



## NANOTUBES

- Nano tubes are one of the wide spread studied and used materials, consists of tiny cylinders of carbon and other materials like boron nitride.
- Nanotubes are cylindrical structures with diameters of ~1–100nm.
- Carbon nano tubes are tubular forms of carbon that can be predicted as grapheme sheets rolled into cylindrical form,
- These nanotubes have diameters of few nanometers and their lengths are up to several micrometers Each nanotube is made up of a hexagonal network of covalently bonded carbon atoms

### Carbon Nanotubes (CNT)

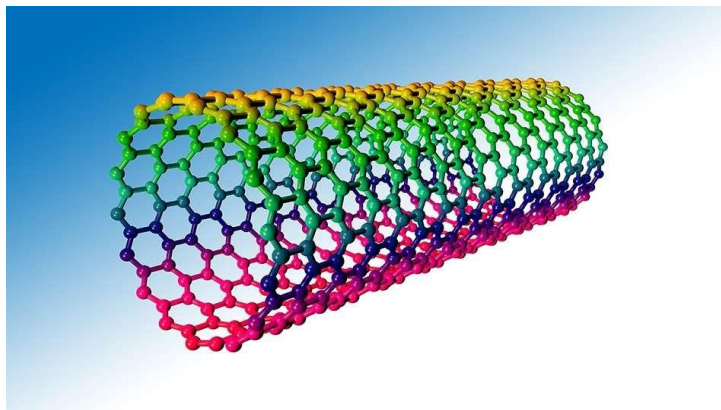
Carbon nanotubes are of two types:

#### 1. Single wall carbon nanotube (SWNT) 2. Multiple wall carbon nanotube (MWNT)

Single wall nanotube (SWNT) consists of one cylinder.

It is made of single graphene sheet rolled up into cylinder closed by two caps (semi fullerenes).

The SWNTs have diameter in the range of 0.5 -2.0 nm. The length is in the range of 50-150  $\mu\text{m}$  length. The SWNTs are micro porous and the specific surface area is in the range of 1300  $\text{m}^2/\text{g}$  (outer surface)



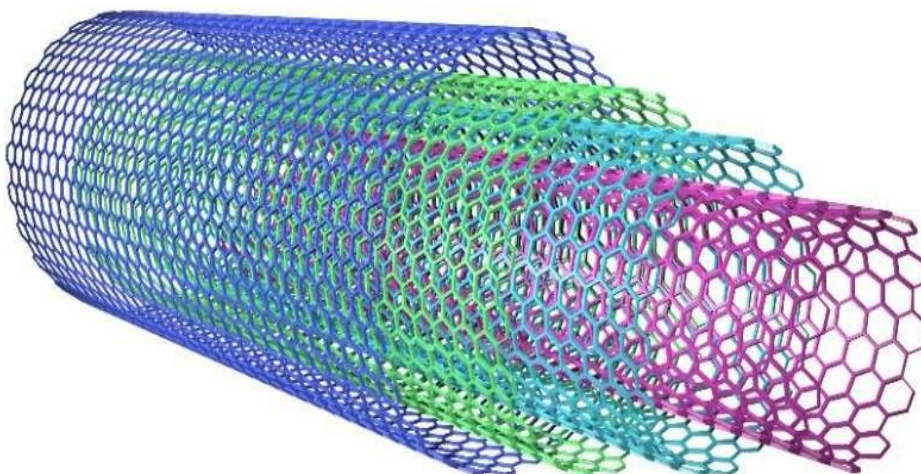


SWCNTs are commonly arranged in bundles. SWNTs have less topological defects and have better mechanical and electro physical properties.

## **Multiwall (MWNT) nano tubes**

Multiwall (MWNT) nano tubes consist of many nested concentric SWNTs cylinders with increasing successive radii

The concentric walls are spaced regularly at 0.34 nm similar to inter graphene distance



MWNTs have outer diameter in range of 2 – 100 nm depending on number of coaxial tubes present.

MWNTs are usually meso porous in nature and specific area depends on the number of walls

The length of MWNTs can range from few to hundreds  $\mu\text{m}$

The advantage of MWNT over SWNT is that the multi-shell structures of MWNTs are stiffer than single wall hence stability is higher.

## **Properties**

- CNTs are very strong.
- It can stand extreme strain in tension and possess elastic flexibility
- The atoms in a Nanotube are continuously vibrating back and forth.



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- It is highly conducting and behaves like metallic or semiconducting materials
- It has very high thermal conductivity and kinetic properties.

## Uses

- It is used in battery technology and in industries as catalyst
- It is also used as light weight shielding materials for protecting electronic equipments
- CNTs are used effectively inside the body for drug delivery
- It is used in composites
- It also act as an efficient catalysts for some chemical reactions
- It acts as a very good biosensor. Due to its chemical inertness carbon nanotubes are used to detect many molecules present in the blood,
- It is also used in water softening process as a filter.