Nanostructured Carbon Based Gas Diffusion Layers for Enhanced Fuel Cell Performance

Project ID: fc192

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Overview

- **Timeline**
  - Start: April 2018
  - End: January 2019
- **Budget**
  - SBIR Phase I: $150,000
- **Partners**
  - Actively looking for collaborators from GDL and fuel cell companies
- **Barriers**
  - A. Durability
  - B. Cost
  - C. Performance
- **Targets (2020 goals)**
  - Corrosion
    - Cathode: <1μA/cm2 for >24 hours
    - Anode: <1μA/cm2 anode for >24 hours with no active peak
  - Conductivity
    - >100 S/cm @ 1.5 MPa

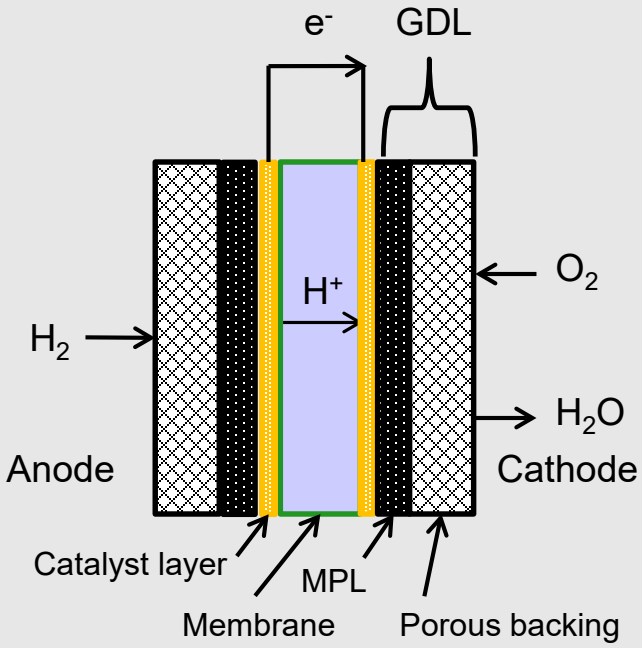
TDA RESEARCH

Problem

- The widespread commercialization of polymer electrolyte membrane (PEM) fuel cells is hindered by the high cost and limited lifetime of the components, including the gas diffusion layers (GDLs)
- TDA Research Inc. (TDA) proposes to lower the cost of GDLs using our specialty carbons to address the mass transport and water management issues that limit their performance

GDL Operation

- The GDLs allow the reactants (hydrogen and oxygen/air) to reach the active sites on the catalyst layers (CLs) and facilitates the removal of the liquid water to prevent flooding and the blocking of the catalyst
- GDLs are carbon fiber substrates impregnated with Teflon to make them hydrophobic and thereby prevent the blockage of pores with water
- A MicroPorous Layer (MPL) made of carbon black is added to the GDL surface between the CL and the GDL which enhances the water removal from the CL



Improved MPL

- The pore sizes of the MPL are the key element to water removal
- MPLs made with carbon black give pore sizes ranging from 100-1000 nm that are too large to efficiently remove water
- TDA's nanostructured carbons with mesopores in the 2-50 nm range allow much better diffusion of gasses to the catalytic sites and better diffusion of water out of the active catalytic layer

