

# Synthesis of Molten Chloride Salt Fast Reactor Fuel Salt from Spent Nuclear Fuel

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*Final CRADA Report*

Chemical and Fuel Cycle Technologies Division

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prepared by  
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Chemical and Fuel Cycle Technologies Division, Argonne National Laboratory

Participants: Elysium Industries USA, Inc.

December 19, 2019

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## Non Proprietary Final CRADA Report

For the Office of Scientific and Technical Information (OSTI)

**CRADA Number:** 2017-17170

**CRADA Title:** Synthesis of Molten Chloride Salt Fast Reactor Fuel Salt from Spent Nuclear Fuel.

**CRADA Start Date** 2/22/2018 – **End Date** 2/22/2019

### DOE Program or Other Government Support

**Program office:** Department of Energy, Office of Nuclear Energy, Gateway to Accelerated Innovation in Nuclear

**Program manager name:** Dr. John H. Jackson

**Program manager phone or email:** john.jackson@inl.gov

### Participant(s)

**Participant 1 name:** Ed Pheil, Elysium Industries USA, Inc.

**Complete address:** 12 Droms Road, Rexford, NY, USA 12148-1401

**Participant 2 name:** [Click or tap here to enter text.](#)

**Complete address:** [Click or tap here to enter text.](#)

**Participant 3 name:** [Click or tap here to enter text.](#)

**Complete address:** [Click or tap here to enter text.](#)

### Argonne National Laboratory

Argonne PI(s): Mark A. Williamson and James Willit

### Funding Table

To add rows, right-click in bottom row and select "Insert" "rows above".

	Planned Funding	Actual Funding	In-Kind
Government - Argonne	\$23,000	\$23,000	
Elysium Industries USA, Inc.	\$4,600	\$4,600	\$
Enter Participant 2 here	\$	\$	\$
Enter Participant 3 here	\$	\$	\$
<b>Total</b>	<b>\$27,600</b>	<b>\$27,600</b>	<b>\$</b>

### Nature of Work

#### Describe the research (summary of Scope of Work and principal objectives of the CRADA):

Elysium Industries USA, Inc. aims to produce safe, cost effective, carbon conscious energy through the development of an advanced liquid-fueled reactor technology. The Elysium liquid-fueled reactor concept comprises a molten chloride salt fueled fast spectrum nuclear reactor, which can accept fissile material recovered from used nuclear fuel and excess fissile material from defense applications. A key technology development need for the system is demonstrating the feasibility of a low cost, efficient method to produce the chloride fuel salt from used nuclear fuel. This approach not only provides a pathway for the disposition of used nuclear but more efficient use of uranium resources for energy production.

Argonne National Laboratory provided technical consultation on the synthesis and characterization of molten chloride fuel salt for the Elysium Industries USA, Inc. molten salt fast reactor. Argonne's consultation work spanned the fields of molten salt chemistry and process engineering.

**DOE mission area(s):**

Energy and Environmental Science and Technology

Choose an item.

Choose an item.

**Conclusions drawn from this CRADA; include any major accomplishments:**

Argonne's thermodynamic assessment of the chemistry used to synthesize chloride salt from oxide feed material confirmed the efficacy of the conversion method. Our analyses show  $UO_2$  (a surrogate for used fuel in the analyses) can be efficiently chlorinated to form  $UCl_3$  in molten  $NaCl - KCl$  by using  $Na_2ZrCl_6$  or  $K_2ZrCl_6$  as the primary chlorinating agent for converting  $UO_2$  to  $UCl_3$  instead of  $ZrCl_4$ . The analysis identified several key factors that will probably enhance the conversion efficiency: (1) For maximum efficiency, both  $UO_2$  and  $Zr$  must be present in the salt before  $K_2ZrCl_6$  is added because  $K_2ZrCl_6$  will otherwise partially decompose to generate  $KCl$  and  $ZrCl_4(g)$ . The  $K_2ZrCl_6$  can be added as a separate reagent or formed in situ by adding chlorine gas to the molten salt with  $Zr$  present. (2) The chlorination agent should be added to the molten chloride incrementally at a rate commensurate with the  $UO_2$  chlorination rate. Real-time measurement of the  $UCl_3$  concentration could be used to control the timing and size of the incremental additions. (3) A slight stoichiometric excess of  $UO_2$  and  $Zr$  should remain in the molten salt until the target equilibrium  $UCl_3$  concentration is reached to minimize the amount of chlorinating species in the final molten salt solution.

**Technology Transfer-Intellectual Property****Argonne National Laboratory background IP:**

None.

**Participant(s) background IP:**

None.

**Identify any new Subject Inventions as a result of this CRADA:**

None.

**Summary of technology transfer benefits to industry and, if applicable, path forward/anticipated next steps towards commercialization:**

Argonne's technical consultation concerning molten chloride fuel salt synthesis yielded a fundamental understanding of the fuel salt synthesis process and supported ongoing molten salt reactor design activities.

**Other information/results (papers, inventions, software, etc.):**

None.

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