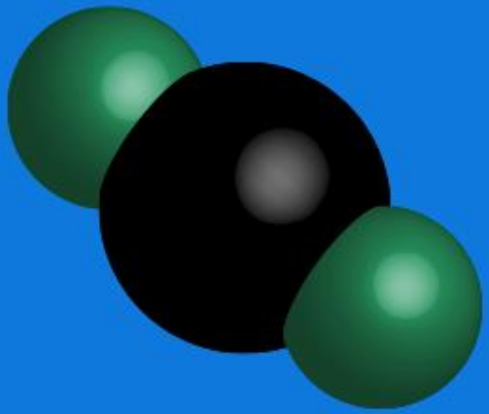
CO_2 Conversion to Fuels



A Progress Report on Liquid Light Inc.

Andrew Bocarsly

Princeton University Department of Chemistry | Frick Chemistry Laboratory

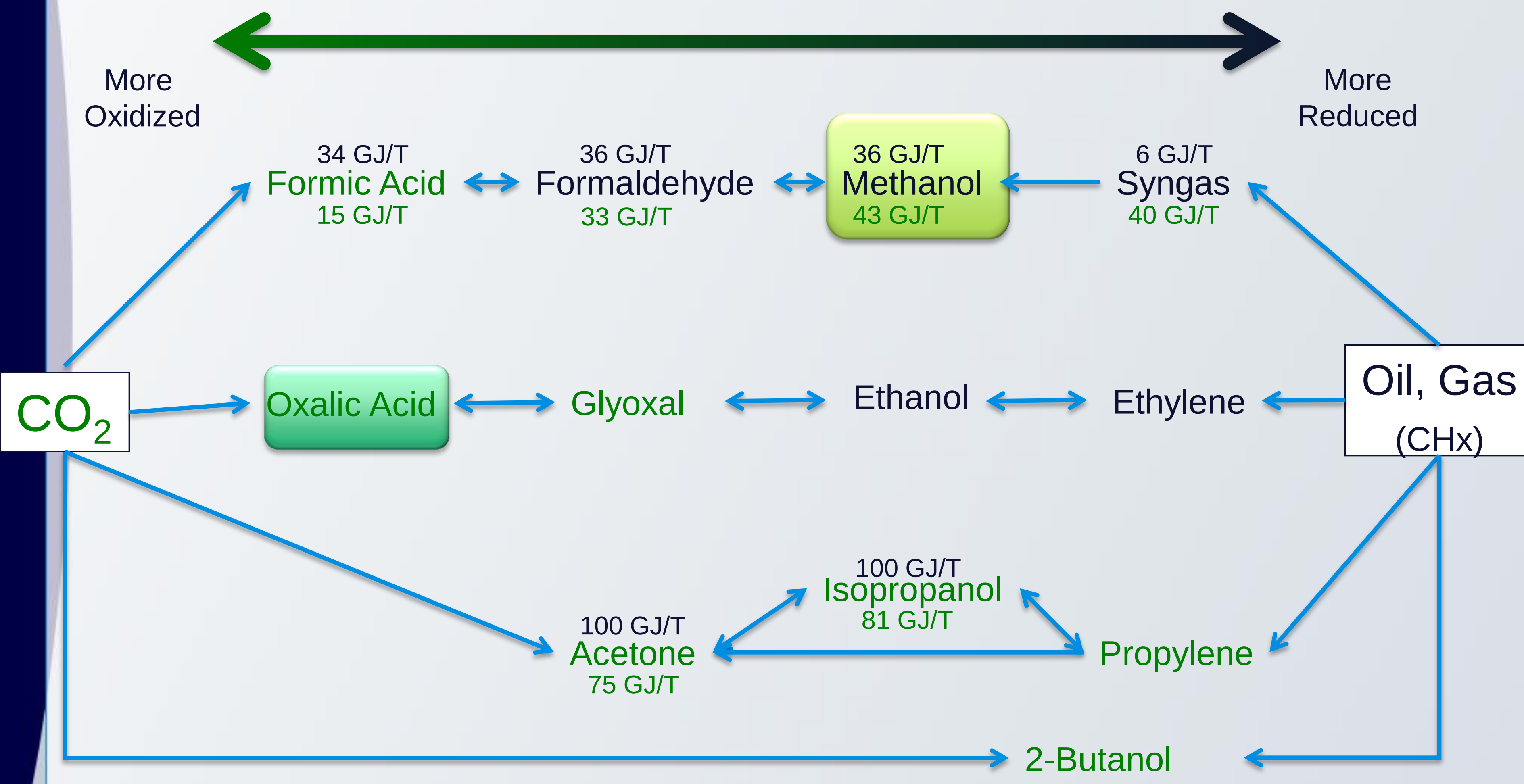
Columbia University, April 2014

Bocarsly Lab Princeton Electrochemistry

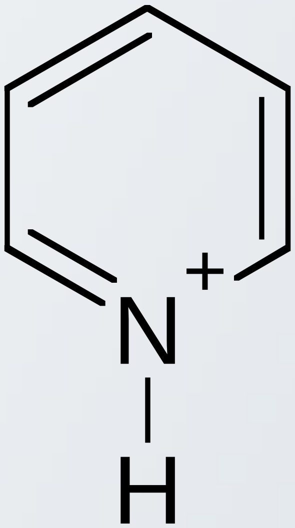
PRINCETON UNIVERSITY

LIQUIDLIGHT

Products and Energetics



One Cannot Achieve the Electrochemical Energy Goals without an Efficient Catalyst

