Carbon nanotubes and the environment

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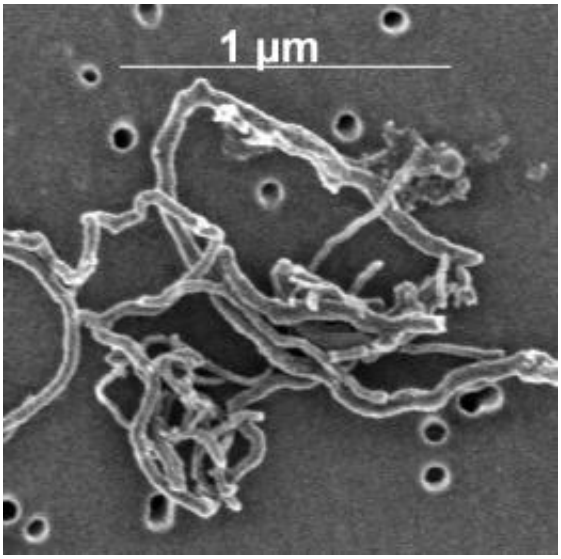

Atomic force microscope image of carbon nanotubes on a nuclear track filter membrane. Apart from the nanotubes, the 50 nanometer sized filter pores are clearly visible (image: E. Christalle).

Carbon nanotubes have made a meteoric career in the past 15 years, even if their applications are still limited. Recent research results show that - apart from their favorable mechanical and electrical properties - they also have disadvantageous characteristics.

One aspect which has rarely been considered so far is now addressed by researchers of the research center Forschungszentrum Dresden-Rossendorf, Germany. “If the application of products and commodities containing carbon nanotubes will increase in the future, then there will

be a higher probability for the tubes to get into the environment during their production, usage or disposal, to be distributed there, and to bind pollutants such as heavy metals on their way trough the environment", says Harald Zaenker, scientist at the FZD.

Via water into the environment

An important way for carbon nanotubes of getting into the environment is the way via the water. In their original state, the flimsy carbon fibers with a diameter of less than 50 nanometers are hardly water-soluble. At first glance, they should therefore not be mobile in groundwater, lakes etc., i.e. they should rapidly settle or deposit. However, carbon nanotubes are able to form colloidal solutions if their surface structure is changed. Changes in the surface structure can be brought about deliberately during the production of the tubes or can be induced by natural processes if the tubes are released into the environment.

A colloidal solution, unlike a true solution of water-soluble substances, is a solution in which the apparently dissolved substance is finely dispersed in the solvent forming tiny particles. These particles are still much bigger than the molecules of a dissolved substance in a true solution. As colloids, carbon nanotubes might be transported anywhere in environmental waters. It is known meanwhile that the tubes can even penetrate cell walls and, thus, might theoretically be able to enter also animal or human cells. In addition, changes in the surface structure of carbon nanotubes cause another effect: their capability to bind heavy metals is increased.

Tubes with changed surface

The scientists investigated carbon nanotubes both in their original state and in a state changed by oxidizing acids (such as a mixture of nitric and

sulfuric acid). They found out that solutions of treated carbon nanotubes scatter light more strongly. “This is an indication that colloids have formed which do not settle”, Harald Zaenker says. The researchers provided evidence for the first time that the heavy metal uranium, which is ubiquitous in the environment and, hence, also in the water, is particularly attached to the surface of treated carbon nanotubes. The scientists found out that the uranium uptake capacity is increased by an order of magnitude in comparison to untreated carbon nanotubes. “Therefore, it is plausible to assume that carbon nanotubes, if released to the environment, influence the transport of uranium in environmental waters and even in biological systems. The possible impact on the environment and on human health has in general been considered too little”, Harald Zaenker says.

On the other hand, the high bonding capacity of carbon nanotubes for uranium and other heavy metals also suggests using them for the removal of heavy metals from waters. However, they are not yet a cost-efficient alternative to classic water purifiers, Zaenker says. “Eventually, it is important to further study the behavior of carbon nanotubes in waters”, the scientist says. “Only then can the positive and negative aspects of carbon nanotubes be better assessed.”

More information: A. Schierz, H. Zaenker: *Aqueous suspensions of carbon nanotubes: surface oxidation, colloidal stability and uranium sorption*, Environmental Pollution 157, 1088 - 1094 (2009). DOI:10.1016/j.envpol.2008.09.045

Source: Forschungszentrum Dresden Rossendorf