




 **Fraunhofer**  

Inaugural Fraunhofer – Delaware Technology Summit

***Inaugural Fraunhofer – Delaware
Technology Summit***

Energy and Life Sciences – Solutions for Sustainability

*University of Delaware
Clayton Hall
March 5/6, 2013*

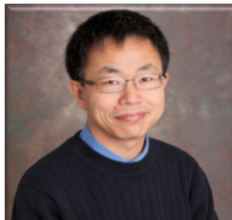
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SESSION B.2: SUSTAINABLE ENERGY CONCEPTS

Plenary Talk
“Clean Energy: Flash without Flame”

– Yushan Yan
Distinguished Professor of Engineering,
Chemical and Biomolecular Engineering
University of Delaware



A diagram illustrating a clean energy cycle. At the top, a sun, a water tap with 'OH⁻' above it, solar panels, and a wind turbine are shown. Below, a globe is the central element. A blue tank labeled 'H₂' is connected to a blue box labeled 'OH⁻' and a red box labeled 'OH⁻'. Arrows indicate the flow of energy and materials. The background includes a water dam, an airplane, and a house.

Clean Energy: Flash without Flame

Yushan Yan
Distinguished Engineering Professor
Department of Chemical and Biomolecular Engineering
University of Delaware

Fraunhofer - Delaware Technology Summit
3:00 – 3:30 pm, Clayton Hall, UD

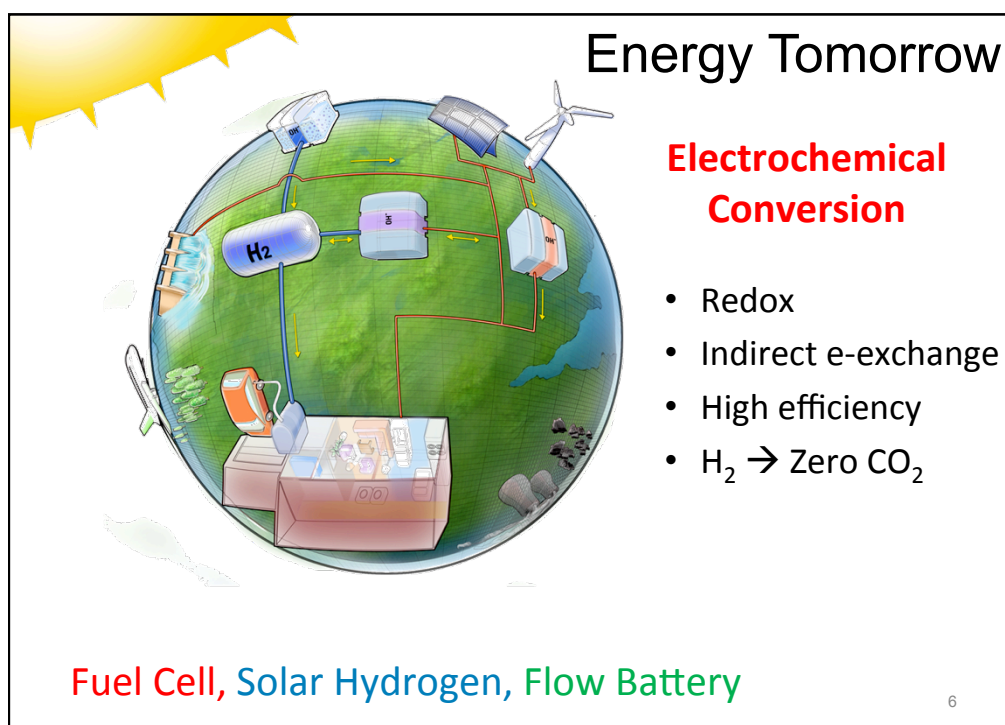
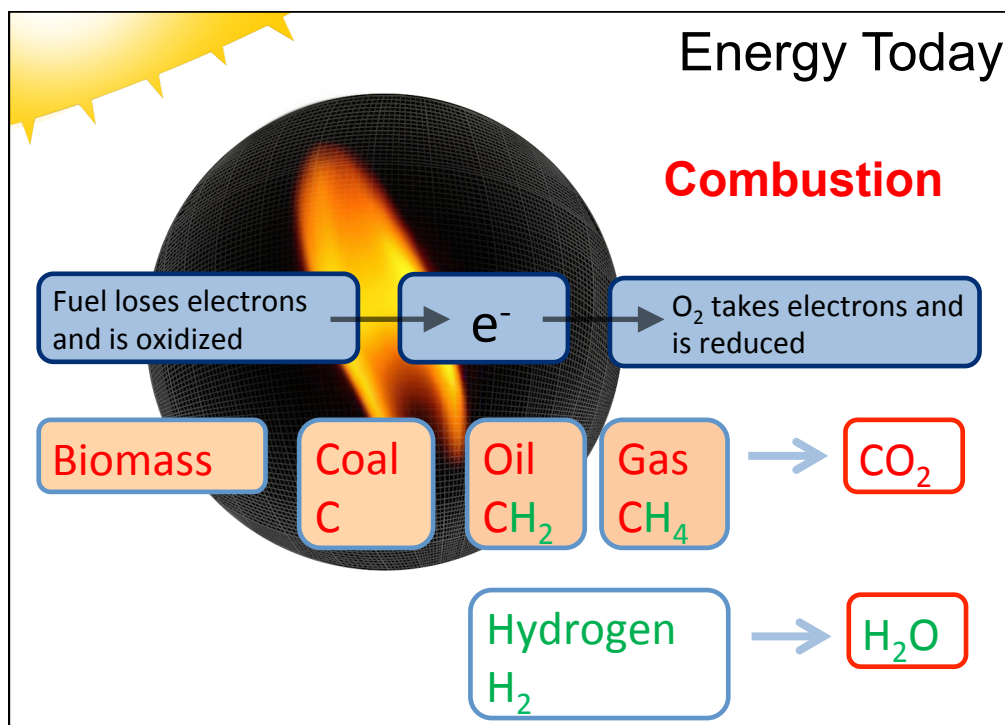
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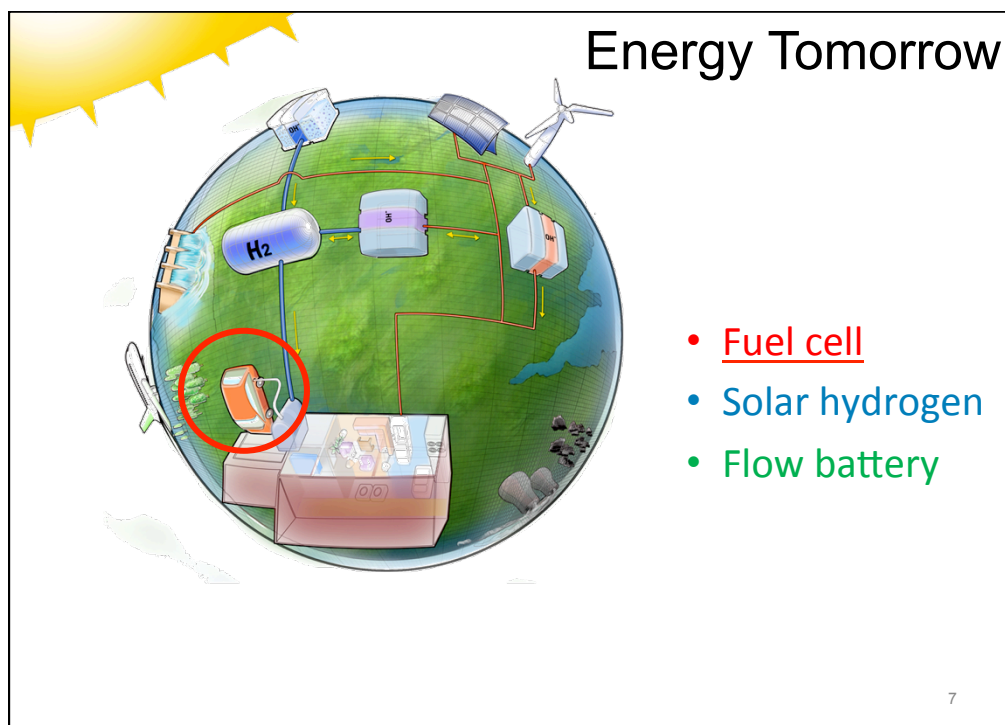
A 3D rendering of a green globe representing Earth, resting on a large green leaf. A yellow sun is in the top left corner.