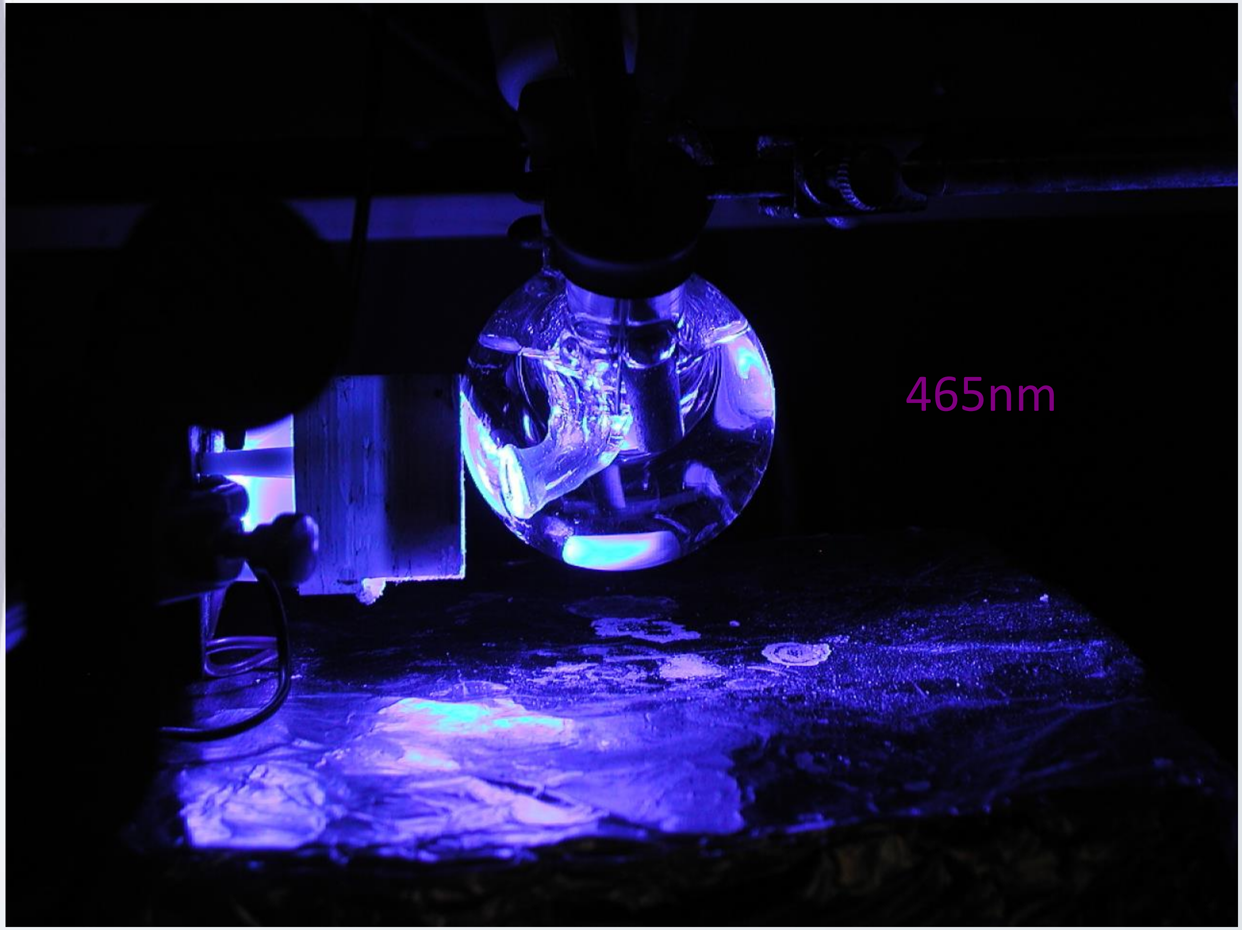


Aromatic Amines Drop the Activation Overpotential to ~200mV

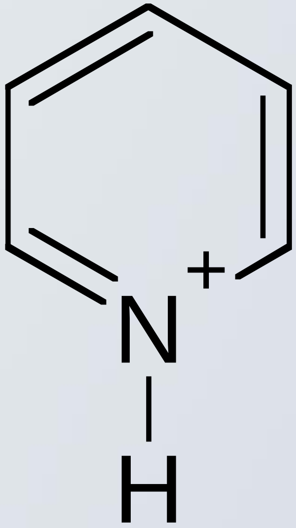
MeOH Evolving PEC Using p-GaP

