



# **Enabling Low-Cost On-Site Hydrogen Production with Advanced AEM Electrodes**

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*MVPC 2025*

A DCL Technology Group Company





DCL originated in the 1980's developing emissions controls for the underground mining industry





# 40 Years of Energy Efficiency

Trusted by power producers to ensure cost effective, reliable emission reduction solutions for a broad range of industries.



Mobile & Stationary Emissions




Cogeneration Energy  
Efficiency



Biogas Conditioning & RNG  
Upgrading



Commitment to the  
future of our world.




**GraniteFuel**  
ENGINEERING  
Manufacturing, Design,  
Engineering, Support



**DCL International Inc.**  
Headquarters, Manufacturing, R&D,  
Engineering, Finance, support




**DCL Europe GmbH**  
Stationary Engine Sales & Support



**AeriNOx**  
A DCL and H+H Company  
SCR Systems for  
NOx Reduction



**DCL America Inc.**  
Stationary Engine Sales, Support,  
Manufacturing



**ROADWARRIOR**  
Mobile Emissions, Lithium  
Batteries - Manufacturing, Sales, &  
Support



40 Years of  
R&D, Engineering, and Manufacturing.

Expertise in emissions controls,  
nanomaterials, catalyst & energy efficiency.





# Decarbonization Solutions

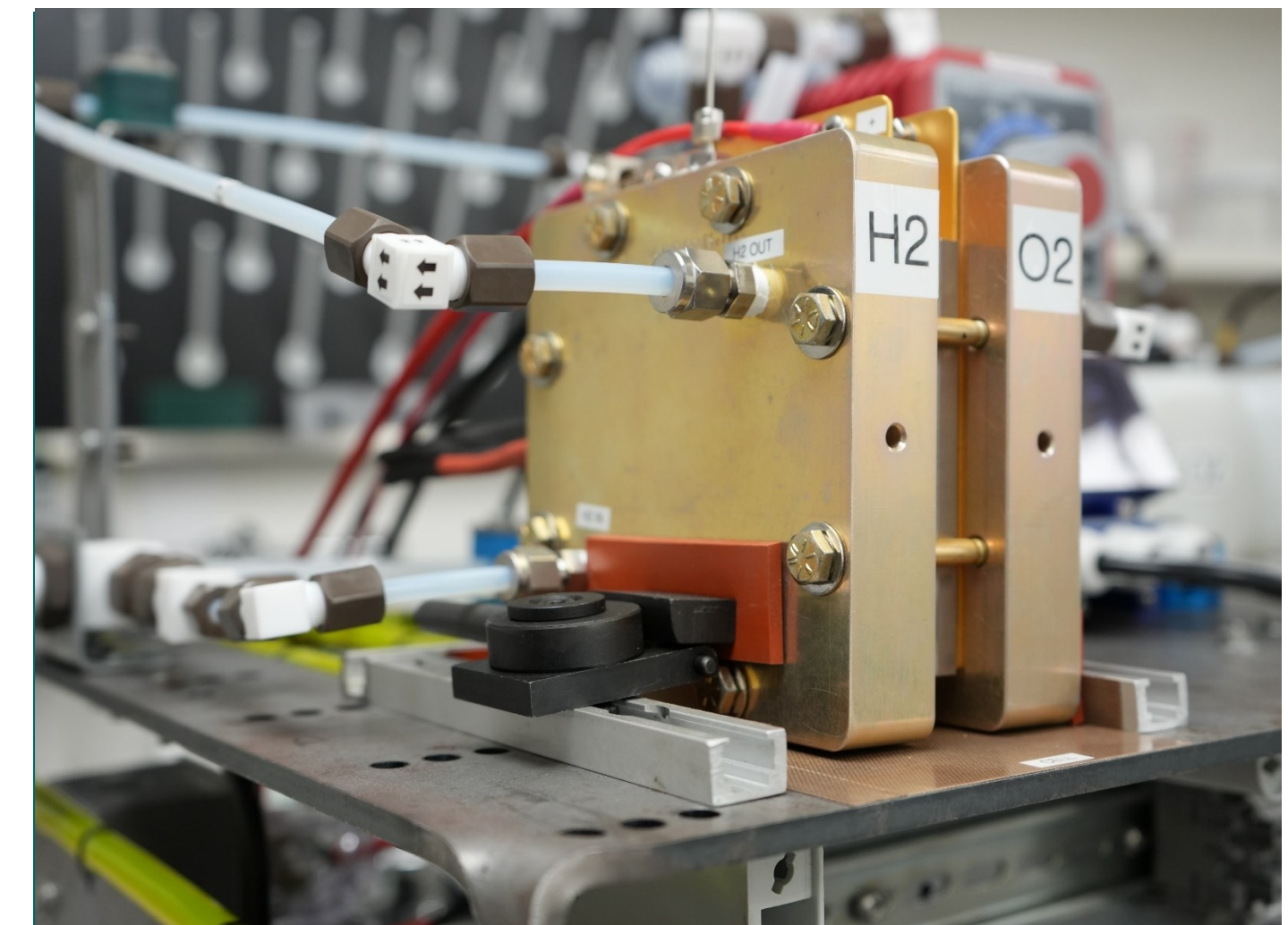
DCL's expertise in designing & manufacturing high-quality components, for maximum efficiency & performance for clean energy applications, including Hydrogen CHP systems.



