Multi-Functional Catalyst Support (SBIR Phase I)

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Columbus, OH

June 6, 2017

Project ID: FC167

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Company Background

- Founded in 2010, located in Columbus, OH
- Mission: to develop and commercialize catalyst-based products for alternative energy applications.
- Expertise in:
  - Catalyst synthesis, development, and scale-up
  - Fuel Cell and electrochemical device development
- Commercialization experience with catalysts, advanced materials, and electrochemical devices

Overview

Timeline and Budget

- Project Start Date: 02-21-2017
- Project End Date: 11-20-2017
- Total Project Budget: $ 155,000

Partners

- None in Phase I

Barriers

- Cost
  - ➢ enhancement of the Pt catalyst activity to reduce its loading levels
- Durability
  - ➢ Optimize the interaction between the catalyst and the support material to improve chemical and thermal stability.
- Performance
  - ➢ Demonstrate improved performance with the engineered supports in an MEA

Relevance

Objective: Develop a multi-functional carbon support that is engineered to perform better than conventional PEMFC pure carbon supports.

- Demonstrate DOE 2020 targets for catalyst durability (<40% loss in activity, < 30 mV loss at 0.8 A/cm^2 and <40% area loss after 30,000 cycles) in an MEA with a target Pt loading in the cathode of 0.125 mg/cm^2

- Demonstrate DOE 2020 targets for support corrosion resistance (<40% loss in activity, < 30 mV loss at 1.5 A/cm^2 and <40% area loss after 5,000 cycles) in an MEA with a target Pt loading in the cathode of 0.125 mg/cm^2

- Show potential for high current density by tuning hydrophobicity

Project Background

- PGM-free catalyst performance is not currently competitive for PEM fuel cells
- Long-term DOE cost targets for PEM fuel cells could be achieved with low-PGM loading
- Optimizing the interaction between the catalyst and the support material can improve low-PGM catalyst performance
- pH Matter's PGM-free catalysts have a number of properties that could make them an attractive support for low-PGM catalysts:
  - ORR activity with selectivity to water (not peroxide)
  - Non-Fe compositions
  - Tunable hydrophobicity
  - Corrosion resistance

Approach

Task / *Milestone*	Month after project initiation								
	1	2	3	4	5	6	7	8	9
Task 1. Material Synthesis and Characterization	——	——	——						
Initial sample matrix complete (15-20 samples will be tested)		•							
Catalysts down-selected for MEA preparation (matches state-of-the-art activity for low-PGM catalyst)			•						
Task 2. MEA Fabrication and Characterization			——	——	——	——	——		
MEAs available for testing				•					
Optimized MEAs prepared							•		
Task 3. MEA Testing				——	——	——	——	——	——
Initial MEA testing reported					•				
Cathode with 0.125 mg_{Pt}/cm^2 achieves >0.8 A/cm^2							•		
30,000 catalyst durability cycles with <40% loss in initial activity, <30 mV loss and <40% area loss									•
5,000 support corrosion resistance cycles with <40% loss in initial activity, < 30 mV loss and <40% area loss									•

Approach

Prepare a matrix of CNxPy candidate supports to examine the effects of different synthesis variables on the ORR performance

