

Developing Methodologies for the Processing and Encapsulation of Orphan Fuels and Residues

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Introduction

Orphan fuels and residues are terms ascribed to non-routine radioactive wastes arising from a range of sources including fuels from prototype, experimental and research reactors, samples from Post Irradiation Examination (PIE) studies and process arisings. They do not have direct routes for reprocessing by current solution based methods (e.g. PUREX, THORP) and for this reason we intend to explore pyrochemical methods for the possible processing of these wastes.

Molten Salts

Molten salt media have found applications in the nuclear industry for over half a century in both research and routine operations.¹ This has included research into waste processing by:

- BNFL (British Nuclear Fuels Plc.) using alkali carbonate melts²
- ANL (Argonne National Laboratory, U.S.A.) using electro-refining processes with a LiCl-KCl eutectic³
- RIAR (The Russian Research Institute of Atomic Reactors) NaCl:KCl 1:1 mol.

Alkali Chlorides and Alkali Carbonate Based Melts

Alkali Chloride based melts have proved to be a popular choice for nuclear research finding use in molten salt reactors as well as nuclear waste treatment research. They have several **advantages** and **disadvantages**:

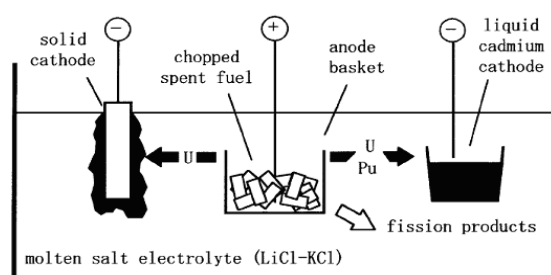
- High Radiolytic Stability
- High Temperature
- Good Solubilising Properties
- Cl⁻ Melts are Hygroscopic
- Anhydrous Nature
- May be corrosive

Alkali carbonates have also been trialled for the processing of oxide fuel with great success as they can produce the highly oxidising superoxide ion (O²⁻). **Alkali carbonate melts are not hygroscopic** in some cases.²

Aims of the Project

The aims of this project are to examine ways in which carbide and halide waste-forms can be processed into a form suitable for re-use or encapsulation and storage by utilising molten salts. It is hoped that methods discovered will not only offer the standard benefits of molten salts over the current aqueous methods (reduced wastage, purer products, etc.) but also meet the following criteria:

Electrorefining



A process used by Argonne National Laboratory (ANL) uses a solid cathode to collect the majority of uranium from spent fuel and a liquid cadmium cathode (LCC) to collect plutonium, trans-uranics and fission products. This technique exploits the fact that uranium does not form intermetallics at the process temperature and so is not trapped in the LCC.³

(image from http://blogs.princeton.edu/chm333/f2006/nuclear/05_reprocessing/possible_methods_of_reprocessing/)

Speciation



Although the molten salt process are at high temperature they can easily be conducted in the laboratory using smaller furnaces with analysis by:

- Electronic absorption spectroscopy
- X-ray absorption spectroscopy
- Electrochemical methods

- Economically viable
- Safe
- As proliferation resistant as sensibly possible
- Environmentally friendly

References: 1. I. B. Polovov, *et al. Inorganic Chemistry*, 2008, 47, 7474-7482. 2. T. R. Griffiths and V. A. Volkovich, in *Symposium on Molten Salt Chemistry and Technology*, Amer Nuclear Soc, Toulouse, FRANCE, 2005, pp. 382-400. 3. J. J. Laidler, *et al. Progress in Nuclear Energy*, 1997, 31, 131-140.

DIAMOND University Research Consortium, funded by the EPSRC