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New Approaches to Improved PEMFC Catalyst Layers

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

Overview of Current Project

Timeline

- Start: April 9, 2018
- End: January 8, 2019
- Phase I Effort Complete: 0%*

*As of 03/31/2018

Budget

- Total Phase I project funding
  - DOE share: $149,981
- Total funding planned for FY18
  - DOE share: $133,316

Barriers

- Performance
- Mechanical Durability
- Cost

Partners

- Lawrence Berkeley National Laboratory

Relevance to DOE

- Catalyst layers. A layer of catalyst is added on both sides of the membrane—the anode layer on one side and the cathode layer on the other. Conventional catalyst layers include nanometer-sized particles of platinum dispersed on a high-surface-area carbon support. This supported platinum catalyst is mixed with an ion-conducting polymer (ionomer) and sandwiched between the membrane and the GDLs. On the anode side, the platinum catalyst enables hydrogen molecules to be split into protons and electrons. On the cathode side, the platinum catalyst enables oxygen reduction by reacting with the protons generated by the anode, producing water. The ionomer mixed into the catalyst layers allows the protons to travel through these layers.

Catalyst Layer Needs Still to be Addressed:

- **High proton conductivity in a range of temperature and humidity conditions**
- **Good compatibility with PFSA membranes enabling low resistance at the membrane-catalyst layer interface**
- **High permeability to gases, including O_2, H_2.**
- **High water permeance**
- **Low or no anion adsorption on Pt**
- **Chemical durability sufficient to pass the accelerated stress tests in the DOE Multi-Year Research Design and Development (MYRD&D) plan**

Catalyst Layer Approach

- A viable solution to reduce the transport resistances in the catalyst layers is to create new ionomers that can provide good proton and oxygen transport needed to accomplish high-performing fuel cell catalysts.

- We propose to develop, optimize, and demonstrate improved fuel cell catalyst ionomers based on new molecular architectures.

- The use of higher conductivities, improved water, oxygen, and hydrogen permeabilities while exhibiting durability and minimizing the potential for adsorption on platinum.

- Characterization of transport properties for these new ionomers will be utilized to identify improved catalyst layer polymer structures.

Approach – Tetramer Ionomers

Polymer Design Elements

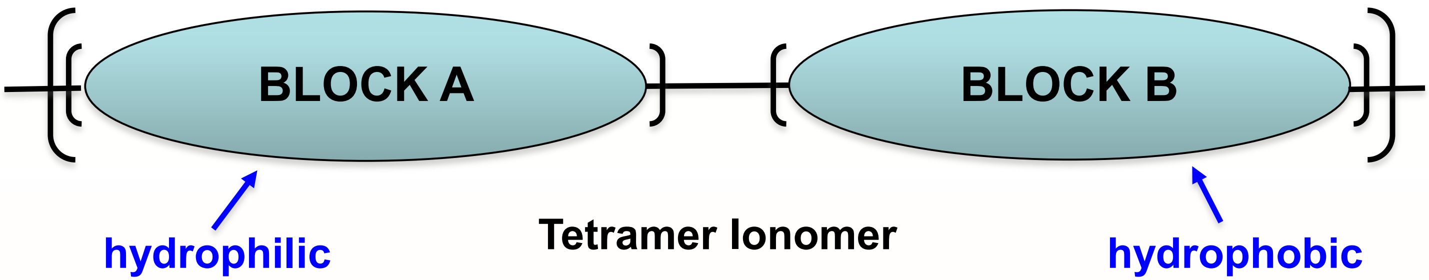
Design proprietary polymer architectures which provide oxygen transport paths while mitigating or eliminating degradation pathways.

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

Commercial Benefits to Approach

- Many electrochemical markets suffer from high loadings of costly platinum group metal (PGM) catalysts.
- These innovative ionomer structures present a unique approach to address the current needs in catalyst layers.
- Reduced loading of PGMs will lower the cost of the fuel cell MEA and has the potential to dramatically advance the field.

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

Phase I Baseline

- A major challenge preventing the widespread use and commercialization of PEM fuel cells is achieving high performance with low-loadings of platinum group metal (PGM) catalysts.
- One of the factors driving performance limitations in the cell is the mass transport losses within the cathode catalyst layers (CCL) due to sluggish oxygen-reduction reactions occurring at the platinum ionomer interface.
- The role of the ionomer in CCL is to provide transport pathways for protons and molecular oxygen so they could meet the electrons and react at the platinum interface.
- Any resistance to transport of these ionic and gaseous species within the CCL results in mass-transport limitations and performance losses, especially at high current densities.
- Mass transport losses increase with reduced platinum loading, thereby creating a performance-cost tradeoff for fuel cells.
- A need to understand these transport losses for low-loading catalyst layers and mitigate them using improved ionomer materials will allow sustainable cell performance without sacrificing the cost targets

This is a kickoff presentation: No work has been done at this time

Future Work

- Synthesis of new ionomers to determine baseline permeability of gasses based on each structure.
- Synthesis of new ionomers possessing favorable molecular architectures and Ion Exchange Capacities (IECs) for improved hydrogen and oxygen transport properties.
- Identification of key variables for performance improvement.
- Optimization of conductivity, water uptake/permeability and hydrogen and oxygen transport properties.
- Optimization of catalyst layer performance.

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

Catalyst Layer Development Summary

Relevance – Much fundamental research remains to fully understand, predict, and control polymer electrolyte membrane (PEM) fuel cells. High power performance of PEMFCs is limited by local transport issues in the catalyst layer, believed to be due at least in part to the catalyst layer ionomer.

Approach – Tetramer's synthetic approach is to design proprietary polymer architectures which provide oxygen transport paths while mitigating or eliminating degradation pathways.

Technical Accomplishments –This is a kickoff presentation, no work has been done at this time.

Collaborations – Partners in place to evaluate polymers and access final performance metrics.

Future Work – Ionomers will be synthesized and evaluated for performance. Key variables will be tuned to optimize transport.

Collaborations

Lawrence Berkeley National Laboratory
Adam Weber
Ahmet Kusoglu

- Tetramer Technologies will design and develop the ionomers and provide them to LBNL for characterizing their structural and transport properties, and performance of the ionomer as the electrolyte thin films in catalyst layers.
- Phase I will focus on measurement of water uptake and transport of the new ionomer in membrane format, while in Phase II more of the focus will be on evaluating the ionomers in thin film form and their functional performance. Transport characterization studies will be carried out using ex-situ tests in the Phase I project and in-situ tests with electrochemical cell testing will be conducted in the Phase II project.
- If successful the newly synthesized ionomers will have a strong impact on the the polymer electrolyte membrane community.

Publications and Presentations

Publications and Presentations:

- None to date

Response to Previous Year Reviewers' Comments:

- Not reviewed last year

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