REDUCTION OF CO_2 VIA CORONA DISCHARGE IN A MICRO REACTOR

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Project Opportunity

Carbon dioxide is widely produced in industrial waste streams. Routing these streams through CO_2 conversion reactors may be much cheaper than traditional carbon sequestration methods. Corona discharge in micro reactors offers a low-energy CO_2 utilization method.

Advantages of Corona Discharge

Corona discharge is a region of ionized gas that forms around a conductor tip at high voltage. Corona discharge can produce a plasma of CO_2 at ambient temperature and pressure. These ions may recombine in the presence of water to form useful products like methane.

Mechanism of Reactions

Ionization

$$e + CO_2 \rightarrow CO + O + e$$

$$e + H_2O \rightarrow H + OH + e$$

Ions Recombine to Form Products

$$H + CO \rightarrow CH + O$$

$$H_2 + CH \rightarrow CH_2 + H$$

$$H_2 + CH_2 \rightarrow CH_4$$

e = electron

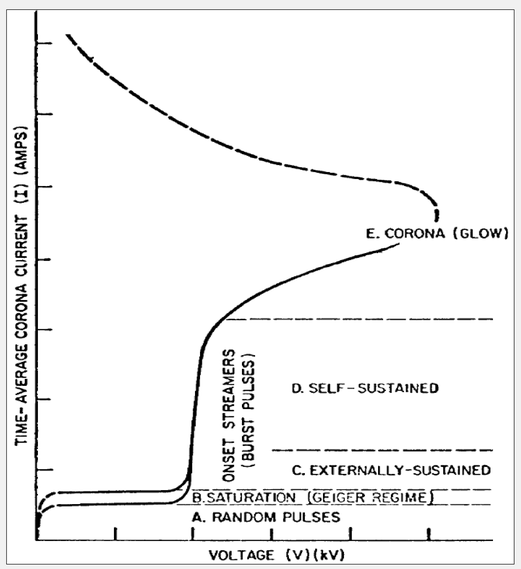

Fig.1: Voltage-current curve from literature* for corona discharge.

*Gallo, C. F., A Brief Status Report

Corona Discharge in Micro Reactor

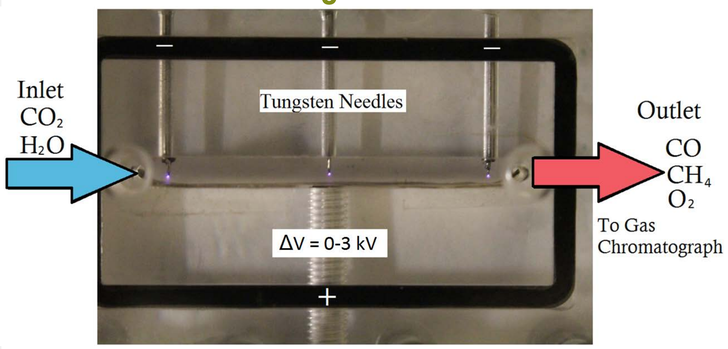

Fig.2: Corona discharge is shown at tip of tungsten needles in the needle-plate micro reactor.

Three-Needle Reactor Flow Diagram

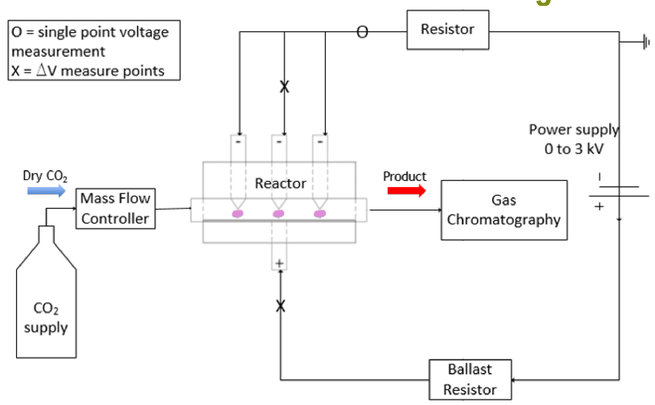

Fig.3: Dry CO_2 flows through the micro reactor and products are analyzed via gas chromatography. Variable resistors above each needle enable fine tuning to produce corona discharge.

