Self-Cleaning and Regenerative Cathode Materials for Cost-Effective and Sustainable Water Treatment

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Abstract. We present an innovative electrochemical advanced oxidation process (EAOP) with great potential for the water treatment industry. By harnessing electrons as green reagents, our approach eliminates the need for additional chemicals. The robust and stable titanium/mixed metal oxide (Ti/MMO) anode facilitates in-situ oxygen production, while our focus on cost-effective and sustainable cathode materials with self-cleaning capabilities ensures continuous generation of reactive oxygen species (ROS) and prolonged activity. Among various carbon-based electrodes, granular activated carbon (GAC) stands out as a promising cathode material. GAC enables the two-electron oxygen reduction reaction (2e-ORR), facilitating in-situ generation of hydrogen peroxide (H_2O_2). Moreover, GAC's catalytic properties promote the decomposition of H_2O_2, leading to the formation of hydroxyl radicals (•OH). Alternatively, we explore the potential of biomass-derived granular biochar (GB) as a sustainable cathode material for in-situ ROS generation. Our findings reveal efficacy of GB in removing recalcitrant organic pollutants, including polyaromatic hydrocarbons, pharmaceuticals, pesticides, synthetic dyes, as well as the heavy metals. We have also investigated various approaches to enhance contaminant removal, including reactor configuration variations and polarity reversal. These techniques prove effective in improving contaminant removal efficiency. Overall, our cost-effective and sustainable Electro-Fenton (EF)-like approach offers an attractive solution for drinking water treatment in remote communities.