Water treatment by heterogeneous photo-Fenton catalysis using Metal-Organic Frameworks (MOFs)

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Water pollution from both chemical contaminants and pathogenic microorganisms poses a growing global challenge. Among advanced oxidation processes, the photo-Fenton reaction stands out for its ability to generate highly reactive hydroxyl radicals under light irradiation, enabling the efficient degradation of a wide range of pollutants. However, traditional Fenton processes often require acidic conditions and generate secondary waste.[1,2] Recent research has turned to heterogeneous photo-Fenton systems that operate under milder conditions and can be activated by visible light—making them more practical and sustainable for real-world applications.[3,4]

In this context, Metal-Organic Frameworks (MOFs), particularly Zeolitic Imidazolate Frameworks (ZIFs), have emerged as promising materials for environmental remediation due to their structural tunability and catalytic potential.[5,6] In this work, we introduce UPO-3, a novel ZIF-based MOF designed for efficient water treatment applications, developed as part of ongoing research into functional MOF materials for photocatalytic processes.

UPO-3 was synthesized through a fast mechanochemical approach combining ZIF-9 with an additional metal and ligand. The resulting material exhibits high crystallinity, improved surface morphology, and enhanced visible light absorption. These features significantly boost its performance in heterogeneous photo-Fenton catalysis.

In previous studies solvothermal UPO-3 demonstrated the ability to degrade 98% of methylene blue under visible light within 45 minutes, five times faster than conventional ZIF-9.[7] However, the mechanochemical approach showed improved photocatalytic properties with strong antibacterial activity, inactivating antibiotic-resistant *S. aureus* and *P. aeruginosa* in just 60 minutes. Moreover, in real river water samples, UPO-3 reduced E. coli and coliform counts below the EU's Class A water quality limit of *E. coli* (1 CFU/100 mL) within 2 hours.

This study highlights UPO-3 as a sustainable and versatile MOF-based catalyst capable of addressing both chemical and biological water contaminants under visible light activation.

References

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