

Microbes at work cleaning up the environment

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It may sound counterintuitive to use a microbial protein to improve water quality.

But some bacteria are doing just that to protect themselves from potentially toxic nanoparticles in their own environments, and clean up crews of the future could potentially do the same thing on a larger scale.

A team from Lawrence Livermore National Laboratory, UC Berkeley and Lawrence Berkeley National Laboratory found that bacteria from an abandoned mine excrete proteins that cause metal nanoparticles to aggregate. The bacteria are binding and immobilizing the metals in the nanoparticles and the nanoparticles themselves, which are potentially toxic to the bacteria.

Sulfate-reducing bacteria can cause heavy metals such as zinc (Zn) to precipitate and form nanoparticles. However, these particles are able to move freely because they are so small (typically 2-6 nanometers in diameter) and can redissolve if conditions change.

In the case of the mine bacteria, the researchers showed that the bacteria are causing the nanoparticle aggregation, thereby protecting themselves. When the metal nanoparticles aggregate, they don't move as easily and are less soluble.

Using secondary ion mass spectrometry, transmission electron microscopy and infra-red spectroscopy, the scientists were able to study

whether protein contributes to the formation of densely aggregated nanoparticulate zinc sulfide spheroids.

They also studied whether various amino acids induce rapid aggregation in metal-sulfide nanoparticles.

The answer was yes in both cases.

“This demonstrates an extracellular biomineralization mechanism that is unexpected because it involves the bacteria excreting proteins for nanoparticle aggregation away from the cells,” said Peter Weber, one of the LLNL authors of the paper appearing in the June 15 edition of the journal *Science*.

Weber and LLNL colleague Ian Hutcheon used LLNL’s NanoSIMS (high-resolution secondary ion mass spectrometer) to study the metal-sulfide nanoparticle aggregation in sulfate-reducing bacteria dominated biofilms collected from the Piquette Mine, a flooded system in southwestern Wisconsin.

The team found that organic nitrogen was highly concentrated in all of the zinc-sulfide aggregates, indicating a high protein or polypeptide content relative to inorganic zinc-sulfide minerals. In combination with the other techniques and experiments, the team concluded that the protein caused the zinc-sulfide nanoparticle aggregation.

The researchers conducted experiments guided by known bacterial metal-binding proteins that bind zinc and other potentially toxic metals at cysteine locales. Cysteine is a sulfur-containing amino acid. Amino acids are the building blocks of proteins.

The researchers found that inorganic aggregation of zinc-sulfide initially occurred rapidly to 100-nanometer diameter aggregates but then slowed

or ceased after one week. However, zinc-sulfide nanoparticles in the presence of cysteine displayed more extensive and prolonged aggregation, accumulating up to 1-10 micron (1/1000th of a millimeter)-sized structures.

“Potentially we can use cysteine or cysteine-rich polypeptides or proteins for nanoparticle clean up,” Weber said. “With the boom in nanoscience, people are naturally asking questions about the potential environmental impacts. Here, we see that naturally produced nanoparticles can be naturally controlled.”

Source: Lawrence Livermore National Laboratory

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