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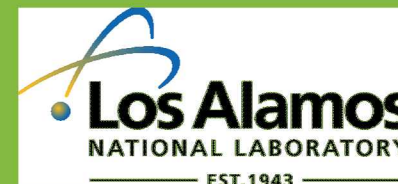
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SANDIA - LOS ALAMOS ADVANCED POLYMER MEMBRANE TECHNOLOGIES

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Sandia National Laboratories

ENABLING THE NEXT GENERATION ENERGY ECONOMY



BRIDGING THE GAP

ENABLING THE NEXT GENERATION ENERGY ECONOMY



Today

- *Abundant*, low-cost renewable energy and natural gas
- *Disruptive* shift towards vehicle electrification
- *Enabling* use of IOT for energy efficiency
- *Widespread* adoption of Li-ion technology

Tomorrow

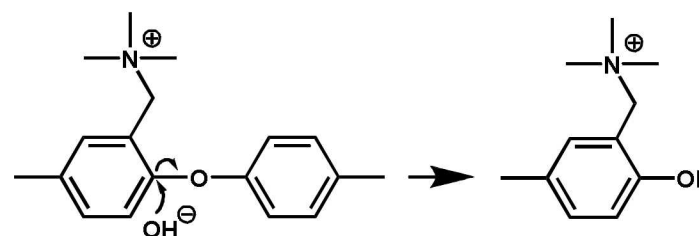
- *Need*: Low-cost, medium to long duration energy storage
- *Need*: Low-cost, less complex H₂ fuel cell vehicle and “energy storage-generation” systems

SANDIA MATERIALS DEMONSTRATE OUTSTANDING DURABILITY, PERFORMANCE, AND COST

Characteristics:

- Chemically stable backbone
- Thermo-mechanically stable up to 250°C
- Versatile chemical functionalization
- Low manufacturing cost and low complexity

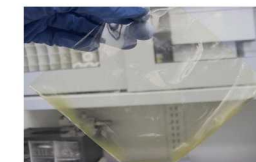
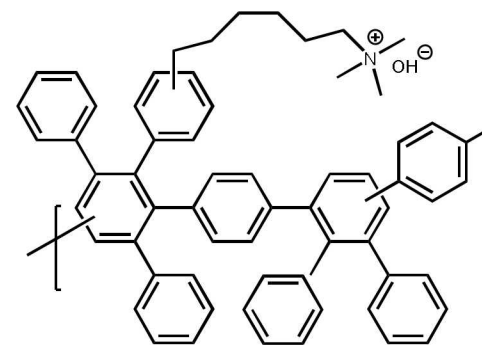
Commercial Alkaline Membranes



Aryl-ether cleavage reaction



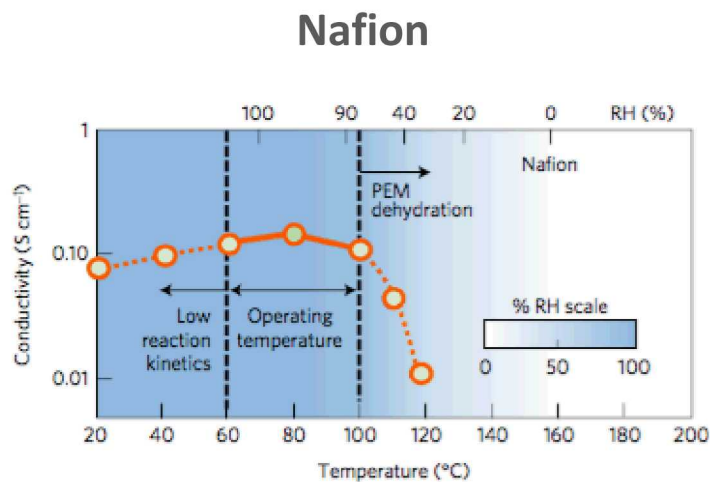
SNL Poly(Phenylene) Alkaline Membrane:



