Mantra Venture Group

ERC and MRFC Technology

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VENTURE GROUP OTCQB: MVTG

About Mantra

Mantra Venture Group Ltd.

- OCTQB: MVTG
- Established 2007
- Clean technology incubator

Mantra Energy Alternatives Ltd.

- Technology development company
- Owner of **ERC Technology**
- Exclusive licenser of **MRFC Technology**
- 13 employees, including 10 full-time R&D staff (5 Ph.D.s)
- Research facilities in Vancouver, BC, Canada

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Mantra Energy's Team

Management

- Larry Kristof - *Founder and CEO* - 20+ years in entrepreneurship and management
- Glenn Parker - *Director* - 25+ years in investment and capital management
- Patrick Dodd - *VP, Corporate Development* - Master's degree in Clean Energy Engineering
- Sona Kazemi, Ph.D. - *Senior Research Engineer* - Ph.D. in fuel cell development
- Ashwin Usgaocar, Ph.D. - *Senior Materials Scientist* - Ph.D. electrochemist
- Piotr Forysinski, Ph.D. - *Product Design Engineer* - Ph.D. physical chemist
- Tirdad Nickchi, Ph.D. - *Senior Electrochemical Engineer* - Ph.D. electrochemist
- Christina Gyenge, Ph.D. - *VP, Marketing & Innovation* - 20+ years in tech innovation
- Randy Gue - *Industry Specialist* - 30+ years in process engineering at Lafarge Canada

Advisory

- Professor Emeritus Colin Oloman - 50+ years in electrochemical engineering & design
- Professor Elod Gyenge - Leading expert in alkaline fuel cells and electrochemical systems
- Professor Plamen Atanassov - Leading expert in electrocatalysis and fuel cells
- Dr. Alexey Serov – Assistant Professor in electrocatalysis and catalyst synthesis
- Norman Chow - President of Kemetco Research, history in technology commercialization

Partners & Collaborations

ALSTOM

LAFARGE

kemira

NORAM Powertech

BC RESEARCH

UBC

INRS Université d'avant-garde

UNM

UNIVERSITY OF TORONTO

Canada

Mitacs

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ERC

Electrochemical Reduction of CO_2

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2014 Officially Hottest Year on Record

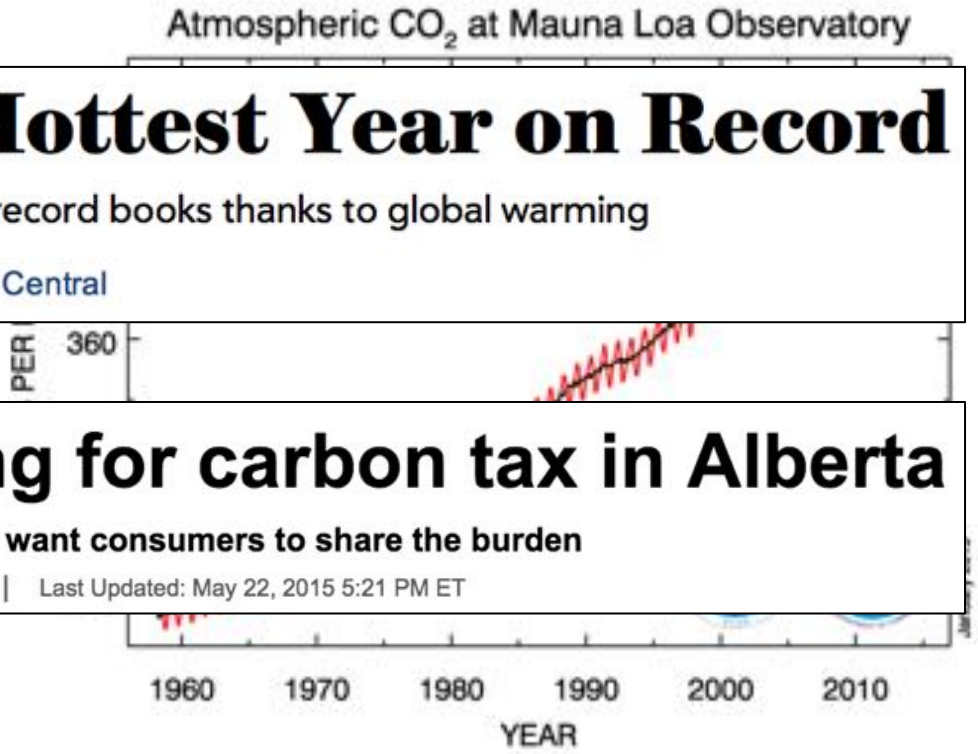
The Japanese declare 2014 one for the record books thanks to global warming

