



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

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Senior Research Scientist

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

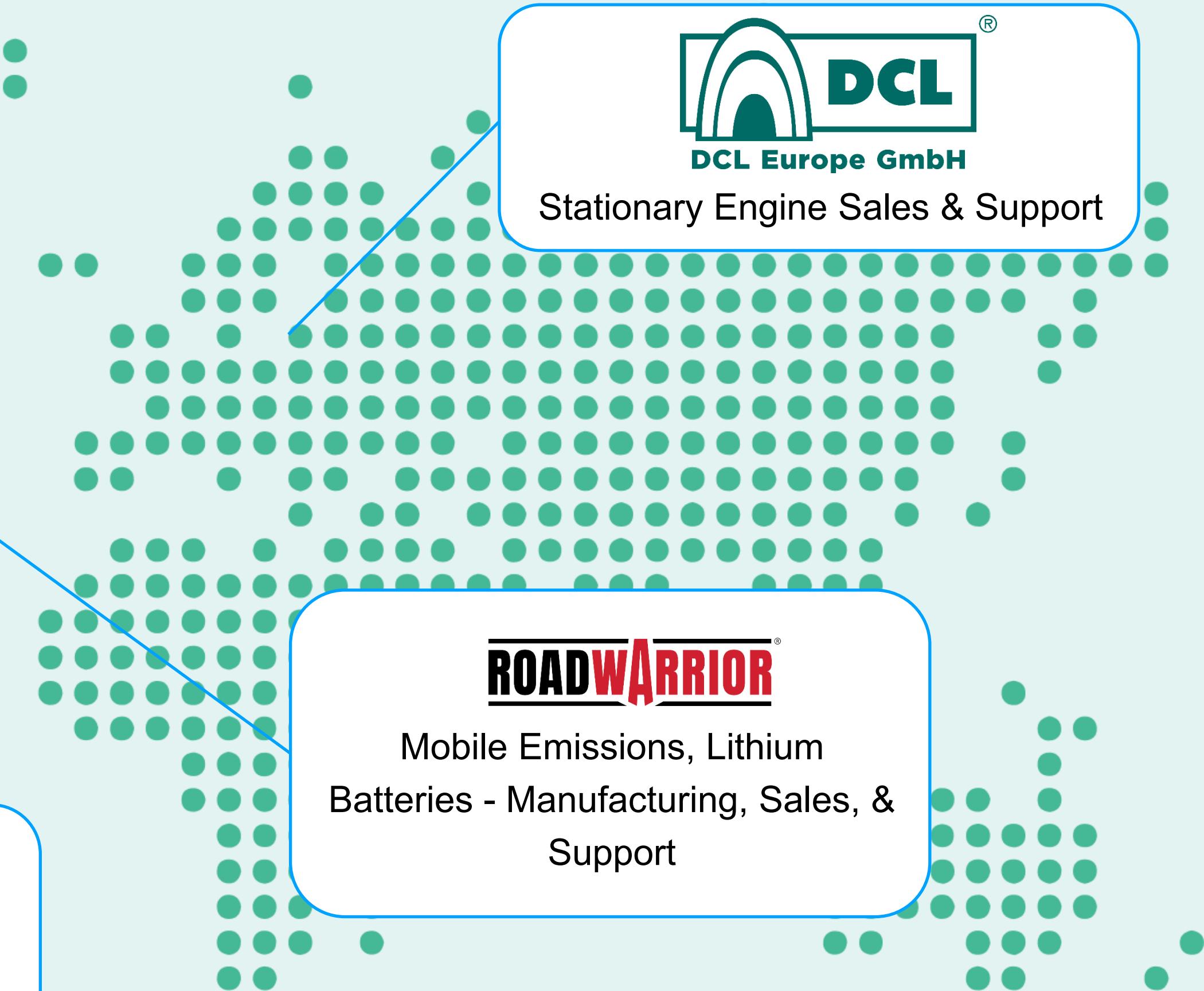
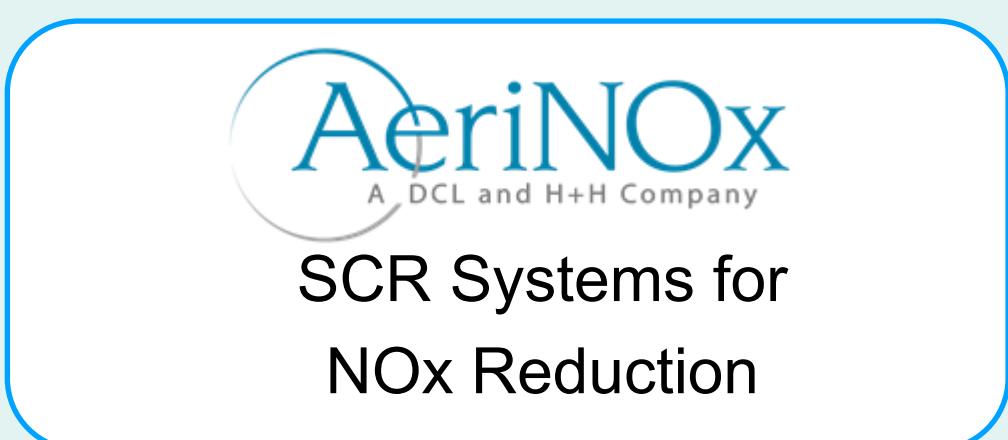


Cogeneration Energy
Efficiency



Biogas Conditioning & RNG
Upgrading

Commitment to the future of our world.



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

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



Decarbonization Solutions

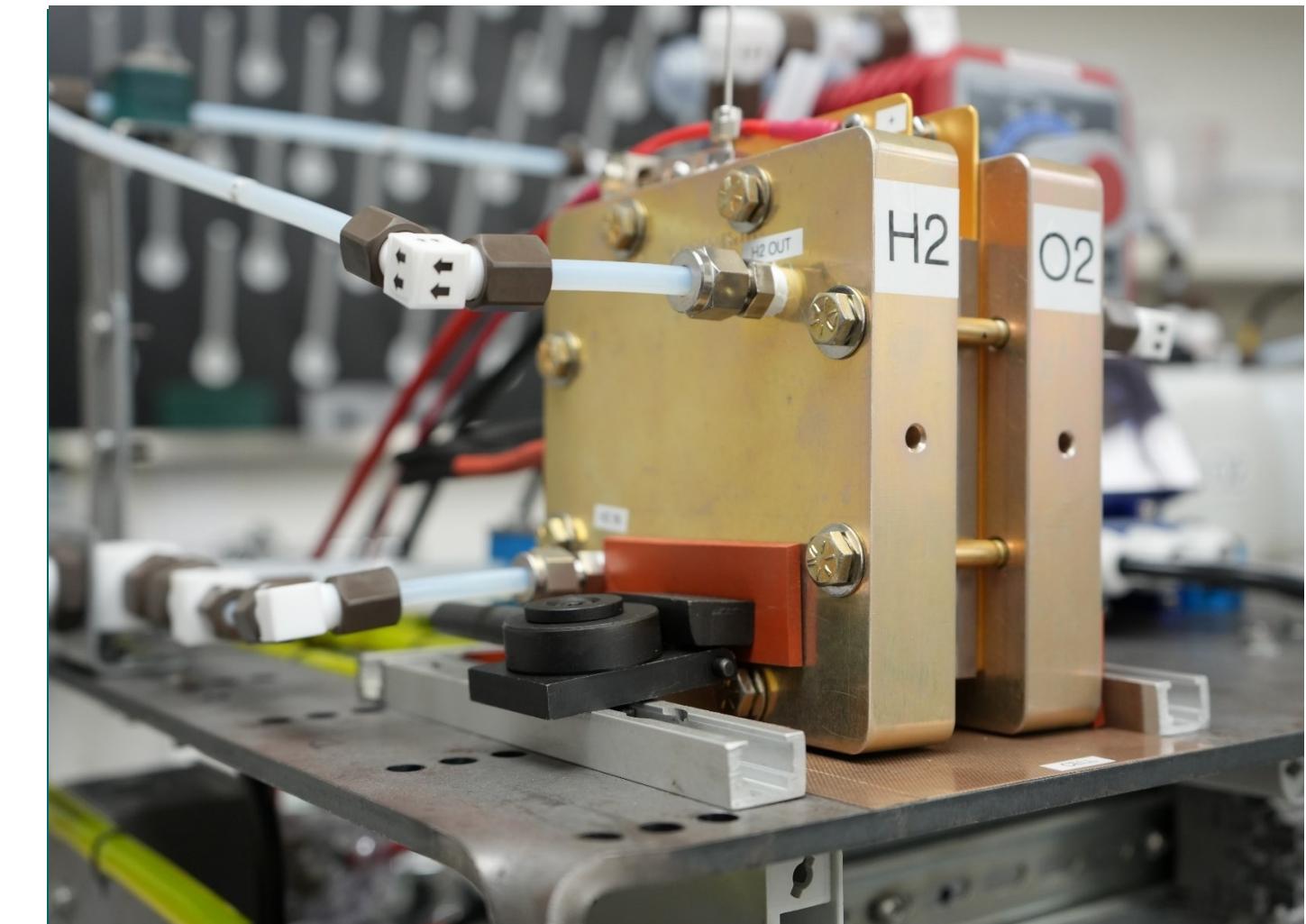
DCL's expertise in designing & manufacturing high-quality components, for maximum efficiency & performance for clean energy applications, including Hydrogen CHP systems.



