Should we worry about nanomaterials?

- Nanomaterials contain particles which are smaller than 100 nanometres (0.0000001 metres) across.
- Their size means they often possess very different properties from the same materials in "bulk", which can make them useful in a wide variety of applications.
- There are many examples of naturally-occurring nanomaterials, such as those found in smoke and certain fried foods.
- Nanoparticles of silver and gold have been used since the time of the Romans to improve the appearance of vases and glass.
- Increasingly, they are also being designed and manufactured for use in a wide range of applications, from medical imaging to rubber tyres to electronics.
- Because of their extremely small size, some people worry that nanomaterials may be able to enter parts of our bodies which were not intended (such as the brain) with the potential to cause harm.
- There is currently no legislation aimed specifically at regulating nanomaterials but they are listed in additions to some existing regulations.

What are nanomaterials?

Nanomaterials contain particles which are smaller than 100 nanometres across. Examples range from the DNA molecule (which has a diameter of 2-3 nm) to the 'flu virus (100 nm). For comparison, a human hair is about 75,000 nm thick.

There are many naturally-occurring nanomaterials, such as smoke particles and in fried foods, and they are also commonly produced in car exhaust fumes, forest fires and some industrial processes. The fine blobs of oil in mayonnaise and the clumped-together molecules of a protein (casein) in milk are also nanomaterials, and give these products their opaque (cloudy) appearance.

Nanomaterials often have very different properties compared with the same material in 'bulk' – just as a snowball is very different from the snowflakes that formed it. Nanomaterials may look different, have different electrical and magnetic properties, and may be more reactive than their larger counterparts.

Did you know?

The prefix 'nano-' comes from the Greek nanos (νανος), meaning dwarf.

Why are we interested in nanomaterials?

Nanomaterials have been used since the time of the Romans, who added nanoparticles of gold and silver to glass to give their bowls and vases a metallic sheen; however, it is only recently that nanoparticles have been deliberately manufactured.

Carbon nanoparticles (known as "carbon black") are used to strengthen the rubber in tyres and give black inks and leather their colour. These nanoparticles are manufactured on a multi-ton scale in a well-established process.

Aside from these large-scale processes, nanomaterials have attracted interest from scientists because of their potential use in advanced materials with a wide variety of applications:

- Nanomaterials are an important topic of research into the next generation of **solar cells**. The small size of nanomaterials often means they have a very high surface area, which can be used to absorb more sunlight than the thin films currently used. Some nanomaterials also have high electrical conductivity, which could allow them to replace the expensive silicon crystals currently used in solar cells at a fraction of the cost.
- The **pharmaceutical applications** of nanomaterials are also of significant interest. Getting drugs to the parts of the body that need them (and avoiding the parts that don't) is a persistent challenge in medicine, particularly in localised diseases such as cancer. Nanosized hollow spheres filled with the drug required for treatment can be used to deliver the medicine to parts of the body which would otherwise be inaccessible to the drug alone.
- There are new possibilities in **biomedical imaging**. Challenges in medical imaging include how far you can "see" inside our bodies, and how many things you can see at once. Because of the tiny size of nanomaterials, they may be able to reach parts of the patient's body that might otherwise be inaccessible and highlight areas, such as deep-seated tumours, that may be missed by conventional methods.
- Nanomaterials are often found naturally in **food**, but anti-fungal and anti-microbial nanomaterials can also be used as additives to prolong the shelf life of perishable goods. Future applications of nanomaterials include in food packaging, which could improve food safety by changing colour if the contents are spoilt.
- Nanomaterials with unusual electronic properties could lead to advances in computing. Carefully-tuned nanoparticles could be used to make quantum computers, which can operate at far higher speeds than is currently possible and completely securely. There are also suggestions that nanomaterials could be used to make new batteries which could hold more energy and last far longer than modern batteries.

Did you know?

The 2010 Nobel Prize in Physics was awarded for the discovery of the nanomaterial 'graphene', a sheet of carbon atoms with many interesting properties. It was first made using only a lump of carbon and a roll of sticky tape!

What are the risks of nanomaterials?

It is possible that the use of nanomaterials could have unintended effects on the environment or human health, which are difficult to predict by looking at the bulk substance.

Nanoparticles can enter the human body in several ways: through inhalation, ingestion, and possibly skin penetration. Most applications of nanomaterials use them in a 'fixed' form (such as coatings on self-cleaning glass), which are not able to move around and so cannot enter the body.

A few uses of nanomaterials require them to be 'free' i.e. able to move around (for example in toothpaste or cosmetics) and it is usually in these products that there is most concern over their use.

There are concerns that the small size of nanomaterials will allow them to penetrate further into the body compared with larger particles, including into critical organs such as the liver and brain. While there is so far no evidence of this occurring in humans, nanomaterials have been shown to enter the brain of mice.

There is as yet no evidence that the presence of nanomaterials in the human body can cause harm. However, concerns have been raised that some nanotubes closely resemble the fibres of asbestos and that they might therefore have similar effects on the body. Similarly, the possibility of finding nanomaterials in parts of the body where they might not be expected has led some people to advocate caution until the long-term effects of nanomaterials on the body can be worked out.

The effects of nanomaterials on the environment are even less understood. There are suggestions that levels of nanomaterials can build up in plants and animals over time, with possible undesirable effects. It is also not known how they behave in water or soil, leading to suggestions that they should be disposed of very carefully.

As is always the case when considering the risk posed by a substance, the risk of using it must be weighed against the risk of not using it. For example, the beneficial effects of nanoparticles in sunscreens may save more lives (through the prevention of skin cancer and sunburn) than any associated health effects from the nanoparticles themselves.

What is being done about nanomaterials?

Some people think that there should be more nanomaterial specific legislation put in place to control their use and protect human health and the environment. The issue of how to regulate nanomaterials is currently being discussed by many countries and at European level. Some countries are starting their own "nano-registers" which aim to keep track of the use of nanomaterials within the country.

At the moment, there are few regulations specifically aimed at nanomaterials, but there are various EU directives and regulations which apply to controlling them; for example the EU Cosmetic Products Regulations has a section on nanomaterials stating that they must be declared when used in cosmetics.

Various relevant directives and regulations, as well as the formal definition of nanomaterials, are listed below.

Further Information Sources

- Health and Safety Executive website, nanotechnology section
- The European Chemicals Agency website
- Commission Recommendation of 18 October 2011 on the definition of nanomaterial OJ L 275, 20.10.2011, p. 38-40
- United Nations Economic Commission for Europe

Directives and regulations that apply (non-specifically) to nanomaterials:

Biocidal Products Directive 98/8/EC

General product Safety Directive 2001/95/EC

Directives 2001/83/EC, 2003/63/EC, 2004/27/EC on the manufacture, sale, supply and importation of medical products

EU General Food Law Regulation

EU Novel Foods Regulation 258/97

The Chemical Agents Directive – COSHH and DSEAR in the UK, REACH REGULATION (EC) No 1907/2006 of the European Parliament and of the Council (corrected version published in the Official Journal of the EU, 29 May 2007).

The formal definition used by the Government's Health and Safety Executive is "A natural, incidental or manufactured material containing particles, in an unbound state or as an aggregate or as an agglomerate and where, for 50 % or more of the particles in the number size distribution, one or more external dimensions is in the size range 1 nm - 100 nm. " This is taken from recommendations from the European Commission. The definition will be reviewed by December 2014.

Reference: http://ec.europa.eu/health/scientific_committees/opinions_layman/nanomaterials/en/l-3/5.htm#0

Click here for a more detailed scientific note on this subject.

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