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## ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК  
РЕСПУБЛИКИ КАЗАХСТАН

АО «ИНСТИТУТ ТОПЛИВА, КАТАЛИЗА И  
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## NEWS

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OF THE REPUBLIC OF KAZAKHSTAN

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## ISOMERIZATION OF LIGHT FRACTION OF STRAIGHT-RUN GASOLINE ON Pt-AND Pd-CATALYSTS SUPPORTED ON PILLARED BY Al, AlZr AND Ti MONTMORILLONITE IN Na-AND Ca-FORMS

**Abstract.** The paper presents data on isomerization of the light fraction of straight-run gasoline on the zeolite-free and mordenite-containing Pt and Pd- catalysts supported on activated and pillared by Al, AlZr and Ti montmorillonite in Na- and Ca-forms. The catalysts were characterized by BET, X-ray phase, and elemental analysis, and their acid properties were determined by thermal desorption of ammonia. It is shown that the isomerization of the light fraction of straight-run gasoline over mordenite-containing Pd / AlZrCaHMM, Pt / Al (2.5) NaHMM and Pt / Ti (5.0) NaHMM catalysts at different temperatures leads to a significant change in the composition of gasoline and an increase in octane numbers. The greatest amount of isomers produced during the isomerization of the light fraction of gasoline was found on a Pt / Al catalyst (26.48%), followed by Pd / AlZr (23.56%), followed by Pt / Ti (23.15%). A comparison of the results on the acidity of the catalysts studied and their strength distribution shows that a correlation is observed between the total number of weak and medium acid sites and the isomerizing activity of the catalysts studied. For further practical use in the process of isomerization of light n-alkanes, 0.35% Pt / Al (2.5) NaHMM catalyst is proposed. The catalyst is characterized by a high yield of isomers, increased selectivity of isomerization of n-alkanes, operates at atmospheric pressure and a temperature of 350 ° C, and is characterized by increased stability.

**Key words:** the isomerization, straight-run gasoline, easy n- alkanes, mordenite, a pillarization, Pt and Pd-catalysts, octane numbers, selectivity.

**Introduction.** The process of an isomerization of paraffin hydrocarbons of oil has acquired high relevance in connection with the transition to use of more effective and ecologically safe fuels [1-4] in recent years. One of the ecologically safest ways of improvement of anti-detonation properties of straight-run gasolines is the use of process of a catalytic isomerization of n- alkanes with receiving high-octane isomers on effective Pt and Pd-catalysts [5-8]. Pt, Pd and Ni-catalysts on pillared montmorillonite have perfectly proved in this process [9-12]. On the example of the process of an isomerization of n- hexane it has been shown that the main advantage of these catalysts their high selectivity to isomers is represented. It has been noticed that on the developed catalysts at temperatures of 250-300°C reactions of hydrocracking practically don't go, and only at more high temperatures in products of reaction there are small amounts gaseous C<sub>1</sub>-C<sub>3</sub> of the hydrocarbons which are formed as a result of hydrocracking [13,14].

The isomerization of the real light fractions of oil consisting generally of pentanes of C<sub>5</sub> and C<sub>6</sub> hexanes gains the increasing value in connection with toughening of ecological requirements to motor fuels and need of production of alkylgasolines with high octane number [15,16]. Earlier it has been shown that on reduction of stationary isomerization activity in reaction of hydroconversion of n-hexane the developed Pt-and Pd-catalysts on pillared with various oxides montmorillonite it is possible to arrange in following row: Pt/Al (2,5) NaHMM (53,0%)>Pd/Al:Zr(1:1)CaHMM (35,0%)> Pt/Ti (5,0) NaHMM+ HM (34,0 of %)>Pd/Al:Zr (3:1) CaHMM(31,0%)>0,1%Pt/Al(5,0)NaHMM+HM(20,2%). Due to stated, the present article is devoted to a research of properties of the mordenitecontaining Pt-and Pd-catalysts

supported on pillared Al, AlZr and Ti the activated montmorillonite in an isomerization of easy fraction of straight-run gasoline (b.b. - 70°C) depending on temperature.

**Experimental** part Clay of Tagandeposit (Kazakhstan), containing up to 95% of montmorillonite (MM) in Na- and Ca-forms transferred to the H-form processing 0,1n H<sub>2</sub>SO<sub>4</sub> solution with the subsequent washing from SO<sub>4</sub><sup>2-</sup> ions. The activated clay was formed, dried in a thin layer at first at the room temperature, then at 150°C and further subjected to calcinating at 500°C. The prepared MM in H-form was used as initial material for a pillaring.

Introduction in interlayered spaces of montmorillonite aluminum, aluminum - zirconium and titanate complexes was carried out by the known techniques. Synthesis of Al-ZrCAHMM was carried out sequential: at first pillared by Al, and then by Zr. The received pillared clays separated by centrifugation, washed before negative reaction to Cl<sup>-</sup> ions, formed, dried at first at the room temperature, then at 150°C and further subjected to calcinating at 500°C.

Pt- and Pd-catalysts on the basis of the modified clays in the mix with mordenite (15%, with the module 20) prepared by an impregnation method on moisture capacity of carriers water H<sub>2</sub>PtCl<sub>6</sub> or PdCl<sub>2</sub> solutions. Samples formed, dried on air and in a drying cabinet, calcinated at temperatures of 200, 400 and 500°C with decomposition of salts to oxides and the subsequent reduction of oxides to a metal state when processing by hydrogen at temperatures of 200 and 450°C. Content of platinum and palladium in catalysts was 0,35 mas. %. Tests of catalysts carried out in flowing laboratory installation with a volume of catalyst of 5 ml at temperatures of 250-400°C, mass loading on hydrocarbon raw materials 0,8h<sup>-1</sup>, pressure of hydrogen 1 atm and a molar ratio hydrogen: hydrocarbons, equal 3,5. Products of reaction were analyzed on the gas chromatograph "Chromos GH-1000" supplied with a capillary column 100 m long, diameter 0,25mm and the flame-ionization detector.

