

# The process of obtaining aromatic hydrocarbons by catalytic aromatization of normal hexane on the (2%LA\*2%CU\*8%ZN/H-HSZ-30) catalyst

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**Abstract.** This study of the aromatic production process by catalytic aromatization of normal hexane on (2%LA\*2%CU\*8%ZN/H-HSZ-30) catalyst is presented. Laboratory studies were conducted on High catalytic activity (2%LA\*2%CU\*8%ZN/H-HSZ-30) catalysts for catalytic aromatization of linearly structured hexane at 400, 450, and 500°C, atmospheric pressure to produce aromatic hydrocarbons. Catalytic aromatization of normal hexane at 400 °C showed high activity of the catalyst for iso-compound formation reactions and high hydrogen cyclization ability at 500°C. Based on the study of the characteristics of the high-catalytic-activity catalyst used to catalytically aromatize regular hexane to produce aromatic hydrocarbons, the used catalyst shows the structural properties, the reduction in the number of active metals in the catalyst used for the catalytic aromatization of regular hexane to produce aromatic hydrocarbons, which has a high catalytic activity. shown and aromatic hydrocarbons, which are the main components of the fuel, were found to form a catalyst with a high octane number.

## 1 Introduction

The main processes that allow the production of high-octane gasoline (autobenzine) of different brands without the use of anti-detonators are the "Tseofforming" process [1]. It is based on the application of catalysts of zeolites and structural pentacyls [2]. Raw materials for this process can also be products that are separated in the preparation and extraction of oil and satellite gas for transportation (condensates of satellite gases, compresses, gas gasoline) and gasoline fractions that are directly driven by oils [3].

Oxygen treatment with the addition of organochlorine compounds to its thermal stability is greatly increased when a catalyst with high activity and selectivity is used to

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The reaction zone is connected to the reactor designed for the catalytic aromatization of linear hexane to obtain aromatic hydrocarbons in the amount corresponding to the volume of 9 cm<sup>3</sup>, and the catalyst (3) with high activity was selected for the aromatization of linear hexane to obtain aromatic hydrocarbons is placed in it. A catalyst with high activity was selected for the aromatization of hexane with a linear structure to obtain aromatic hydrocarbons placed in the constant temperature oven circle, which was set before the experiment with the help of a thermocouple. The volume of the reaction zone is calculated by setting the length of the "area" at equal temperature. The catalyst with high activity selected aromatization of hexane with a linear structure to obtain aromatic hydrocarbons was activated at 600 °C for 2 hours in an air stream, followed by 40 minutes in a helium stream [12-15].

The rate (1-2 ml/h) is set by dropping into a glass before transferring the raw material to the reactor designed for the catalytic aromatization of linear hexane to aromatic hydrocarbons. Gaseous products formed in the process of obtaining aromatic hydrocarbons by catalytic aromatization of linear hexane are collected and measured in a gasometer (10) [13].

### 3 Results and Discussion

The main products of the 2%LA\*2%CU\*8%ZN/H-HSZ-30 catalyst with high activity, were selected for aromatization of hexane with a linear structure, are iso-compounds represented by 2,2-dimethylbutane, 2-methylpentane, 3-methylpentane and 2,2-dimethylpentane; carbon-carbon bond cleavage products under the influence of hydrogen are mainly methane, ethane, propane, butane: aromatic hydrocarbons - benzene, toluene, xylenes, trimethylbenzene, ethylbenzene. The formation of cycloparaffins and unsaturated ethylene series hydrocarbons occurs in small amounts in the entire range of investigated temperatures (Table 1). At the same time, at 450 °C, the formation of hydrocarbons of the unsaturated ethylene series occurs, their percentage content in catalysis is almost 7 mass. is %. As the temperature increases, the amount of cycloparaffins decreases from 3 to 1 wt.% at 400 and 500 °C.

