NANOCHEMISTRY

Nanotechnology Definition

Nanotechnology is manipulation of mater in atomic, molecular or supramolecular scale in the size range of 1nm - 100nm at least one dimension in its shape.

Nanochemistry is the study of atoms or molecular interactions of the materials in the size range of 1nm-100nm.

Sol Gel Process

Sol Gel process is a chemical solution deposition technique may be described as Formation of oxide network through hydrolysis and polycondensation reactions of a molecular precursor in a liquid.

In this process dissolve the compound in a liquid in order to bring it back as a solid in a controlled manner.

Sol is stable dispersion of colloidal particles or polymers in a solvent

A **Gel** consists of a three dimensional continuous net work, which encloses a liquid phase. In a colloidal gel the network built from agglomeration of colloidal particles.

Sol gel chemistry based on the hydrolysis and condensation of alkyl metal oxide $M(OR)_z$ such as $Si(OEt)_4$ can be described as follows

$$MOR + H_2O \rightarrow MOH + ROH \quad \text{(Hydrolysis)}$$

$$MOH + ROM \rightarrow MOM + ROH \quad \text{(Condensation)}$$

Sol gel process can be characterized by series of distinct steps

step 1: Formation of different stable solutions of the alkoxide metal precursor (sol)

Step 2: Gelation resulting from the formation of an metal oxide or metal hydroxide bridged network by polycondensation which increase in viscosity of the solution

Step 3: Ageing of the gel, during which the polycondesation reaction continue untill the gel transformation into a solid mass.

Step 4:Drying of the gel, when water and other volatile liquids are removed from the gel net work(xerogel)

Step 5: Dehydration which is achieved by calcining the monolith at temp up to 800^{o}C. (Aerogel)

Step 6: Densification and decomposition of the gel at high temp,ie >800^{o}C.(gel film)

Advantages

Low temperature, cheap technique. Avoids co precipitation & mixture of precursors can be taken and grown

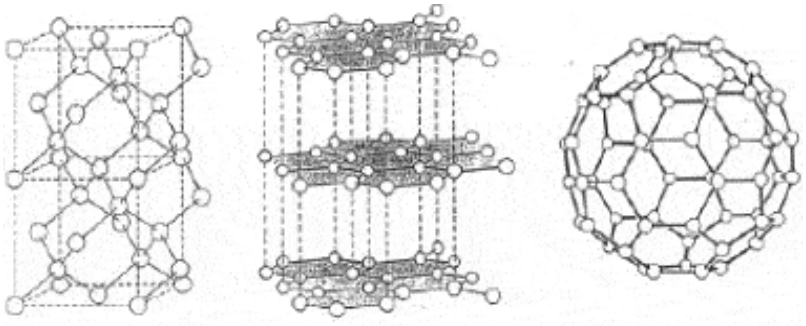
Limitations

Controlling the growth of the particle, production rate is very slow.

Structure, properties and applications of fullerenes

- Fullerenes are the third allotropic form of carbon material after graphite and diamond.
- It is a spherical surface entirely built up from pentagons and hexagons.

- They are called fullerenes because Fuller was renowned for his geodesic domes, those are based on hexagons and pentagons.



- Fullerenes are composed entirely of carbon. They can be found in three different forms: spherical, elliptical and in the form of tubes.

Buckyball Structure

- The structure of the C_{60} Buckyball is a combination of 12 pentagonal and 20 hexagonal rings, forming a spheroid shape with 60 vertices for 60 carbons.
- The structure of the molecule, which reveals how the pentagonal rings sit at the vertices of an icosahedron such that no two pentagonal rings are next to each other.
- In these each carbon atom is bonded to three others and is sp2 hybridized.
- The average C-C bond distance measured using nuclear magnetic resonance (NMR) is 1.44 A°. A diameter of 7.09 A° is calculated for the C60 based on the fact that the C-C distance is equal to 1.40 A° for the hexagon bonds and 1.46 A° for the pentagonal bonds length..
- As hexagon bonds has shorter bond length which consist of ' double bond'
- C60 is not "superaromatic" as it tends to avoid double bonds in the pentagonal rings, resulting in poor electron delocalisation.
- As a result, C60 behaves like an electron deficient alkenes and reacts readily with electron rich species.
- he geodesic and electronic bonding factors in the structure account for the stability of the molecule.

Synthesis of Fullerenes

- When the graphite electrodes contact arcs passing alternating or direct current through them in an atmosphere of helium in approximately 200 torr. The evaporated graphite takes the form of soot, which is dissolved in a nonpolar solvent.
- The solvent is dried away and the C60 and C70 fullerenes can be separated from the residue. Optimal current, helium pressure and flow rate leads to yields of up to 70% of C60 and 15% of C70 with this method

Applications

Fullerenes can be used as

- organic photovoltaics(OPV),
- powerful antioxidants, reacting readily and at a high rate with free radicals which are often the cause of cell damage or death.
- catalysts,
- in water purification and biohazard protection
- Hydrogen gas storage
- Sensors
- Preparation of composites

Carbon nanotubes

- These are cylindrical fullerenes, hallow tubes of very small dimensions.
- These are two types 1.Single wall nano tube(SWNT) 2.Multi Wall Nano Tube(MWNT)
- SWNT consist only of a single graphene sheet with atomic layer in thickness
- MWNT is formed from 2 to several graphene sheets arranged concentrically into tube structure
- These tubes have either closed ends or open ends.hey show excellent properties like high tensile strength, electrical conductivity, ductility and chemical reactivity etc.
- these show applications in electronic industry, drug delivery, composites etc