High Entropy LDH Catalyst Derived from Electroplating Wastewater for Durable H_2O_2 Activation and Organic Pollutant Degradation

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Abstract

Transition metal-based catalysts are effective for advanced oxidation processes (AOPs), but their practical application is often limited by structural degradation and catalytic deactivation caused by metal leaching. Herein, we report a high entropy layered double hydroxide catalyst (MgAlCrFeCuNi-LDH, HE-LDH) directly synthesized from heavy metal containing electroplating wastewater through a simple coprecipitation method. The HE-LDH exhibits a high configurational entropy of 1.67R (13.91 J mol^{-1} K^{-1}). Combined characterizations confirm the formation of a structurally stable LDH framework based on Mg and Al, enabling the effective stabilization of multiple transition metals. The HE-LDH exhibits high catalytic activity for H_2O_2 activation toward bisphenol A (BPA) degradation, achieving >97% removal of 46 mg L^{-1} BPA within 1 h under acidic conditions, with an apparent rate constant of 3.40 h^{-1}. The catalyst shows negligible metal leaching and retains >95% BPA removal efficiency after five consecutive cycles. It also maintains high activity in natural water matrices, indicating strong resistance to water chemistry interference. In contrast, the MgAl-free counterpart, CrFeCuNi-LDH, exhibited a lower initial BPA removal efficiency (<93%), significant metal leaching, and rapid deactivation, with the BPA removal efficiency declining to below 70% after five cycles. The superior catalytic activity and durability of HE-LDH are most likely attributed to the synergistic stabilization of multimetal active centers by the brucite-like Mg-Al host layers and the structural confinement of the LDH framework, which together suppress metal leaching and sustain efficient H_2O_2 activation. This work provides a feasible wastewater to catalyst strategy for transforming electroplating wastewater into stable AOP catalysts, enabling heavy metal resource utilization and organic pollutant remediation.

Keywords

Layered Double Hydroxides, Electroplating Wastewater, Advanced Oxidation Processes, Hydrogen Peroxide Activation, Resource Recovery, Pollutant Degradation