January 5, 2015 | By Brian Kahn and Climate Central

Oil industry pushing for carbon tax in Alberta

But if heavy emitters are going to pay, they want consumers to share the burden

By Kyle Bakx, CBC News Posted: May 22, 2015 1:16 PM ET | Last Updated: May 22, 2015 5:21 PM ET



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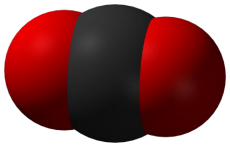
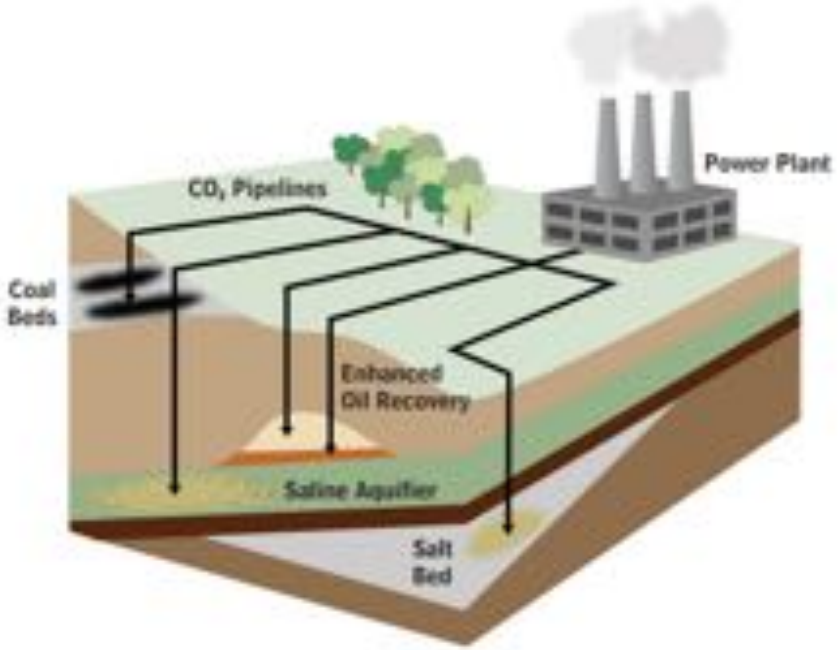


CO_2

Carbon Capture and Storage



- >$20 billion invested
- $80 per tonne CO_2 stored

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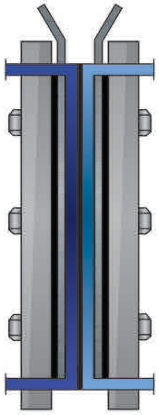
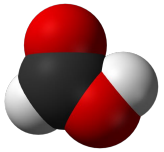
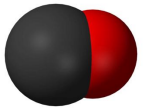
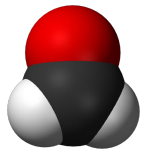
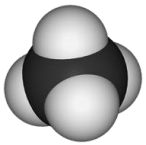
CO_2

ERC

Electrochemical Reduction of CO_2



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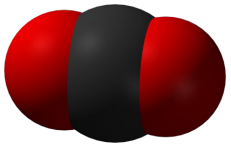
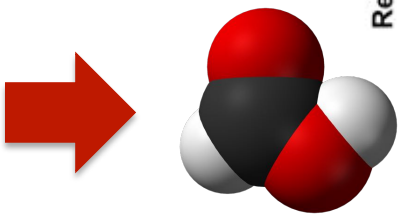