Results

Corona discharge was successfully produced on all three needle points using tungsten needles with a tungsten plate and 1-3 kV applied voltage. The current vs. voltage curve indicates stable corona regime. Electrochemical needle etching is not recommended for larger needles due to high manufacturing time and lack of uniformity.

Methods

A needle and plate micro reactor was constructed and tested for corona discharge with various metals and gap distances. Tungsten needles were electrochemically etched in sodium hydroxide. Current and voltage across the gap distance was plotted to determine the operating regime for corona discharge.

Needle Etching

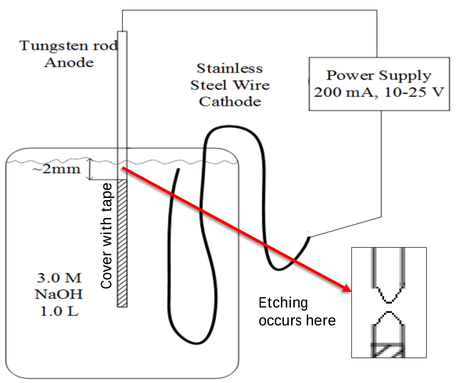

Fig.4: Tungsten needles were electrochemically etched in sodium hydroxide. Sharper needles create larger corona discharge regions and improve reactor efficiency.

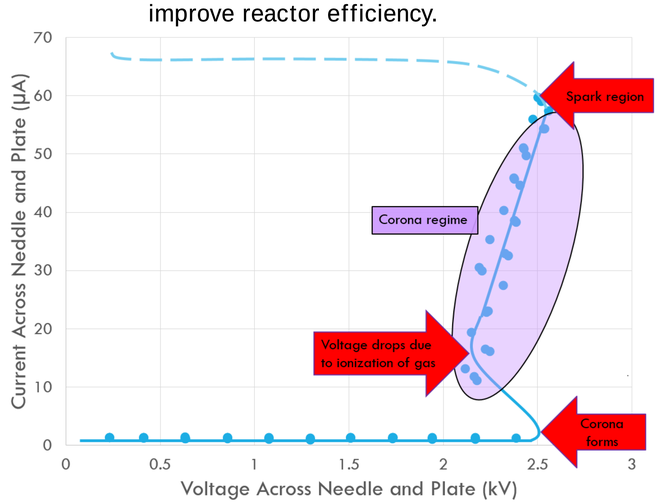

Fig.5: Voltage and current across a single needle and plate are plotted to determine the corona regime.

Future Work

- Fix or replace Gas Chromatograph to record and analyze products from the reactor.
- Determine conversion from Gas Chromatograph results.
- Determine power efficiency of the reactor.

Recommendations

- A detailed parameter space exploration should be done for corona generation in CO_2. Parameters include gap distance, needle sharpness, voltage, distance between needles, and number of needles.
- Model reactor flow to determine bypass area.

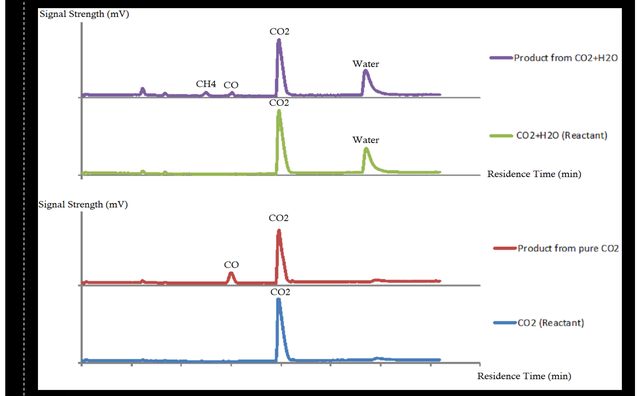

Fig.6: Gas chromatographs for reactants and products compared to determine reaction conversion. The plots shown here are expected results based on previous work by Yu Miao.

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