Fabrication of UO_2-Mo composite fuel candidates with enhanced thermal conductivity from sol-gel feedstock

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Uranium dioxide (UO_2) is the most commonly used fuel in nuclear power plants for energy production. Enhancing the UO_2 performance by increasing its thermal conductivity and its ability to retain fission products will improve operation of the worldwide fleet of light water reactors. Enhancement of thermal conductivity in UO_2 can be achieved by the addition of a secondary phase with a significantly higher thermal conductivity compared to UO_2. The resulting enhancement of the composite fuel will lower the temperature profile of the fuel pellet, thereby reducing the stored energy in the fuel and lowering the extent of fission gas release. Here, Molybdenum (Mo) was chosen as a secondary phase due to its high thermal conductivity, high melting point and moderate neutron absorption cross section. In contrast to common powder processing methods, the UO_3 feedstock was fabricated via an internal gelation route resulting in a microspherical feedstock. In a first attempt the microspherical feedstock was mixed with Mo powder and subsequently pressed into a composite fuel pellet. Further enhancement of the fabrication route enabled the synthesis of UO_3-Mo microspheres. Therefore, Mo powder was added directly to the complexing and gelation agent (HMTA/urea), dispersed well and subsequently mixed with the acid-deficient uranyl nitrate (ADUN) solution prior to the gelation experiment. These feedstocks were utilized to fabricate composite fuel pellets. XRD measurements confirmed the formation of a composite fuel for UO_2-Mo with 5 and 10 vol% Mo. An increase of the thermal conductivity by nearly 30% was measured via laser flash analysis. A reference pellet was fabricated from an ADU powder feedstock, showing a lower increase of the thermal conductivity for the same Mo dopant levels. Future irradiation studies within the MiniFuel project at the Oak Ridge National Laboratory will enable post irradiation examination studies to evaluate the in-reactor performance of this potential composite fuel candidate.