Policy on Nanotechnology

Introduction

Nanotechnology is a word describing a collection of technologies which enable manipulation of materials at the nanoscale, that is, nanostructures, which are at the atomic scale between 1 and 100 nanometres in one of their dimensions. A nanometre is one millionth of a millimetre.

Nanotechnology reaches back to the late 19th century, when colloidal science first took root. Although not referred to as nanotechnology at the time, many of these same techniques are used today to synthesize nanometer-sized materials.

The term "nanotechnology" was defined by Tokyo Science University Professor Norio Taniguchi in a 1974 paper (1) as follows: "Nano-technology …. consists of the processing of, separation, consolidation, and deformation of materials by one atom or one molecule."

Health aspects

Many products of nanotechnology pose no threat to human health; for example, 'fixed' nanostructures on the surface of glass to make it 'self-cleaning' (see *nanostructure types* below). However, Doctors for the Environment, Australia (DEA) has concerns about some particles, namely the 'free' nanoparticles, which are potentially hazardous to health. This is apart from any hazards to health from the application of the science to military weaponry.

It has been known for many decades that inhaled particles of many sorts cause damage to the lungs and to the lining of arteries. Recent research has shown that most of the damage appears to be caused by the smallest particles. The toxicology of insoluble particles in bulk (coarse) form on living systems is well understood. However, when such particles are made into very small particles of a few hundred atoms, it leads to changes in their physical and chemical properties. Apart from their smaller size, they may also become electrically charged and chemically reactive, because of changes in their surface chemistry: an example of this is heterogeneous catalysts made from inert materials such as gold and platinum. Understanding how this new nano-particulate surface chemistry reacts with the 'wet' biochemistry of living organisms is in its very early stage.

Most nanoparticles in the environment come from diverse human activities. These include naturally-occurring diesel smoke, candles, cooking stoves and wood smoke, as well as industrial sources such as power plants and cement kilns. Some manufactured nanoparticles may or may not be more reactive or toxic than nanoparticles from natural sources, as they can be designed with a specific action in mind.

The spectrum of biological problems associated with exposure to nanoparticles has a large range. It extends from their ability to induce acute inflammation, through to cell death by membrane disruption by lipid peroxidation and other mechanisms. Free nanoparticles seem to be able to travel through the body using pinocytotic mechanisms similar to those employed by viruses. Regions of the body which have evolved special protection mechanisms, such as skin and the blood-brain barrier, may be unable to resist nanoparticle ingress. This is a major concern.

Nanostructure Types

In describing nanostructures we need to differentiate between the number of dimensions of the nanoscale. **Nanotextured surfaces** are **one** dimension on the nanoscale, i.e. only the thickness of the surface of an object is between 0.1 and 100 nm. **Nanotubes** are **two** dimensions on the nanoscale, i.e., the diameter of the tube is between 0.1 and 100nm; its length could be much greater. Finally, **spherical nanoparticles** are **three** dimensions on the nanoscale, i.e., the particle is between 0.1 and 100 nm in each spatial dimension. The terms nanoparticles and ultrafine particles (UFP) often are used synonymously, although UFP can reach into the micron range.

Nanoparticles are used in two main types of structural formats, ‘fixed’ and ‘free’:

(1) ‘fixed’, where nanoscale particles are incorporated on to a substance, material or device, or where a surface may be etched at the nanoscale;

(2) ‘free’, where at some stage in production, or usage, individual nanoparticles of a substance are present and mobile.

Regulation of Nanoparticles

Some products on the market already contain nanoparticles, including cosmetics. In Australia, the National Industrial Notification and Assessment Scheme (NICNAS) undertook in February 2006 a voluntary call for information to obtain an indication of the extent of nanomaterial use in industrial chemicals (excluding cosmetics) in the nation (2). This showed that the bulk production of a number of nano-powders, although relatively small, has already commenced on an industrial scale.

The fact that prior licensing of a particulate material at sizes larger than the nanoscale already exists, should not be seen as a good enough reason for allowing the same material to be untested at the nanoscale.

DEA considers that nanoparticles developed for commercial use should be regulated separately, and permits should be issued only after relevant hazard assessments, including disposal of waste in solid, gas and liquid form, have been satisfactorily completed.

Technology to measure nanoparticle wastes is in its infancy, and research needs to be supported to develop these tools.

This is seen to be an urgent requirement.

The Future

DEA calls upon, and supports, government regulators to continue enquiries at depth.

DEA sees the need to develop appropriate legislation to ensure adequate risk assessments are put in place before licensing any products which contain free nanoparticles.

DEA also supports the work of NanoSafe Australia (3), a network of researchers with interests in nanotechnology, which encourages and co-ordinates some of the research effort directed towards environmental and occupational health issues, and maintains links with overseas research programs.

In Summary

Nanoparticles are physical structures of a size scale at, or below, 100 nm.

They have potentially harmful effects on human life.

The processes of manufacture of nanomaterials, and the resulting products for human use, require monitoring and regulation by legislation.

DEA supports efforts by government and non-government agencies to protect human and environmental health from nanoparticle threats.

Written by Dr Don Reid

References

(1) N. Taniguchi, "On the Basic Concept of 'Nano-Technology'," Proc. Intl. Conf. Prod. Eng. Tokyo, Part II, Japan Society of Precision Engineering, 1974.

(2) See report in NICNAS Information Sheet, January 2007: www.nicnas.gov.au

(3) Their URL is: www.rmit.edu.au/rd/nanosafe

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