ZEOLITES IN PHOTOCATALYTIC TREATMENT OF WATER

Ivana Grčić[1]
[1]University of Zagreb Faculty of Geotechnical Engineering, Hallerova aleja 7, 42000 Varaždin, Croatia
E-mail: igrcic@gfv.hr

ABSTRACT

The unique properties of zeolites make them useful in various applications, including photocatalysis, a process where light energy is used to activate a catalyst, initiating a chemical reaction. Zeolites play a significant role in enhancing the efficiency, selectivity, and stability of photocatalytic processes, making them valuable materials in the fields of environmental remediation, energy production, and chemical synthesis. Zeolites are utilized as excellent support materials for immobilizing and stabilizing photocatalytic materials, leading to improved recyclability in various photocatalytic applications, especially water purification.

There are several highlights regarding the use of zeolites in water treatment:

1. Surface Area: Zeolites have a large surface area and well-defined pore structures. This property provides ample active sites for the adsorption of reactants and facilitates efficient contact between the reactants and the photocatalyst.
2. Adsorption: Zeolites can adsorb organic molecules onto their surface. This adsorption process can concentrate reactants near the active sites of the photocatalyst, enhancing the efficiency of the photocatalytic reaction.
3. Selective Catalysis: The unique pore structure and chemical composition of zeolites enable selective adsorption and catalysis of specific molecules. This selectivity is beneficial for photocatalytic reactions involving complex mixtures of compounds.
4. Enhanced Stability: Incorporating zeolites into photocatalytic systems can enhance the stability and recyclability of the catalyst. Zeolites provide a stable framework that can withstand harsh reaction conditions and prevent the aggregation or deactivation of the photocatalyst.
5. Light Harvesting: Zeolites can be modified or doped with different metal ions or organic molecules to enhance their light-harvesting properties. This modification extends the spectral range of light absorption, enabling the photocatalyst to utilize a broader range of light energies for catalytic reactions.
6. Controlled Release: Zeolites can serve as carriers for photocatalytic active species, enabling the controlled release of the catalytic agents. This controlled release mechanism improves the efficiency and selectivity of the photocatalytic reaction by regulating the concentration of active species in the reaction medium.

This work gives a review of the successful application of zeolites in photocatalytic water treatment. The review focused on emerging trends, innovative reactor design, challenges regarding the application in water bodies and commercially important zeolite technologies.

Regarding the application challenges, there is substantial agreement on the necessity of the development of cost-effective synthetic routes for zeolite production and studies related to the evaluation of the regeneration performance of zeolites, especially synthetic ones, for environmental applications. Many studies are focused on combining zeolites with heterojunction or Z-scheme structures to optimize the separation of photogenerated charge carriers and the overall efficiency of pollutant degradation rates. Zeolite-based composites showed superior efficiency leading to even zero pollution in water after the treatment. However, the mechanisms and pathways of photocatalytic degradation of many organic species by zeolite-based materials are not well understood. The underlying mechanisms with an emphasis on intermediate products should be extensively studied. The optimization of zeolite structure and

chemistry could also lead to selective photocatalytic degradation of organic pollutants by avoiding undesired reaction pathways.

In conclusion, practical environmental applications depend on many factors. By summarizing all research efforts, available publications and critical reviews, three aspects of real-scale application of zeolite-based photocatalysis were defined:

1. The compromise between material cost and green strategies for the fabrication of zeolite-based photocatalysts, including the use of natural zeolites and water materials.
2. The clear picture of real water treatment, including advanced simulation models, analyses of representative samples and the existence of validated results.
3. Standardization of water treatment systems with a focus on the innovative reactor/system design.

Key words: environmental applications, reactor design, zeolite-based composites

REFERENCES

[1] G. Hu et al., Recent developments and challenges in zeolite-based composite photocatalysts for environmental applications, *Chemical Engineering Journal*, 2021, 417, 129-209.

[2] F. Collins, A. Rozhkovskaya, J.G.Outram and G.J. Millar, A critical review of waste resources, synthesis and applications for Zeolite LTA, *Microporous and Mesoporous Materials*, 2020, 291, 109667.

[3] H.M. Ali, F.A. Roghabadi and V. Ahmadi, Solid-supported photocatalysis for wastewater treatment: Supports contribution in the photocatalytic process, *Solar Energy*, 2023, 255, 99-125.