



Simultaneous removal of Cr, Cu, Zn, and Cd by nano zero-valent iron modified sludge biochar in high salinity wastewater

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ABSTRACT

Cr, Cu, Zn, and Cd coexisted in the electroplating wastewater with high salinity and organics, while their removal was often investigated individually. In this study, the simultaneous removal of Cr, Cu, Zn, and Cd was investigated by nano zero-valent iron modified sludge biochar (nZVI@SBC). The results showed that nZVI@SBC could significantly improve the removal efficiency of the four heavy metals (HMs) in high salinity wastewater. NO₃⁻ (N-NO₃⁻) and humic acid (HA) could promote the removal of Cr, Cu, Zn, and Cd, and PO₄³⁻ (P-PO₄³⁻) could enhance the removal of Cd. EPR analysis demonstrated the generation of [•]O₂ in different water matrices. The [•]O₂ intensity increased in the presence of NO₃⁻ and HA, which indicated the acceleration of the nZVI corrosion and the promoted electron transfer in the system. To further understand the reaction mechanisms, the variation of nZVI@SBC structures and compositions during the treatment process were characterized by SEM-EDS, XRD, BET, and XPS. Cr and Cu were removed through adsorption and co-precipitation after reduction by nZVI, while Cd and Zn were removed by alkali precipitation and coprecipitation. This work improves the understanding of simultaneous removal of HMs by nZVI@SBC and provides a cost-effective approach for the electroplating wastewater treatment.

1. Introduction

In recent years, the electroplating industry has experienced rapid development and been extensively applied in the precision electronics, instrument manufacturing, military, and machinery industries [1]. As one of the world's top polluting industries, the environmental accidents related with electroplating have gained increasing attention. Previous reports have indicated that only about 30 % of the metals used in the electroplating process were effectively utilized. Hence, significant amounts of heavy metals (HMs) are discharged to the wastewater, with concentrations up to hundreds of mg/L [2,3]. Heavy metal ions such as Cr, Cu, Zn, and Cd are always simultaneously detected in electroplating wastewater [4]. HMs as the typical non-biodegradable contaminants, pose significant threats to the public health and natural ecosystems.

Except for the high occurrence of HMs, electroplating wastewater is also characterized by high salinity, including nitrate (N-NO₃⁻) and phosphate (P-PO₄³⁻), and high organic matters. Nitrogen (5.92–501 mg/L) are used for pH adjustment during pre-treatment and stripping processes. Phosphates (50–270 mg/L) are utilized for cleaning, decoloring, and corrosion prevention [4,5]. Organic additives, i.e. EDTA, citric acid, acrylamide are employed to improve the coating quality, leading to the

enhanced chemical oxygen demand (COD) in the wastewater [4]. Furthermore, electroplating wastewater is often characterized by low pH owing to the use of acid in electroplating process [4]. The coexistence of complicated water matrices and low pH solution undoubtedly present significant challenges to the treatment of HMs in electroplating wastewater [6].

At present, chemical precipitation, coagulation, ion exchange, membrane filtration, and electrochemistry are widely used to remove HMs in electroplating wastewater [7]. Chemical precipitation with low cost and simple operational steps is not effective in treating strong acidic wastewater [7]. Ion exchange is low efficient in removing high concentrations of HMs, and the exchange resins are easily contaminated by organic matter [8]. Membrane filtration technology used in high organic wastewater is susceptible to membrane fouling [9,10]. Although the electrochemical process is highly efficient without additional chemical dosing, the pH sensitivity and high investments of electrodes restrict the wide application in electroplating wastewater [10,11]. Therefore, efficient technologies to remove HMs in high salinity and high organic matters containing wastewater are urgently demanded.

Absorption has received increasing attention due to the low cost, and easy operation [12,13]. Biochar as the sustainable and eco-friendly

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