Uranium reveals its true nature

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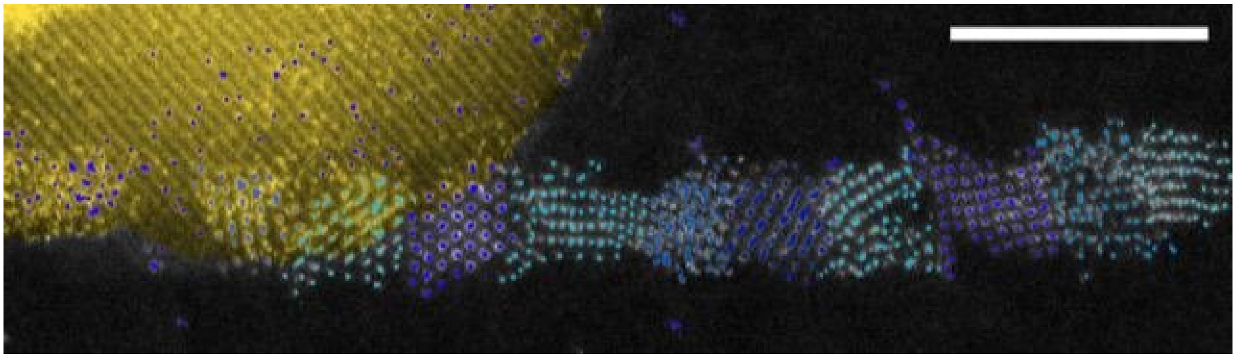

Credit: EPFL/EML

Most people are familiar with uranium as a fuel for nuclear power plants. And while that's the most common application, this element is also used in many other fields, such as dyes, medical devices, and weapons. Scientists at EPFL's Environmental Microbiology Laboratory (EML) have recently made an important discovery about uranium that could have major implications for soil and groundwater remediation as well as radioactive waste management. Their research has just been published in *Nature Communications*.

Uranium is a radioactive heavy metal found in the Earth's crust and in tiny concentrations in water, air, plants and living organisms—humans have small amounts of uranium in their bones. The EML scientists studied the properties of uranium as it occurs naturally in the environment, and made significant breakthroughs in understanding how it goes from one oxidation state to the other, transitioning from a water-soluble compound to a stable mineral.

"At the +6 oxidation state, uranium is mostly soluble and can therefore spread uncontrolled in the environment," says Zezhen Pan, an EML scientist and the study's lead author. "But at the +4 oxidation state, it is less soluble and less mobile. In our research we were able to pinpoint the nanoscale mechanisms of interaction between uranium and particles of magnetite, a magnetic iron oxide, to transition from one oxidation state to the other. We showed the persistence of Uranium at the +5 oxidation state, which is usually considered metastable."

A nanowire structure

Most interestingly, the scientists also identified a molecular phenomenon that occurs during the transformation from the +6 to the +4 oxidation state: they discovered the formation of novel nanowires composed of very small nanoparticles (~1-2 nm) that assembled spontaneously into chains. These chains eventually collapse as individual nanoparticles grow larger.

The scientists were able to view the nanowires—which have a diameter of just 2–5 nm, or 100,000 times thinner than a human hair—thanks to the electron microscopes at EPFL's Interdisciplinary Center for Electron Microscopy (CIME). The identification of the nanowire structure could improve understanding of how radioactive compounds spread in the subsurface at contaminated sites.

"These findings hold a lot of promise because they provide insight into how nanoscale minerals form naturally through interactions at the water-mineral interface," says Rizlan Bernier-Latmani, the head of the EML. "We now have a better understanding of the molecular mechanisms at work for this process."

More information: Zezhen Pan et al. Nanoscale mechanism of UO2 formation through uranium reduction by magnetite, *Nature Communications* (2020). DOI: 10.1038/s41467-020-17795-0

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