$CO_2 + 6e^- + 6H^+ \rightarrow CH_3OH + H_2O$

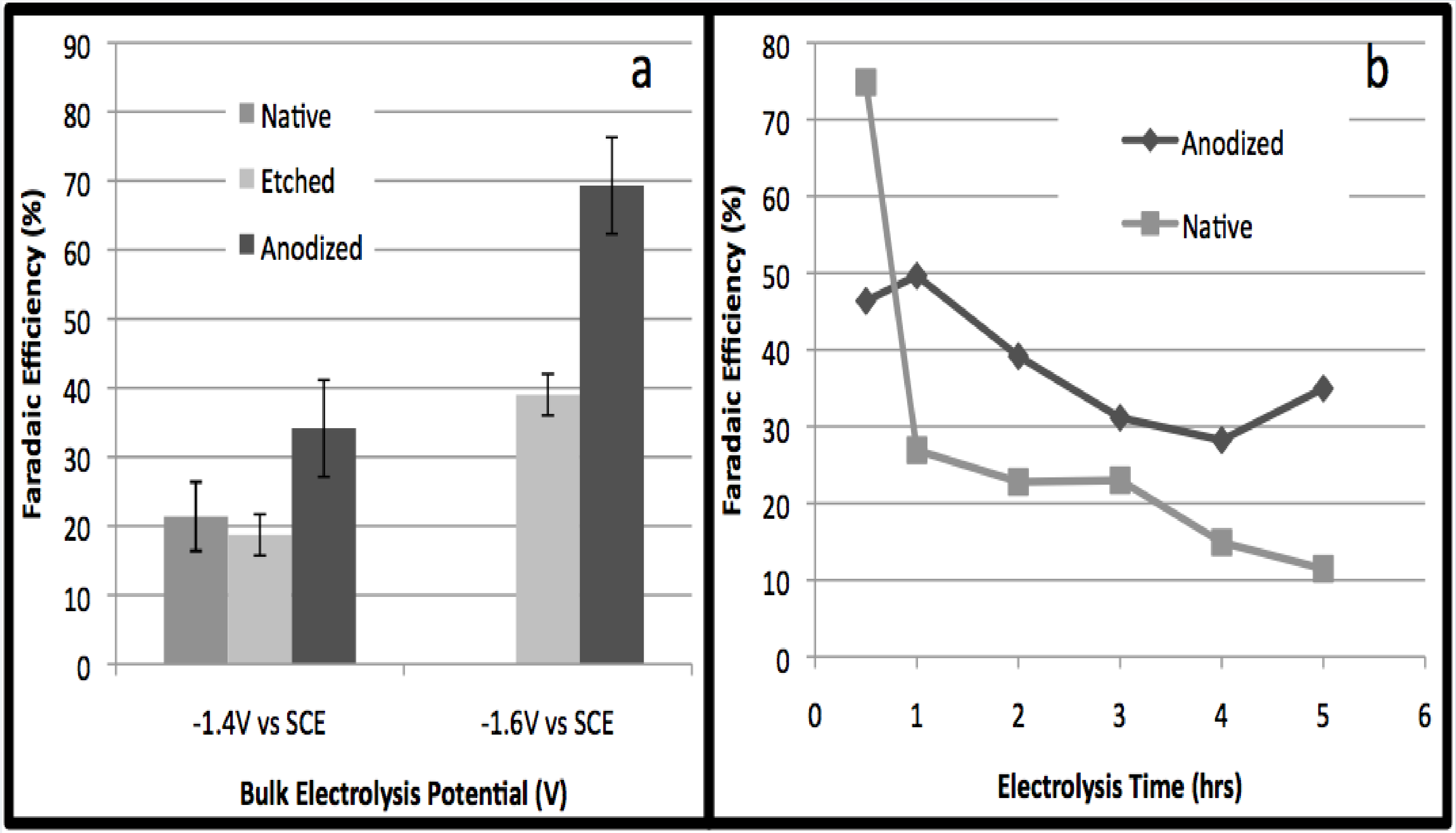
pH 5.2, 10mM pyridine



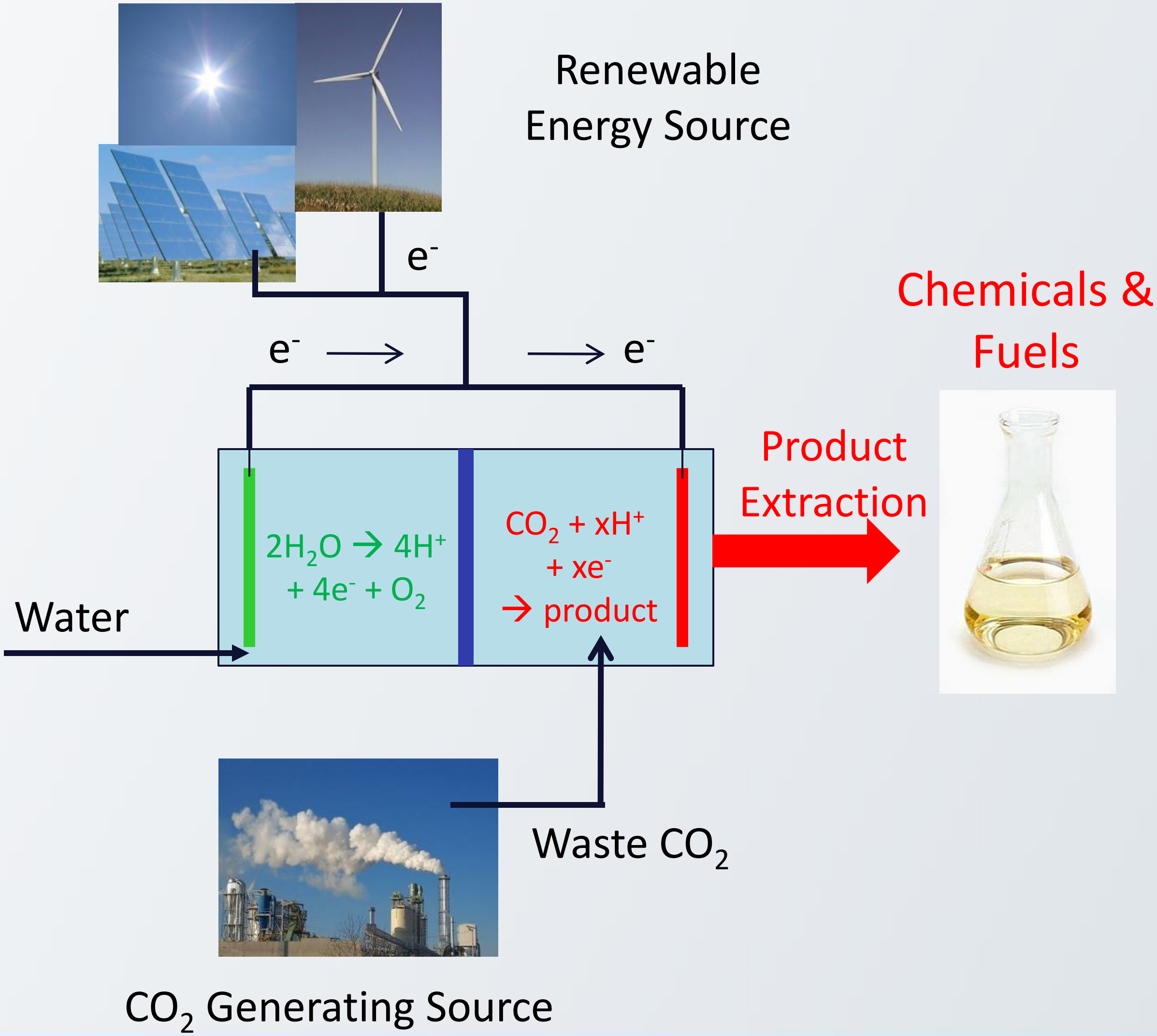
96% Faradaic Yield of MeOH @ 200mV UNDERpotential