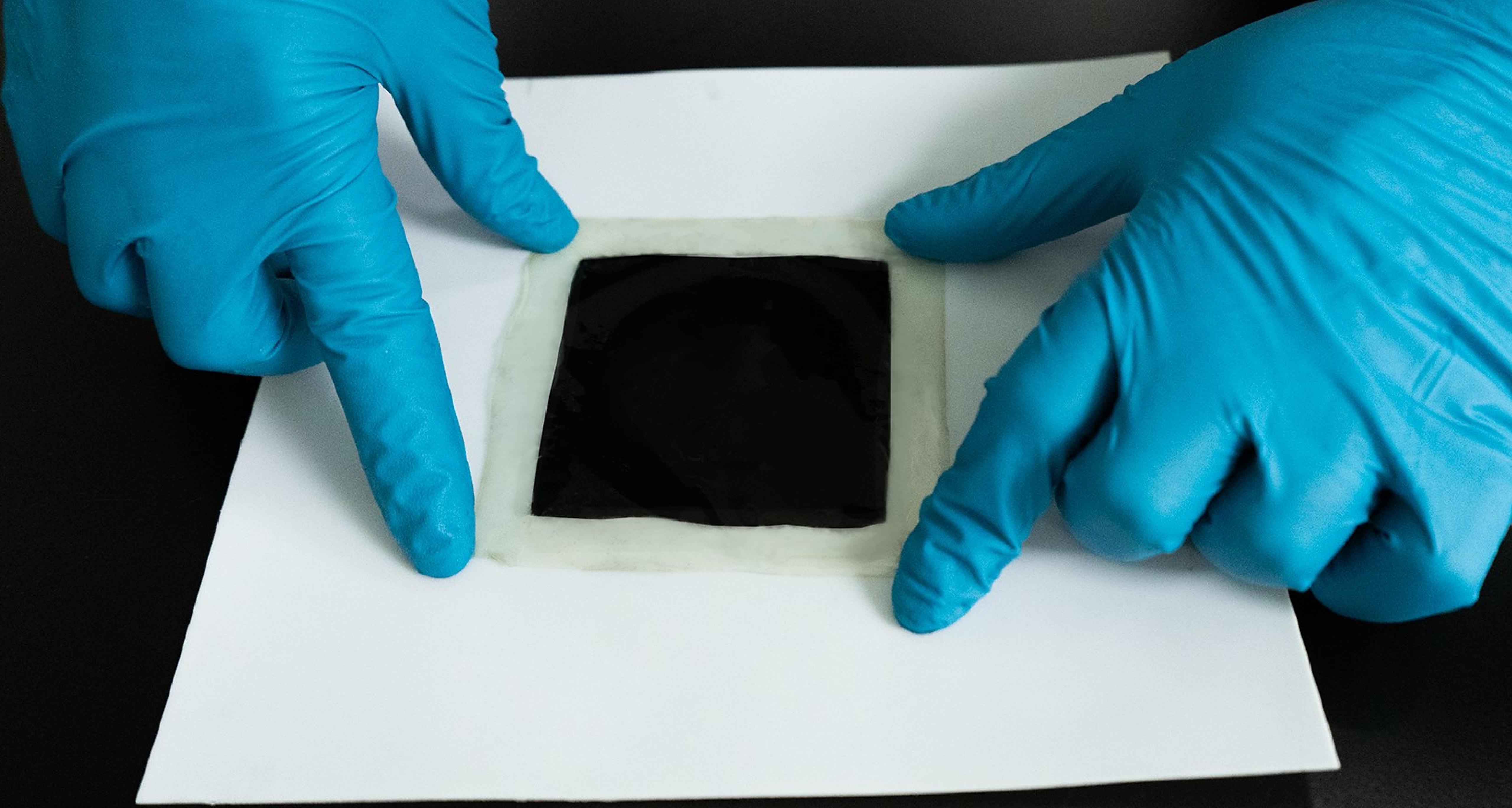
Fuel Cells



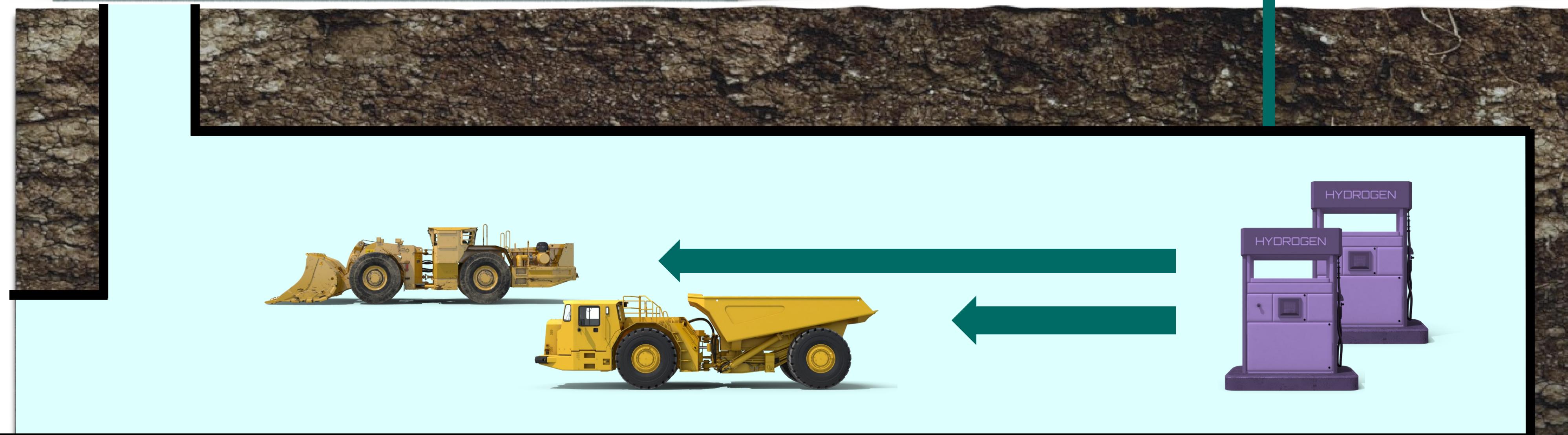
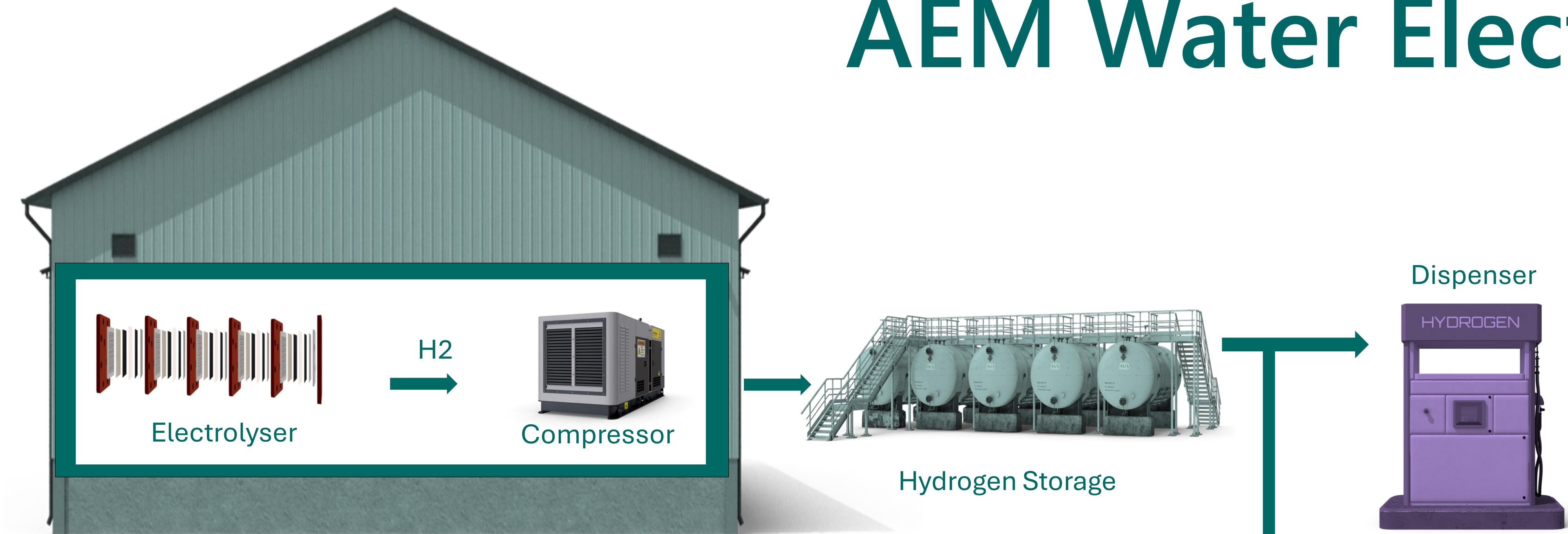
Methane Destruction



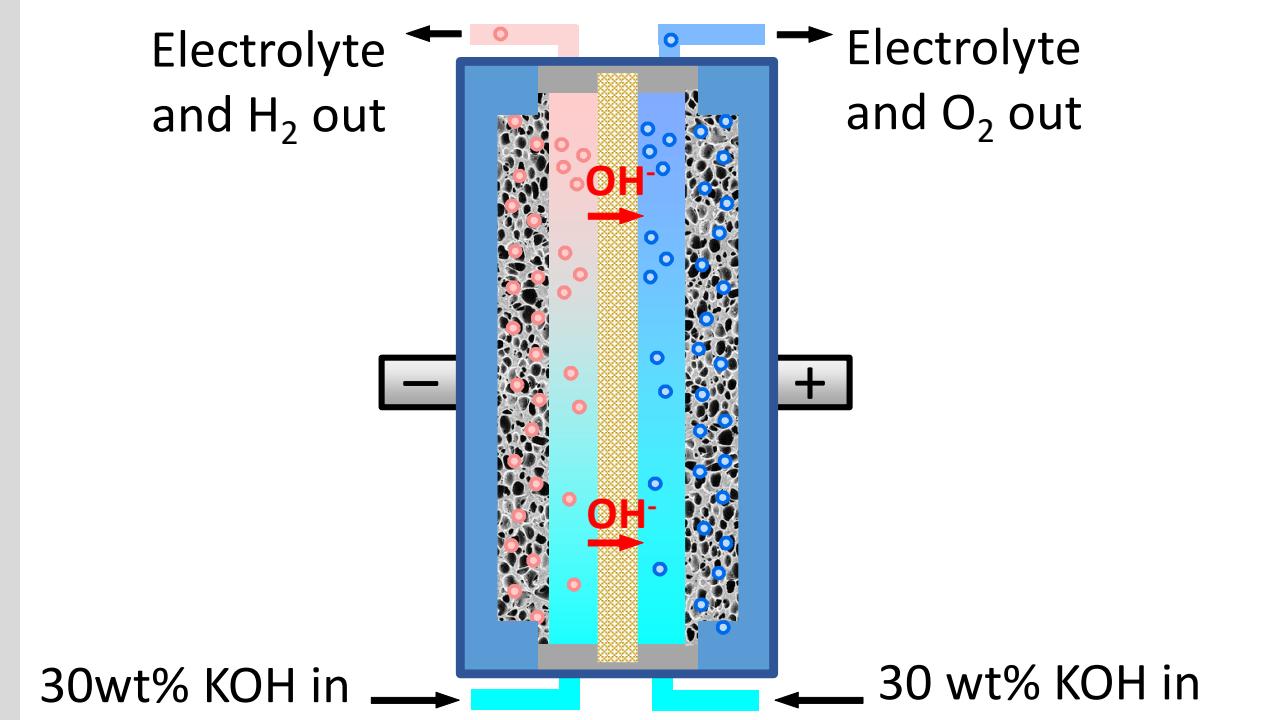
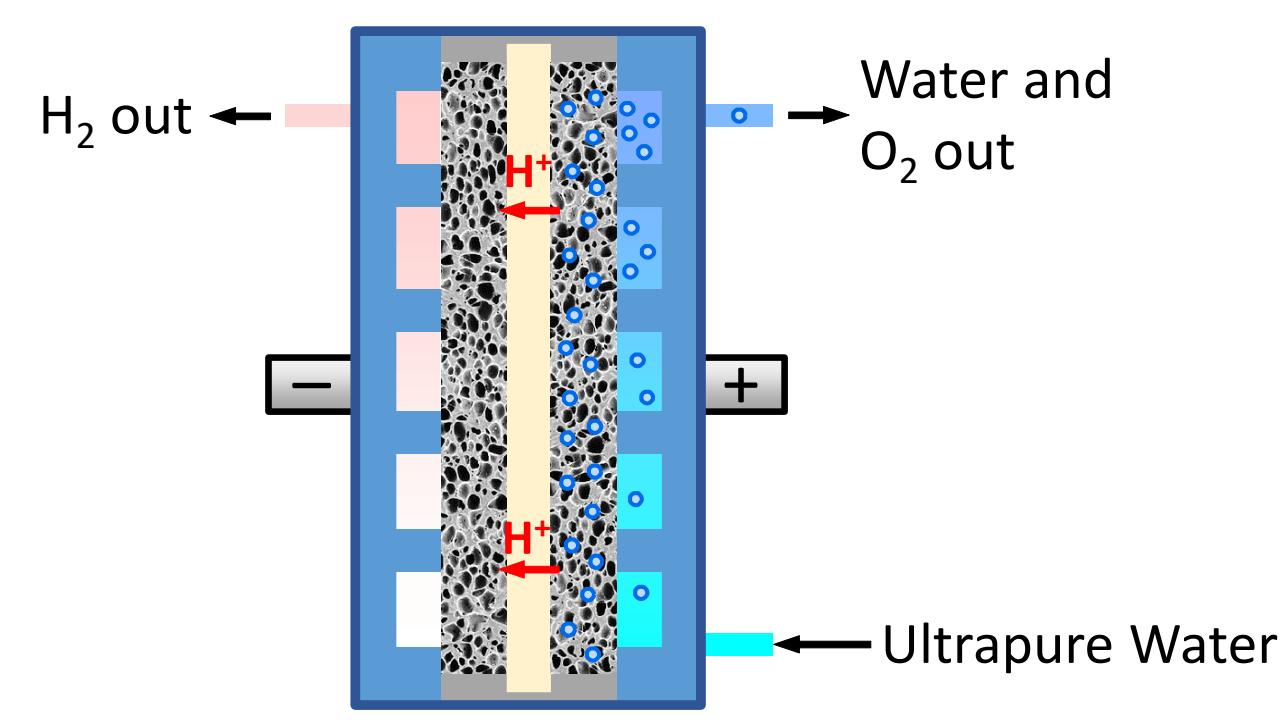
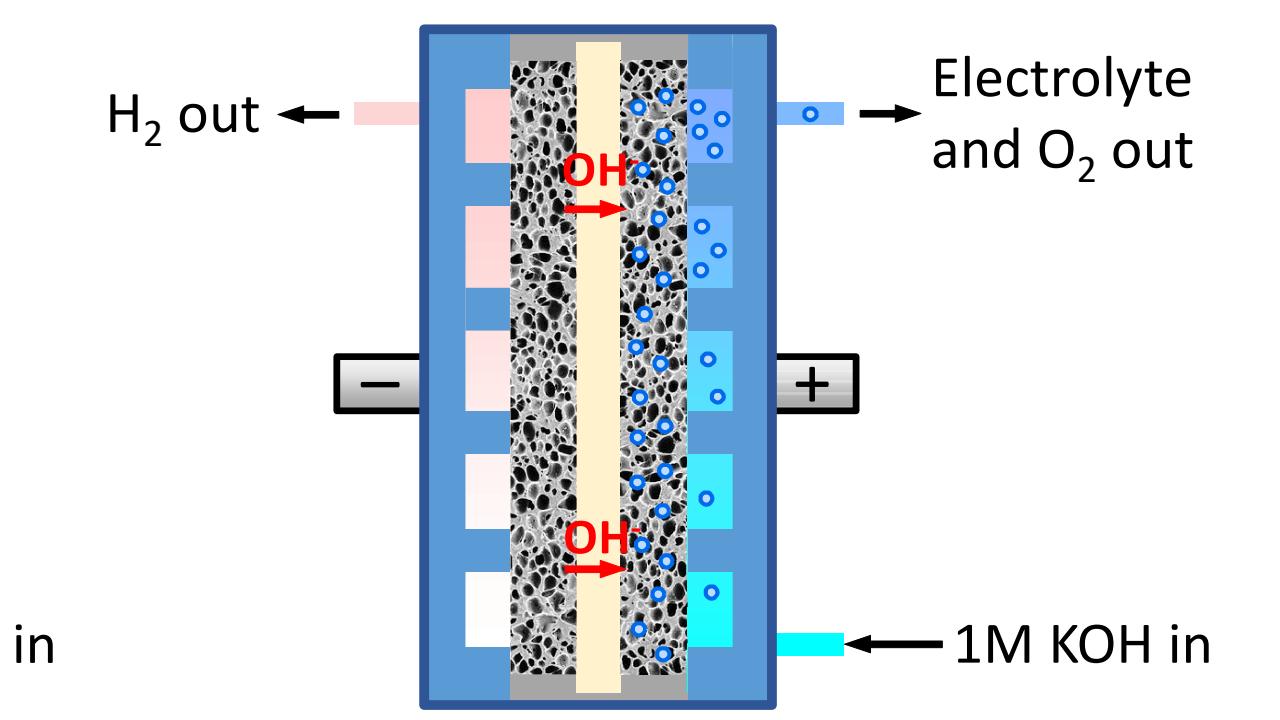
Electrolyzers



