Background

In principle, uranium hydride may be formed wherever uranium metal comes into contact with water, by reaction of the metal with hydrogen formed by corrosion of the uranium (or other metals in the system):

\[ U + 2H_2O \rightarrow UO_2 + 2H_2 \]
\[ U + 1.5H_2 \rightarrow UH_3 \]

Uranium hydride can be pyrophoric, reacting very vigorously with atmospheric oxygen. Small fires at Argonne & Lawrence Livermore laboratories have been ascribed to corrosion product containing uranium hydride reacting with air.

If further water is present, uranium hydride can also be destroyed by hydrolysis:

\[ UH_3 + 2H_2O \rightarrow UO_2 + 3H_2 \]

The objectives of this work were to examine the formation of uranium hydride across a range of conditions and to determine the rate of reaction between uranium hydride and water. This information, together with determination of the rate of water transport through the storage media, can be used to estimate whether reactive uranium hydride may persist under a given storage regime.

Preparation of Uranium Hydride

Uranium hydride was prepared in two thermogravimetric analysers, under two regimes. In both cases Magnox-grade uranium metal in the form of 5mm cubes was reacted with a continuous flow of hydrogen gas, diluted in argon.

In the first set of trials the simultaneous formation and hydrolysis of uranium hydride was studied by the reaction of uranium cubes with 25% hydrogen in argon containing 400-600ppm water vapour. Hydride formation was carried out across a range of temperatures from 65°C to 160°C. Hydride could be formed at 65°C even in the presence of moderately high levels of oxygen (85-150ppm) and water vapour (1000-5200ppm).

The second set was carried out using a TGA located in an inert-atmosphere glovebox. In both cases Magnox-grade uranium metal in the form of 5mm cubes was reacted with a continuous flow of hydrogen gas, diluted in argon containing 400-6000ppm water vapour. Hydride formation was carried out at temperatures of 10°C to 70°C.

The increase in mass as hydride was formed showed an induction period, where the change in mass was immeasurably small, followed by a gradually increasing rate and then by a gradual decrease in rate as the metal was consumed. The rate profile and absolute rates were completely consistent with literature results for this reaction.

Conclusions

Extrapolation of results obtained using uranium hydride prepared at high temperatures to hydride formed at temperatures more typically experienced during, for instance, uranium fuel storage may need to be carried out with caution.