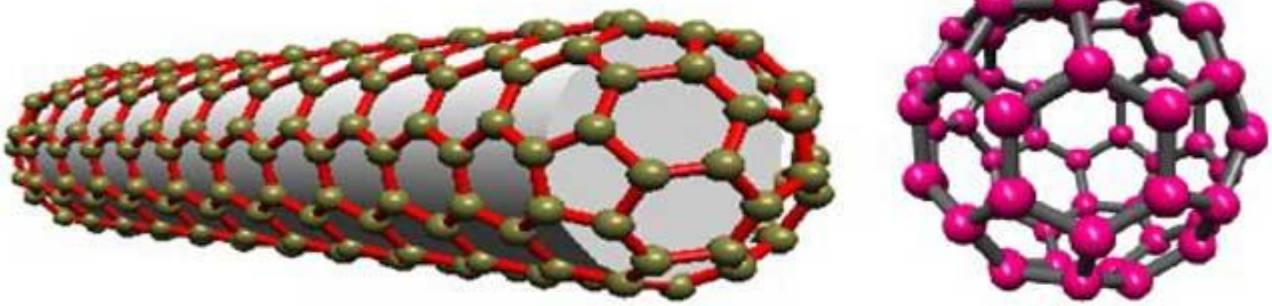
6 - Carbon Nanotube Application :

Carbon nanotubes are used in a wide range of fields, including electronics, energy, pharmaceuticals, and industrial materials, due to their exceptional strength, durability, and electrical and optical properties .

In 1985, Kroto and Smalley discovered a monolayer sphere made up of 60 carbon atoms. It was the most stable of the carbon spheres with more or less than 60 atoms, thus fulfilling Euler's theorem. After its discovery, it was named Buckminsterfullerene after the architect Buckminster Fuller, and later it was named **Fullerene** .



Carbon nanotubes are a highly advanced technology
They are hollow cylinders in the shape of nanometer-sized tubes, and they consist of a huge group of hexagonal structures that are in turn composed of carbon atoms.

7 - Discovery of Nano carbon:

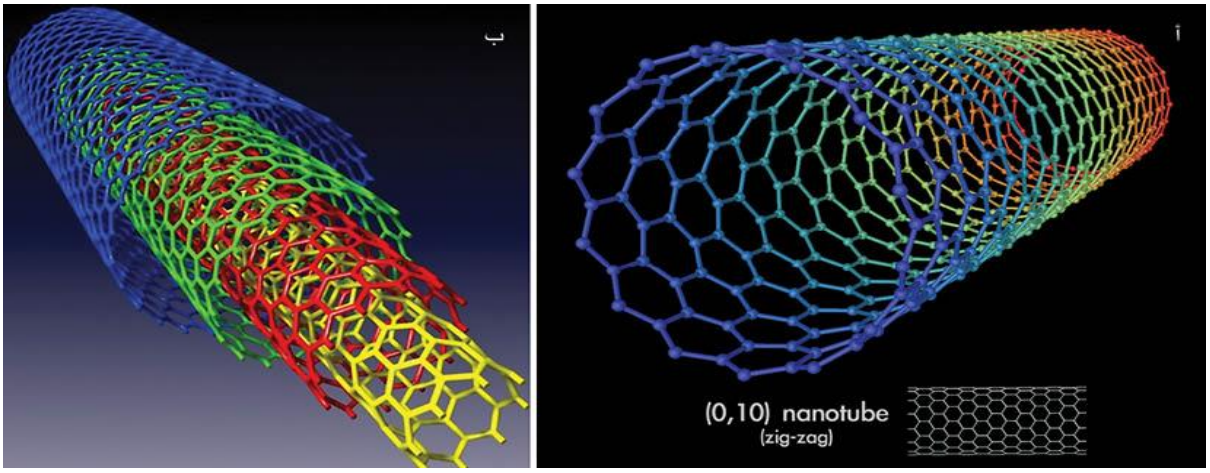
Carbon nanotubes are a physical phenomenon that was first observed in 1991 at **the NEC Electronics** Corporation in Japan by the scientist **Sumio Ijima,** while he was studying the ash produced by the electrical discharge process between two carbon electrodes using a high-efficiency electron microscope.

