Plutonium's unusual interactions with clay may minimize leakage of nuclear waste

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As a first line of defense, steel barrels buried deep underground are designed to keep dangerous plutonium waste from seeping into the soil and surrounding bedrock, and, eventually, contaminating the groundwater. But after several thousand years, those barrels will naturally begin to disintegrate due to corrosion. A team of scientists at Argonne National Lab (ANL) in Argonne, Ill., has determined what may happen to this toxic waste once its container disappears.

"We want to be sure that nuclides (like plutonium) stay where we put them," says Moritz Schmidt, an ANL post-doctoral researcher who will present his team's work at the AVS Symposium in Nashville, Tenn., held Oct. 30 – Nov. 4. Understanding how these radioactive molecules behave is "the only way we can make educated decisions about what is a sufficient nuclear waste repository and what is not," he adds.

Plutonium, with its half-life of 24 thousand years, is notoriously difficult to work with, and the result is that very little is known about the element's chemistry. Few labs around the world are equipped to handle its high radioactivity and toxicity, and its extremely complicated behavior around water makes modeling plutonium systems a formidable task.

Plutonium's extraordinary chemistry in water also means scientists cannot directly equate it with similar elements to tell them how plutonium will behave in the environment. Other ions tend to stick to the surface of clay as individual atoms. Plutonium, on the other hand, bunches into nanometer-sized clusters in water, and almost nothing is known about how these clusters interact with clay surfaces.

To better understand how this toxic substance might respond to its environment, the Argonne team examined the interactions between plutonium ions dissolved in water and a mineral called muscovite. This mineral is structurally similar to clay, which is often considered for use in waste repository sites around the world due to its strong affinity for plutonium. Using a range of X-ray scattering techniques, the scientists reconstructed images of thin layers of plutonium molecules sitting on the surface of a slab of muscovite.

What they found was "very interesting," Schmidt says. The Argonne scientists discovered that plutonium clusters adhere much more strongly to mineral surfaces than individual plutonium ions would be expected to. The result of this strong adherence is that plutonium tends to become trapped on the surface of the clay, a process which could help contain the spread of plutonium into the environment.

"In this respect, it's a rather positive effect" that his group has observed, Schmidt says; but, he adds, "it's hard to make a very general statement" about whether this would alter the rate of plutonium leaking out of its repository thousands of years from now.

Schmidt cautions that these are fundamental studies and probably will not have an immediate impact on the design of plutonium-containing structures; however, he stresses that this work shows the importance of studying plutonium's surface reactivity at a molecular level, with potential future benefits for nuclear waste containment strategies.

"This is a field that is only just emerging," Schmidt says.

More information: The AVS 58th International Symposium &

Exhibition will be held Oct. 30 – Nov. 4 at the Nashville Convention Center. Presentation AC+TF-ThA-1, "Plutonium Sorption and Reactivity at the Solid/Water Interface," is at 2 p.m. on Thursday, Nov. 3.

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