AEM Water Electrolyzer



AEM Water Electrolyzer

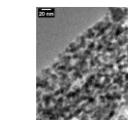
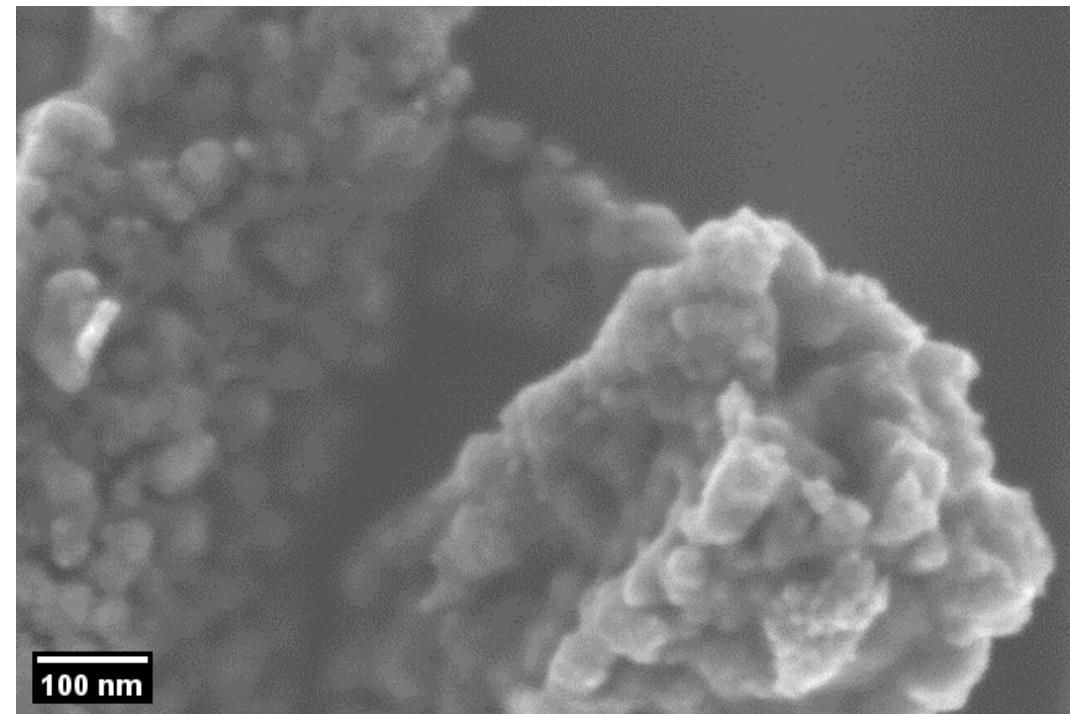
	Alkaline Water Electrolyzer (AWE)	PEM Water Electrolyzer (PEMWE)	AEM Water Electrolyzer (AEMWE)
Concept	Uses a diaphragm as separator	Uses a Proton Exchange Membrane as separator	Uses an Anion Exchange Membrane as separator
Structure			
Process	<ul style="list-style-type: none"> - Non-noble metals as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

Electrocatalyst Formulation

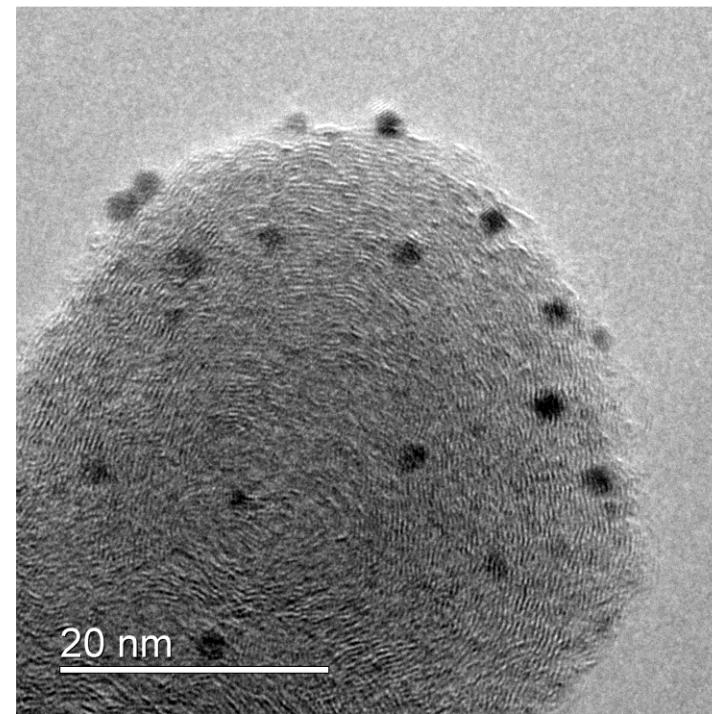
- Scalable catalyst preparation
- Efficient synthesis with low waste
- Wide range of available compositions
- Iron-free catalytic materials



