Extensive Characterisation of a Material for understanding its Behaviour as a Nuclear Fuel: the Case of a Zirconia - Plutonia Inert Matrix Fuel.

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Recent developments of an inert matrix fuel (IMF) have led to the selection of yttria stabilised zirconia doped with erbia and plutonia, a $(Pu,Er,Y,Zr)O_{2-x}$ cubic solid solution, at PSI Switzerland. This IMF is foreseen to utilise plutonium in LWR and to destroy it in a more efficient way than MOX. The physical properties of the material depend on the choice of stabiliser as well as on other dopants e.g. burnable poison or fissile material and their influence on the lattice parameter. For the material qualification, relevant fuel properties were considered: fuel and component densities, micro/nano structural studies, thermal conductivity, stability under irradiation, efficient retention of fission products and solubility as key property for the disposal of the spent fuel.

As a consequence of the studies performed so far, a coherent picture is emerging. The suggested zirconia based IMF has a very strong thermodynamic stability as well as a good behaviour under irradiation. Its density and that of its constituents may be calculated from the single component fractions and with the theoretical density derived from the lattice parameter gained by XRD. The local distortions identified by XAS yield decreases of the thermal conductivity. Its measured values for the Pu-IMF were found around 2 W K^{-1} m^{-1} that is somewhat low compared to classical MOX but comparable to $(Gd,U)O_{2-x}$. However, study of cesium, xenon and iodine retention was investigated at the nanoscopic level after implantation, and comparison of results for $(Y,Zr)O_{2-x}$ with that reported for UO_2 shows that their retention is stronger in zirconia. In addition, the low solubility of the non-redox sensitive zirconia IMF makes this fuel material very attractive for a once through then out strategy for plutonium utilisation.

Among others this material has been fabricated by wet and dry routes for irradiation experiments in the Proteus reactor at PSI, in the Petten High Flux Reactor, and in the Halden Reactor.