**Table 1.** Transformation products of hexane on the 2%LA\*2%CU\*8%ZN/H-HSZ-30 catalyst with high activity selected for aromatization of linear structured hexane to obtain aromatic hydrocarbons at atmospheric pressure with 0.5 h<sup>-1</sup> volumetric feed rate.

Group of substances	Catalyst content, %		
	400 °C	450 °C	500 °C
Alkanes	46.4	36.6	15.5
Iso-alkanes	33.3	10.0	4.6
Aromatic compounds	5.6	30.0	60.5
Cycloparaffins	3.2	1.3	0.7
Olefins	0.1	6.9	0.6
ΣS <sub>1</sub> -S <sub>5</sub>	9.2	15.1	18.0

It can be seen from Table 1 that the optimum temperature for the highest amount (60.5%) of aromatic hydrocarbons formed in 2%LA\*2%CU\*8%ZN/H-HSZ-30 catalyst with high catalytic activity is 500 °C.

**Table 2.** Results of conversion of linear hexane on 2%LA\*2%CU\*8%ZN/H-HSZ-30 catalyst with high activity selected for aromatization of linear hexane to aromatic hydrocarbons at atmospheric pressure with 0.5 h<sup>-1</sup> volumetric feed rate.

T, °C	Depth of change of hexane with a linear structure, %	Selective susceptibility to rupture of carbon-carbon bonds under the influence of hydrogen, %	Isomer selectivity, %	Selectivity for obtaining aromatic hydrocarbons mainly benzene, toluene and xylenes by aromatization, %
400	56.3	16.4	62.7	9.9
450	66.0	20.9	15.1	45.4
500	88.4	22.3	5.2	68.4

As can be seen from Table 2, the depth of transformation of linear structured hexane was observed to increase from 56.3 % to 88.4 % as the temperature increased from 400 °C to 500 °C, respectively. Table 3 shows the octane numbers of catalysts with high catalytic activity selected for the catalytic aromatization of hexane with a linear structure to produce aromatic hydrocarbons [13-14].

**Table 3.** The octane number of hydrocarbons for the transformation of hexane with a linear structure on the 2%LA\*2%CU\*8%ZN/H-HSZ-30 catalyst, the volumetric consumption rate is 0.5 h<sup>-1</sup>.

Group of substances	IM			MM		
	400 °C	450 °C	500 °C	400 °C	450 °C	500 °C
Alkanes	11.9	9.9	6.9	20.4	16.4	9.6
Isoalkanes	32.6	11.0	5.2	27.2	9.6	4.0
Aromatic hydrocarbons	6.5	40.0	76.6	5.7	31.2	69.4
Cycloparaffins	3.9	1.3	0.9	3.7	1.1	0.7
Ethylene hydrocarbons	0.9	7.2	0.8	0.8	5.4	0.5
Unknown	2.2	1.0	1.0	1.2	0.8	0.3
Total	58.0	70.7	91.6	59.0	65.7	84.6

As a result of improving the fraction of low-octane gasoline, the reduction of saturated open-chain hydrocarbons and cycloparaffins occurs. The content of isostructural hydrocarbons at 400 °C is 13.4 wt. % increases and when the temperature increases, it decreases by 3 wt.% compared to the initial raw material.

**Table 4.** Results of fraction change at 85-180 °C on 2%LA\*2%CU\*8%ZN/H-HSZ-30 catalyst with high activity selected for the aromatization of linear structured hexane to obtain aromatic hydrocarbons at atmospheric pressure and raw material transfer volumetric rate of 0.5 h<sup>-1</sup>.

