New Waste Streams from Advanced Reprocessing Technologies

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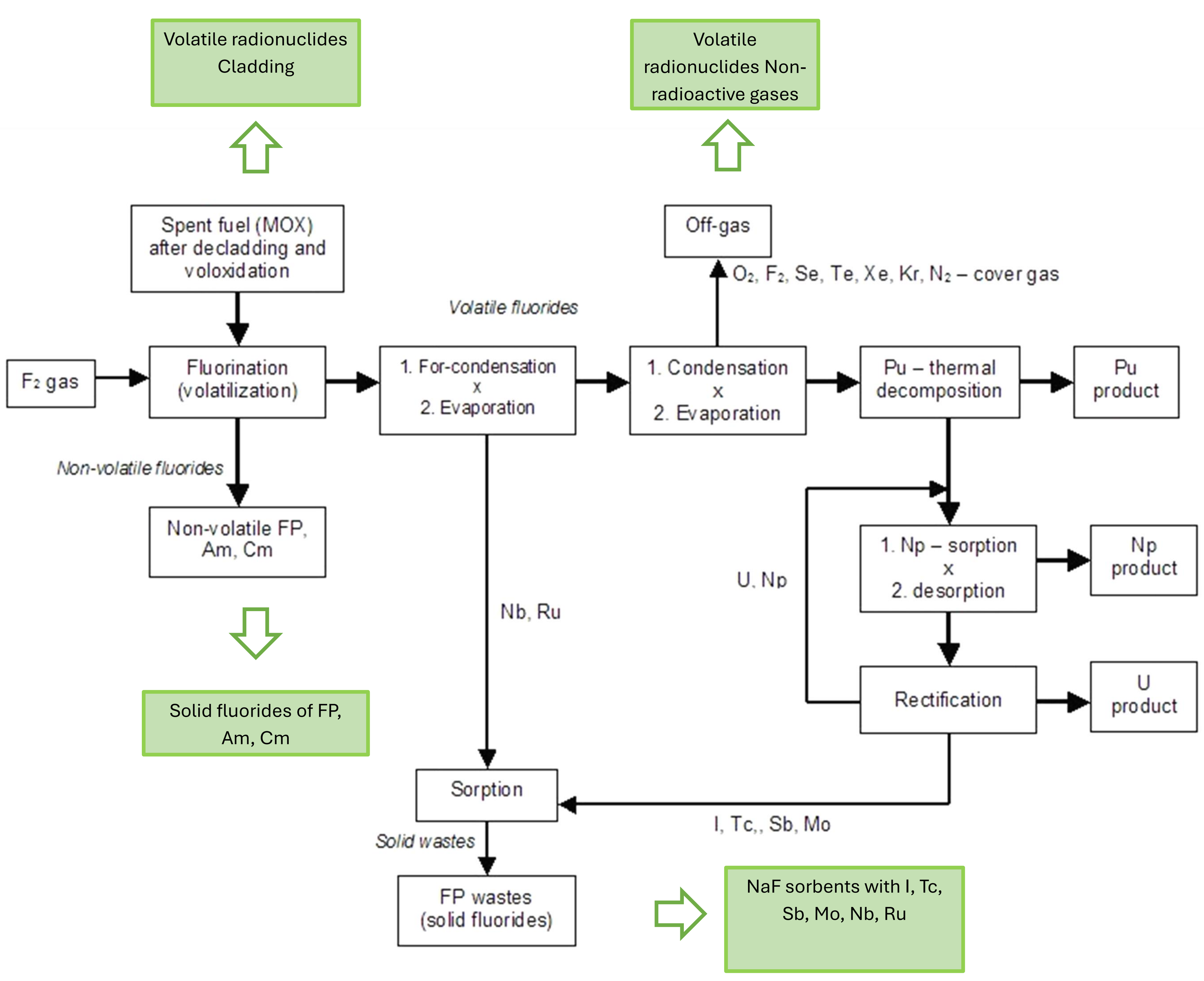
Abstract

Current efforts in the exploitation of nuclear energy consider the introduction of advanced reactor systems, including fast and molten salts reactors. These systems may also require new pyrochemical and pyrometallurgical reprocessing technologies resulting in the generation of new types of waste. This waste needs to be processed and eventually disposed of, but due to its radiochemical properties and chemical composition its waste management may be challenging.

