https://doi.org/10.1051/e3sconf/202452403018

Aromatization patterns of hexane in high silicon zeolite

Khudoyor Rahmatov[1], *Normurot* Fayzullaev[2], *Firdavsiy* Buronov[1], *Shavkat* Matmuratov[3], *Yuldash* Takhirov[3], *Mohamed* Rifky[4], *Kasun* Dissanayake[1] and *Murodjon* Samadiy[1]*

[1]Karshi Engineering-Economics Institute, Qarshi, 180100, Uzbekistan
[2]Samarkand State University, Samarkand, 140100, Uzbekistan
[3]Urgench State University, Urgench, 220100, Uzbekistan
[4]Eastern University, Sri Lanka, Chenkalady, 30350, Sri Lanka

Abstract. In this article, methods of preparation of catalysts in analogues of in high-silica zeolite, conversion of n-hexane in the catalysts keeping in high-silica zeolite, of n-hexane to aromatic hydrocarbons, n-hexane to aromatic hydrocarbons in catalysts with high catalytic activity and selectivity modified with copper, 2%Cu*8%Zn/H-High silica zeolite-40 conversion of n-hexane to aromatic hydrocarbons in the composition catalyst, activity in chain branching and aromatization processes to obtain high-octane components of fuels 2%Cu*8%Zn/H- High silica zeolite-40 high silicon, A mesoporous aluminosilicate catalyst with high catalytic activity and selectivity was studied for the catalytic Aromatization of n-hexane to aromatic hydrocarbons. H-High silica zeolite-40 and 2%Cu*8 %Zn/H-High silica zeolite-40 catalysts with high catalytic activity and selectivity selected for catalytic Aromatization of n-hexane to aromatic hydrocarbons, Aromatization, chain branching and carbon-carbon by hydrogen action activity in the process of breaking the bond was studied.

1 Introduction

Oxide catalysts with high catalytic activity and selectivity selected for the catalytic Aromatization of unbranched standard structure hexane to aromatic hydrocarbons, mainly benzene, toluene, and xylenes, involve the transfer of charge from hydrocarbons to the active centre [1-2]. Therefore, the concept of acidity in catalysts with high catalytic activity and selectivity selected for catalytic Aromatization of unbranched standard structure hexane to aromatic hydrocarbons, mainly benzene, toluene and xylenes, is very simplified and needs Catalysts with high catalytic activity and selectivity selected for the catalytic Aromatization of unbranched standard structure hexane to aromatic hydrocarbons, mainly benzene, toluene and xylenes, contain more dispersed platinum (in the form of dendrites). In the processes of chain branching, cyclization with hydrogen release and hydrogenation of hydrocarbon activity increases [3-5].

---

* Corresponding author: samadiy@inbox.ru

Promotion of catalysts with high catalytic activity and selectivity with halogen acids or haloalkyls, selected for catalytic Aromatization of aluminium-platinum unbranched standard structure hexane to aromatic hydrocarbons, mainly benzene, toluene, and xylenes, has a dual character. Aluminium oxide can redistribute hydrogen and increase the activity of chain branching and hydrocarbon polymerization, which occurs by breaking the carbon-carbon bond [6-8]. On the other hand, the presence of halogen atoms in the tetrahedron platinum [9] stabilizes the ionic state, which contributes to more efficient aromatization processes of saturated hydrocarbons of standard structure. Due to the improvement of the reforming process, depending on the composition of the raw materials and the process conditions, there was a need to flexibly change the properties of the catalyst with high catalytic activity and selectivity, selected for the catalytic Aromatization of hexane with an unbranched standard structure to aromatic hydrocarbons, mainly benzene, toluene, and xylenes.

From this point of view, it turned out to be much more convenient to use chlorine as a promoter; its content in the catalyst with high catalytic activity and selectivity was selected to carry out the catalytic Aromatization of unbranched standard structure hexane to aromatic hydrocarbons, mainly benzene, toluene and xylenes, by adding organochlorine compounds to the raw materials can be changed. A catalyst with high catalytic activity and selectivity selected for the catalytic Aromatization of new or regenerated unbranched standard structure hexane to aromatic hydrocarbons, mainly benzene, toluene and xylenes, oxygen treatment with the addition of organochlorine compounds (often dichloroethane,) significantly increases its thermal stability [10].