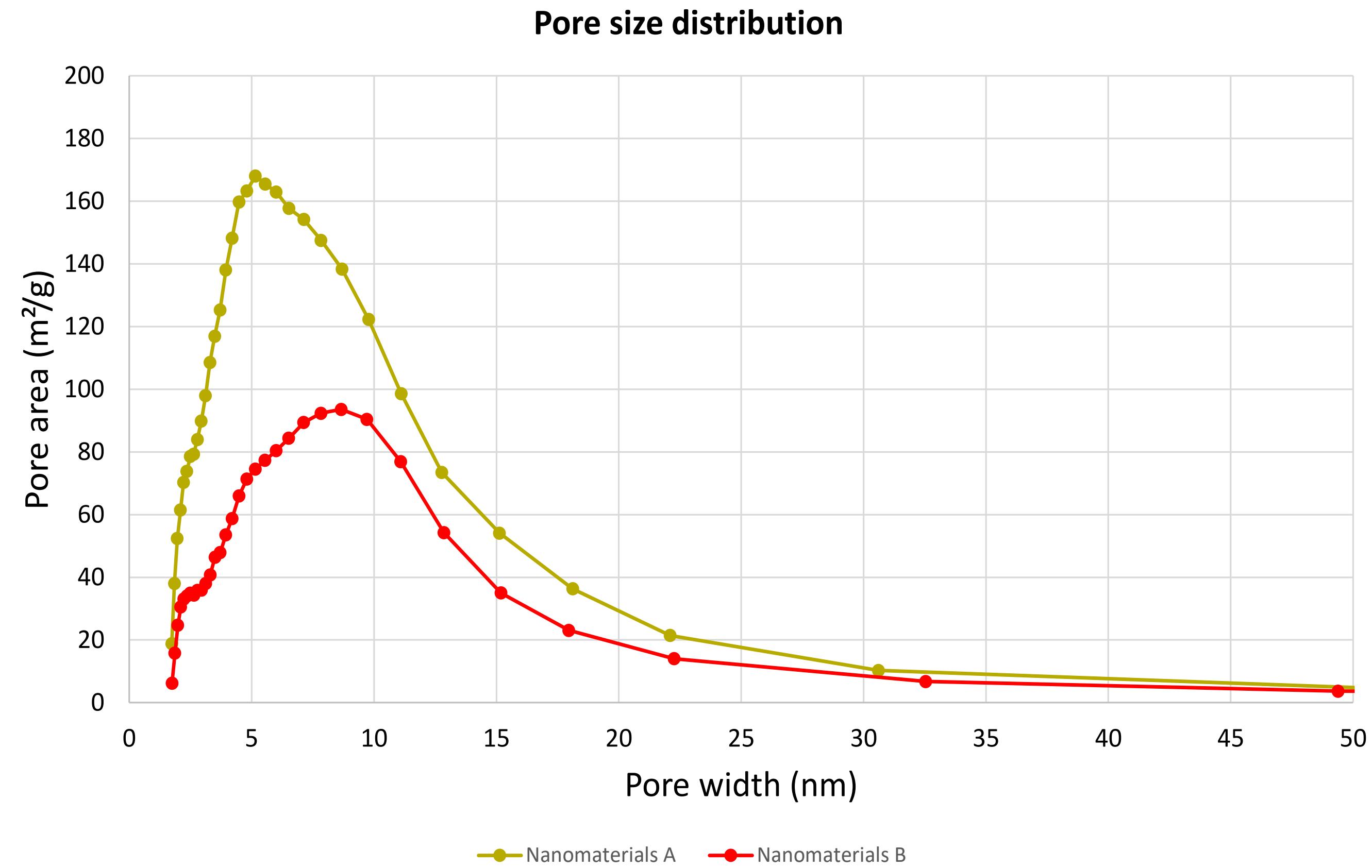
High Surface Area



Nanostructured non-PGM materials with surface area from up to 100 m²/g



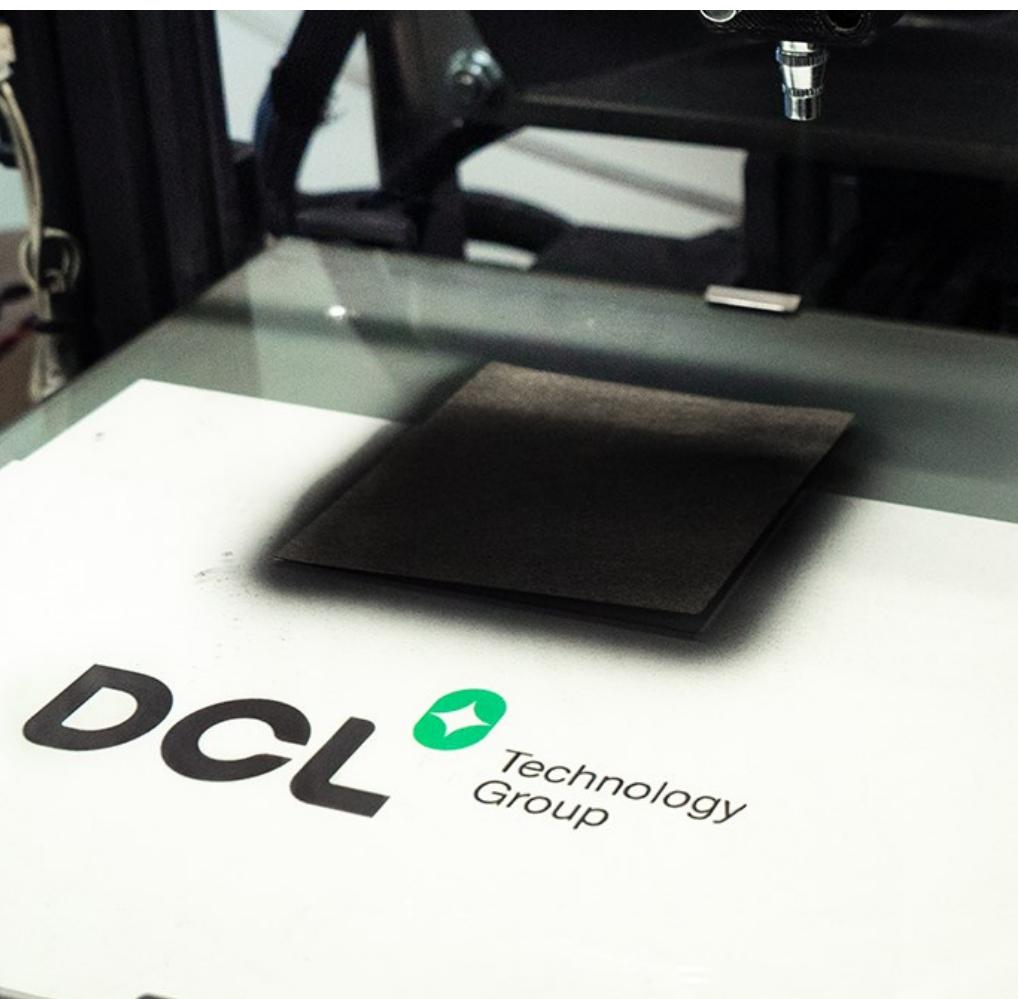
High surface area noble metal alloys for low PGM content cathode



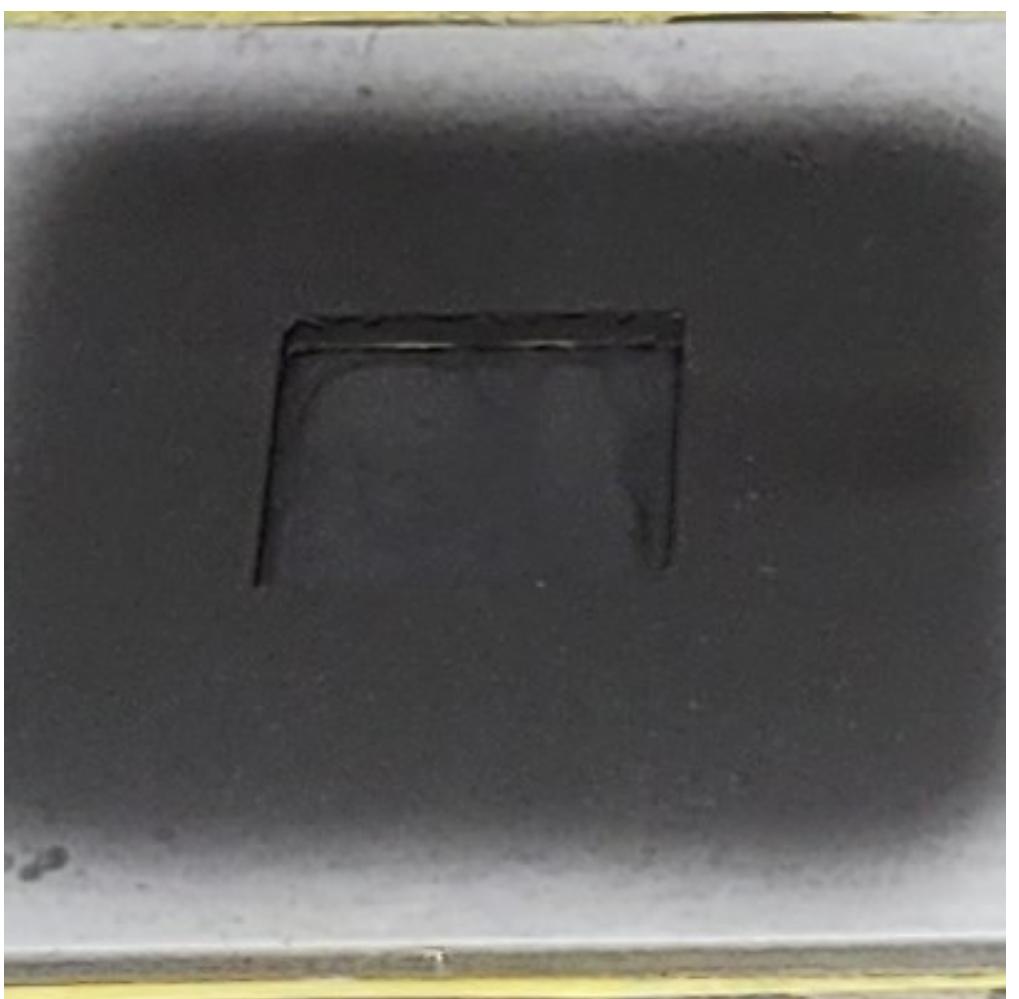
Electrode Coating

Spray coating for CCS and CCM configurations.

Optimized formulations of anodes and cathodes adapted to different substrates.