LOS ALAMOS SYSTEM PROVIDES BREAKTHROUGH IN HIGH-TEMPERATURE MEMBRANE FUEL CELL

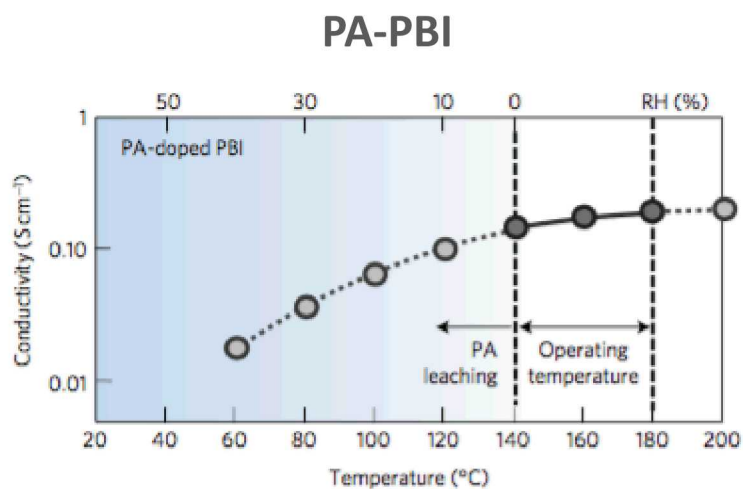
Industry Goal: Operate without humidification; large T and RH operating window

COMMERCIAL LT FC
DOW, GORE, 3M, ...



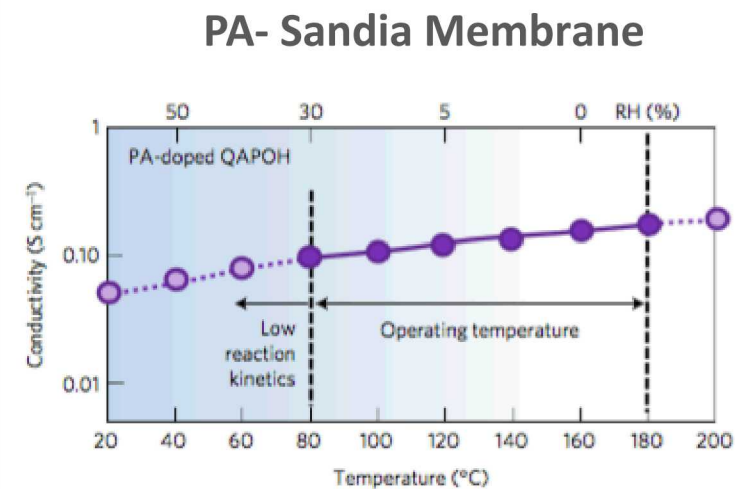
Complex BOS

COMMERCIAL HT MEMBRANE FC
ADVENT, DANISH POWER SYSTEMS



Non-Starter

LOS ALAMOS CONCEPT



Wide operating window

TARGET MARKETS

ENERGY STORAGE AND ADJACENT MARKETS ARE ENORMOUS



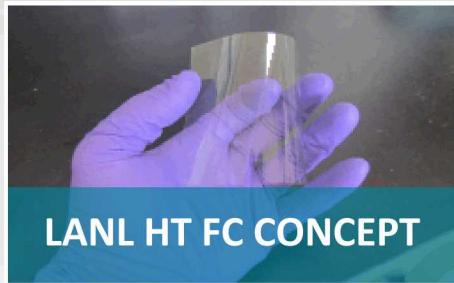
SANDIA & LOS ALAMOS IP



SNL ALKALINE
MEMBRANE

DISTINCT ADVANTAGES ACROSS ALL MARKETS

- COST
- PERFORMANCE
- DURABILITY
- O&M



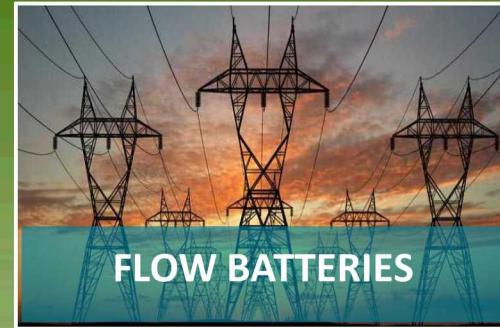
LANL HT FC CONCEPT



LANL HT FC SYSTEM

INDUSTRY

ENERGY STORAGE
(HOURS-DAYS)



FLOW BATTERIES

ADJACENT MARKETS

TRANSPORTATION



H₂ FUEL CELL VEHICLES

ENERGY STORAGE
(WEEKS-MONTHS)