Aluminum-platinum unbranched standard structure hexane catalysts with high catalytic activity and selectivity selected for the catalytic Aromatization of aromatic hydrocarbons mainly to benzene, toluene, and xylenes exhibit the characteristics of high carbon-carbon bond breaking during the initial period of operation, which makes the hydrocarbon leads to a decrease in the amount of hydrogen in the gas and an increase in coking of a catalyst with high catalytic activity and selectivity, selected for the catalytic Aromatization of unbranched standard structure hexane to aromatic hydrocarbons, mainly benzene, toluene and xylenes [11-13]. To prevent such phenomena, the catalysts with high catalytic activity and selectivity selected for catalytic Aromatization of unbranched standard structure hexane to aromatic hydrocarbons, mainly benzene, toluene and xylene, were developed after reducing H2 flow. Catalysts with high catalytic activity and selectivity, selected for the catalytic Aromatization of the resulting unbranched standard structure hexane to aromatic hydrocarbons, mainly benzene, toluene and xylenes, have low sensitivity to poisoning by sulfur-containing compounds during the reforming process and to the effects of moisture or micro-pollution in the operating mode was found to be [14-19].

2 Methods

Experiments for extracting aromatic hydrocarbons from unbranched standard structure hexane were carried out in a flow-type apparatus. A 2-3 mm glass mesh is placed inside the reactor, on which a catalyst with high catalytic activity and selectivity is selected for the catalytic Aromatization of non-branched normal-structured hexane to aromatic hydrocarbons, mainly benzene, toluene, and xylenes, corresponding to a process zone volume of 9 cm^3 placed in quantity.

A catalyst with high catalytic activity and selectivity selected for the catalytic Aromatization of unbranched standard structure hexane to aromatic hydrocarbons, mainly benzene, toluene, and xylenes, is placed in the constant temperature zone of the furnace, which is set by serial temperature measurement using a thermocouple before the experiment. The volume of the process zone is calculated by setting the length of the test tube to equal temperature. Catalytic Aromatization of unbranched standard structure hexane to aromatic hydrocarbons based on benzene, toluene and xylenes to prevent the formation of a liquid layer of a catalyst with high catalytic activity and selectivity. It is coated with quartz on top of the catalyst, has high catalytic activity, and has selectivity selected to increase [20-24].

A catalyst with high catalytic activity and selectivity was selected for the catalytic Aromatization of non-branched normal structure hexane to aromatic hydrocarbons, mainly benzene, toluene, and xylenes. It was heated at 500 °C for 5 hours in an air stream, then in a helium stream for 1 hour and in a hydrogen stream for 1 hour. It was activated for 2 hours.

3 Results and Discussion

High silica zeolite conversion of non-branched normal structured hexane on storage catalysts. Advances in Hydrocarbon Conversion Chemistry High-silicon, mesoporous aluminosilicate unbranched standard structure, characterized by selectivity, high activity, thermal stability, and resistance to poisoning by organometallic, sulfur, and nitrogen compounds, has been selected to carry out the catalytic Aromatization of hexane to aromatic hydrocarbons, mainly benzene, toluene, and xylenes. It is inextricably linked to creating catalysts with catalytic activity and selectivity. In addition, a catalyst with high catalytic activity and selectivity selected for the catalytic Aromatization of non-branched standard structure hexane to aromatic hydrocarbons based on benzene, toluene and xylenes, and the conversion of both the hydrocarbon feedstock in it to aluminium-metal non-branched standard structure hexane to aromatic hydrocarbons based on benzene, does not require the use of hydrogen-containing gas, unlike the reforming process carried out on catalysts with high catalytic activity and selectivity, selected for catalytic Aromatization to toluene and xylenes.

