Nanotechnology

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DRAFT: Nanotechnology: Health and Environmental Risks of Nanoparticles– Research strategy –

The extensive and logically structured report examines what research is needed to support the risk regulation of nanotechnologies. Attention is restricted to poorly soluble, engineered particles that may be encountered during manufacture or as free particles in a product and which have the potential to persist once in the body. In our view, a significant absence from the plan is the understanding of the mode of action of the nano particles; i.e. those actions which make them commercially exploitable.

It confirms that none of the current risk control regulations in Germany include specific accommodation for size-specific effects. Risks are dealt with on a CAS number basis [a system which deals with atomic composition only] even when the only point of adding the material to a product is that it is nano sized e.g. silver biocides. The same situation pertains in the UK, though the authorities do have powers to respond in case of adverse events.

The research needs identified are based entirely on classical toxicology and exposure assessment concepts e.g. surface area, bio persistence, surface reactivity, stereochemistry. There is no mention of risk assessment for the intended property or action of the nano engineered product. The rationale is based on passive properties.

Research needs identified:

Physical/ chemical:
Particle size and size distribution, solubility, agglomeration state (before and after introduction to the body presumably), shape, crystal structure, surface physical characteristics, surface chemistry, charge and porosity.

Cell-free:
in vitro studies to provide information on bio persistence in biological media, interaction with proteins, activation of the complement system [part of the immune system] and induction of oxidative stress.

cellular systems:
to provide information, for instance, on the translocation of the particles, genotoxicity and the biological mechanism of action in cells of the portal of entry and systemic target organs.

In *in vivo* studies:
the toxic reactions at the portal of entry or at the inner organs after single and repeated exposure and information on inflammatory and fibrogenetic reactions, oxidative stress and cell proliferation. Furthermore, information is needed on deposition, intake into the blood circulation, toxicokinetics, toxicodynamics and biopersistence.

Studies of lung reactions:
e.g. oxidative stress and cell proliferation. Determination of acute phase proteins and coagulation factors to provide insights into the effects on the cardiovascular system.

Distribution:
of nanoparticles in the human organism (as a function of route of entry).

The monitoring of workplace exposure and epidemiological studies on the effects of nanoparticles are other important areas of research.

All the above need to be measured as a function of particle size and, arguably, surface finish.

Silicon dioxide and zinc oxide are singled out for special attention; they are already in widespread use.

The environmental end points also need to be studied. For example, what becomes of nano scale food additives? How do they fare in the sewage treatment process, should they be permitted back into agriculture via sewage sludge?

Comment

The report confirms high degree uncertainty over nanoparticle toxicological properties. This doesn't mean the technology must be harmful. Current knowledge tends to support the application of soluble nanoparticles and those which are permanently included in macroscopic media.

Absent from the proposals is the development of understanding as to why the nanoparticles have the desirable commercially exploitable properties that they do. Also, what toxic properties are specific to those desired modes of action? As nano particles are processed by the body, how will those properties change and will they become more, or less, problematic? If the regulator doesn't deal with the active properties of the technology he will always be assuming that it is only the passive properties that determine toxicity. This approach is consistent with the current approach to toxicology but is not guaranteed to lead to successful regulation. For example, a virus may contain inherently toxic properties e.g. a specific protein that interferes with nerve action, but no-one would risk assess the virus as if it were not capable of wider modes of action [e.g. to trigger cell wall disruption] than just delivering those chemicals to the body.

For example, some nano particles have size-specific optical properties e.g. silicon dioxide. These properties, apart from being directly useful as e.g. sun screens or tracers, also make them able to convert light energy into chemical energy with potentially destructive consequences. As the particles decompose in the body the optical properties could, predictably (a normal result of quantum physics), shift to higher energies with greater potential to cause damage. If the regulator doesn't ask how the particle achieves its aim it will fail to test the effect of light on the observed toxicological properties; they will be in the dark.
As nanotechnology becomes more sophisticated, the need to assess mode of action will become more apparent.