The interesting new world of Nanotechnology

Price 30p

What is nanotechnology?

Nano comes from the Latin *nanus* and Greek *nanos* meaning dwarf. A nanometre (nm) is one millionth of a millimetre with a human hair being about 80,000 nm diameter. Nanotech products currently use items about 100 nm in size.

The main uses

There are already over 1000 nano-influenced products on the market including 33 different sunscreens. Silver nano-particles are found in 25% of all products with carbon, zinc, silicon, titanium and gold also widely used. Nanotechnology is also an element in precision engineering which enables not only better machines but smaller ones. In recent times precision has increased by a factor of 10 every 10 years. Where two metal parts move against each other as, for example, in engines, the improved precision means less wear and longer life, fewer rejections and less remedial work. In optics, lenses can be ground with greater accuracy giving less distortion. Micro motors for example can go where conventional motors can not.

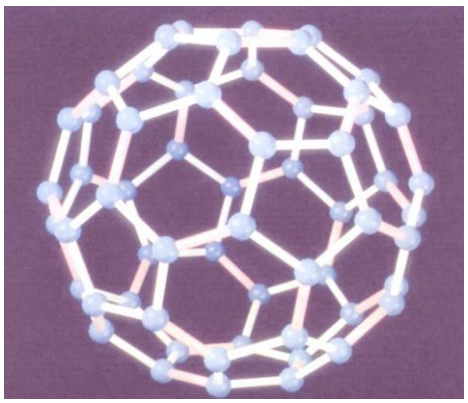
Some 50 years ago Richard Feynman, considered the founder of nano-science, offered a prize for the first person to construct an electric motor of 1/4 inch (6 mm) cube or equal volume. The manufacturing excellence to do this is astounding yet modern nano motors, used to turn disc drives in some MP3 players, are a fraction of this size. In theory motors could be built small enough to travel up human veins. Once in mass production micro devices will be cheaper than larger ones because they use less material and be economic in more applications. Already nano devices which can be implanted in the heart and detect trouble are being tested.

A second nanotech area is computing. A computer's speed depends on the distance signals travel. The more precisely an electrical circuit can be laid down, the shorter the distance can be and, again, the lower the cost. It is greater precision that has allowed the dramatic increase in computer power, miniaturisation of devices and electricity saved.

The third and most productive use of nanotechnology depends on particle size. Viewed through a microscope, a superficially smooth coating will be seen as a series of irregular bumps and lumps and it can be thin and vulnerable in parts. The smaller the particle the more even the coating so coatings containing nano particles can be thinner as well as better. Some dentists are already using nano based filling materials which, by giving a smoother surface, look better and prevent plaque adhering so reducing tooth decay. Additives of 'nano' size also improve materials. Pilkington found that nano particles added to glass allowed it to retain flexibility where before it was rigid and risked cracking. Gold nano particles coated with antibodies have been found to have a preferential affinity for cancer cells. Once attached they can be heated by photothermal therapy killing the cells.

Particle size is particularly important because smaller particles have a larger surface area for the same weight so chemical reactions are faster and more efficient. Drugs at the nano size can be wholly soluble in the stomach where some parts of larger particles can pass through the body without therapeutic benefit. Sunscreen lotions can contain nano size zinc or titanium oxide particles which filter out more UV light per unit of weight than normal lotions. It is no surprise that L'Oreal owns more nano based patents than IBM.

Applications exploiting the advantage of nano size are multiplying. The nano size oxidation catalyst Envirox added to diesel improves combustion. Higher temperatures are reached so more power is extracted and emissions are less polluting. The bus company Stagecoach has found 5% savings of fuel and cleaner emissions. Many refrigerators are now coated inside with silver nano particles which are toxic



A 60 carbon molecule 'buckyball'

to food bugs. Moulds can not grow and hygiene is improved. The same particles can be used in socks and other clothing to prevent smell as well as hospital surfaces and medical dressings. Bactericidal nano particles are being incorporated in medical facemasks, for example for defence against bird flu or MRSA. Tiny weights of oil/grease resistant nano particles in paints and other coatings ensure that graffiti, dust and dirt do not adhere to surfaces. Pilkington have developed a coating for glass which contains nano size particles which act as a catalyst in natural UV light to decompose dirt, and a second particle which renders the glass hydrophilic (spreads

