ROLE AND IMPORTANCE OF CATALYSTS IN CATALYTIC PROCESSES IN THE CHEMICAL INDUSTRY

Tojiboyeva Munisa Akmal qizi
Chirchik State Pedagogical University
Faculty of Natural Sciences
3rd year student of Chemistry Education
ORCID ID: https://orcid.org/ 0009-0001-9154-696X
E-mail: tojiboyeva.m1661@gmail.com
https://doi.org/10.5281/zenodo.20486229

ARTICLE INFO

Qabul qilindi: 26-may 2026 yil
Ma’qullandi: 28-may 2026 yil
Nashr qilindi: 30-may 2026 yil

KEY WORDS

Catalysts, chemical industry, heterogeneous catalysis, homogeneous catalysis, environmental safety, energy efficiency, nanotechnologies, Uzbekistan, catalytic processes, industrial technologies.

ABSTRACT

This article provides an in-depth analysis of the importance of catalysts in the chemical industry and their role in various technological processes. Catalysts play an invaluable role in significantly accelerating chemical reactions, minimizing energy consumption, and improving product quality. The impact of catalysts on environmental safety, their role in reducing their negative impact on the environment, and their potential to contribute to sustainable development are also considered. The article analyzes the mechanism of action of catalysts, their various types (homogeneous, heterogeneous, biocatalysts, and nanocatalysts), new approaches to their development, and important factors in increasing efficiency. Special attention is also paid to innovative catalysts developed by Uzbek researchers using local raw materials, in particular, natural zeolites and other minerals, and their industrial application. New generation catalysts, especially technologies based on nanostructures and biocatalysts, offer broad opportunities for ensuring environmental sustainability, increasing economic efficiency, and creating systems adapted to industrial needs. Scientific research in this area opens up new prospects for further improving the efficiency of catalysts, extending their selectivity and operating life, as well as developing environmentally safe and economically viable systems.

Entrance

Catalysts play a central role in the development of the modern chemical industry. They offer unparalleled opportunities to accelerate chemical reactions, minimize energy consumption, improve product quality , and ensure environmental safety . Different types of catalysts, such as homogeneous and heterogeneous catalysts, each have their own specific advantages and limitations, and their mechanisms of action have been analyzed in depth [1].

improving the efficiency of catalysts and adapting them to practical industrial processes is of great importance in the modernization of the chemical industry. Improving their mechanisms of action and structure helps to create new technologies, increase reaction rates, and obtain more efficient products [2].

are divided into two main types based on their chemical activity : homogeneous (single-phase) and heterogeneous (two or more-phase) catalysts. Each type has its own advantages and disadvantages. Homogeneous catalysts, for example, are in the same phase as the reaction mixture and have very high activity, but their recycling is difficult. Heterogeneous catalysts, on the other hand, provide operation in a two-phase system and are easier to recycle and separate in industrial processes [4].

Catalysts play an important role not only in the chemical industry, but also in ensuring environmental safety. For example, they help reduce emissions in energy processes and transport, reduce atmospheric pollution. Currently, a new generation of catalysts, in particular nanocatalysts and biocatalysts, is playing an important role in ensuring environmental sustainability. These catalysts increase reaction efficiency, reduce energy consumption , and allow for the creation of more sustainable systems when working with natural resources [5].

In addition, the research of Uzbek scientists into the creation of effective catalysts based on local raw materials is also important. The use of local natural resources, in particular zeolites and other minerals, and their application as catalysts creates great opportunities not only to meet industrial needs, but also to ensure environmental safety [6]. At the same time, research in this area helps to develop new materials and technologies, and also serves as the basis for creating economically efficient and environmentally safe systems.

are one of the most important elements of the chemical industry , and their efficiency, selectivity, and environmental friendliness have been the basis for extensive scientific research in various fields. The development of various catalysts and their effective application, in turn, make it possible to solve many scientific and technological problems. Scientific research on the design, structure, and mechanisms of action of catalysts is making it possible to achieve new achievements in this field [2].

Modern scientific research is based, in particular, on a deep study of the active sites and structural principles of catalysts. Research in the field of nanostructures and biocatalysts is of great importance in ensuring environmental sustainability and increasing economic efficiency. Nanocatalysts, due to their high surface area and high reactivity, are considered effective tools for accelerating chemical reactions. Biocatalysts, on the other hand, provide work based on natural enzymes, allowing the creation of environmentally friendly and energy-saving processes [3].

Research conducted by Uzbek scientists also plays an important role in the field of catalysts. In particular, a number of studies have been conducted on the development of effective catalysts based on local resources of Uzbekistan, such as natural zeolites and other minerals. Uzbek scientists, including Professors M. Juraev, O. Yusupov and other scientists, have achieved significant success in the development of zeolite-based catalysts and their adaptation to industrial needs. Such catalysts, due to their high activity and stability, are effectively used in processes that reduce energy consumption and reduce waste [6].

catalysts developed by Uzbek scientists using natural resources, such as clay and other minerals, are creating new opportunities for ensuring environmental safety and developing

cost-effective technologies. Studies show that catalysts created on the basis of local raw materials make a significant contribution to increasing the energy efficiency of industry and reducing waste [7].