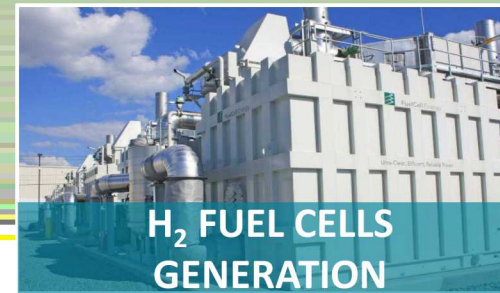
H₂ PRODUCTION

CHEMICAL MANUFACTURING



PRODUCTION OF
CHLORINE & AMMONIA

HYBRID SYSTEM FOR RE STORAGE

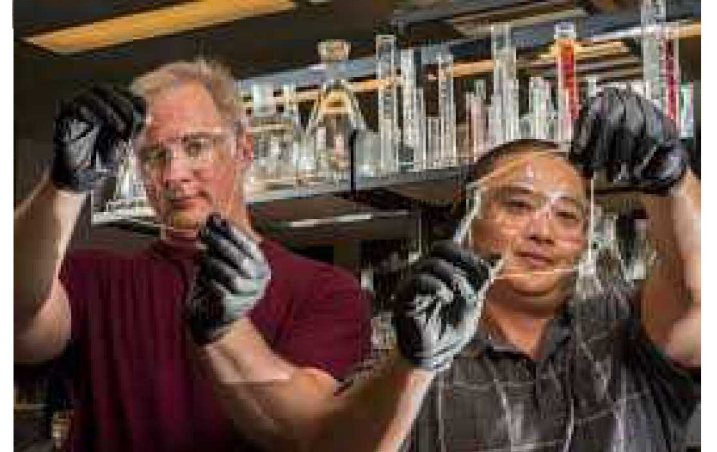
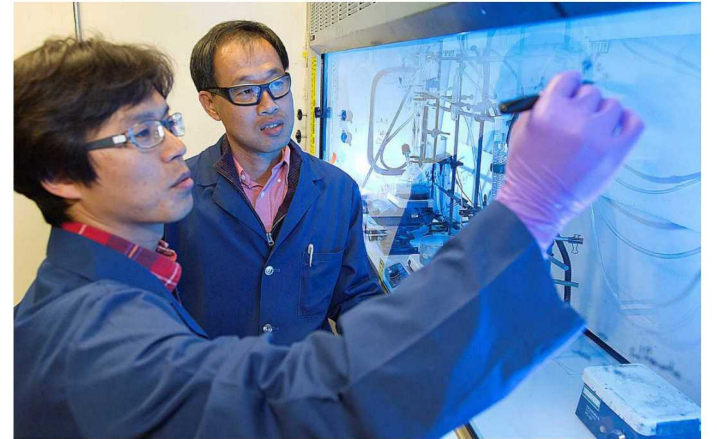


H₂ FUEL CELLS
GENERATION

STATUS OF THE TECHNOLOGY

Ready for commercialization!

- Strong intellectual property
- Fully characterized in the laboratory
- Performance and durability demonstrated
- Industry sampled for validation
- Manufacturing scale-up considerations initiated (right now, 1ft x 1ft samples routine)



TIMELINE AND RESOURCES NEEDED

We have initial products, need commercial manufacturing Ask: \$3M

Use of Proceeds (24 months)

People and Operations

Year 1

- New Mexico Business
- 5-7 person company; strengthen management team
- 10,000 sq. ft. facility, including office space, modest volume manufacturing capability, and instrumentation – enough for customer sales and sampling
- Secure intellectual property
- Develop strategic partnership relationships
- Secure non-dilutive R&D funds

Year 2

- Expand team by 3-4: manufacturing, business development
- Secure several strategic partnership agreements
- ...

Products

Year 1

- Establish alkaline and HT membrane manufacturing
- Customer sampling and small volume sales
- Complete development of Flow Battery (FB) membrane

Year 2

- Establish capability to manufacture Membrane Electrode Assemblies (MEA) for H₂ and HT FC
- Customer sampling and small volume MEA sales
- Customer sampling and small volume FB membrane sales
- ...

TECHNICAL TEAM



Cy Fujimoto, *Sandia*



Michael Hibbs, *Sandia*



Yu Seung Kim, *Los Alamos*



Jeff Nelson, *Sandia*

World-class team with a track record of innovation and industry experience and collaborations