New Approaches to Improved PEM Electrolyzer Ion Exchange Membranes

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Project ID # P151

This presentation does not contain any proprietary, confidential, or otherwise restricted information

Overview of Current Project

Timeline

- Start: April 10, 2017
- End: April 9, 2019
- Phase IIB Effort Complete: 90%

Budget

- Total Phase IIB project funding
  - $~1,000,000
- Funding received in FY 17
  - $184,272
- Funding received in FY18
  - $657,373
- Total funding planned for FY19
  - $158,215

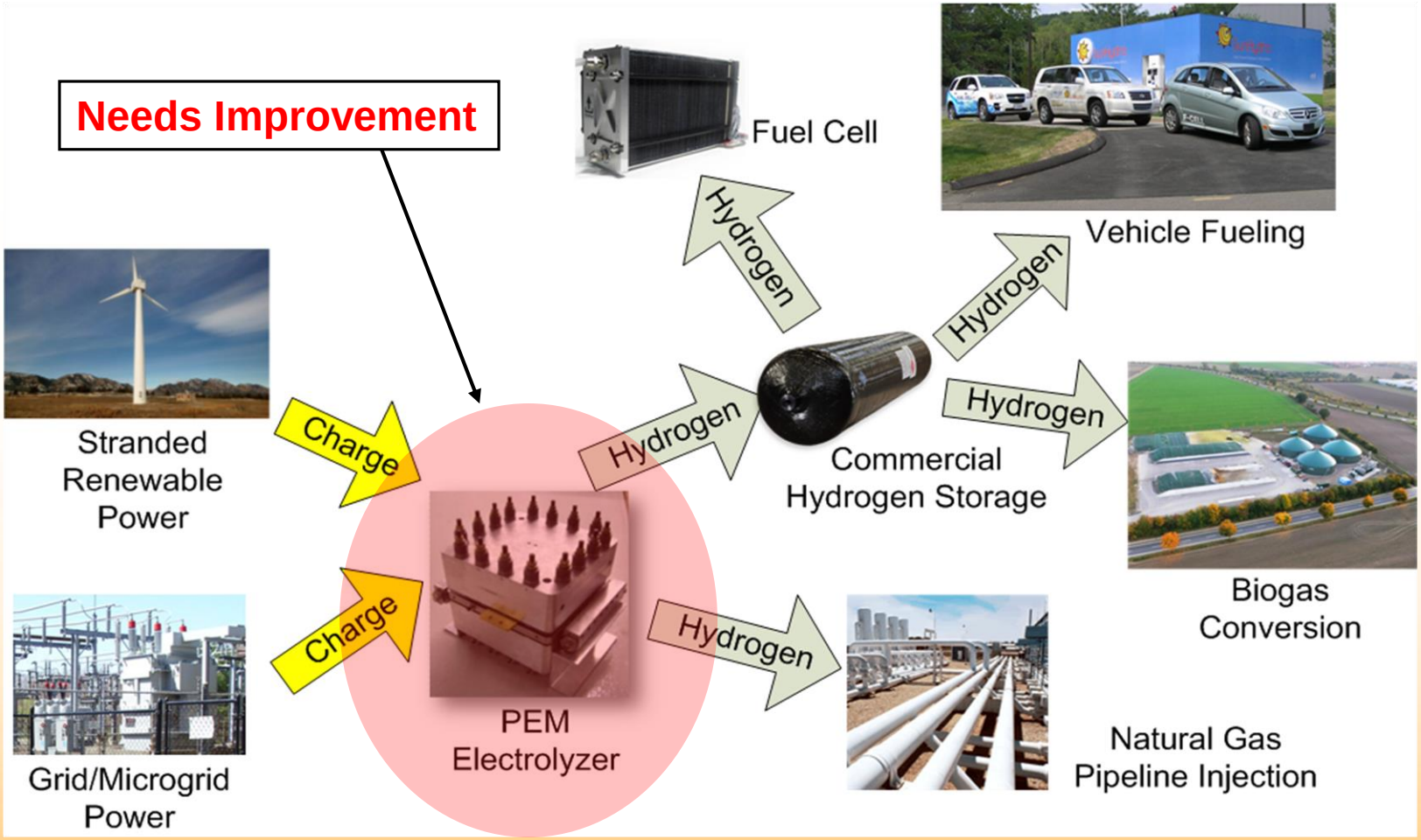
Barriers

- Performance
- Mechanical Durability
- Cost

Partner

- Proton OnSite / Nel Hydrogen (Wallingford, CT)

Relevance to DOE



Hydrogen Production for Grid Stabilization and Energy Storage

Approach – Tetramer Ionomers

Polymer Design Elements

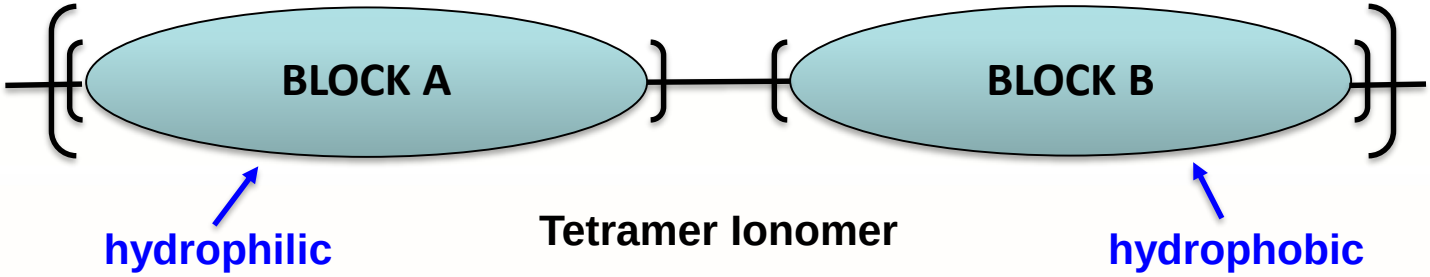
Design proprietary conductive polymer molecular architectures to enable cost efficient hydrogen generation while minimizing physical and chemical degradation.

Performance	***Mechanical Strength***	***Processability***	***Stability***
Conductive Ionic Groups & Morphology	Rigid Structures & Hydrophobic Linkages	Stereoisomeric & Solubilizing Groups	Chemical Resistance Crosslinking & Mw

Goals

- Optimize ionomer molecular architecture and membrane configuration to enhance performance and durability.
- Further develop synthetic procedures and scale-up.
- Work closely with Proton OnSite to build a prototype electrolyzer unit and assess performance and durability under customer operating conditions.

Approach – Tetramer Ionomers



Molecular Architecture
[Backbone structure]

Hydrophilic : hydrophobic ratio
Block lengths of A and B

IEC
[Degree of functionalization]

Conductivity

Distribution of IEC
[Selective Functionalization]

Effective conductivity & backbone stability
Performance and Durability

Synthesis - Process Developments

Monomers

- Refined synthetic processes
- Further improved purity
- Scale-up demonstrated, SOPs in place
- Reproducibility demonstrated
- Quality control parameters defined

