

DE LA RECHERCHE À L'INDUSTRIE



Research & Development for the Fabrication of Minor Actinide-Bearing Fuel Materials and Technologies

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Related article: T1-CN-199/296

The transmutation of minor actinides (MA*) in 4th-generation fast reactors can be envisioned by:

*Am, Np & Cm

■ Homogeneous recycling:

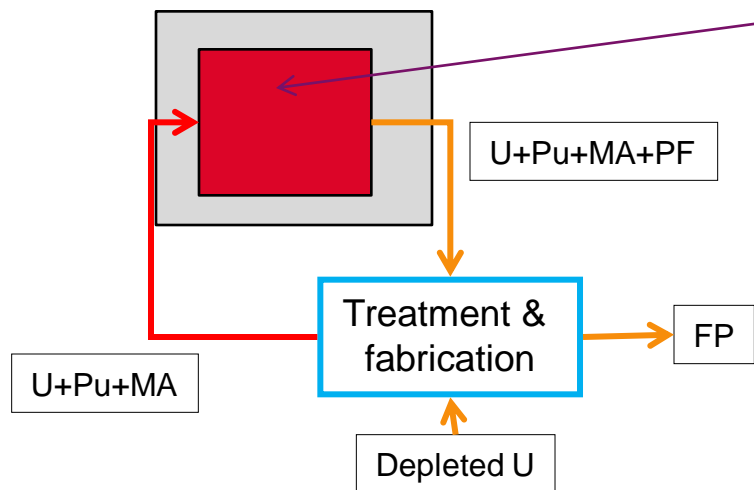
- Incorporates MA in small quantities (1% to 3%) in the reactor driver fuel

■ Heterogeneous recycling:

- Concentrates MA in dedicated assemblies containing 10 to 15% MA, placed in the core periphery

