NBICS Technologies

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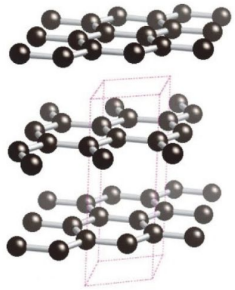
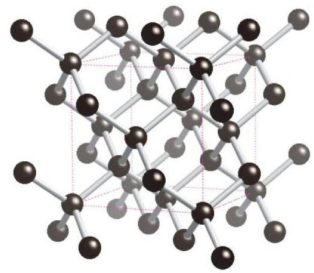
Carbon allotropes

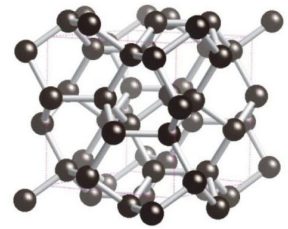
Allotropy is the property of some chemical elements to exist in several different geometries (known as *allotropes*) in the same physical phase.



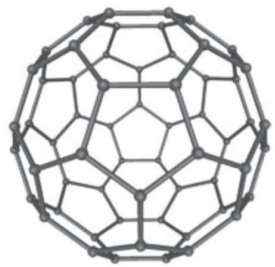
graphite



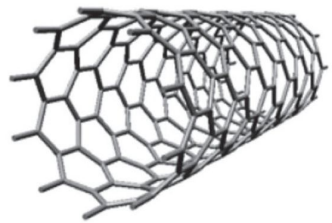
diamond



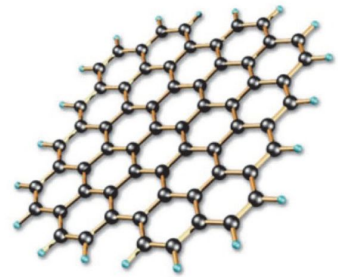
BC8



fullerene



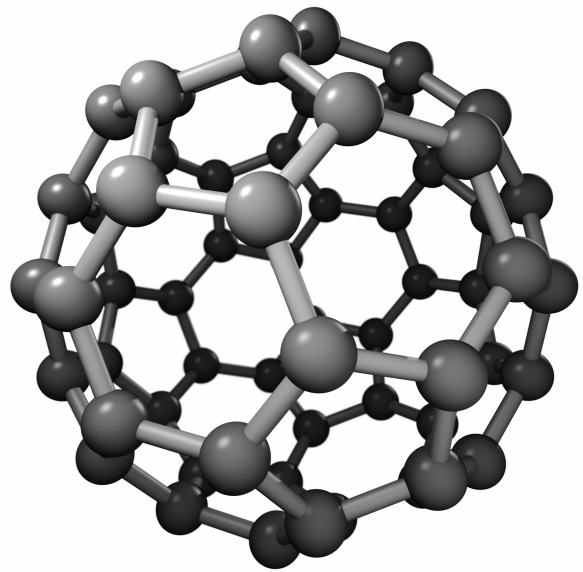
nanotube



graphene

The Buckyball

- The Buckminsterfullerene (named after inventor Richard Buckminster Fuller) was one of the first nanoparticles to be discovered (1985)
- Number of atoms: 20 to over 100; the most common type (C60) contains 60 carbon atoms
- Modifying a buckyball by adding or replacing an atom in order to change the properties of the buckyball is called **functionalization**

