

Electroreduction of CO₂ (aq) with an Atmospheric-Pressure Plasma Cathode

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Abstract — The electrochemical reduction of carbon dioxide has shown significant promise as a method for reforming CO₂ into more useful products including syn gas (CO + H₂) and clean burning hydrocarbons. This study experimentally investigates a novel approach for the reduction of aqueous carbon dioxide (CO₂(aq)) by solvated electrons from a plasma cathode at atmospheric pressure, which is in stark contrast to conventional electrochemical CO₂(aq) using a metal cathode. We measured the equilibrium concentration of solvated electrons, (e⁻)_{aq}, at the plasma liquid interface using a total internal reflection absorption spectroscopy method. The optical measurements indicate that the concentration of (e⁻)_{aq} decreases with increasing CO₂(aq) concentration, confirming electrochemical reduction. By investigating the reaction pathways, we show that the CO₂(aq) is first reduced to the carboxyl radical anion, CO₂⁻(aq), at the plasma/liquid interface before either recombining to form oxalate or reacting with H⁺(aq) to produce formate. Liquid ion chromatography (IC) tests confirm both oxalate and formate byproducts, and we demonstrate control over their relative concentrations by varying the pH of the solution. For both products, the net faradaic efficiency is close to 10%. This work shows the feasibility of using plasma electrochemistry to process CO₂ for the production of alternative fuels.