Is nanosilver toxic?

February 28 2013

According to Finnish-Estonian joint research with data obtained on two crustacean species, there is apparently no reason to consider silver nanoparticles more dangerous for aquatic ecosystems than silver ions. The results were reported in the journal *Environmental Science and Pollution Research* late last year. Jukka Niskanen has utilized the same polymerisation and coupling reactions in his doctoral dissertation.

For his doctoral dissertation Niskanen has been studying several hybrid nanomaterials, i.e. combinations of synthetic polymers and inorganic (gold, silver and montmorillonite) nanoparticles. He will defend his doctoral thesis at the University of Helsinki in April.

Part of the magic of nano-science is that on the scale of a billionth of a metre, matter and materials behave in ways that are not yet known. Neither is it always known what types of effects the nano version of the parent matter will have on its environment.

"Due to the fact that silver in nanoparticle form is bactericidal and also fungicidal and also prevents the reproduction of those organisms, it is now used in various consumer goods ranging from wound dressing products to sportswear," says Niskanen from the Laboratory of Polymer Chemistry at the University of Helsinki, Finland.

While the usefulness of silver has been established, the debate over the toxicity mechanisms of its various forms to microorganisms but also to non-target species continues. Anne Kahru, Head of the Laboratory of Environmental Toxicology at the National Institute of Chemical Physics

and Biophysics, Estonia, talks about a whole new field of ecotoxicology: nanoecotoxicology.

So far, little is known about the environmental effects of silver nanoparticles and their toxicity to aquatic organisms. A joint study from the University of Helsinki and the National Institute of Chemical Physics and Biophysics (Tallinn, Estonia), "Toxicity of two types of silver nanoparticles to aquatic crustaceans *Daphnia magna* and *Thamnocephalus platyurus*", shows that silver nanoparticles are apparently no more hazardous to aquatic ecosystems than a water-soluble silver salt. The study compared the ecotoxicity of silver nanoparticles and a water-soluble silver salt.

"Our conclusion was that the environmental risks caused by silver nanoparticles are seemingly not higher than those caused by a silver salt. However, more research is required to reach a clear understanding of the safety of silver-containing particles," Niskanen says.

Indeed, silver nanoparticles were found to be ten times less toxic than the soluble silver nitrate – a soluble silver salt used for the comparison.

The bioavailability of silver varies in different test media

To explain this phenomenon, the researchers refer to the variance in the bioavailability of silver to crustaceans in different tested media.

University lecturer Olli-Pekka Penttinen from the Department of Environmental Sciences of the University of Helsinki goes on to note that the inorganic and organic compounds dissolved in natural waters (such as humus), water hardness and sulfides have a definite impact on the bioavailability of silver. Due to this, the toxicity of both types of

tested nanoparticles and the silver nitrate measured in the course of the study was lower in natural water than in artificial fresh water.

The toxicity of silver nanoparticles and silver ions was studied using two aquatic crustaceans, a water flea (*Daphnia magna*) and a fairy shrimp (*Thamnocephalus platyurus*). Commercially available protein-stabilised particles and particles coated with a water-soluble, non-toxic polymer, specifically synthesised for the purpose, were used in the study. First, the polymers were produced utilising a controlled radical polymerisation method. Synthetic polymer-grafted silver particles were then produced by attaching the water-soluble polymer to the surface of the silver with a sulfur bond.

Jukka Niskanen has utilised such polymerisation and coupling reactions in his doctoral dissertation, Polymeric and hybrid materials: polymers on particle surfaces and air-water interfaces, studying several hybrid nanomaterials, i.e., combinations of synthetic polymers and inorganic (gold, silver and montmorillonite) nanoparticles. Niskanen will defend his doctoral thesis in the field of polymer chemistry at the University of Helsinki in April 2013.

It was previously known from other studies and research results that silver changes the functioning of proteins and enzymes. It has also been shown that silver ions can prevent the replication of DNA. Concerning silver nanoparticles, tests conducted on various species of bacteria and fungi have indicated that their toxicity varies. For example, gram-negative bacteria such as *Escherichia coli* are more sensitive to silver nanoparticles than gram-positive ones (such as *Staphylococcus aureus*). The difference in sensitivity is caused by the structural differences of the cell membranes of the bacteria. The cellular toxicity of silver nanoparticles in mammals has been studied as well. It has been suggested that silver nanoparticles enter cells via endocytosis and then function in the same manner as in bacterial cells, damaging DNA and hindering cell

respiration. Electron microscope studies have shown that human skin is permeable to silver nanoparticles and that the permeability of damaged skin is up to four times higher than that of healthy skin.

More information: link.springer.com/article/10.1 … 07/s11356-012-1290-5

Provided by University of Helsinki