Corrosion Characteristics Study on Uranium and Its Alloys (U-Nb, U-Zr, AND U-Zr-Nb)

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Abstract

Uranium metal (U) and its alloys, such as U-Zr, U-Nb, and U-Zr-Nb, can be used as fuel in nuclear reactors, especially in research reactors. These fuels have various characteristics, including physical, chemical, mechanical, and corrosion properties. Among these characteristics, fuel corrosion properties play a critical role during the reactor operation, after use, and also during the storage period. Fuel damage due to corrosion is influenced by several factors, such as the concentration of oxidizing agents, the flow rate of corrosive fluids, temperature, and acidity (pH). The corrosion process in uranium metal produces hydrogen gas (H_2), which reacts with uranium to form pyrophoric uranium hydride (UH_3), and uranium oxidation produces UO_2. If the oxidation process continues for an extended period, the uranium metal will be depleted. The corrosion potential (E_{corr}) and corrosion rate (CR) of uranium metal in a passive state do not depend on pH until the pH reaches 7. The corrosion potential increases once the pH exceeds 7 and continues to rise to pH 11. Uranium alloys with low Zr, Nb, or Ru content, when alloyed with Zr and Nb up to 2.5 wt.% and Ru up to 5.0 wt.%, show minimal impact on the corrosion potential (E_{corr}) in the pH range of 4.0–9.0 unless there is a dissolved oxidant. U-Nb alloys with higher Nb content, exhibit greater resistance to corrosion and depleted uranium (without Nb). Under acidic conditions (pH 1.18), U-6Zr-2Nb alloys demonstrate the best corrosion resistance. In demineralized water, U-6Zr-5Nb alloys show the best corrosion resistance, while under basic conditions (pH 11.02), U-6Zr-8Nb alloys exhibit the best corrosion resistance

Keywords

Corrosion, U metal, U-Zr alloy, U-Nb, and U-Zr-Nb.