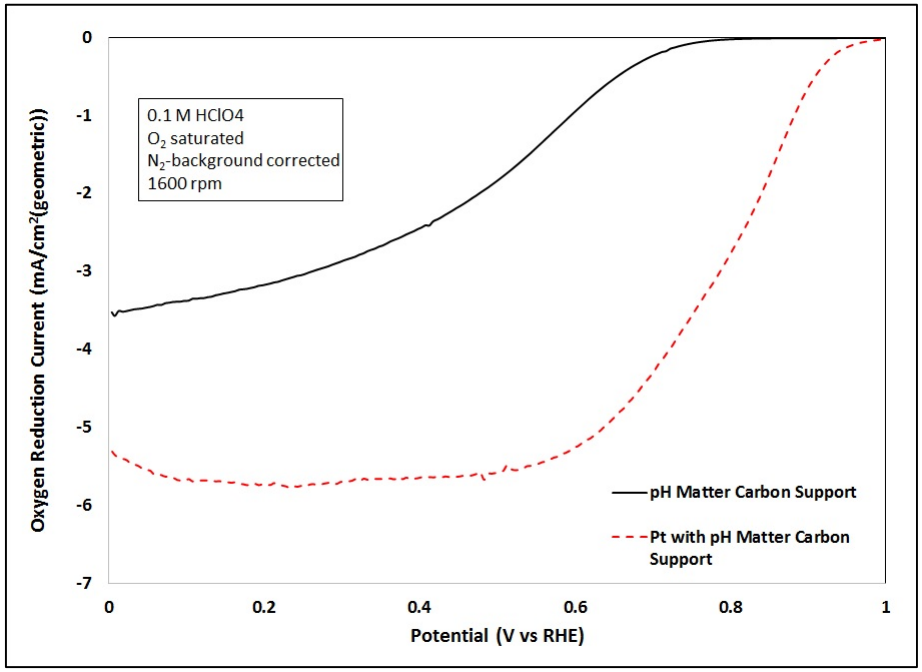
Platinum deposition using scalable methods such as incipient wetness or solution based chemical reduction.

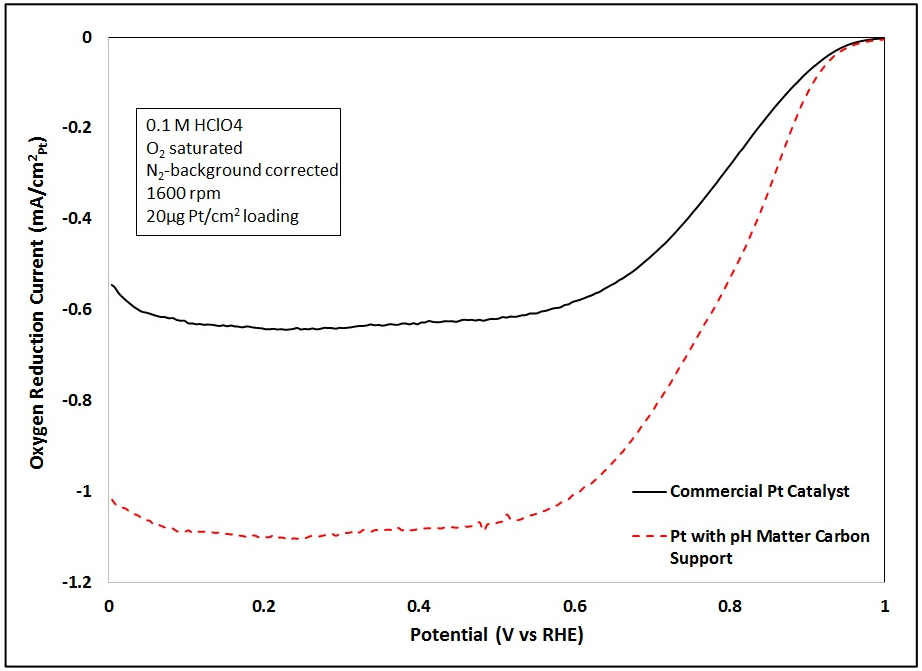
Demonstrate support intrinsic ORR performance and enhanced oxidation resistance in RDE testing

Transfer RDE results to GDEs for MEAs testing. Optimize GDE synthesis parameters, including catalyst loading, hydrophobicity, and ionomer ratio.

Accomplishments

Developed a catalyst with pH Matter engineered CNxPy support that showed excellent ORR activity with low Pt loading:



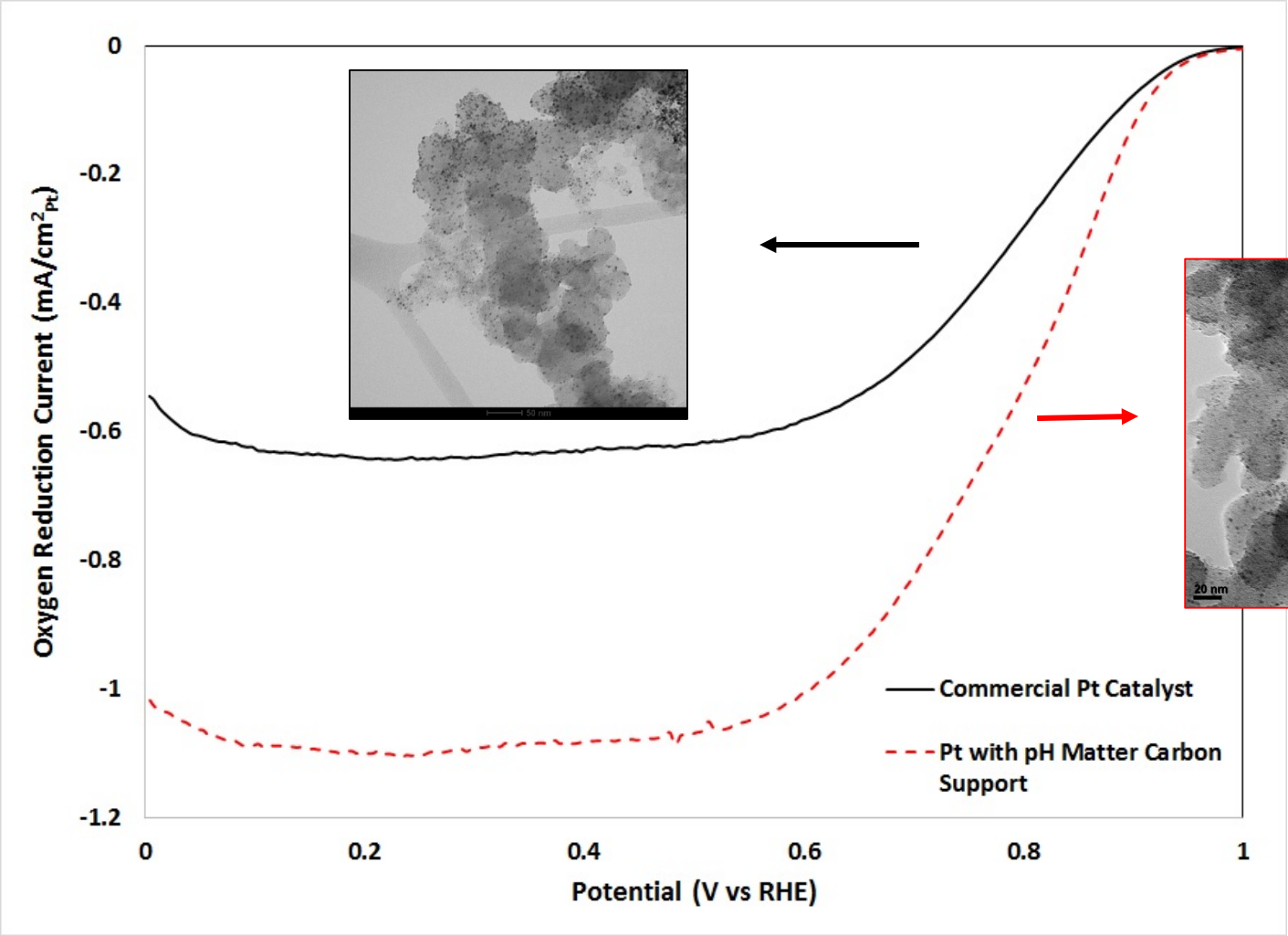


- Before and after platinization of pH Matter carbon support
- ORR activity of carbon support

