Chemistry of nanomaterials

Ankita Ojha
Department of Chemistry
Maharaja College
Arrah

What are nanomaterials???

materials of which a single unit small sized (in at least one dimension) between 1 and 100 nm.

The definition given by the European Commission states that the particle size of at least half of the particles in the number size distribution must measure 100nm or below.

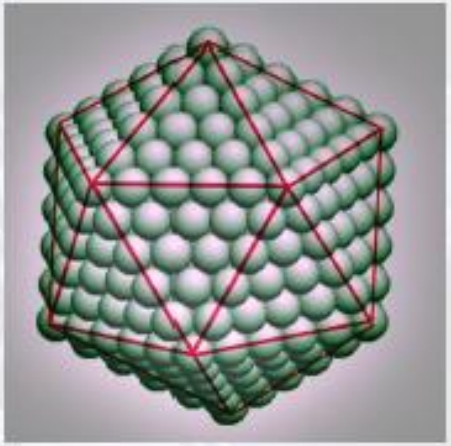
Nanomaterials can occur naturally, be created as the by-products of combustion reactions, or be produced purposefully through engineering to perform a specialized function. These materials can have different physical and chemical properties to their bulk-form counterparts.

Sources of nanomaterials

NATURAL:

- Virus Capsid
- Lotus Leaf
- Gecko Foot
- Peacock feather

Are certain natural examples of nanoparticles/nanomaterials.



Engineered Nanomaterials

- They are designed and synthesized as per the need of human activity.

		
Chantecaille Nano Gold Energizing Cream	Trucare Nano Silver Toothpaste Anti Bacterial, Fights Ulcers Canker Sore	Melaklear Nano Alpha Arbutin Anti Melasma Spots SPF20 Skin Lightening Cream
		
Research In Beauty Nano-Complex Keratin Gold Shampoo	Acz Nano Zeolite Extra Strength-Detoxification Supplement	Cyclic Nano Silver Cleanser Soap

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6192267/bin/nihms-986927-f0001.jpg

Incidental Nanomaterials

- Nanomaterials may be incidentally produced as a byproduct of mechanical or industrial processes. Sources of incidental nanoparticles include vehicle engine exhausts, welding fumes, combustion processes from domestic solid fuel heating and cooking.
- For instance, the class of nanomaterials called fullerenes are generated by burning gas, biomass, and candle.

Uses of nanomaterials

Healthcare:

- Drug delivery such as in nanoparticles are being developed to assist the transportation of chemotherapy drugs directly to cancerous growths or to areas of arteries that are damaged in order to fight cardiovascular disease.
- Carbon nanotubes are also being developed in order to be used in processes such as the addition of antibodies to the nanotubes to create bacteria sensors.

In aerospace, carbon nanotubes can be used in the morphing of aircraft wings. The nanotubes are used in a composite form to bend in response to the application of an electric voltage.

- Titanium oxide has been used extensively by the cosmetics industry, in sunscreen, due to the poor stability that conventional chemical UV protection offers in the long-term.
- The sports industry has been producing baseball bats that have been made with carbon nanotubes, making the bats lighter therefore improving their performance.
- As a lubricant additive, nano materials have the ability to reduce friction in moving parts. Worn and corroded parts can also be repaired with self-assembling anisotropic nanoparticles called TriboTEX.
- Nanomaterials can also be used in three-way-catalyst (TWC) applications. TWC converters have the advantage of controlling the emission of nitrogen oxides (NOx), which are precursors to acid rain and smog.

Properties of Nanomaterials

- large specific surface area
- crystalline structure
- shape (that regulates most of its properties as well as their unique attributes)
- surface morphology and assembling phenomena.
- highly tunable synthetic pathways, sensitive characterization methods, and multiple action properties make them materials of advanced applications
- quantum effect in nanoparticles is responsible for their unusual physicochemical properties such as thermal, electrical, or optical properties
- strong adsorption, superior redox, and photocatalytic activity

Characterization of nanomaterials

- Photon-correlation Spectroscopy (PCS) Or Dynamic Light Scattering (DLS)
- Atomic Force Microscopy (AFM),
- Scanning Electron Microscopy (SEM)
- Transmission Electron Microscopy (TEM)
- X-ray Photoelectron Spectroscopy (XPS)
- Nanoparticle Tracking Analysis (NTA)
- Brunauere-emmett-teller (BET) Technique