CO_2 to Formate at an In Surface



The Liquid Light Process



Highlights

Abundant cathode materials

Efficient and selective catalysts

Low cell voltages (energy efficient)

Stability

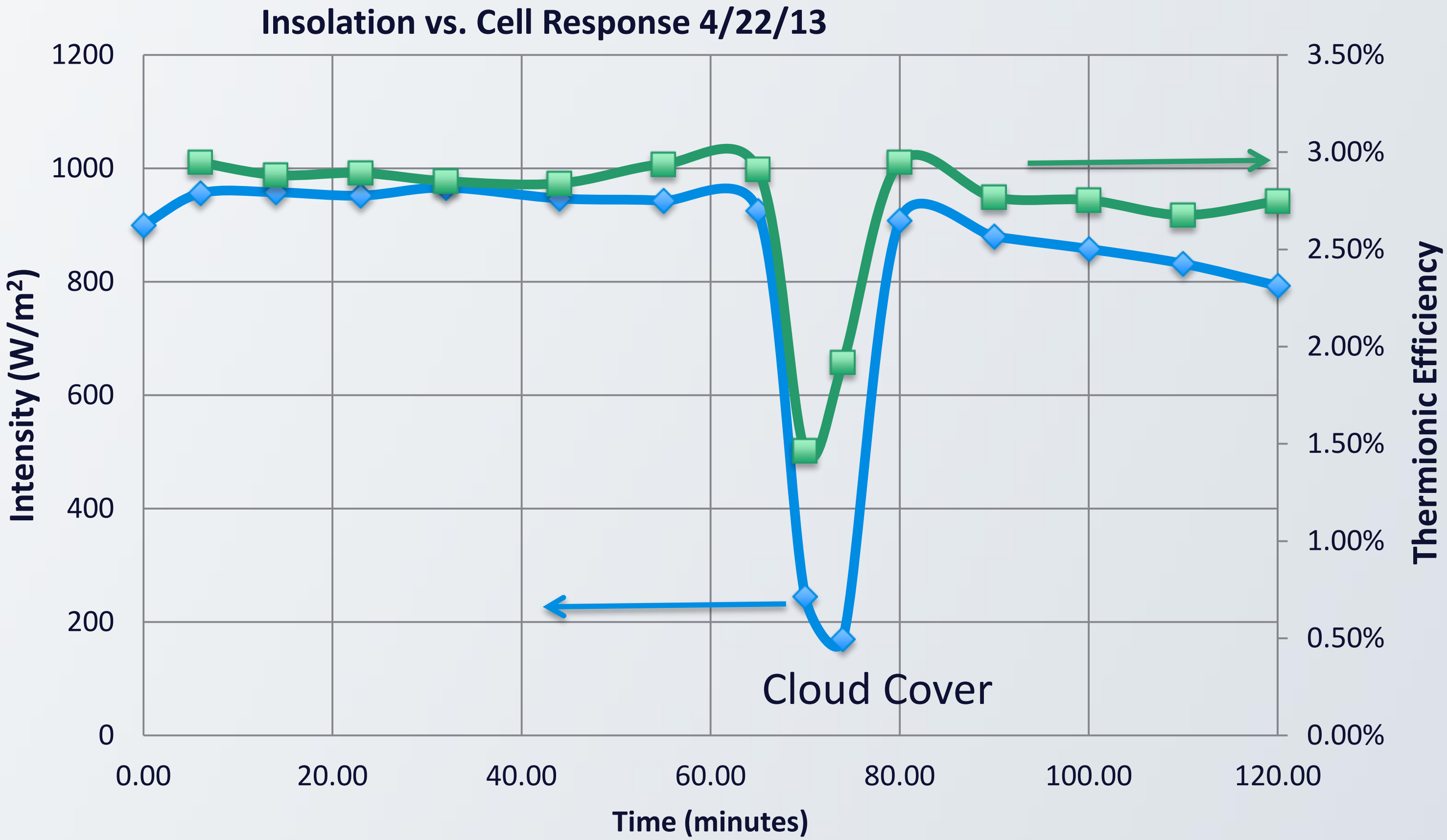
Solar Fuel is Here!