- Improved ORR activity using pH Matter carbon support

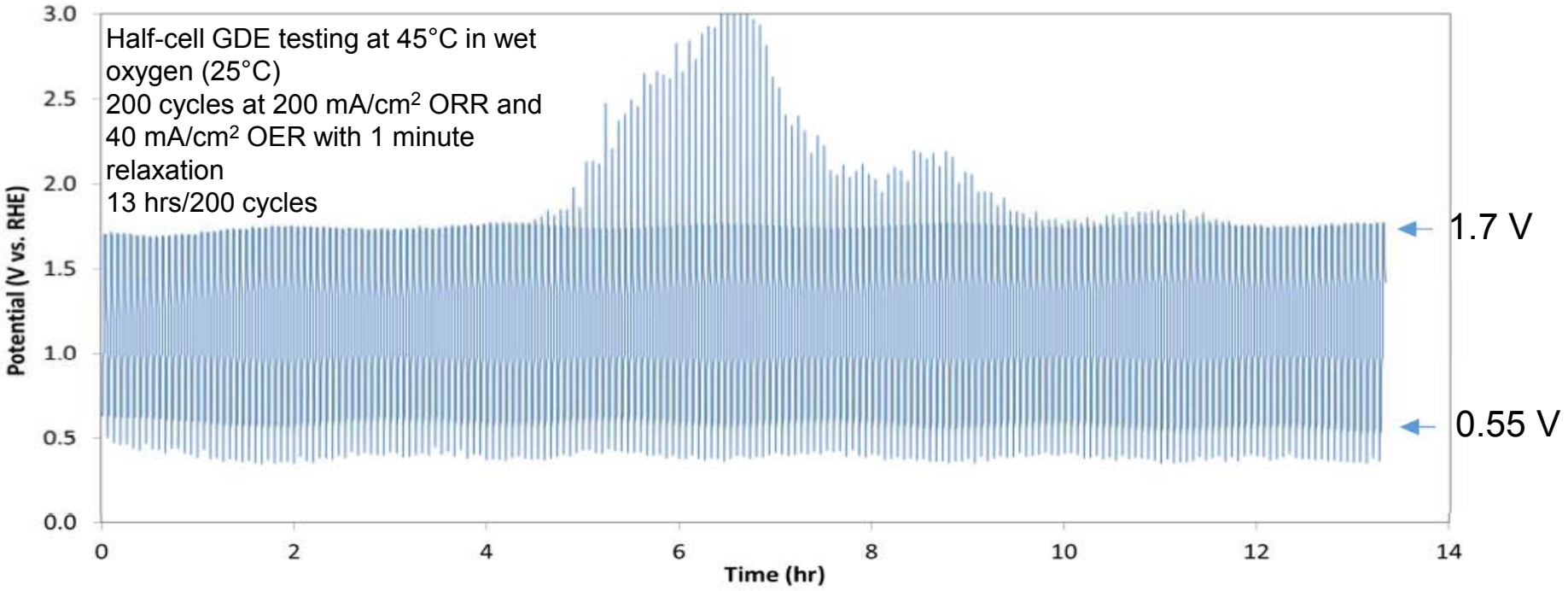
Accomplishments

Identified platinum synthesis and deposition methods that showed good dispersion on the carbon support via TEM



Related Work

pH Matter has an ongoing DOE Phase II SBIR in cooperation with Giner and NREL to develop PGM-free catalysts for a reversible alkaline fuel cell.



- pH Matter's PGM-free catalysts has improved metal-support adhesion and improved resistance to oxidation.
- Was able to demonstrate CNxPy catalyst cycling durability over 200 ORR/OER cycles.

Related Work

Demonstrated improved performance with tuned hydrophobicity GDEs using a patent-pending treatment process:

Contact angle measurements

Technology has already been incorporated into GDEs for the reversible alkaline fuel cell project

Remaining Challenges and Barriers

- Demonstrate catalyst intrinsic performance and acceptable support oxidation resistance in RDE testing
  - Ensure repeatability of results by comparing standards with literature value and adherence to established DOE testing protocols
  - Gauge corrosion resistance and start-stop cycle performance in RDE testing

- Transfer RDE results to GDEs for MEAs testing
  - GDE synthesis parameters optimization (catalyst loading, ionomer ratio and hydrophobicity)
  - Demonstrate DOE targets for catalyst durability and support corrosion resistance.

Proposed Future Work

- Explore alternative preparation methods for low-PGM alloy catalysts such as electrochemical methods, colloidal or ion-exchange.
- Further MEA optimization to address mass transport and cathode flooding issues
- Electrode characterization before and after cycling to better understand degradation mechanisms
- Partner with MEA manufacturers

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

Summary

- Optimizing the interaction between the catalyst and the support material can improve low-PGM catalyst performance and reduce fuel cell costs.
- pH Matter, LLC is developing a multi-functional support with advantages that will include better durability, improved oxidation resistance, and increased hydrophobicity.
- The technology being developed in this project aims to demonstrate DOE 2020 targets for catalyst durability and support corrosion resistance in an MEA for low-PGM loading catalyst.
- Future work aims to explore other Pt catalyst preparation methods and improve MEA activity and cycling stability.