Journal of Environmental Health and Sustainable Development

Using Nanozymes in the Removal of Persistent Organic Pollutants from Water Environments

Seyedeh Mahtab Pormazar [1,2*]

[1] Environmental Science and Technology Research Center, Department of Environmental Health Engineering, School of Public Health, Shahid Sadoughi University of Medical Sciences, Yazd, Iran.
[2] Student Research Committee, Shahid Sadoughi University of Medical Sciences, Yazd, Iran.

ARTICLE INFO

LETTER TO EDITOR

Article History:
Received: 18 May 2024
Accepted: 10 July 2024

***Corresponding Author:**
Seyedeh Mahtab Pormazar

Email:
smp.mahtab@gmail.com

Tel:
+98 916 2522016

Citation: Pormazar SM. ***Using Nanozymes in the Removal of Persistent Organic Pollutants from Water Environments.*** J Environ Health Sustain Dev. 2024; 9(3): 2301-3.

Natural enzymes, with their distinct amino acid sequences, are large biocatalysts primarily composed of proteins. A few are made of catalytic nucleic acid molecules, playing a crucial role in metabolism and catabolism [1]. These enzymes have unique characteristics and high efficiency in various aspects of human life, including clinical diagnosis, environmental monitoring, and pollution treatment [2, 3]. However, natural enzymes have limitations such as performance in a narrow range of pH and temperature due to their high structural sensitivity, high cost, low stability and difficulty in storage [4, 5]. In addition, research has been done on synthetic enzymes with the structure and function of enzyme mimics. However, the higher activity of synthetic enzymes cannot meet the needs of industrial applications [6].

Advances in technology have led to the development of nanobiotechnology, which combines material science and biology to create novel nanomaterials capable of mimicking the activity of enzymes [7]. These nanomaterials, known as 'nanozymes', can catalyze reactions similar to natural enzymes in a physiologically relevant environment[8, 9]. However, their catalytic mechanism may differ from that of natural enzymes[10]. Nanozymes have significant advantages such as high stability, high catalytic activity, low cost, easy fabrication, greater reusability, and ease of modification[11, 12]. In addition, their unique nano-structural and physicochemical properties allow them to disperse effectively in aquatic systems and perform better in pollutant treatment. Furthermore, large-scale production can be cost-effective [3, 11].

One of the important aspects of this technology is that nanomaterials combine with a wide range of natural enzymes such as tyrosinases, glucose, proteins, spermine, phosphotriesterases, laccases, lignin peroxidase, soybean peroxidase, nitroreductases, reducing dehalogenases and quinone reductases in purifying pollutants [13-17]. Laccases and peroxidases are enzymes widely used in biological wastewater treatment to reduce oxidation of emerging hazardous pollutants such as phenols, bisphenols, herbicides, pesticides, textile dyes, pharmaceutical compounds, and others [2, 18].

Studies show that some of these nanozymes are used to break down specific pollutants and some others are multi-purpose [19]. Many nanozymes have both adsorption capacity and catalytic ability;

[Downloaded from jehsd.ssu.ac.ir on 2026-11-22]

[DOI: 10.18502/jehsd.v9i3.16577]

however, they predominantly act as catalysts for degrading pollutants, with adsorption capacity serving as an auxiliary role in wastewater treatment[6]. Their catalytic mechanism involves converting several compounds through the oxidation of phenolic groups found in organic compounds. At the same time, they reduce molecular oxygen or hydrogen peroxide until it turns into water[2]. Additionally, some specially nanozymes have significant bactericidal activity [20]. The degradation of persistent organic pollutants, such as phenolic compounds, pharmaceutical compounds, dyes, pesticides, and organic phosphorus compounds, has seen significant progress through the use of nanozymes with catalytic activity[21-24]. Studies have demonstrated that composite nanoenzymes containing Fe_3O_4MNPs on carbon materials or MOFs exhibit higher catalytic efficiency compared to metal/metal oxide-based nanozymes[21]. The rate of degradation of nanoenzymes is influenced by several factors, including the composition and structural characteristics of nanozymes and pollutant compounds, the presence of other substances, and environmental variables such as pH and temperature[25].

Public concerns about environmental safety require the use of new and effective methods to reduce the toxicity of persistent pollutants. Nanozymes are a great solution to meet this need and improve the environment. Researchers are actively exploring and developing synthetic enzymes and nanozymes for environmental applications in water treatment. This would be highly relevant in treating complex contaminated media such as wastewater and leachates.

This is an Open-Access article distributed in accordance with the terms of the Creative Commons Attribution (CC BY 4.0) license, which permits others to distribute, remix, adapt, and build upon this work for commercial use.

