperature is varied in the range of 350–450 °C and the ozonation time is from 30, 60 to 90 min, the total yield of distillate fractions and the yield of distillate fractions from so on. up to 180° C and 180–320° C separately have a maximum at a temperature of 400° C. It appears that at 350 °C the reaction of decomposition of coal tar macromolecules to radicals with lower molecular weight slow down, and at higher temperature (450 °C) the reactions of recombination of radicals occur, resulting in the compaction the coal tar products.

It should be noted that ozonation of the coal tar during 60 min makes it possible to remove sulfur from the coal tar by 95% during the subsequent hydrogenation processing and to produce low-sulfur gasoline fractions with sulfur content of 0.001% (Table 2) and with arena content up to 55% (Table 3). At that, polycyclic arenas, unsaturated compounds and alkyl substituents of aromatic structures with the formation of monocyclic arenas and new com-

**Table 3**

Hydrocarbon-type content of hydrotreated gasoline fractions with boiling point up to 180 °C (5.0 MPa, 400 °C,  $\tau$  = 15 min, ozone feeding rate 0.25 ml/min, coal tar: oil paste-forming agent = 1:1, laboratory unit).

Hydrocarbons	The implementation of the process of the hydrofining of coal tar	
	Without ozonation	Ozonation time 60 min
Parafins	56,40	25,65
Iso-Paraffins	10,14	11,41
Aromatics	17,20	55,10
Naphthenes	1,40	6,27
Olefins	2,30	1,57

pounds with cycloalkyl hydrocarbon framework mainly enter into reaction with ozone.

It can be seen from the Table 4 that during hydrofining of the coal tar after ozone exposure the content of aromatic hydrocarbons of the fraction with boiling point to 180 °C increased from 17.2 to 55.1%, iso- paraffin + naphthenetic - from 11.54 to 17.68%, and the content of olefins decreased from 2.3 to 1.57%, which shows the efficiency of the pretreatment of coal tar with ozone. In addition, the hydrofining of the ozonated coal tar in the presence of nanoheterogeneous molybdenum disulfide changes the chemical and hydrocarbon-type content, as well as the yield of light distillate CT fractions.

## 3. Conclusion

As a result of ozonation and hydrofining of the semi-coking coal tar from the Shubarkol Deposit in the presence of nanoheterogeneous molybdenum sulfide catalyst, the yield of distillate fractions with a boiling point up to 180 °C and the yield of total light distillates increases significantly in comparison with the process without ozonation. The conversion of the hydrocarbon-type content of the fractions with boiling point up to 180 °C is achieved with increasing the yield of aromatic hydrocarbons and reducing sulfur and unsaturated compounds. Introduction of hydrogenation