Fuel Cells

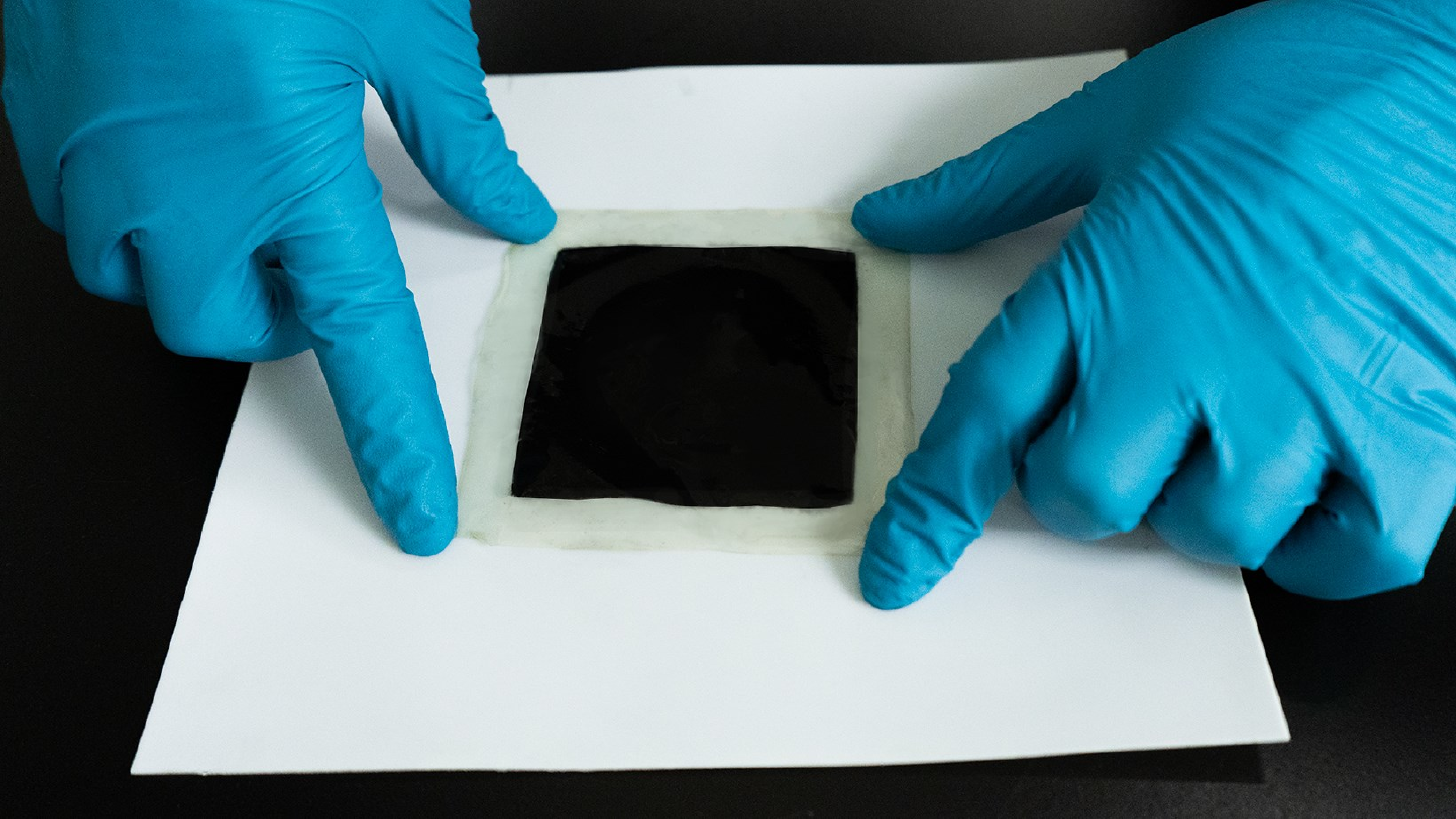


Methane Destruction



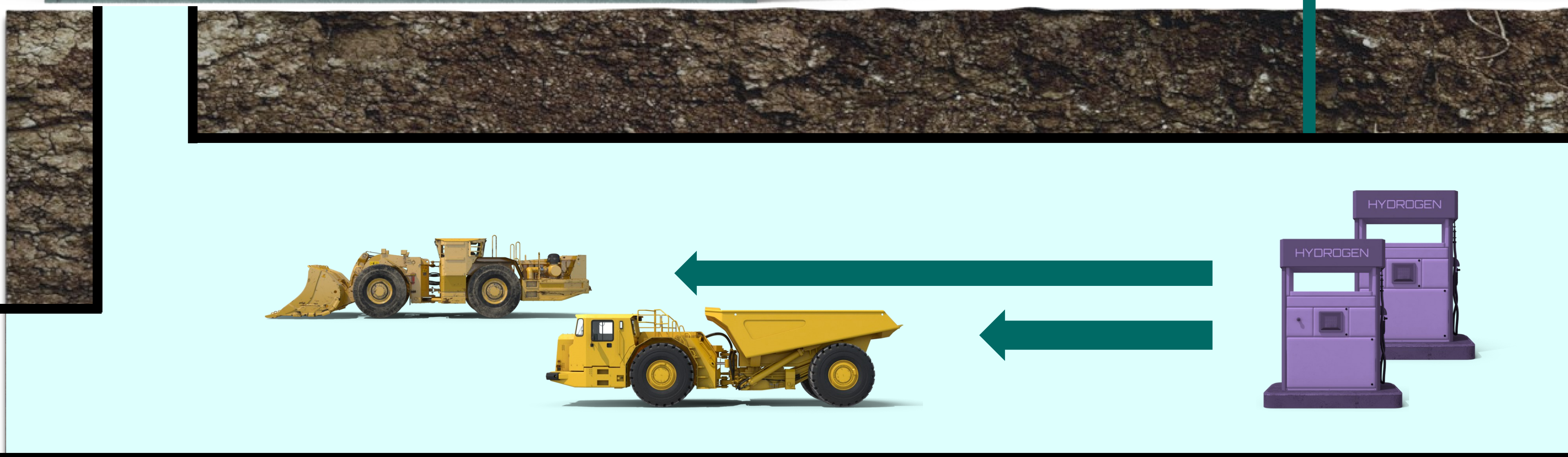
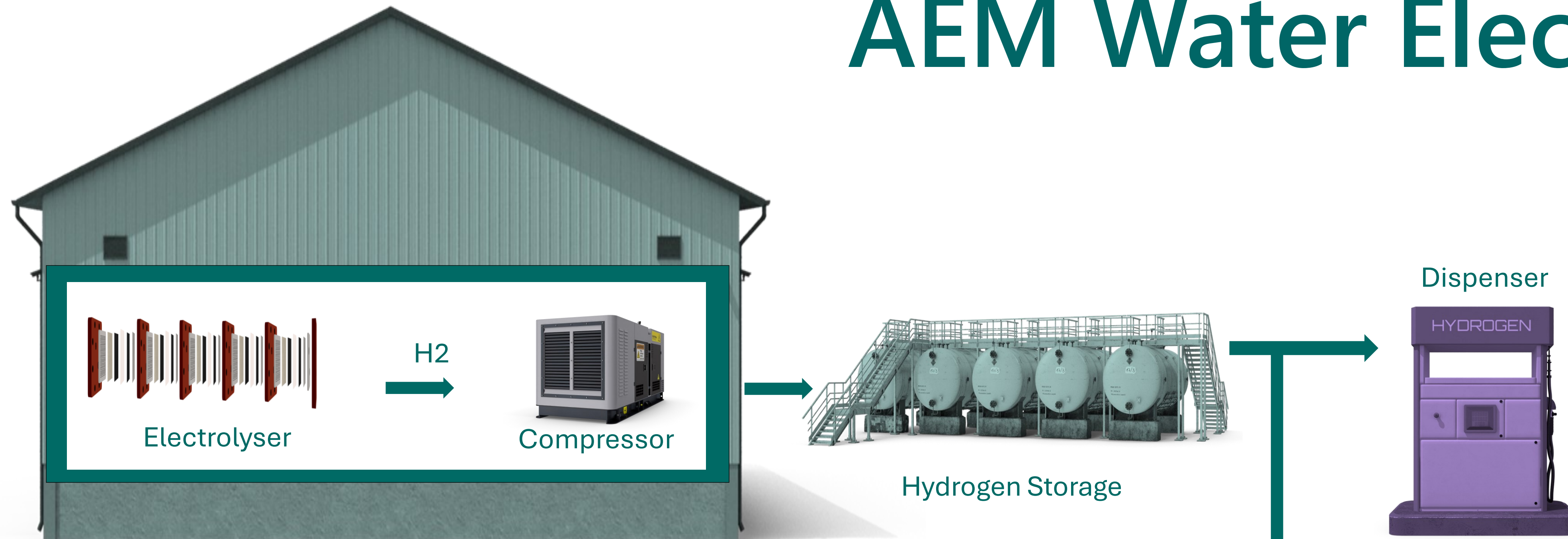
Electrolyzers





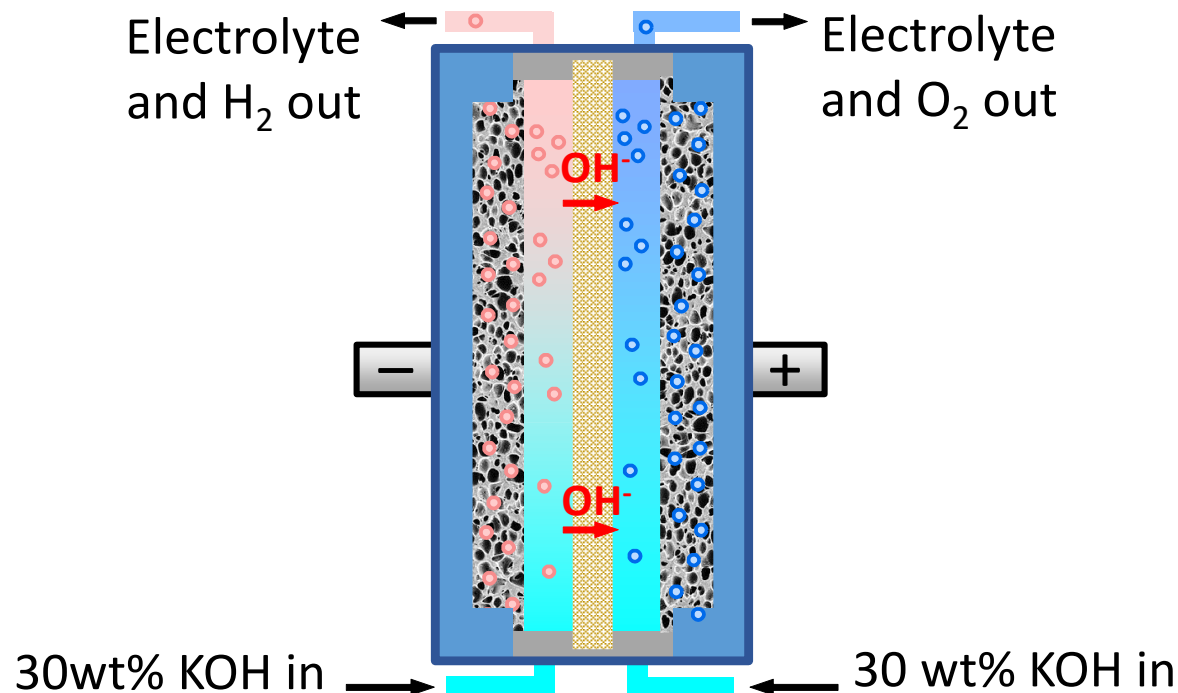
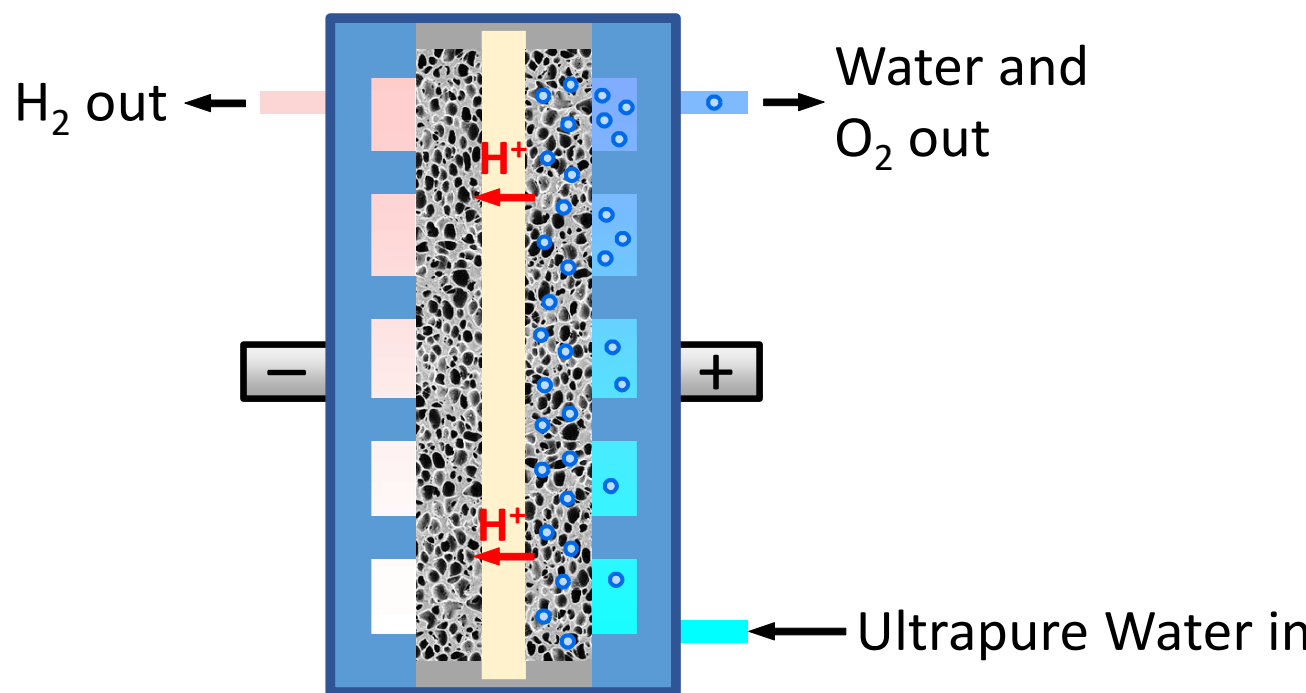
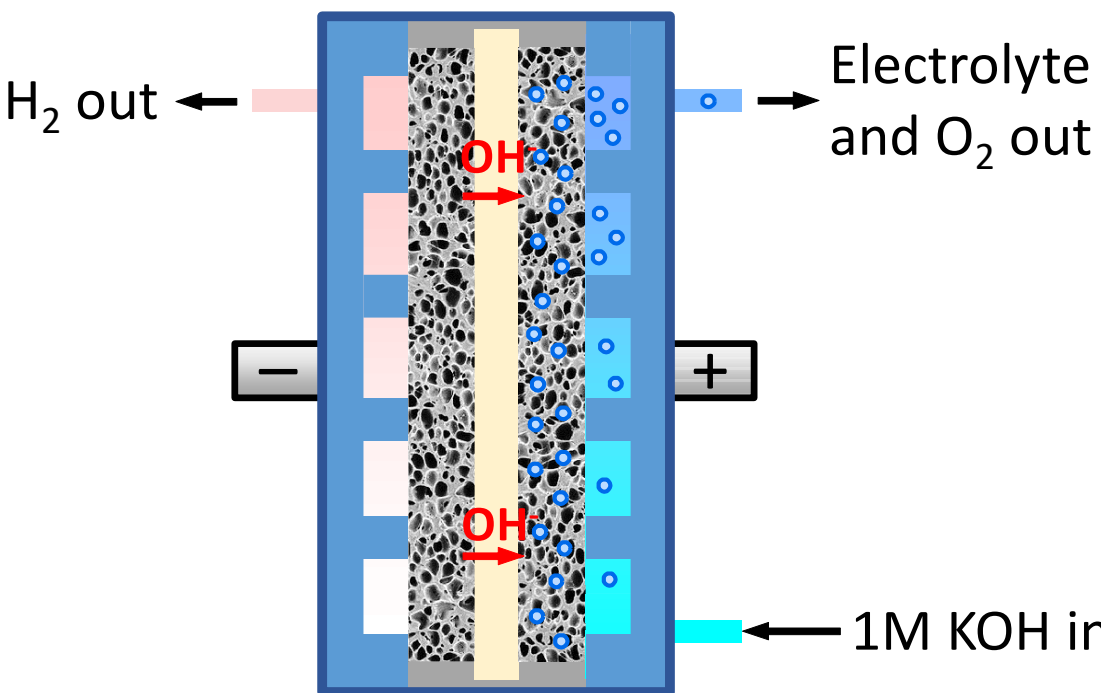