Physical and chemical characteristics of the prepared samples have been determined by the X-ray method, the element analysis, low-temperature adsorption of N<sub>2</sub> by BET method on the ACCUSORB device, and acid properties - an ammonia thermal desorption method.

### Results and their discussion

According to the X-ray phase analysis (RFA) all catalysts contain the reflexes characteristic for Ca- and Na-forms of the MM (2,50; 4,45; 14,6), quartz (3,34), mordenite (3,44; 3,96; 6,5; 9,08; 10,2), platinum or palladium and also oxides of pillared ions-Al<sub>2</sub>O<sub>3</sub>, TiO<sub>2</sub> - anatase, the tetragonal phase ZrO<sub>2</sub> (3,00 and 1,84). According to RFA on 0,35%Pt/Ti (2,5) NAHMM-catalyst besides the above-named phases metal Ti (ASTM 5-682) and metal Pt is identified (ASTM 4-802 on reflexes 2,26; 1,95; 1,39). According to a data of X-ray fluorescent analysis except the elements making a basis of aluminosilicates Al, Si, O, the catalyst contains small amounts of Mg, Ca, Fe, insignificant quantities of Na, S, Cl (table 1). Besides according to the element analysis, in 0,35% Pt/Ti (5.0) NaHMM+HM -catalyst 0,26% of Pt, 9,9% of Ti are found.

Table 1 - The elemental analysis of Pt and Pd-catalysts supported on pillared MM and modified by mordenite. 0,35%Pt/Ti(5.0)NaHMM+HM

Element	C	O	Na	Mg	Al	Si	S	Cl	Ca	Ti	Fe	Pt	Total
Specter 1	9,04	48,18	0,08	0,71	11,59	19,68	0,04	0,17	0,20	9,81	0,19	0,32	100
Specter2	8,24	48,9	0,10	0,72	11,98	19,62	0,04	0,19	0,19	9,85	0,31	0,28	100
Specter3	8,45	48,81	0,9	0,74	10,84	20,32	0,00	0,12	0,19	10,06	0,19	0,18	100
<b>Average</b>	<b>8,58</b>	<b>48,49</b>	<b>0,09</b>	<b>0,72</b>	<b>11,47</b>	<b>19,87</b>	<b>0,03</b>	<b>0,16</b>	<b>0,19</b>	<b>9,90</b>	<b>0,23</b>	<b>0,26</b>	<b>100</b>

0,35%Pd/AlZrCaHMM+HM

Specter	O	Na	Mg	Al	Si	S	Cl	Ti	Fe	Zr	Pd	Total
Specter1	49,55	0,09	0,87	15,32	23,72	0,06	0,14	0,09	0,69	9,36	0,14	100,00
Specter2	49,46	0,07	0,82	14,34	24,78	0,06	0,10	0,14	0,74	9,34	0,14	100,00
Specter3	49,79	0,09	0,84	13,92	24,67	0,05	0,11	0,11	0,79	9,43	0,22	100,00
<b>Average</b>	<b>49,60</b>	<b>0,08</b>	<b>0,84</b>	<b>14,53</b>	<b>24,39</b>	<b>0,06</b>	<b>0,12</b>	<b>0,11</b>	<b>0,74</b>	<b>9,38</b>	<b>0,17</b>	<b>100,00</b>

0,35% Pt/Al(2,5) NaHMM+HM

Specter	O	Na	Mg	Al	Si	S	Cl	Ca	Fe		Pt	Total
Specter1	51,51	0,13	1,30	24,20	21,91	0,03	0,07	0,18	0,42		0,24	100,00
Specter2	51,65	0,13	1,27	24,76	21,33	0,02	0,05	0,17	0,39		0,27	100,00
Specter3	51,99	0,16	1,35	23,44	22,07	0,04	0,05	0,20	0,39		0,30	100,00
<b>Average</b>	<b>51,7</b>	<b>0,14</b>	<b>1,31</b>	<b>24,13</b>	<b>21,77</b>	<b>0,03</b>	<b>0,06</b>	<b>0,19</b>	<b>0,40</b>		<b>0,27</b>	<b>100,00</b>

The elemental analysis of the 0,35%Pd/AlZrCaHMM+HM-catalyst has also shown decrease in concentration of alkaline and alkaline-earthmetals in the course of activation, pillaring and supporting active metal. The amount of sodium in the ready catalyst doesn't exceed 0,08mas. %. From data of table 1 it is visible that the average content of palladium in powder of the catalyst is 0,17% that in  $\sim 2$  times are lower, than calculated. Besides, small amounts of chlorine are found in powder of the catalyst, other results of quantitative elemental analysis of the catalyst in comparison with the support after palladium introduction practically don't change. Similar results have been received in case of 0,35%Pt/Al (2,5) NaHMM+HM –catalyst. According to the analysis the amount of platinum in this catalyst is 0,27% that is close to the introduced his quantity.

Textural properties of three studied catalysts are characterized by small decrease in a specific surface of the catalyst when supporting platinum from 172,7 to 169,0  $\text{m}^2/\text{g}$  in a case 0,35%Pt/Al (2,5) NaHMM+HM (table 2) and from 190,7 to 182,7 $\text{m}^2/\text{g}$  for 0,35%Pt/Ti (5) NaHMM+HM. The support of these catalysts differs in the considerable maintenance of micropores which quantity grows when supporting platinum. In case of the Pd-catalyst supported on pillared by Al and Zr montmorillonite in Ca-form more essential reduction of a specific surface area and decrease of quantity of micropores is observed.

