AVAILABLE FOR LICENSING

# PROTON EXCHANGE MEMBRANE FUEL CELLS: NON-PT METAL ELECTROCATALYSTS

**This IP bundle combines novel, high-performance materials that will propel companies into the next level of fuel cell technology. We include non-platinum catalysts and non-platinum group metal catalysts (non-PGM) combined with membrane electrode assemblies (MEA). Pt catalysts are the major cost driver in current PEM Fuel cells. The focus here is to accelerate the commercialization of new generation of non-Pt based PEM fuel cells.**

## KEY TECHNICAL ADVANCES

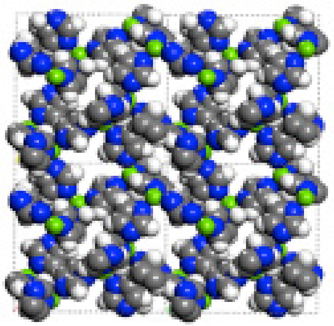
- The non-Pt binary noble metal-base metal catalysts reduce noble metal content utilizing a base metal core and substitute other currently less expensive noble metals for Pt, potentially reducing cost.
- The non-PGM electrode catalysts prepared from MOFs have several advantages over various conventional non-PGM catalysts, including high surface area, high active site density, and uniform site distribution without the dilution of a carbon support. High ORR activities have been reported for different versions of these MOF-derived non-PGM catalysts.
- The directionally oriented, functionally decorated carbon nanotubes provide a method to prepare Non-PGM catalysts with catalytic sites exposed over a graphitic carbon nanotube surface, which is more stable than the amorphous carbon supported catalyst. In addition, the aligned carbon nanotubes offer unique shapes, orientation and spatial patterns, which offer improved mass/charge transfer and water management compared to conventional electrode materials.
- Membrane electrode assemblies (MEA)s fabricated with decalin-treated membranes exhibited significant increase in power density in a $H_2$/Air fuel cell at 60% relative humidity.

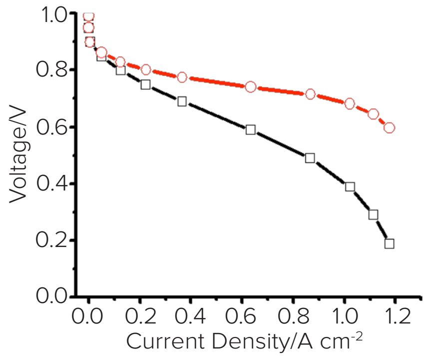
## PARTICIPATING LABS & RESEARCH CAPABILITIES

**Argonne** is running active research projects to develop new materials and support existing ones to overcome the major barriers to allow the use of fuel cell technology in a variety of applications.

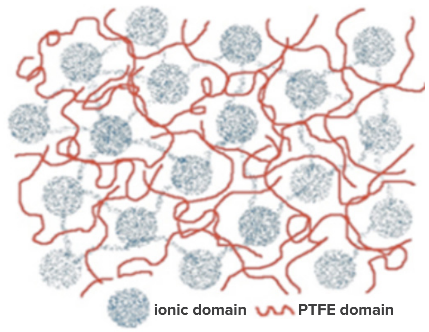
**Berkeley's** current research projects include developing new materials and optimizing fuel-cell performance and durability. LBNL's core competencies in fuel cells include cell performance and durability diagnostics and modeling, modeling of membranes, stationary cell cost and life-cycle analysis, and integrated systems modeling of the interactions between stationary hydrogen, vehicle, and grid resources.

**Oak Ridge** is the leading resource for characterization of fuel cell materials and offers fuel cell evaluation equipment. ORNL's researchers also conduct studies of infrastructure deployment scenarios and fuel cell vehicle market analysis to provide data for industry leaders and policy makers to use in strategic decision making






**Lattice Structure of a Co-based MOF (Co-ZIF) *S. Ma, G. Goenaga, A. Call and D.-J. Liu, Chemistry: A European Journal, 17 (2011) 2063 – 2067* and single cell performance of MOF derived catalyst in H2/O2 at 30 psi and 70C (red iR corrected data, black uncorrected).**




**Krishnan, Yeager, Clark, Kerr, Soloveichik. Enhanced Fuel Cell Performance of Decalin Treated Nafion® Membranes. Fuel Cells. 2015, 15, 239. Schematic representation of Teflon and ionic domains in decalin treated N212.**

**CONTACT**
**Argonne National Laboratory Technology Commercialization & Partnerships**
Phone: 800-627-2596
E-mail: partners@anl.gov

**MOTIVATION, CHALLENGE, AND OPPORTUNITY** As the interest for “hydrogen-based economy” grows, the research on its major elements like hydrogen production, hydrogen storage, and energy conversion in fuel cells is expanding. Proton exchange membrane fuel cells (PEMFCs) held around 60% of global revenue (ca. US$3.5 Bn) in 2015.[Transparency Market Research] PEMFCs are being considered for applications that require quicker start-up times and repeated starts and stops, such as automotive applications, material handling equipment, and backup power. PEMFC typically use Pt catalysts, and the high cost of Pt makes it difficult for PEMFC to compete in the market. Hence, PEMFCs need to minimize or eliminate Pt metal loading, improve component durability, and manage water transport within the cell. Additionally, this IP bundle includes membrane electrode assemblies (MEAs) that are capable of operation at higher temperatures for automotive applications (≤120 °C) and stationary applications (≥120 °C). This IP bundle, overall, includes valuable strategies to increase performance and durability of fuel cells, while decreasing their cost. Industry leaders will have the opportunity to leverage the expertise from 3 National Labs, through one standard and convenient agreement.

## INTELLECTUAL PROPERTY INCLUDED IN THIS BUNDLE

| TECHNOLOGY | NUMBER |
|---|---|
| Non-platinum bImetallic polymer electrolyte fuel cell catalyst | US8129306, ANL |
| Non-platinum group metal electrocatalysts using metal organic framework materials and method of preparation | US8835343, US 2015 0056536A1, US 2015 0180045, ANL |
| Method of fabricating electrode catalyst layers with directionally oriented carbon support for proton exchange membrane fuel cells | US7758921, ANL |
| Catalytic membranes for fuel cells | US7927748, ANL |
| Membrane-electrode structures for molecular catalysts for use in fuel cells and other electrochemical devices | US9455451, LBNL |
| Electrically conductive cellulose composite | US7709133, ORNL |