Civilization

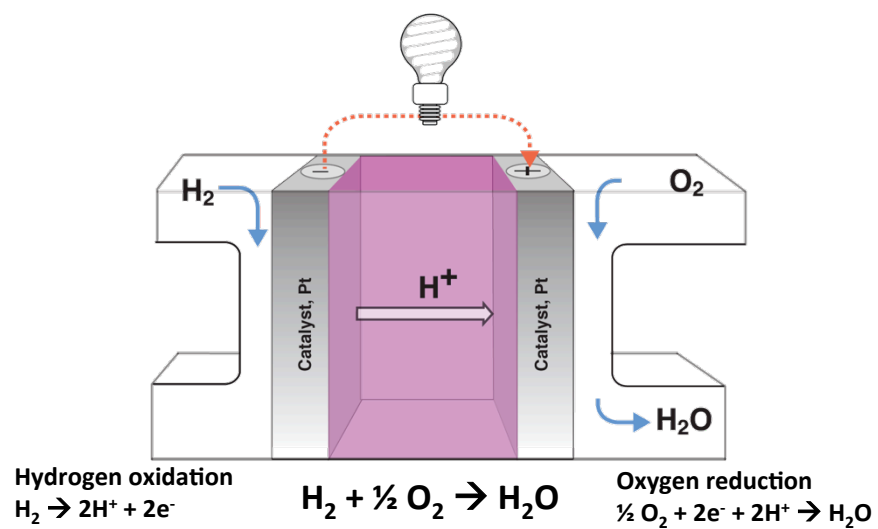
- Food
- Air
- Water
- ...
- **Energy**

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Proton Exchange Membrane Fuel Cell

