Functional Materials for Rapid Detection and Effective Removal of Orthophosphates

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Abstract

Industrial water cooling systems often face significant challenges, especially corrosion and scale formation. To address the issues, 2-phosphonobutane-1,2,4-tricarboxylic acid (PBTC) is widely used as a corrosion and scale inhibitor. However, optimizing the PBTC level is essential to avoid underdosing or overdosing. Traditional methods for PBTC monitoring are often labor-intensive, time-consuming, need chemical reagents, and unsuitable for real-time applications. This work focuses on developing advanced materials and effective technology for rapid detection and enhanced adsorption of PBTC. An electrochemical impedance spectroscopy (EIS) sensor utilizing molecularly imprinted polymers (MIPs) based on polydopamine is developed, providing high sensitivity and selectivity for PBTC detection in real-time applications. For adsorption, polyethylene terephthalate (PET) waste is upcycled into the terephthalic acid linker for synthesizing aluminum-based metal-organic frameworks (MOFs). The materials provide an effective solution for orthophosphate removal while promoting sustainable waste management. Furthermore, magnetic cored-MOF adsorbents are fabricated *via* layer-by-layer techniques. The materials demonstrated high capacity and efficiency across diverse environmental conditions, with easy collection by magnetic fields and regeneration after applications. This research highlights the integration of sustainable materials and advanced detection techniques, offering innovative solutions for industrial PBTC management and decontamination.

Keywords: PBTC, MOF, Molecularly imprinted, Sensor, Adsorbent