# AEM Water Electrolyzer





# AEM Water Electrolyzer

	Alkaline Water Eletrolyzer (AWE)	PEM Water Electrolyzer (PEMWE)	AEM Water Electrolyzer (AEMWE)
Concept	Uses a diaphragm as separator	Uses a Proton Exchange Membrane as separator	Uses an Anion Exchange Membrane as separator
Structure			
Process	<ul style="list-style-type: none"> <li>- Non-noble metals as catalysts</li> <li>- Concentrated KOH electrolyte circulation in both compartments</li> <li>- Lower adaptability to electrical signal variation</li> </ul>	<ul style="list-style-type: none"> <li>- Noble metals as catalysts (Iridium)</li> <li>- Ultrapure water circulating in the anode compartment (dry cathode)</li> <li>- PFAS containing polymers for the membrane</li> <li>- High adaptability to electrical signal variations (renewable sources)</li> </ul>	<ul style="list-style-type: none"> <li>- Non-noble metals as catalysts</li> <li>- Diluted KOH electrolyte (deionized water)</li> <li>- PFAS-free membrane</li> <li>- High adaptability to electrical signal variations (renewable sources)</li> </ul>



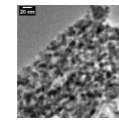
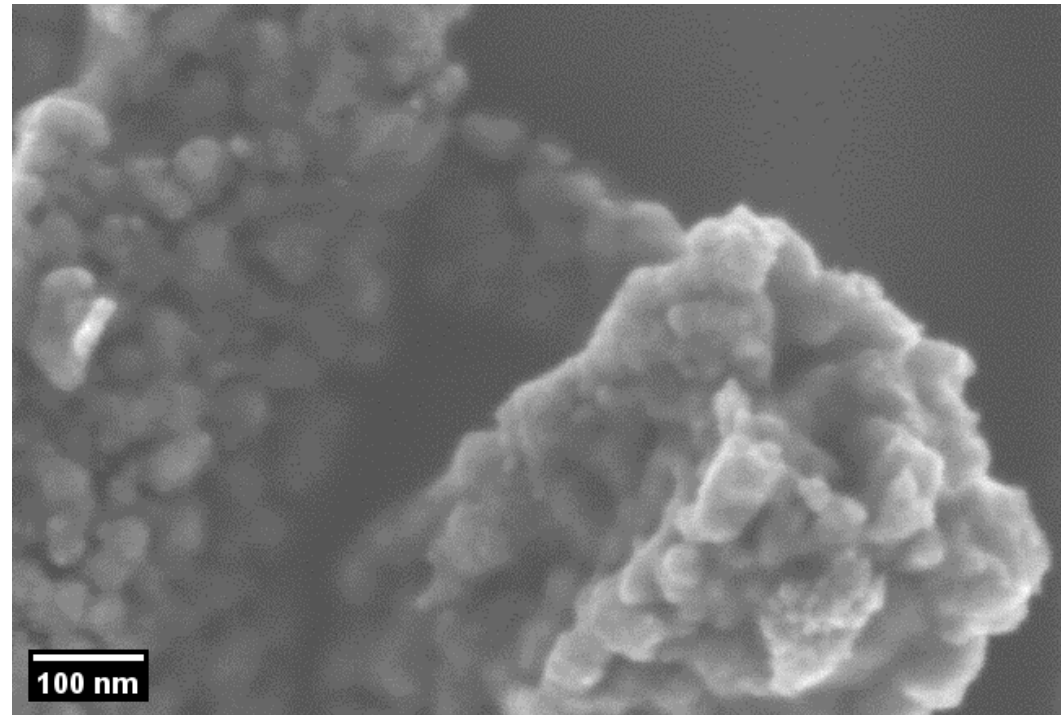
# Electrocatalyst Formulation

- Scalable catalyst preparation
- Efficient synthesis with low waste
- Wide range of available compositions
- Iron-free catalytic materials

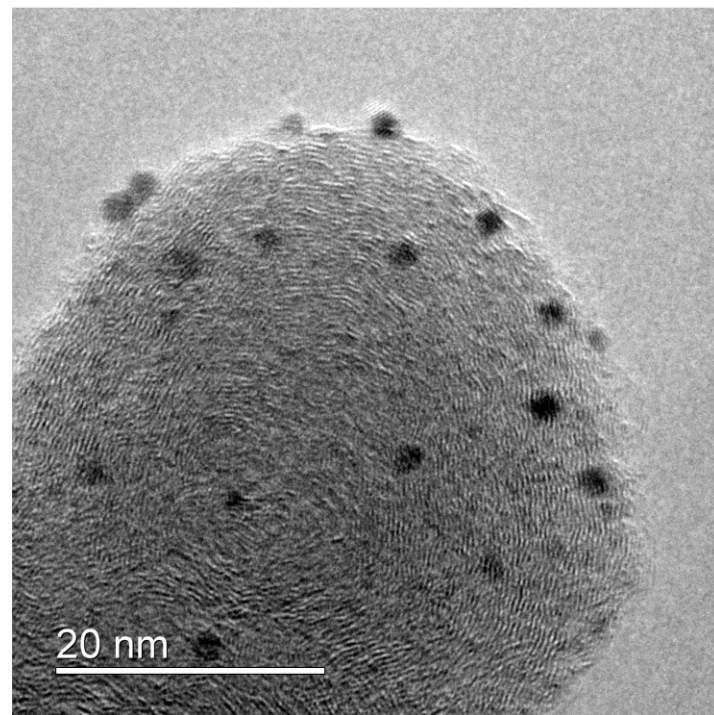




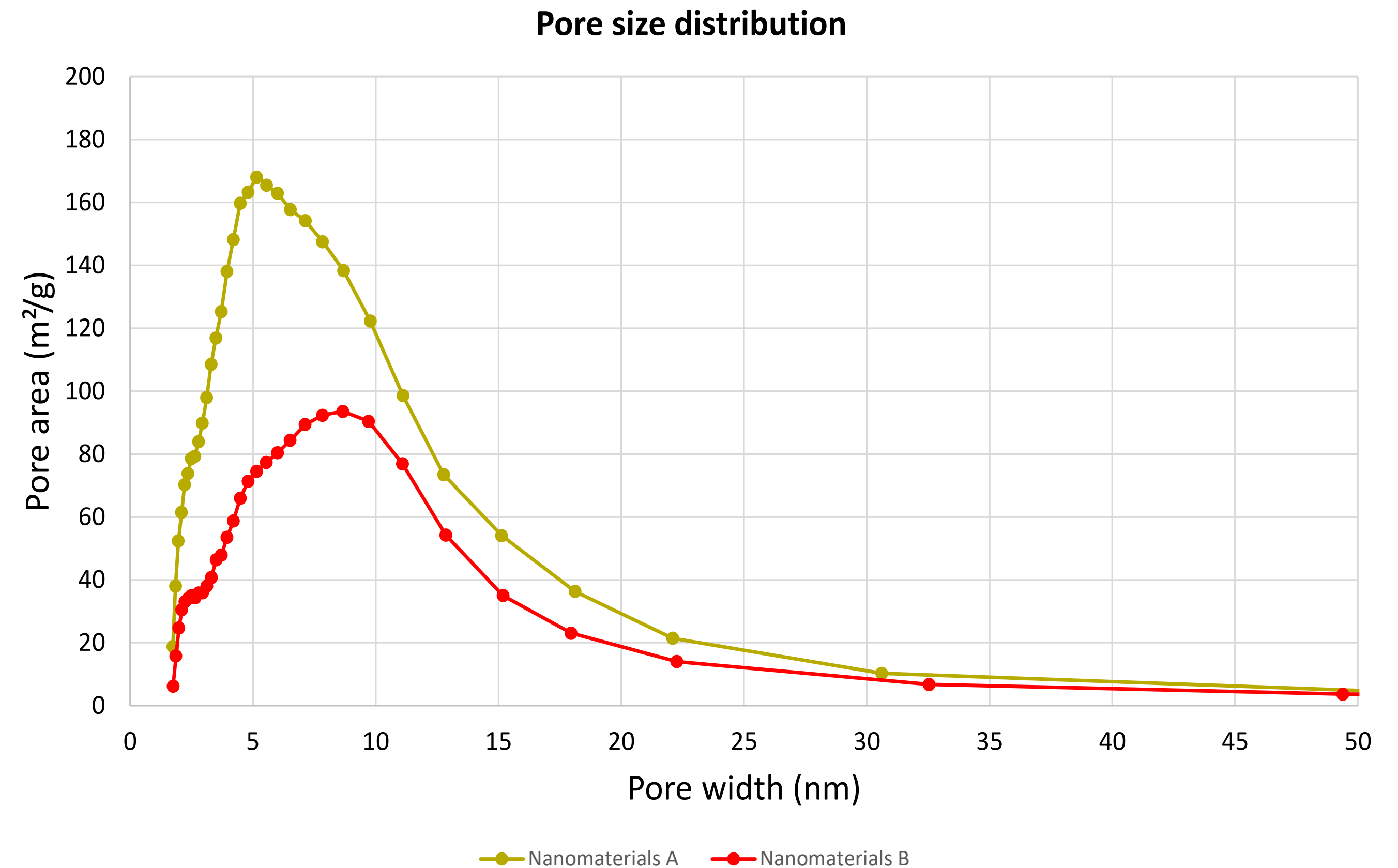
# High Surface Area



Nanostructured non-PGM materials with surface area from up to 100 m<sup>2</sup>/g



High surface area noble metal alloys for low PGM content cathode





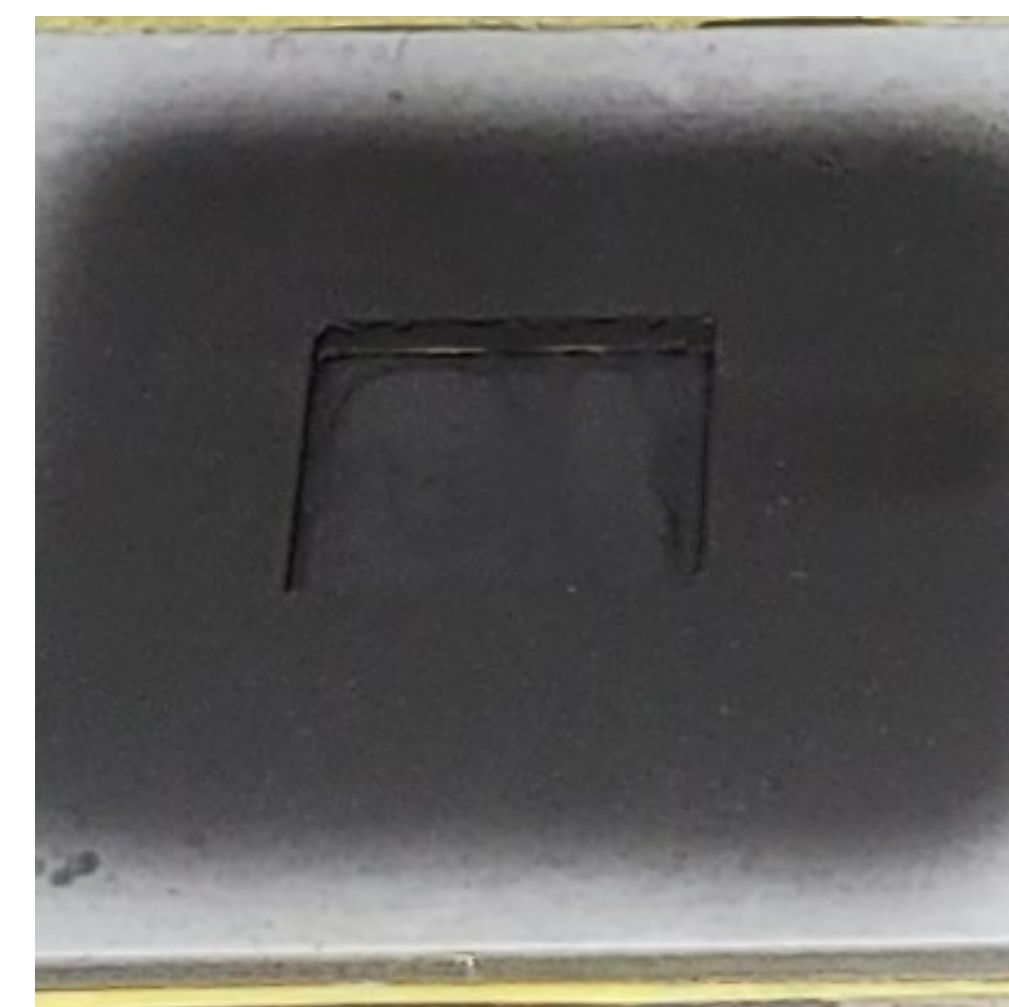
# Electrode Coating

Spray coating for CCS and CCM configurations.

