

Partitioning of Fissile Materials and Radiotoxic Materials from Spent Nuclear Fuel.

RIAR current and future activities



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International cooperation in the field of advanced FC. Russian research needs. RIAR view

	Fuel production		Repro- cessing	P&T	Advan- ced	Cladd. Materials	Concept Studies	Funda- mental Studies
	MOX	other						
China	pellet/ vibro?	-	-	-	-	-	-	-
France	-	MA oxide	-	Am, Cm recovery	Pyro/ RTIL's?	+	FS	Cm
India	-	Met/Th? Carbide?	?	?	?	?	?	?
Japan	MOX vibro	-	MOX / nitrides?	MA/REE separ.	Pyro/ Fluorex/(MoO ₄ ²⁻	ODS	FS	MA
Korea	-	MA met. ?	Metalliz. / vibro- DUPIC	MA/REE separ.	Pyro	+ ?	-	-
US	Vibro?		UREX+1a	-	TRU fuel	-	-	RTIL's
EU	-	MA nitride	-	-	MSR fuel	-	-	Cm

Blue – current and past activities, red – planning, discussing and desired, black – without RIAR, but in any case – in all topics and cases RIAR is ready to participate

RIAR DOVITA experience in adding of minor actinides in fuel compositions



Microstructure and macrostructure of irradiated (U, Np)O₂ fuel, 19% burn-up

- # Pyrochemical technology of adding Np into oxide fuel (5-20%) has been developed
- # Performance of vi-pack fuel with (U,Np)O₂ fuel has been validated experimentally to a burnup of ~20% in BOR-60
- # No evidence of significant difference in performance of fuel rods with (U,Np)O₂ fuel compared with UO₂ or MOX fuel rods has been noticed
- # Pyrochemical process of codeposition of Am with MOX fuel (2-5%) has been developed
- # Methods of Am/REE separation in melts has been tested (AMBOINE-1)
- # Special vi-pack targets containing Am oxide with UO₂ or inert matrix have been developed (AMBOINE-1)
- # Transmutation of Np, Am, Cm is being studied in BOR-60

Examples of RIAR ISTC activities related to partitioning

Integrated projects

- # ISTC 17
- # ISTC 272

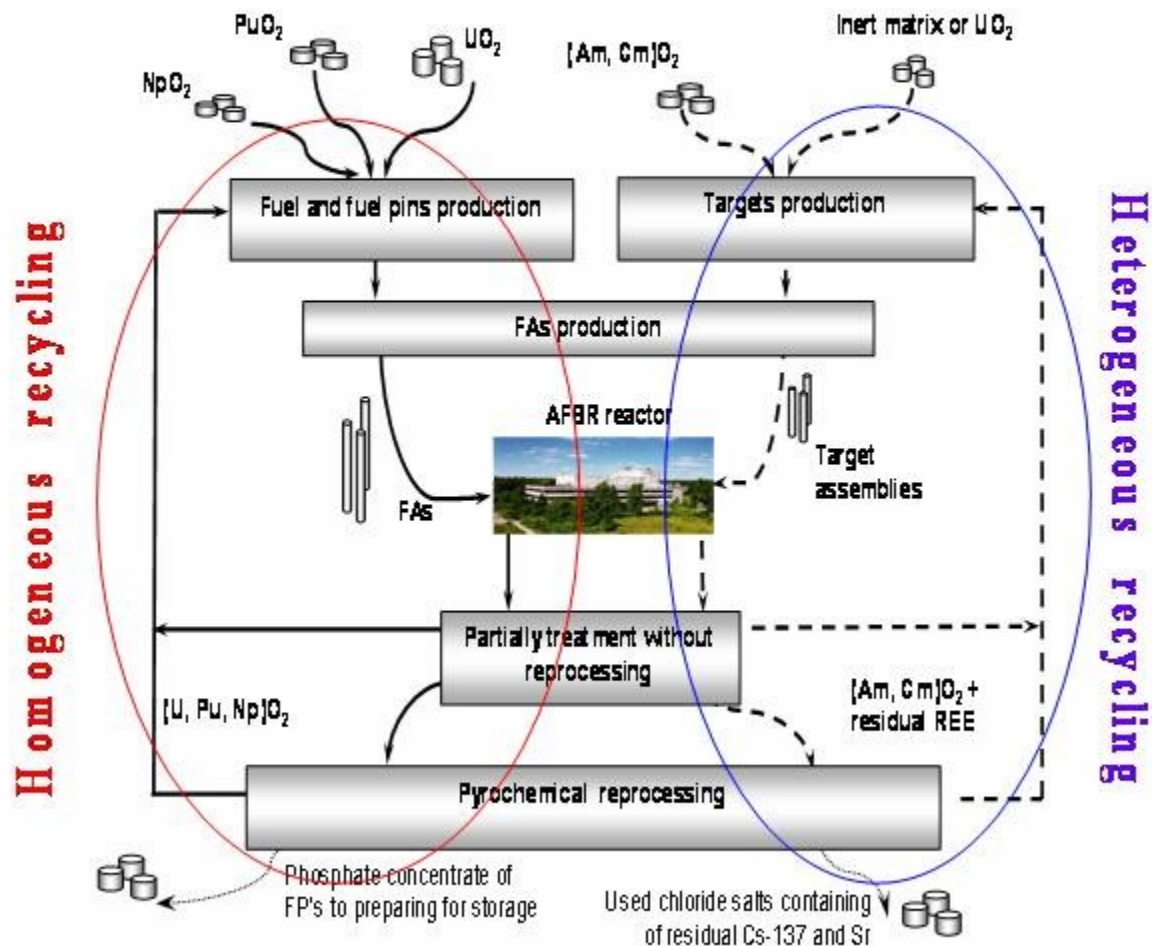
Pyrochemical partitioning

- # ISTC 279
- # ISTC 3231p
- # ISTC 3261

Targets with MA

- # ISTC 2680

DOVITA fuel cycle



ISTC Partner Project 3231p (RIAR-KAERI) - under completion

Separation of MA from REE on a liquid metallic cathode in molten chlorides

Objectives:

- Task 1: Polarization curves on electrodeposition of actinides and lanthanides on bismuth and cadmium cathodes
- Task 2. Electrodeposition tests for effective separation of actinides and lanthanides on liquid-metal cathodes
- Task 3. Effect of uranium content in molten salt to electrodeposition and separation of actinides and lanthanides on liquid metallic cathode
 - Actinides - U, Np, Am, Cm,
 - REE - Nd, La, Ce
 - Systems: - Bi / LiCl-KCl and Cd / LiCl-KCl

Nitrides with MA. "MATINE: Study of MA Transmutation in Nitrides: modeling and measurements of out-of-pile properties". ISTC Project#2680

⊕ Objectives

- performance modeling of (Pu,Am,Cm,Zr)N (with ZrN=55-65%, Pu/Am/Cm=40/50/10) fuel under irradiation in ADS fast spectrum up to high burn-up in order to compare relative performance of helium, sodium and lead-bismuth bonded pins.
- Two different fuel forms (pellet and vibropacked).
- Experimental study of PuZrN properties .

- The Project continuation - **MATINE-2** (ISTC Project # 3608) - including in particular the development and **fabrication the unique (Pu,Am,Cm,Zr)N micro-targets (containing up to 1 g of Cm-244) by vi-pack technique in RIAR** and further irradiation in the BOR-60 reactor - is waiting the ISTC approval

Future ISTC Proposals

Continuation of recently investigated subjects:

So called Phase 2 of ISTC #3261

Partitioning of fissile and radiotoxic materials from spent fuel (proposed subjects):

- # Molten Salt chemistry of Cm and Am for chlorides and fluorides
- # Partitioning of MA/REE in molten salts
- # Molten salt chemistry of Tc
- # Partitioning of noble and semi-noble FP (including Tc) from spent fuel
- # FP Immobilization from SNF Pyrochemical reprocessing

Application of Room Temperature Ionic Liquids for Separation of TPE and REE

RIAR proposal for ISTC project

The R&D program includes the following stages:

- selection of the RTIL with a rather wide electrochemical window, study of its properties,
- study of solubility of the TPEs and REEs salts with different anions (NO_3^- , Cl^- , F^- , CN^-) in the chosen RTILs
- study of composition of the complexes and electrochemical behavior of the TPEs and REEs in the chosen RTILs
- study of TPE and REE cathodic deposition in the alloy form with transient metals (Zn, Cu, Ni, Al ...) and/or on a liquid Ga metallic cathodes
- study of separation Al and actinides from Al-An-alloys by Al electrorefining process

ISTC Project proposals from RIAR: Preparation of monographs related to P&T and advanced fuel cycle

- # **A.Mayorshin** **Fuel elements with vibropacked oxide fuel** - preparation Russian and English editions
- ISTC Project Proposals # 3587
- # V.Nickolaev, E.Karelin, R.Kuznetsov, Yu.Toporov. **Technology of Transplutonium Elements** - second edition and translation to English and publishing
- # V.Radchenko, M.Ryabinin, etc. **Physical Metallurgy of Transplutonium Elements** - preparation Russian and English editions
- # O.Skiba, A.Bychkov, V.Ivanov. **Pyroelectrochemical process in nuclear fuel cycle** - preparation Russian and English editions

Experimental study on actinide transmutation in the BOR-60 fast reactor neutron spectrum

Participating Institutions

Federal State Unitary Enterprise “State Scientific Center of the Russian Federation – Research Institute of Atomic Reactors”, Dimitrovgrad

Federal State Unitary Enterprise “ State Scientific Center of the Russian Federation –Institute of Physics and Power Engineering, Obninsk

Governmental Agency

Federal Agency for Nuclear Power (Rosatom)

Project Duration

36 months



Main idea: maximal precise reactor experiment

Experimental study on actinide transmutation in the BOR-60 fast reactor neutron spectrum

Scope of Activities

- # Task 1 covers the work related to the selection of a set of isotopes to be tested, substantiation of the target design and requirements to the substances to be irradiated
- # Task 2 covers irradiation of the targets in BOR-60, information acquisition on irradiation conditions and calculation-analytical support of irradiation
- # Task 3 consists in examination of irradiated targets and includes development of the high-precision procedures for determining the key elements and their analysis
- # Task 4 includes development of the irradiation models, analysis of data according to the irradiation program, acquisition and analysis of data by the irradiation conditions and calculation-analytical support of irradiation.

Research area of pyrochemical (non-aqueous) methods for MA/FP partitioning development

Melts/ media	Electrochemical methods				Oxides Precipitation	Metallization
	Liquid cathodes	Solid cathodes	Anodic dissol-n	E/Chem. oxide titration		
Chlorides	Cd, Bi, Ga	Al,	+	+	+	+
Fluorides	Bi, Ga, Al, Pb	-	+	+	+	-
Cl ⁻ /F ⁻	Cd, Bi, Ga, Al, Pb	Al	+	+	+	-
Molibdates	-	+	-	-	+	-
RTIL	Ga, Hg	Zn, Cu, Ni, Al, ...	+	-	-	-

+ Methods of Volatility of Fluorides and /or Chlorides