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Biomass-Derived FeCo Phosphides on Graphene for Efficient Ammonia Synthesis via Electrochemical N_2 Reduction

Eduardo A. Reis[a,b], Anelisse B. Silva[c], Hermenegildo Garcia[d], Caue Ribeiro[a,b], Lucia H. Mascaro[c]
[a]Institute of Chemistry of São Carlos, University of São Paulo, São Carlos-SP, Brazil.
[c]National Nanotechnology Laboratory for Agribusiness, Embrapa Instrumentation São Carlos, São Carlos-SP, Brazil.
[c]Department of Chemistry, Federal University of São Carlos, São Carlos-SP, Brazil.
[d]Universidad Politécnica de Valencia, Valencia, Spain.
eduardoarizono@gmail.com

Ammonia is a crucial chemical feedstock and a potential green energy carrier; however, its industrial production relies on the Haber-Bosch process, which requires high energy inputs and emits substantial CO_2. Electrochemical nitrogen reduction reaction (N_2RR), powered by renewable energy, offers a promising alternative under ambient conditions [1]. Despite its advantages, N_2RR is hindered by challenges such as low faradaic efficiencies, slow reaction kinetics, and insufficient ammonia yield, necessitating the development of more efficient electrocatalysts [2]. This work explores Fe and Co-based metal phosphides as electrocatalysts for ENRR, synthesizing (Fe)CoP/N-graphene via a sustainable chitosan-hydrogel method followed by thermal conversion. This method avoids traditional phosphorus sources like red phosphorus and hypophosphite, thus preventing the release of phosphine gas (PH_3) during synthesis. The chitosan-hydrogel was initially converted into microspheres, dried using CO_2 supercritical drying—a process known to enhance porosity—and then annealed under an argon atmosphere. High-resolution transmission electron microscopy analysis revealed well-distributed Fe-Co nanoparticles embedded within the spongy graphene matrix. For N_2RR, individual Fe and Co phosphides, as well as FeCo-supported graphene, were evaluated for catalytic activity in a 0.1 M Na_2SO_4 electrolyte at applied potentials ranging from -0.20 to -1.2 V vs. RHE. The FeCo phosphide catalyst demonstrated a threefold increase in ammonia production rate compared to single-metal phosphide, indicating a synergistic effect between Fe and Co bimetallic active sites. These findings suggest that FeCo phosphides are promising materials for efficient electrochemical ammonia synthesis, advancing the potential for sustainable, low-emission ammonia production.

References:

[1] IEA. Global Hydrogen Review 2021; 2021.
[2] Ma et al. Nano Research., 555–569, 2021.

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