Freestanding Fe_3O_4-incorporated porous carbon monoliths for application in heterogenous electro-Fenton membrane contactors

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Abstract:

Environmentally harmful micropollutants (MPs) are nowadays detected in most water bodies, as they are not degraded in conventional wastewater treatment. To overcome this challenge, electro-Fenton (EF), an ecofriendly and cost-effective process is emerging as promising technology. In an EF process, hydrogen peroxide is produced electrochemically at the cathode through two-electron oxygen reduction reaction, which then forms hydroxyl radicals with ferrous ions. Main problems for direct application of EF in wastewater treatment are operation at acidic pH and the low solubility of oxygen in water. To overcome this, heterogeneous electro-Fenton (HEF), in which the Fenton reaction occurs at the solid catalyst surface can be employed. Although there are already several studies on the fabrication of freestanding iron incorporated carbons, they are mostly time and energy consuming.

This study introduces a facile approach for the production of bio-based freestanding electrodes using chitosan and sucrose as raw materials which can be utilized as membrane contactors in HEF. The production of the carbon includes ice- and hardtemplating followed by a simultaneous carbonization and activation step, yielding in a tailorable hierarchical porosity.

In scanning electron microscopy of the carbon a radial pattern of the macropores for good solution ingress, introduced by ice-templating, was observed. N_2-physisorption analyses indicated that final carbons are micro/mesoporous, reaching a specific surface area of 574 m^2/g. For Fe-incorporated carbons, commercial Fe_3O_4 nanoparticles were added as catalyst to the production recipe without imposing any additional step. Field emission scanning electron microscopy and energy dispersive X-ray spectroscopy analyses illustrated homogenous incorporation of catalyst into the carbon. Finally, the activity of the Fe_3O_4-incorporated electrodes was showed in degradation experiments of carbamazepine (CBZ), achieving a degradation of 0.036 mgCBZ/cm^2h at pH 7. Consequently, the tailorable, freestanding Fe3O4-incorporated electrodes hold great potential for the degradation of persistent pollutants in membrane contactors at neutral pH.

Keywords: Advanced oxidation processes, Heterogeneous electro-Fenton, Freestanding carbon material, Membrane contactor