Group of substances	Fraction composition, %	Catalyst content, %		
		400 °C	450 °C	500 °C
Alkanes	28.6	11.1	5.1	3.0
Isoalkanes	23.8	37.2	20.6	20.2
Aromatic hydrocarbons	9.8	12.8	35.7	46.1
Cycloparaffins	34.8	25.8	22.3	7.6
Ethylene hydrocarbons	2.8	3.5	2.7	4.7
ΣS <sub>1</sub> -S <sub>5</sub>		9.3	13.5	18.1

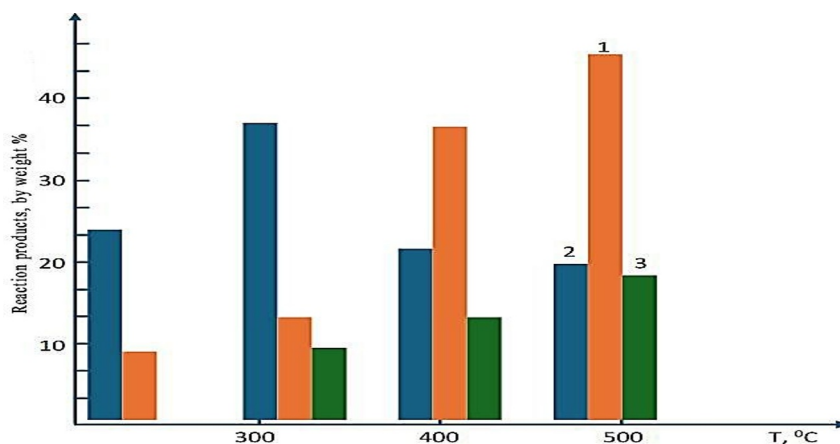
As can be seen from the analysis of the experimental results, the 2%LA\*2%CU\*8%ZN/H-HSZ-30 catalyst with high activity, selected for the aromatization of hexane with a linear structure to obtain aromatic hydrocarbons, is the main direction of the processes taking place in the reaction thereby causing aromatic hydrocarbons to develop and the breaking of carbon-carbon bonds under the influence of hydrogen (Figure 2). The

resulting catalysts have a much higher octane number compared to the raw materials (Table 5). At 400 °C [15-18], the main contribution to the octane number is 11.1 units of isostructural hydrocarbons. According to IM, aromatic hydrocarbons are 5.8 birl. According to IM, it introduces unreacted cycloparaffins, the amount of which is slightly reduced compared to the raw material. When the temperature rises to 500 °C, the octane number of the obtained catalyst increases to 98.8 by IM due to the formation of a large amount of aromatic hydrocarbons [19-22].

**Table 5.** Results of fractional change at 85-180 °C on H-HSZ-30 catalyst with high activity selected for aromatization of linear structured hexane to obtain aromatic hydrocarbons at atmospheric pressure and volumetric feed rate of 0.5 h<sup>-1</sup>.

Group of substances	Raw material		300 °C		400 °C		500 °C	
	IM	MM	IM	MM	IM	MM	IM	MM
Alkanes	3.215	14.25	1.522	5.125	1.925	4.130	2.230	2.915
Isoalkanes	22.15	15.65	34.15	28.95	23.15	17.50	22.01	18.20
Aromatic hydrocarbons cycloparaffines	11.01	9.825	15.40	13.01	46.20	43.01	60.54	55.15
Naphthenes	28.65	19.45	24.50	15.02	18.15	11.02	8.820	5.445
Ethylene hydrocarbons	2.520	2.520	3.620	2.030	3.225	2.335	5.550	3.775
Unknown			5.235	4.020	0.225	0.220	1.130	0.715
Total	67.545	61.695	84.427	68.155	92.875	78.215	99.95	86.2

Because automotive fuels now have more stringent environmental regulations, the data on the content of benzene in the products of the improvement of low-octane gasoline fractions on the catalyst with high catalytic activity selected for obtaining aromatic hydrocarbons by catalytic aromatization of hexane with a linear structure under these conditions are of interest. Table 6 shows that the content of benzene in all catalysts is much lower than the norm (5 wt.%): 2.4 wt.% at 400 °C, 1.0 wt.% at 450 °C, 2.1 wt.% at 500 °C.



**Fig. 2.** The composition of the main components of the 85-180°C fraction after improvement on the 2%LA\*2%CU\*8%ZN/H-HSZ-30 catalyst with high catalytic activity.

