Copper-based Catalyst for Electrochemical Nitrate Reduction toward Ammonia Synthesis in Water

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Nitrate from agricultural runoff and industrial waste streams is one of the major impurities in water. As high level of nitrate in drinking water may cause methemoglobinemia in infants and gastrointestinal cancer in adults, previous efforts on electrochemical wastewater treatment have aimed to solve this problem by converting nitrates to environmentally benign nitrogen gas. In the present study, we adjust this approach and propose an opportunity to transform nitrates to ammonia, which can serve as a key chemical used in fertilizer and fuel. Additionally, the electrochemical reduction of nitrate to ammonia can also offer an appealing alternative to the energy- and resource-intensive Haber-Bosch process. In this work, we explore the structure-activity relationship of copper catalysts using Cu foil, Cu particle, and porous Cu in terms of their performances in electrochemical nitrate reduction toward ammonia. Under the optimal conditions, the synthesized porous Cu exhibits a nitrate conversion of 84% with an ammonia selectivity of 85% and a Faraday efficiency of 58% at an applied potential of -0.75 V. Further investigations on surface structural effects reveal that the electrochemical surface area and the fraction of Cu(100)/Cu(111) crystal facets significantly impact their catalytic activity for electrochemical ammonia production.