Optimized formulations of anodes and cathodes adapted to different substrates.



CCS Coating



CCM Coating

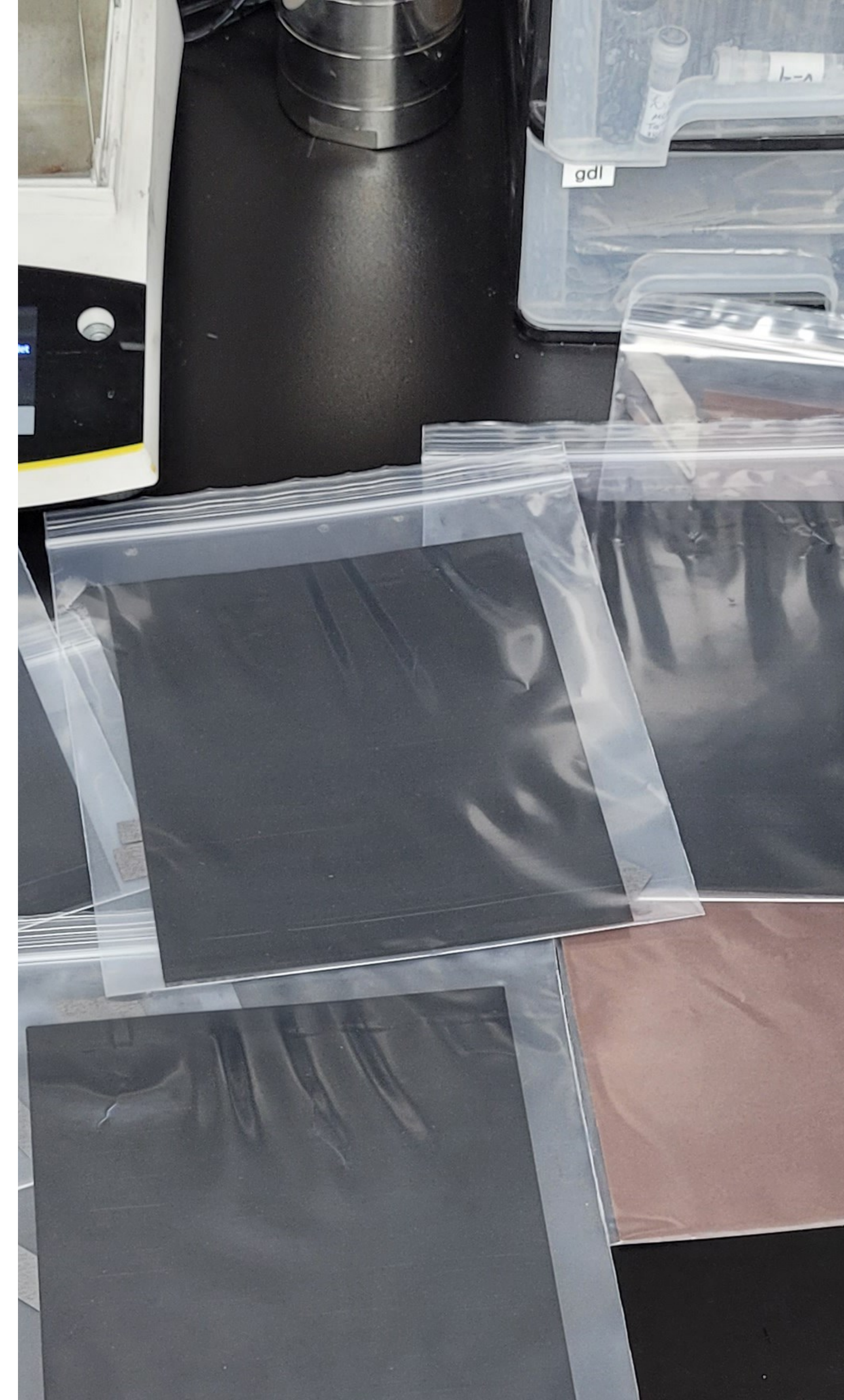




# CCS Coating

Coatings adapted for a variety of substrates

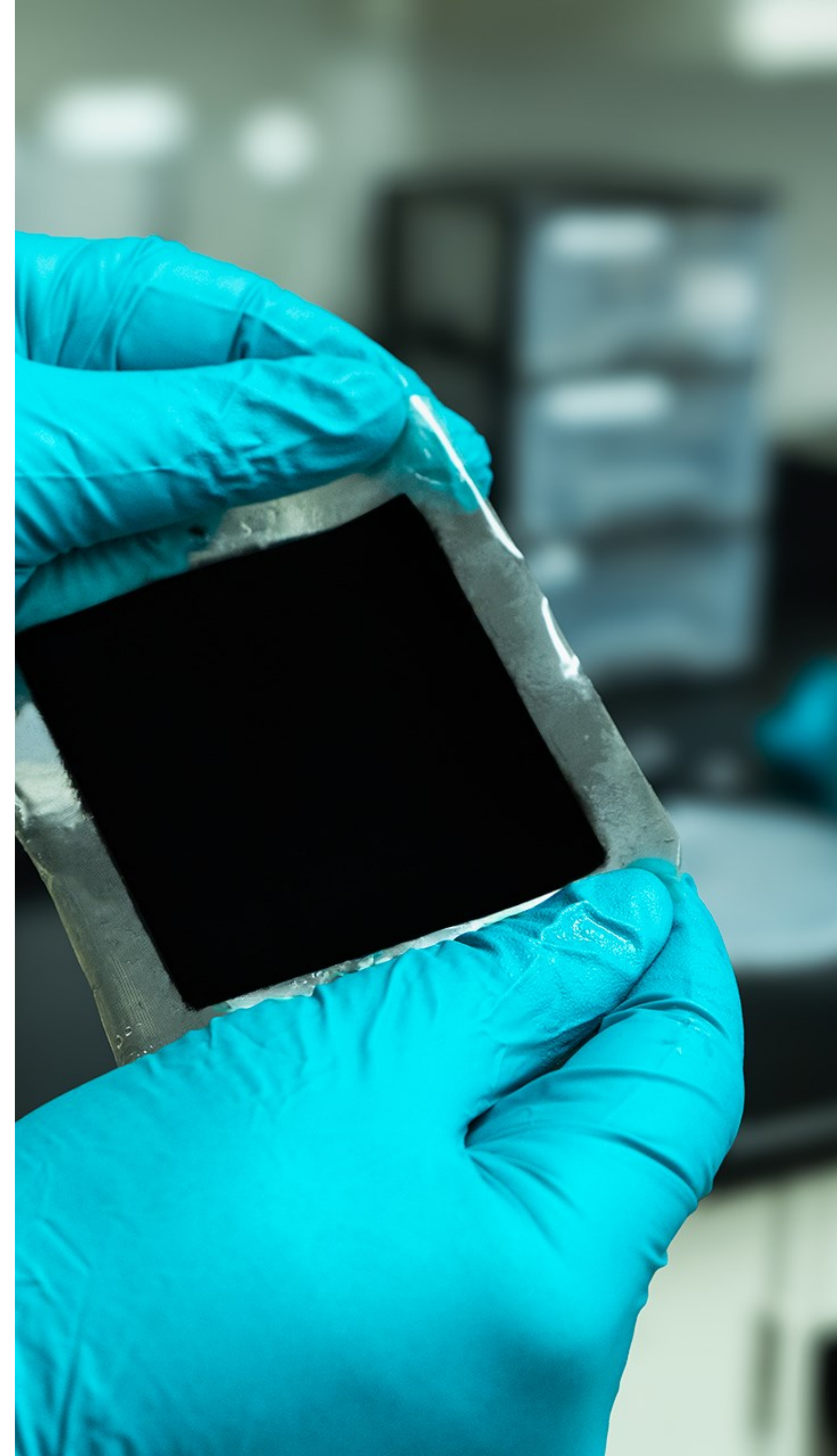
- Nickel or stainless steel
- Wide range of thickness and porosity





# CCM Coating

- Coatings adapted for a direct coating on membranes.
- Membrane optimized formulation.





