PRESENTATION

By

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NANOTECHNOLOGY

❑Introduction:

- ➢Nanotechnology is a toolbox that provides nanometer-sized building blocks for the tailoring of new materials, devices and systems.
- ➢Nanotechnology is concerned with work at the atomic, molecular and supramolecular levels in order to understand and create materials.
- ➢Development and utilization of structures and devices with organizational features at the intermediate scale between individual molecules and about 100 nanometers where novel properties occur as compared to the bulk materials.

Prefix	Symbol	Multiple
atto	a	10^{-18}
femto	f	10^{-15}
pico	p	10^{-12}
nano	n	10^{-9}
micro	u	10^{-6}
milli	m	10^{-3}
centi	c	10^{-2}
deci	d	10^{-1}
deka	da	10^{1}
hecto	h	10^{2}
kilo	K	10^{3}
mega	M	10^{6}
giga	G	10^{9}
tetra	T	10^{12}
peta	P	10^{15}
exa	E	10^{18}

❑Properties:

It is therefore clear that nanomaterials and nanotechnology, depends on size dependent properties. In general they can be recognized as follows:

- ➢Chemical properties- reactivity, catalysis.
- ➢Thermal property- melting temperature .
- ➢Mechanical property- adhesion, capillary forces.
- ➢Optical properties- absorption, scattering of light.
- ➢Electrical properties- tunneling of current.
- ➢Magnetic properties- super paramagnetic effect.

This list can be extended to include many other sensing and biochemical properties and functions. Normally the size of a nanometer is compared to that of human hair which is 80,000 nm wide.

❖Nano-

- A prefix meaning one billionth (1/1,000,000,000)

❖Nanochemistry

- The study of the synthesis and characterization of materials in the nanoscale size range (1 to 10 nm).

- These materials includes large organic molecules, inorganic cluster compounds, and metallic or semiconductor particles.

❖Nanometer

- One billionth of a meter, approximately the length of 3 to 6 atoms placed side-by- side, or the width of 10 hydrogen atoms or the width of single strand of DNA (2 to12 nm wide in size); the thickness of human hair is between 50,000 and 100,000 nm.

❑Nanoparticle:

➢ A nanoscale spherical or capsule-shaped structure. Most, though not all, nanoparticles are hollow, which provides a central reservoir that can be filled with anticancer drugs, detection agents, or chemicals, known as reporters, that can signal if a drug is having a therapeutic effect.

➢The surface of nano particle can also be adorned with various targeting agents, such as antibodies, drugs,imaging agents, and reporters.

➢Most nano particles are constructed to be small enough to pass through blood capillaries and enter cells.

➢In recent years, there has been intense interest in the synthesis and characterization of nanoparticles, which range 1-100 nm in diameter. Semiconductor nanoparticles around 1-20 nm in diameter are often called quantum dots, nano crystals or Q-particles.2.

❑Synthetic strategies:

- In this section we shall briefly consider the various strategies adopted for the preparation of nanomaterials.

- Even though this section is subdivided in subsections, it should be remarked that there exists a certain overlap between the different methods.

❖Gas Phase Evaporation Method:

- This technique is based on the vapourization of metals in a pressure of static inert gas.
- Vapourization can be achieved by using resistive heating, electron beam or laser vapourization.
- Cluster growth occurs in gas phase and depends on the gas temperature and pressure. The clusters formed can be condensed on suitable substrates.

❖Matrix Isolation Technique:

- It is based on the con-condensation of metal vapours with weakly interactive supports such as inert gases (Ar, Kr, Xe) at low temperatures.
- This has been widely used to isolate small and well defined ligand free metal clusters.

❖Metal Vapour-covalent Codeposition Method:

➢**Con-condensation of metal vapours with organic compounds as weakly coordinated solvents followed by warming to room temperature is adopted method to produce solvated metal particle.**

➢**Con-condensation is usually carried out at surfaces cooled to low temperatures (say 77 K).**

➢ **At these temperatures almost all organic substances are in the solid state, so upon con-condensation, metals atoms and clusters are embedded into solid organic matrices.**

➢**A variation of this method is to react the metal atoms with reactive organic substrates (like arenes) and this will results in formation of metal arene complex thus resulting in cluster arene complex containing strained ring substituents.**

➢**Other variations are metal vapour deposition into polymer, decomposition of organo-metal compounds and cluser complexes for the preparation of metal clsters.**

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❖Sol Gel Processing:

➢**One of the most successful method adopted for the synthesis of nanomaterials is the sol gel processing route under appropriate experimental conditions.**