CO_2

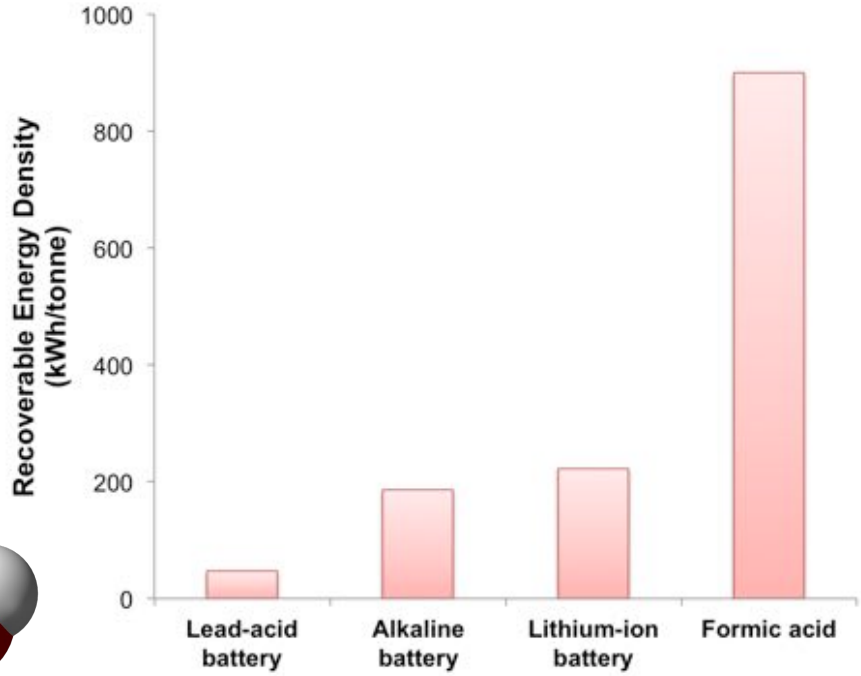


Formic Acid

- Animal feed
- Leather tanning
- Textiles
- De-icing

Price Per Tonne: **$1,000 - $1,500**

Global Market: **$1 billion**



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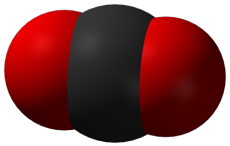
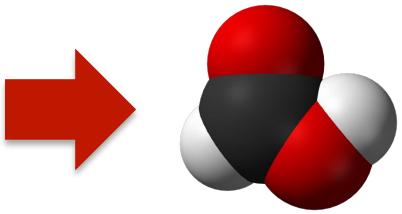


CO_2



Formic Acid

- Animal feed
- Leather tanning
- Textiles
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Price Per Tonne: **$1,000 - $1,500**

Global Market: **$1 billion**

Hydrogen Storage

Direct Fuel Cells

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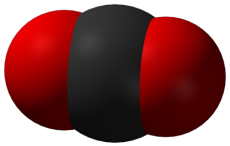
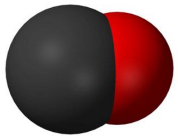


CO_2



Carbon Monoxide

- Synthesis gas
- Methanol
- Acetic acid
- Fuel

Price Per Tonne: **$800 - $1,200**

Global Market: **>$70 billion**

- Methanol
  - Formal-dehyde
  - MTBE
  - Acetic Acid
    - Phosgene
- Oxo Alcohols
- Fischer-Tropsch
  - Gasoline
  - Diesel/ Waxes