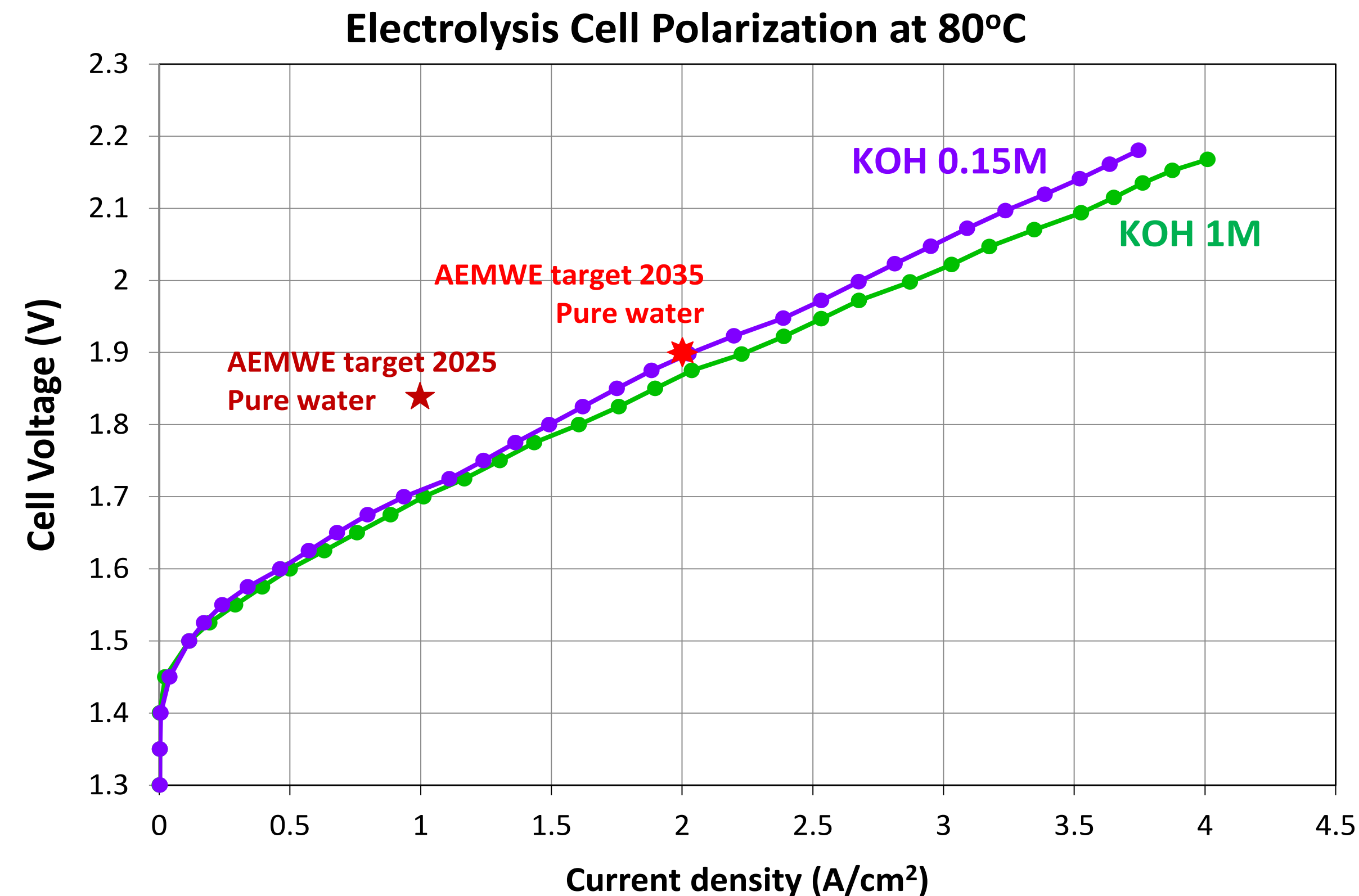
# Electrode and membrane coating options

- 35 cm x 35 cm electrodes in production (both CCM and CCS configurations)
- Custom configurations available (square, circular or custom shapes).
- **Physical Stability Tested:** 1M KOH (7 days) under sonication (1 h/day).



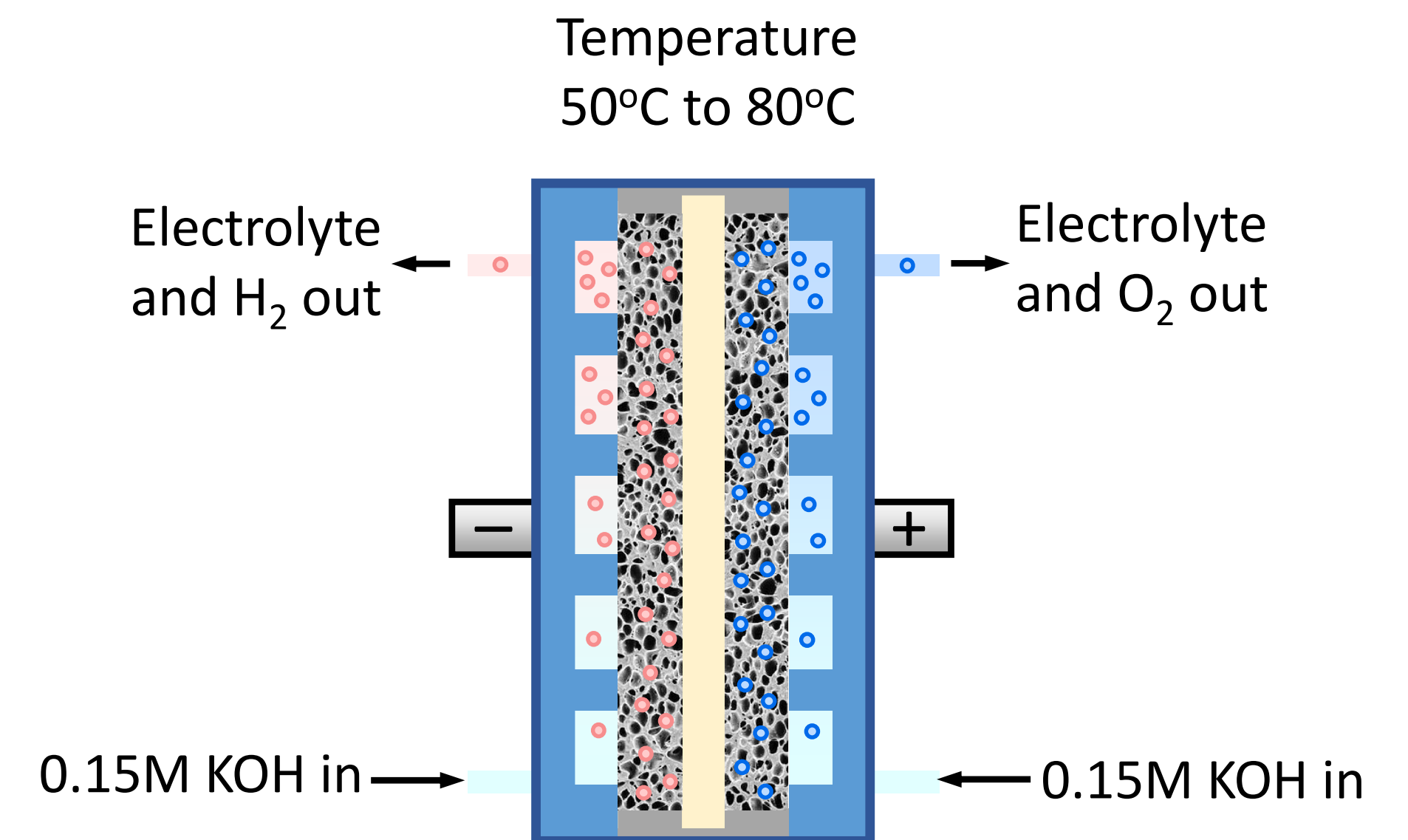


# Optimization of electrodes and membrane/electrode interface



Operation in mild conditions

- Diluted electrolyte
- Low temperature



DOE targets

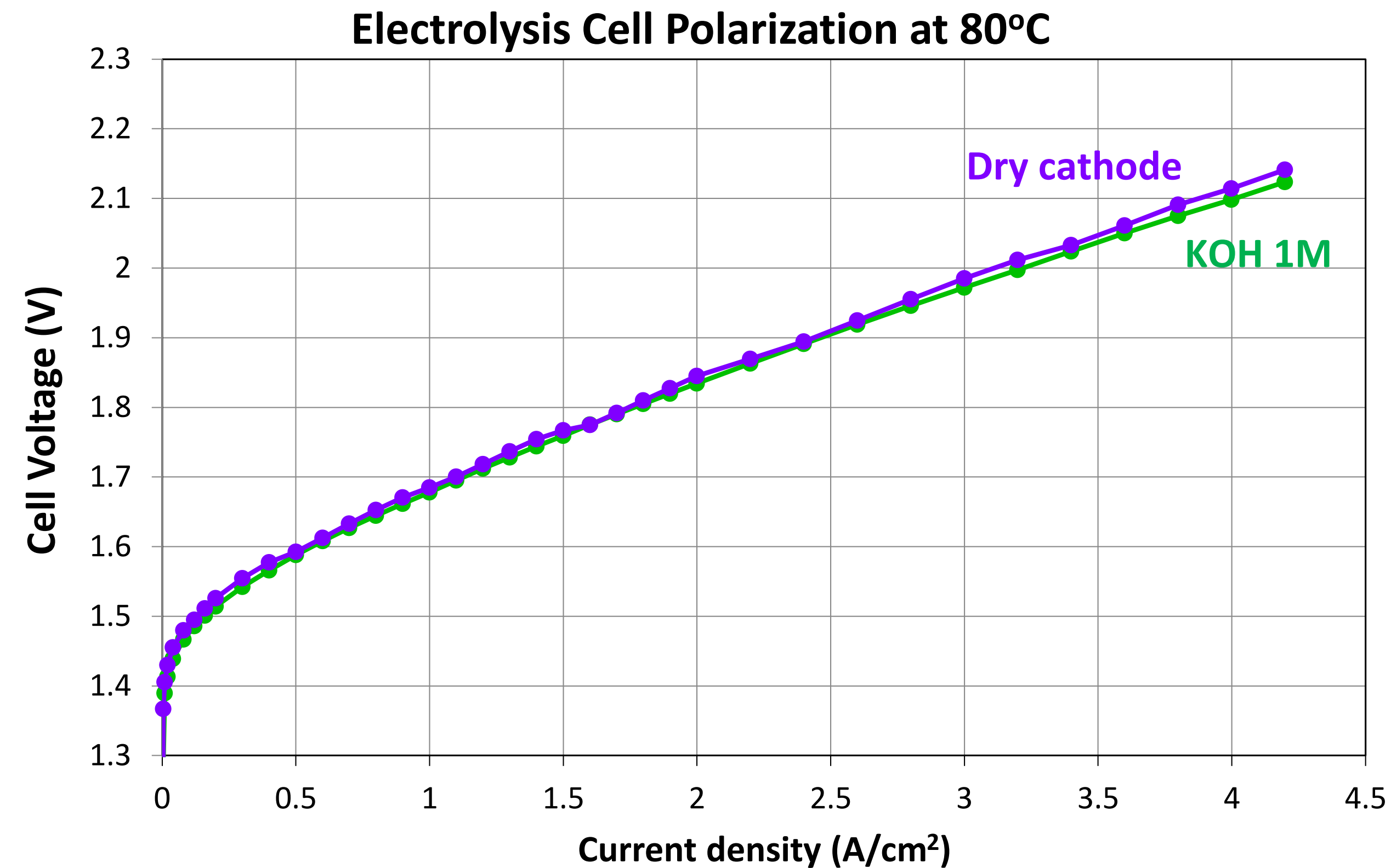
Hydrogen Production Cost and Performance Analysis.

DOE Hydrogen Program, 2022 Annual Merit Review and Peer Evaluation Meeting.

