The implications and potential of
Nanotechnology

Price 30p

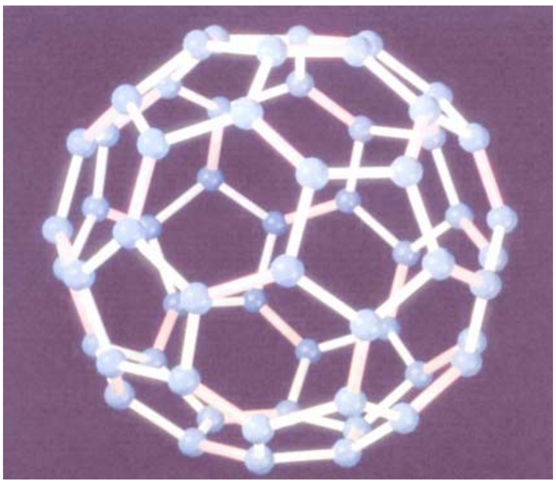
What is nanotechnology?

Nano comes from the Latin *nanus* and Greek *nanos*, meaning dwarf. Nanotechnology could be described as micro or precision engineering. A nanometre is one millionth of a millimetre. There are about 80,000 nanometres in the diameter of a human hair and nanotechnology products currently concern items about 100 nanometres in size.

Throughout the ages mankind has developed better and better tools, from the stone age axe onwards, to make all kinds of devices with greater precision. 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.

The main uses

Nanotechnology is in its infancy, but there are 5 areas where it is already possible to see actual or potential commercial uses. The first relies on precision engineering to give not only better machines but smaller ones. Micro motors for example can go where conventional motors can not. 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 materials and so can be used in many more applications. Already individual disposable blood pressure sensors are in use.



A 60 carbon molecule 'buckyball'

The second area is in computing. The speed of a computer depends on the distance signals have to travel. The more precisely the pathways of a circuit can be laid down, the shorter the distances can be and, again, the lower the cost. It is greater precision that has been a main contributor to the dramatic increase in computer speed, in miniaturisation of devices and in reduction of power needed. Precision also enables thinner (and hence less expensive) layers to be 'shaved off', for example from expensive pure silicon used for computer 'chips' - and also solar cells.

The third area depends on particle size and concerns coatings. 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 can be the coating so 'nano' coatings can be better, thinner and cheaper. Additives of 'nano' size can also improve materials. Pilkington found that when nano particles were added to glass, the glass retained a flexibility where before it was rigid and vulnerable to cracking. Pilkington have also developed a coating which self cleans glass!

The fourth area reflects the relationship of surface area to weight. Smaller particles have a higher area/weight ratio. This is significant because the speed and efficiency of chemical reactions depend on surface area rather than volume or weight. Drugs at the nano size can be wholly soluble in the stomach whereas part of a drug made up of larger particles will pass through the body without therapeutic benefit. Sunscreen lotions can contain nano size titanium oxide particles which filter out more UV light per unit of weight than normal lotions. The nano size oxidation catalyst Envirox improves fuel burn efficiency and claims to improve fuel economy by 12%.

The fifth area concerns structure. Balls and tubes can be remarkably strong at the nano size. So called 'bucky-balls' are made up of 60 carbon atoms (see figure) and are very strong. It is thought nano tubes could be 30 - 100 times as strong as steel but only 1/6th the weight, creating huge possibilities as strengthening fibres for example in car doors. The tubes might also provide lightweight stores for hydrogen fuel.

Opposition

Operating at the nano level is in one sense a logical progression from what has gone before. Nonetheless while new opportunities are opening up, hazards exist. 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

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concentrated in laboratories and factories, but safeguards will be required nonetheless. A more serious concern is that nano tubes could be thin enough to reach the deep lung and long enough to get caught in the natural self flushing mechanism as can happen with blue asbestos fibre. Problems with asbestos only arise with heavy exposure (several hundred/breath) over many months or even years, but again it will be necessary to contain the problem during manufacture (including dispersal in the waste streams), in any recycling process and in eventual disposal.

Generally nano particles will be safe in use. They will be bonded to surfaces or contained in liquids. 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. Often nano particles will join together but this will not always be the case. An experiment with buckyballs at Rice University in Texas found that they behaved ‘normally’ in soil when they clumped together but unexpectedly when by themselves. They adsorbed a ‘skin’ of water as do clay particles and could be taken in by earth worms though it was not clear whether this presented a real problem.

A good example of an opportunity and concern is where nano particles are able to enter human cancer cells deliberately and directly so providing ’targets’ for chemo and radio cancer therapies, removing the present ‘shot gun’ approach. The challenge is to achieve this without causing intrusion into other human cells by accident.

Regulation

Laboratory and industrial processes are subject to Health and Safety legislation but it is clearly very difficult for the Health and Safety Executive to be expert in every field and impossible for them to be at the leading edge of every new technology. Recognising that difficultythe Government asked the Royal Society and Royal Academy of Engineering in June 2003 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 nanotechnology to gain public confidence and be able to rebut unfair criticism and expose needless scares. There is already a Canadian group called LTC who want to stop nanotechnology 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. (There is little evidence of any actual problems at present). The group were also keen that promoters should not over hype the potential of the technology nor opposers 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. Currently a chemical such as zinc oxide can be used at nano size because there is no threshold on the particle size. Concerns have been raised about the use of zinc oxide in sunscreens.

Conclusion

Nanotechnology is already contributing to items on sale. At present it is in its infancy but some commentators believe it will be as important to 21st century prosperity 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. The public attitude that emerges will say a great deal about the UK as a society. Is it prepared to take risks or will it prefer to stagnate? Perhaps the key conclusion of the review group is that not only should the public be kept informed but be informed in an honest and balanced way both by groups wishing to push it forward and others with reservations. Instead of shouting past each other as has happened in the GM dispute, there must be an better attempt to seek consensus so that genuine benefits can be realised.

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