Table 2 – Comparative structural and adsorptive properties of Al (2,5) NaHMM+HM, Ti (5) NaHMM+HM, AlZr (1:1) CaHMM+HM, 0,35%Pt/Al (2,5) NaHMM+HM, 0,35%Pt/Ti (5) NaHMM+HM and 0.35% Pd/AlZrCaHMM+HM- catalysts

Sample	$S_{\text{av.}, \text{m}^2/\text{g}}$	Total true volume of a pores, $\text{cm}^3/\text{g}$	Relative quantity, %	
			Micropores 0-20 Å	Mesopores 20-80 Å
Al(2,5)NaHMM+HM	172,7	0,161	38,7	61,3
0,35%Pt/Al(2,5)NaHMM+HM	169,0	0,194	46,9	53,1
Ti(5)NaHMM+HM	190,7	0,190	32,2	67,8
0,35%Pt/Ti(5)NaHMM+HM	182,7	0,176	33,7	66,3
AlZr (1:1) CaHMM+HM	249,9	0,167	70,7	29,3
0.35% PdAlZrCaHMM+HM	228,6	0,153	54,0	46,0

It is possible to see the growth of the amount of micropores and the decrease of amount of a mesopores when supporting platinum by comparison of curves of distribution of a pores by the sizes in the support and in Pt/Al (2,5) NaHMM+ HM - the catalyst (fig. 1).

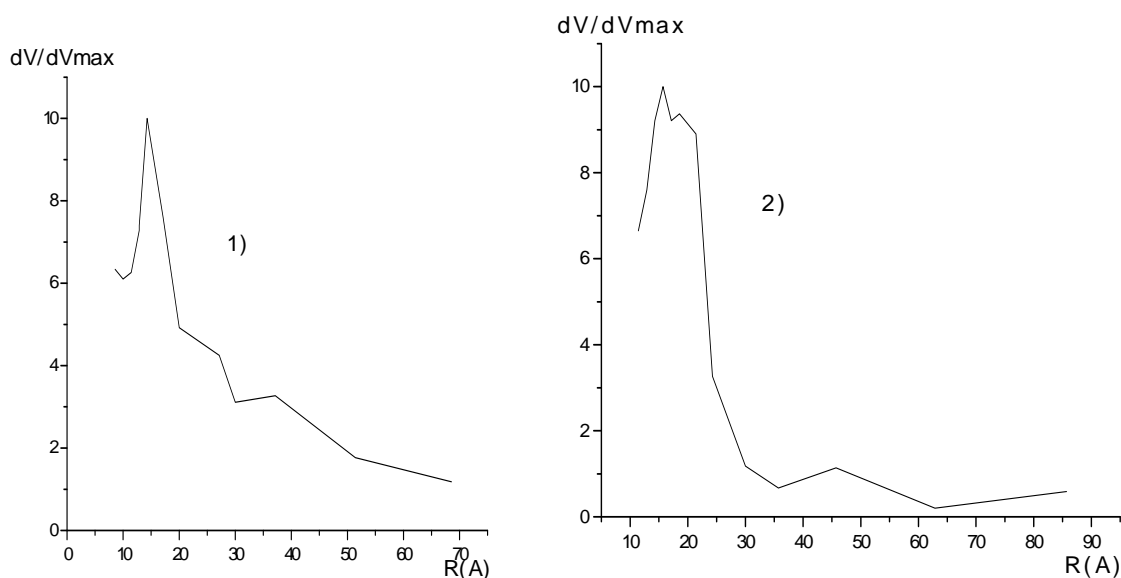


Figure 1- Distributions of a pores on their effective radiuses on Al(2,5)NaHMM+HM and 0,35Pt/Al (2,5) NaHMM+HM-catalysts. 1)Al(2,5) NaHMM+15%HM; 2)0,35Pt/Al (2,5) NaHMM+15%HM



The listed above samples of catalysts, optimum on the isomerization activity, have been tested in an isomerization of easy fraction of straight-run gasoline (b.b.-70<sup>0</sup>C). Light fraction of straight-run gasoline (b.b. – 70<sup>0</sup>C) according to the chromatografy analysis contains C<sub>3</sub>-C<sub>15</sub>-hydrocarbons which on to group composition consist from 15,9mass. % of paraffins, 12,5mass. % of isoparaffins, 1,0mass % of aromatic compounds, 13,6mass. % of naftens and 43,9mass. % of olefins. The total number of the identified compounds in initial light gasoline is 87,0% (table 3).

Table 3 - The group composition of initial light fraction of straight-run gasoline, in mass. %

Group on C-hydro-carbon	Paraffins	Isoparaffins	Aromatic compounds	Naphtenes	Olefines	Oxygen-containing	Sum on C-group
1	0,001	0,000	0,000	0,000	0,000	0,000	0,001
3	0.030	0.000	0.000	0.000	0.000	0.000	0.030
4	2,270	0,438	0,000	0,000	0,498	0,000	3,205
5	11,748	0.049	0.000	0.000	0.353	0.000	12.151
6	0,000	0,000	0,000	0,000	0,203	0,000	0,203
7	0,000	6,087	0,000	8,614	41,458	0,000	56,159
8	0,000	4,146	0,913	4,880	0,149	0,000	10,088
9	0,791	1,495	0,013	0,082	1,338	0,000	3,719
10	1,040	0,271	0,044	0,052	0,000	0,000	1,407
11	0,043	0,006	0,045	0,000	0,000	0,000	0,094
12	0,013	0,000	0,000	0,000	0,000	0,000	0,013
15	0,002	0,000	0,000	0,000	0,000	0,000	0,002
Сумма	15,937	12,491	1,0158	13,628	43,999	0	87,072

The octane number of this fraction by a research method is equal 41,8 units. Influence of temperature of an isomerization on the group composition of light fraction of straight-run gasoline and change of the octane numbers in the course of hydroconversion on the studied catalysts is presented in tables 4 and 5.