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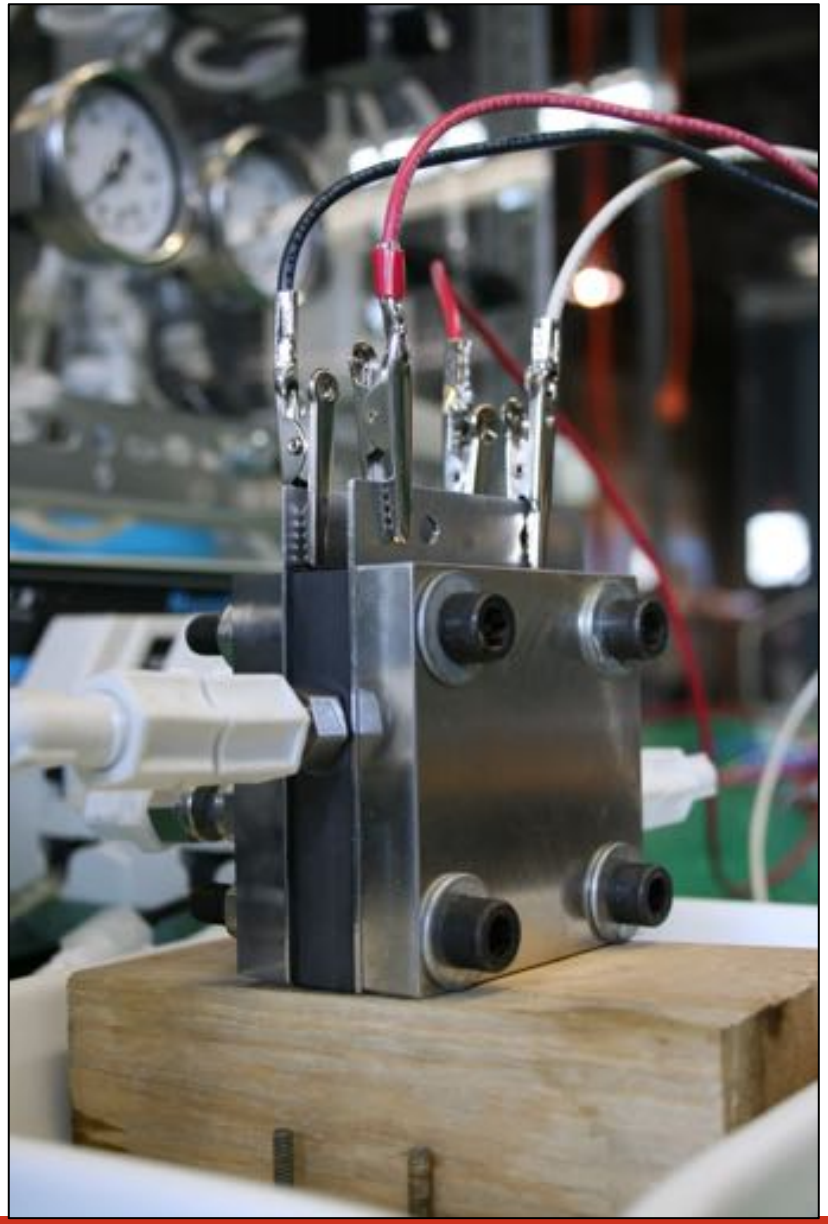