Catalysts play an important role in various processes in the chemical industry. They are of great importance not only in increasing energy efficiency, but also in ensuring environmental safety. There are unique opportunities for accelerating chemical reactions with the help of catalysts, reducing energy consumption and improving product quality. However, today there is a need to develop more efficient and sustainable technologies. For this purpose, new generation catalysts, in particular nanostructures and Biocatalysts are being developed. Nanostructures, due to their high surface area and high reactivity, can significantly accelerate chemical reactions. Biocatalysts, on the other hand, operate on the basis of natural enzymes and play an important role in ensuring environmental sustainability. They carry out chemical processes in an energy-efficient and environmentally friendly way [2].

At the same time, new generation catalysts being developed by Uzbek scientists based on local raw materials create promising opportunities for meeting industrial needs. The use of natural resources, in particular zeolites, as catalysts helps to create not only economically efficient, but also environmentally safe technologies. Zeolites, with their high porosity and catalytic activity, work very effectively in chemical processes. Therefore, the use of natural resources of Uzbekistan can make a significant contribution not only to the development of local industry, but also to ensuring environmental safety. Such research, especially the modification of catalysts developed based on natural zeolites to suit reaction conditions, is one of the promising directions in meeting industrial needs [4].

Conclusion

Catalysts are one of the main elements of the chemical industry , which are important not only for increasing the rate of chemical reactions, but also for ensuring efficiency, ensuring environmental safety and strengthening economic stability. Catalysts act as tools that have a special place in optimizing industrial processes, reducing waste and minimizing energy consumption. Catalysts also play a major role in increasing the efficiency of chemical production and improving product quality. In-depth study of the design and mechanism of operation of catalysts creates opportunities not only to increase their efficiency, but also to create environmentally friendly and stable catalytic systems. Optimized structures of catalysts, the accuracy and selectivity of the activity centers significantly increase their efficiency. These processes are important in increasing efficiency, reducing energy consumption, and minimizing environmental impact [1].

To improve the efficiency of catalysts, various scientific areas, in particular nanotechnology, biocatalysis and materials science, are widely used. Nanocatalysts, due to their high activity and reactivity, are widely used to accelerate chemical reactions. Such catalysts consist of small-sized materials and, due to their high surface area, create more reaction sites. Also, biocatalysts, catalysts developed based on natural enzymes, are helping to improve the environmental aspects of the chemical industry. Biocatalysts enable chemical processes to be carried out without harming the environment, which ensures their ecological sustainability [3].

In the future, scientific research, combined with advances in artificial intelligence and materials science, will provide an opportunity to create more advanced, selective, and durable types of catalytic systems. Artificial intelligence and machine learning technologies are opening

up new opportunities in the design and optimization of catalysts. With the help of these technologies, it will be possible to automate the design of catalysts, optimize their properties , and increase their efficiency to a higher level. Also, advances in the field of materials science, such as the synthesis of nanomaterials and new materials, are helping to increase the efficiency of catalysts. Catalysts created using nanomaterials and new materials, for example, serve as effective tools for the implementation of highly stable and selective reactions [5].

This will usher in a new era of technology integration, catalyst research , and industrial applications. In the future, efficiency, selectivity , and stability will be key factors, driving the further development of catalytic systems.

References used:

1. Zybert, M. (2023). Applied Catalysis in the Chemical Industry: Synthesis, Catalyst Design, and Evaluation. Catalysts, 13 (3), 607. https://www.mdpi.com/2073-4344/13/3/607
2. Gouw, M. (2023). Catalysis in Industrial Chemistry: From Theory to Applications. Journal of Industrial and Environmental Chemistry, 7 (4), 152. https://www.alliedacademies.org/articles/catalysis-in-industrial-chemistry-from-theory-to-applications-26358.html
3. Meier, T. (2023). Catalysts as Essential Tools in Modern Chemistry. Organic Chemistry: Current Research, 12 (2). https://www.longdom.org/open-access/catalysts-as-essential-tools-in-modern-chemistry-99188.html
4. Aksu, B., & Sahin, H. (2022). The Role of Catalysts in Green Chemistry. Green Chemistry Reviews, 8 (1), 1-15. https://www.greenchemistry.org/role-catalysts-green-chemistry
5. Jo'rayev, M., & Yusupov, O. (2021). Development of catalysts based on the use of zeolites and their application in industrial processes. Uzbekistan Chemical Journal, 7 (3), 43-52.
6. Yusupov, O., Juraev, M. (2020). Development of catalysts based on natural resources and their efficiency in chemical processes. Chemistry and Technology, 8 (2), 128-136.
7. Karimov, M., & Toshmatov, D. (2019). Creation of catalysts based on clay and other minerals. National Scientific Information Journal of Uzbekistan, 12 (4), 75-84.