High silica, mesoporous aluminosilicate-containing unbranched standard structure hexane catalysts with high catalytic activity and selectivity are selected for the catalytic Aromatization of hexane to aromatic hydrocarbons, mainly benzene, toluene, and xylenes. Processing fractions of a flammable liquid hydrocarbon mixture has significant advantages over pure aluminium oxide, which is used as a basis in catalysts with high catalytic activity and selectivity, selected for the catalytic Aromatization of non-branched standard structure hexane to aromatic hydrocarbons, mainly benzene, toluene and xylenes. High-silica, mesoporous aluminosilicates are sound absorbers of straight-chain, lower molecular weight saturated hydrocarbons in large quantities (about 30%) in the feedstock, so the 20-point octane number is low. Still, high-silica, mesoporous aluminosilicates are non-branched normal structure hexane with aromatic hydrocarbons, mainly benzene, toluene and to obtain high-quality gasoline and aromatic hydrocarbons in the presence of catalysts with high catalytic activity and selectivity selected for catalytic Aromatization to xylenes, fractions of gasoline and oil highly flammable liquid hydrocarbon mixtures are enriched with aromatic hydrocarbons and iso-low molecular saturated hydrocarbons depending on the process conditions allows you to get components of motor fuel.

H-High silica zeolite-40 converts the catalyst's unbranched standard structure hexane to aromatic hydrocarbons, mainly benzene, toluene, and xylenes. High-silicon, mesoporous aluminosilicate H-In high-silica zeolite-40 is selected for the catalytic Aromatization of hexane to aromatic hydrocarbons, primarily benzene, toluene, and xylenes, to obtain high-octane components of aromatic hydrocarbons and lower molecular weight saturated hydrocarbons with isostructure. It was studied in a flow-type device with a catalyst, at normal atmospheric pressure, at a flow rate of 0.5 s^{-1} in the temperature range of 400, 450, and 500 °C. The activity of the catalyst with high catalytic activity and selectivity selected for the catalytic Aromatization of the studied unbranched standard structure hexane to aromatic hydrocarbons, mainly benzene, toluene and xylenes, was evaluated by the number of aromatic hydrocarbons, isostructural, hydrocarbons and hydrocarbons with C_1-C_5 composition. The results of the conversion of unbranched standard structure hexane to aromatic hydrocarbons, mainly benzene, toluene and xylenes in the catalyst with high catalytic activity and selectivity selected to carry out the catalytic Aromatization of this unbranched standard structure hexane to aromatic hydrocarbons mainly benzene, toluene and xylenes are shown in Table 1 and Figure 1 given.

Table 1. H-High silica zeolite-40 results from the conversion of unbranched standard structure hexane in the catalyst at atmospheric pressure and volume velocity of 0.5 s^{-1}.

T,⁰C	**ΣC_1-C_5, %**	**Σ_i,%**	**Σ_{Ar},%**	**Conversion rate. %**	**Selectivity. %**		
					Hydrocracking	**Isomerization**	**Flavouring**
400	10.25	28.8	58.85	94.82	8.56	31.28	58.1
450	17.45	8.2	72.85	96.35	16.46	6.89	74.1
500	16.26	1.8	78.18	97.48	17.28	4.28	79.0

It can be seen from Table 1 that under the conditions of this process, the conversion of unbranched standard structure hexane in the catalyst with high catalytic activity and selectivity selected to carry out the catalytic Aromatization of the studied unbranched standard structure hexane to aromatic hydrocarbons mainly benzene, toluene and xylenes is a high conversion at 400 °C (94.82%) and the conversion rate at 500 °C is almost 97.48%. As shown in Figure 1, with increasing temperature, the selectivity of isostructural compounds in the direction of formation processes decreases sharply.

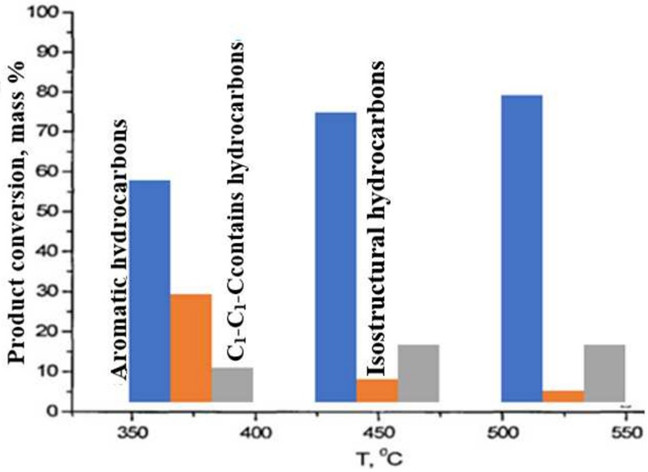

Fig. 1. H-High silica zeolite-40 conversion of unbranched standard structure hexane to aromatic hydrocarbons, mainly benzene, toluene and xylene in the catalyst.

