DESIGNING EFFECTIVE ELECTROCATALYTIC SYSTEM FOR DECARBONIZED ELECTROCHEMICAL REACTIONS

by

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ABSTRACT

In response to growing concerns over carbon emissions and climate change, the demand for sustainable chemical production methods has risen significantly. Traditional fossil fuel-based processes operate at high temperatures and pressures, generating substantial greenhouse gases. In contrast, electrocatalysis offers a promising, renewable electricity-driven approach to synthesize valuable chemicals with the potential for net-zero or even negative carbon emissions. My Ph.D. research focuses on advancing electrocatalytic technologies, particularly through innovations in electrolytes and electrode design, to support decarbonized chemical production.

A central part of my work involves the electrochemical CO_2 reduction reaction (CO2RR), converting CO_2 into useful chemicals such as CO, CH_4, and C_2H_4. This thesis demonstrates that acidic electrolytes can enhance energy efficiency and product selectivity compared to conventional neutral/alkaline systems. My work details the synthesis of size-controlled Cu nanoparticles on carbon black and their electrochemical active surface area (ECSA)-dependent performance, with particular emphasis on C_2H_4 production.

To address the flooding and stability issues of traditional carbon-based gas diffusion layers (GDLs), I developed a novel GDL composed of poly(3,4-ethylenedioxythiophene)-coated PTFE (PEDOT-PTFE). This conductive, hydrophobic GDL significantly improved operational stability. Further optimization of gas permeance and conductivity was achieved by tuning dopants and charge density during electropolymerization. The final PEDOT-PTFE GDL exhibited excellent compatibility with various electrocatalysts and maintained high performance at industrially relevant current densities for over 150 hours.

Overall, this work provides new insights into catalyst/electrolyte effects and GDL engineering for electrocatalytic decarbonization, advancing the field toward scalable, green chemical manufacturing.