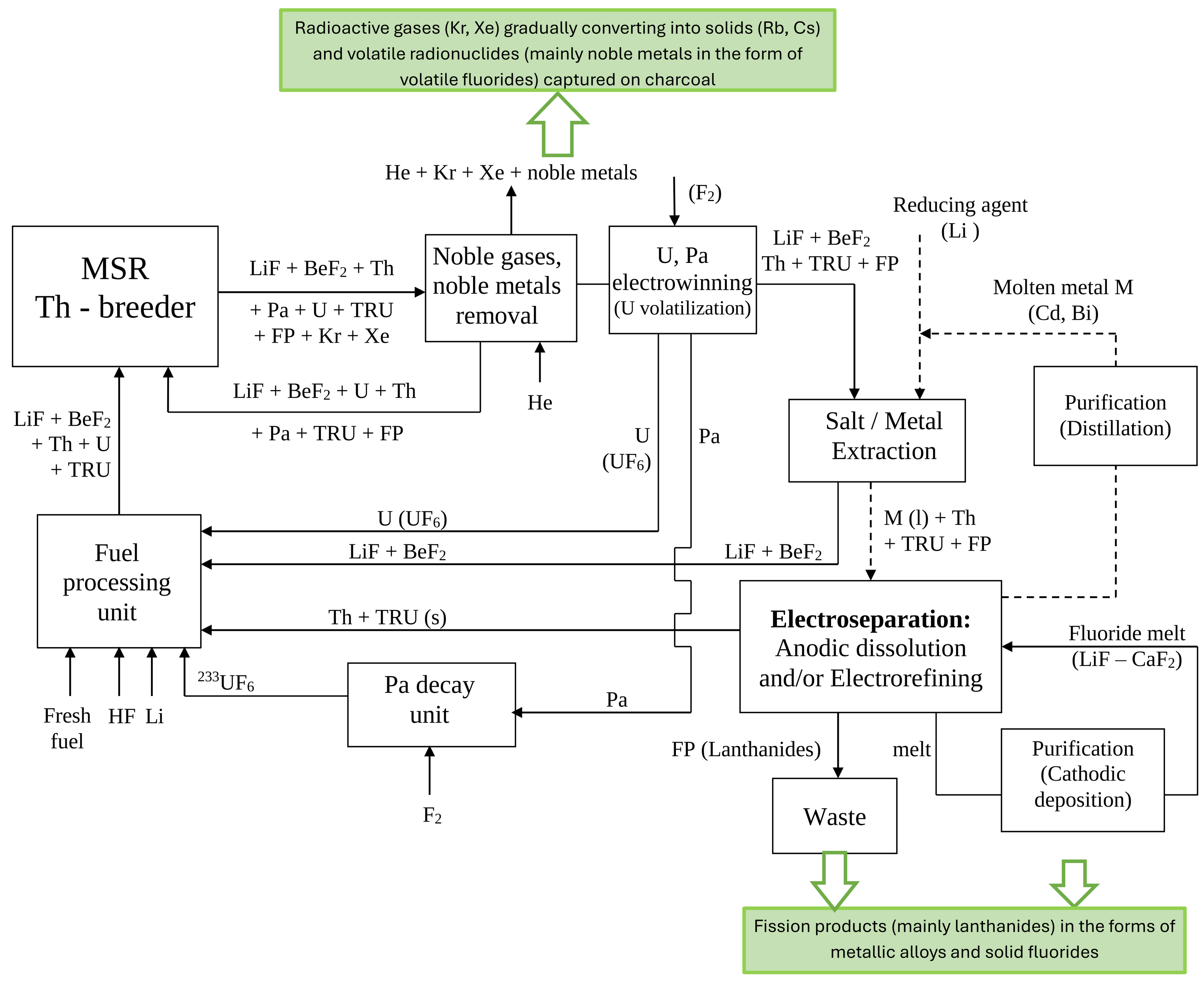
The poster provides an overview of potential types and basic characterisation of anticipated waste streams generating by pyrochemical and pyrometallurgical reprocessing technologies, in particular:

- Molten salt / liquid metal reductive extraction proposed as a separation method to be used for the molten salt fuel processing. The main principle of the technology is based on the selective molten-salt / liquid metal reductive extraction into liquid bismuth in multistage counter-current extraction system.
- Electrochemical separation is also proposed for molten salt reactor systems. There are two methods: cathodic deposition (electrowinning) or anodic dissolution (electrorefining). Both of these electrochemical processes allow for the separation of spent fuel components either in pure metallic form, or in the form of solid or liquid metal alloys, as well as in the form of mixed fluoride or chloride melts.
- Fluoride volatility method which is proposed for reprocessing of spent MOX fuel from fast reactors or LWRs containing high concentrations of plutonium. The separation process comes out from ability of uranium, neptunium and plutonium to form volatile hexafluorides, whereas most of fission products (lanthanides) and transplutonium elements form non-volatile trifluorides. The arising products will thus be represented by gaseous phase containing U, Np, Pu and solid fluoride waste comprising fission products and the rest of transuranium elements (Am, Cm) captured on an inorganic high surface area sorbent, e.g. Al_2O_3 (alumina). Fluoride volatility method can individually separate uranium, plutonium, and potentially also neptunium. However, this technology (like hydrometallurgical PUREX) cannot individually separate americium and curium which then accompany the fission product stream.

REPROCESSING BY FLUORIDE VOLATILITY METHOD



PYROCHEMICAL REPROCESSING OF MOLTEN SALT REACTOR FUEL



WASTE STREAM MANAGEMENT OPTIONS

Waste stream	Category	Possible conditioning method	Disposal
Cladding	ILW	Melting, compaction	GR / DGR
Volatile radionuclides (Cs, Tc, Ru, and I)	ILW	Sorption, HEPA filtration	GR / DGR
Gaseous radionuclides (Xe, Kr, C, T)	ILW	Retention	GR / DGR
Solid FP, Am, Cm fluorides	HLW	Melting (fluorine glass)	DGR
Sorbents with I, Tc, Sb, Mo and Nb, Ru fluorides	ILW	Cementation, geopolymerisation	DGR

ILW – intermediate level waste GR – geological (subsurface) disposal

HLW – high level waste DGR – deep geological repository

CHALLENGES

Management of gaseous radionuclides (container, sorption?)

Conditioning of sorbents with captured radionuclides (media?)

Processing waste containing fluorides (suppression of reactive and corrosive properties?)

Conversion of fluoride salts into a stable form (technologies?)

Long term performance of new waste form (durability of disposal containers, mobilisation of radionuclides?)

Management of gaseous and volatile elements (I, Tc, Cs, Xe, Kr)

Recycling of metals & chemicals advanced cycles (Cd, Pb, Bi, Zr)

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SÚRO Státní ústav radiační ochrany, v. v. i. National Radiation Protection Institute

eurad 2 European Partnership on Radioactive Waste Management

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