Nanotechnology: Benefits and Risks

A Challenge for Occupational Safety

Dr. Thomas Brock, Germany, gives an overview on nanotechnology for the readers of ISSA Mining's site, on its use in the industry and effects on the worker's health from todays point of view.

Man had been exposed against chemical substances for all times. He was breathing the air earth provided and this air contained gases, fumes and airborne solids—and it still does. Among these airborne solids always have been very small scale dusts well below the range of visibility. In nature these dusts are produced by volcanoes or all kinds of fires, e. g. Man has been producing this kind of materials too, most of the time being unaware of the formation.

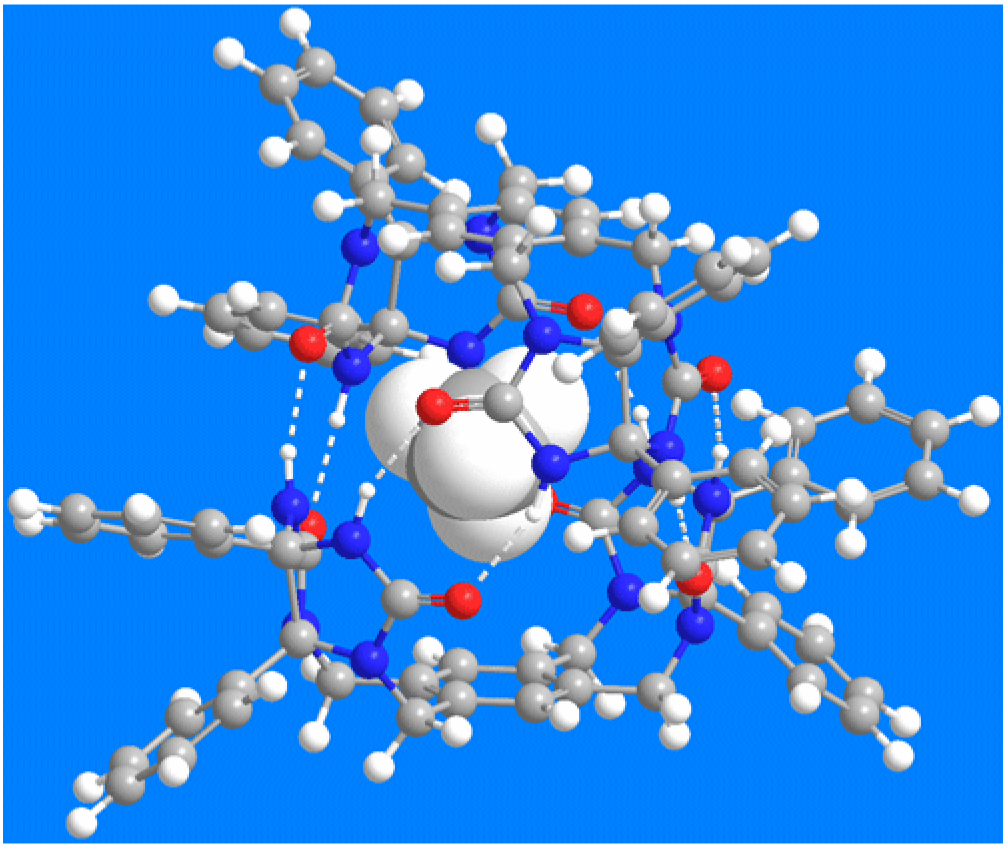
Baking bread means that huge amounts of particles are released from the oven, producing the beautiful dark-red coloured stained glasses in medieval times meant performing a reaction in the molten glass forming clusters $Au_{n\ (n\sim100)}$ of gold atoms, welding produces a broad range of particles, a lot of them in the nanometer scale. So the production of man made nanoparticles is not exactly to be called new, also the application of nanotechnology—although unrealised–started at least hundreds of years ago.