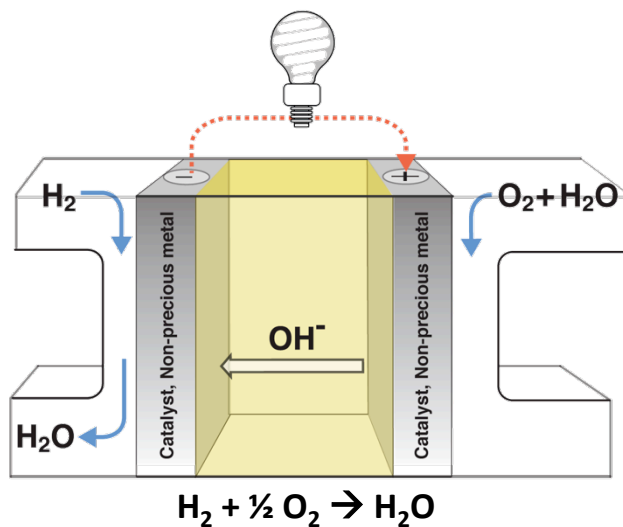


PEM Fuel Cell Economics

- | | |
|---|---|
| <ul style="list-style-type: none"> • Commercialization barrier: <ul style="list-style-type: none"> – Cost • Solution: <ul style="list-style-type: none"> – Switch to non-precious-metal catalysts and inexpensive membranes | <ul style="list-style-type: none"> • Pt: \$2,200/oz • Ag: \$22/oz • Ni: \$0.56/oz <p>Metal prices
(5-year-average:
2007/09-2012/09, from
www.metalprices.com)</p> |
|---|---|

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Hydroxide Exchange Membrane Fuel Cell



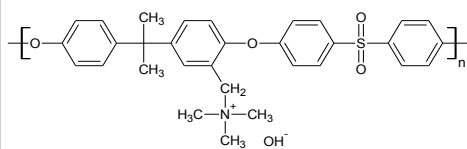
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Development of HEMFC

- Membranes
- Cathode catalysts
- Anode catalysts

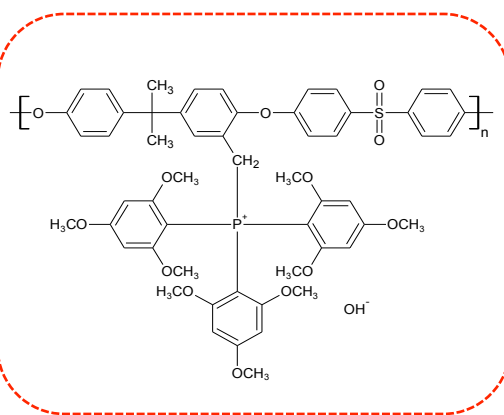
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Quaternary Phosphonium Cation Functionalized Polymers (QPOH)

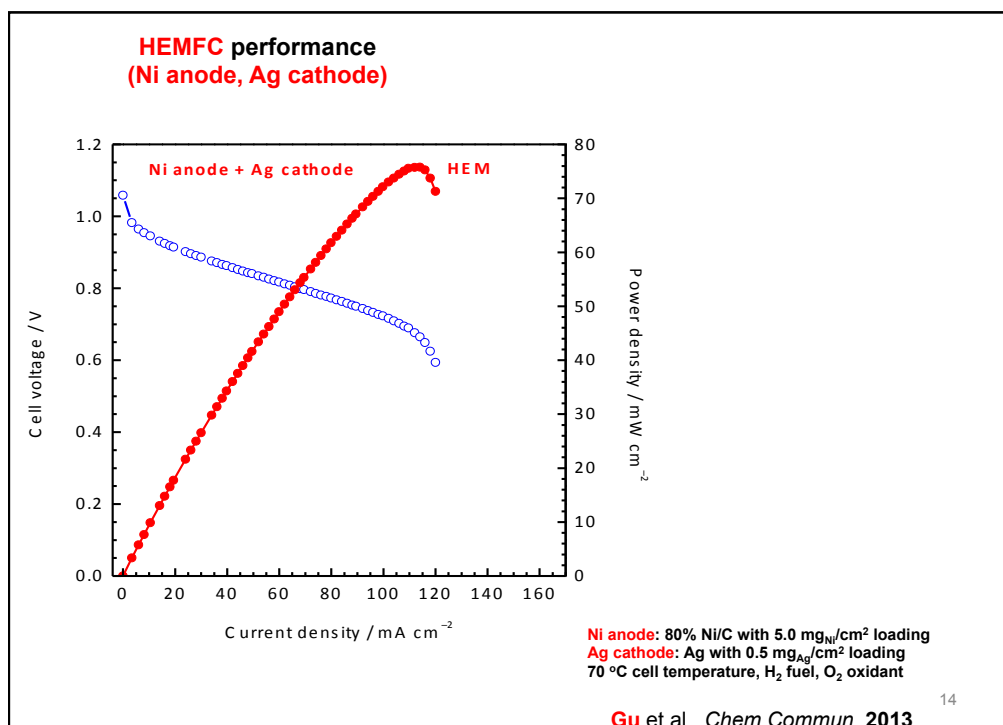
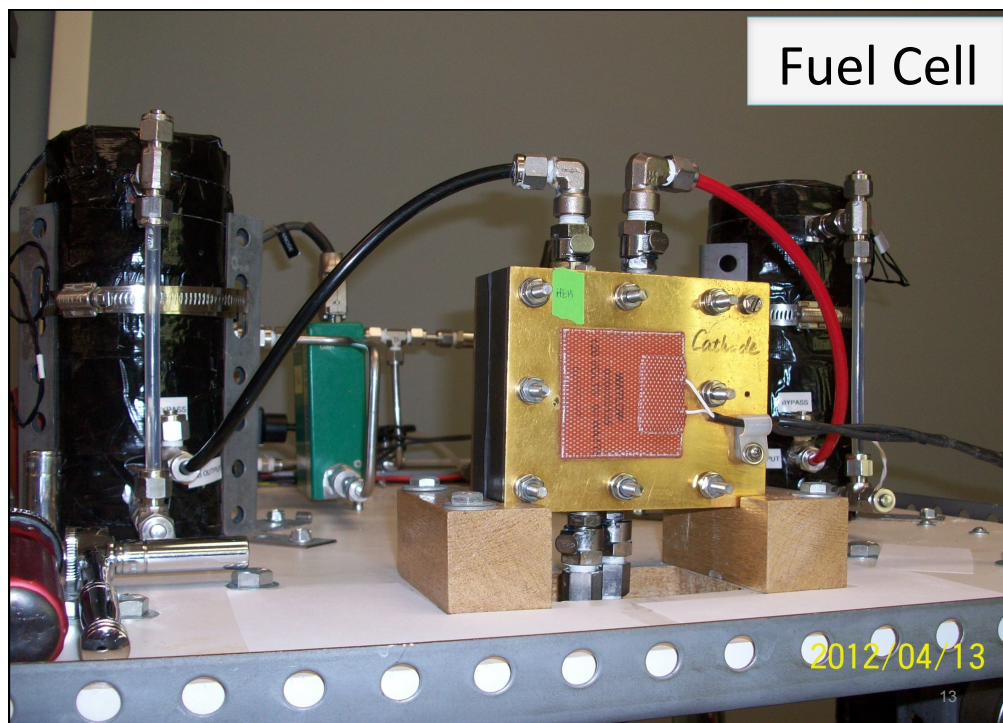


