



Hawai'i Natural Energy Institute Research Highlights

Electrochemical Power Systems

Anion Exchange Membrane Fuel Cell

OBJECTIVE AND SIGNIFICANCE: Interest in anion exchange membrane fuel cells (AEMFCs) is driven by the potential for lower cost and increased durability. The goals of this project are to: 1) evaluate the performance of AEMFCs with platinum group metal (PGM) content and PGM-free cathode catalysts under various operating conditions; 2) study effects of membrane electrode assembly (MEA) components on mass transport, water management, and durability; and 3) develop electrochemical diagnostic and analysis methods applicable for AEMFC evaluation.

BACKGROUND: The most compelling motivation for exploring AEMFCs technology stems from the prospect of eliminating Pt-based catalysts from both the anode and cathode. This is due to the fact that PGM-free materials exhibit higher intrinsic catalytic activity towards oxygen reduction in alkaline media compared to Pt-based catalysts (Figure 1).

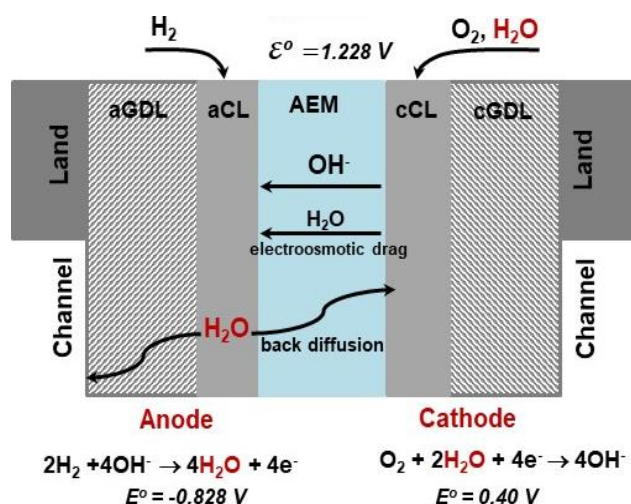


Figure 1. Schematic representation of an AEMFC.

Operation in an alkaline environment is less corrosive and can improve durability. Finally, AEMFCs are notable for their ability to operate with liquid fuels and oxidants, a feature that enhances their versatility for a range of applications and derivative technologies.

AEMFC operation requires oxygen and water at the cathode, while water is produced at the anode, an arrangement that is the exact opposite of that in proton exchange membrane fuel cells (PEMFCs). This fundamental difference introduces additional complexity and makes it difficult to directly apply

PEMFC MEA fabrication methods to AEMFCs. Enhancing AEMFC performance and durability largely depends on the design of catalyst layers with optimized porosity, hydroxide ion conductivity, and thickness to ensure the formation of effective three-phase boundaries and efficient transport of reactants.

The main approach to improve AEMFC performance and durability is a design of catalyst layers with optimal porosity, hydroxide ion conductivity, and thickness to insure development of three phase boundaries, and sufficient reagents transport, as well as adequate choice of gas diffusion layers (GDLs) for better water management. In addition, there is a lack of harmonized testing protocols and procedures and development of electrochemical diagnostics and approaches are critical for AEMFCs.

PROJECT STATUS/RESULTS: To date, HNEI's efforts under this project has allowed us to reach the following results:

- **In-house capabilities for manufacturing catalyst-coated membranes and catalyst-coated substrates** were established, enabling rapid screening and evaluation of new materials;
- **Break-in procedures for AEMFCs were optimized**, recognizing their differences from PEMFCs. Based on literature review and discussions with manufacturers, holding the cell voltage at 0.4 V under operating conditions was selected as the most effective approach.
- **Operational parameters, particularly gas humidification**, were shown to significantly impact AEMFC performance. Reduced anode humidification improved power density, achieving values up to 800 mW cm^{-2} ;
- **Compression ratio studies identified an optimal range of 20-25%** to ensure MEA durability and stable performance;
- **Variability in MEA performance was observed**, with higher electrochemical surface area (ECA) and lower high-frequency resistance (HFR) correlating with better results. Ink preparation temperature and deposition conditions were identified as critical factors influencing catalyst layer quality;
- **Pretreatment of CCMs in KOH was necessary for ionomer alkalization**. A short-term KOH soak (3 hours) was found to be as

effective as longer treatments, simplifying MEA preparation; and

- **The application of PtRu/C bimetallic catalysts improved hydrogen oxidation reaction activity** and overall fuel cell performance compared to conventional Pt/C catalysts.

Due to funding cuts resulting from various policy decisions, the continuation of this work is being reevaluated.

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