Table 4 - Influence of temperature and the nature of catalysts on the group composition of light fraction of gasoline in the course of a catalytic isomerization

Sample	T, °C	Paraffins	Isoparaffins	Aromatics	Naphtenes	Olefines	Oxygencontaining
0,35%Pd/AlZrCaHMM+HM	250	0.807	23.565	0.160	6.158	27.834	24.871
	300	0.181	10.543	8.697	17.292	31.713	0
	350	8.727	7.522	9.116	6.309	31.481	13.321
	400	14.912	21.046	3.743	3.068	42.916	0.287
0,35%Pt/Al(2,5)NaHM M+HM	250	0.667	10.401	1.787	19.032	55.836	0
	300	6.935	5.460	2.757	8.337	59.706	10.834
	350	24.530	26.484	6.854	24.523	1.193	0
	400	3.812	2.483	4.973	2.857	9.442	52.661
0,35%Pt/Ti(5.0)NaHM M+HM	250	6.896	23.151	0.998	21.457	40.641	0
	300	9.368	19.364	3.808	9.807	50.585	0
	350	7.227	9.184	9.221	12.655	52.299	0.004
	400	4.022	4.154	10.046	2.426	21.782	0

The isomerization of light fraction of straight-run gasoline on 0,35% Pd/AlZrCaHMM+HM - catalyst at various temperatures leads to essential change of composition of gasoline and increase its octane numbers (table 4,5). At 250<sup>0</sup>C the amount of the isoparaffins which is formed from light fraction of straight-run gasoline on Pd/AlZrCaHMM+HM considerably grows from 12,49 to 23,56 mas. %, and amount of paraffin and aromatic hydrocarbons decreases (paraffin from 15,93 to 0,80 mas.% and aromatic hydrocarbons from 1,01 to 0,16 mas. %). Such change of composition of gasoline is followed by growth of octane number for 29 units by a research method and for 13 units by a motor method. Temperature increase of an isomerization on 0,35%Pd/AlZrCaHMM - the catalyst to 300<sup>0</sup>C decreases the amount of

paraffins from 15,93 to 0,18mas. % in comparison with the initial composition of light fraction of straight-run gasoline. In these conditions, the amounts of iso-paraffins and olefins also decrease by 2 and 12% accordingly. At the same time, the content of aromatic compounds grows more, than by 8 times. The increase of octane number makes 11 units by a research method possibly due to increase in the amount of aromatic hydrocarbons. At 350<sup>0</sup>C the content of paraffins and naphthenes decreases almost twice, and the amount of aromatic hydrocarbons grows from 1,01 to 9,11mas. %. On this catalyst at 350<sup>0</sup>C the increase of octane number makes 25 units by a research method. At 400<sup>0</sup>C the amount of paraffin decreases, and isomers grows from 12,49 to 21,04mas. %. However an increase of the octane number of gasoline in these conditions small (5 units) in comparison with octane number of initial gasoline that is possible caused by the decrease of a quantity of the identified compounds for 10,5%. It is possible to draw a conclusion on isomerization ability of the studied catalysts by the amount of the isomers which are formed in process in comparison with their quantity in initial gasoline. The greatest number of isomers, equal 26,48%, is found on the Pt/Al-catalyst at 350<sup>0</sup>C (table 4), it is followed by Pd/AlZr (23,56%) at 250<sup>0</sup>C, and further Pt/Ti (23,15%) at 250<sup>0</sup>C. The largest value of conversion of hydrocarbons about which it is possible to make a conclusion is an increase of octane numbers was observed on the Pt/Ti-catalyst (table 5)

Table 5 - Influence of temperature and the nature of catalysts on the value of octane numbers of light fraction of gasoline after an isomerization

Catalyst	T, °C	O.n. by research method	Increase of o.n.	O.n. by motor method
0,35%Pd/AlZrCaHMM+HM	250	70.96	29,1	63.23
	300	52.81	10,95	40.62
	350	67.15	25,29	53.62
	400	46.75	4,89	42.38
0,35%Pt/Al(2,5)NaHMM+HM	250	46.83	4,97	50.68
	300	67.82	25,96	53.10
	350	53.52	11,66	51.06
	400	34.57	7,29	37.44
0,35%Pt/Ti(5.0)NaHMM+HM	250	54.02	12,16	58.0
	300	74.81	32,95	60.78
	350	60.03	28,20	55.59
	400	33.20	8,66	30.92
Initial gasoline		41.86		50.32

On reduction of a increase of octane numbers of the studied catalysts settle down in the sequence: Pt/Ti(33,0)>Pd/AlZr(29,1)> Pt/Al(26,0). The highest increase in o.n., equal to 33.0, was observed on Pt / Ti-catalyst at 300<sup>0</sup>C. All studied catalysts provide a high increase of o. n. not only due to the formation of isoalkanes, but also aromatic compounds with high o. n. From data table.4 it can be seen that the quantity of aromatic compounds increases with increasing temperature on all catalysts, but the greatest quantity is formed on Pt/Ti-catalyst at 350 and 400<sup>0</sup>C-9.2 and 10.0%, which explains the raised increase of o.n. gasoline on this catalyst.

It is known that the selectivity of the isomerizing action of bifunctional catalysts is determined by the ratio of acidic and hydro-dehydrating activities of the catalyst. In this regard, it is of interest to compare the acidic properties of the studied catalysts (table.6) according to NH<sub>3</sub> thermal desorption data.

When modifying mordenite Pt and Pd-catalysts, supported on pillared MM, redistribution of the acid centers for the strength is observed (figure 2 and table 6). This is illustrated by figure 2 on the example of Pd/AlZr.

From figure 2 it can be seen that the introduction of mordenite in Pd/AlZrCaHMM-catalysts a small decrease in the total number of acid centers of different strengths is observed, regardless of the content of Pd.

So, for the 0,1%Pd-catalyst the total acidity decreases from 220,3 to 211,0 mcmol NH<sub>3</sub>/g, and in case of the 0,35%Pd-catalyst mordenite reduces acidity from 249,3 to 230,0 mcmol of NH<sub>3</sub>/g. Such reduction of the total acidity is followed by redistribution of a.c.on strength. At the introduction of the mordenite the quantity of weak a. c. decreases, and keeping of middle and strong increases.