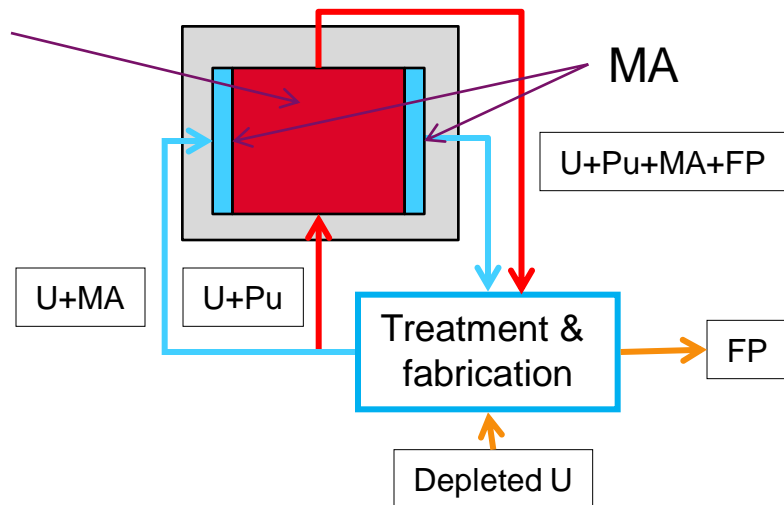
Homogeneous (U,Pu,MA)O₂

- **Slight impact** on core safety parameters



Heterogeneous (U,MA)O₂

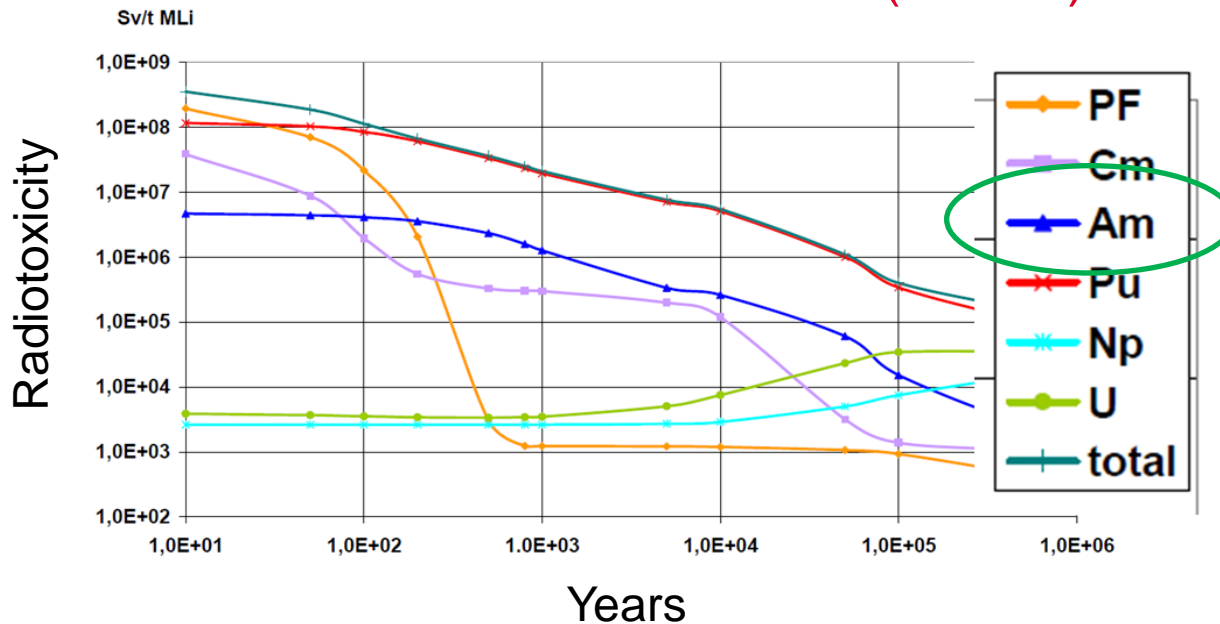
- **No impact** on core safety parameters



Focus on heterogeneous mode : (Minor Actinides Bearing Blankets)

- Homogeneous mode : already a subject of research (Superfact*)
- Heterogeneous mode and minor actinide-bearing blankets (MABB) still poorly known

Minor actinides: first americium (AmBB)

