Challenges in Nanotechnology : Health Hazards

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From an historical point of view, the beginning of nanotechnologies is generally situated around Feynman's 1959 talk: "there's plenty of room at the bottom". Although electronic miniaturization began in 1965, the break through occurred in 1981 with the scanning tunnelling microscope (STM), an observation and manufacturing instrument. This paper introduce the development of nanotechnology and material engineering with the concept of molecular nanotechnology.

APOCALYPTIC GOO: PERILS IN NANOTECHNOLOGY

Eric Drexler, the man who introduced the word nanotechnology, presented a frightening apocalyptic vision -- self-replicating nanorobots malfunctioning, duplicating themselves a trillion times over, rapidly consuming the entire world as they pull carbon from the environment to build more of themselves. It's called the "**grey goo**" scenario, where a synthetic nano-size device replaces all organic material. Another scenario involves nanodevices made of organic material wiping out the Earth -- the "**green goo**" scenario. Need we be afraid of nanotechnologies? Risk management must go hand in glove with progress. There must be a reasoned acceptance of nanotechnologies. What are the challenges that have to be met? Potential risks for health and the environment? The basis of knowledge of nanoparticle toxicity is different from conventional chemical toxicity. Size determines the rules of penetration and settling into cells, directs the mechanisms of nanoparticle internalisation in cells, migration in the cytoplasm and the nucleus, even passing through the hematoencephalic barrier. The significant reactivity of nanoparticles produces a negative impact at a biological level. It is no longer the toxicity of the particle itself which must be taken into account, but that which it conveys. The combination of these effects with the biopersistency of particles those are difficult to detect via global analyses risks provoking, at cell level, a loss of function, hyperactivity or a disruption in their cycle. Such abnormal cellular responses can bring about an inflammatory reaction which, when it persists and is self-maintaining, is liable to engender fibroses and cancers. Nanoparticles, in particular those of carbon and titanium dioxide, have a high degree of penetration in the respiratory apparatus and the capacity to pass through cellular membranes. The residues and additives used to produce them also represent a toxicity risk.

Nanotechnology : Risks and Hazards

Nanoparticles are likely to be dangerous for a multiple of reasons:

1. Nanoparticles may **damage the lungs**. We know that 'ultra fine' particles from diesel machines, power plants and incinerators can cause considerable damage to human lungs. This is both because of their size (as

they can get deep into the lungs) and also because they carry other chemicals including metals and hydrocarbons in with them.

2. Nanoparticles can get into the body through the **skin, lungs and digestive system**. This may help create 'free radicals' which can cause cell damage and damage to the DNA.

Nanotechnology : Dangers |Roadmaps

The danger of contact with nanoparticles is not just speculation. As more research is undertaken, concerns increase. Here are some of the recent findings:

- some nanoparticles cause lung damage in rats. Several studies have shown that carbon nanotubes, which are similar in shape to asbestos fibres, cause mesothelioma in the lungs of rats (see below)
- other nanoparticles have been shown to lead to brain damage in fish and dogs
- a German study found clear evidence that if discrete nanometer diameter particles were deposited in the nasal region (in rodents in this case), they completely circumvented the blood/brain barrier, and travelled up the olfactory nerves straight into the brain
- inhaled carbon nanotubes can suppress the immune system by affecting the function of T cells, a type of white blood cell that organises the immune system to fight infections.
- A US worker is reported to have developed an acute allergy as a result of exposure to nanomaterial containing nickel, a known sensitizer. The 26-year-old chemist was unaware that she was working with nickel nanoparticle powder at work and no arrangements were made to protect her from exposure.
- It has been suggested that nanomaterials that have photocatalytic activity may have a greater potential to cause inflammation because the particle becomes more reactive when exposed to light.
- Because elements at the nanoscale behave differently than they do in their bulk form, there's a concern that some nanoparticles could be toxic. Some doctors worry that the nanoparticles are so small, that they could easily cross the **blood-brain barrier**, a membrane that protects the brain from harmful chemicals in the bloodstream.
- Nanoparticles : As hazardous as asbestos? A major study published in *Nature Nanotechnology* in May 2008 suggested some forms of carbon nanotubes could be as harmful as asbestos if inhaled in sufficient quantities. The study used established methods to see if specific types of nanotubes have the potential to cause mesothelioma. The results show that long, thin multi-walled carbon nanotubes that look like asbestos fibres, behave like asbestos fibres. The study shows there is strong evidence that if carbon nanotubes get into the wrong place, they can cause mesothelioma.

Nanotechnology : Remedial

✓ A newer publication: *Safe Sunscreen Guide* - gives brand information to choose nano-free sunscreens. This year's guide lists 25 sunscreen brands that are actively avoiding use of nanoparticles in their products. There is also a list of 16

nano-free secondary sunscreens (moisturizers, anti-ageing creams and mineral foundations).

- ✓ An ever-increasing number of consumer products contain silver nanoparticles (cling wrap, refrigerators, washing machines, socks, tooth paste, 'Band Aids', vacuum cleaners, disinfectants). In fact, according to the consumer products inventory hosted by the Woodrow Wilson Center for International Scholars' Project on Emerging Nanotechnologies, nanosilver may be the most common nanomaterial now used in consumer products. In response to growing concerns about the toxicity risks of nanosilver, Friends of the Earth Australia has prepared a detailed background paper on which outlines the threat of nanosilver to soil, water and human health. The paper also discusses regulatory issues surrounding the use of nanosilver and reviews the toxicological literature.

The scientific community still does not have a good understanding of all of the health effects likely to arise from exposure to different types of engineered nanomaterials. Knowledge gaps exist in key areas that are essential for predicting health risks such as routes of exposure, the way nanomaterials are taken up into the body, the way nanomaterials are transported once inside the body and the ways in which nanomaterials interact with the body's biological systems. Although work is underway that will help to fill these knowledge gaps, the range of nanomaterials for which comprehensive hazard data are available and will be available in the foreseeable future is very narrow. Given the wide diversity of nanomaterials and observations that different nanoforms with the same chemical composition can have different toxicological properties, it likely that new approaches that do not rely on conventional toxicity testing approaches will need to be found to assess the hazards of nanomaterials.

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