High silicon, high-silicon, mesoporous aluminosilicate H-High silica zeolite-40 is a catalyst with high catalytic activity and selectivity selected for the catalytic Aromatization of unbranched normal structure hexane to aromatic hydrocarbons based on benzene, toluene, and xylenes. Conversion to xylenes is significantly contributed by hydrogen-induced carbon-carbon bond-breaking processes (8.2% at 400 °C and 15.3% at 500 °C).

High silica zeolite conversion of unbranched normal-structured hexane to aromatic hydrocarbons, mainly benzene, toluene, and xylene, in the catalyst.

To obtain high-octane components of the iso-structure of motor fuel and aromatic hydrocarbons, high-silicon, mesoporous aluminosilicate High silica zeolite, an analogue of H-High silica zeolite-40, but with a high silicate modulus, perform catalytic Aromatization of unbranched standard structure hexane to aromatic hydrocarbons mainly benzene, toluene and xylene. A catalyst with high catalytic activity and selectivity was also studied, for which the silicate modulus is 55 for H-High silica zeolite-40 and 88.7 for High silica zeolite. Table 2 and Figure 2 show information about the conversion products of unbranched normal structure hexane in High silica zeolite catalyst with high catalytic activity and selectivity selected for the catalytic Aromatization of unbranched normal structure hexane to aromatic hydrocarbons, mainly benzene, toluene and xylenes.

Table 2. High silica zeolite Results from the conversion of unbranched standard structure hexane in the catalyst at atmospheric pressure and volume velocity of 0.5 s^{-1}.

T,^{0}C	**ΣC_1-C_5 %**	**Σ$_i$ %**	**Σ$_{Ar}$,%**	**Conversion rate %**	**Selectivity %**		
					Hydrocracking	**Isomerization**	**Flavouring**
400	3.6	27.6	0.56	57.9	7.5	50.9	2.00
450	5.3	5.8	49.2	63.3	8.9	8.9	80.3
500	8.2	4.2	51.9	70.4	11.7	5. 5	74.9

As can be seen from Table 2, under the conditions of this process, the catalyst with high catalytic activity and selectivity was selected for catalytic Aromatization of unbranched normal structure hexane to aromatic hydrocarbons based on benzene, toluene, and xylenes. Conversion to xylenes at 400 °C has a high conversion rate of 57.9%, while this figure is 63.3% at 450 °C and almost 70.4% at 500 °C.

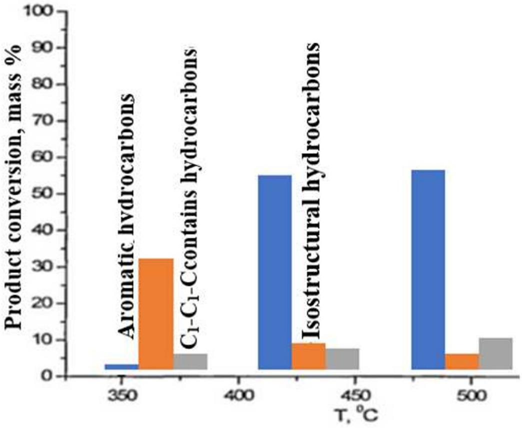

Fig. 2. High silica zeolite conversion of unbranched standard structure hexane to aromatic hydrocarbons, mainly benzene, toluene and xylene in the catalyst.

This indicates that the high silica zeolite-40 catalyst has a higher activity than the high silica zeolite catalyst. As can be seen from Figure 1, initially, at a temperature of 350 °C, the conversion of unbranched standard structure hexane to aromatic hydrocarbons and hydrocarbons with C_1-C_5 content in the high silica zeolite catalyst was low compared to the conversion to isostructural hydrocarbons. Still, when the temperature increased to 500 °C, it was observed that the conversion of unbranched standard structure hexane to aromatic hydrocarbons was much higher.

