

Robust Chiral Metal-Organic Framework Coatings for Self-Activating and Sustainable Biofouling Mitigation

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Abstract: Surface coatings designed to mitigate pervasive biofouling herald a new era of surface protection in complex biological environments. However, existing strategies are plagued by persistent and recurrent biofilm attachment, despite the use of bactericidal agents. Herein, we develop a chiral metal-organic framework (MOF)-based coating with conformal microstructures to enable a new anti-biofouling mode that involves spontaneous biofilm disassembly followed by bacterial eradication. A facile and universal metal-polyphenol network (MPN) is designed to robustly anchor the MOF nanoarmor of biocidal Cu²⁺ ions and anti-biofilm D-amino acid ligands to a variety of substrates across different material categories and surface topologies. Incorporating a diverse array of chiral amino acids endows the resultant coatings with widespread signals for biofilm dispersal, facilitating copper-catalyzed chemodynamic reactions and inherent mechano-bactericidal activities. This synergistic mechanism yields unprecedented anti-biofouling efficacy elucidated by RNA-sequencing transcriptomics analysis, enhancing broad-spectrum antibacterial activities, preventing biofilm formation, and destroying mature biofilms. Additionally, the chelation-directed amorphous/crystalline coatings can activate photoluminescent properties to inhibit the settlement of microalgae biofilms. This study provides a distinctive perspective on chirality-enhanced antimicrobial behaviors and pioneers a rational pathway toward developing next-generation anti-biofouling coatings for diverse applications.

Keywords metal-polyphenol network, metal-organic framework, D-amino acid, robust nanostructures, synergistic anti-biofouling

Reference

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