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Highly Reactive Cu-Pt Bimetallic 3D-Electrodes for Selective Nitrate Reduction to Ammonia

Background Reducing nitrate from water streams is an untapped source of nitrogen that could be used for decentralized ammonia production at ambient conditions for agricultural use with a significantly lower cost. Decentralized production of ammonia in rural areas can minimize environmental impacts of the Haber-Bosch process (including produced ammonia distribution), while remediating polluted water sources by artificially reinstating the nitrogen cycle. Worldwide, nitrate is considered one of the top ten drinking water pollutants, posing human health risks such as cancer, thyroid problems, and adverse respiratory effects. Electrocatalytic processes, by operating at ambient conditions as well as being compact and easy to handle, are emerging as encouraging sustainable technologies. The electrochemical reduction of nitrate (ERN) can selectively reduce nitrate to ammonia. Sustainable ERN from polluted water sources holds the potential to enable fossil-free ammonia production through nitrogen-recycling approaches when operated with renewable energy sources. However, the major barrier is the identification of electrocatalytic materials with a fast kinetic conversion of nitrate to deliver ammonia with high selectivity. Invention Description Researchers at the National Center for Scientific Research (CNRS) and Arizona State University have developed a novel electrocatalytic bimetallic (copper-platinum) electrode on a three-dimensional substrate that enables faster reduction of nitrate to selectively produce ammonia. These bimetallic Cu-Pt foam electrodes enhance electrochemical reduction of nitrate (ERN) by the introduction of bimetallic catalytic sites. Growth of platinum nanoparticles on the surface of copper foam alter the electrocatalytic response of electrodes, e.g., by synergistic effects induced by Cu-Pt nanointerfaces that promote hybridized mechanisms of catalytic electrochemical and hydrogenation reduction processes. These bimetallic active catalytic sites present a higher nitrate conversion than monometallic copper electrodes at least in part by overcoming the limiting step related to the nitrate-to-nitrite initial reduction reaction. While the copper surface promotes the reduction of nitrate to nitrite, the platinum nanoparticles boost the conversion of nitrite to ammonia.

The electrochemical reduction process, which can be implemented using a flow-by or flow-through electrochemical cell, can reduce nitrate from polluted sources (e.g., groundwater, agricultural runoff) to generate ammonia-enriched water for agricultural applications. Potential Applications • Denitrification technology for water treatment • Decentralized ammonia production Benefits and Advantages • Compact units can be deployed as decentralized treatment devices • Can be operated off-grid through the use of solar energy • Transforms nitrate into a value-added product Related Publication: Highly reactive Cu-Pt bimetallic 3D-electrocatalyst for selective nitrate reduction to ammoniaFaculty Profile of Sergio Garcia-Segura