Development of Nonconsumable Anode for Electrolytic Reduction of Spent Oxide Fuel

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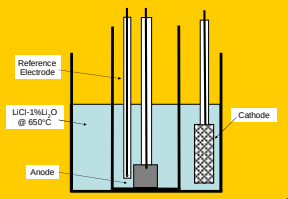
Purpose:

- To develop a non-consumable, oxygen-evolving anode for the electrolytic reduction of UO_2 to metal in the challenging environment:
  - 650°C
  - LiCl + 1 wt % Li_2O
  - Oxygen generation
  - Possible chlorine generation
  - Possible dissolved lithium metal

Anode Polarization Cell Schematic



Electrochemical Test Results

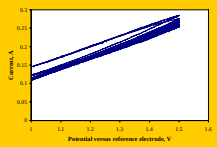
RuO_2-based anode pre-test

RuO_2-based anode post-test

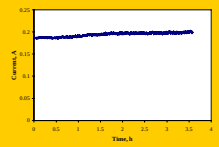
No visible corrosion following testing

RuO_2-based Anode Performance

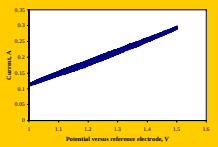
Initial cyclic voltammograms (CVs) at O_2 evolution potentials



Potentiostatic hold at O_2 evolution potentials (1.25 V versus reference)



Final CVs at O_2 evolution potentials

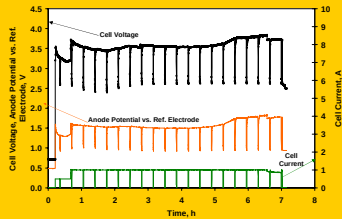


Demonstrates initial conditioning of anode and subsequent stability

Criteria for Material Evaluation

- Thermodynamic evaluation of candidate materials in application environment
- Immersion testing at 650°C in:
  - LiCl + 1 wt % Li_2O
  - Lithium-saturated LiCl + 1 wt % Li_2O
- Physical properties
  - High conductivity to enhance efficiency
  - Good high-temperature mechanical properties
- Corrosion resistance to maximize lifetime
- Electrochemical performance
  - Oxygen evolution characteristics
- Ease of fabrication and scale-up

RuO_2-based Anode Performance in UO_2 Reduction



Sample Characteristics:

Material	Resistivity relative to Au at 650°C, Ω-m	Bulk density, g/cm³	Immersion Test
$LiFeO_2$	10^8	4.4	Pass
$CoFe_2O_4$	10^8	4.9	Pass
$BaCrO_4$	N/A	4.5	Fail
RuO_2-based ceramic*	10^6	3.1	Pass
Stannex (doped SnO_2)	10^3	9.0	Pass
Au	1	19.3	Pass
Pt	10	21.5	Pass

*RuO_2-based ceramic resistivity measured at room temperature. Conductivity improves with increasing temperature.

Advanced Anode Polarization Cell

- Increased current and voltage capability for more comprehensive testing
- Precise control of exposed anode area for accurate current density measurements
- Video capture to monitor real time electrode performance characteristics
- Enhanced capability to control and monitor gas phase in apparatus
- Increased options for geometric configuration of electrodes

Summary

RuO_2-based anodes are viable

- Current densities 0.1-1.0A/cm²
- Excellent physical integrity in process environment
- Extended operation feasible
- Produced with simple sintering techniques
  - Scalable
  - 95% dense
- Highly reproducible results achieved

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