

The Effect of Diluted CO₂ Streams on the Electrochemical Reduction of CO₂

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Excessive carbon dioxide (CO₂) emissions are widely recognized as one of the most significant contributors to global climate change. To reduce CO₂ emissions, multiple strategies are being considered, including the improvement of fuel economy, the utilization of renewable energy resources and carbon capture and sequestration (CCS). Alternatively, as a new strategy to tackle this challenge, electrochemical conversion of CO₂ into valuable chemicals such as carbon monoxide (CO), formic acid, methanol, and ethylene is being considered. This strategy may not only help reduce greenhouse gas emissions, but also could utilize wasted excess electrical energy generated from renewable sources to synthesize chemicals that normally would have been derived from fossil fuels.

One of the major sources of global CO₂ emissions is flue gas of fossil fuel-based power plants, which contains mainly nitrogen (N₂) and about 15% CO₂. CO₂ separation from flue gas can be accomplished, but is an energy intensive process. Ideally, flue gas can be used directly as the feed for a CO₂ conversion process. We studied the use of diluted CO₂ streams as the feed. To mimic the flue gas, we used diluted CO₂ streams (10 to 100% by volume, using N₂ for dilution), and examine its impact on product selectivity, CO₂ utilization, and rate of reaction (partial current density CO).

Figure 1 shows product selectivity between CO and H₂ as a function of CO₂ concentrations. With a diluted CO₂ feed, the Ag cathode generates > 80% CO at -2.75 V and > 85% CO at -3.0 V cell potentials. On the contrary, at -2.5 V cell potential, the Faradaic efficiency for CO started to decrease upon lowering the CO₂ concentration. The relationship between H₂ evolution and CO₂ concentration was not as clear. Except for the high H₂ evolution observed when providing 10% CO₂ and applying a -3 V cell potential, the Faradaic efficiencies for H₂ were below 8% at all other conditions, suggesting that the use of diluted CO₂ stream as the feed did not significantly affect H₂ evolution. We also studied the utilization of CO₂ per pass and explored the higher utilization of CO₂ at low CO₂ concentrations (Figure 2). In addition, the utilization of CO₂ is enhanced with increasing cell potentials.

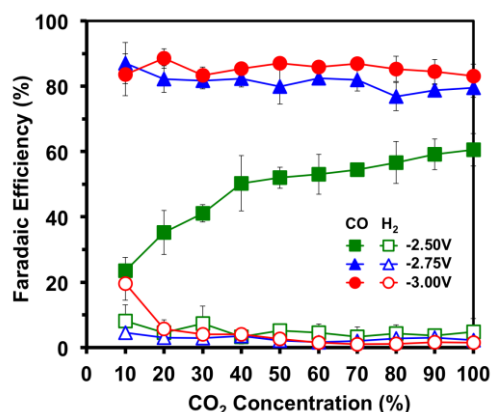


Figure 1. Faradaic efficiency for CO and H₂ as a function of CO₂ concentrations using N₂ for dilution. N=4 for error bars.

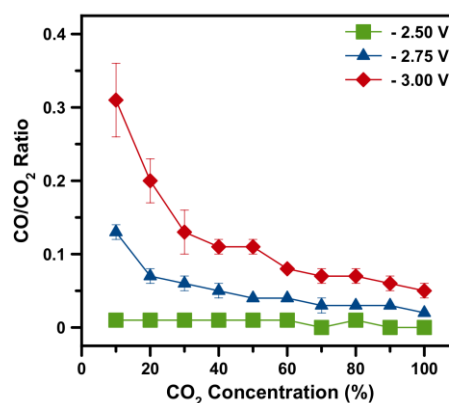


Figure 2. Ratio of CO over CO₂ as a function of CO₂ concentration using N₂ for dilution. N=4 for error bars.