German Joint Research Project on “Conditioning of long-lived Radionuclides in Ceramic Waste Forms”

Introduction:
The disposal of high level radioactive waste is one of the most pressing and demanding challenges of the 21st century. With respect to long-term safety aspects of geological disposal, the minor actinides (MA) such as Am, Cm and Np and long-lived fission and activation products such as $^{14}$C, $^{35}$Cl, $^{79}$Se, $^{90}$Sr, $^{90}$Tc, $^{135}$Cs, and $^{129}$I may be of particular concern due to their long half-lives, their high radiotoxicity and mobility, respectively.

Ceramic waste forms for the immobilisation of these radionuclides have been investigated extensively in the last decades since they exhibit certain advantages compared to other waste forms (incl. borosilicate glasses and spent fuel) such as high loadings and chemical durability. This project focuses on basic research on long-term behaviour of ceramic waste forms.

Project goal:
- Fundamental studies on ceramic waste forms
- Solid state chemistry of actinides
- Networking between Research Center, university and industry
- Promoting young scientists
- Sustainability of competence

Why ceramics?
- Chemical flexibility
- High actinide loading
- Mechanical stability
- Chemical durability
- Natural analogues contain significant amounts of Th and U without any indication of radiation damages over billions of years

Phases:
- Monazites ($LnPO_4$, $Ln = La-Gd$)
- Pyrochlore ($Ln,An,La$)$_2$(Zr,Hf)$_2$O$_7$
- Apatite
- Layered Double Hydroxides
- Phosphosilicates

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Working packages:

Physical properties
- Density, hardness, fracture toughness
- Heat capacity, elasticity
- Sinterkinetics

Structural Characterisation
- Microstructure (Optical microscope, SEM, FIB/TEM)
- Long range order (XRD)
- Short and medium range order (IR, Raman, TRLFS, EXAFS)

Synthesis, Pelletisation

Dissolution behaviour

Radiation damages

Self Irradiation
- Incorporation of short-lived actinides
- $^{40}$K$^{+}$ (87.7 a half-life)
- Long-term experiment

Heavy ion Irradiation
- Heavy ion bombardment (Xe$, K^+, Ar^+, Au$, Bi$^+$)
- o-irradiation; (Nuclear recoil effect neglected)
- Short-term experiment
- Surface sensitive

Funding:
- Project duration: 3 years
- Funding: ~ 2.6 Mio. EUR
- 7 national partners from research centers, university and industry

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