References

1. Winkler M, Geier M, Hanlon SP, et al. Human enzymes for organic synthesis. Angew Chem Int Ed Engl. 2018;57(41):13406-23.
2. Martínez-Zamudio LY, González-González RB, Araújo RG, et al. Emerging pollutants removal from leachates and water bodies by nanozyme-based approaches. Curr Opin Environ Sci Health. 2023;37:100522.
3. Sadaf A, Ahmad R, Ghorbal A, et al. Synthesis of cost-effective magnetic nano-biocomposites mimicking peroxidase activity for remediation of dyes. Environmental Science and Pollution Research. 2020;27:27211-20.
4. Reetz MT. What are the limitations of enzymes in synthetic organic chemistry? The Chemical Record. 2016;16(6):2449-59.
5. Unnikrishnan B, Lien C-W, Chu H-W, et al. A review on metal nanozyme-based sensing of heavy metal ions: challenges and future perspectives. J Hazard Mater Lett. 2021;401: 123397.
6. Hong C, Meng X, He J, et al. Nanozyme: a promising tool from clinical diagnosis and environmental monitoring to wastewater treatment. Particuology. 2022;71:90-107.
7. Ahmadi S, Rahimizadeh K, Shafiee A, et al. Nanozymes and their emerging applications in biomedicine. Process Biochemistry. 2023;131:154-74.
8. Kumawat M, Madhyastha H, Umapathi A, et al. Surface engineered peroxidase-mimicking gold nanoparticles to subside cell inflammation. Langmuir. 2022;38(5):1877-87.
9. Ugru MM, Sheshadri S, Jain D, et al. Insight into the composition and surface corona reliant biological behaviour of quercetin engineered nanoparticles. Colloids Surf A Physicochem Eng Asp. 2018;548:1-9.
10. Wei H, Gao L, Fan K, et al. Nanozymes: a clear definition with fuzzy edges. Nano Today. 2021;40:101269.
11. Singh R, Umapathi A, Patel G, et al. Nanozyme-based pollutant sensing and environmental treatment: trends, challenges, and perspectives. Science of The Total Environment. 2023;854: 158771.
12. Horzum N, Metin AÜ. Environmental remediation with nanozymes. Nanozymes. 2024: 457-90.

[Downloaded from jehsd.ssu.ac.ir on 2026-11-22]

[DOI: 10.18502/jehsd.v9i3.16577]

13. Zhong Y, Tang X, Li J, et al. A nanozyme tag enabled chemiluminescence imaging immunoassay for multiplexed cytokine monitoring. Chemical communications. 2018;54(98): 13813-6.
14. Liu R, Zuo L, Huang X, et al. Colorimetric determination of lead (II) or mercury (II) based on target induced switching of the enzyme-like activity of metallothionein-stabilized copper nanoclusters. Mikrochim Acta. 2019;186: 1-8.
15. Dehghani Z, Hosseini M, Mohammadnejad J, et al. Colorimetric aptasensor for Campylobacter jejuni cells by exploiting the peroxidase like activity of Au@ Pd nanoparticles. Mikrochim Acta. 2018;185:1-9.
16. Kuo P-C, Lien C-W, Mao J-Y, et al. Detection of urinary spermine by using silver-gold/silver chloride nanozymes. Anal Chim Acta. 2018;1009:89-97.
17. Bhatt P, Gangola S, Bhandari G, et al. New insights into the degradation of synthetic pollutants in contaminated environments. Chemosphere. 2021;268:128827.
18. Zeybekler SE. Nanozymes based detection of antibiotics in water sources. Nanozymes. 2024: 445-56.
19. Chen Q, Zhang X, Li S, et al. MOF-derived CO_3O_4@ CO-Fe oxide double-shelled nanocages as multi-functional specific peroxidase-like nanozyme catalysts for chemo/biosensing and dye degradation. Chemical Engineering Journal. 2020;395:125130.
20. Fang G, Kang R, Cai S, et al. Insight into nanozymes for their environmental applications as antimicrobial and antifouling agents: progress, challenges and prospects. Nano Today. 2023;48:101755.
21. Bittencourt GA, de Souza Vandenberghe LP, Martínez-Burgos WJ, et al. Emerging contaminants bioremediation by enzyme and nanozyme-based processes–a review. Iscience. 2023;26(6).
22. Boruah PK, Das MR. Dual responsive magnetic Fe_3O_4-TiO_2/graphene nanocomposite as an artificial nanozyme for the colorimetric detection and photodegradation of pesticide in an aqueous medium. J Hazard Mater Lett. 2020;385:121516.
23. Yang H, Wu X, Su L, et al. The Fe–N–C oxidase-like nanozyme used for catalytic oxidation of NOM in surface water. Water research. 2020;171:115491.
24. Tang Y, Jiang S, Li W, et al. Confined construction of COF@ Cu-nanozyme with high activity and stability as laccase biomimetic catalyst for the efficient degradation of phenolic pollutants. Chemical Engineering Journal. 2022;448: 137701.
25. Li Y, Liu J. Nanozyme's catching up: activity, specificity, reaction conditions and reaction types. Mater Horiz. 2021;8(2):336-50.

[Downloaded from jehsd.ssu.ac.ir on 2026-11-22]

[DOI: 10.18502/jehsd.v9i3.16577]

CC BY 4.0