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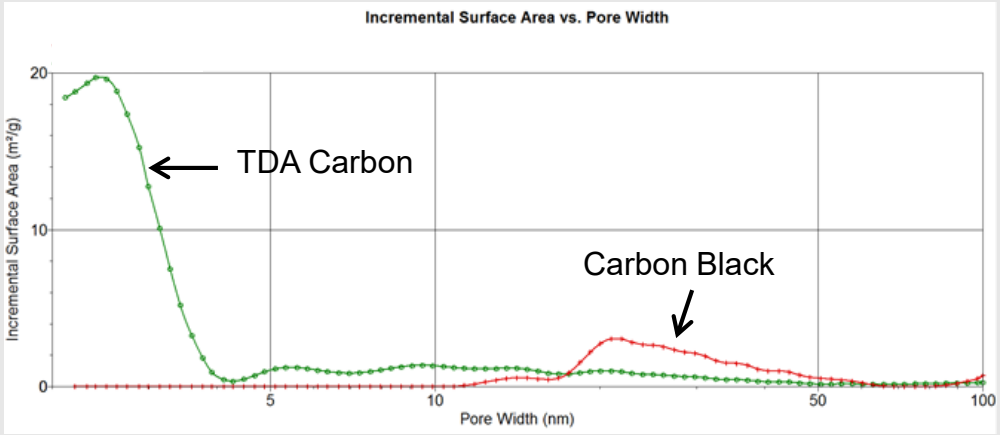
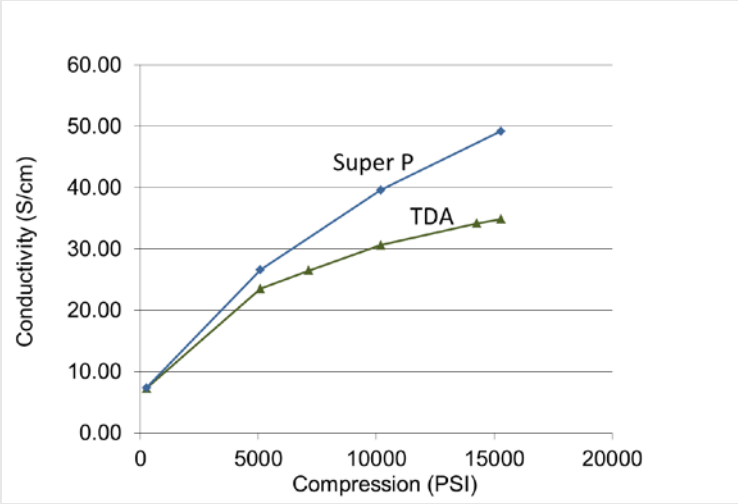
Comparison of TDA Nanostructured Carbon with Carbon Black

- Compared to carbon black, TDA carbons have:
  - High surface areas
  - Mesoporosity
  - Similar electrical conductivity





Relevance

- Objective: The main focus of this Phase I project is to develop nanostructured carbons with controllable pore sizes and specific surface areas to provide a much improved alternative to carbon blacks in the MPL of the GDL
- DOE 2020 Technical Targets
  - Corrosion
    - Cathode: <1μA/cm2 for >24 hours
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  - Conductivity
    - >100 S/cm @ 1.5 MPa

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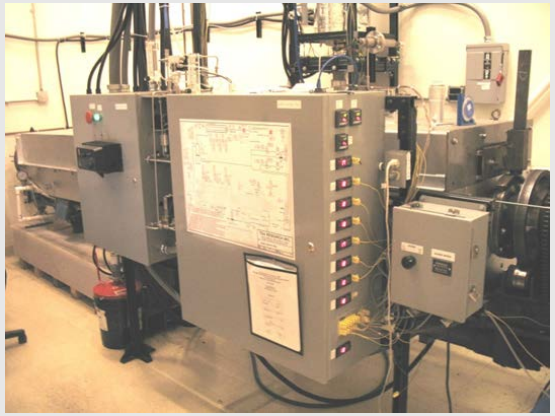
Approach

- **The specific research objectives are to:**
  - Prepare and characterize TDA carbons for use in the MPL
  - Prepare and characterize GDLs using TDA's carbons for the MPL
  - Prepare membrane electrode assemblies (MEAs) using the most promising GDLs
  - Evaluate the performance and long-term durability of MEAs using TDA's GDLs
  - Evaluate the cost of the new materials and compare their performance against today's commercial GDLs
- The successful completion of Phase I will allow us to assess the merits of the new GDLs using TDA carbons and provide us a basis for their further design and development.

Approach: Fabrication

- **Prepare carbons for the MPL**
  - Equipment available at TDA
  - Low-cost precursors
- **Characterize carbons**
  - Surface area and pore size distribution
  - Elemental composition
  - Electrical conductivity

TDA's Lab-Scale Rotary Furnace



TDA's Pilot-Scale Rotary Furnace

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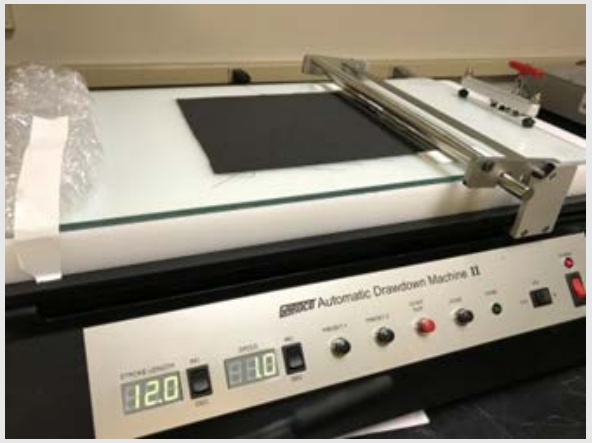
Approach: Evaluation