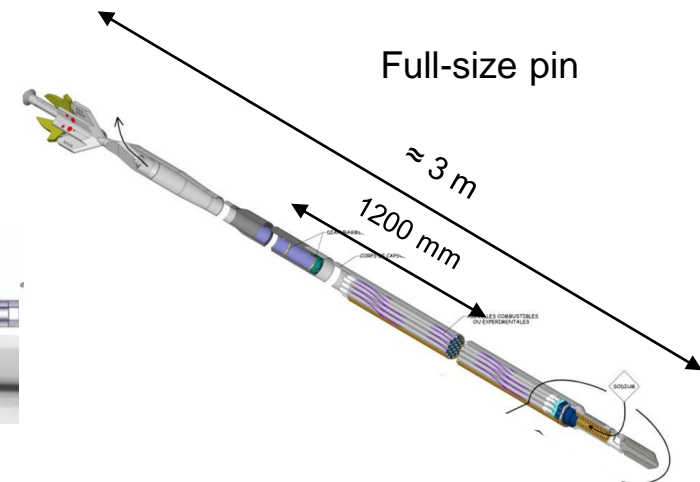
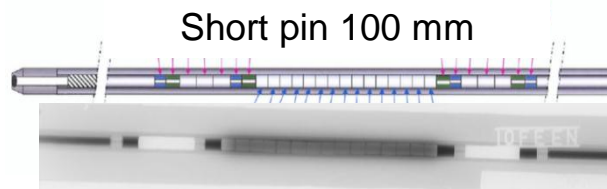
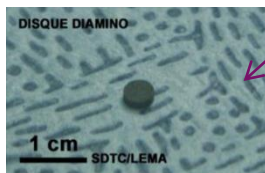
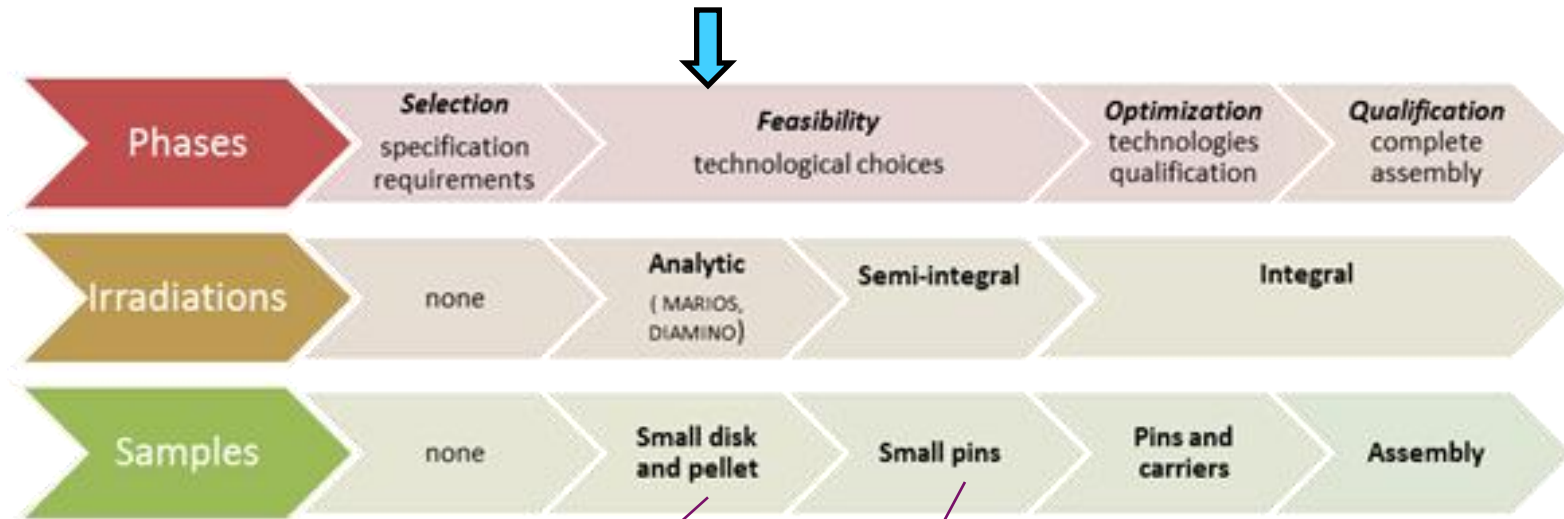


- Higher radiotoxicity
- Curium later because it is difficult to handle

* Prunier, C.; Boussard, F.; Koch, L.; Coquerelle, M. *Nucl. Technol.* (1997) 119, 141–148.

QUALIFICATION PROCEDURE

CEA qualification procedure : 4 phases



What are the characteristics of the minor actinides?

■ Gamma and neutron emitters

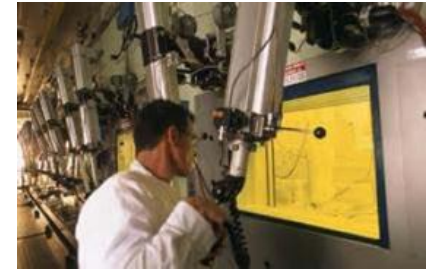
- Requires remote operation in a shielded cell

■ Strong alpha emitters

- Requires simple processes with few fabrication steps to manage contamination of the fabrication lines
- Requires simple and robust technologies (hostile environment)
- Investigate radiolysis and thermal decomposition (high specific heat) of additives

■ High rate of helium release during irradiation expected

- Develop fuel with a porous microstructure to ensure better release of fission gases



Conversion : Actinide solution to oxide

Toward co-conversion of $(U,Am)O_2$ to improve homogeneity and eliminate the milling/blending steps