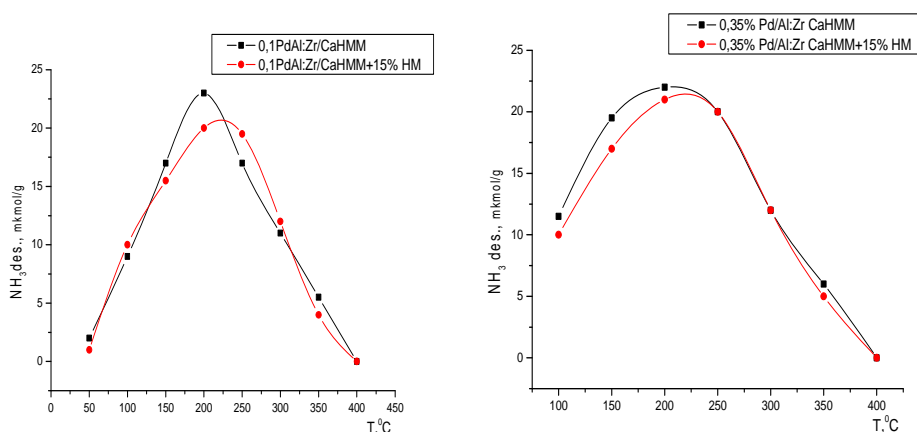


Figure 2 - Curves of thermal desorption of NH<sub>3</sub> from Pd/AlZrCaHMM-catalysts with various quantity of Pd and modification by mordenite

Table 6 – Distribution of acid centers in the mordenite containing Pt-and Pd-catalysts supported on pillared Al, Al-Zr and Ti montmorillonite

Sample	Quantity of acid centers	Acid centers			Total acidity
		Weak <200 <sup>0</sup> C	Middle 200-300 <sup>0</sup> C	Strong >300 <sup>0</sup> C	
0,35%Pt/Al(2,5)NaHMM+HM	%	49,81	40,19	10,0	100
	mcmolNH <sub>3</sub> /g	106,89	86,24	21,46	214,6
0,35%Pd/Al:ZrCaHMM +HM	%	44,51	42,55	12,94	100
	mcmolNH <sub>3</sub> /g	102,38	97,87	29,76	230,0
0,35%Pt/Ti(5.0)NaHMM+HM	%	45,42	44,06	10,52	100
	mcmolNH <sub>3</sub> /g	84.10	81.58	19.48	185.2

Comparison of results on acidity of the studied catalysts shows that on reduction of total acidity catalysts it is possible to arrange in the following row: Pd/AlZrCaHMM+HM (230,0 mcmol NH<sub>3</sub>/g)> Pt/Al(2,5)NaHMM+HM(214.6)> Pt/Ti(5.0) NaHMM+HM (185.2). The same row on the decrease of the sum of the weak and middle acid centers is observed for studied catalysts: Pd/AlZr (200,25)> Pt/Al(193,13)>Pt/Ti (165,68 mcmol NH<sub>3</sub>/g). In the same sequence, the catalysts are arranged to reduce the content of isomers formed during the hydroconversion of the light fraction of straight-run gasoline, which indicates that the isomerizing activity is determined by the sum of weak and medium acid centers at which isomerization is carried out.

Now the most modern of technologies of a skeletal isomerization of n- alkanes which are already used in the industry [17-21] are the technologies with the use of Pt-catalysts on sulfated oxides of metals developed in the late 90-ies by firms UOP (USA) - and JSC NPP Neftekhim (Russia, Krasnodar). Comparison of the results received on the catalysts developed by us will be carried out with data on sulfated zirconium oxide catalysts of UOP and JSC “Neftekhim” (table 7). From table 7 it is visible that depth of processing of light alkanes on the example of n-hexane which was defined as the relation 2,2ДМБ/ΣC<sub>6</sub>, masses %, (depth of isomerization of n-hexane, DIH), hesitates in ~ identical limits 30-32 and 30-31 on the RussianСИ-2 catalysts in process of Izomalk-2 at two different plants while in JSC Ufaneftekhim depth of an isomerization of n-hexane was 18-22 that is possibly connected with more high temperature of the process. On the similar catalyst of UOP of the brandPI-242 value of DIH was 20-27 that is also explained by more high temperature of process.

The laboratory and enlarged laboratory researches of the catalyst developed in IFCE have shown higher depth of an isomerization of hexane equal 28-39mass. %, in comparison with modern Pt/ZrO<sub>2</sub>catalysts. Despite more high temperature of carrying out process of an isomerization, the selectivity on isomers remain very high -98-99%. The developed catalyst is characterized by increased stability, easily regenerated and is certainly of interest for practical use.

Table 7 - Indicators of isomerization process of n-alkanes on industrial UOP, JSC NPP "Neftekhim" and ITKE catalysts

Catalyst	Petroleum refining plant	Process	Process parameters	Octane number	Depth of isomerization, %
Pt/ZrO <sub>2</sub> -SO <sub>4</sub> (CH-2)	CJSC Ryazanskaya Oil Refinery	Isomalk-2	T=130 <sup>0</sup> C P=2,8-2,9 MPa	83-84	DIH=30-32
Pt/ZrO <sub>2</sub> -SO <sub>4</sub> (CH-2)	JSC Ufaneftekhim	Isomalk-2	T=170-180 <sup>0</sup> C P=3 MPa	81-82	DIH=18-22
Pt/ZrO <sub>2</sub> -SO <sub>4</sub> (CH-2)	Kirishinefteorgsintez	Isomalk-2		85	DIH=30-31
Pt/ZrO <sub>2</sub> -SO <sub>4</sub> (PI-242)	UOP	Par-Isom	T=140-190 <sup>0</sup> C	81-83	DIH=20-27
Pd/AlZrCaHMM+HM	Laboratory of Institute of fuel, catalysis and electrochemistry	Isomerization - hexane	T=300- 350 <sup>0</sup> C		DIH=28-39