- **MPL layer will be applied to macroporous backing layer using TDA's automatic drawdown machine**



TDA's Automatic Drawdown Machine

- **Ex-situ Characterization**
  - Porosity
  - Bulk Density
  - Electrical Conductivity
  - Corrosion
  - Surface Morphology

- ***In-situ* Characterization**
  - Prepare MEAs
  - Polarization Curves
  - Long-term Stability

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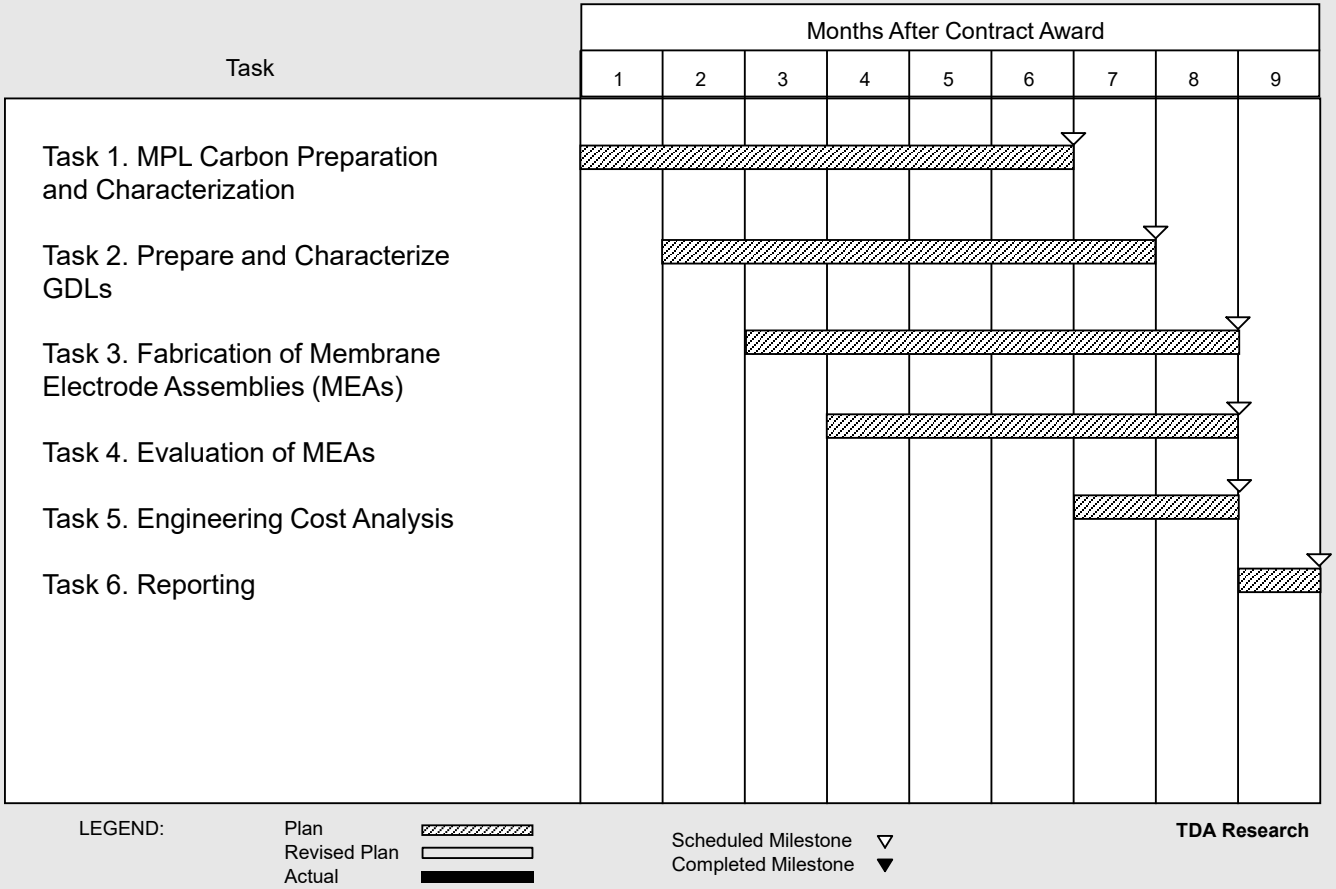
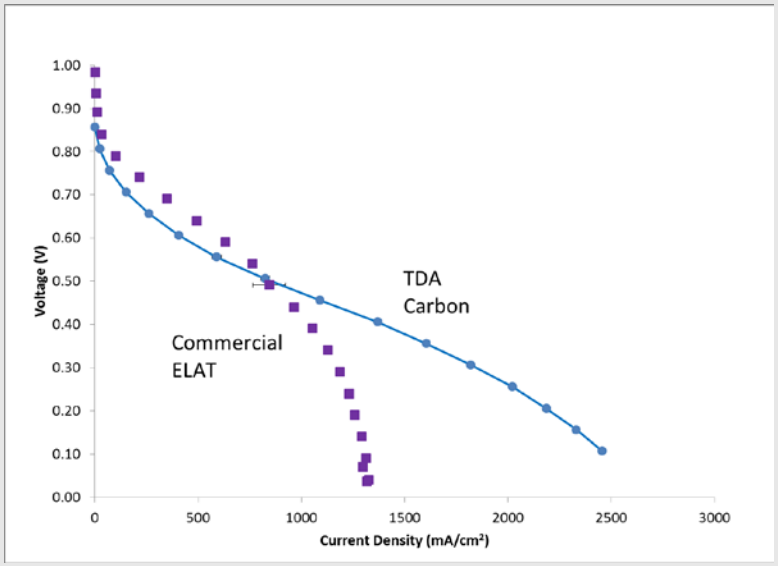
Approach: Schedule

