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Co-conversion of minor actinides in uranium based oxidic precursors by internal gelation

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In the context of advanced nuclear fuel cycles including partitioning and transmutation (P&T), actinide co-conversion processes, such as sol-gel routes, play an important role to close the fuel cycle. During the heterogeneous recycling of minor actinides, oxidic materials containing uranium as main matrix are used as innovative nuclear fuels.
Advanced fuel concepts replace the conventionally used pellets by particles (Sphere-pac or Vipac fuel) [1]. Particle fuels show good swelling behavior and can easily be fabricated. A suitable dustless preparation method is the internal gelation. This wet chemical method is a conversion process which transforms an aqueous colloidal solution sol into a solid gel.
The internal gelation method was used for the particle synthesis during this work. Acid deficient uranyl nitrate (ADUN) and neodymium nitrate solutions were used as precursor, while urea acts as complexing agent and hexamethylenetetramine (HMTA) as gelification agent [2]. Pure uranium oxide and uranium / neodymium oxide microspheres with a variable content of Nd (5 % - 40 %) were fabricated in the framework of the EU project ASGARD [3]. Neodymium is used as surrogate for trivalent actinides, such as americium.
Mass- and size- characteristics of the prepared particles were studied. TG/DSC analyses were performed to investigate the thermal behavior. Finally the particles were thermally treated under reducing conditions at 1300 ℃ and 1600 ℃. The products were investigated by the use of SEM/EDX and X-ray powder diffraction (XRD). Lattice parameter calculations were performed using the XRD data.
The particles, treated at 1300 ℃ showed only one cubic phase, for the whole observed χ(Nd) range. The expected linear behavior according to Vegard's rule was observed for compositions $\chi(Nd) \leq 27.59$ %. The thermal treatment of the particles with compositions $\chi(Nd) \geq 33.49$ % was repeated for 5 hours with a higher temperature (1600 ℃). The expected linear trend could be confirmed and it could be demonstrated that equilibrium solid solutions of the UO2 / Nd2O3 system can be fabricated with the internal gelation synthesizing route.
References
[1] M. Pouchon et al., chapter 3.11 Sphere-Pac and VIPAC fuels, Comprehensive Nuclear Materials, Elsevier Ltd., 2012, p. 275 – 312
[2] J. L. Collins et al. , Radiochim. Acta, 1987, 42: p. 121–134
[3] http://asgardproject.eu/

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