Ijima noticed some shine or luster inside this ash, so he thought that the carbon had turned into a diamond, so he decided to examine it carefully.

Sumio Ijima used the electron microscope to examine the ash and found that the carbon molecules were in an abnormal position, as the arrangement of carbon molecules is supposed to be in the form of a flat plate. However, **Ijima** was surprised by something else, which is that the carbon molecules had twisted to connect with each other, forming what It resembles a tube.

The experiment was repeated several times, and **Sumio Iijima's** conclusions were that:
1. The carbon molecules are arranged in a tube-like arrangement .
2. The resulting carbon tubes are unequal in size .
3. The resulting tubes are multilayered, meaning they are a collection of interlocking tubes with different color and properties .

In 1993, IBM scientist **Donald Bethune** observed single-walled carbon nanotubes measuring 12 nanometers in diameter.
Scientists then expanded their exploration of nanotubes, until a team of Chinese scientists discovered the smallest nanotube in the world, measuring just 0.5 nanometers in diameter.
This tiny tube was discovered after Chinese scientists developed new methods in nanotechnology.

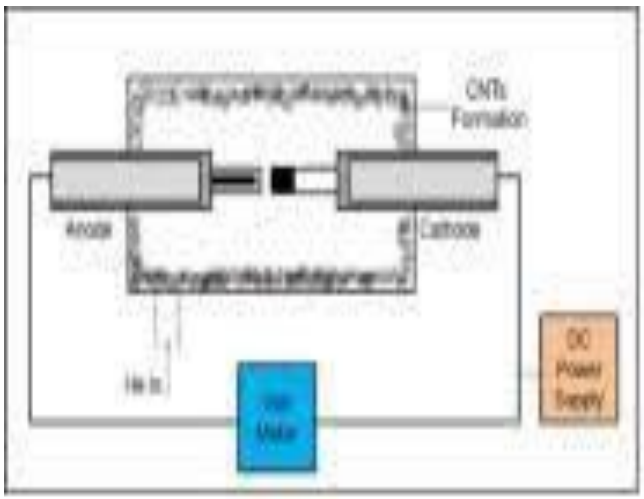


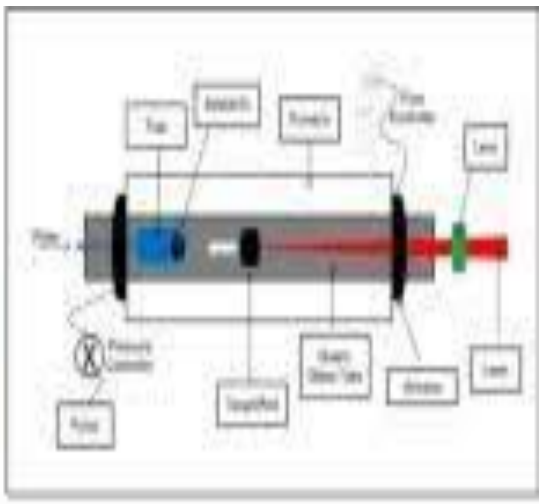
8 – Methods of producing Nano carbon :

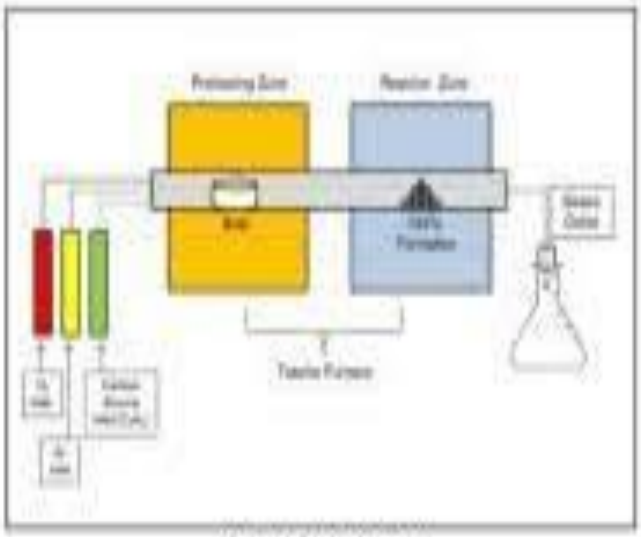
There are several methods for producing the carbon molecules that make up nanotubes, including:

1 . Electrolysis using graphite electrodes in molten salts .
2 . Catalytic thermal decomposition of hydrocarbons .
3 . Laser evaporation of graphite .