These small scale solids are categorised using the dimensions. One category is dealing with particles, fibres and plates in the range of some nanometers. These *nanoobjects* show at least one dimension on a scale of length between 1 nm and about 100 nm. Nanostructures can also be attached to surfaces or can be embedded in macroscopic structures, e. g. as pores in polymer foams. When nanoplates (only one dimension below 100 nm) like graphene—single-layered structures of carbon atoms with interesting semiconducting properties—and nanofilms on surfaces are of less concern to occupational safety, the fibre-like structures (two dimensions below 100 nm) like nanotubes and nanoparticles (all three dimensions below 100 nm) are in the focus of interest, because they can easily become airborne and—theoretically—can penetrate the skin.

So these types of nanomaterials are prone to yield higher levels of exposure. Exposure can occur when preparing the nanomaterials, but can also be shown to play a role in processing them in the down-stream use. A second source of exposure is the formation of nanoobjects (typically nanoparticles) in many kinds of technical processes, but also in everyday life. This on one side includes technical processes like grinding, welding or combustion, on the other side so common ones like baking, lighting a candle or smoking (the latter hopefully not so common any more).

Additionally, there is concern that after application of modern “nano-labelled” products like sealing agents to high performance surfaces e.g. of stones might lead to a re-release of nanoparticles during processing. This effect does not seem to play a significant role according to current knowledge. Not much is known about the formation of nanoparticles during other processes in the natural stone industry but the release of quartz dust seems to be the dominating problem in comparison.

One effect has to be into consideration. Free nanoobjects tend to be quite unstable. Very rapidly they start clinging together to form aggregates or agglomerates, that are fine dusts but no nanoparticles any more. This rapid process is even sped up with other particles (dust particles e. g.) around working as nuclei for this process. On the other hand nanoparticles can function as carriers for airborne toxic substances.



A new dimension of problem awareness has come up during the last few years. With more and more designed nanoobjects, the number of new patents exploding and applications pushing on the markets, public awareness turned to the effects of nanotechnology on human health and the environment.

At this point the dichotomy of nanotechnology becomes clearly visible: Nanotechnology is one of the —if not the—key technologies of the 21st century. The benefits are clearly visible, starting with simple amenities like shoe leather that does not get soaked with oily dirt and keeps clean for quite a long time, serving the environment with new systems for energy generation and storage or providing new means of cancer treatment with ferromagnetic nanoparticles that can heat tumours from inside the tumour tissue by coupling these nano-scaled antennae with an electromagnetic field.

The label "Nanotechnology"—still—has a positive connotation for consumers. Some nanomaterials are high-production volume substances, titanium dioxide (sun blockers), carbon black (tyres) or silicon dioxide (polymers, ketchup), e. g. Others are to be produces in higher volumes. A good example are the carbon nanotubes, which have developed from laboratory curiosities to several tons per year products. Other nanomaterials still are in the state of research and development but have the potential to become big sellers.

But there is the other side of the coin: we still do not know enough about the effects on the environment and on human health in particular. A lot of toxicological research has been done and is still going on, but the results are difficult to interpret, even sometimes inconclusive. Without dispute there are effects in organisms with inhaled nanoobjects, starting in the lungs but tend to become systemic due to the effect of translocation due to the small dimensions. Whether these effects are to be classified as adverse effects is still in discussion. Also the ability to penetrate skin has to be clarified, so far the results from tests are not conclusive. But there is no evidence for workers form facilities producing nanoobjects for years to be statistically more imperilled. So the call for a moratorium seems to be unreasonable, but occupational safety faces the challenge to take measures derived from incomplete knowledge.

Research and development in nanotechnology has to be improved. We need to define the metrics to cope with the hazards and better measurement equipment. Toxicology has to face the problem that an incredible number of standard tests is laying ahead of it due to the fact, that an enormous amount of different nanomaterials (differing in their chemistry, physics, morphology, impurities, coatings, enclosed or absorbed substances, zeta potentials …) has to be characterised well and tested. So a better approach to cope with this problem is needed urgently. REACH covers nanomaterials too, and here meaningful test results are required in due course, if not very soon.

As far as we know our well established repertoire of measures is sufficient to cope with this challenge without risking workers health. Closed systems, good ventilation, respiratory protection (2 or 3) and gloves can reduce the exposure by magnitudes. The strategy is the minimisation of exposure as low as reasonably possible. Several papers and guidelines on these topics have been published.

So it is possible to use this fascinating and valuable technology, but this has to be done with great care and expert knowledge.