WHAT IS A NANOTUBE?

Carbon nanotubes are atom-thick sheets of graphite formed into cylinders. They may be formed from a single layer of graphite (called graphene), or they may consist of multiple concentric layers of graphite, resulting in Multi Walled Carbon NanoTubes (MWCNTs). While the diameter of a nanotube can vary from a few nanometers up to tens of nanometers, they can be hundreds or even thousands of nanometers long. Carbon nanotubes come in many forms, with different shapes, different atomic arrangements, and varying amounts and types of added chemicals—all of which affect their properties, and might influence their impact on human health and the environment. Japanese researcher Sumio Ijima is generally credited with discovering carbon nanotubes in 1991.

WHAT IS NANO?

Nanotechnology is the ability to measure, see, manipulate and manufacture things usually between 1 and 100 nanometers: at the scale of atoms and molecules. A nanometer is one billionth of a meter; a dollar bill is roughly 100,000 nanometers thick. Nanotechnology is a new technology, and it is expected to have broad applications in the coming decades in fields as diverse as, medicine, energy, computing, manufacturing, space travel, and sporting goods—to name a few. According to manufacturer claims, nanotechnology is already used in over 600 consumer products on the market today, ranging from sporting goods to cosmetics to food packaging. By 2014, Lux Research projects that $2.6 trillion in global manufactured goods will incorporate nanotechnology, or about 15 percent of total global output.

Carbon Nanotubes (computer rendering)
Image from the National Geographic Magazine ▶

nanotubes: at a glance

Properties

Carbon nanotubes have an extremely high strength-to-weight ratio. They can be made stronger and lighter than steel.

Nanotubes can be made to conduct both heat and electricity well—combining desirable properties found separately in graphite and diamond, two other forms of carbon.

Nanotubes are adaptable, and can be designed to alter their properties based on their environment.

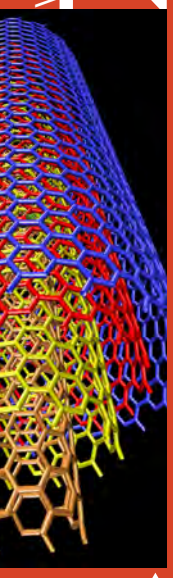
Uses

Nanotubes are used today as structural reinforcement in bicycle frames, baseball bats, and automotive body parts, which need to be very light, yet strong.

Value

The total global market value of carbon nanotubes is expected to exceed $1.9 billion by the year 2010.

WHAT IS A MULTIWALLED CARBON NANOTUBE?



A Multi Walled Carbon Nanotube (computer rendering)
Each color is an individual nanotube.
Rendering by A. Rochefort, nano@polyMTL.ca

Appearance

Multi walled carbon nanotubes (MWCNTs) are either multiple sheets of graphite formed into concentric cylinders (the "Russian Doll" model"), or a single layer rolled around itself multiple times (the "Parchment" model). They are often produced as a black powder consisting of a fluffy mass of tangled nanotubes.

Production

Multi walled carbon nanotubes can be made with relative ease in large quantities, though manufacturing material reproducibly with high purity and few structural defects is more difficult. Various production methods are in use, which lead to nanotubes with different properties.

Economic Value

Currently, MWCNTs can be purchased for ~$150 per kg ($0.15 per gram) for semi-industrial applications (but the price is rapidly decreasing).

The global market for MWCNTs was estimated at $290 million in 2006.

Present Applications

Multi walled carbon nanotubes are currently designed to:

- produce strong, lightweight composite materials;
- help prevent the buildup of static charges, which can lead to explosions, in commercial automotive gas liners, filters, and pump modules;
- make plastics more suitable for use in environments where chemical cleanliness is critical, in silicon chip manufacture and in computer disk drives; and
- help improve the performance of electronics by providing smoothness to and uniform conductivity throughout the polymer composite.

Future Applications

In future, multi walled carbon nanotubes are predicted to:

- support precious-metal catalysts that can offer faster or more selective chemical reactions, and
- increase the efficiency of solar cells by reducing optical reflectance across the whole light spectrum and by allowing the cells to absorb light from many different angles.

Additionally, MWCNTs are expected to have applications in:

- high-intensity emitters in flat panel displays,
- advanced batteries and fuel cells,
- high performance metals and plastics,
- electronics (as carbon nanotube resistors and wires),
- highly sensitive sensors for detecting chemicals,
- biocompatible surfaces on medical devices, and
- new drugs (both as an active ingredient and as a carrier for other agents).

Health Implications

Uncertain at the moment, but research suggests some forms of multi walled carbon nanotubes may be harmful if inhaled in sufficient quantities.

Since their discovery, similarities in shape between carbon nanotubes and asbestos have raised concerns.

Recent research suggests very long MWCNTs might behave like asbestos if inhaled. This behavior is limited to long MWCNTs, and is not associated with short nanotubes, or compact tangles of nanotubes.

Experts have called for more research further establish the possibility of long MWCNTs causing asbestos-like health effects if inhaled.

Shorter MWCNTs may interfere with the lungs in other ways if inhaled; additional research is needed to establish safe exposure levels.

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The Project on Emerging Nanotechnologies