Nanomaterials

1. What are nanomaterials?

Ans: Nanomaterials could be defined as those materials with size less than 100nm at least in one dimension.

2. Why do nanomaterials exhibit different properties?

Ans: (a) Increase in surface area to volume ratio: Nanomaterials have larger surface area when compared to the bulk material of same volume. As particle size reduces to nano level greater portion of atom comes to the surface and makes the material more chemically reactive than its bulk state.

(b) Quantum confinement: When materials are reduced to nano size, the electrons and holes are squeezed into a dimension called exciton Bohr radius. This can affect the optical, electrical and magnetic behaviour of materials.

(c) Dominance of electromagnetic forces. The electromagnetic forces come into domination at nanoscale affecting the chemical and physical behavior of nanomaterials.

(d) Random molecular motion: Motion of molecules gets affected at nanoscale as one of the dimensions of nanomaterial is reduced below critical length.

3. What is Bottom- up technique? Explain how do you prepare nanomaterials by sol-gel method.

Ans: Bottom- up Technique: In this technique materials are built up atom by atom via chemical reactions, allowing the precursor particles to grow to nano size.

Sol-Gel Method:

It is a wet Chemical method.

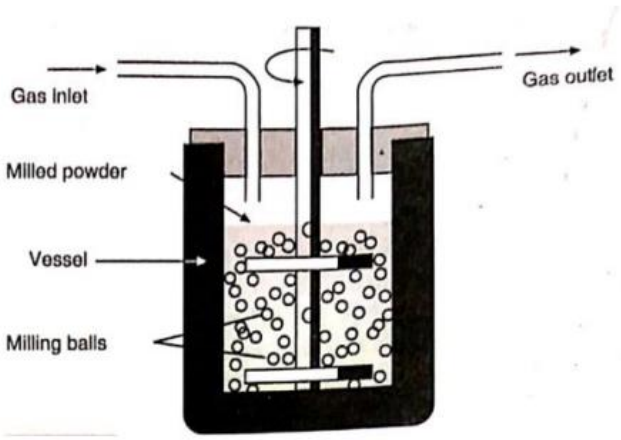
Step-1: A homogenous solution is prepared by dissolving metal salt in water or metal alkoxide (M-OR) in an organic solvent.
Step-2: This homogenous solution converts into sol due to hydrolysis reaction.
M-OR + H2O --------→ M-OH + R OH
The hydrolysis results in formation of metal hydroxide (sol).
Step-3: The colloidal solution is kept for aging. During aging condensation leads to M-O-M bonds
M-OR + HO-M --------→ M-O-M + R – OH
The condensation continues and finally results in a ‘gel’.
Step-4: The liquid phase is removed from gel network by drying. Supercritical drying gives aerogel and evaporative drying gives xerogel

4. What is Top-down technique? Explain how do you prepare nanomaterials by Ball milling method.

Ans: Top down technique: In this technique nanomaterials are synthesized from large pieces of material. One way of doing this is by mechanical crushing.

High Energy Ball milling:

1. High energy is top-down approach technique.
2. Coarse grained materials are crushed mechanically in rotating drums by hard steel and tungsten carbide balls.
3. The high energy ball milling system consists of a container packed with stainless steel balls of few millimeters in diameter.
4.The material to be crushed is added as powder. Rotating shafts crush the material with liquid nitrogen in the container.



5. What are Carbon nanotubes? Give their properties and applications.

Ans: A carbon nanotube (CNT) is a cylindrical rolled up sheet of graphene. They are typically few nanometers in diameter and several micrometers to centimeters long.

Types of CNTs

They are of two types (a) Single-walled nanotubes (SWNT) (b) Multi-walled nanotubes (MWNT)

Single walled nanotube consists of graphene sheet rolled on leading to a single cylinder. A multi walled carbon nanotube is the arrangement of several coaxial tubes of graphene sheets forming a tubelike structure

Properties: (remember any 3)

1. They have high tensile strength and Young's modulus of best nanotubes can 5 times greater than steel.
2. Because of vibration of covalent bonds between carbon atoms they have high thermal conductivity.
3. The electrical conductivity of some CNT's is superior to copper.
4. They have high chemical reactivity.

Applications of CNTs: (remember any 3)

1. CNT's make better energy storages (fuel cells).
2. They can store hydrogen in inner cores.
3. They are used as field emitting devices in AFM, flat panel displays etc.
4. They are used in aerospace applications because of their lightness.

6. Give some applications of nanomaterials.

Applications of Nanomaterials:

1. Better insulation materials: The aerogels synthesized by the sol-gel technique are porous with air trapped inside. So they are used for insulation. They are also used as materials for smart windows which darken when sun is too bright.

2. Elimination of pollutants: Nanomaterials can be used as catalysts to react with harmful and toxic gases as carbon monoxide and nitrogen oxide in automobile catalytic convertors and power generation equipment. This can avoid environmental pollution.

3. High energy density batteries: Nanocrystalline materials are useful for separator plates in batteries because of their foam like structure, which can hold considerably more energy. Eg. Nanocrystalline Nickel and metal hydrides batteries requires far less frequent recharging .

4. Nanomachines and nanodevices: Nano sized machines found in biological systems inspired researchers to design mechanical nano machines like interactive nanogears by adding benzene molecules to the outer walls of CNTs.