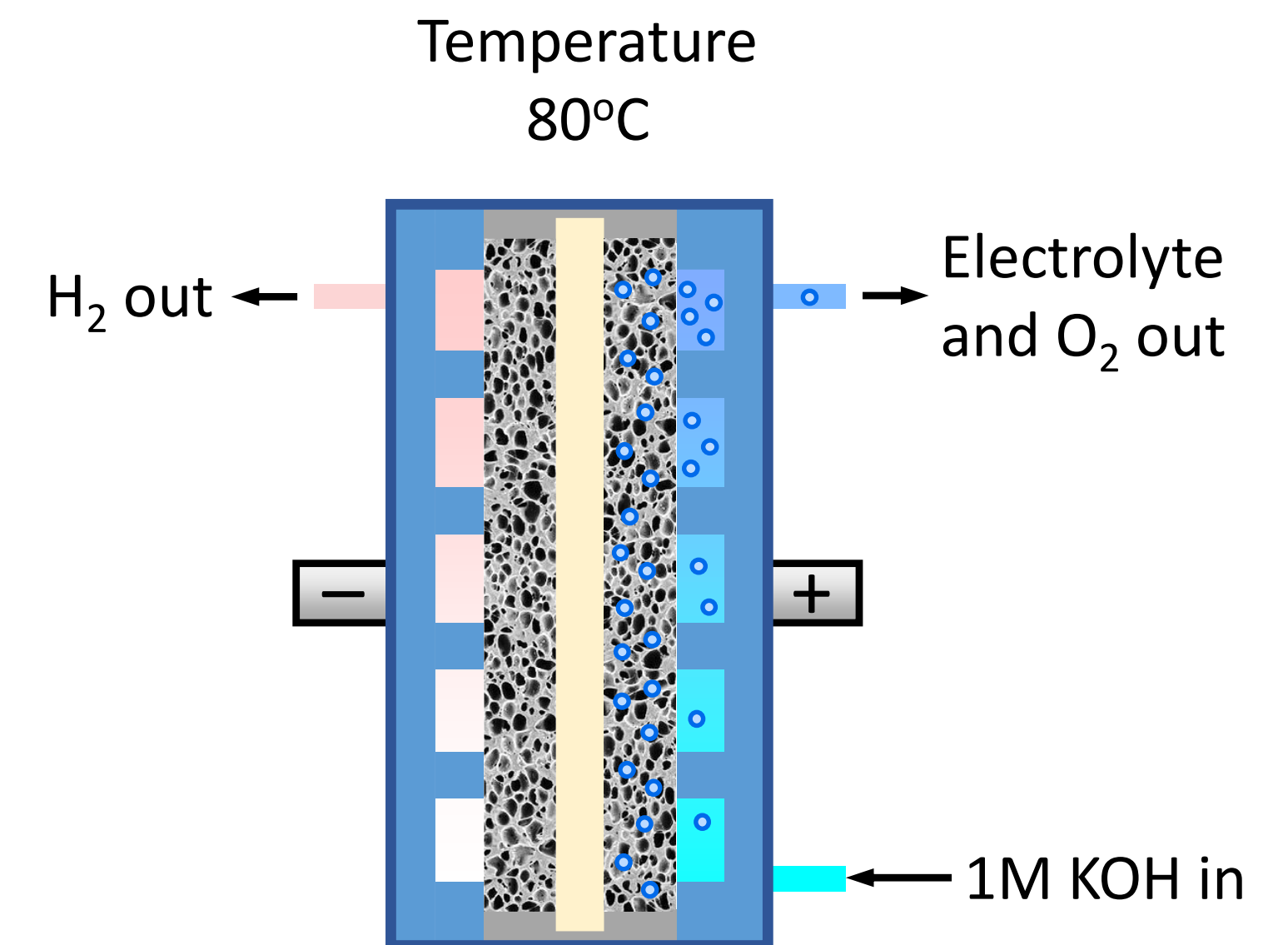




# Optimization of electrodes and membrane/electrode interface



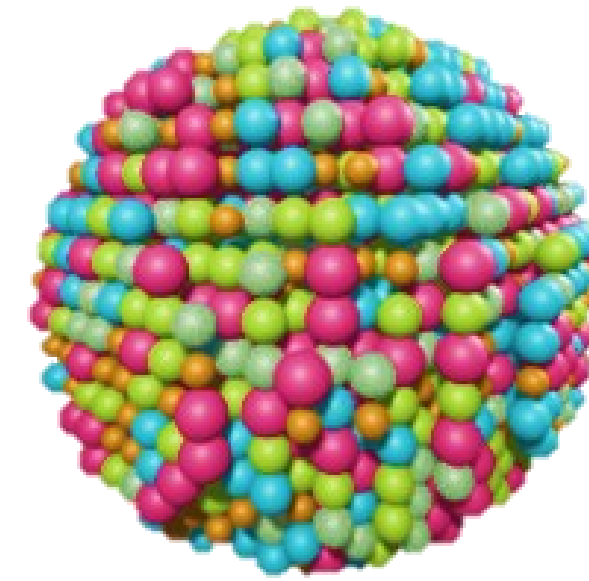
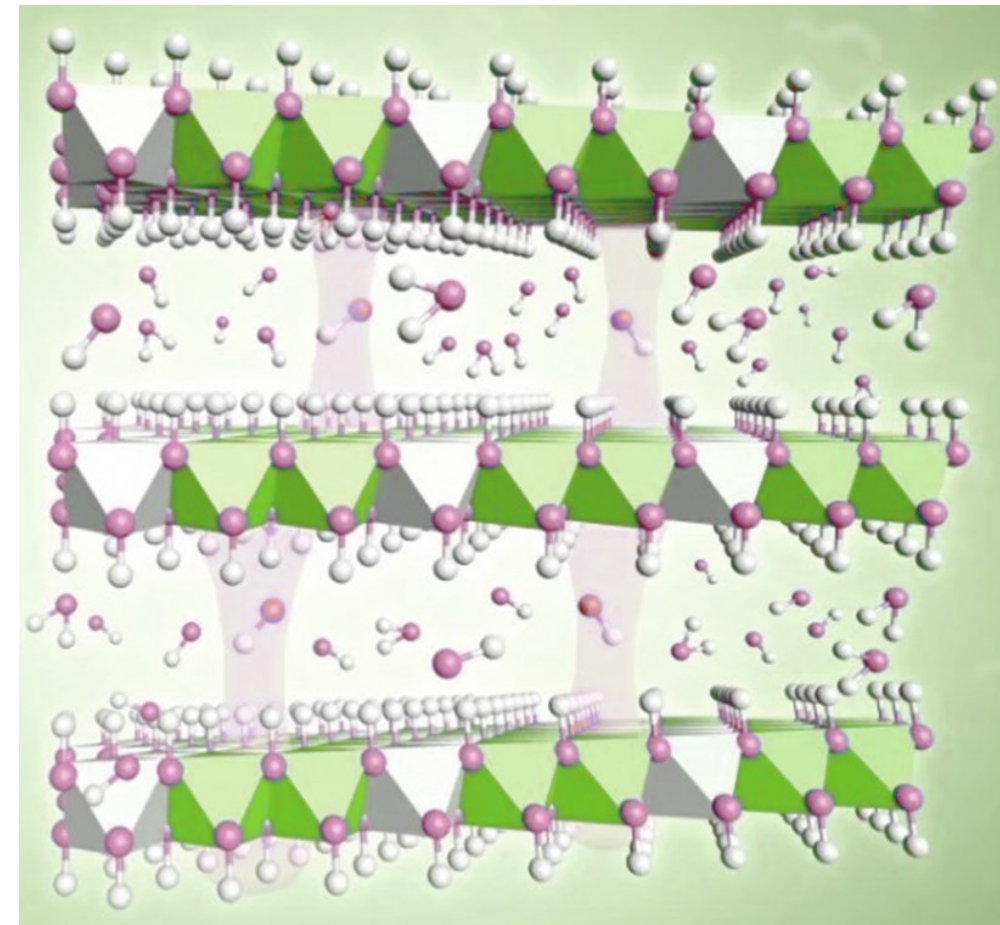
Operation without electrolyte circulation in the cathode compartment



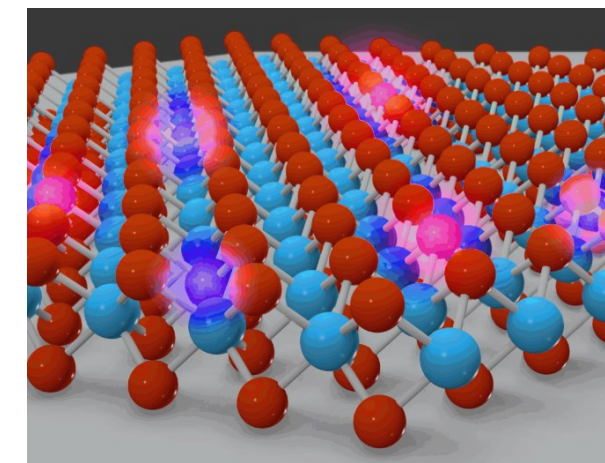


# High Activity, High Stability Anodes

High stability  
non-PGM  
oxide/hydroxide



High entropy  
nanomaterials

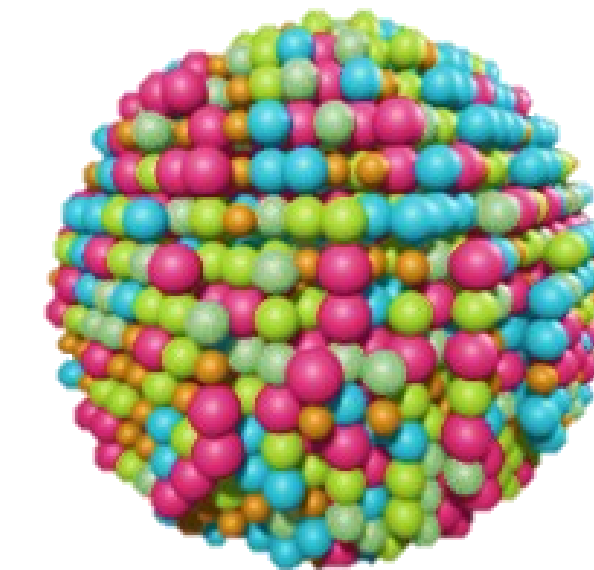
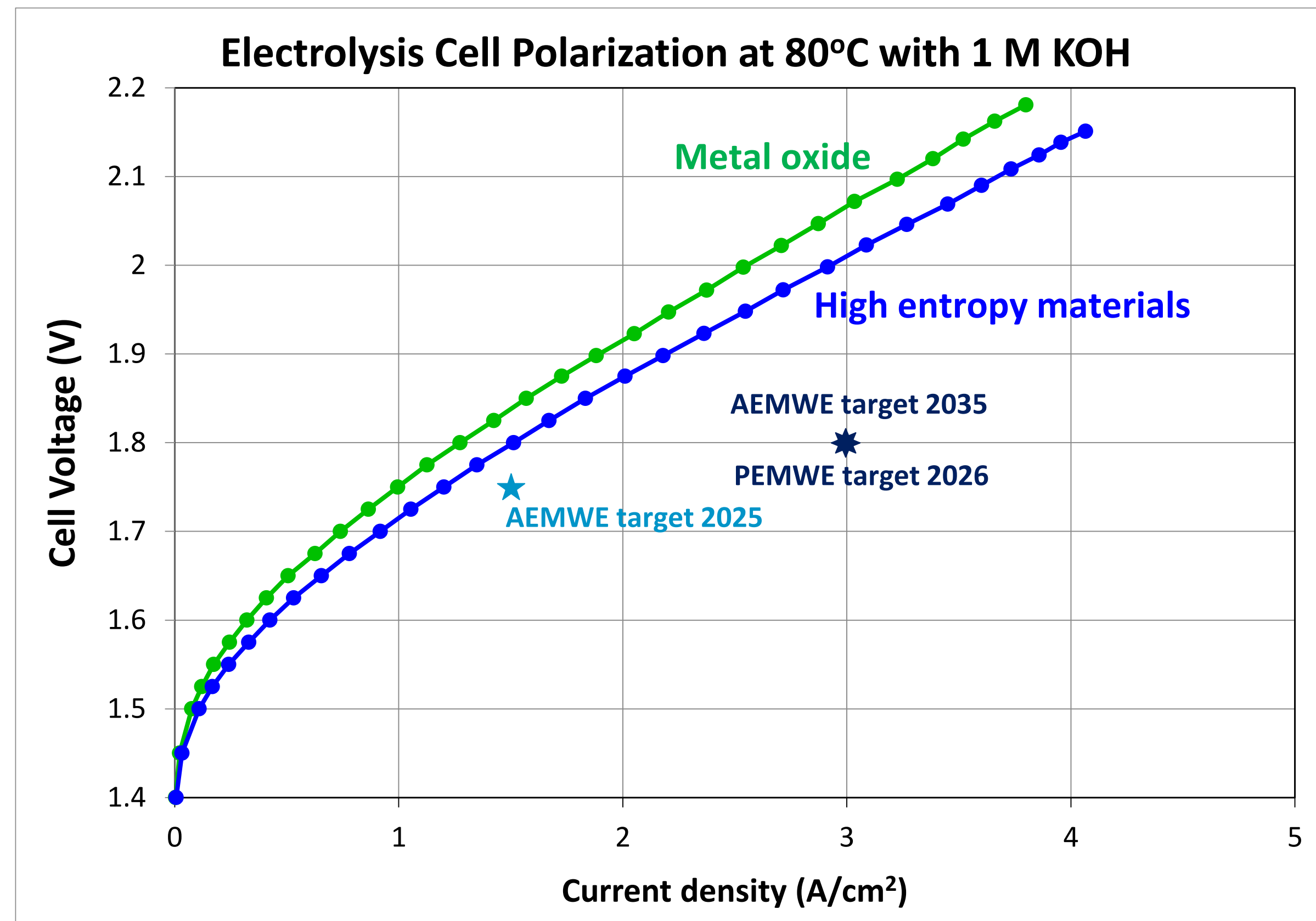