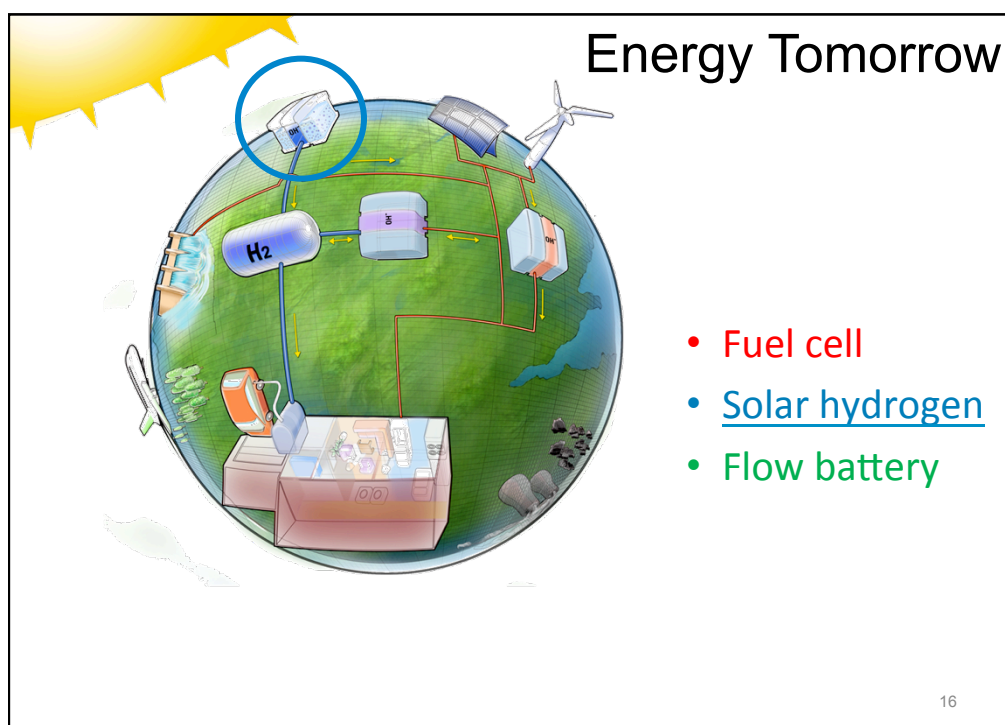
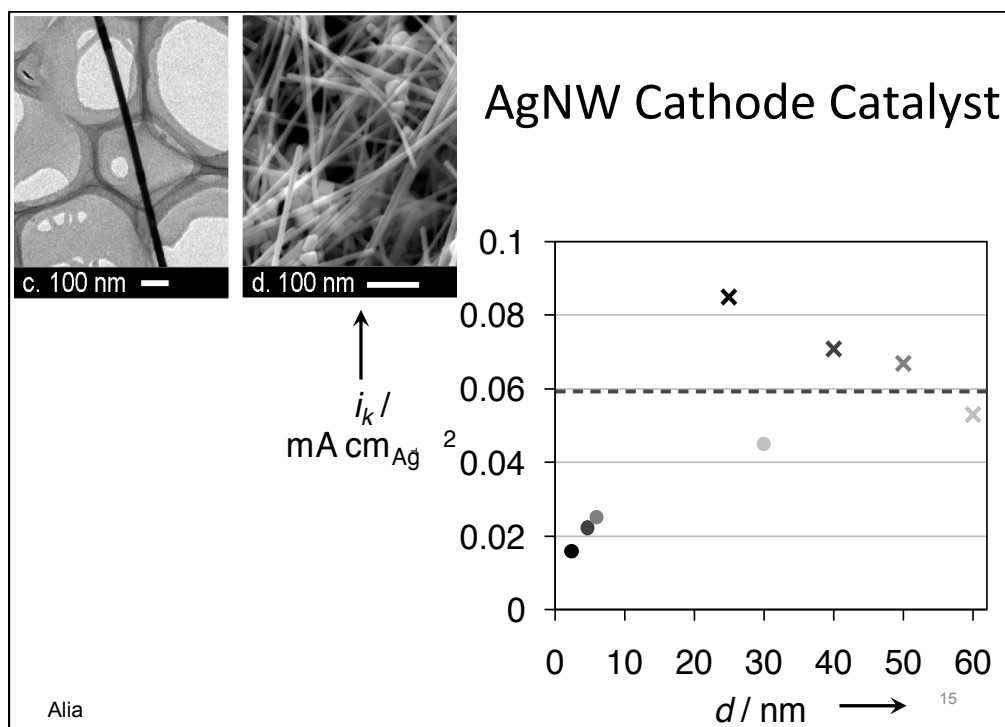
R_4N^+ :