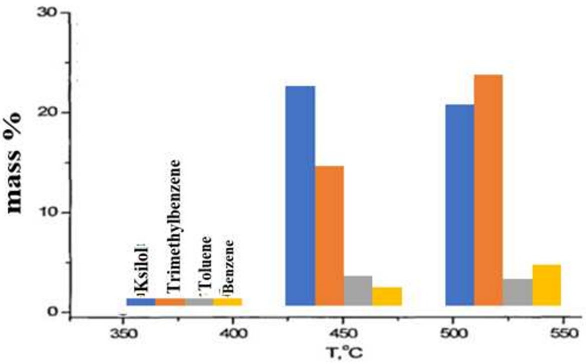

Fig. 3. The composition of aromatic hydrocarbons in the transformation of hexane with unbranched standard structure on the high silica zeolite catalyst.

Figure 3 shows that as the temperature increases, the conversion of unbranched standard structure hexane to xylene and trimethyl benzene increases on the high silica zeolite catalyst. Conversely, the conversion to toluene and benzene is insignificant and very low.

The selectivity of the catalyst with high catalytic activity and selectivity is only 0.9%, but at 450 °C, it is 78%. 5% less than the selectivity of a catalyst with high catalytic activity and selectivity selected for the process at 450 °C to carry out the catalytic Aromatization of unbranched standard structure hexane to aromatic hydrocarbons, mainly benzene, toluene and xylenes. The toluene content is significantly lower in High silica zeolite-40, a catalyst with high catalytic activity and selectivity, selected for the catalytic Aromatization of unbranched standard structure hexane to aromatic hydrocarbons, mainly benzene, toluene and xylenes, compared to the same conditions for the conversion of unbranched normal structure hexane (Figures 2-3) and at 500 °C is only 2.3%.

With an increase in temperature, the octane number increases due to the rise in the conversion rate of unbranched standard-structure hexane and the formation of high-octane aromatic hydrocarbons. The main reason for the increase at 400 °C is the addition of isostructural hydrocarbons.

Conversion of unbranched standard structure hexane to aromatic hydrocarbons, mainly benzene, toluene and xylene, in the high silica zeolite catalyst. Aromatization, chain branching, and hydrogen-induced carbon-carbon bond breaking of the high-silica, high-silica, mesoporous aluminosilicate high-silica zeolite-30 catalyst with high catalytic activity and selectivity selected for the catalytic Aromatization of hexane to aromatic hydrocarbons, mainly benzene, toluene, and xylenes activity in processes was also studied, which in turn is an analogue of the catalyst with high catalytic activity and selectivity selected for the catalytic Aromatization of the two previous unbranched normal structure hexanes to aromatic hydrocarbons mainly benzene, toluene and xylenes. The value of the silicate modulus of the catalyst with high catalytic activity and selectivity selected for the catalytic Aromatization of the studied unbranched standard structure hexane to aromatic hydrocarbons, mainly benzene, toluene and xylenes, is 78.5 units. In contrast, between magnitudes, H- high silica zeolite-40 (55) and high silica zeolite (88.7) are equal. As can be seen from Table 3, the catalyst with high catalytic activity and selectivity selected for the catalytic Aromatization of this non-branched standard structure hexane to aromatic hydrocarbons, mainly benzene, toluene and xylenes, has a high conversion rate of non-branched-normal-structure hexane and is 82% at 400 °C. is 13.1% more than H-High silica zeolite -40 and 28.6% more than high silica zeolite at the same temperature.

Table 3. Results of conversion of unbranched standard structure hexane on high silica zeolite catalyst at normal atmospheric pressure and volume velocity of 0.5 s^{-1}.

T,^{0}C	ΣC_1-C_5%	Σ_i %	Σ_{Ar},%	Conversion rate %	Selectivity %		
					Hydrocr acking	Isomeri zation	Flav oring
400	3.20	12.18	62.38	84.08	4.48	13.08	67.68
450	6.78	13.45	68.86	92.49	6.87	14.58	75.28
500	7.08	14.08	73.09	96.25	8.38	15.69	78.72

The selectivity of the catalyst with high catalytic activity and selectivity, selected for the catalytic Aromatization of hexane with unbranched standard chain structure to aromatic hydrocarbons, mainly benzene, toluene, and xylenes, practically does not change with increasing process temperature and is only 12% at 400 °C to 500 °C. Increases to 13.6% in C, Fig. 4.