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Scale-up and Demonstration

Demonstration I LAFARGE

- Lafarge cement plant in Richmond
- 100 kg/day CO_2 to formate/formic

Demonstration II Ayinger

- Ayinger brewery in Bavaria
- 100 kg/day CO_2 to other products

ALSTOM

NORAM

BC RESEARCH

kemira

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MRFC

Mixed-Reactant Fuel Cell

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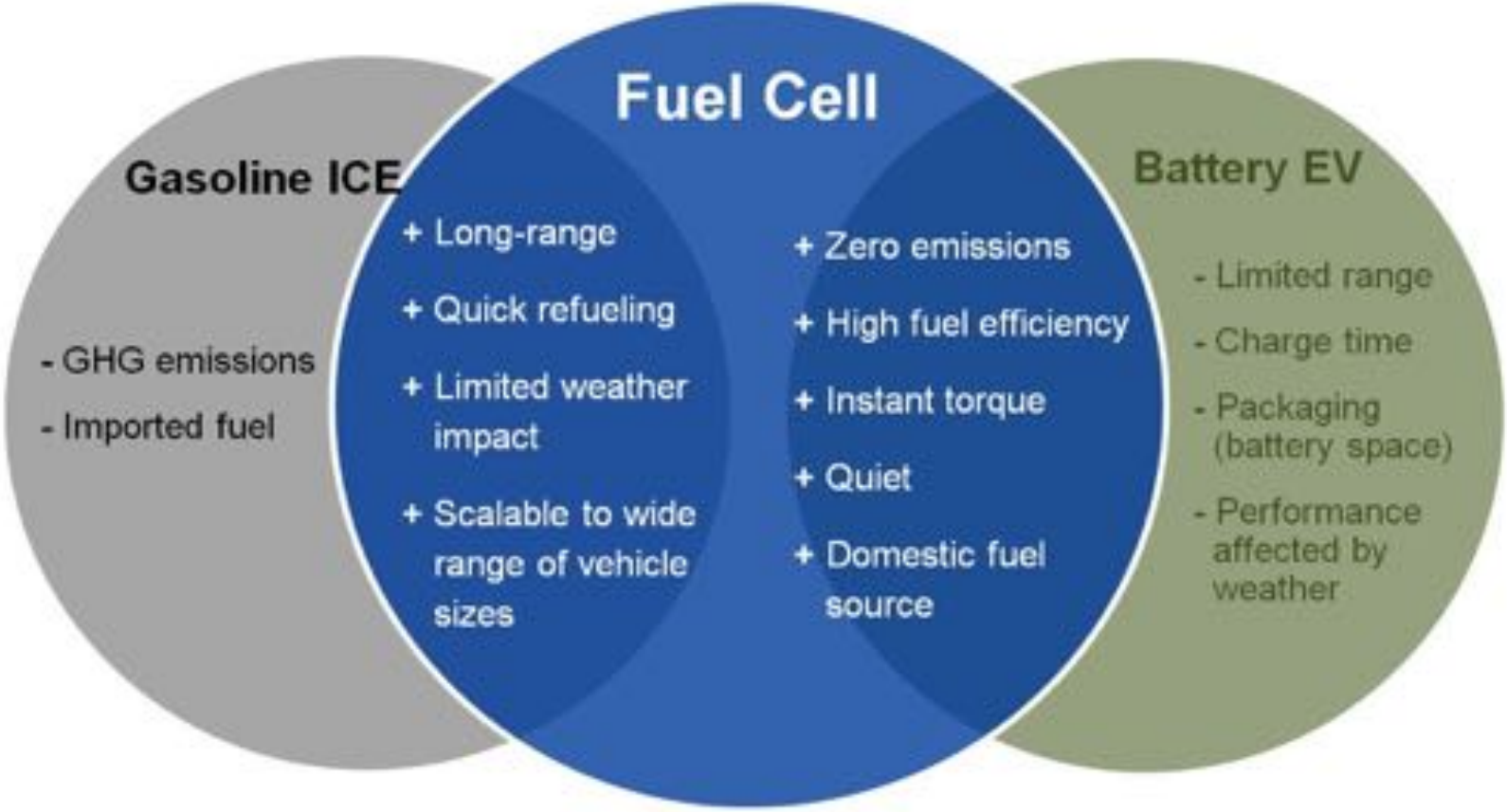
Fuel Cells: Advantages



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Conventional Fuel Cells

- x H_2-based fuel cell stacks
- x Expensive polymeric membrane (15-68% of cost)
- x Heavy/bulky flow-field plates (10-25% of cost)
- x Flat-plate design
- x Lifetime challenges
- x Expensive platinum catalyst

MRFC

Revolutionary unconventional design

- ✓ Liquid fuel-based fuel cell stacks
- ✓ No polymeric membrane
- ✓ No flow-field plates (smaller and lighter)
- ✓ Cylindrical design
- ✓ Improved lifetime
- ✓ No platinum catalyst