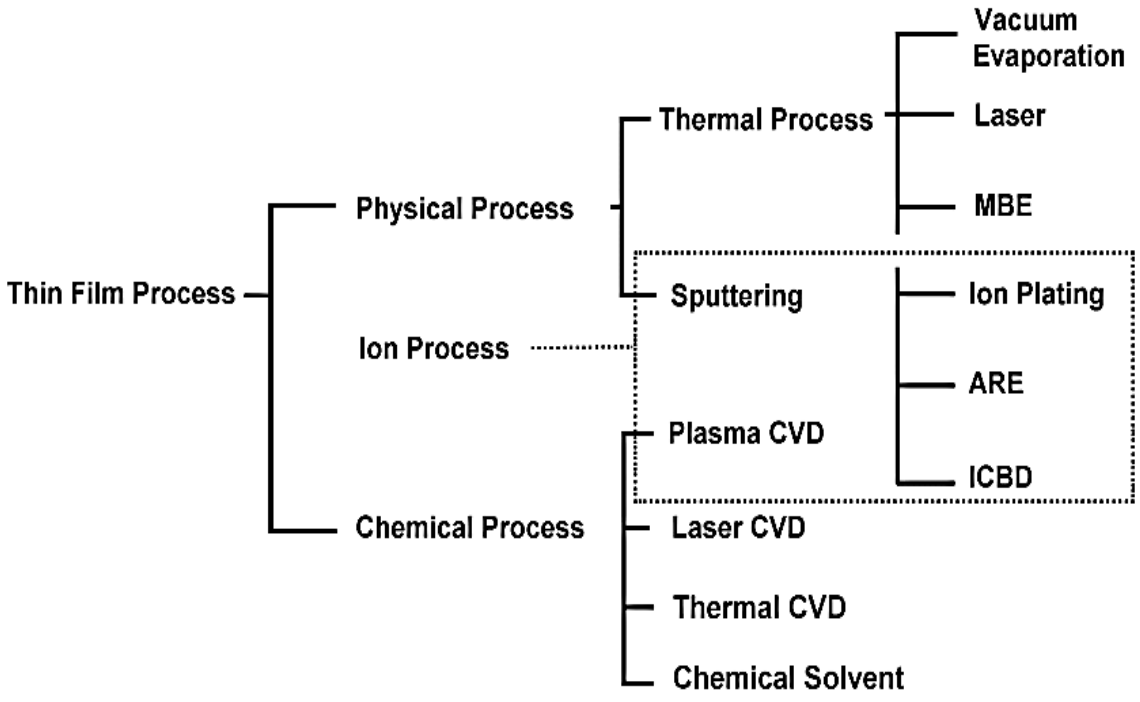
Due to the different methods used to create nanotubes, they have different electronic properties. Some are expected to be metallic, while others are semiconductors. These nanotubes have proven to be incredibly strong, hundreds of times stronger than steel. This is due to their hexagonal geometry, which can distribute forces and deformations due to the strength of the carbon-carbon bond, thus giving them extraordinary electronic properties .







Methods of CNTS Synthesis



9 - Single Walled Carbon Nanotube (SWCNT) :

Carbon is the main component of graphite, which in turn is the main component of carbon nanotubes.

A single sheet of graphite, called graphene, forms a single-walled carbon nanotube that is one carbon atom thick. Rolling-up of the graphene sheet and bending it positively or negatively changes the electronic properties of graphene to show this curvature in the form of a closed cylinder.

The structure of this Nano cylinder is composed of hexagonal shapes, and one carbon atom is distributed on each corner of the hexagonal shape.The two ends of the cylinder are closed by two hemispheres (caps) composed of hexagonal and pentagonal shapes. The pentagonal shape is necessary to close the nanotube based on Euler's theorem.

To close the spherical structure, this structure must contain 12 pentagonal shapes among the hexagonal shapes that compose it.