The catalyst was selected for obtaining aromatic hydrocarbons by catalytic aromatization of hexane with a linear structure: 1-aromatic hydrocarbons, 2 - iso-saturated open chains, cleavage products of C-C bonds under the influence of 3-hydrogen,  $\Sigma Ap/\Sigma C_1-C_5$ .

**Table 6.** Composition of aromatic hydrocarbons in gasoline fraction catalysts at 85-180 °C on 2%La\*2%Cu\*8%Zn/N-HSZ-30catalyst with high activity selected for catalytic aromatization of linear hexane to obtain aromatic hydrocarbons.

Group of substances	Raw materials,%	Catalyst content,%		
		2%La*2%Cu*8%Zn/N-YuKTs -30		
		400 °C	450 °C	500 °C
C <sub>6</sub>	0.2	2.50	1,505	2,330
C <sub>7</sub>	1.5	4.50	6,405	10.65
C <sub>8</sub>	4.0	2.40	13.01	18.40
C <sub>9</sub>	4.0	3.20	8,525	11.70
C <sub>10</sub>	2.0	0.65	5,335	3,020
C <sub>11</sub>	1.0	0.15	1,825	0.775
C <sub>12</sub>	0.05	-	0.445	0.425
Total	12.75	13.4	37.05	47.3

As can be seen from Table 6, the aromatic hydrocarbon content in the catalysts of gasoline fraction at 85-180 °C was 9.8% in the 2%LA\*2%CU\*8%ZN/H-HSZ-30 catalyst. It is 46.2% at a temperature of 500°C. As a result, the amount of aromatic hydrocarbons in raw materials increased by 4.7 times. Experiments were conducted in hydrogen, and helium flow and without any gas circulation to study the effect of low octane gasoline fraction improvement environment at 500 °C temperature (Table 7).

**Table 7.** The effect of the environment on the process of improving the gasoline fraction at 85-180 °C on the 2%LA\*2%CU\*8%ZN/H-HSZ-30 catalyst with high activity selected for the aromatization of hexane with a linear structure at 500 °C to obtain aromatic hydrocarbons.

Group of substances	The composition of the faction	Catalyst content, %		
		Hydrogen flow	Helium flow	Without gas supply
Alkanes	29.65	12.10	5.525	4.015
Isoalkanes	24.50	19.20	24.15	21.20
Aromatic hydrocarbons cycloparaphines	10.25	42.40	22.30	47.25
Naphthenes	35.70	14.15	28.30	8,660
Ethylene hydrocarbons	3.330	-	9,250	5,550
ΣS <sub>1</sub> -S <sub>5</sub>		16.15	13.40	19.25

As can be seen from Table 7, the influence of the environment on the process of improving the gasoline fraction at 85-180 °C was studied on the 2%LA\*2%CU\*8%ZN/H-HSZ-30 catalyst with high activity selected for aromatization of hexane with a linear structure at a temperature of 500 °C to obtain aromatic hydrocarbons and the mount was 46.2%.

The content of benzene in all catalysts meets environmental standards and 5 wt. does not exceed % (Table 8). Also, the total content of aromatic hydrocarbons does not exceed the permitted limited values (55 wt.%) and the maximum of 46.2 wt. %, in which benzene was found to be only 2.2%. This makes it possible to obtain fuel that meets the standards of environmental requirements.

**Table 8.** The amount of aromatic hydrocarbons in gasoline fraction catalysts at 85-180 °C on the 2%La\*2%Cu\*8%Zn/H-HSZ-30 catalyst with high catalytic activity selected for obtaining aromatic hydrocarbons by catalytic aromatization of hexane with a linear structure during experiments in different environments.

Group of substances	Fraction composition, %	Catalyst content, %		
		Hydrogen flow	Helium flow	Without gas supply
C6	0.1	4.3	1.6	2.2
C7	1.0	11.9	4.8	10.5
C8	3.8	14.3	7.5	18.1
C9	3.0	7.1	6.5	11.5
C10	1.0	3.9	0.9	3.0
C11	0.8	0.2	0.1	0.6
C12	0.03	0.1	-	0.3
Total	9.8	41.8	21.6	46.2

The octane numbers of the obtained catalysts at different operating conditions are presented in Table 9.