CCS Coating



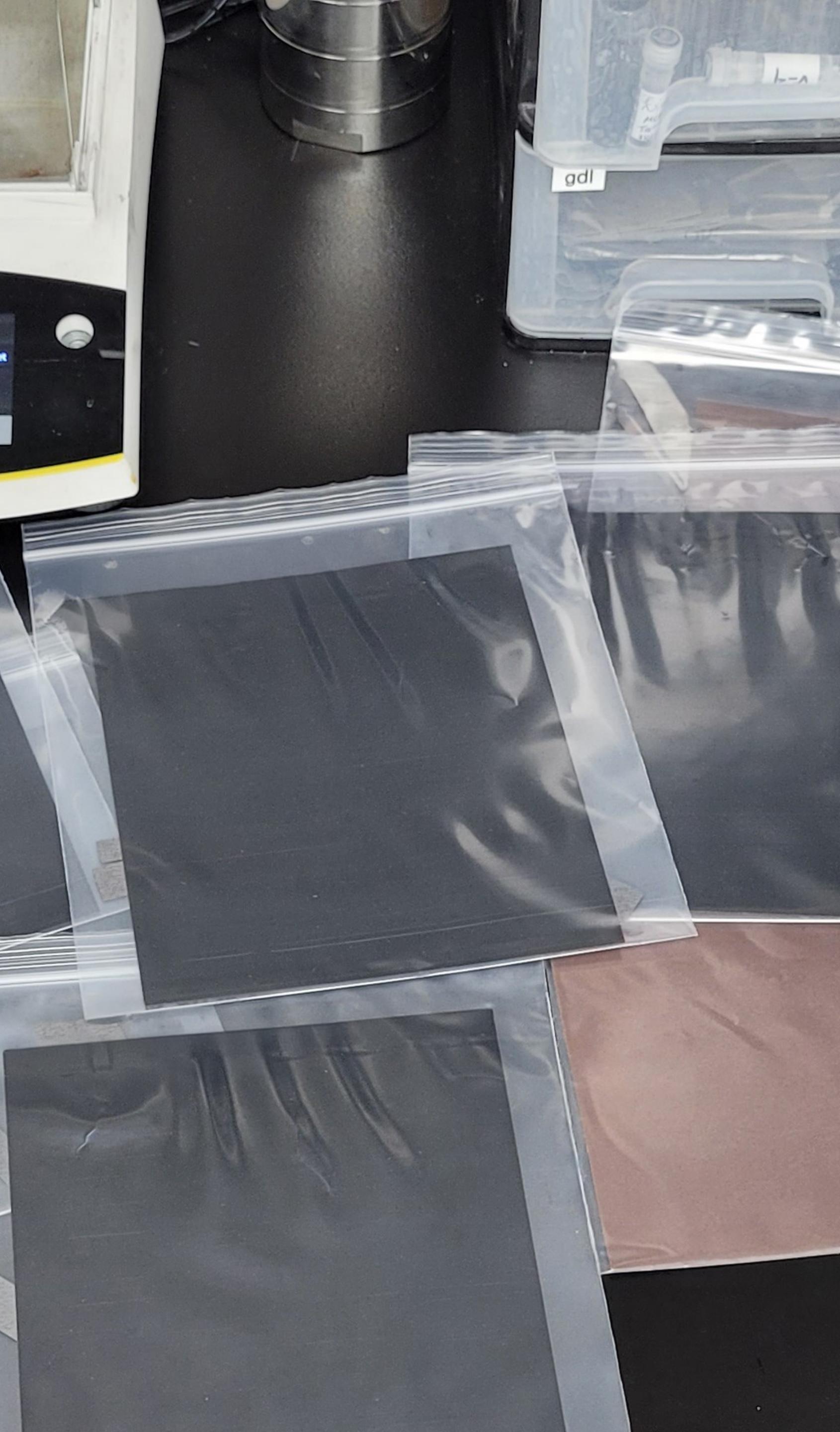
CCM Coating



CCS Coating

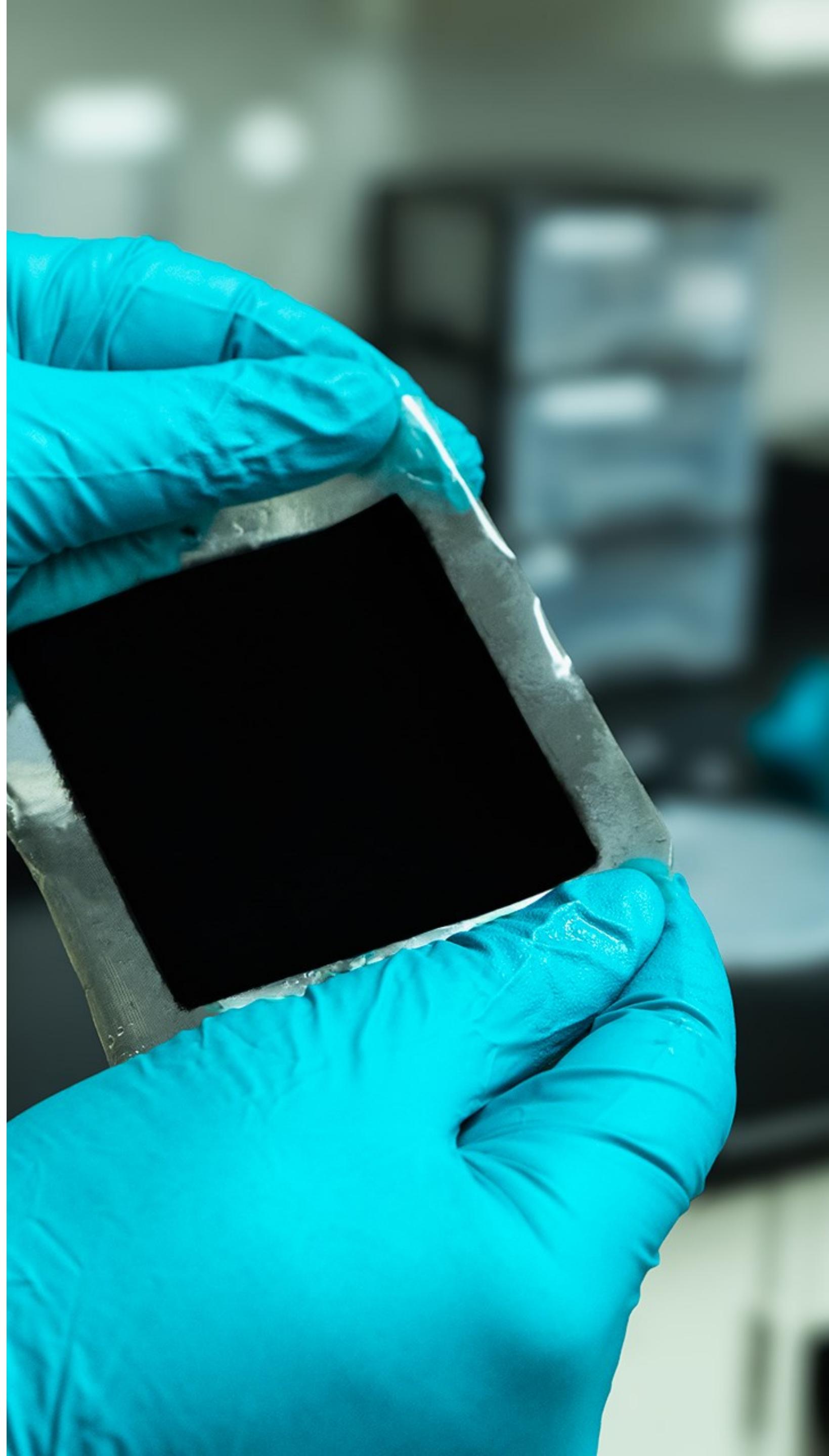
Coatings adapted for a variety of substrates

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



CCM Coating

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

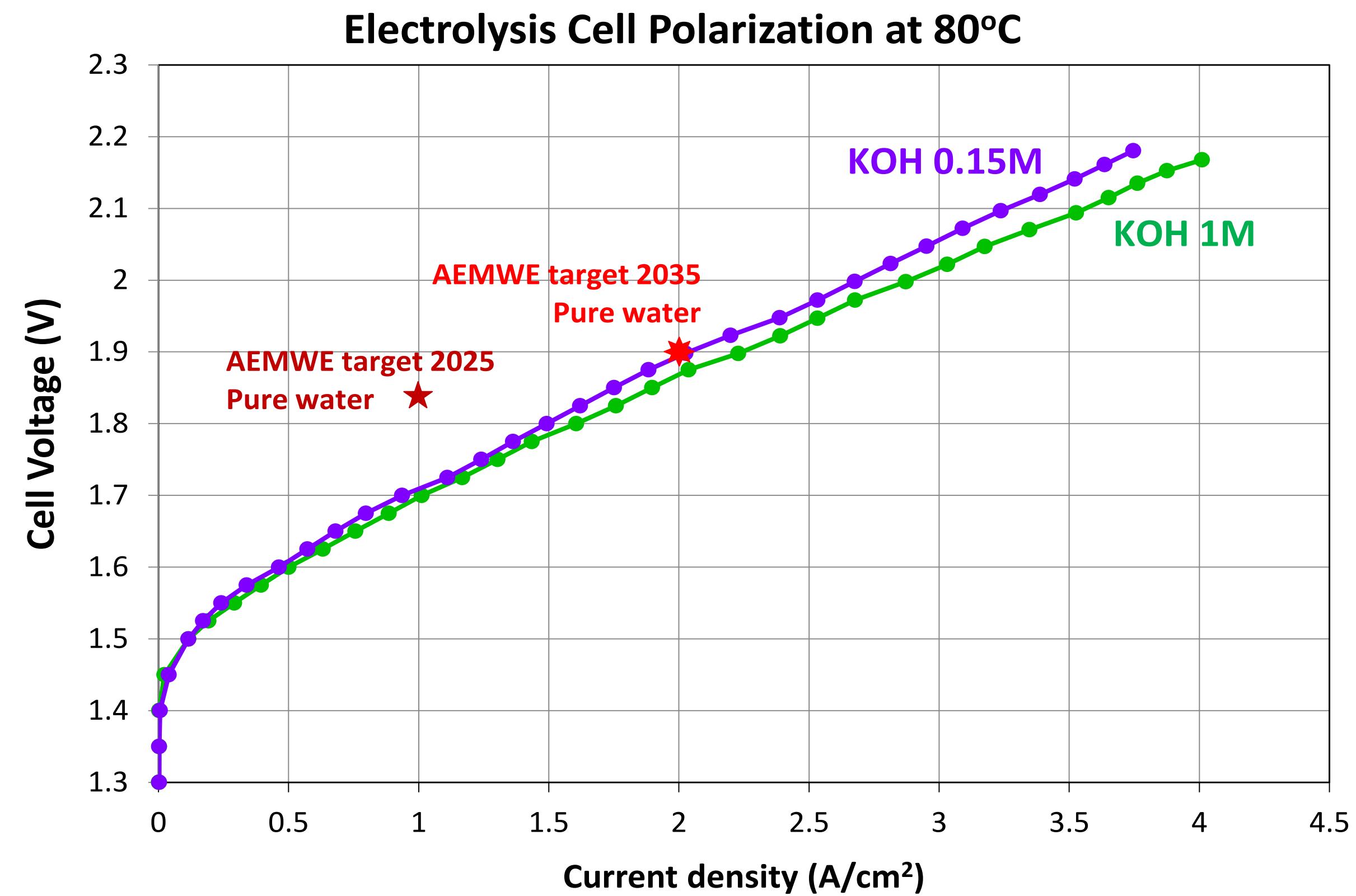


Electrode and membrane coating options

- 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).