- Low OH^- conductivity
- Low stability

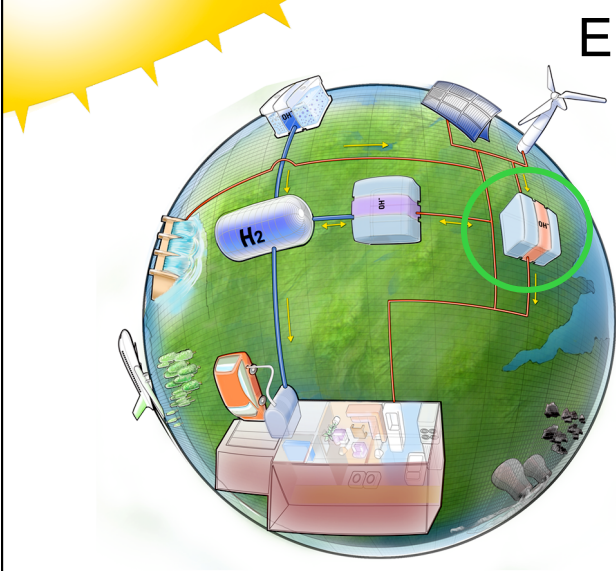


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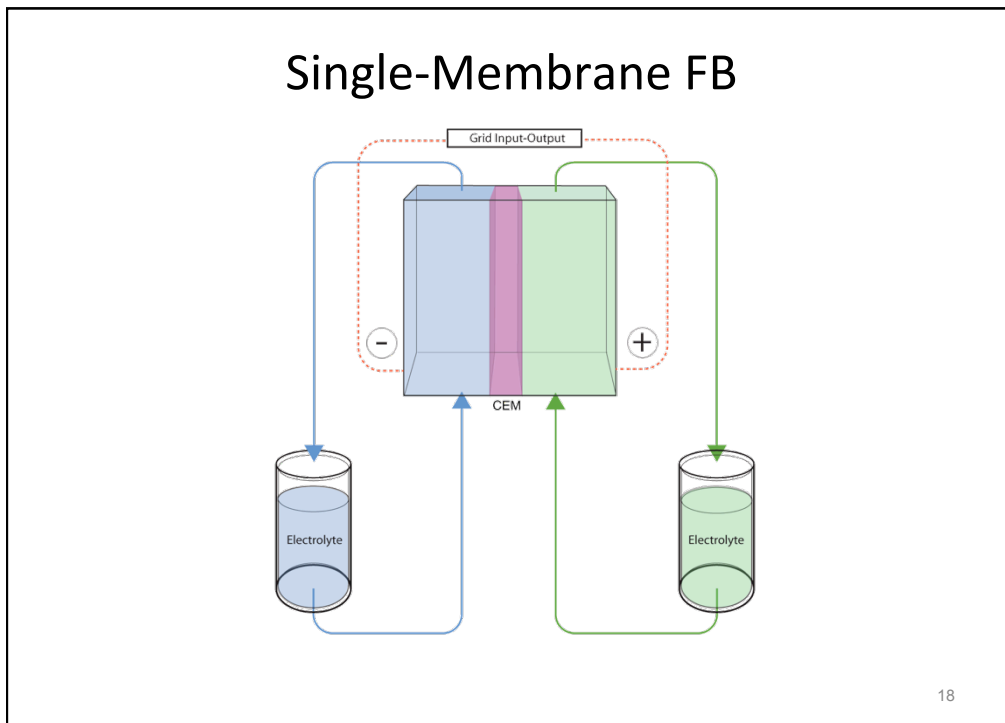