Polymers

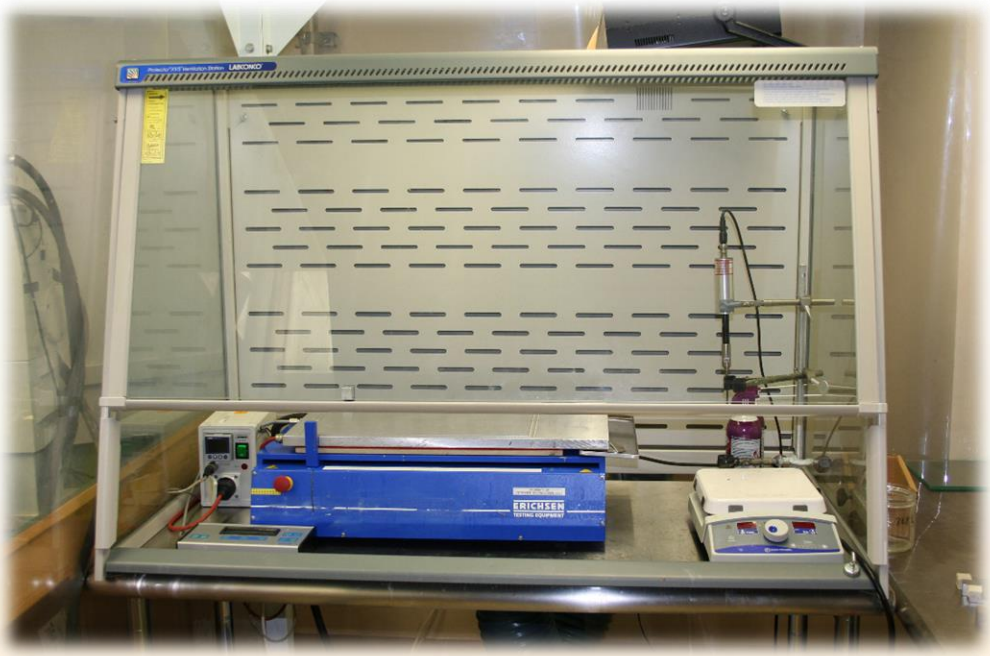
- Molecular weight defined
- Polymerization parameters optimized
- Scale-up demonstrated, SOPs in place
- Reproducibility demonstrated
- Quality control parameters defined

Ionomers

- Improved reactor design
- Reaction and processing conditions optimized
- Scale-up demonstrated, SOPs in place
- Reproducibility demonstrated
- Quality control parameters defined