Nanoparticles Synthesis

Top-Down Approach of synthesis

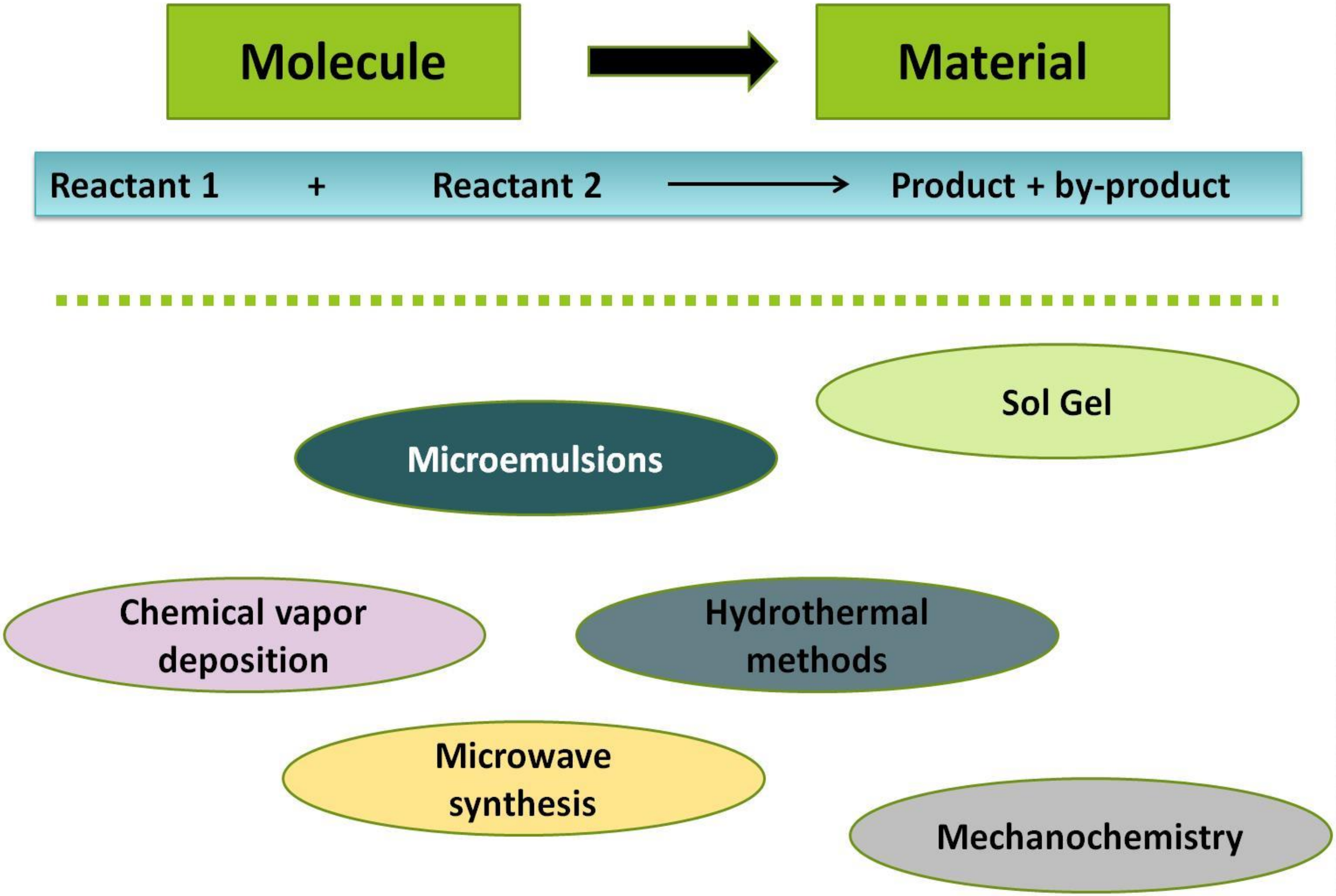
Achieved Through Attrition or Milling

It mainly involves subjecting bigger particles to mechanical and thermal cycles

The particles of varying diameter is obtained ranging from 10-1000 nm. The shape of the particles also vary accordingly. The product contains many impurities.