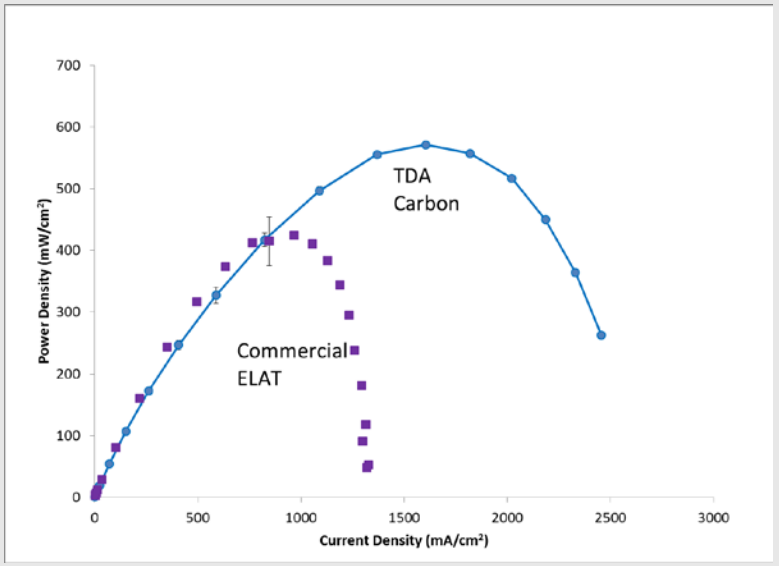


Accomplishments and Progress

- Preliminary studies show that TDA GDL has <u>30% greater</u> power density than commercial ELAT GDL (both with 0.5 mg-Pt/cm^2)



Polarization Curves



Power Density Curves

Collaboration & Coordination

- **Engineered Fibers Technology, LLC**
  - **Relationship**: Subcontractor and Commercial Partner
  - **Industry**: Manufacturer of Spectracarb™ GDL
  - **Outside** of DOE Hydrogen and Fuel Cells Program
  - **Extent of Collaboration**: Key partner in development and commercialization of improved GDLs

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Remaining Challenges and Barriers

- Validation of enhanced performance of TDA's GDLs
- Demonstration of durability and reliability
- Testing in existing FC platforms
- Production scale-up
- Working with commercialization partner

Proposed Future Work

- **Current activities:**
  - Preparation and characterization of TDA carbons for use in the MPL
  - Preparation and characterization of GDLs using TDA's carbons for the MPL
- **Next activities**
  - Preparation of membrane electrode assemblies (MEAs) using the most promising GDLs
  - Evaluation of the performance and long-term durability of MEAs using TDA's GDLs
  - Evaluation of the cost of the new materials and compare their performance against today's commercial GDLs
  - Work with DOE funded vendor to draft a commercialization plan
- **Preparation of Phase II proposal**

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

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Summary

- **Objective:** The main focus of this Phase I project is to develop nanostructured carbons with controllable pore sizes and specific surface areas to provide a much improved alternative to carbon blacks in the MPL of the GDL
- **Approach:**
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  - Evaluate the cost of the new materials and compare their performance against today's commercial GDLs
- **Accomplishments:** Preliminary studies show that TDA GDL has 30% greater power density than commercial ELAT GDL