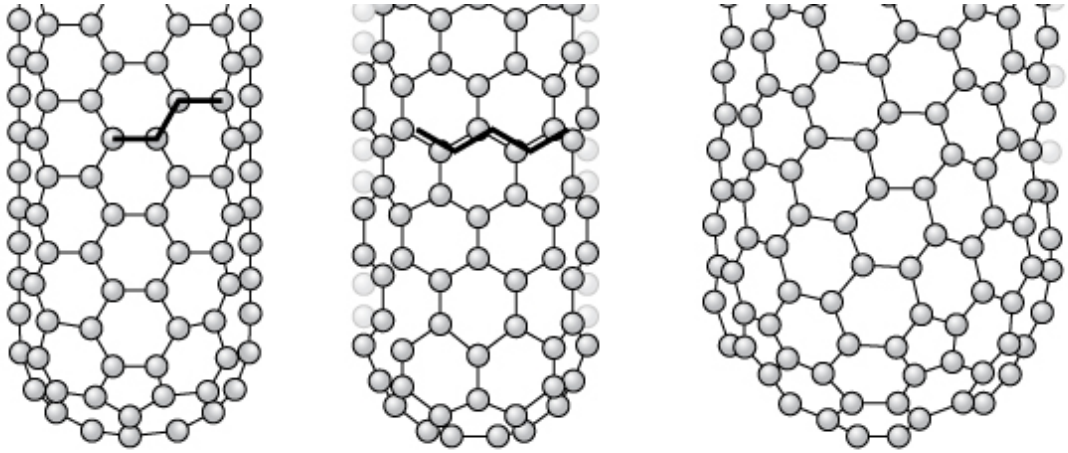


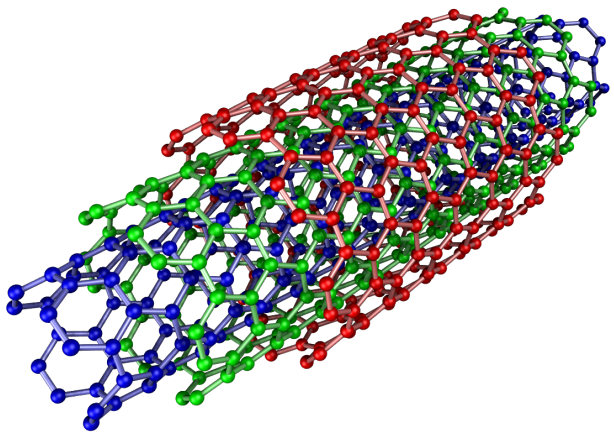
Uses

- **Armor**. Hard as diamonds, buckyballs are potentially useful within armor
- **Medicine**. Functionalized buckyballs can be made soluble by body cells, and hence find the following medical applications:
  - As antioxidants, because of their ability to absorb electrons in free radicals
  - In targeted drug delivery. The buckyball encases a minute dose of a particular drug. By controlling the functionalization of the buckyball the drug is absorbed only by the necessary cells
- **Fiber optics**. Because of their perfect spherical shape, buckyballs are able to transmit light

The nanotube

- Diameter < 1 nm
- A few nano- up to a millimeter in length
- Symmetry: armchair, zig-zag, chiral
- Single/multiple wall CNTs
- Compared to steel:
  - 100 $\times$ more difficult to tear apart
  - 5 $\times$ as elastic
  - a quarter density
- High thermal conductivity
- Metallic/semi-conductive contingent on symmetry



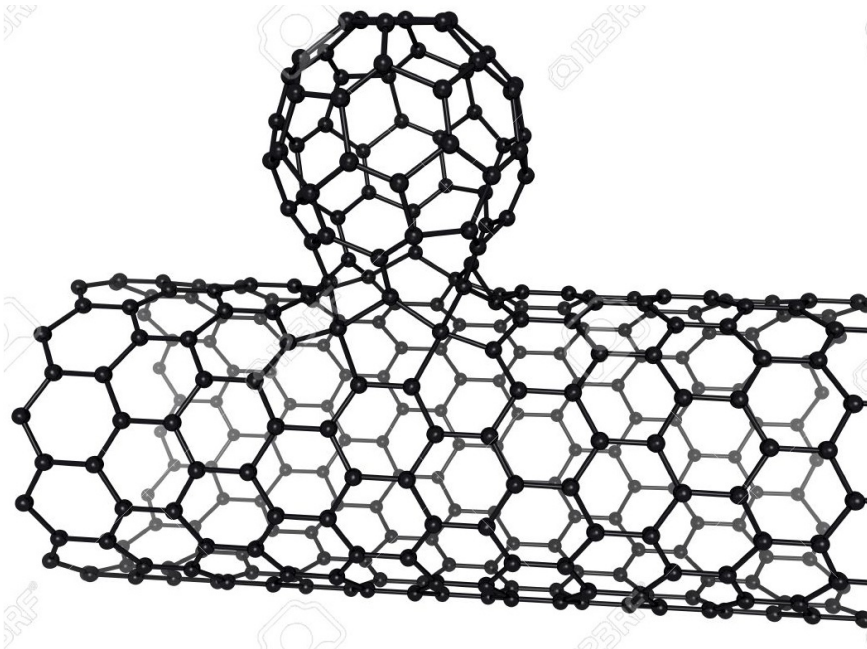


Uses

1. **Medicine**: functionalization, as well as their natural fluorescence, enable the use of CNTs as chemical sensors; they have also been shown to fuse well with bone, which could be used to diminish the implant rejection rate
2. **Conductive plastics**: CNTs are the best known conductive fillers because of their high aspect ratio
3. **Energy storage**: good battery electrodes due to high surface area ($\sim 1000\ m^2/g$), good electrical conductivity, and linear geometry; the high surface area and thermal conductivity also make them useful as electrode catalysts in fuel cells
4. **Molecular electronics**: their geometry, electrical conductivity, and the ability to be precisely derived, make CNTs invaluable connectors between switches at the nanoscale; their properties as semiconductors also make them usable as switches themselves

The nanobud

- A nanotube with a fullerene ball attached to it
- As chemically reactive as the fullerenes, as electrically conductive as the nanotubes
- The fullerene buds serve as additional anchors, modifying the mechanical properties of the whole structure
- Efficient field emitters, with the emission threshold 0.65 V/μm (a third of that of the nanotubes)
- Highly scalable production processes, therefore applications of industrial importance



Synthetic biology