Bottom-up Approach of synthesis

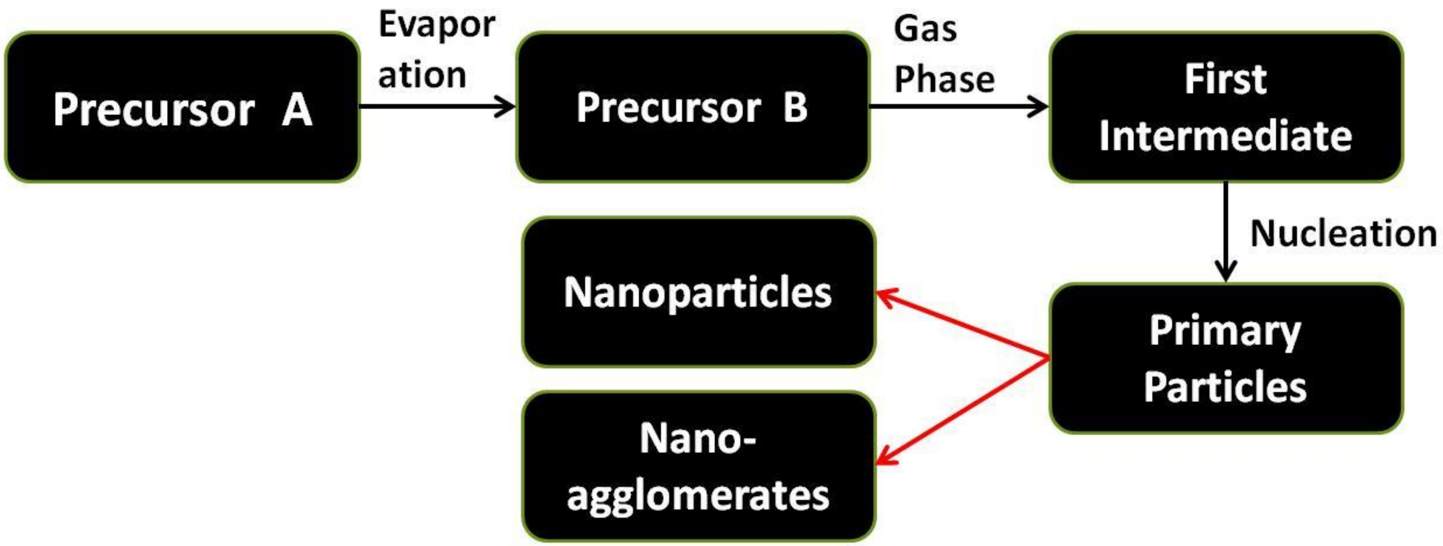
- **Pyrolysis**
- **Condensation of Inert gases**
- **Solvothermal Reaction**
- **Sol-Gel fabrication method**
- **Medium structuration**


Molecule
Material
Reactant 1 + Reactant 2 → Product + by-product
Sol Gel
Microemulsions
Chemical vapor deposition
Hydrothermal methods
Microwave synthesis
Mechanochemistry

Bottom – Up Synthesis

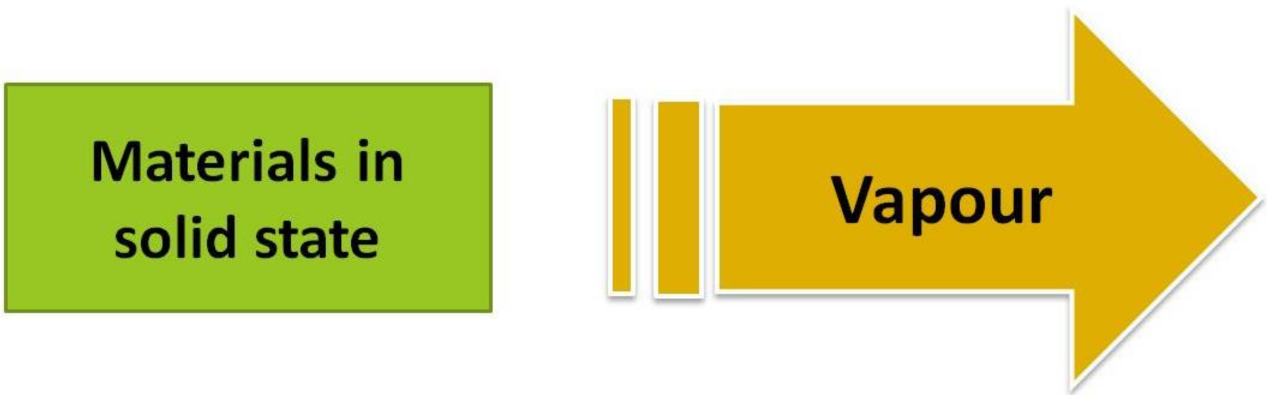
- There are mainly two ways for this:

1. Vapour Phase deposition which either physical vapour deposition or chemical vapour deposition
2. Liquid Phase fabrication by solvothermal methods or sol-gel synthesis or micelle medium of synthesis.



Physical Vapor Deposition (PVD)

Physical Vapor deposition (PVD) is a variety of vacuum methods and it is mainly used to deposit thin films by the condensation of a vaporized form of material into various surfaces.



The coating method mainly involves purely physical processes such as high temperature vacuum evaporation or ion bombardment rather than following chemical reaction at the coating surface.

Thank You

Stay Home Stay Safe