Commercially viable process in place

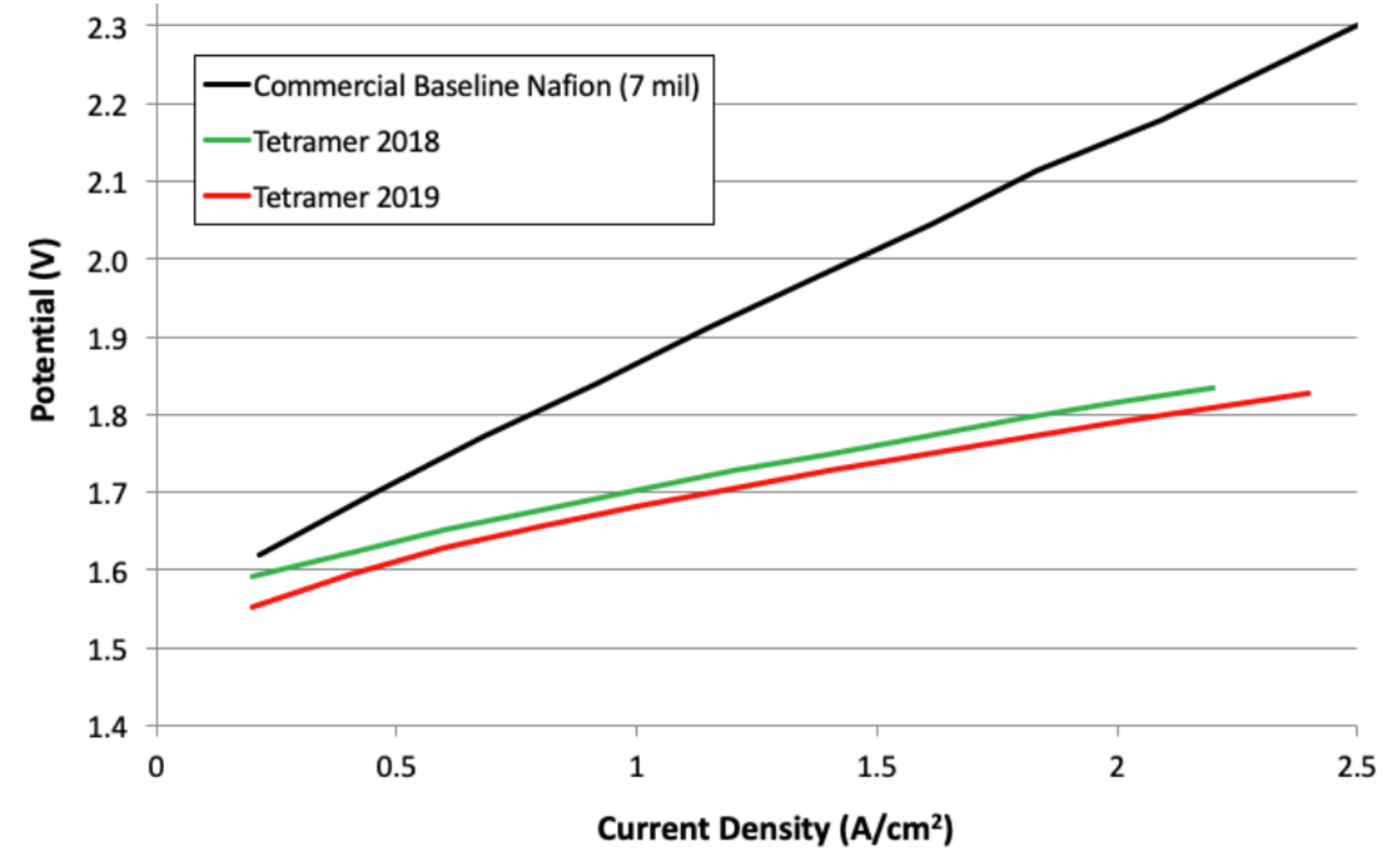
Membrane Configuration



Erichsen Automated (Heated) Casting Table in Clean Room

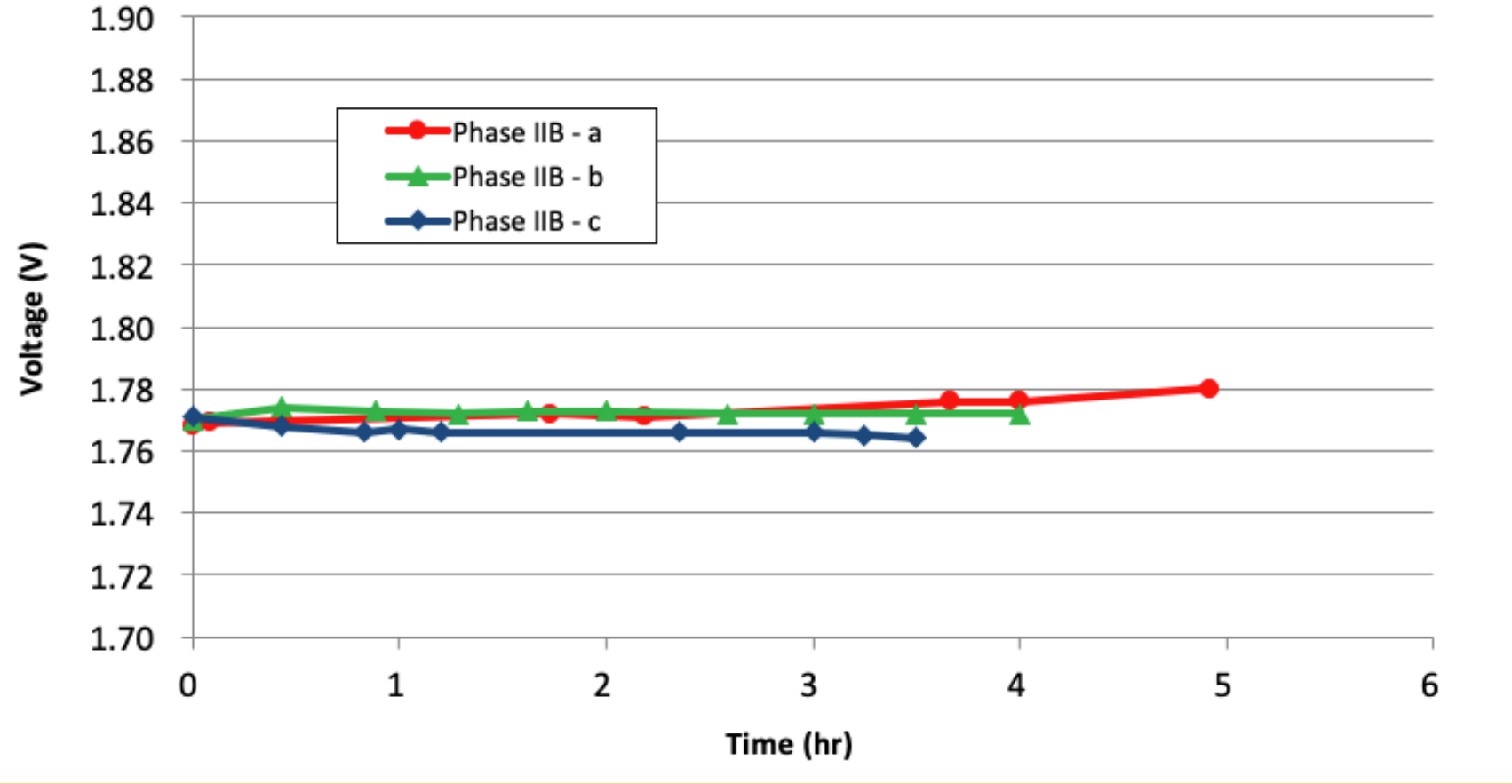
- **Membrane Down-Selection based on:**
  - **45 different membranes (from 19 different ionomers) – Phase II**
  - **>40 different membranes (from 29 different ionomers) – Phase IIB**
- **Membrane production SOPs defined**
- **Scalable for commercial continuous casting**

Phase IIB Down-Selection



Demonstrated Performance Improvements

Reproducible Initial Performance (<1.8 V)



Reproducible short term durability with excellent performance
Multi-cell stack durability test is currently in progress

Summary of Achievements

- Demonstrated performance exceeding current commercial electrolyzer membranes, with excellent durability and low hydrogen crossover
- Reproducible, commercially viable ionomer scale-up synthesis developed
- All SOPs are in place and ready for manufacturing
- Membrane configuration fully defined and scalable for commercial continuous casting
- Performance improvements demonstrated throughout Phase IIB
- Reproducible short term durability with excellent performance
- Multi-cell stack durability test is currently in progress

Collaborator

Proton OnSite:

A leader in on-site hydrogen generation and the largest manufacturer of hydrogen generators across the globe.

Critical Role:

Testing and qualification of membranes materials according to commercial specifications.

Cell design and manufacturing.

Future Work

No-Cost extension will allow extended durability testing

- Monitoring of prototype – performance and long term durability
- Customer evaluation
- Evaluation of market potential based on performance, cost and customer feedback

Any proposed future work is subject to change based on funding levels

Electrolyzer Development Summary

Relevance – The need still exists for improved electrolyzer membranes that will enable the cost effective production of hydrogen. Further development is needed to enhance grid stabilization and facilitate renewable remote energy storage.

Approach – Tetramer's synthetic approach to new polymer molecular architectures has generated versatile ionomers that have outperformed commercial membranes.

Technical Accomplishments – Improved short term performance has been demonstrated. Reproducible production has been demonstrated. Commercial electrolyzer stack tests are in progress to verify long term performance.

Collaborations – Partners are capable of producing and marketing commercial modules.

Future Work – Commercialization of G-Series electrolyzer units using Tetramer proton exchange membranes.

Publications and Presentations

Publications and Presentations:

- None to date

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