Pacific Northwest
NATIONAL LABORATORY

Developed at Pacific Northwest National Laboratory (PNNL), E-Cell is a powerful in-situ, automatic-resolution instrument that could greatly benefit the nuclear industry as well as environmental cleanup and monitoring. (Photo by Wlad74 | Shutterstock)

E-CELL DEVICE

Characterizes spent nuclear fuel on the microgram scale

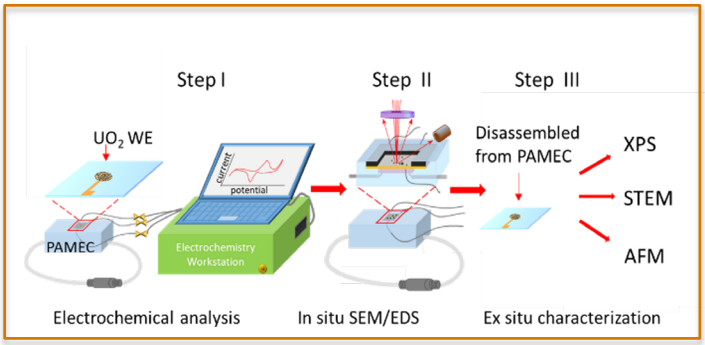
ELIMINATE SHIELDING REQUIREMENTS FOR SAMPLE ANALYTICS

Developed at PNNL, E-Cell allows users, for the first time, to characterize micro-scale nuclear materials (solid particles, particles in liquid slurry, and high-level waste). The device can establish elemental, organic, and isotopic compositions—key factors to understanding the material properties during nuclear fuel cycle processes. This allows for an improved ability to manage and control nuclear materials. Techniques to evaluate this detailed information, even at small concentrations, can support nuclear materials and science programs by increasing the ability to manage and control nuclear materials.

Traditional characterization experiments require bulk amounts of radioactive materials, such as spent nuclear fuel (SNF), are expensive and require shielded hot-cell facilities to protect researchers from the intense beta and gamma radiation.

TECHNOLOGY FEATURES

- Establish elemental, organic, and isotopic compositions for an improved ability to manage and control nuclear materials
- Run smaller experimental samples, thereby significantly reducing the overall cost and hazard of sample handling during analysis
- Benefit from direct visualization and spectral analysis
- Investigate SNF and other nuclear materials under various controlled conditions to provide insights to nuclear waste management, nuclear fuel performance, and reactor modeling for the future
- Benefits the nuclear and environmental cleanup and monitoring industries



E-Cell is a three-step process that includes electrochemical analysis, in-situ SEM/EDS, and EX-situ characterization.

REDUCE SAMPLE PREP COSTS

By reducing the sample amount of SNF needed to determine material composition by several orders of magnitude, researchers can run experiments outside of a shielded facility, thereby significantly reducing the overall cost and hazard of sample handling during analysis.

E-Cell bridges this gap. The powerful, patent-pending, in-situ, atomic-resolution instrument addresses radioactive sample handling and subsequent limitations. The specialized particle-attached microfluidic electrochemical device, or PAMEC, allows researchers to use microgram quantities of radioactive materials, such as uranium dioxide (UO_2) particles, rather than bulk analysis to gain the same observation of electrochemical and spectroscopic properties. The E-Cell device eliminates the need for running experiments in shielded facilities and allows for in-operando, real-time investigations of electrochemical properties and morphological changes of micrograms of particles. This novel design offers a promising platform to investigate SNF and other nuclear materials under various controlled conditions to provide insights to nuclear waste management, nuclear fuel performance, and reactor modeling for the future.

E-Cell is vacuum compatible. The technology, a three-electrode E-Chem cell, comprises

- particles serve as the working electrode (WE)
- a platinum wire reference electrode (RE)
- a platinum wire counter electrode (CE).

The particle-composed WE is attached underneath the thin detection window membrane (50-nm thick Si_3N_4) using a chemically inert and electron conductive binder of polyvinylidene fluoride/carbon black. E-Cell can be mounted on an instrument stage (e.g., SEM, TEM, XPS, AFM, etc.) and connected to the electrochemical analyzer outside the sample chamber for in-operando spectroscopic and electrochemical analysis.

E-CELL PROVIDES NUMEROUS BENEFITS OVER CURRENT METHODS

- Allows direct visualization and spectral analysis of WE sample in electrolyte using in-operando SEM/EDS and electrochemical analyzer, capturing the real-time spectrochemical and electrochemical properties of the active martials.
- Keeps the detection window (made of 50-nm thick Si_3N_4 membrane) intact after analyses, which is particularly beneficial for oxygen-sensitive specimens.
- Enables the same sample to be further analyzed by other analytical techniques, such as XPS and TEM, which can provide complementary information on the same sample.
- Secures the particle-composed WE under the detection window throughout the entire in-operando SEM/EDS and electrochemical analysis, enabling the comparison of the same region of interest or even the same particle before and after electrochemical reactions. This captures any microstructural and compositional changes of the sample from a redox reaction.
- Provides a microfluidic platform for detecting the electrochemical reaction—using only a microgram of particulate material of interest, as compared to the large amounts of radioactive materials required for bulk analysis.
- Greatly reduces the cost in sample preparation and associated hazards and waste.

LET'S CONNECT

If you have questions, regarding this technology, please send inquiries to commercialization@pnnl.gov. You can view all PNNL technologies available for licensing at www.pnnl.gov/available-technologies