M.SC Semester II
Core Course V
Advances in Chemistry

Department of Chemistry

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TOPIC: -Chemistry of Nano Materials
Introduction of topics.

Synthesis Of Nano Materials

Introduction

1) Nanomaterials describe, in principle, materials of which a single unit is sized (in at least one dimension) between 1 and 1000 nanometres.
2) Biological systems often feature natural, functional nanomaterials. The structure of foraminifera and viruses (capsid), the wax crystals covering a lotus or nasturtium leaf, spider and spider-mite silk are few examples of natural nanomaterials.

3) Natural inorganic nanomaterials occur through crystal growth in the diverse chemical conditions of the earth's crust. For example clays display complex nanostructures due to anisotropy of their underlying crystal structure, and volcanic activity can give rise to opals, which are an instance of a naturally occurring photonic crystals due to their nanoscale structure.

Photonic Crystals

1) A photonic crystal is a periodic optical nanostructure that affects the motion of photons. They are used to manipulate light flow. Used to form colour changing paints and inks.

Synthesis

- Includes two methods
- Bottom Up Approach
- Top Down Approach

Top Down

- Start with bulk material and “cut away material “ to make what you want.
- Examples:
- ATTRITION: In attrition, macro- or micro-scale particles are ground in a ball mill, a planetary ball mill, or other size-reducing mechanism. The resulting particles are air classified to recover nanoparticles.

- **Lithography** : It is a wafer scale process to prepare homogenous 1D,2D or 3D nanomaterials.
- The method combines the advantages of both top down and bottom up approaches and is a two step process :
- The preparation of colloidal crystal mask (CCM) made of nano spheres.
- The decomposition of desired material through the mask.
- The mask is then removed and the layer keeps the ordered pattern of the mask interstices.

Bottom Up

- Building what you want by assembling it from building blocks (Such as atoms and molecules).

Chaotic

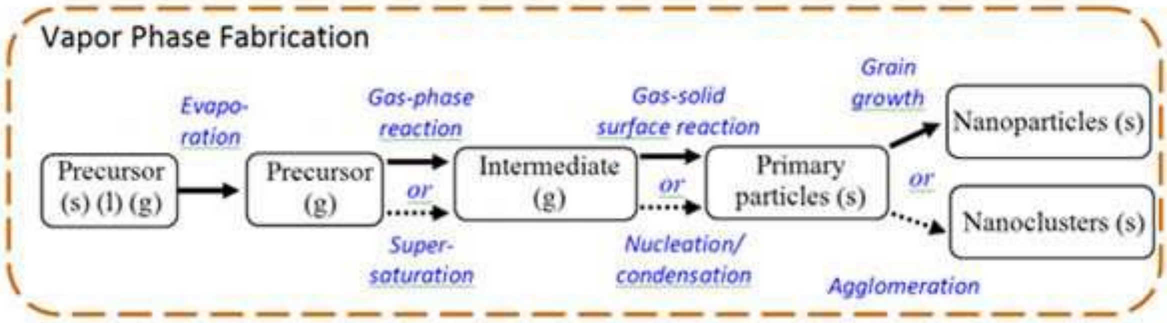
- Chaotic processes involve elevating the constituent atoms or molecules to a chaotic state and then suddenly changing the conditions so as to make that state unstable. Through the clever manipulation of any number of parameters, products form largely as a result of the insuring kinetics.

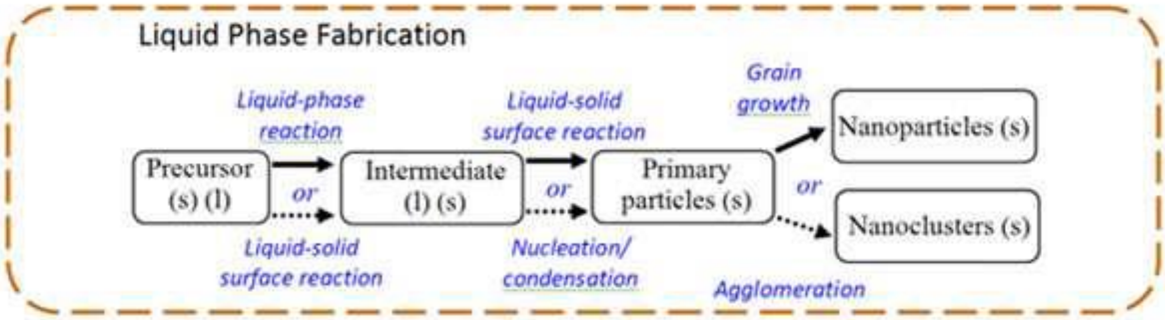
Controlled

- Controlled Processes involve the controlled delivery of the constituent atoms or molecules to the site(s) of nanoparticle formation such that the nanoparticle can grow to a prescribed size in a controlled manner.

- Bottom up approach are further classified into
  1.) Gas (Vapor) Phase Fabrication: Pyrolysis
  2.) Liquid Phase Fabrication: Solvo thermal Reaction, Sol-gel.

Bottom Up Approach Types





Pyrolysis

- In pyrolysis, a vaporous precursor (liquid or gas) is forced through a hole or opening at high pressure and burned. The resulting solid is air classified to recover oxide particles from by-product gases. Pyrolysis often results in aggregates and agglomerates rather than singleton primary particles.
- The advantages of vapor phase pyrolysis include it being a simple process, cost effective, a continuous operation with high yield.

Solvothermal Process

- Precursors are dissolved in hot solvents (e.g., n-butyl alcohol) and solvent other than water can provide milder and friendlier reaction conditions. If the solvent is water then the process is referred to as hydrothermal method.
- It is synthesis method for growing for crystals from a non aqueous solution in a autoenclave (a thick walled steel vessel) at high temperature (400 deg.C) and pressure.

Sol-Gel

- The sol-gel process is a wet-chemical technique (also known as chemical solution deposition) widely used recently in the fields of materials science and ceramic engineering.

Steps Include

- Formation of stable sol.
- Gelation via a polycondensation or polyesterification reaction.
- Gel aging into a solid mass. This causes contraction of the gel network, also phase transformations and Ostwald ripening.
- Drying of the gel to remove liquid phases. This can lead to fundamental changes in the structure of the gel.

Steps Include

- Dehydration at temperatures as high as 8000 degree C, used to remove M-OH groups for stabilizing the gel, i.e., to protect it from rehydration.
- Densification and decomposition of the gels at high temperatures (T > 8000 degree C), i.e., to collapse the pores in the gel network and to drive out remaining organic contaminants

Applications

- Drug delivery systems
- Anti-corrosion barrier coatings
- UV protection gels
- Lubricants and scratch free paints
- New fire retardant materials
- New scratch/abrasion resistant materials
- Superior strength fibers and films

Future Works

- Nanoparticles can provide significant improvements in traditional biological imaging of cells and tissues using fluorescence microscopy as well as in modern magnetic resonance imaging (MRI) of various regions of the body.
- Among the different application areas of nanoparticles, drug delivery is one of the most advanced. This is large part due to the success of polymer- and liposome-based drug delivery systems.
- Nanoparticles have made a tremendous impact in the treatment of various types of cancer, as evidenced by the numerous nanoparticle-based drugs and delivery systems. Paclitaxel is an anti-cancer agent used to treat several types of cancer (such as ovarian, skin, esophageal, and lung).