

Engineering a BiPO₄–CuBi₂O₄ Heterojunction for Highly Selective and Stable Electrochemical Conversion of CO₂ Into a Liquid Hydrogen Carrier

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Global carbon dioxide (CO₂) emissions exceed 37 billion tons annually, intensifying climate change and motivating technologies that convert CO₂ into valuable chemicals. Electrochemical CO₂ reduction (eCO₂RR) provides a promising pathway for utilizing captured CO₂ while storing renewable electricity. Among potential products, formic acid (HCOOH) is an attractive liquid organic hydrogen carrier, many existing catalysts suffer from insufficient selectivity toward formate and poor stability. This research investigates whether constructing a BiPO₄–CuBi₂O₄ heterojunction electrocatalyst can improve catalytic activity, selectivity, and durability for CO₂-to-formate conversion. A BiPO₄–CuBi₂O₄ heterostructure catalyst was synthesized using a hydrothermal method and deposited onto carbon paper electrodes. The catalyst structure and composition were verified through standard characterization techniques. eCO₂RR performance was evaluated in a CO₂-saturated electrolyte using voltammetry, product quantification, and long-term tests. To assess scalability, the catalyst was further implemented in a membrane electrode assembly (MEA) electrolyzer for continuous formic acid production. The heterojunction catalyst achieved 99% faradaic efficiency for formate at -0.9 V vs. RHE, with a partial current density of 30 mA·cm⁻² and stable operation for over 70 hours. In the MEA electrolyzer, the system enabled direct production of pure formic acid at low cell voltages (3–4V), reaching current densities up to 200 mA·cm⁻² and maintaining 50 mA·cm⁻² for more than 70 hours of continuous operation. These results demonstrate that heterojunction engineering significantly enhances catalytic performance, offering a promising strategy for scalable CO₂ utilization and sustainable hydrogen-carrier production.

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