- Anticipated 60-80% cost reduction
- Demonstrated highest reported current density for a mixed-reactant system

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Intellectual Property

Intellectual Property Status

	US	UK	EU	Canada	Australia	China	India
ERC PATENT	Pending		Pending	✓	✓	✓	✓
MRFC PATENT	✓	✓		Pending			

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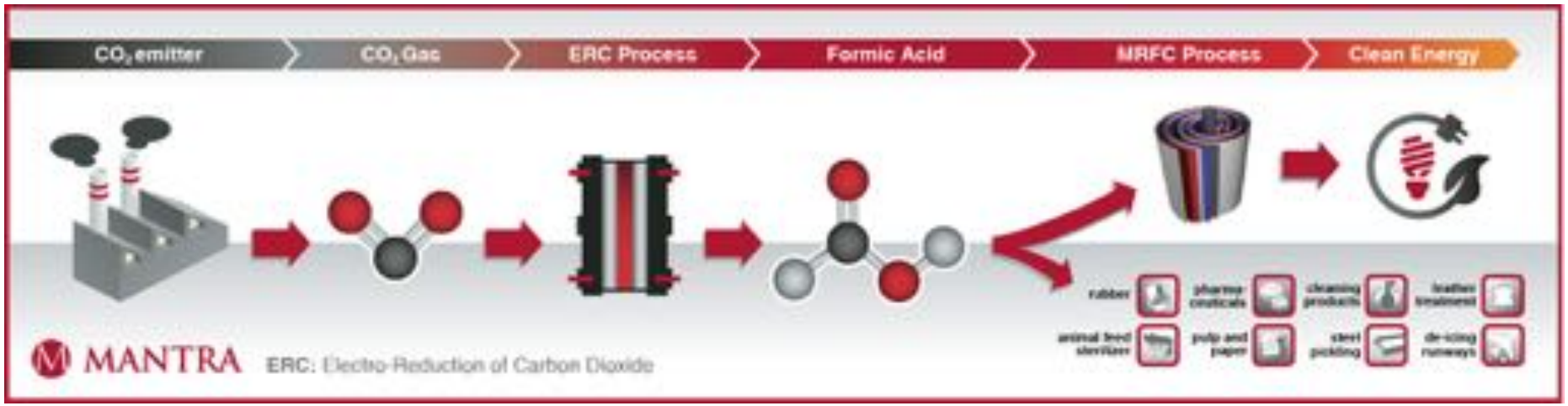
Technology Integration



Mantra is developing effective, affordable solutions for some of the world's biggest challenges.

