Smart Catalysts for Water Disinfection: Bimetallic Metal-Organic Frameworks and Advanced Oxidation Processes Synergy

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Abstract

The increasing presence of pathogens in treated wastewater has become a major concern, especially following global health emergencies. Conventional treatment systems often fail to fully eliminate these microorganisms, prompting the development of more efficient technologies. Among them, Advanced Oxidation Processes (AOPs) stand out for their ability to generate reactive species, such as hydroxyl and sulfate radicals, that degrade pollutants and inactivate pathogens. This study explores the use of bimetallic Metal-Organic Frameworks (MOFs), synthesized via solvothermal methods, as heterogeneous catalysts to generate reactive species in two AOP strategies: electro-Fenton and sulfate radical-based processes. A bimetallic Zn-MIL53(Fe) was synthesized [1] and applied in electro-Fenton reactions, achieving complete inactivation of *Pseudomonas aeruginosa* and *Lactobacillus crispatus* within 5 min at 25 mA, with a catalyst dose of 4.32 g/L. Its reusability across multiple cycles highlights its potential for sustainable water disinfection. In parallel, a series of CuFe-based MOFs with varying metal ratios (Fe:Cu=3:1, 2:1 and 1:1) were synthesized [2] and evaluated for their ability to activate peroxymonosulfate (PMS) and generate sulfate radicals. Among them, Cu_1Fe_1-(BDC-NH_2), under 0.1 mM PMS and a catalyst dose of 0.25 g/L, exhibited superior antibacterial activity against *Escherichia coli*. These findings demonstrate the catalytic advantages of bimetallic MOFs over monometallic ones, including enhanced stability and efficiency. Therefore, the results support their integration into advanced wastewater treatment systems.

Keywords: Metal Organic Frameworks, Advanced Oxidation Processes, Disinfection.

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