Energy Tomorrow

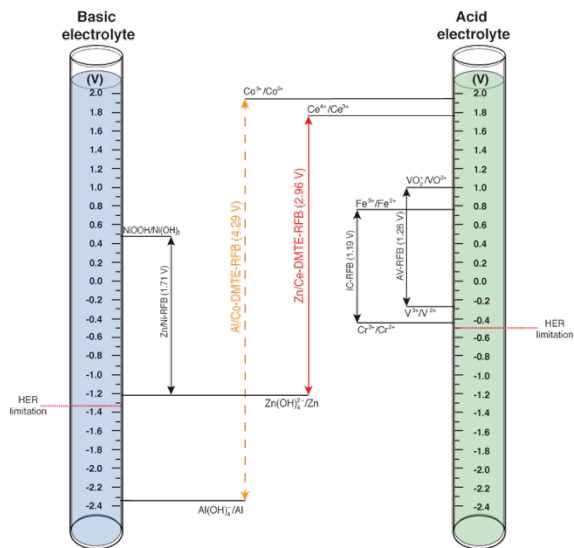


- Fuel cell
- Solar hydrogen
- Flow battery

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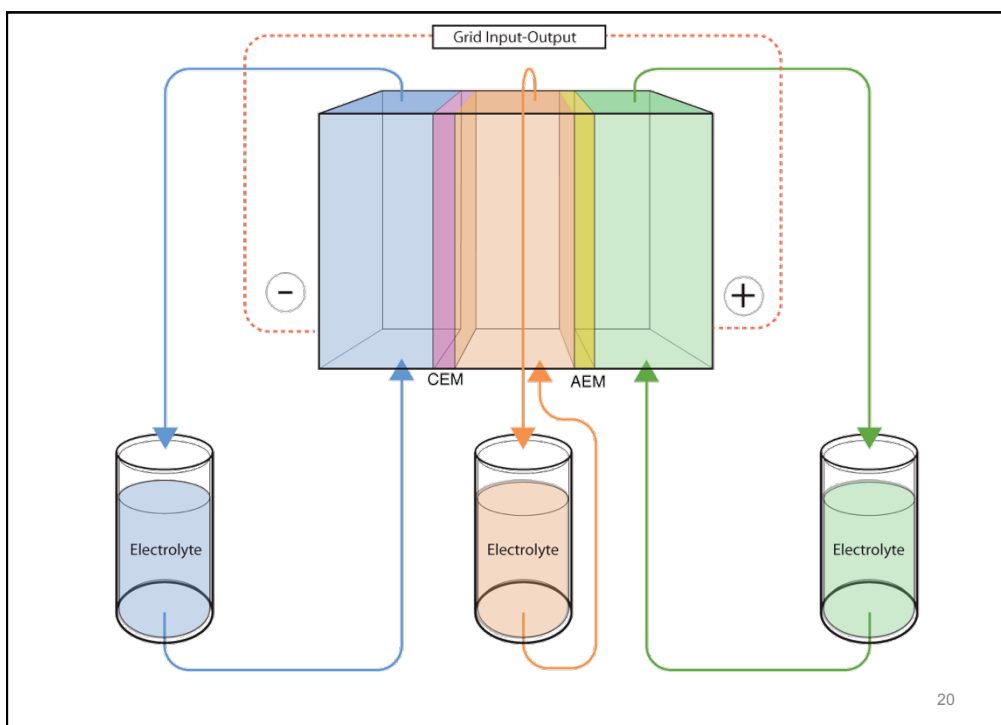


Double-Membrane Triple-Electrolyte (DMTE) FB



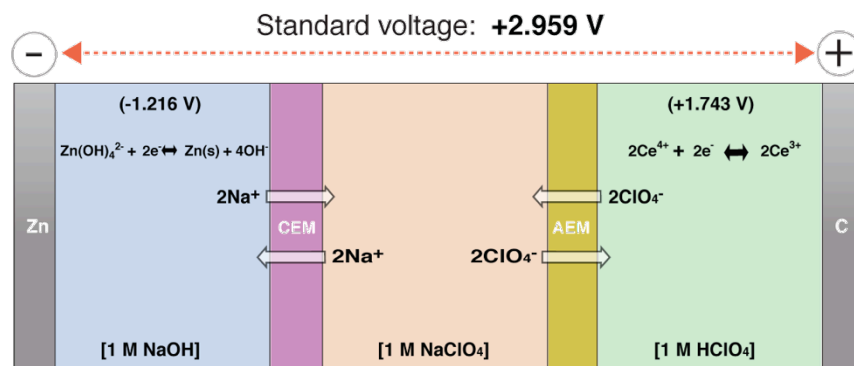
- High voltage
- High energy density
- High power density
- Low cost