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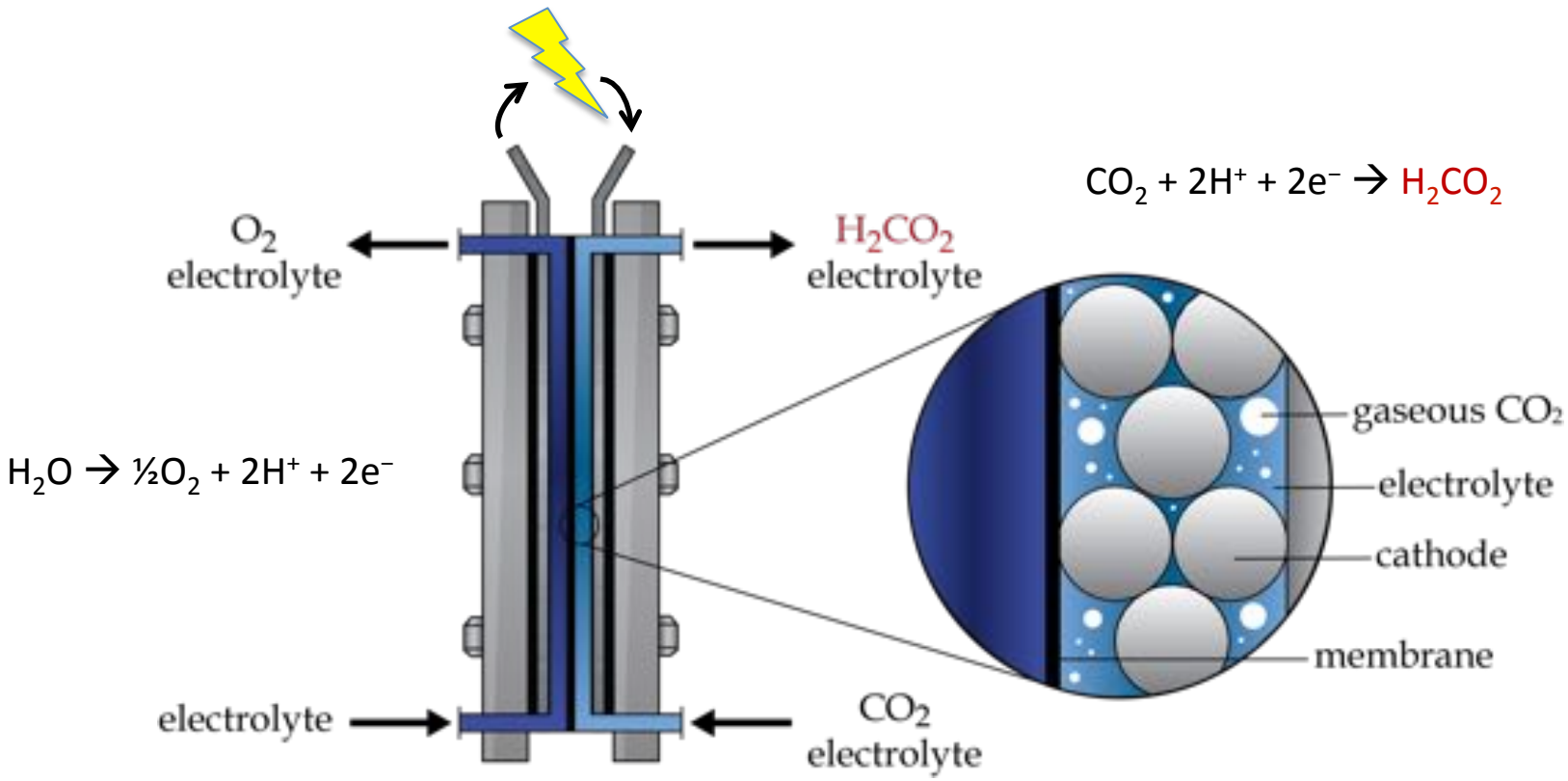
ERC Reactor (CO_2 to Formic Acid)