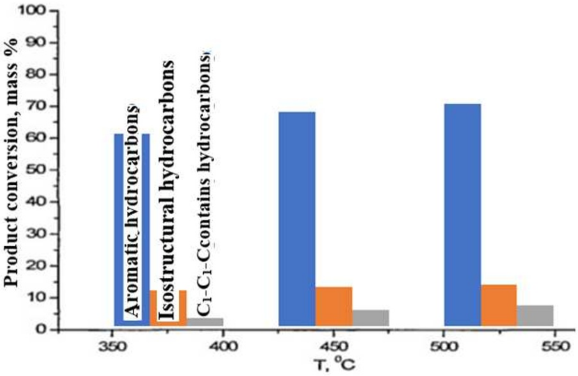

Fig. 4. Conversion of non-branched standard structure hexane to aromatic hydrocarbons, mainly benzene, toluene and xylenes in high silica zeolite catalyst.

As can be seen from Figure 4, the conversion of unbranched normal-structure hexane to aromatic hydrocarbons, isostructural hydrocarbons, and S_1-S_5 hydrocarbons in the high silica zeolite catalyst in the temperature range of 350-500 °C was imperceptible and very low.

In the processes leading to aromatic hydrocarbons, the selectivity of the catalyst with high catalytic activity and selectivity, selected for the catalytic Aromatization of unbranched standard structure hexane to aromatic hydrocarbons, mainly benzene, toluene and xylenes, on the contrary, is high and 66.6% at 400 °C. Makes up to 75.6% at 500 °C. The fact that amount of aromatic hydrocarbons in the catalyst with high catalytic activity and selectivity is 8.5% higher than H- high silica zeolite-40, which was selected for catalytic Aromatization of unbranched standard structure hexane to aromatic hydrocarbons mainly benzene, toluene and xylenes at 400 °C, which for the process, the selective sensitivity of high silica zeolite is the same, only the difference is 0.9%. At 500 °C, the amount of benzene does not exceed 6%; at 400 °C it is 2.5%; at 450 °C it is 3.0% and 3.1%. For the conversion of unbranched standard structure hexane under severe conditions (500 °C), a catalyst with high catalytic activity and selectivity selected to carry out the catalytic Aromatization of unbranched standard structure hexane to aromatic hydrocarbons mainly benzene, toluene and xylenes, respectively for toluene, xylene and trimethylbenzenes the amount is 19.7; 17.3; 20.4% is presented in Figure 5.

The selectivity of the catalyst with high catalytic activity and selectivity, on the contrary, is high, and at 400 °C, it is 66.6%, but it increases to 75.6% when the temperature rises to 500 °C. The benzene content does not exceed 6% and is 2.5% at 400 °C, 3.0% at 450 °C and 3.1% at 500 °C. For the conversion of unbranched standard structure hexane

(500 °C), the catalyst with high catalytic activity and selectivity selected for the catalytic Aromatization of unbranched standard structure hexane to aromatic hydrocarbons mainly benzene, toluene and xylenes, as toluene, xylene and trimethyl benzene content of 19, respectively. 7; 17.3; It is 20.4%, Fig. 5. Hydrocracking processes do not significantly affect the conversion of unbranched standard structure hexane to aromatic hydrocarbons, mainly benzene, toluene, and xylenes, and the number of C_1-C_5 hydrocarbons does not exceed 6% at (500 °C).

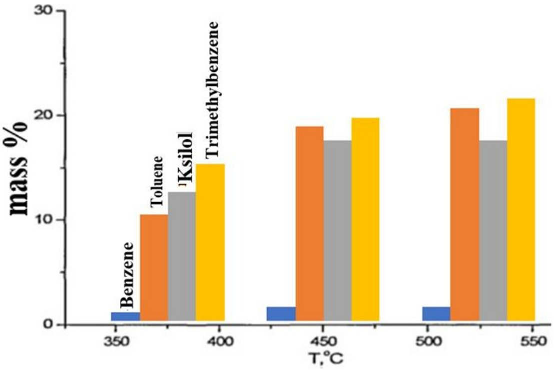

Fig. 5. The composition of aromatic hydrocarbons in the conversion of hexane of unbranched standard structure on the high silica zeolite-30 catalyst.

