Use of spinel ferrite oxides and rGO composite electrode in capacitive deionization for Copper (II) removal

Rahat Alam[a], Muhammad Faheem[a], Ahmed Al Hajaj[b], Linda Zou[a]
[a]*Department of Civil Infrastructure and Environment Engineering, Khalifa University of Science and Technology, P.O. Box 127788, Abu Dhabi, United Arab Emirates*
[b]*Department of Civil Infrastructure and Environment Engineering, Khalifa University of Science and Technology, P.O. Box 127788, Abu Dhabi, United Arab Emirates*
100060837@ku.ac.ae

Abstract

Copper ions are a hazardous component in wastewater, which can be effectively removed using capacitive deionization (CDI). Nanosized spinel ferrite oxide crystals are promising for enhancing copper ion adsorption through lattice-based intercalation. In this study, two nanocomposite electrodes, $NiFe_2O_4$/rGO (NFO/rGO) and $CoFe_2O_4$/rGO (CFO/rGO), are synthesized via a hydrothermal method. The rGO nanosheets are intertwined with the dense structures of NFO and CFO crystals, forming a scaffold that increases specific surface area, conductivity, and adsorption capacity. The synthesized materials are characterized using SEM, EDS, TEM, XRD, BET, and XPS techniques. The hybrid pseudocapacitive nanocomposites, NFO/rGO and CFO/rGO, exhibited electrochemical capacitances of 125.15 F g^{-1} and 186.08 F g^{-1}, respectively, at 10 mVs^{-1}. CDI experiments demonstrated that the nanocomposites NFO/rGO and CFO/rGO have high copper ion removal capacities of 132.42 mg g^{-1} and 137.00 mg g^{-1}, respectively, outperforming previously reported electrodes. A thorough quantitative electrochemical analysis revealed the adsorption mechanism and their percentage contributions. Out of both electrodes, CFO/rGO possesses better crystallinity, smaller crystal size, and narrower pore size, leading to a higher surface area, more active sites for Cu^{2+} adsorption, and improved diffusion kinetics. Both nanocomposite electrodes show excellent regeneration and stability over multiple cycles. The outstanding adsorption performance is attributed to the nanosized spinel's channels and narrow pore size distribution in the NFO/rGO and CFO/rGO nanocomposites, which facilitate efficient ion intercalation/deintercalation. This study underscores the potential of high-performance ion-intercalating spinel ferrite oxide electrodes for heavy metal removal from wastewater.

Figures

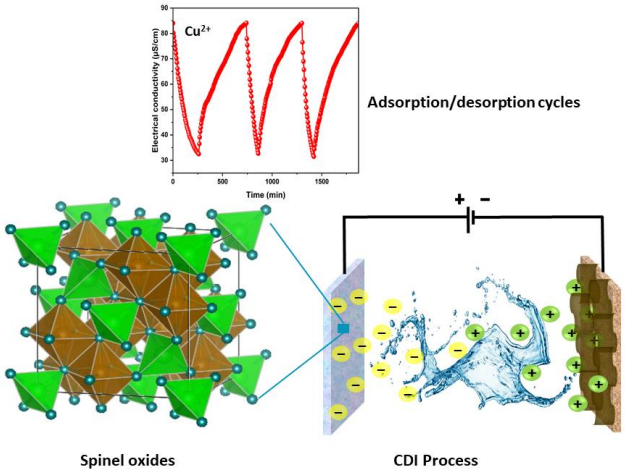

Figure 1: Adsorption process in capacitive deionization