An ALDES Briefing Note

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This briefing note has been written for ALDES by Richard Balmer but any opinions expressed are his own. This updated version includes material from an excellent presentation by Prof Mike Gibbs at the 2007 Spring Conference. It should be technically accurate but if you see errors or have comments, please contact Richard at richardbalmer162@btinternet.com

water) so that the dirt washes off with the next rain. Pilkington Activ, the self-cleaning glass, is already here, and Gortex are among other manufacturers using hydrophobic nano coatings on their outdoor clothes to prevent them becoming soaking wet in rain. Nano particles are increasingly likely to be used in medicine. Trials are underway with an anti prostate cancer drug. The active nano particle is covered with a sheath so, that it is not destroyed by the body's immune system, and an enzyme bonded to the sheath. The enzyme then recognises the cancer molecule and binds to it. The effect is to target more of the active drug on the cancer and reducing the often unpleasant side effects of other chemotherapy.

The last area where nano-technology will play an increasingly important role concerns structures. It has been discovered that a molecule made up of 60 carbon atoms, the so called 'bucky-ball' (see figure) after Buckminster Fuller the discoverer, is incredibly strong. Long *cylinders* of carbon atoms, linked in a similar matrix to bucky-balls, are called nano-tubes. They are over 100 times as strong as steel but only 1/6th the weight and, though very expensive, are beginning to be used in composite materials used in aircraft and vehicles. If the manufacturing processes can be improved and the costs brought down the potential, including being used as lightweight stores for hydrogen fuel, is enormous. Another form of carbon, with the same matrix structure but in sheet form, called graphene has the same advantage of great strength and is currently creating great excitement among researchers.

Concerns

Operating at the nano level is in one sense a mere progression of improvements gone before. Nano sized particles arise naturally from fires and pollen. Cooking produces an abundance and smoking and car exhaust, especially from diesel, has added to this. The quantity of manufactured nano particles released to the air will be trivial in comparison and will tend to be concentrated in laboratories and factories but it is recognised that safeguards will still be required. For example nano tubes could be thin enough to reach the deep lung and long enough to get trapped as can happen with blue asbestos fibres which are not always removed by the lungs' natural self flushing mechanism. Similar safety precautions are essential.

Generally nano particles will be safe in use because they will be bonded to surfaces or embedded in liquids or lotions. Nano particles used in sunscreen lotions should not normally enter the body through the skin but this might happen if the skin is damaged by eczema or sun burn.

Regulation

Laboratory and industrial processes are subject to Health and Safety legislation. Back in June 2003 the Government asked the Royal Society and Royal Academy of Engineering to review and report on whether additional or specialist regulation was necessary. ALDES contributed to the review and made 3 particular points:

First that scientists had an ethical responsibility to pursue those possibilities that were most likely to bring benefit to mankind and a duty of care to do so in ways to minimise risk of harm.

Second that scientists should be required to look for possible hazards as part of their research and expect that their funding bodies would provide contingency money for any necessary 'safeguarding' research.

Third that any new regulatory body should be pro-active in disseminating information about nano-technology to gain public confidence and be able to rebut unfair criticism and expose needless scares. There have been groups, including one called LTC in Canada, as well as the UK Green Party who wanted to stop all nano-technology research.

The review group reported very fully at the end of July 2004*. Many detailed recommendations were made which covered the above points and several others. The group were very keen that, despite problems of commercial confidentially, research findings should be made widely available should a company or researcher discover an area of concern. The group were also keen that promoters should not over hype the potential of the technology nor detractors exaggerate anxieties, so that positions do not become entrenched. Only if this is done can the public be in a position to take a balanced view on whether to welcome a particular use of the technology or not. Critically the group recommended that nano sized particles should be treated as new chemicals for the purpose of regulation. This would allow more extensive testing and restriction on use if there were concerns.

Conclusion

Nano-technology will almost certainly be as important to 21st century technology as biotechnology will be to health. It is unlikely to pose as many health or ethical problems as biotechnology but it is also unlikely to be risk free. Currently development is heavily regulated, some say suffocatingly so.

So far the public attitude towards nano-technology has been fairly relaxed. Having been scared irresponsibly by the press over MMR citizens seem more prepared to accept assurances from scientists and industry than even a few years ago. Potentially the UK *needs* to develop nano products to replace exports in traditional industries now lost overseas.

* "Nanoscience and nanotechnologies: opportunities and uncertainties" RS Policy document 19/04