Press release

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ETH/Empa Team awarded «Best Paper 2007» in Environmental Sciences field

How metal-containing nanoparticles can stress cells

Every year the scientific journal «Environmental Science & Technology» selects the best scientific works in the fields of environmental science, technology and policy from the over 1200 papers it publishes. The chosen works are those "expected to have a significant and long-lasting impact on the field", as the editors write in the April edition of the journal. This year a cooperative project between Empa and the ETH Zurich has been honored as the best work in the environmental sciences category. In their paper the researchers describe the mechanism by which metal-containing nanoparticles can cause oxidative stress in human lung cells.

There is hardly another technology which has over the past few years found such a wide range of applications and been so talked about as nanotechnology. From developments such as more powerful, non-deletable magnetic data storage devices through ultra light and yet robust sports equipment all the way to functional textiles, they all have nanotechnology to thank for their existence. But how safe is this new technology? Which applications are harmless, which demand more caution in their use?

In addition to developing novel «Nano» materials with improved properties, Empa and the ETH Zurich, in partnership with various other research institutions, have also been investigating the possible dangers associated with the new technology, primarily resulting from the release of free, "long-lasting" nanoparticles. The most important questions to be answered are those such as "What effects do nanoparticles have on human and animal cells and tissue and what happens when they are ingested?"

The more reactive the nanoparticles, the stronger the cells react

On of the most popular "guinea pigs" used in toxicological investigations are cell cultures, which are exposed to various chemical substances, or – in this case – nanoparticles. In a test using human lung cells the team of scientists from the ETH Zurich and Empa came across a mechanism by which metal-containing nanoparticle were able to "stress" cells, and in doing so obtained the first indications of which properties of some nanoparticles make them potentially dangerous to cells.

Inflammation reactions and other cell damage frequently begin with "oxidative" stress, an over-production of reactive oxygen compounds including, for example, so called free radicals or peroxides. These substances can damage cellular proteins and DNA. For this reason the research team investigated different types of

metal-containing nanoparticles which are used as catalysts in various chemical reactions and which in their catalytic activity are in some cases significantly different, such as titanium oxide, cobalt oxide and manganese oxide particles.

The experiments showed that catalytically active nanoparticles such as cobalt oxide and manganese oxide cause significantly more stress to the cells than inert titanium dioxide particles do, the latter having hardly any effect on them. It seems that it is primarily the chemical composition (and therefore the chemical reactivity) of the nanoparticles which makes them dangerous to cells. Should this suspicion be confirmed, according to Empa scientists Peter Wick, “this could give us a sort of priority list showing which particles first need to be examined more closely.”

A Trojan horse on the nanometer scale

Astonishingly, water-based solutions of manganese or cobalt salts would have been significantly less damaging to the cells, since the cell membranes protect them from dissolved heavy metal ions. When the cells are exposed to comparable nanoparticles containing cobalt or manganese, however, they produce up to eight times more reactive oxygen compounds. Nanoparticles therefore seem somehow to “smuggle” the catalytically active metal oxides into the cells, where they then cause oxidative stress. For this reason researchers liken them to a Trojan horse.

The development of safe and sustainable «Nano» applications lies at the core of both the basic and applied research conducted at the ETH Zurich and Empa. “In the long term, we can only take advantage of the enormous benefits to be derived from nanotechnology if we perform a risk and sustainability analysis in parallel to every new development,” says ETH scientist and leader of the study group Wendelin Stark. “In this context interdisciplinary collaboration such as here between the ETH Zurich and Empa takes on a key role by allowing us to combine know-how from various scientific fields.”

The next step for the Empa researchers is to address the question of how the human immune system reacts to nanoparticles. In a research project which began at the start of 2008 and is supported within the EU 7th Framework Program, scientists from eleven European countries and American laboratories are investigating the effects of nanoparticles on T and B cells or macrophages, the defense cells of the immune system. They also aim to establish cultures consisting of complex tissue systems, which will provide them with a more realistic estimation of the dangers posed by nanomaterials than pure cell cultures can.

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The award winning paper can be downloaded at:
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