As can be seen from Figure 4, the conversion of aromatic hydrocarbons from aromatic hydrocarbons to toluene, xylene and trimethyl benzene in the conversion of unbranched standard structure hexane at the temperature of 350-500 C on the high silica zeolite -30 catalyst showed high activity. Still, the conversion to benzene was very slow.

A catalyst with high catalytic activity and selectivity was selected for the catalytic Aromatization of unbranched standard structure hexane to aromatic hydrocarbons, mainly benzene, toluene, and xylenes. The catalyst contributes little to the octane number due to the large number of isostructural hydrocarbons under the influence of the catalyst, about 10 points in technological processes.

Comparison of the activity of catalysts with high catalytic activity and selectivity selected for the catalytic Aromatization of the studied high-silicon unbranched standard structure hexane to aromatic hydrocarbons, mainly benzene, toluene and xylenes shows that at 400 °C all unbranched standard structure hexane mostly aromatic hydrocarbons are benzene, Iso-structured hydrocarbons are formed in catalysts with high catalytic activity and selectivity selected for the catalytic Aromatization of toluene and xylenes. Their amount is the same ~27% in high silica zeolite and H-high silica zeolite-40. The conversion of unbranched normal structured hexane Due to the low productivity, the selectivity is much higher in high silica zeolite-30. High silica zeolite -30, a catalyst with high catalytic activity and selectivity, selected for the catalytic Aromatization of hexane with an unbranched standard structure to aromatic hydrocarbons, mainly benzene, toluene and xylene, has a content of so low molecular saturated hydrocarbons of about 10%. The selectivity in this process direction is low, only 13% at all temperatures, but the degree of conversion of hexane with an unbranched standard structure is much higher and equals 95.2% at 500 °C. In high silica zeolite and H-high silica zeolite-40, the number of aromatic hydrocarbons increases at temperatures of 450 and 500 °C, and the values of 71.4 and 67.8% at 450 °C and 76.9 and 72% at 500 °C are very high. Thus, catalysts with high catalytic activity and selectivity selected for catalytic Aromatization of unbranched standard structure hexane to aromatic hydrocarbons, mainly benzene, toluene, and xylenes, show high activity in aromatization processes at all studied temperature ranges.

The advantages of this method are simplicity, high dispersion, less harmful waste, and effective use of active ingredients due to the availability of starting materials. The pore structure of the catalyst with high catalytic activity and selectivity is selected for the catalytic Aromatization of non-branched standard structure hexane activated with a small amount of active ingredient to aromatic hydrocarbons, mainly benzene, toluene and xylenes. They are choosing a base with an optimal structure to create catalysts with high catalytic activity and selectivity for the catalytic Aromatization of hexane to aromatic hydrocarbons, mainly benzene, toluene, and xylenes. H-high silica zeolite-40 (Si/Al=55; specific surface area) catalysts selected for the catalytic Aromatization of hexane with aromatic hydrocarbons mainly to benzene, toluene and xylenes with high silicon, mesoporous aluminosilicate unbranched standard structure. 273 m^2/g) was used [23-25].

4 Conclusion

Increasing the temperature to 450-500 °C promotes the redistribution of non-branched standard structure hexane conversion processes. Catalysts with high catalytic activity and selectivity are selected for the catalytic Aromatization of unbranched standard structure hexane to aromatic hydrocarbons, mainly benzene, toluene, and xylenes, for hydrogen evolution and hydrogen evolution cyclization processes, which increases the selectivity of aromatic unbranched standard structure hexane. leads to increased aromatic hydrocarbons in catalysts with high catalytic activity and selectivity selected for catalytic Aromatization of hydrocarbons, mainly benzene, toluene and xylenes. Catalyst with high catalytic activity and selectivity selected for catalytic Aromatization of unbranched standard structure hexane to aromatic hydrocarbons based on benzene, toluene and xylenes with the introduction of copper to a catalyst with high catalytic activity and selectivity selected for catalytic Aromatization of unbranched standard structure hexane to aromatic hydrocarbons based on benzene, toluene and xylenes Catalysts with catalytic activity and selectivity also decrease their selectivity to carbon-carbon bond breaking processes under the influence of hydrogen.