LIQUIDLIGHT

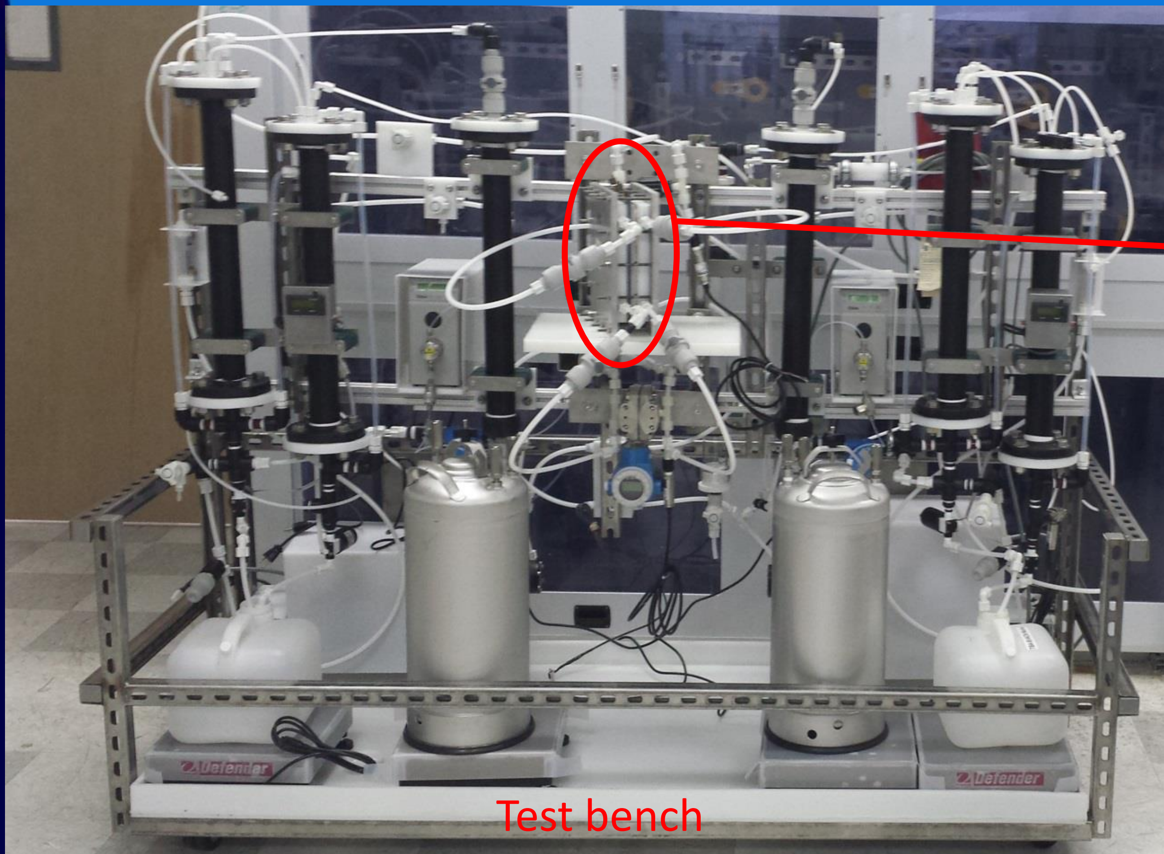
Solar Panel Provided By

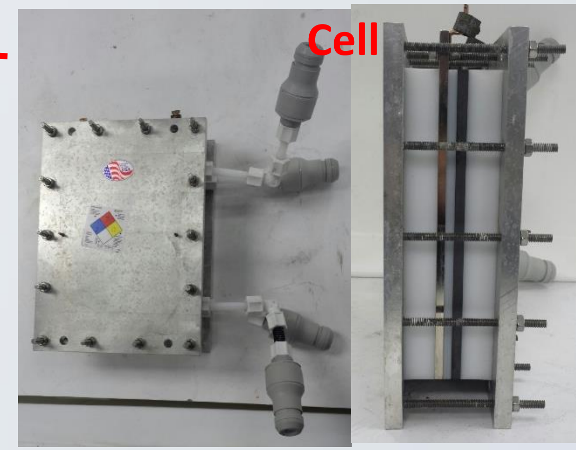
PSEG and PETRA SOLAR Intelligent Energy By Design

System Runs Utilize Real Sunlight (AM 1.5)



Liquid Light's 100cm^2 scale electrochemical cell test bench

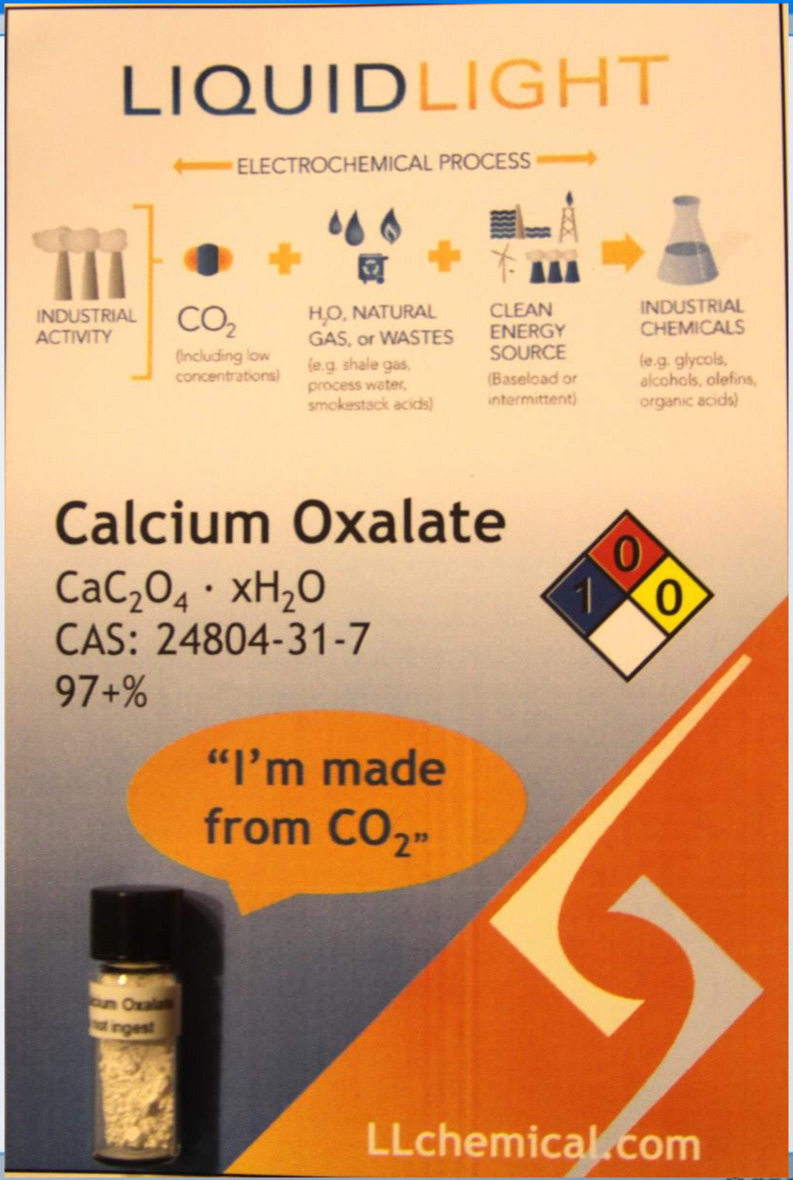




Controls

Photo shows 100cm2 active area electrochemical cell for conversion of CO2 to multi-carbon product along with test bench used to operate and control electrochemical cell. System includes control of electrolyte feed and circulation and instrumentation for process monitoring and control.

They Did It!
Anyone want a good deal on Oxalate?

