Development and Evaluation of Perfluorinated Electrolytes

Cooperative Research and Development Final Report

CRADA Number: CRD-16-610

NREL Technical Contact: Bryan Pivovar

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

This report is available at no cost from the National Renewable Energy Laboratory (NREL) at www.nrel.gov/publications.

CRADA Report
NREL/TP-5900-71295
June 2018

Contract No. DE-AC36-08GO28308

NOTICE

This work was authored by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Bioenergy Technologies Office. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government.

Cover Photos by Dennis Schroeder: (left to right) NREL 26173, NREL 18302, NREL 19758, NREL 29642, NREL 19795.

Cooperative Research and Development Final Report

In accordance with Requirements set forth in the terms of the CRADA agreement, this document is the final CRADA report, including a list of Subject Inventions, to be forwarded to the DOE Office of Science and Technical Information as part of the commitment to the public to demonstrate results of federally-funded research.

Parties to the Agreement: Midwest Energy Group Incorporated

CRADA number: CRD-16-610

CRADA Title: Development and Evaluation of Perfluorinated Electrolytes

Joint Work Statement Funding Table showing DOE commitment:

Estimated Costs	NREL Shared Resources a/k/a Government In-Kind
Year 1	$125,000.00
TOTALS	$125,000.00

Abstract of CRADA Work:

Novel fluoropolymer-based anion-exchange membranes as well as membrane-electrode-assembly comprising such polymers/membranes will be examined for use in fuel cells and/or regenerative electrolyzers. Specifically, novel perfluorinated polymers will be evaluated and optimized for performance and durability in alkaline membrane fuel cells (AMFCs). MEG Inc. will be responsible for providing novel perfluorinated membranes to NREL for evaluation in AMFCs. MEG Inc. will focus initially on imidazolium tethered functional groups and later provide materials based on proton/lithium cage structures. NREL will fabricate the supplied membranes into membrane electrode assemblies (MEAs), using a variety of ionomers and/or catalysts, and test the resulting MEAs for performance and durability. These results will be compared to similar results obtained either with commercial materials or NREL's own perfluorinated materials. NREL also plans to perform ex-situ tests on membranes to determine conductivity and durability under ex-situ conditions that mimic or accelerate the conditions that occur within AMFCs.

Summary of Research Results:

NREL fabricated supplied membranes into membrane electrode assemblies, MEAs, (using a variety of ionomers and/or catalysts) and tested the resulting MEAs for performance and durability. These results were compared to similar results obtained either with commercial materials or NREL's own perfluorinated materials. NREL performed ex-situ tests on membranes to determine conductivity and durability under ex-situ conditions that mimicked or accelerated the conditions that occur within AMFCs.

The polymer membranes and fuel cells had good performance when tested, particularly for conductivity and stability, however, upon ion exchange, it was determined that the polymers were cation exchange membranes and behaving as proton conductors rather than cation exchange membranes acting as hydroxide conductors. We titrated these materials and found they behaved as perluorosulfonic acid polymers, which was confirmed by NaCl and HCl titration and conductivity measurements, shown in Tables below.

Conductivity (NaCl Soak)

	Resistance (ohms)	Width(cm)	Thickness(cm)		**Results mS/cm**
1	9097.0	0.48	0.005		**21.5**
2	9092.0	0.50	0.0057		**18.1**
3	10304.0	0.43	0.0053		**20.0**
				Avg	19.9

Conductivity (HCL soak)

	Resistance (ohms)	Width(cm)	Thickness(cm)		**Results mS/cm**
1	2177.6	0.398	0.0063		**86.1**
2	2525.7	0.47	0.0056		**71.3**
3	2414.9	0.476	0.0059		**69.3**
				Avg	75.6

Anion exchange membranes would be in Cl^- form for both measurements and not show a change in conductivity, whereas these samples showed ~4x conductivity increase in H^+ form compared to the Na^+ form as would be expected for a cation exchange membrane. Small molecule studies were also performed and shared but determined not to be the limiting factor for membrane performance in this system.

Based on NREL's experience with other perfluorinated anion exchange membrane synthesis, we suggested that this was likely due to solubility/reactivity challenges that exist for perfluorinated polymers. As performing specific chemistries and maintaining solubility of reactants and products is exceptionally difficult for perfluorinated anion exchange membranes. The approach was sound, but target materials were never explicitly tested due to the synthesis challenges, and work was limited to materials supplied and supporting efforts.

Subject Inventions Listing:

N/A

Report Date:

12 February 2018

ROI #:

N/A

Responsible Technical Contact at Alliance/NREL:

Bryan Pivovar

Name and Email Address of POC at Company:

Yong Gao, ygao@chem.siu.edu

DOE Program Office:

Basic Energy Science (BES)**;** DOE Small Business Vouchers Pilot (Sarah Truitt, Pilot Manager)

This document contains NO confidential, protectable, or proprietary information.