References

1. P. Herman, The chemistry of catalytic hydrocarbon conversions, Elsevier (2012)
2. M. Sami and F.H Lewis, Chemistry of petrochemical processes, Elsevier (2001)
3. G.M. Nguyet, T.T. Chau, S. Noel, A. Denicourt-Nowicki, F. Hapiot, A. Roucoux, E. Monflier and K. Philippot, Current Organic Chemistry, **17**, 4 (2013)
4. F.J. Hinrich and J.urgen Koning, Membranes and molecular assemblies: the synkinetic approach. Royal Society of Chemistry (2007)
5. P. Radislav, K. Rajan, K. Stoewe, I. Takeuchi, B. Chisholm and H. Lam, ACS combinatorial science, **13**, 6 (2011)
6. N.B. Ubaydullaeva, Q. Dilrabo, S. Maksumova, J. Shosalimova, M. Rifky. In E3S Web of Conferences, EDP Sciences, **486**, 02025 (2024)
7. Y. Haibin, J. Zang, C. Guo, B.L.B. Li, X. Zhang and T. Chen, Separations, **10**, 1 (2022)
8. B.E. Rittmann, In situ bioremediation (1994)
9. T.R. Cook, D.M. Brian, A.L. Daniel and G.N. Daniel, Inorganic Chemistry, **51**, 9 (2012)

10. L. Maximilian, Glossary of Combustion-eBooks and textbooks (2014)
11. P. Herman, The chemistry of catalytic hydrocarbon conversions, Elsevier (2012)
12. B. Abdullayev, I. Usmanov, M. Samadiy, and T. Deng, International Journal of Engineering Trends and Technology, **70**, 9 (2022)
13. K. Dissanayake, M. Rifky, M. Jesfar, J. Makhmayorov, S. Rakhimkulov, B. Abdullayev, In IOP Conference Series: Earth and Environmental Science, IOP Publishing, **1275**, 1 (2023)
14. W. Weidong, T. Yang, W. Guan, W. Peng, P. Wu, B. Zhong, C. Zhou, Journal of Environmental Sciences, **110** (2021)
15. Z. Xupo, G. Cheng, S. Xu, Y. Bi, C. Jiang, S. Ma, D. Wang and X. Zhuang, Environmental Science and Pollution Research, **30**, 44 (2023)
16. K. James and Z. Yisheng, eds. Green China: Chinese insights on environment and development. London: International Institute for Environment and Development, (2011)
17. L. Ran, X. Ci, L. Liu, X. Wang, M. Rifky, R. Liu, W. Sui, T. Wu, M. Zhang, International Journal of Biological Macromolecules, **260**, 129615 (2024)
18. Z. Fan, M. Zeng, R. D. Yappert, J. Sun, Y. Lee, A. M. LaPointe, B. Peters, M. M. Abu-Omar, and S. L. Scott. Science, **370**, 6515 (2020)
19. B. Abdullayev, N. Askarova, R. Toshkodirova, M. Rifky, N. Ayakulov, B. Kurbanov, M. Samadiy, Asian Journal of Chemistry, **36**, 2 (2024)
20. S.G. James, Handbook of Industrial Hydrocarbon Processes, Gulf Professional Publishing (2019)
21. B. Abdullayev, M. Rifky, J. Makhmayorov, I. Usmanov, T. Deng, M. Samadiy, International Journal of Engineering Trends and Technology, **71**, 9 (2023)
22. I. Shamshidinov, A. Kambarov, R. Najmiddinov, I. Rustamov, I. Usmanov, M. Samadiy, In E3S Web of Conferences, **392**, 02036 (2023)
23. V.H. Díaz, R.C. Camacho, M.L.M. Mondragón, J.G.H. Cortez, J.A.M. de la Fuente, M.L.H. Pichardo, T.A.B. Oviedo and R.M. Palou, Catalysis Reviews, **65**, 4 (2023)
24. J. Xiao, J. Wang, F. Yuan, X. Pan, M. Samadiy, T. Deng, Y. Guo, Journal of Molecular Liquids, **366**, 120174 (2022)
25. M, Mirsaidov, A. Nimchik, O. Khodjiyev, M. Jesfar, K. Zokirov, S. Shamatov, Kh, Toshpulatov, A. Kambarov, E3S Web of Conferences, **498**, 02016 (2024)