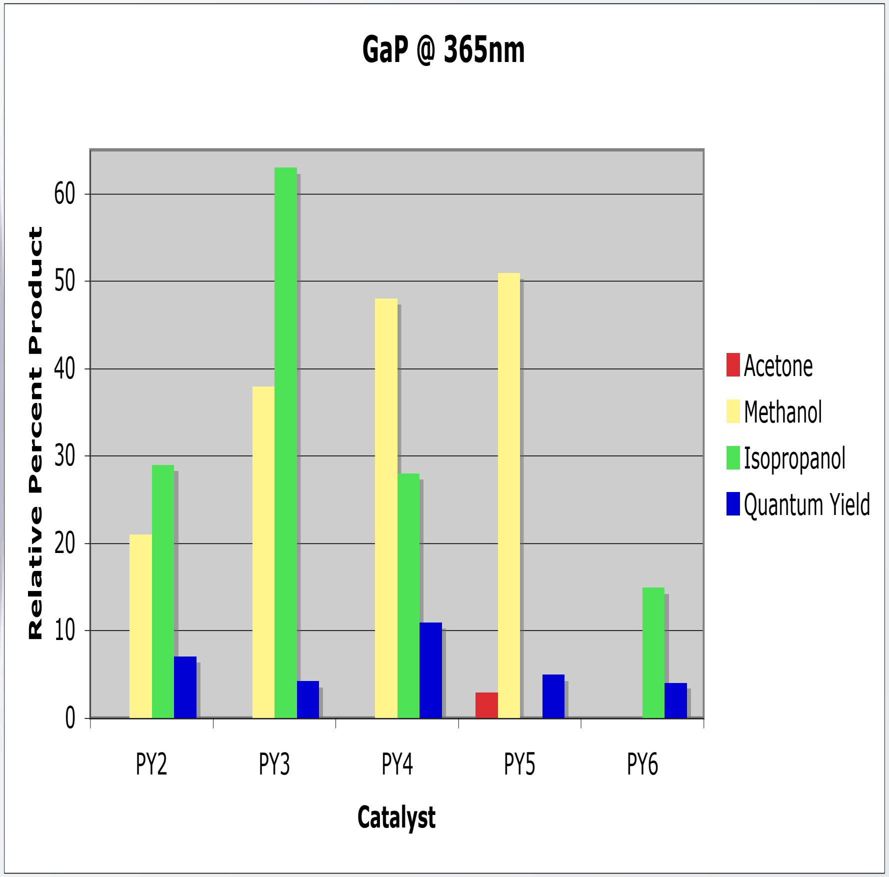


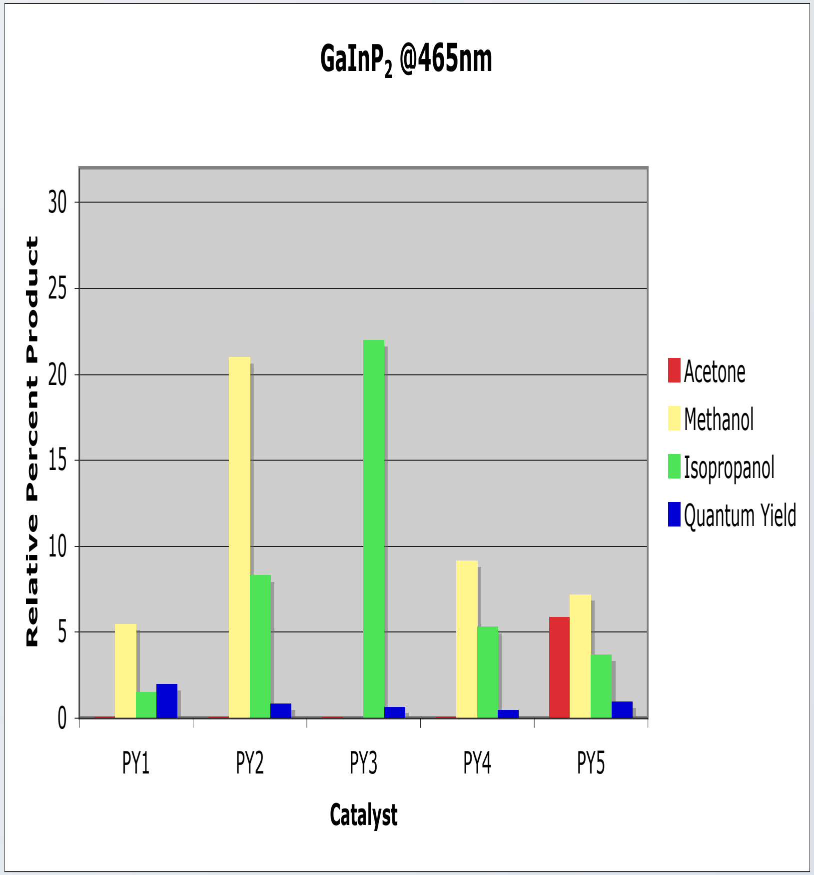
Acknowledgement

LIQUIDLIGHT

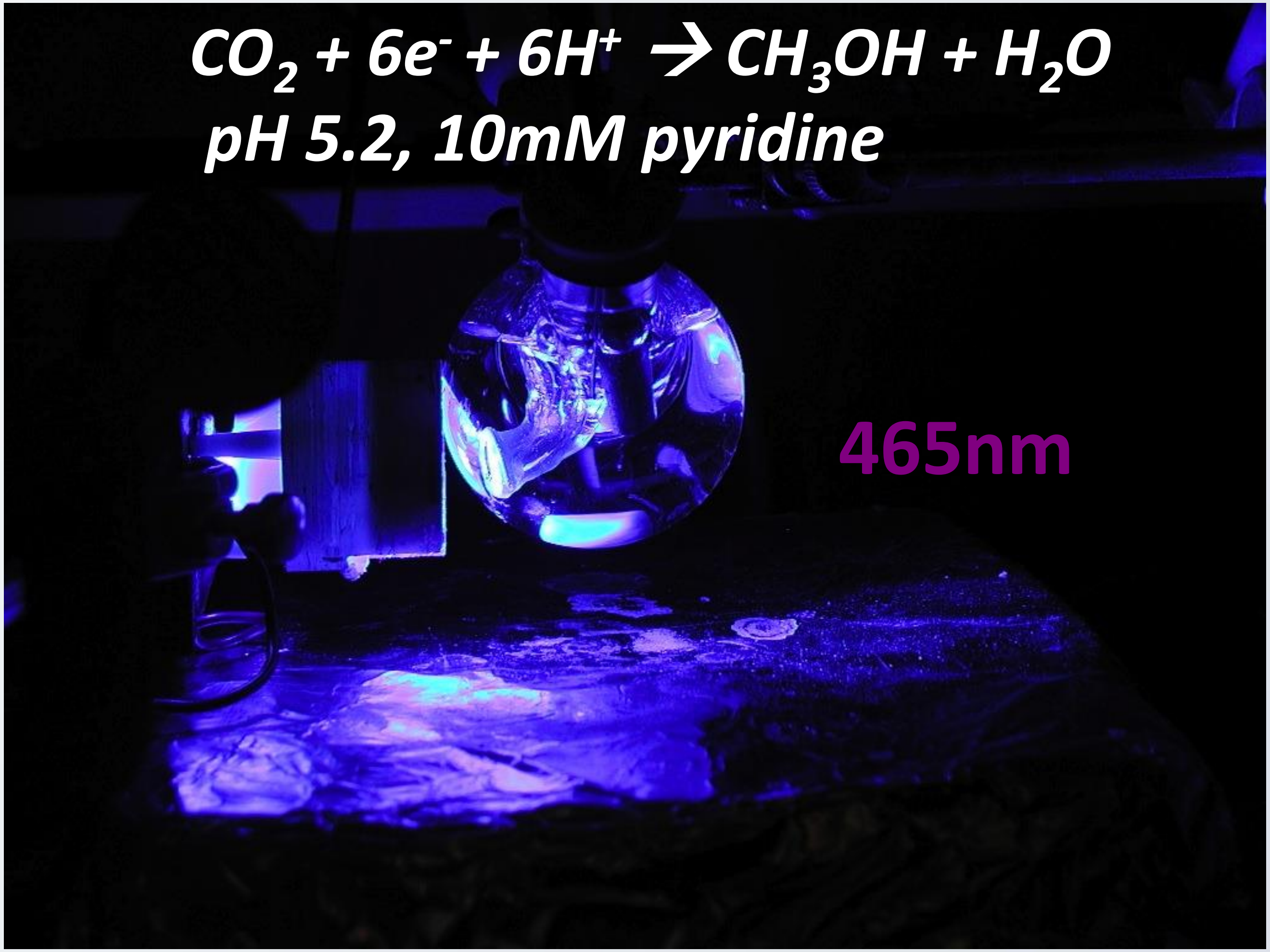
Advancing CO_2 Chemistry

A Complex Synergy





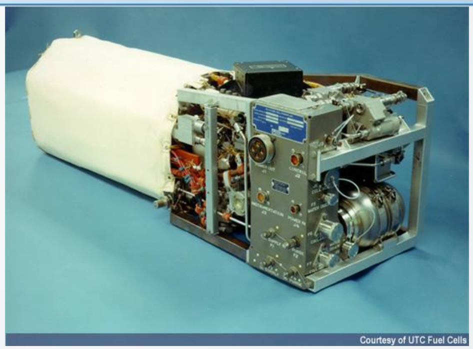
p-GaP MeOH Evolving Cell



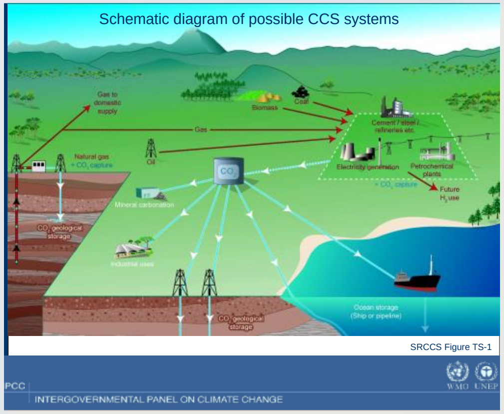
Formic Acid System Scale-Up

Currently producing target chemicals at grams/day with product concentration streams ≥ 3% and CD > 100 mA/cm^2 and 1000 hr stability testing, now scaling up to kg/day over the next year

What should we do with CO_2?