Best known co-conversion processes

- Chemical precipitation followed by calcining

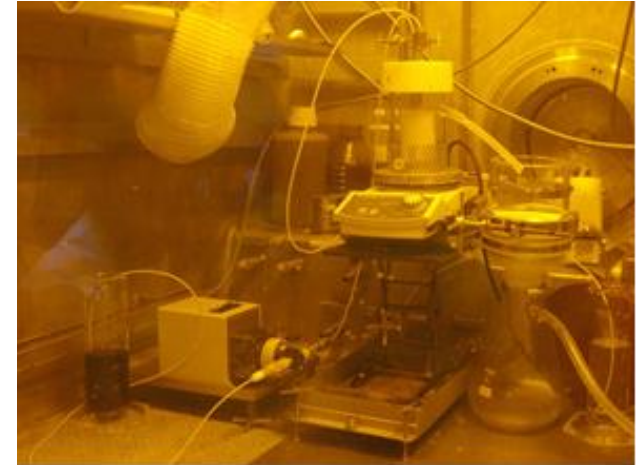
- Binding to a substrate by ion exchange followed by suitable heat treatment

- Sol-gel route

- Thermal denitration based on evaporation of nitric acid solutions

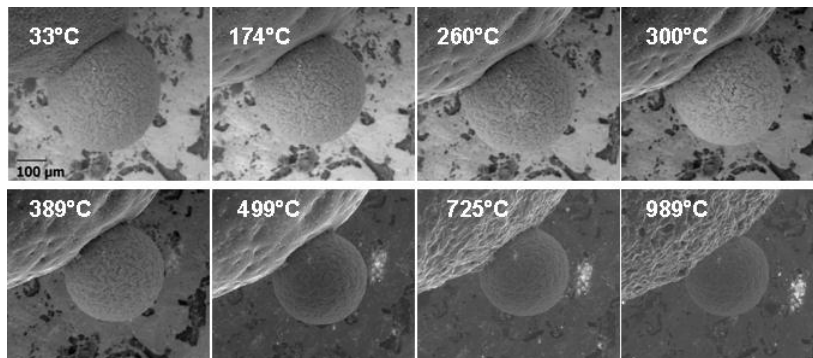
(U,Am)O₂ powder (reference)

- Oxalate coprecipitation (U,Am)O₂
- Heat treatment in inert atmosphere



Pressable spherical (U,Am)O₂ particles

co conversion on ion exchange resin followed by calcining in air (+ reduction)



Non dispersed – excellent flowability

UCeO_{2±x} microspheres produced by the **CRMP**[©] process

Calcined Resin Microsphere Pelletization

PROCESSES: FABRICATION (from oxide to pin)

