

Editorial

Advances in Photocatalytic Methods for Organic Pollutant Removal

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Over the past decade, the application of photocatalysis has significantly increased, now recognized as an essential technique for purifying water and air from harmful organic substances. Commonly used materials include titanium dioxide (TiO₂) and zinc oxide (ZnO), which are stable and show good activity under light. However, they face challenges such as poor performance under visible light and rapid recombination of charge carriers, reducing their effectiveness. To solve these issues, scientists have developed improved materials like Z-scheme and S-scheme systems, which enhance charge separation and maintain strong redox capabilities [1, 2]. Additionally, the incorporation of noble metals such as silver and gold has been explored. These metals enhance light absorption and accelerate the photocatalytic reaction [3]. A recent study by Thakur et al. [4] also showed the use of nano-sized powder photocatalysts in removing pollutants and other harmful chemicals from water.

Recently, scientists started using carbon-based materials such as graphene, biochar, and carbon nanotubes into photocatalysis. These materials enhance the adsorption of pollutants, improve electrical conductivity, and foster better contact between the pollutant and the catalyst [5, 6].



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Additionally, materials like metal-organic frameworks (MOFs) and covalent organic frameworks (COFs) have gained popularity due to their modifiability and large surface areas, which aid in selectively removing certain pollutants [7]. Meanwhile, some researchers are experimenting with new types of reactors, including thin-film systems, solar-driven setups, and continuous-flow designs, to enhance the practical application of photocatalysis in real-world scenarios [8, 9].

Photocatalysis is increasingly recognized as an effective method for protecting the environment by cleaning water from harmful chemicals [9]. This method uses sunlight and safe materials such as modified titanium dioxide to break down dangerous substances—including dyes, pesticides, and medicine waste—into safe products like water and carbon dioxide. Unlike other treatments that merely transform pollutants into another form, photocatalysis completely destroys them. This clean, energy-saving process is particularly valuable in areas with limited water resources. With the help of nanotechnology, photocatalysts have improved and can work under normal sunlight, allowing treated water to be reused for farms or factories. Also, photocatalysis is being integrated with other treatment methods, making it a component of more modern systems. This contributes to achieving global environmental goals, such as the UN Sustainable Development Goals.

Since the 1990s, the number of studies focusing on photocatalysis has increased significantly (see Figure 1). Many research papers and review articles have been published in the past decade [10–13]. This special issue of *Catalysis Research* includes different new ideas—from the design of new materials to their application in real conditions. It shows the progression of photocatalysis from laboratory experiments to actual use. The research also focuses on the removal of challenging pollutants such as PFAS, medicine waste, pesticides, and dyes. But there are still problems like using the same catalyst again, avoiding new pollution, and saving energy. In the future, combining photocatalysis with other techniques, such as membrane technology, electrochemical treatment, or adsorption, and examining its entire lifecycle will be important to build better and more eco-friendly systems.

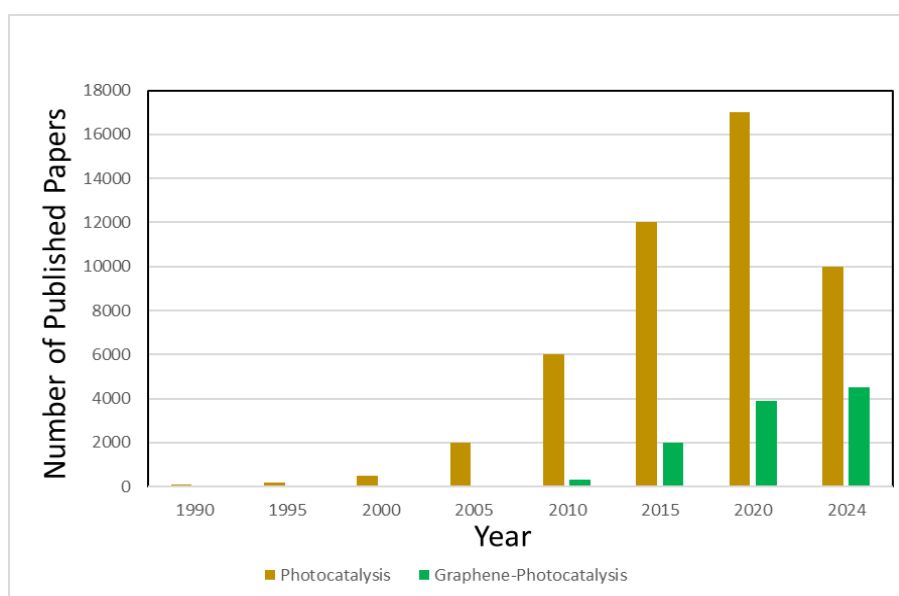


Figure 1 The visual summary of how many research papers were published about photocatalysis in general during the past 25 years. It also shows the number of papers that focus on using graphene with photocatalysis. The data is taken from Science Direct.

Author Contributions

The author did all the research work for this study.

Competing Interests

The author declares no conflict of interest.

AI-Assisted Technologies Statement

AI tool, ChatGPT, was used for language editing purposes only, and the author takes full responsibility for the content of the manuscript.

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