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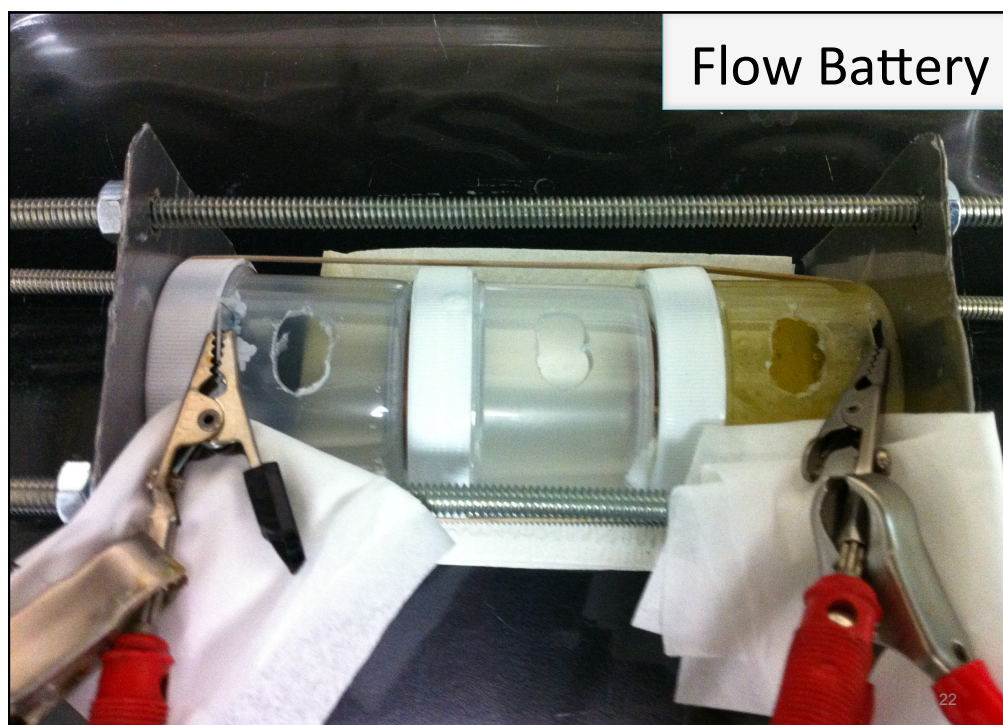
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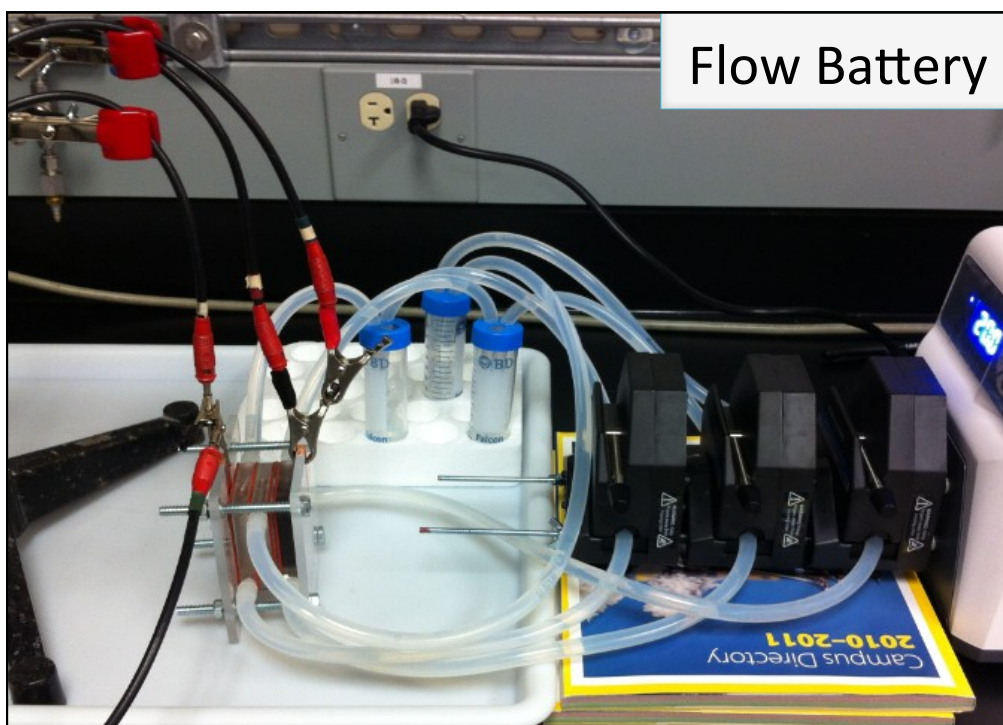
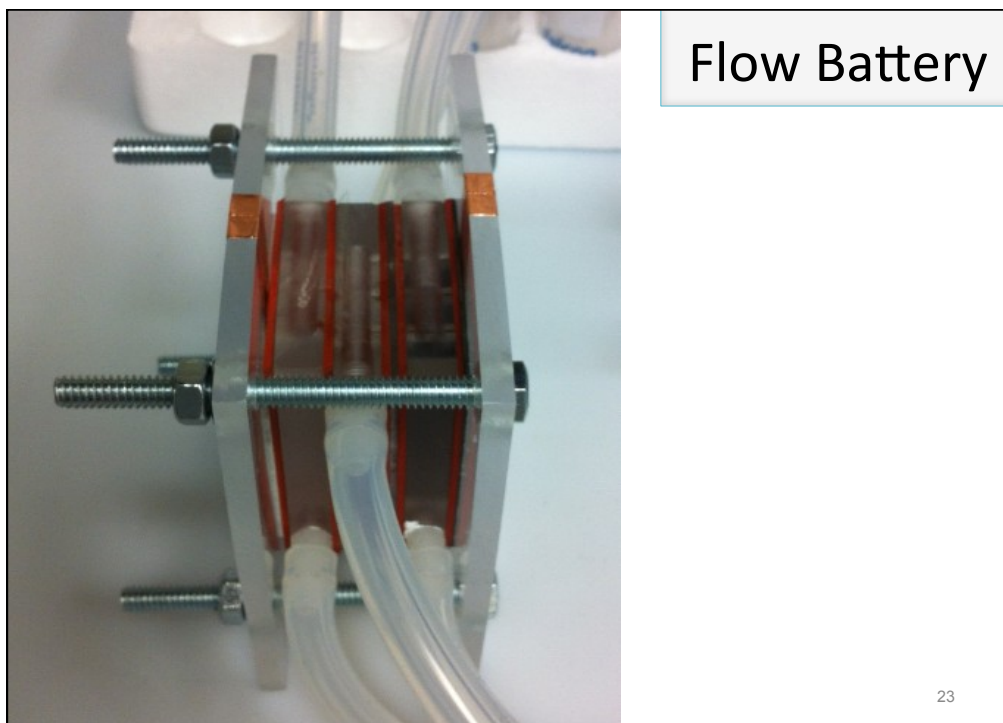
Double-Membrane Triple-Electrolyte (DMTE) FB