Modified oxide  
materials





# High entropy nanomaterials



High entropy nanomaterials present an enhanced activity.

These materials should also exhibit an enhanced stability.

## DOE targets

*Technical Targets for Proton Exchange Membrane Electrolysis, 2022.*

*Hydrogen Production Cost and Performance Analysis.*

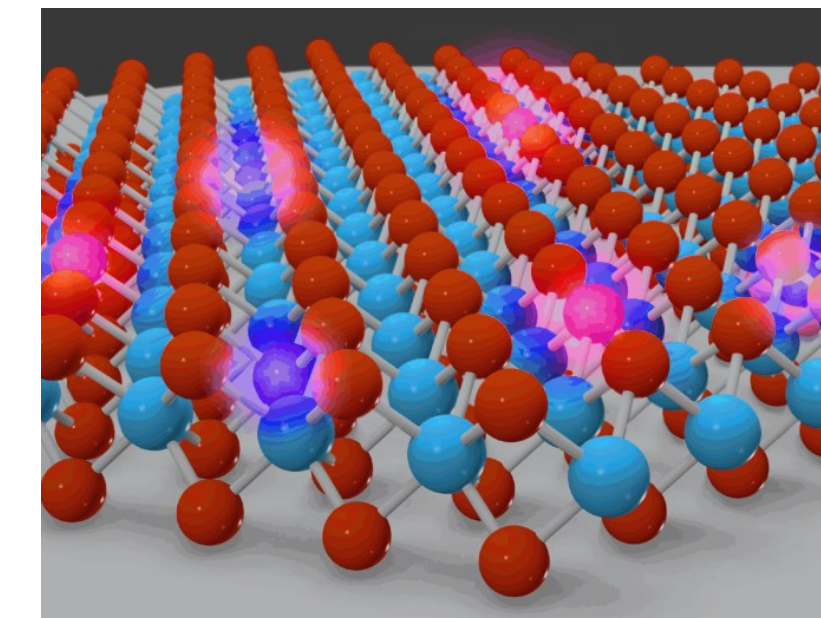
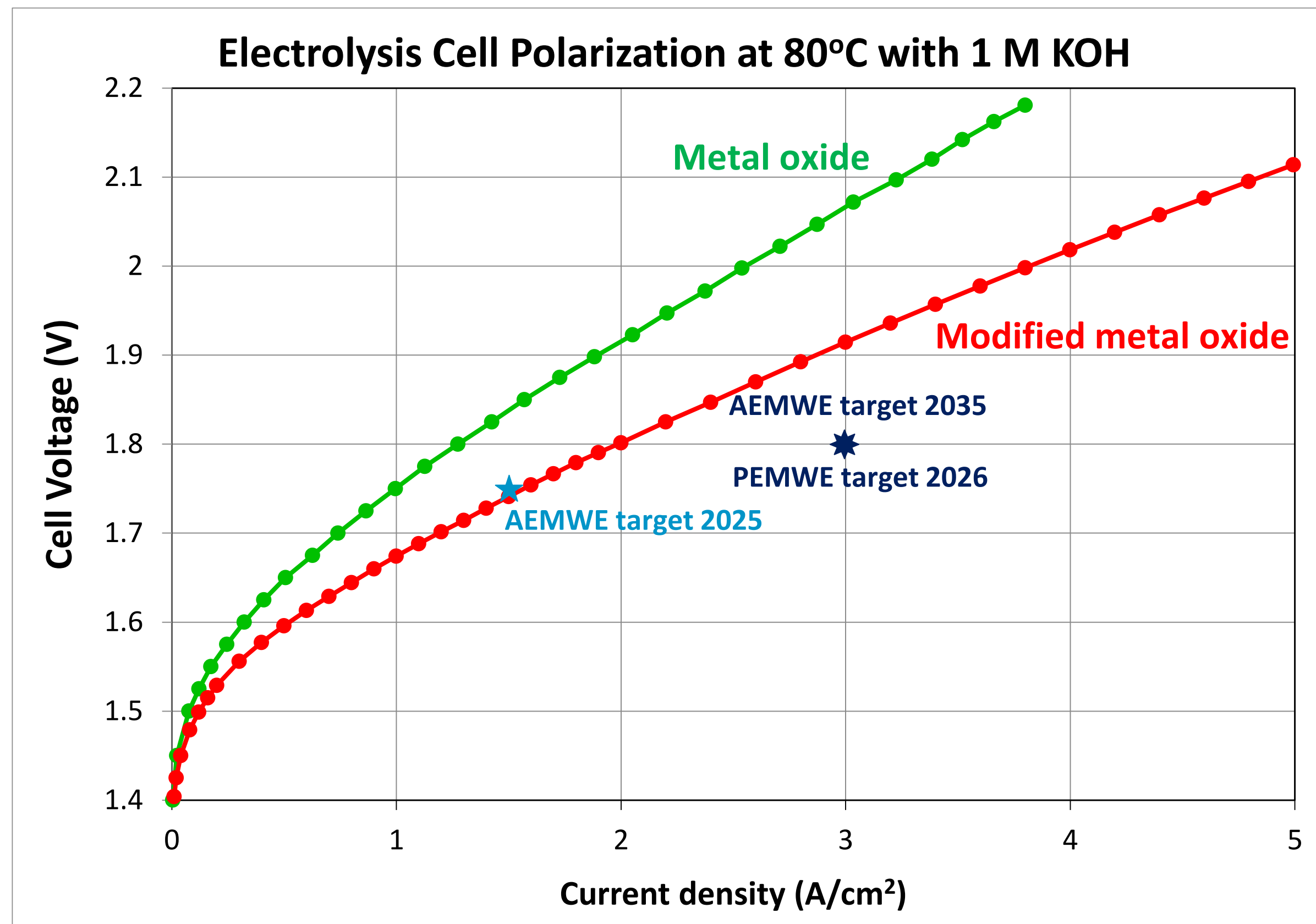
*DOE Hydrogen Program, 2022 Annual Merit Review and Peer Evaluation Meeting.*



Picture:  
Wikimedia Commons



# Modified oxide materials



Performance of modified oxide materials enable AEM cells to reach PEM cell targets.

## DOE targets

*Technical Targets for Proton Exchange Membrane Electrolysis, 2022.*

*Hydrogen Production Cost and Performance Analysis.*

*DOE Hydrogen Program, 2022 Annual Merit Review and Peer Evaluation Meeting.*



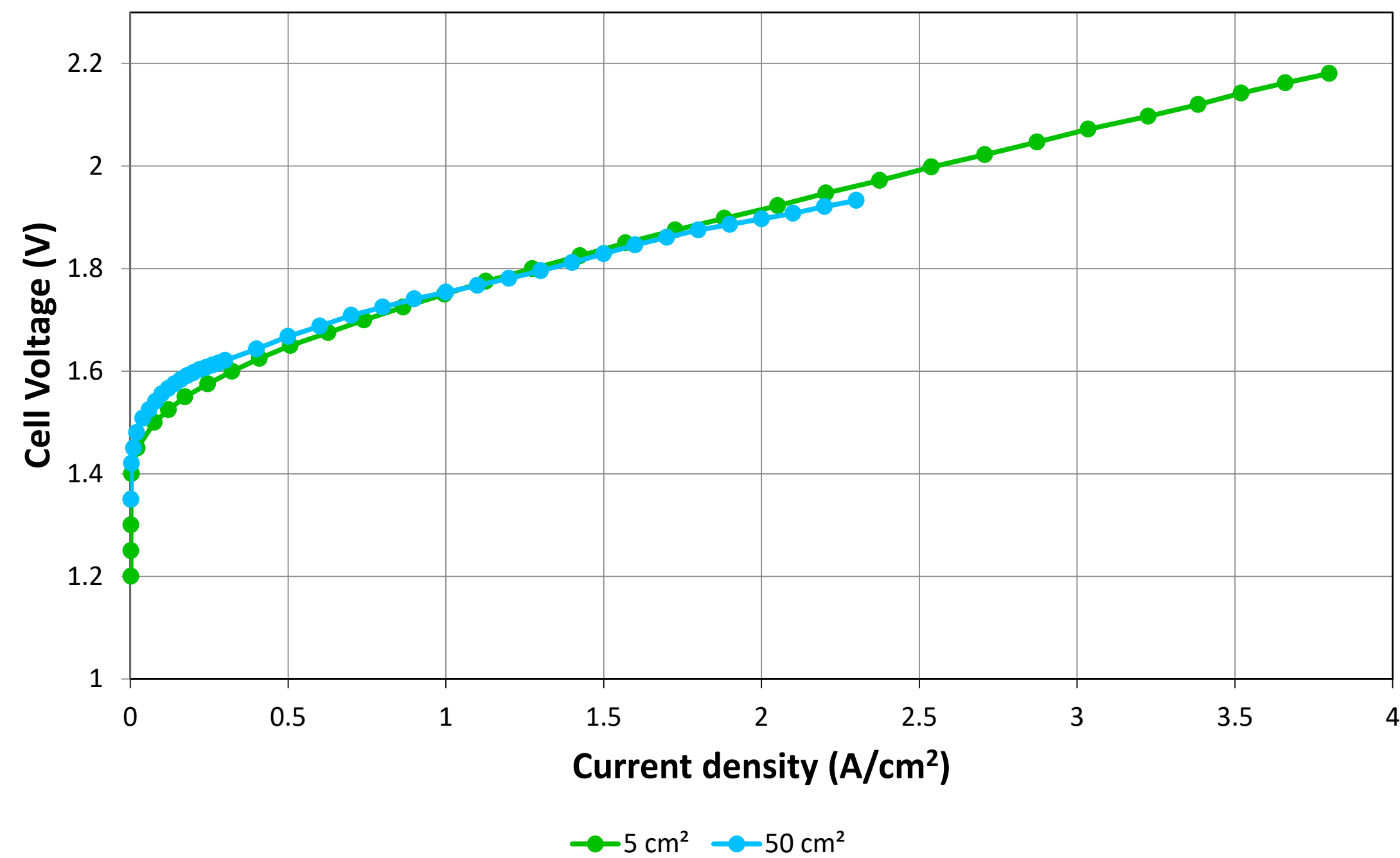
Picture:

L. Loh, Z. Zhang, M. Bosman, G. Eda, *Nano Res.* 14 (2021) 1668–1681



# High stability system

Electrolysis Cell Polarization

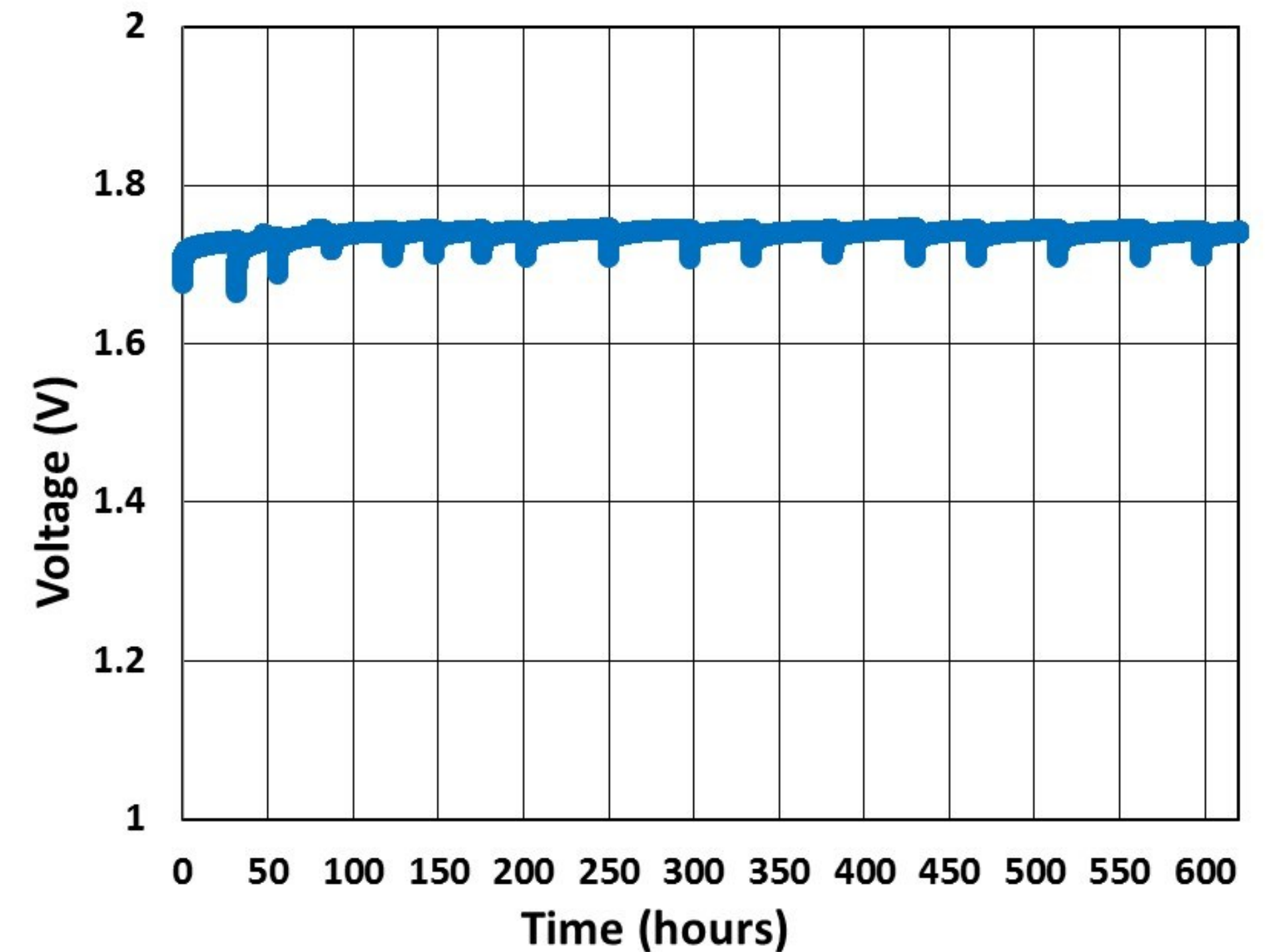


50cm<sup>2</sup> cell demonstrated good initial stability.

Long-term stability tests in progress.



Chronovoltammetry at 1 A/cm<sup>2</sup>



Measure over 600 hours, with 1M KOH solution circulating in both anode and cathode compartments, temperature 80°C



# Summary

- Large scale production of high surface area non-noble metals with a wide range of compositions
- Optimized coating capability for CCS and CCM configurations
- Three families of materials available for improved performances





CCMs & CCS Electrodes by DCL®  
AEM High Stability Electrodes & Catalyst Coated Membranes

DCL® electrodes are high-performance catalytic coated membranes designed for efficient use in AEM electrolyzers. These electrodes support the production of clean hydrogen at an efficiency comparable to PEM electrolyzers at a lower cost.

DCL International Inc.® electrocatalyst expertise with Ionomr Innovations Inc. membranes, produce high performing CCS & CCMs for electrolyzers.

**Catalyst Coated Substrate (CCS)**  
Electrodes in standard and custom sizes comprising high stability catalyst layers, coated onto gas diffusion layers and porous transport layers.

**Catalyst coated membranes (CCMs)**  
Membranes in standard and custom sizes, coated with high stability catalyst layers



**High Efficiency Technology** ideal for AEM electrolyzers, renewable energy storage, industrial processes, fuel cell technology.

**Highly Durable** DCL electrocatalyst coatings and Aemion® membranes are optimized for strong alkaline stability and long-term operation with minimal degradation.

**High Catalytic Activity** ensures efficient electrolysis for maximum hydrogen production.

**Custom Designs** available in various sizes and with different catalyst loadings to meet specific performance requirements.



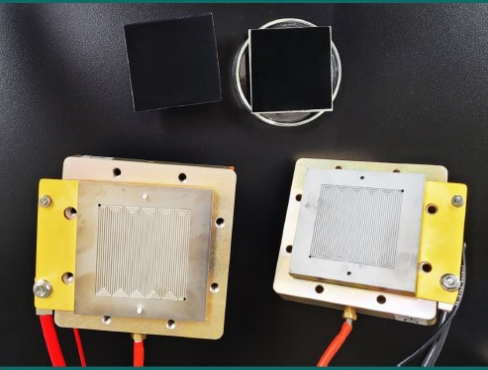
Leveraging nearly four decades of catalyst innovation and emissions control, DCL International Inc.® has made advancements for AEM electrolyzer technologies for the production of hydrogen. Our expertise in nanomaterial applications has fueled the development of high performance electrocatalyst technology, designed to meet the rigorous demands of hydrogen production.

**Nanomaterials Expertise**  
Utilizing nanotechnology to enhance electrode performance and longevity.

**Hydrogen Lab for R&D**  
State-of-the-art facilities dedicated to the refinement of electrolyzer components.

**Emissions Reduction Heritage**  
A solid foundation in clean air innovations for various industries and applications.

*At DCL®, our dedication to the hydrogen energy landscape is driven by a commitment to environmental sustainability, energy efficiency and clean air technologies.*



CCMs & CCS Electrodes by DCL®  
AEM High Stability Electrodes & Catalyst Coated Membranes



Water Electrolysis Electrodes

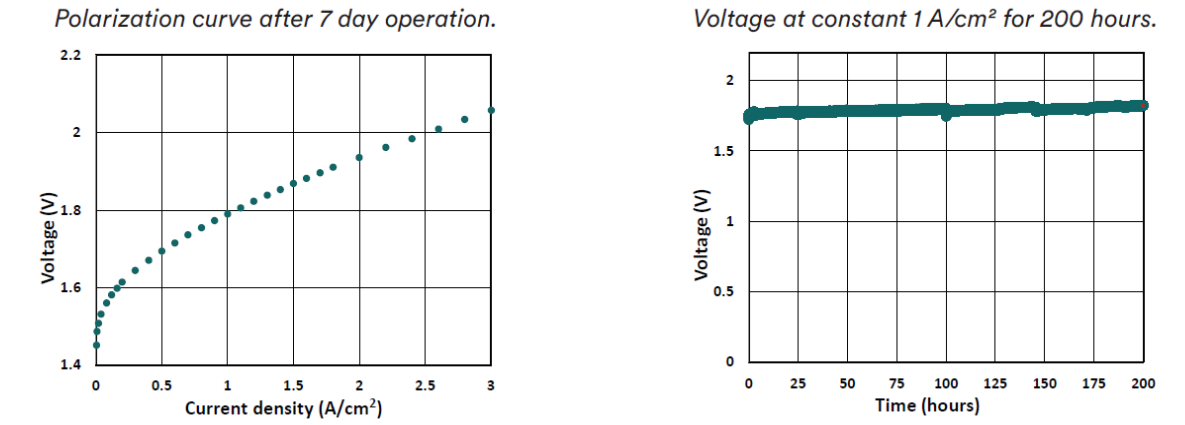
Active area	5cm² to 900cm²
Membrane	CCM - AF3-HWC9-70-X
Anode	10 to 20wt% (in total solids)
Cathode	Aemion® AP3-HNN9-00-X Ionomr 10wt%
Catalyst	DCL International Inc.®
Anode	DCL-anode loaded on 300 µm sintered Ni Felt PTL
Cathode	Pt 40 wt% / C loaded on 200m Carbon Paper GDL

MEA Options For Water Electrolysis

Catalyst Coated Substrate	DCL-CCS: PTL coated with high stability anode and GDL coated with Pt 40 wt% / C cathode catalyst layers
Catalyst Coated Membrane	DCL-CCM: high stability anode and Pt 40 wt% / C cathode catalyst layers coated onto Aemion® Membrane

Performance of DCL-anode

Catalyst Coated Substrate in 1M KOH and 80 °C



To Order

DCL International Inc.® can apply electrocatalyst coatings to Aemion® membranes or porous transport layers (PTL) up to 300mm x 300mm. Contact your DCL® representative for more information or to place an order.



CCMs & CCS Electrodes by DCL®





Thank You