➢**The sol gel process involves the combination of chemical reactions which turns a homogeneous solution of reactants into an infinite molecular weight polymer.**

➢**This polymer is a three dimentional interconnected pores. The polymer is isotropic, homogeneous and uniform and it replicates its mold exactly and miniatureizes all features without distortion.**

➢**Thus the polymer net works provide nanostructure and nanophase porosity. A pictorial representation is shown in fig.**

➢**A variety of reaction conditions are employed for suitably architecturing the nanomaterials. In the case of metal nanomaterials preparation with various capping agents are employed and a pictorial representation of the same is as shown in fig.**

exactly and miniaturizes all features without distortion. Thus the polymer net works provide nanostructure and nanophase porosity. A pictorial representation of this technique is shown in Fig. 1.3.

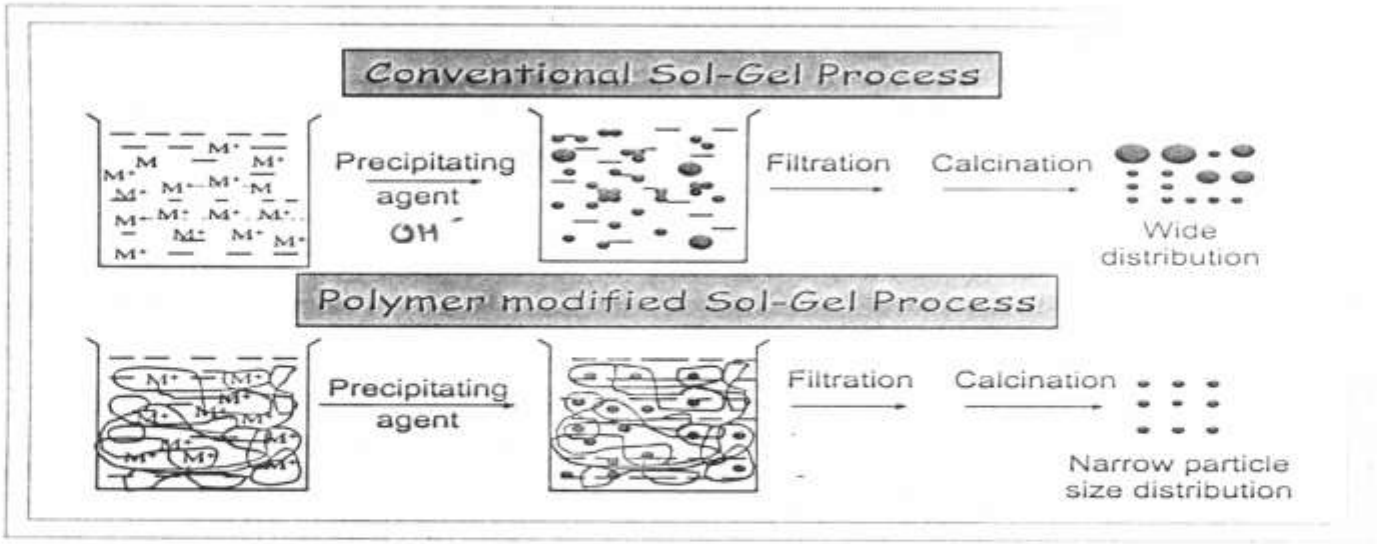

Fig. 1.3 Pictorial representation of conventional and polymer modified sol-gel process