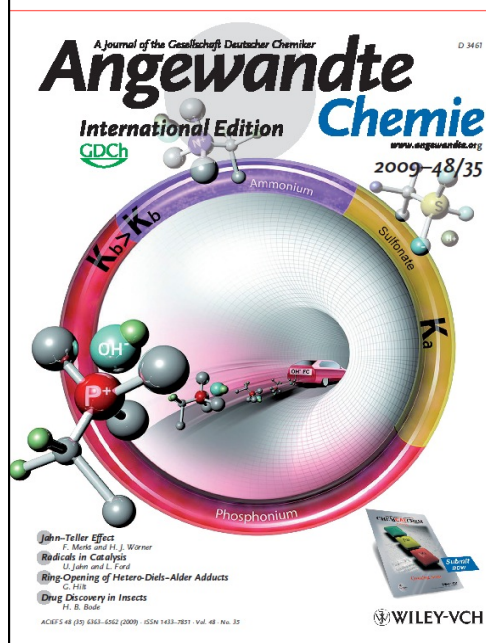
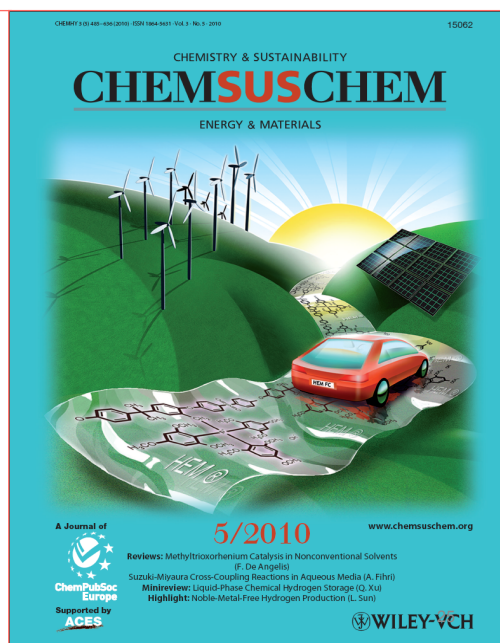
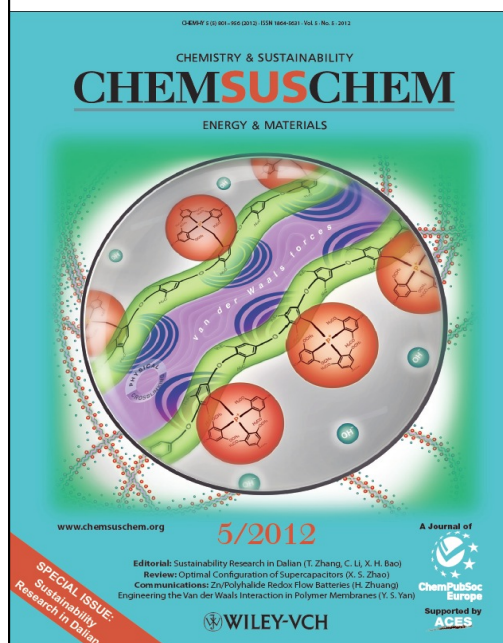


- Highest voltage of all known aqueous redox flow batteries
- Low cross-over of electrochemically active ions

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S. Gu et al. *Angew. Chem. Int. Ed.* 2009S. Gu et al. *ChemSusChem* 2010S. Gu et al. *ChemSusChem* 2012S. Gu et al. *Chem. Comm.* 2013

