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EDITORIAL

Progress and challenges in heterogeneous advanced oxidation processes for water treatment

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Advanced oxidation processes (AOPs) have become a vital solution for eliminating emerging organic contaminants (EOCs) from water. These processes, which generate highly reactive species like hydroxyl radicals, are particularly effective in degrading EOCs that resist conventional treatment methods. As a key technology for reducing refractory pollutants, heterogeneous AOPs have developed rapidly in recent years. Low-cost heterogeneous catalysts are commonly used to activate chemical oxidants and produce various reactive oxygen species through interfacial reactions to degrade pollutants. Compared with the traditional homogeneous Fenton process, heterogeneous AOPs can significantly reduce reagent consumption and sludge production. Heterogeneous catalysts, such as single atom catalysts, carbon materials, metal oxides, and metal-organic frameworks, have been extensively studied for their ability to activate oxidants (e.g., persulfate, peracetic acid, periodate, hydrogen peroxide, and ozone) under various conditions. These catalysts offer high catalytic activity and are ideal for large-scale water treatment.

However, the long-term stability of heterogeneous catalysts and the toxicity of degradation products remain areas of attention and are not yet fully understood in the context of heterogeneous advanced oxidation technologies. Extensive monitoring and research are needed to assess the potential risks posed by residual by-products to public health, and such risks should be reasonably controlled. With continuous innovation in catalyst design and process optimization, there is an urgent need to prioritize sustainable and practical methods. Future researchers are encouraged to test the performance of the material over long durations or under adverse conditions to avoid the use of functional materials prone to leaching harmful substances. Addressing these challenges will further promote the development of AOP technology and provide an important theoretical and practical basis for advancing water treatment methods targeting new pollutants.

Conflict of interest

Chengyun Zhou is the Editor-in-Chief of this journal and declares no known competing financial interests or personal relationships that could have influenced the work reported in this editorial.