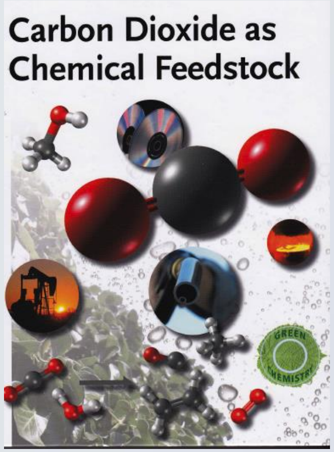


Sequestration



Fuels ← 93% — CO_2 Utilization

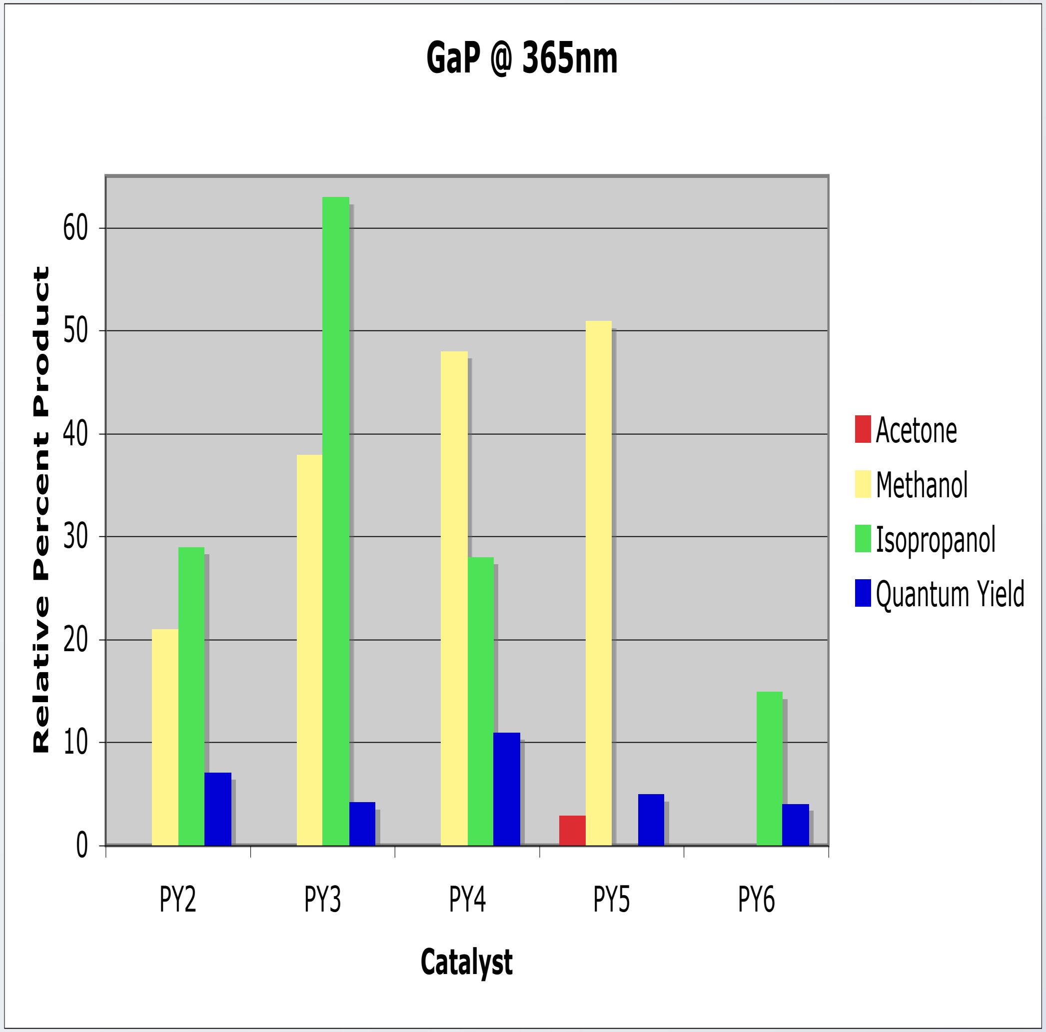
7%



Utilization:

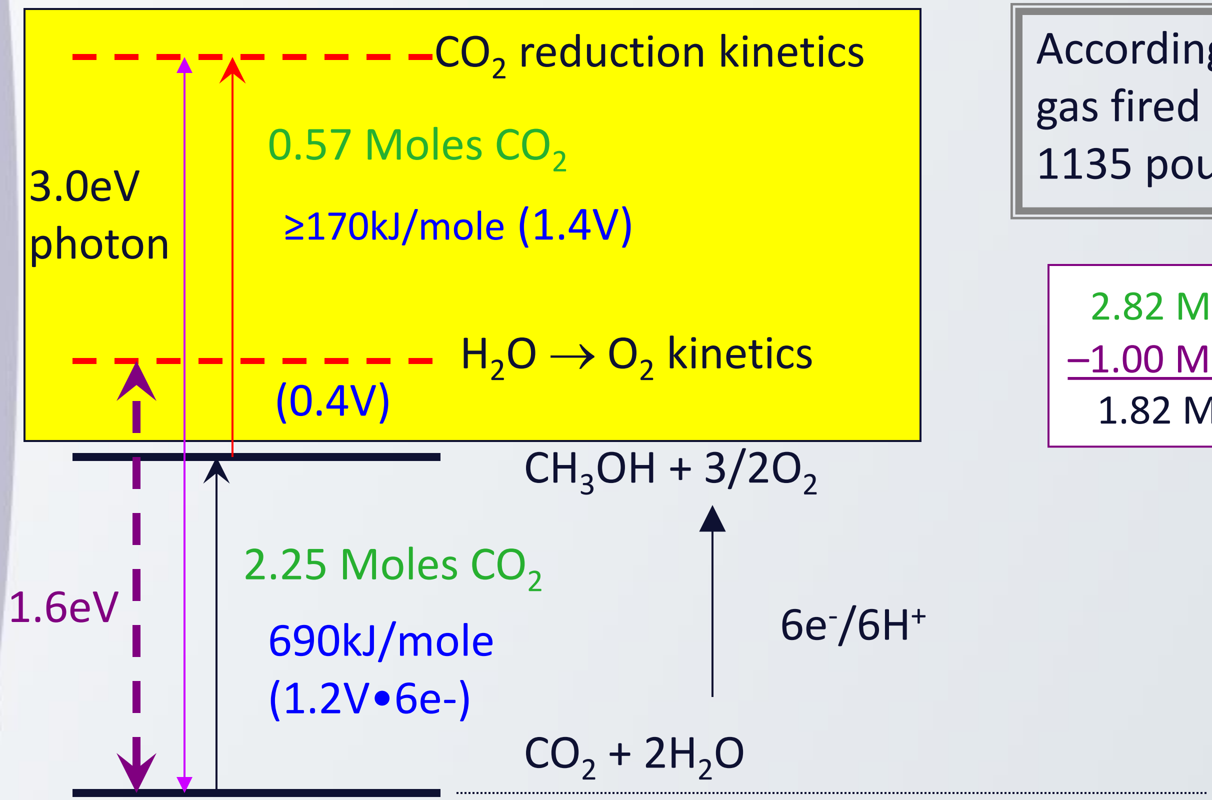
Polymers, Solid-State Products

Carbon-Carbon Coupling is Possible!



Counting the Cost

If 1 Mole of CO_2 is converted:



According to the US DOE a gas fired power plant generates 1135 pounds of CO_2/MWH

2.82 Moles CO_2
–1.00 Moles Consumed
1.82 Moles Net Formed!