Australian Government
Department of Innovation, Industry, Science and Research

Nanotechnology – working with the smallest things

Nanotechnology is a field of science that deals with very small things — objects measuring from one nanometre (one millionth of a millimetre) to 100 nanometres.

Typically, these objects are very small particles of normal materials, but they can also be molecules or clusters of atoms. A DNA molecule, for example, is about two nanometres wide, and viruses are about 75–100 nanometres wide. In contrast, a human hair is about 80 000 nanometres wide.

The word nanotechnology comes from the Greek word *nanos*, which means dwarf. It describes the work that scientists and engineers undertake to manipulate these minute objects to make useful products. The term 'nanotechnologies' is sometimes used to cover the many different nanotechnology applications, materials and processes that exist.

Nanoparticles can be naturally-occurring or synthetic. The term 'manufactured nanomaterial' distinguishes synthetic nanomaterials made for specific applications from naturally-occurring nanoparticles.

Naturally-occurring nanoparticles can be found in the air and in food and water. Some milk components, for example, are nanosized, and traditional processes such as pasteurisation and curdling are known to change the size of these particles.

Manufactured nanomaterials include:

- gold nanoparticles, used to make ruby-coloured glass since Roman times
- some of the particles in carbon black, used in tyres
- iron oxide particles in disc drives
- platinum particles in catalytic converters in vehicle exhaust systems.

Nanomaterials are not new. What is new is the ability of scientists to engineer nanoscale products and processes, and thereby exploit the properties of materials at the nanoscale. Scientists have focused on 'going small' because on the nanoscale, the properties of materials can change.

Some nanoscale metals and other nanomaterials produce improved or novel effects that cannot be achieved using larger particles. For example, carbon nanotubes, which are hollow fibres of pure carbon, are much stronger than graphite-based carbon fibre and have more versatile conductivity properties. Future potential applications of yarn spun from carbon nanotubes include artificial muscles, electronic textiles and bulletproof clothing.

Applications of nanotechnology

Nanotechnology has a wide range of applications, and nanoparticles are incorporated in the production of many different materials and processes. Some familiar products such as invisible sunscreens and protective paints use nanotechnology. Other current applications of nanotechnology include:

- protective coatings for television screens

- OLED (organic light-emitting diode) computer screens
- fast computer chips
- protective coatings that cut glare
- coated glass that resists dirt
- water-repellent construction wood
- stain-resistant clothing
- purification of drinking water
- storage bags and containers that keep food fresher for longer
- cosmetics with skin-protection capabilities.

Future uses of nanotechnology may include:

- new ways to regenerate damaged parts of the human body, including blood vessels, brain, nerves, bone and cartilage
- pharmaceuticals tailored to individual needs
- microscopic robots
- quantum computers
- intelligent clothing.

Nanotechnology research will not generally lead to specific nanotechnology products, but to new, cheaper or more effective ways of developing or making existing products. Researchers are also developing techniques to make devices at the nanoscale.

Tiny builders

Developments in microscopy and manufacturing processes have enabled scientists to see and work with matter at the nanoscale. Two main methods are used to build devices out of nanoparticles: top-down and bottom-up.

The top-down method involves etching away material to 'sculpt' the features required, such as in the manufacture of computer chips. An example of the bottom-up method is depositing a thin mist of atoms on to a surface, building up a ‘sandwich’ of different layers that conduct electrical currents in various ways. These materials can be used to make electronic devices such as ultra-fast computer chips. In another bottom-up approach, nanoscientists imitate nature by mixing chemicals and allowing them to 'self-assemble' into the desired structures, much like the way salt crystals or our teeth grow.

Heath, safety and environment aspects of nanotechnology

The physical and chemical properties of some nanomaterials may differ from those of the parent material. These properties may have potential impacts on health, safety, and the environment.

The following are some of the health, safety and environmental issues that are being considered by employers, workers, manufacturers, suppliers, regulators and consumers.

- Very small particles may penetrate the body more easily, requiring testing and regulation to prevent harm.

- The properties of nanomaterials may affect how materials need to be handled in the workplace.

- Community awareness about nanotechnology and issues related to public health, safety and environmental conditions needs to be raised.

Nanotechnology holds the promise of enormous benefits in many areas, from health and medical applications to new materials for building, and from food packaging to electronics. However, to provide an environment in which businesses and the public can apply nanotechnology with confidence, any risks arising from nanomaterials need to be managed.

Nanotechnology products are currently regulated under the regulatory frameworks for hazardous substances, dangerous goods, consumer goods, therapeutic goods, food, cosmetics, agricultural chemical products, veterinary chemical products, genetically modified organisms, explosives and other chemicals.

New applications of nanotechnology will continue to be monitored by government agencies responsible for health, safety and the environment. The Government's emphasis is on identifying those nanomaterials of potential concern in terms of impact on health or the environment, and ensuring that current regulatory systems can identify and manage those concerns.

More information:

The Australian Office of Nanotechnology: **www.nanotechnology.gov.au**

Telephone (1800 631 276).

Other aspects of nanotechnology will be addressed in future fact sheets.

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