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**Al, AlZr ЖӘНЕ Ti-мен ПИЛЛАРИРЛЕНГЕН Na- ЖӘНЕ Ca-ФОРМАЛЫ МОНТМОРИЛЛОНИТКЕ  
ЕНГІЗІЛГЕН Pt- ЖӘНЕ Pd-КАТАЛИЗАТОРЛАРЫНДАҒЫ ТІКЕЛЕЙ АЙДАЛҒАН БЕНЗИННІҢ  
ЖЕҢІЛ ФРАКЦИЯСЫНЫҢ ИЗОМЕРИЗАЦИЯСЫ**

**Аннотация.** Бұл жұмыста Al, AlZr және Ti-мен пилларирленген және белсендірілген Na- және Ca-формалы монтмориллонитке енгізілген цеолитсіз және морденитқұрамдыPt- және Pd-катализаторларындағы тікелей айдалған бензиннің жеңіл фракциясының изомерленуі бойынша мәліметтер келтірілген. Катализаторларға БЭТ, рентгенфазалық және элементтік талдау әдістерімен сипаттама берілді, аммиак термодесорбциясы бойынша олардың қышқылдық қасиеттері анықталды. Бензиннің жеңіл фракциясын изомерлеу процесінде пайда болатын изомерлердің көбірек саны Pt/Al(26,48%), сосын Pd/AlZr(23,56%), одан кейін Pt/Ti (23,15%) катализаторларында табылды. Зерттелген катализаторлардың қышқылдық нәтижелері мен олардың күштері бойынша таралуын салыстырғанда, әлсіз және орташа қышқылды орталықтардың суммалық мөлшері мен зерттелген катализаторлардың изомерлеу белсенділігі арасында өзара байланыс болатыны көрсетілді. Бұдан әрі қарай жеңіл қ-алкандарды изомерлеу процесінде қолдану үшін 0,35%Pt/Al(2,5)NaНММ-катализаторы ұсынылды.

**Түйін сөздер:** изомерлеу, тікелей айдалған бензин, жеңіл-алкандар, морденит, пилларирлеу, Pt мен Pd-катализаторлары, октан саны, селективтілік.

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**ИЗОМЕРИЗАЦИЯ ЛЕГКОЙ ФРАКЦИИ ПРЯМОГОННОГО БЕНЗИНА НА Pt-  
И Pd-КАТАЛИЗАТОРАХ, НАНЕСЕННЫХ НА ПИЛЛАРИРОВАННЫЙ Al,  
AlZr И Ti МОНТМОРИЛЛОНИТ В Na- И Ca-ФОРМАХ**

**Аннотация.** В работе приведены данные по изомеризации легкой фракции прямогонного бензина на бесцеолитных и морденитсодержащих Pt и Pd-катализаторах, нанесенных на активированный и пилларированный Al, AlZr и Ti монтмориллонит в Na- и Ca-формах. Катализаторы охарактеризованы методами БЭТ, рентгенофазового и элементного анализа, определены их кислотные свойства по термодесорбции аммиака. Наибольшее количество изомеров, образующихся в процессе изомеризации легкой фракции бензина, найдено на Pt/Al-катализаторе (26,48%), за ним следует Pd/AlZr(23,56%), а далее Pt/Ti (23,15%). Сопоставление результатов по кислотности изученных катализаторов и их распределению по силе показывает, что наблюдается корреляция между суммарным количеством слабых и средних кислотных центров и изомеризующей активностью изученных катализаторов. Для дальнейшего практического использования в процессе изомеризации легких н-алканов предложен 0,35%Pt/Al(2,5)NaНММ-катализатор.

**Ключевые слова:** изомеризация, прямогонный бензин, легкие н-алканы, морденит, пилларирование, Pt и Pd-катализаторы, октановые числа, селективность.

