Development of microstructurally-engineered uranium mononitride

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Uranium mononitride (UN) is a promising candidate for accident tolerant fuels because of its high thermal conductivity and uranium density, as compared with uranium(IV) oxide (UO_2). Higher thermal conductivity results in lower fuel centerline temperatures during operation and, thus, lower stored energy of the reactor core. High uranium density results in an increased fission density and, thus, accommodate a greater neutronic penalty from potential accident tolerant fuel claddings. Proposed accident tolerant claddings include stainless steel, Fe-Cr-Al (and derivative alloys), and silicon carbide because of their improved resistance to waterside corrosion as compared to zirconium-based fuel cladding. Despite the aforementioned advantages over UO_2, resistance of UN to waterside corrosion during a cladding breach has been shown to be poor. In particular, UN exposed to high-temperature steam and simulated pressurized water reactor environments has been observed to degrade by rapid pulverization. To reliably deploy UN as a fuel for light water reactors, it is important to develop and assess methods of preventing degradation during such scenarios.

For this study, three concepts developed to control the microstructure of UN to prevent oxidation included: (1) sintering with a more electropositive metal (i.e. cermet), (2) sintering with an oxidation-resistant ceramic (co-sintering), and (3) coating pellets with a corrosion-resistant material, either metal or ceramic. Fabricated composite samples were tested for corrosion resistance in steam using thermogravimetry. Feasibility of concepts to develop microstructurally-engineered uranium mononitride will be discussed with relation to microstructure and resistance to steam oxidation.

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