Total Reaction: $CO_2 + H_2O \longrightarrow \frac{1}{2}O_2 + H_2CO_2$

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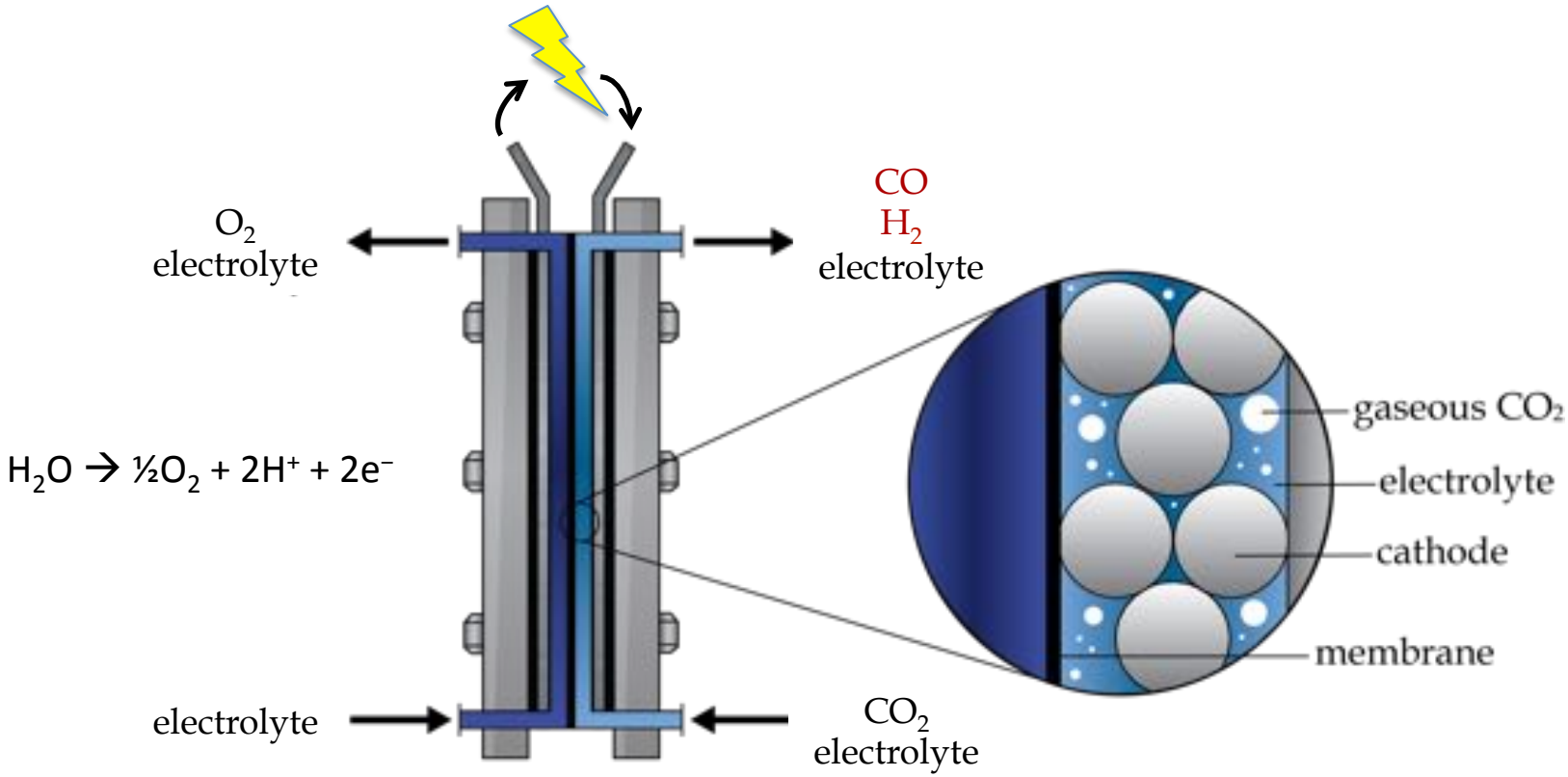
ERC Reactor (CO_2 to Syngas)



Total Reaction:

$$CO_2 \longrightarrow CO + ½O_2$$
$$H_2O \longrightarrow H_2 + ½O_2$$

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Electro-Reduction of CO_2 (ERC)

Table 1. Half-cell reactions for the electroreduction of carbon dioxide.

	Reaction	E° [V][a]
a	$2CO_2 + 2H^+ + 2e^- \leftrightarrow H_2C_2O_4$	−0.475
b	$CO_2 + 2H^+ + 2e^- \leftrightarrow HCOOH$	−0.199
c	$CO_2 + 2H^+ + 2e^- \leftrightarrow CO + H_2O$	−0.109
d	$CO_2 + 4H^+ + 4e^- \leftrightarrow HCHO + H_2O$	−0.071
e	$CO_2 + 6H^+ + 6e^- \leftrightarrow CH_3OH + H_2O$	+0.030
f	$CO_2 + 8H^+ + 8e^- \leftrightarrow CH_4 + 2H_2O$	+0.169

[a] E° versus normal hydrogen electrode (NHE) at 298 K.

C.W. Oloman, H. Li, "Electrochemical Processing of Carbon Dioxide", ***ChemSusChem*** 1 (2008) 385-391.