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МАЗМҰНЫ

<i>Кантуреева Г.О., Defrancesco E., Алибеков Р.С., Уразбаева К.А., Ефимова И.Е.</i> Қазақстанның дәстүрлі азық-түлік өнімдерді сәйкестендіру жаңа тенденциялары .....	6
<i>Туктин Б.Т., Теңізбаева А.С., Нұрғалиев Н.Н., Шаповалова Л.Б., Яскевич В.И.</i> Модифицирленген Ni(Co)-Mo- Al <sub>2</sub> O <sub>3</sub> катализаторларында тура айдалған бензин фракциясын гидроизомерлеу және гидроөңдеу .....	13
<i>Ахметалимова А.М., Ивасенко С.А., Марченко А.Б., Ишмуратова М.Ю., Ползчак Э., Людвичук А., Посева И.В.</i> Қарағанды өңіріндегі <i>THYMUS EREMITA</i> KLOK. және <i>THYMUS RASITATUS</i> KLOK. өсімдіктерінің химиялық құрамын зерттеу.....	20
<i>Фазылов С.Д., Нұркенов О.А., Журинов М.Ж., Әрінова А.Е., Туктаров А.Р., Исәева А.Ж., Шаихова Б.К.</i> С <sub>60</sub> фуллеренге гидразондардың палладий комплекстерімен катализденетін циклооксиділуы .....	26
<i>Опимах Е.В., Левданский А.Э., Голубев В.Г., Корганбаев Б.Н., Сарсенбекулы Д.</i> Ұсақтау барысындағы меншікті энергия шығындарын төмендетудің келешекті бағыттары .....	32
<i>Қапсәмет М.Ж., Тәжібаева С.М., Уракаев Ф.Х., Уралбеков Б.М., Бүркімбаев М.М., Бачилова Н.В.</i> Нанокүкіртті алу және тұрақтандыру .....	41
<i>Байсанов С.О., Толоконникова В.В., Нарикбаева Г.И., Корсукова И.Я., Жучков В.И.</i> Күй диаграммасына талдау жасау негізінде марганецті және хромды феррокорытпаларды балқытуға термодинамикалық бағалау.....	47
<i>Құлекеев Ж.Ә., Нұртаева Г.Қ., Мұстафин Е.С., Айнабаев А.А., Мұстафин Т.Е., Борсынбаев А.С., Жарикесов Ф.А.</i> Теңізге төгілген мұнайды жоюда хердерлерді пайдаланудың мүмкіндіктері .....	58
<i>Туктин Б.Т., Нурғалиев Н.Н., Тенизбаева А.С., Шаповалова Л.Б., Комашко Л.В.</i> Бензиннің әртүрлі фракцияларын модифицирленген алюмокобальтмолибден катализаторларында гидрожақсарту .....	67
<i>Қалдыбекова А.Ж., Амангазиева А.Т., Халменова З.Б., Үмбетова А.К.</i> <i>Harlophyllum</i> A. Juss шөбінен биологиялық белсенді заттардың кешенді бөліну технологиясын дамыту .....	74
<i>Опимах Е.В., Левданский А.Э., Волненко А.А., Жумадуллаев Д.К.</i> Флотациялық процесстерді жүргізу әдістері .....	82
<i>Чиркун Д. И., Левданский А. Э., Волненко А.А., Сарсенбекулы Д.</i> Соккылы-ортдан тепкіш диірмендердегі бөлшектердің динамикасын зерттеу .....	92
<i>Баймұқашева Г.К., Қалауова А.С., Құспанова Б.К., Насиров Р.Н.</i> Үшфенилфосфиннің анион-радикалы.....	102
<i>Баешова А.К., Молайган С., Баешов А.Б.</i> Сутектік энергетиканың қазіргі замандағы жағдайы және сутекті алу әдістері .....	107
<i>Закарина Н.А., Дәлелханұлы О., Жумадуллаев Д.А., Акурпекова А.К., Джумабаева Л.С.</i> Al, AlZr және Ti-мен пилларирленген Na- және Ca-формалы монтмориллонитке енгізілген Pt- және Pd-катализаторларындағы тікелей айдалған бензиннің жеңіл фракциясының изомеризациясы.....	117
<i>Нәсіров Р.Н.</i> ЭПР спектроскопия көмегімен каспий маңындағы мұнайлардағы ванадийді анықтау.....	125
<i>Байжуманова Т.С., Тунгатарова С.А., Xanthopoulou G., Жексенбаева З.Т., Кауменова Г.Н., Еркибаева М.К., Жумабек М., Касымхан К.</i> Метанның олефиндерге дейін каталитикалық конверсиясы.....	132
<i>Калимукашева А.Д., Калиманова Д.Ж., Иманкулова З.А.</i> Формативті бағалау-химия сабақтарында оқыту процесінің ажырамас бөлігі.....	139
<i>Масенова А.Т., Калыкбердиев М.К., Сасс А.С., Кензин Н.Р., Канатбаев Е.Т., Цыганков В.П.</i> Бензин фракцияларындағы хош иісті көмірсутектерді жоғары қысымда отырғызылғын катализаторларды қолдану арқылы сутектендіру.....	146

## СОДЕРЖАНИЕ

<i>Кантуреева Г.О., Defrancesco E., Алибеков Р.С., Уразбаева К.А., Ефимова И.Е.</i> Новые тенденции в идентификации традиционной пищевой продукции Казахстана .....	6
<i>Туктин Б.Т., Тенизбаева А.С., Нурғалиев Н.Н., Шаповалова Л.Б., Яскевич В.И.</i> Исследование гидроочистки и гидроизомеризации прямогонной бензиновой фракции на модифицированных Ni(Co)-Mo- Al <sub>2</sub> O <sub>3</sub> - катализаторах .....	13
<i>Ахметалимова А.М., Ивасенко С.А., Марченко А.Б., Ишмуратова М.Ю., Полезчак Э., Людвичук А., Лосева И.В.</i> Исследование химического состава <i>THYMUS EREMITA KLOK.</i> и <i>THYMUS RASITATUS KLOK.</i> Карагандинского региона .....	20
<i>Фазылов С.Д., Нуркенов О.А., Журинов М.Ж., Аринова А.Е., Туктаров А.Р., Исаева А.Ж., Шахова Б.К.</i> Катализируемое комплексами палладияциклоприсоединение гидразонов к фуллерену C <sub>60</sub> .....	26
<i>Опимах Е.В., Левданский А.Э., Голубев В.Г., Корганбаев Б.Н., Сарсенбекулы Д.</i> Перспективные направления снижения удельных энергозатрат при измельчении .....	32
<i>Кансамет М.Ж., Тажибаева С.М., Уракаев Ф.Х., Уралбеков Б.М., Буркитбаев М.М., Бачилова Н.В.</i> Получение и стабилизация наносеры .....	41
<i>Байсанов С.О., Толоконникова В.В., Нарикбаева Г.И., Корсукова И.Я., Жучков В.И.</i> Термодинамическая оценка выплавки марганцевых и хромистых ферросплавов на основе анализа их диаграмм состояния .....	47
<i>Кулекеев Ж.А., Нуртаева Г.К., Мустафин Е.С., Айнабаев А.А., Мустафин Т.Е., Борсынбаев А.С., Жарикесов Г.А.</i> Возможности использования хердеров при ликвидации разливов нефти на море .....	58
<i>Туктин Б.Т., Нурғалиев Н.Н., Тенизбаева А.С., Шаповалова Л.Б., Комашко Л.В.</i> Гидрооблагораживание различных бензиновых фракций на модифицированных алюмокобальтмолибденовых катализаторах .....	67
<i>Калдыбекова А.Ж., Амангазиева А.Т., Халменова З.Б., Умбетова А.К.</i> Разработка технологии комплексного выделения биологических активных веществ из растений рода <i>Naplophyllum</i> A. Juss .....	74
<i>Опимах Е.В., Левданский А.Э., Волненко А.А., Жумадуллаев Д.К.</i> Методы проведения флотационных процессов .....	82
<i>Чиркун Д. И., Левданский А. Э., Волненко А.А., Сарсенбекулы Д.</i> Исследование динамики частиц в ударно-центробежных мельницах .....	92
<i>Баймукашева Г.К., Калауова А.С., Куспанова Б.К., Насиров Р.Н.</i> Анион-радикал трифенил-фосфина .....	102
<i>Баешова А.К., Молайган С., Баешов А.Б.</i> Современное состояние водородной энергетики и способы получения водорода .....	107
<i>Закарина Н.А., Дәлелханұлы О., Жумадуллаев Д.А., Акурпекова А.К., Джумабаева Л.С.</i> Изомеризация легкой фракции прямогонного бензина на Pt- и Pd-катализаторах, нанесенных на пилларированный Al, AlZr и Ti монтмориллонит в Na- и Ca-формах .....	117
<i>Насиров Р.Н.</i> Определение ванадия в нефтях прикаспийского региона методом ЭПР-спектроскопии .....	125
<i>Байжуманова Т.С., Тунгатарова С.А., Xanthoroulou G., Жексенбаева З.Т., Кауменова Г.Н., Еркибаева М.К., Жумабек М., Касымхан К.</i> Каталитическая конверсия метана в олефины .....	132
<i>Калимукашева А.Д., Калиманова Д.Ж., Иманкулова З.А.</i> Формативное оценивание - неотъемлемая часть процесса обучения на уроках химии .....	139
<i>Масенова А.Т., Калыкбердиев М.К., Сасс А.С., Кензин Н.Р., Канатбаев Е.Т., Цыганков В.П.</i> Гидрирование ароматических углеводородов в бензиновых фракциях на нанесенных катализаторах под давлением .....	146

