The Electrochemical Processing and Electrocatalysis (EPEC) Lab

A team of researchers working to understand novel materials in the EPEC lab.

Idaho National Laboratory established a world-class program in electrochemical reactions at elevated temperatures using unique solid oxide electrochemical cells and membrane reactors. Elevated temperatures, from 350 to 650 Celsius, drive electrochemical process efficiency.

One of the biggest electrochemical processes using these solid oxide cells is breaking water apart for hydrogen production. Hydrogen holds promise as a near-zero-carbon-emission fuel. It could be game changing, particularly in transportation and manufacturing.

The primary research interests of the EPEC lab include developing new strategies, novel materials and structures, and unique processes for manufacturing. Their efforts will facilitate efficient and cost-effective chemical and energy transformation. Additionally, this program focuses on understanding material structure, composition, morphology and defects. This understanding in turn informs knowledge of electrochemical properties of ionic and electronic conductors.

EPEC FUNCTIONS

The lab helps researchers discover better ways to convert inexpensive materials to higher value chemicals, fuels and hydrogen. They also investigate techniques to apply these processes on a larger scale, while keeping energy usage and carbon emissions low.

The lab can fabricate cells ranging in size from small buttons for fundamental study, single cell units (10 x 10 cm_2), to short stacks, which are the industrial standard, for prototype demonstrations. INL also offers high-temperature electrolysis test facilities at different scales, providing fast feedback for manufacturing and operation optimization.

The research team is capable of not only transferring scientific knowledge to applied technologies by themselves but also bridging the gaps between academia and industry. They promptly adopt innovations of materials and structures developed by the former and provide scaling-up experience and recommendations to the latter.

Idaho National Laboratory

An EPEC researcher examines a sample up close.

This team has demonstrated a series of processes with high yield and efficiency including:

- Hydrogen production via water electrolysis (from materials design through scale-up)
- Chemicals and fuels production via low-temperature alkane activation
- Carbon dioxide capture using a hybrid-electrolyte membrane-electrode assembly
- Carbon dioxide conversion via electrolysis or co-electrolysis
- Ammonia electrosynthesis (for fertilizers or energy carriers)
- Solid oxide fuel cells and direct carbon fuel cells (for power generation)

EPEC projects leverage unique capabilities, outlined below.

High Temperature Roll-to-Roll Manufacturing

This capability allows the EPEC team to fabricate systems in all cell sizes. It bridges gaps between fundamental research and industrial deployment by guiding scale-up.

Solid Oxide Additive Manufacturing

This capability consists of a tape casting process to make an electrode support that serves as the substrate for layer-by-layer cell coatings. A continuous inkjet printing process is applied to coat the functional layer, electrolyte layer and subsequent electrode layer. The unique coating technology can facilitate an electrode's surface modification via catalyst coating, enhancing its performance and lifetime.

High Throughput Material Testing

INL offers more than 30 electrochemical testing stands for button cells, and six testing kilns for single unit cells. All are equipped with multichannel testing fixture reactors to meet requirements. These tools are powerful for quick materials screening and selection, enabling prompt material and catalyst research and development.

Advanced Synthesis and Bulk Supply of Powders

This capability synthesizes raw oxide powders and achieves controlled particle size, distribution and morphology for desired properties. Bench-scale to production-scale facilities enable the bulk supply of these powders in quantities up to 5 kg in one batch with reproducible performance for scale-up needs. This process is facilitated by particle analyzers, surface area analysis, and chemical and thermal expansion measurement in a controlled gas atmosphere.

Electrode Engineering and Diagnosis

This EPEC team can manipulate the microstructure and porosity of an electrode by tuning pore formation or integrating novel 3D electrode architectures. Electrocatalyst coatings can be introduced subsequently through wet infiltration, hydrothermal deposition or atomic layer deposition. The team can also study solid oxide electrochemical cell microstructural evolution that affects performance change observed both experimentally and through simulation.

Elevated Temperature Electrocatalysis

This platform consists of the electrochemical testing stands and a series of specially designed reactors that can integrate solid catalyst materials with electrochemical cells. This capability allows the EPEC team to conduct electrocatalysis measurements under elevated temperatures and pressures. Ultimately, this capability enables fundamental studies of catalytic materials for electrochemical processing.

Large-scale Electrochemical Testing

INL's 25 - kW high temperature electrolysis flexible test facility can evaluate solid oxide electrochemical cells stacks operating independently or in thermal integration with co-located systems.

FOR MORE INFORMATION

Technical contact
Dong Ding
678-956-4752
dong.ding@inl.gov

General contact
Michelle Goff
208-932-6581
michelle.goff@inl.gov

www.inl.gov

A U.S. Department of Energy National Laboratory

Battelle Energy Alliance manages INL for the U.S. Department of Energy's Office of Nuclear Energy.