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Fundamental investigations of actinide immobilization by incorporation into solid phases relevant for final disposal

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This contribution provides an overview of a current research network funded by the German Federal Ministry of Education and Research (BMBF), entitled "Fundamental investigations of actinide immobilization by incorporation into solid phases relevant for final disposal"–AcE. The AcE project aims at understanding the incorporation and immobilization of actinides (An) in crystalline, repository-relevant solid phases, such as zirconia (ZrO2) and UO2, but also in zircon (ZrSiO4), pyrochlores (Ln2Zr2O7) and orthophosphates of the monazite type (LnPO4), which may find use as host matrices for the immobilization and safe disposal of high-level waste streams.
The main objectives of the AcE project are (i) the development of synthesis strategies for An(IV)-doped solid phases, (ii) understanding their associated structural and physical properties using combined modelling and experimental approaches and (iii) determining their performance after irradiation with particular regard to an assessment of their long-term stability, dissolution behavior, and suitability for An matrix incorporation.

Recent results obtained for ZrO2, the main corrosion product of the Zircaloy cladding material surrounding nuclear fuel rods, will also be discussed. ZrO2 is monoclinic phase (P2(1)/c) at ambient conditions, and transforms into tetragonal (P4(2)/nmc) and cubic phases (Fm3¯m) at high temperatures of around 1200 ℃ and 2370 ℃, respectively. However, particle size effects, the incorporation of foreign ions such as the actinides, as well as high radiation fields are known to also influence the stability fields of the polymorphs. A short overview of experimental studies conducted by the AcE partners, addressing both the ZrO2 bulk structure, irradiation-induced changes, as well as the An environment during and after such structural transformations, will be given.

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