Reference process

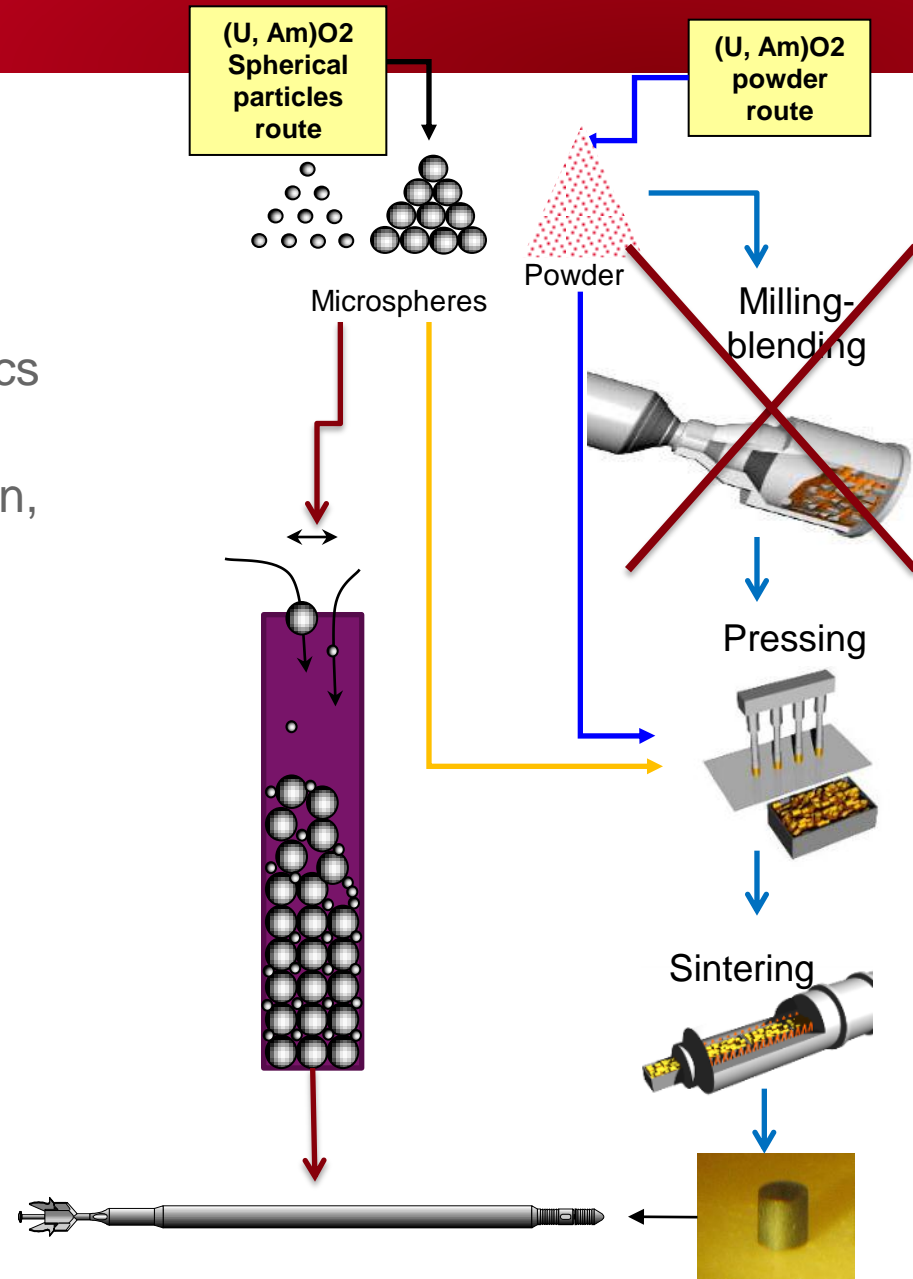
“Simplified” powder metallurgy

- Requires specific characteristics of co-converted powders (flowability, particle size fraction, specific surface area, etc.)

Alternative processes

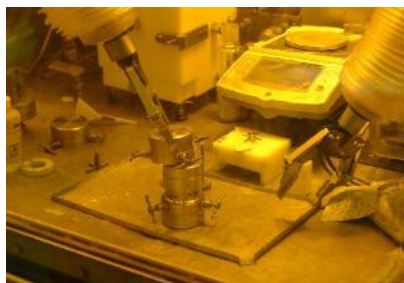
Spherical particle metallurgy

Sphere-Pac process

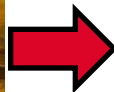


Qualification of an Americium-bearing blanket requires

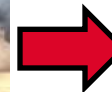
- to develop technologies for the equipment and hot cells to fabricate irradiation materials of large size.
- To anticipate future production facilities.



Manual:
15 minutes/pellet



Automatic industrial
press in a glove box



1 kg or more
in a shielded cell
(to be developed)



For transmutation, the CEA research effort focuses on:

- Heterogeneous mode and development of americium-bearing blankets (AmBB)
- Co-conversion of $(U,Am)O_2$ by two techniques:
 - Oxalate coprecipitation
 - Ion exchange on resin
- Fabrication operations:
 - Powder metallurgy without milling and blending (press compaction/sintering/insertion in cladding)
 - Spherical particle metallurgy (press compaction/sintering/insertion in cladding)
 - Sphere-Pac process
- Major technological developments have been undertaken to scale up the irradiation objects and open the way toward future production facilities .

Thank you
for your attention

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