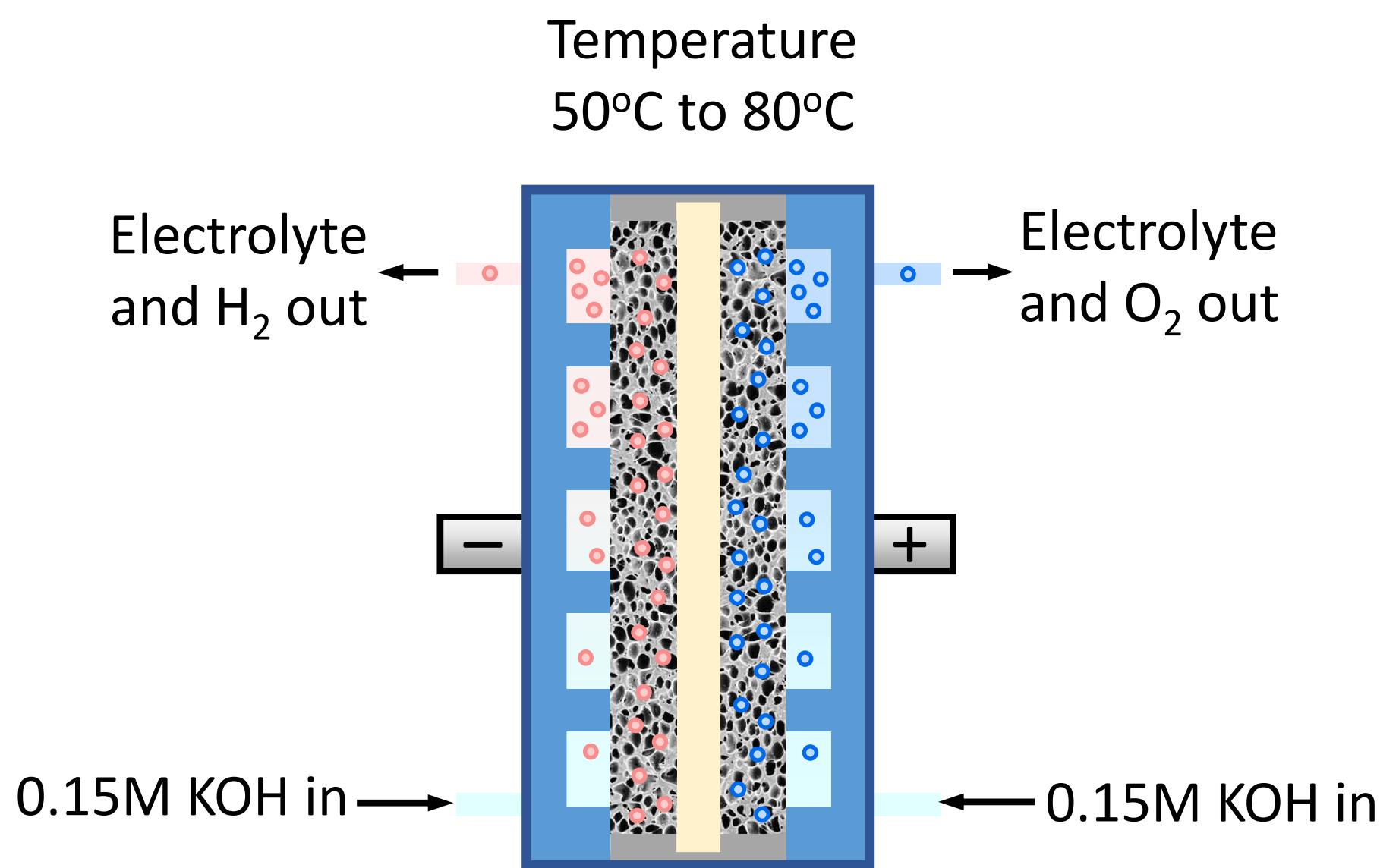


Optimization of electrodes and membrane/electrode interface



Operation in mild conditions

- Diluted electrolyte
- Low temperature



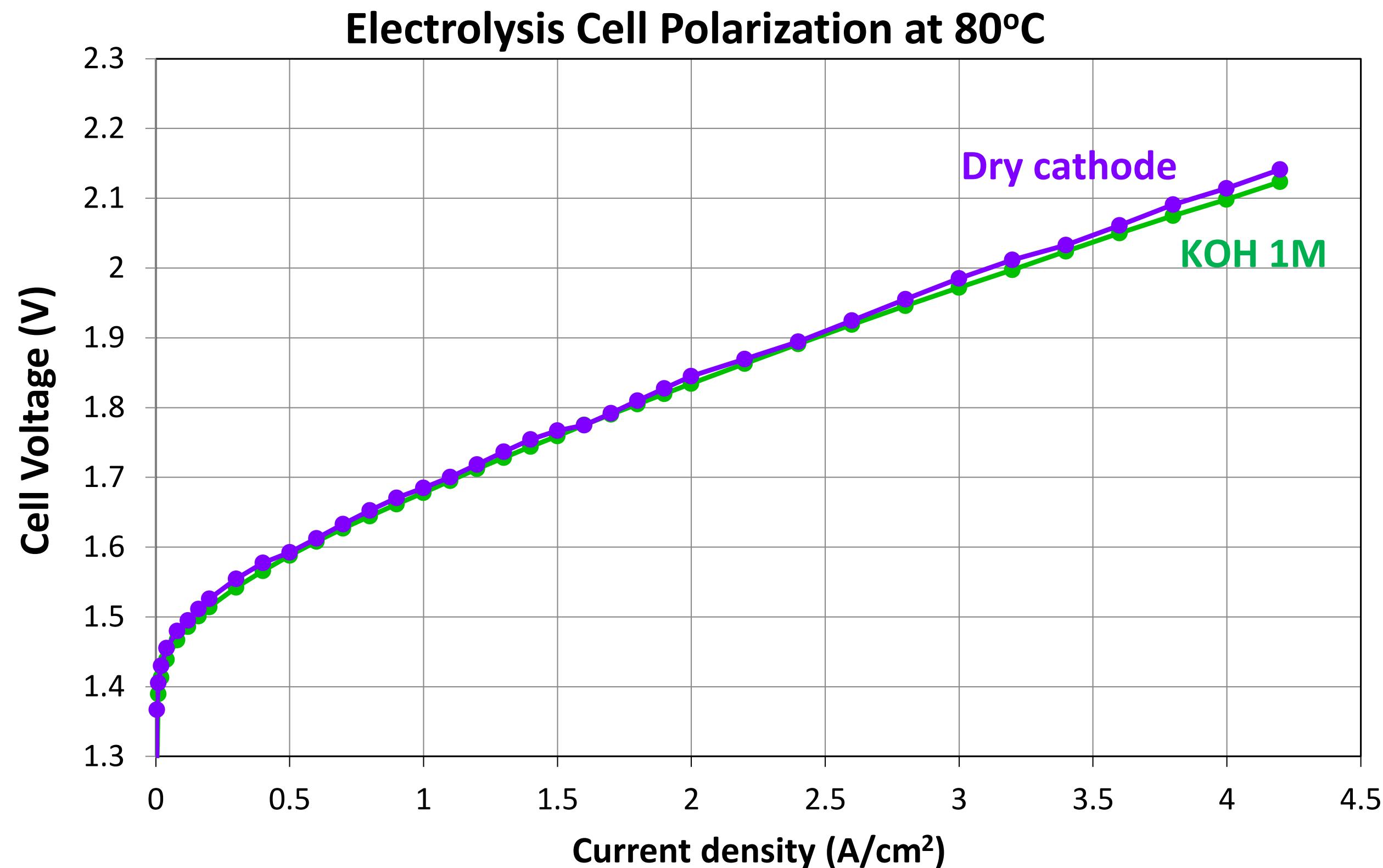
DOE targets

Hydrogen Production Cost and Performance Analysis.

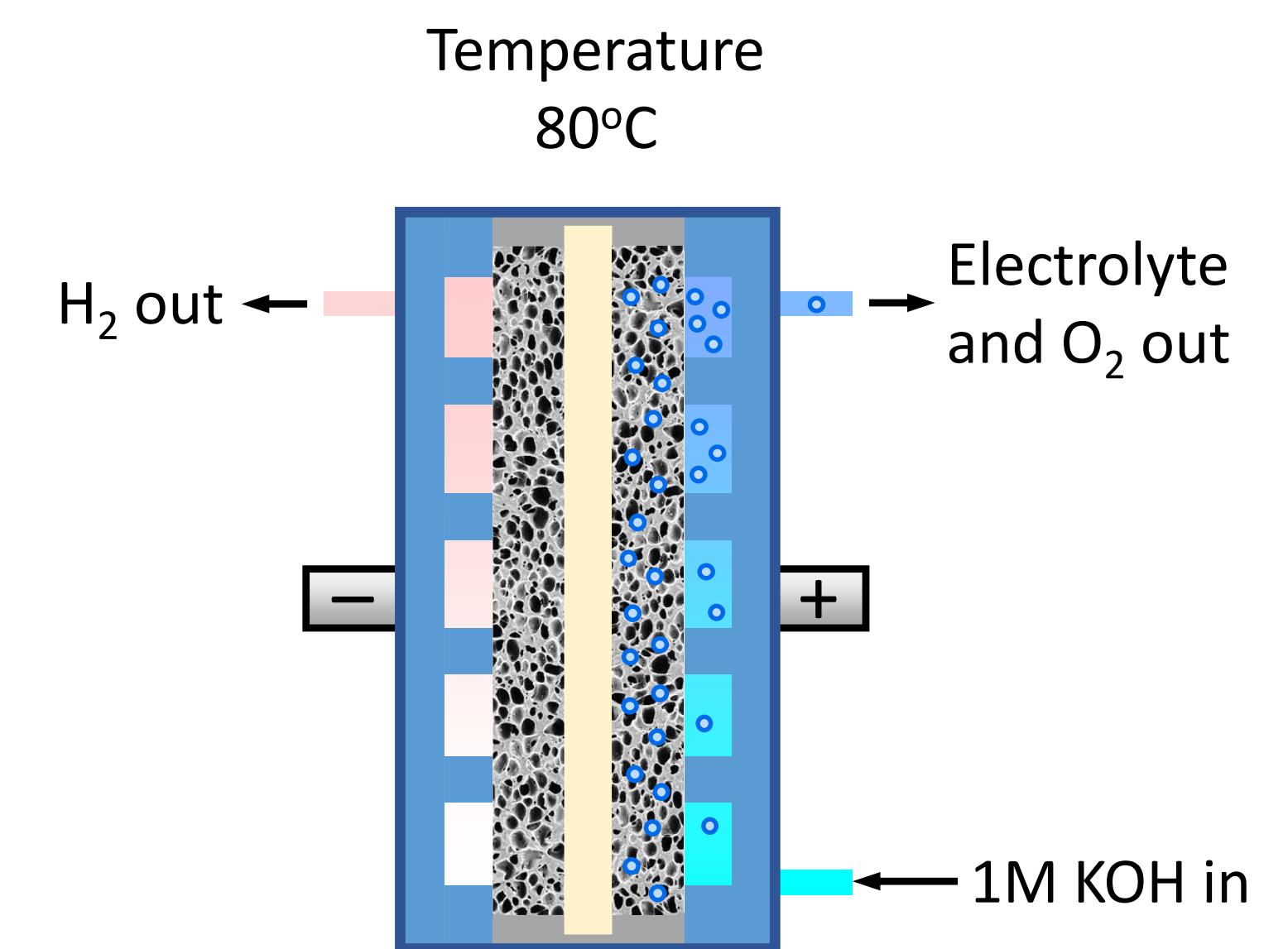
DOE Hydrogen Program, 2022 Annual Merit Review and Peer Evaluation Meeting.



Optimization of electrodes and membrane/electrode interface

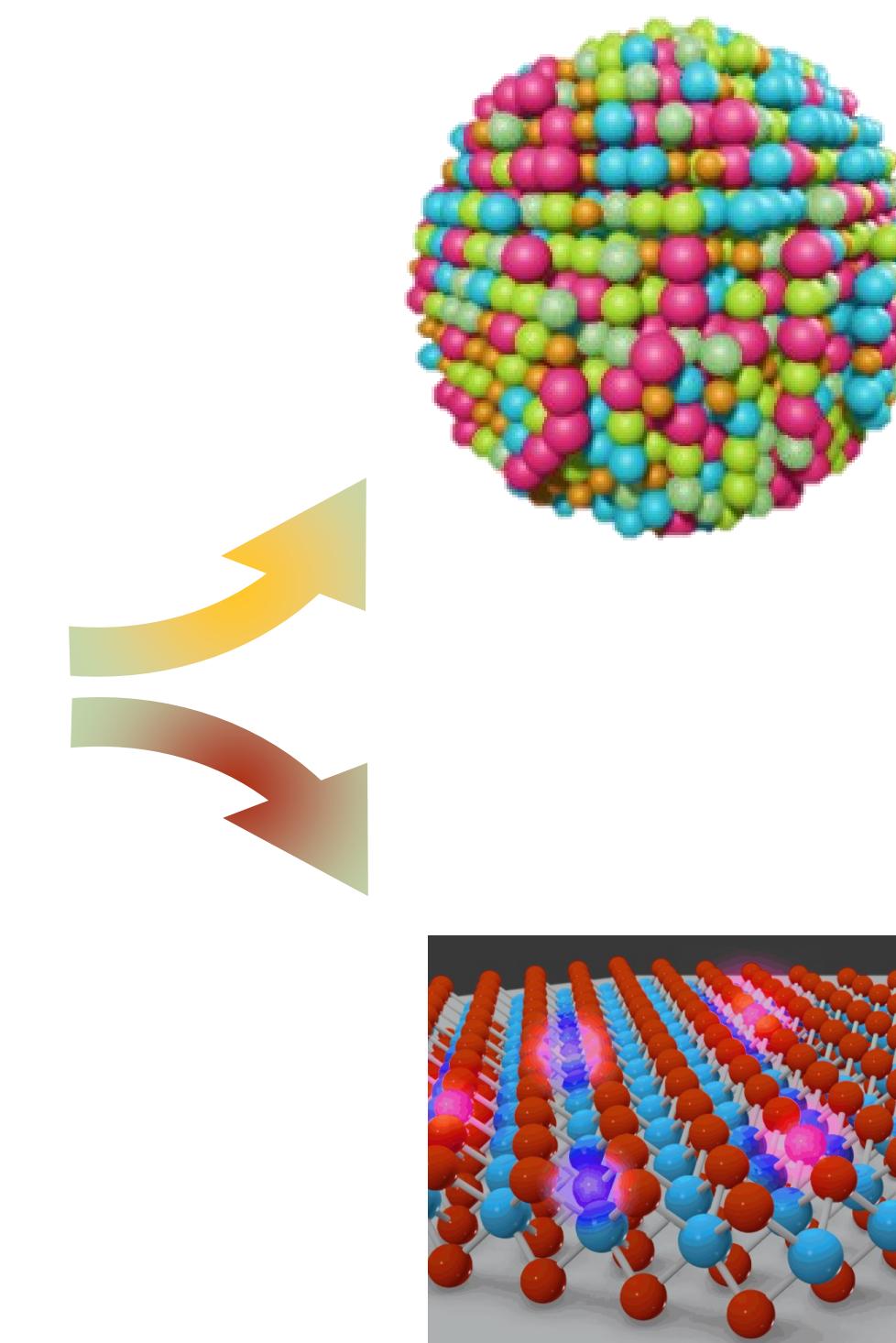
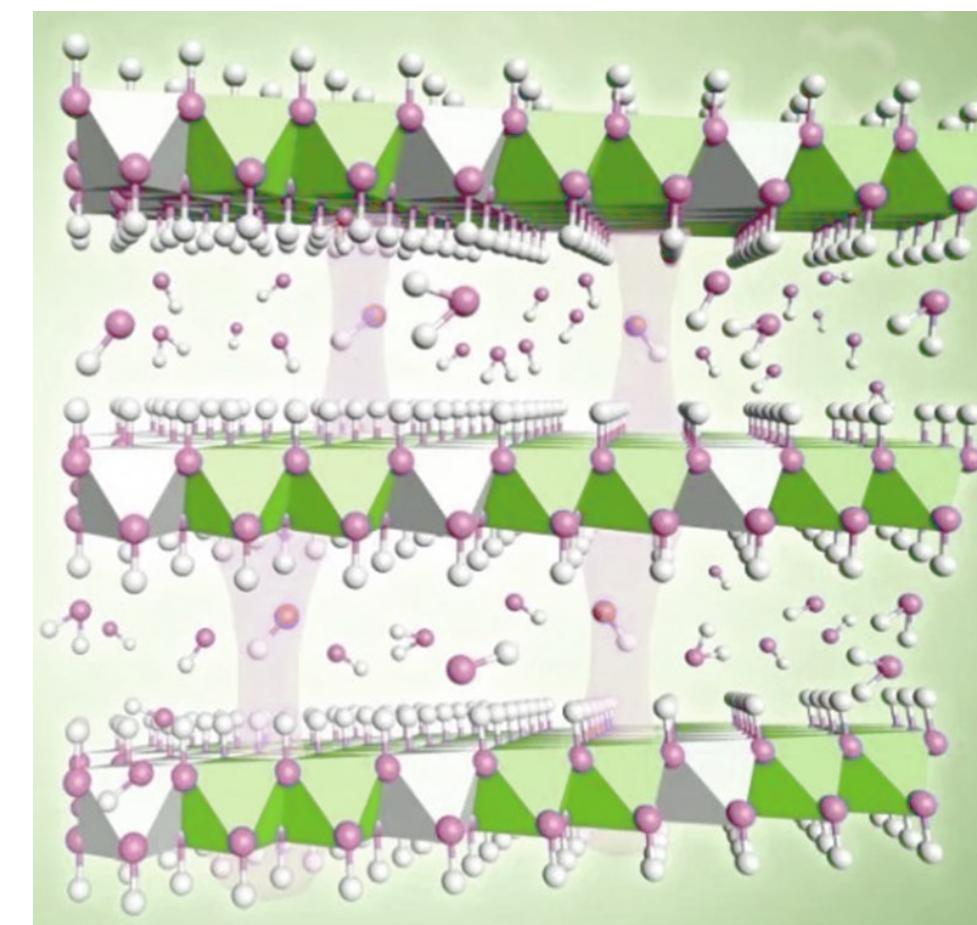