CONTENTS

<i>Kantureeva G.O., Defrancesco E., Alibekov R.S., Urazbayeva K.A., Efimova I.E.</i> New trends in the identification of the traditional food products of Kazakhstan .....	6
<i>Tuktin B.T., Tenizbaeva A.S., Nurgaliyev N.N., Shapovalova L.B., Yaskevich V.I.</i> Study of hydro purification and hydroisomerization straight-run gasoline fraction over modified Ni(Co)-Mo- Al <sub>2</sub> O <sub>3</sub> - catalysts .....	13
<i>Akhmetlimova A.M., Ivashenko S.A., Marchenko A.B., Ishmuratova M.Yu., Poleszak E., Ludwiczuk A., Loseva I.V.</i> The study of the chemical composition of <i>THYMUS EREMITA</i> KLOK. and <i>THYMUS RASITATUS</i> KLOK. from the Karaganda region .....	20
<i>Fazylov S.D., Nurkenov O.A., Zhurinov M.Zh., Arinova A.E., Tuktarov A.R., Issayeva A.Zh., Shaihova B.K.</i> Catalyzed by palladium complexes the cycloaddition of hydrazones to fullerene C <sub>60</sub> (in English).....	26
<i>Apimakh Ye.V., Leudanski A.E., Golubev V.G., Korganbayev B.N., Sarsenbekuly D.</i> Promising directions of reducing specific energy costs in grinding (in English).....	32
<i>Kapsamet M.Zh., Tazhibayeva S.M., Urakaev F.Kh., Uralbekov B.M., Burkitbayev M.M., Bachilova N.V.</i> Obtaining and stabilization of nanosulfur .....	41
<i>Baisanov S.O., Tolokonnikova V.V., Narikbayeva G.I., Korsukova I.Ya., Zhuchkov V.I.</i> Thermodynamic assessment of smelting of manganese and chromium ferroalloys based on the analysis of their state diagrams .....	47
<i>Kulekeyev Zh.A., Nurtayeva G.K., Mustafin E.S., Ainabayev A.A., Mustafin T.E., Borsynbayev A.S., Zharikessov G.A.</i> Using herders for oil spill response in the sea .....	58
<i>Tuktin B.T., Nurgaliyev N.N., Tenizbaeva A.S., Shapovalova L.B., Komashko L.V.</i> Hydrotreating of various petrol fractions over modified alumocobaltmolybdenic catalysts .....	67
<i>Kaldybekova A.Zh., Amangazyeva A.T., Halmenova Z.B., Umbetova A.K.</i> Development of technology for the complex isolation of biological active substances from plants of the genus <i>Haplophyllum</i> A. Juss .....	74
<i>Apimakh Ye.V., Leudanski A.E., Volnenko A.A., Zhumadullaev D.K.</i> Methods of carrying out flotation processes .....	82
<i>Chyrkun D.I., Levdanskiy A.E., Volnenko A.A., Sarsenbekuly D.</i> Study of the particle dynamics in impact-centrifugal mills (in English).....	92
<i>Baymukasheva G.K., Kalauova A.S., Kuspanova B., Nasirov R.N.</i> Triphenylphosphine anion radical.....	102
<i>Bayeshova A.K., Molaigan S., Bayeshov A.B.</i> Hydrogen energetics current state and hydrogen production methods.....	107
<i>Zakarina N.A., Dolelkhanyly O., Jumadullaev D.A., Akurpekova A.K., Djumabaeva L.S.</i> Isomerization of light fraction of straight-run gasoline on Pt- and Pd-catalysts supported on pillared by Al, AlZr and Ti montmorillonite in Na- and Ca-forms.....	117
<i>Nasirov R.N.</i> Determination of vanadium in the precaspian region's oil by the EPR-spectroscopy method.....	125
<i>Baizhumanova T.S., Tungatarova S.A., Xanthopoulou G., Zheksenbaeva Z.T., Kaumenova G.N., Erkibaeva M.K., Zhumabek M., Kassymkan K.</i> Catalytic conversion of methane into olefins.....	132
<i>Kalimukasheva A.D., Kalimanova D.Z., Imankulova Z.A.</i> Formative evaluation is an uninterrupted part of the training process on lessons of chemistry.....	139
<i>Massenova A.T., Kalykberdiyev M.K., Sass A.S., Kenzin N.R., Kanatbayev E.T., Tsygankov V.P.</i> Hydrogenation of aromatic hydrocarbons in gasoline fractions over supported catalysts under pressure.....	146



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