Contract No:

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High temperature water electrolysis testing of gold-based electrodes for H_2 production

Project highlight. High performance was obtained with the use of SDAPP membrane developed by SNL. The process improvements show a path to reaching DOE targets for hydrogen production.

Intellectual Property Review

This report has been reviewed by SRNL Legal Counsel for intellectual property considerations and is approved to be publicly published in its current form.

SRNL Legal Signature

Signature **Date**

High temperature water electrolysis testing of gold-based electrodes for H_2 production

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Project Type: Standard

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The Hybrid Sulfur (HyS) process is a promising thermochemical water-splitting cycle with global scale hydrogen production potential. The SO_2-depolarized electrolyzer (SDE) is a critical component of the cycle. At the core of the SDE is the membrane-electrode assembly (MEA), which consists of a polymer electrolyte membrane (PEM) sandwiched between two electrocatalyst layers. New electrocatalyst and membrane materials are being developed with the goals of improving the electrolyzer performance and extending the lifetime of the MEA. In this work, we evaluated the performance of three different membranes and optimized operating conditions, resulting is one of the highest performances in the literature.

FY20 Objectives

- Electrolyzer Performance Evaluation under various operating conditions
- Write manuscript

Introduction

There exists a significant and growing need for clean, efficient, and large-scale hydrogen production. Using high temperature heat, thermochemical cycles can provide an energy-efficient route for hydrogen production. The HyS process is a promising thermochemical water-splitting cycle with significant scalability. The HyS process, one of the most researched thermochemical cycles, is a sulfur-based water-splitting cycle which contains a low temperature electrolysis step, and thus can be considered an electrochemical and thermochemical hybrid process.

The electrolysis step must be maintained at the highest possible conversion fraction to minimize unreacted SO_2 and obtain high H_2SO_4 concentration. Unreacted SO_2 must be recycled, and water must be removed prior to the high temperature decomposition step. Both of these are energy intensive steps and must be minimized to keep process efficiency high. Operation of the electrolyzer at the target conditions, however, is unfeasible using the current state-of-the-art materials. Therefore, new materials will be required to achieve the electrolysis performance goals. This project is focused on the development of new membranes and their effect on process efficiency, with the goals of improving the electrolyzer performance and extending the lifetime of the MEA.

Approach

A collaborative effort between SRNL, USC, and SNL was continued to develop novel materials designed to operate under the HyS process conditions with superior performance compared to the state-of-the-art. SRNL is utilizing its expertise in electrode design long with SNL's expertise in membrane development and USC in electrolyzer modeling to achieve improvements in the HyS and meet DOE-EERE's hydrogen production goals. The work is a conclusion of previous funded LDRD work. The final approach takes the optimized materials and characterizes the electrolyzer conditions to achieved high performance. Flowrates, temperatures, and water input locations were evaluated for three MEAs fabricated with N212, N115 and SDAPP MEAs.

Results/Discussion

The electrochemical performance of various MEAs were evaluated in an electrolysis cell. Figure 1, shows the SO_2 electrooxidation performance of the various MEA using different membranes. As observed the highest performance is observed for the SDAPP based membrane. Figure 2 shows the effect of temperature for the different MEAs under constant current. As observed, all MEAs show an increase in performance with an increase of temperature until 105 ºC. However, the performance using the SDAPP remains superior to that of commercial Nafion® membranes.

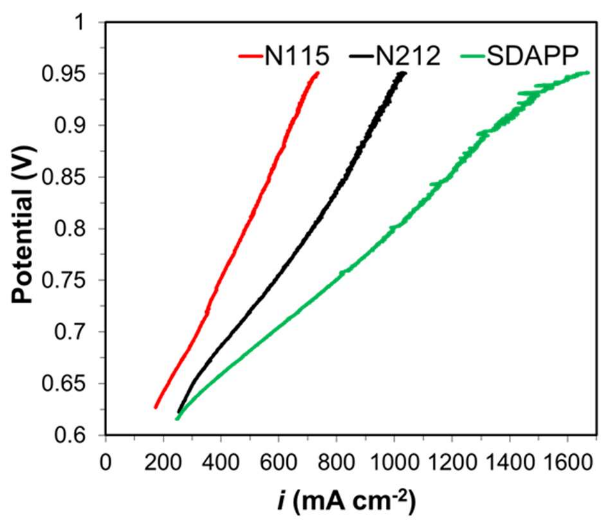

Figure 1. Performance comparison at 95 ºC.

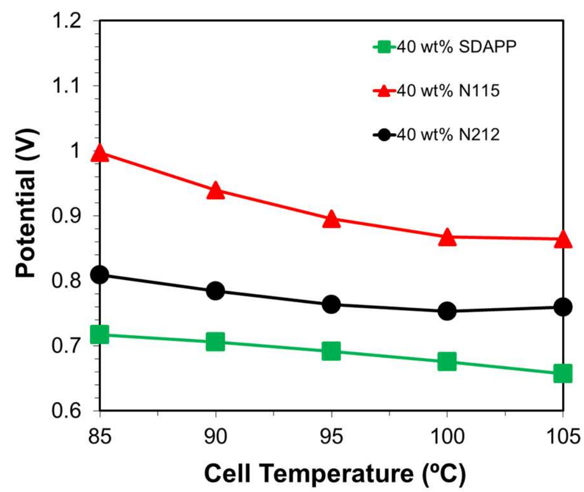

Figure 2. Constant Current performance as a function of cell temperature

FY20 Accomplishments

- Completed constant current measurements, impedance measurements, cell operation effects, and long duration testing on N212, N115 and SDAPP based MEAs.

Future Directions

- Publish results and apply for funding at various DOE-EERE solicitations

Acronyms

DOE-EERE		Department of Energy-Office of Energy Efficiency and Renewable Energy
HyS		Hybrid Sulfur
MEA		membrane electrode assembly
N212	-	Nafion® 212
N115	-	Nafion® 115
PEM	-	polymer electrolyte membrane
SDE	-	SO_2-depolarized electrolyzer
SNL	-	Sandia National Laboratory
SRNL	-	Savannah River National Laboratory
USC	-	University of South Carolina

External Collaborators

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