Operation without electrolyte circulation
in the cathode compartment



High Activity, High Stability Anodes

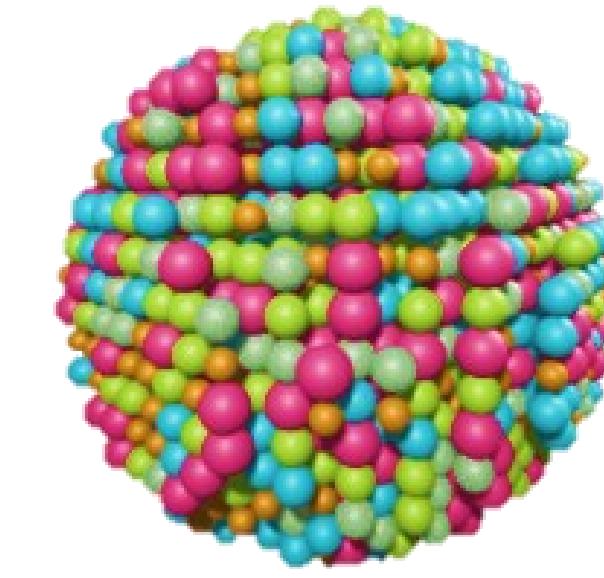
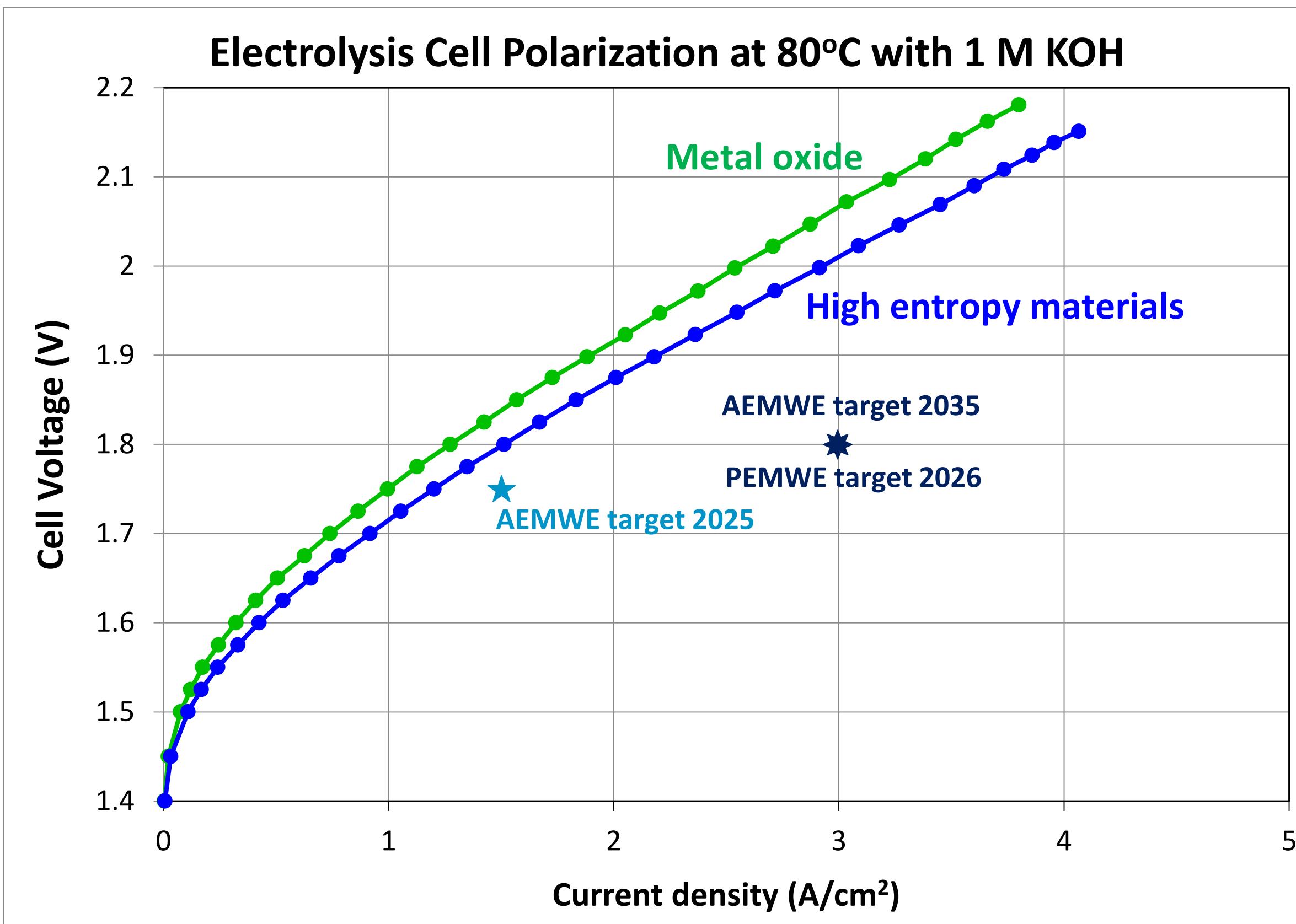
High stability
non-PGM
oxide/hydroxide



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.

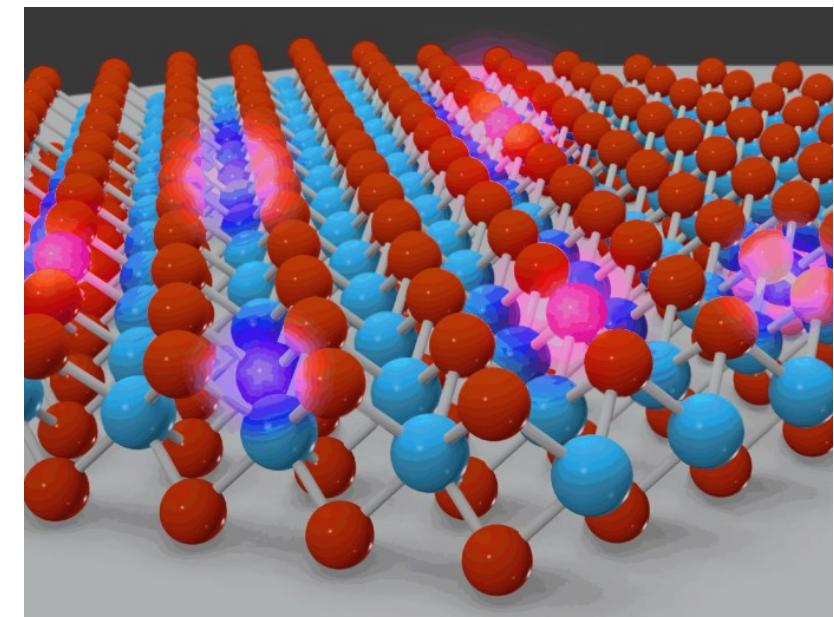
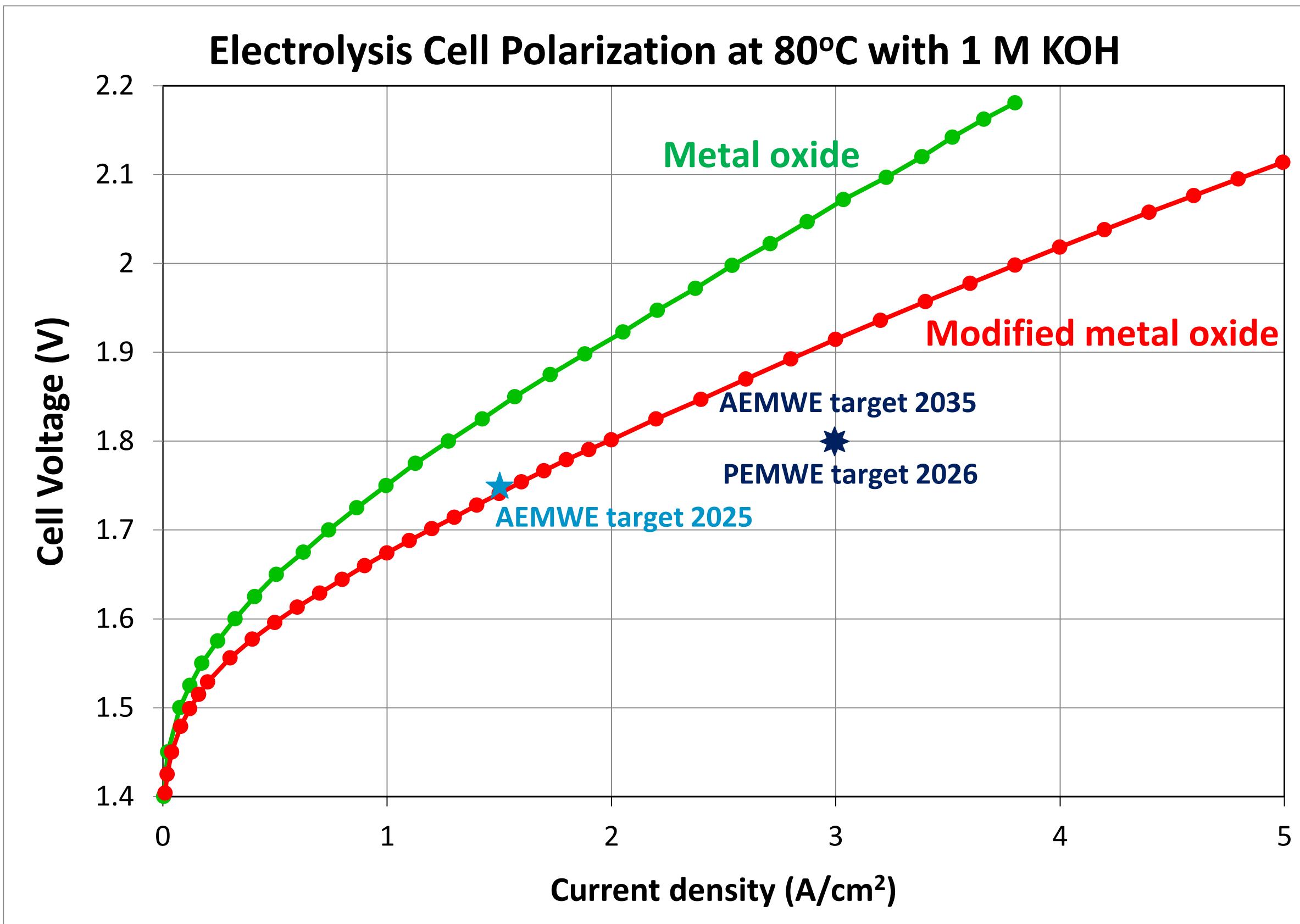
Hydrogen Production Cost and Performance Analysis.