**Table 9.** The octane number of 85-180 °C gasoline fraction hydrocarbons in 2%La\*2%Cu\*8%Zn/N-YuKts-30 catalyst with high catalytic activity selected to obtain aromatic hydrocarbons by catalytic aromatizing of linear-structured hexane at 500 °C in different environments of the process.

Group of substances	Raw material		Hydrogen		Helium		Without gas supply	
	IM	MM	IM	MM	IM	MM	IM	MM
Alkanes	3.215	14.25	3.330	6.445	1.620	3.885	2.230	2.915
Isoalkanes	22.15	15.65	19.15	15.86	23.87	15.45	22.01	18.20
Aromatic hydrocarbons cycloparaffines	11.01	9.825	52.55	46.65	28.25	22.75	60.54	55.15
Naphthenes	28.65	19.45	17.85	12.25	30.85	16.35	8.820	5.445
Ethylene hydrocarbons	2.520	2.520	-	-	11.01	4.925	5.550	3.775
Unknown			1.775	2.015	0.320	0.220	1.130	0.715
Total	67.545	61.695	94.655	83.22	95.92	63.58	99.95	86.2

The catalytic aromatization of linear hexane to obtain aromatic hydrocarbons reduces the contribution of hydrogen evolution and hydrogen-induced cyclization reactions occurring in the metal centres of the catalyst with high catalytic activity.

The octane number of the catalyst obtained from the gasoline fraction at 85-180 °C increases by 22.8 units compared to the raw material according to IM and is 89.2 according to IM and 75.1 according to MM (Table 10).

**Table 10.** The 85-180 °C octane numbers of gasoline fraction improvement hydrocarbons.

Group of substances	Raw material		Used 2%LA*2%Cu*8%Zn/H-HSZ-30		New 2%LA*2%Cu*8%Zn/H-HSZ-30	
	IM	MM	IM	MM	IM	MM
Alkanes	3.1	13.7	4.8	8.6	2.1	2.8
Isoalkanes	21.4	15.5	26.7	21.3	21.9	17.2
Aromatic compounds	10.9	9.6	30.2	25.7	60.5	54.1
Cycloparaffins	28.6	19.3	21.4	15.4	8.8	5.3
Unsaturated ethylene series hydrocarbons	2.4	1.9	5.9	4.1	5.5	3.6
Unidentified			0.1	0.1	1.1	0.6
Total	66.4	60.0	89.2	75.1	98.8	83.7

The physicochemical properties of 2%LA\*2%CU\*8%ZN/H-HSZ-30 catalyst with high catalytic activity selected to increase the output of gaseous products formed in the process of obtaining aromatic hydrocarbons by catalytic aromatization of hexane with a linear structure, and to determine the reasons for the decrease in activity in cyclization reactions under the influence of hydrogen, were studied [23-25].

## 4 Conclusion

The catalyst with high activity selected for aromatization of hexane with a linear structure to obtain aromatic hydrocarbons was found to have high activity in hydrocarbon formation reactions of iso-compounds at 400 °C and high hydrogen cyclization ability at 500 °C. At 500 °C, the effect of low-octane gasoline fraction improvement environment was studied: helium, hydrogen and without passing gas. Cycloparaffins are 27.9 wt.% in the helium environment, and aromatic hydrocarbons (41.8 and 46.2 wt.%) in the hydrogen environment. All catalysts have a high octane number (more than 90 according to IM). In the selected catalyst with high catalytic activity for the catalytic aromatization of linear hexane to obtain aromatic hydrocarbons a decrease in the amount of active metals in the catalyst is shown, which is reflected in the redistribution of the main directions of the process of improving the fraction of low-octane gasoline (dehydrogenation, ringing under the influence of hydrogen, high gas formation).

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