

Fact Sheet - Carbon Nanotubes

What are carbon nanotubes?

- Carbon nanotubes are molecular-scale structures made from carbon graphite
- They consist of a flat sheet of carbon atoms rolled into a very thin, cylindrical tube, a bit like rolled up chicken wire
- The carbon atoms are arranged in a hexagonal network and then rolled up to form a seamless cylinder which measures several nanometres across, but can be thousands of nanometres long
- There are many different types, but the two main categories are single-walled nanotubes (SWNTs) and multi-walled nanotubes (MWNTs), which are made from multiple layers of graphite, effectively creating cylinders within cylinders
- When produced, they usually have the appearance of a fine black powder, consisting of a tangled mass of microscopic nanotubes
- They were first created in the 1970s; however, it wasn't until 1991 that they were studied in detail for the first time, leading to the creation of their own specialised area of research.

More on the scale

- Carbon nanotubes are an example of a **nanostucture**, varying in size from 1-100 nanometres (the scale of atoms and molecules)
- A nanometre (nm), the unit of measurement used for structures on the atomic scale, is one billionth of a metre
- Normal office paper is about 100,000 nanometres thick
- One nanometre is about one fifty thousandth the width of a human hair, and about a million times smaller than a pinhead.

What are the properties of carbon nanotubes?

- Carbon nanotubes have several unique properties. As well as their size, they are also very light and extremely strong – they can be 100 times stronger than steel, while being about six times lighter
- They are among the strongest and stiffest materials yet produced owing to their extremely high strength-to-weight ratio

- They have unique electrical, thermal and optical properties which make them highly conductive to electricity and heat
- They also have distinctive flexible and kinetic properties, which means that carbon nanotubes could be used to manipulate other materials at the molecular level
- Many of these properties are still being discovered – carbon nanotubes have a wide range of properties which vary according to the size and structure of the nanotube, and the arrangement of its atoms. This variability translates into a potentially very wide range of applications.

What can they be used for?

- One of the main potential applications of carbon nanotubes is in the production of very strong, lightweight materials that can be used in areas such as building, structural engineering and aerospace
- They can also be incorporated into materials used in clothing and specialised products such as body armour and combat gear
- Due to their electrical properties, they have a wide range of applications in the production of electrical devices and circuits, including on the atomic scale, and plastics that can conduct electricity
- Nanotubes could potentially be used to create molecular 'wires' capable of transmitting single electrons; as such they have strong potential applications in the production of quantum computers
- They also have potential pharmaceutical applications; for example, as vessels for drug delivery on the molecular scale.

What are they currently used for?

- Multi-walled carbon nanotubes are presently used as an element in the production of some lightweight materials, such as certain types of carbon fibre used in bicycle frames and sports equipment
- Other current applications include flat-panel displays (for example in flat screen TVs), high-resolution microscopes and devices designed to prevent the buildup of static charge in gas transportation equipment
- Many of these applications remain in the early stages due to the technological obstacles and expense currently associated with producing carbon nanotubes on industrial scales.

Sources/further information

Physics World: <http://physicsworld.com/cws/article/print/1761>

New Scientist Special Reports site on nanotechnology includes a collection of articles on nanotubes:

<http://technology.newscientist.com/channel/tech/nanotechnology>

The A to Z of Nanotechnology: www.azonano.com

Centre for Advanced Microscopy, University of Reading:

<http://www.personal.rdg.ac.uk/~scscharip/tubes.htm>

Nanotech site at Michigan State University:

<http://www.pa.msu.edu/cmp/csc/ntproperties/>