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.

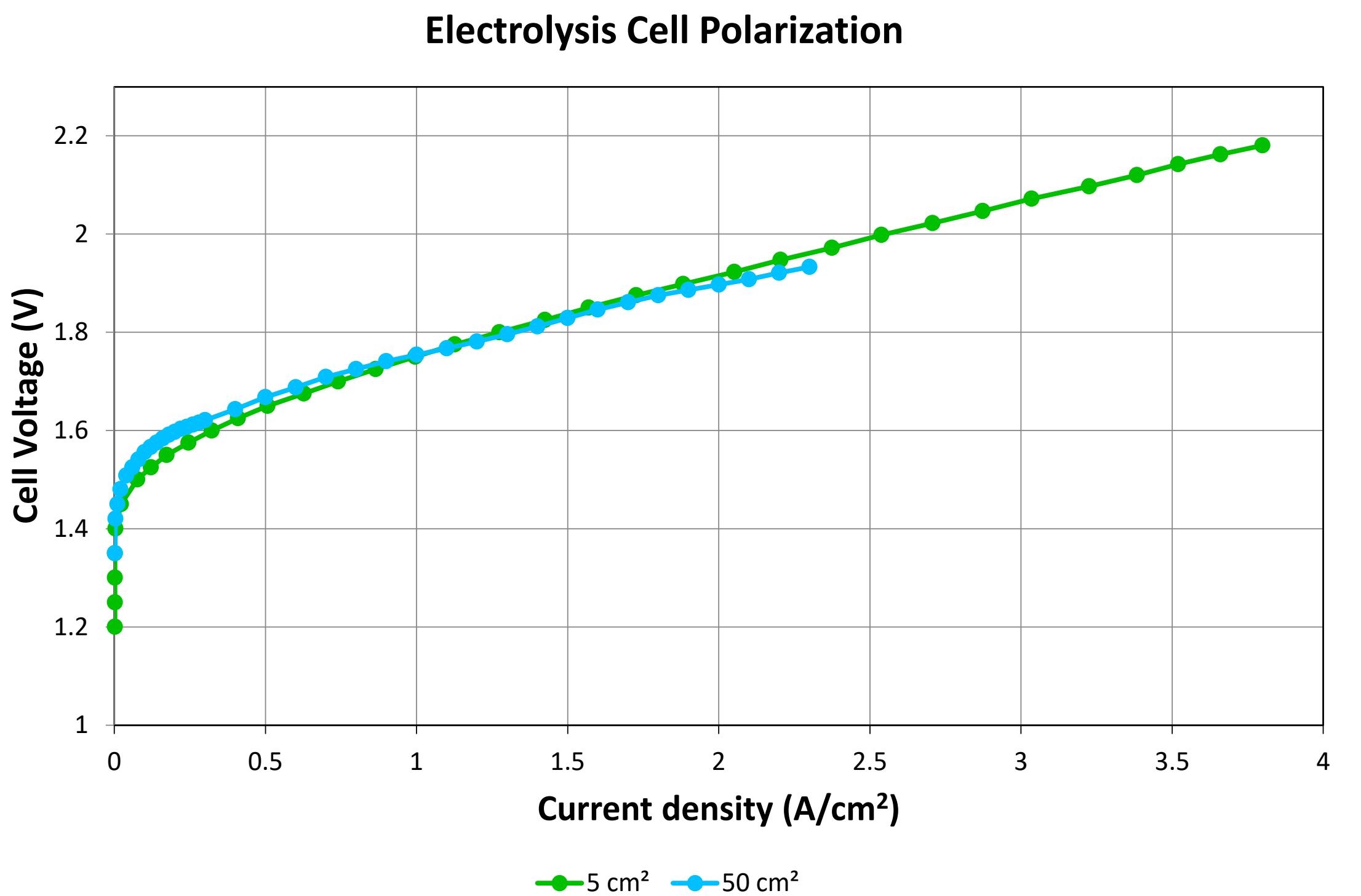
DOE Hydrogen Program, 2022 Annual Merit Review and Peer Evaluation Meeting.



Picture:

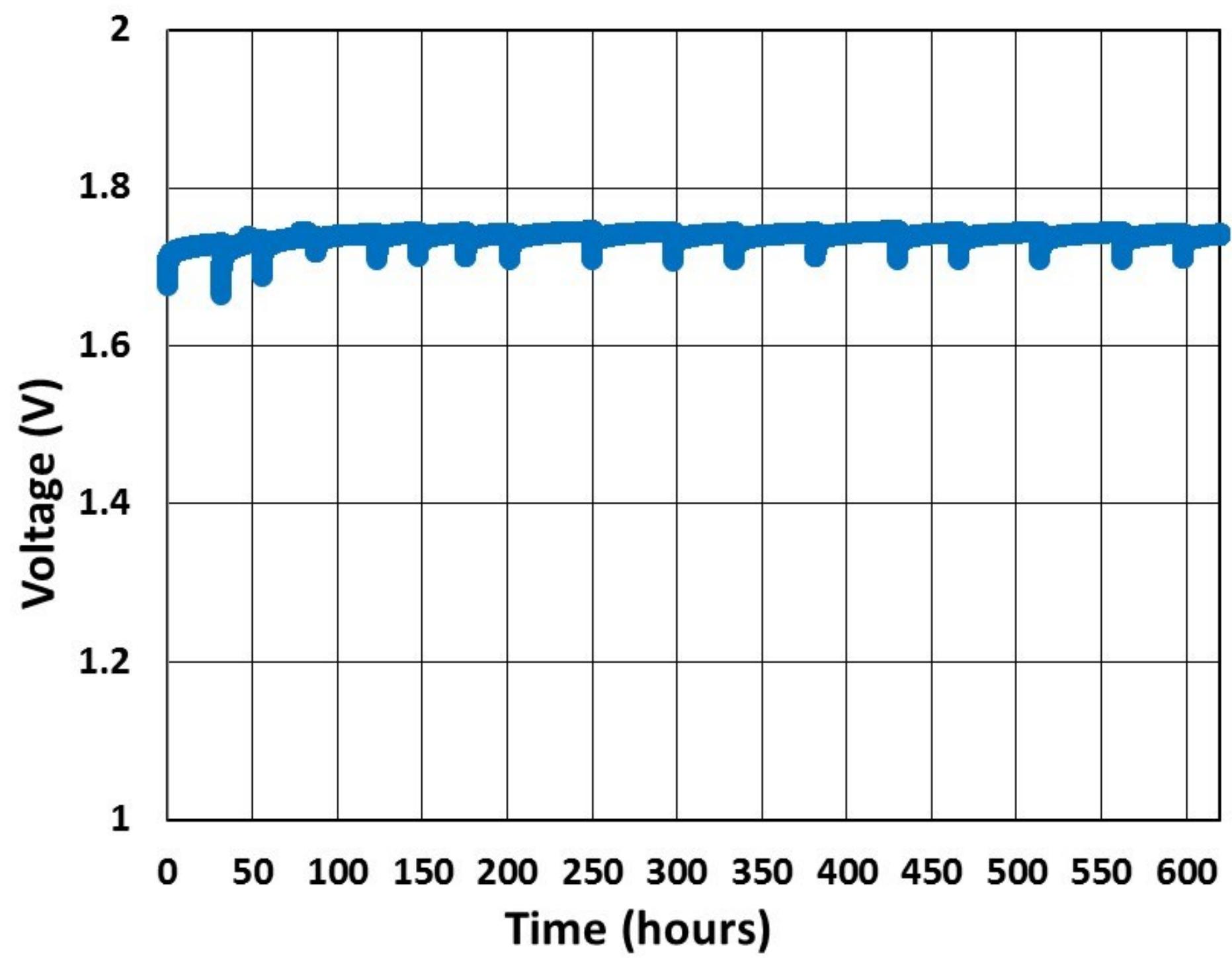
L. Loh, Z. Zhang, M. Bosman, G. Eda, *Nano Res.* 14 (2021) 1668–1681

High stability system



50cm² cell demonstrated good initial stability.
Long-term stability tests in progress.

Chronovoltammetry at $1\text{ A}/\text{cm}^2$



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®

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 Ionomer 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

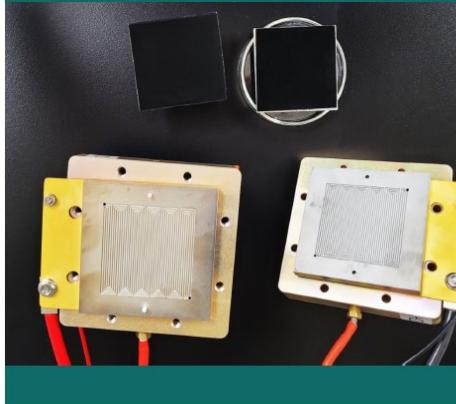


High Efficiency Technology ideal for AEM electrolyzers, renewable energy storage, industrial processes, fuel cell technology.

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.



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

Water Electrolysis Electrodes

Active area	5cm ² to 900cm ²
Membrane	CCM - AF3-HWC9-70-X
Anode	10 to 20wt% (in total solids)
Cathode	Aemion® AP3-HNN9-00-X Ionomer 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

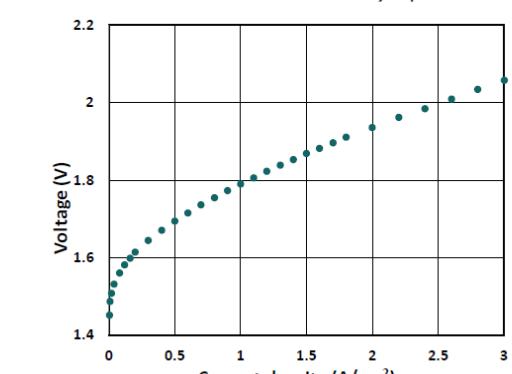
MEA Options For Water Electrolysis

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

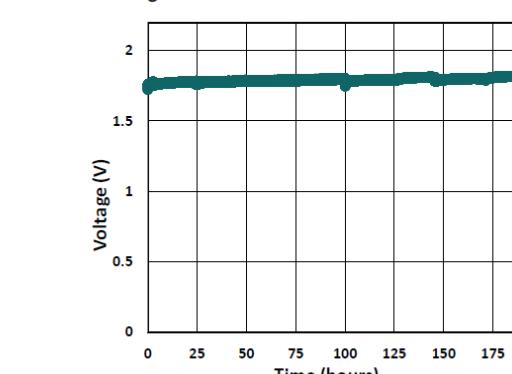
Performance of DCL-anode

Catalyst Coated Substrate in 1M KOH and 80 °C

Polarization curve after 7 day operation.



Voltage at constant 1 A/cm² for 200 hours.



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.

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Thank You