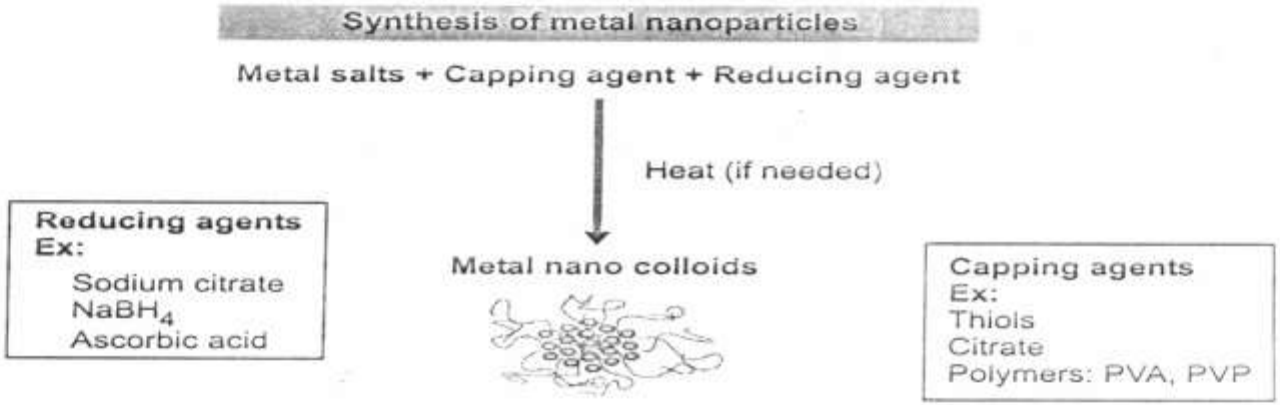

Fig. 1.4 Pictorial representation of the formation of metal nanoparticles employing capping agents

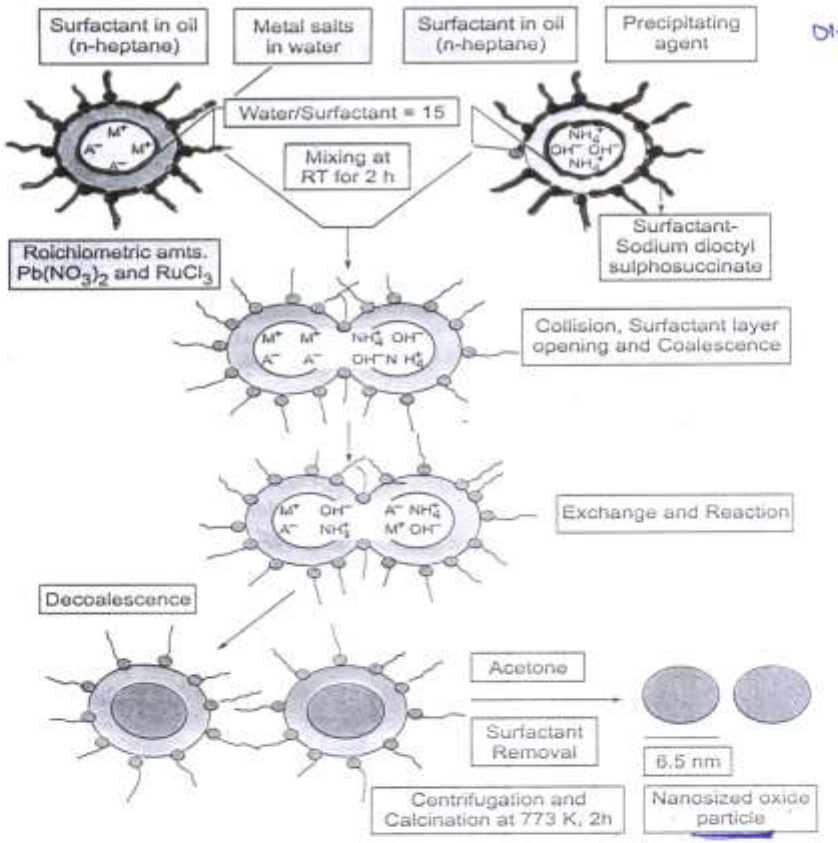

Fig. 1.6 A pictorial representation of reverse micellar technique for the preparation of nanomaterials

❖ **The factors that controls the nucleation and growth routes of the nano particles formed are given in table:**

Table: Governing the factors for the growth of nanostructures

- **Kinetics of nucleation and growth**
- **Concentration of stabilizing agent**
- **Structure of stabilizing agent**
- **Nature of the capping agent**
- **pH of the medium employed and temperature**

The nucleation and growth of the particles are the crucial factors for controlling the size of nano particles formed. This is usually achieved by choice of the suitable capping agents and also the functionality of the capping agents, their hydrophilic and hydrophobic parts interacting suitably with the particles formed and thus preventing growth mechanism. The nucleation and growth kinetics is determined by various factors and this is illustrated pictorially in fig.

Table: Examples of nanotechnology-based applications

Industry	Applications on the market
Automotive	Automobile General motors GMC safari nanocomposite step from southern Clay. Advantage: stiff and light car parts. Antireflection coating on instruments of Audi cars and DaimlerChrysler truck based on nanolayers on glass. Advantage: better antireflection.
Building Materials	Duravit sinks and toilets using nanocoatings from Nanogate. Advantage: improved anti-stick properties.
Consumer Electronics and Instruments	Kodak EasyShare LS633 using nanoenhanced OLEDs. Advantage: brighter and less energy consuming displays. Germicidal nanocoating in Audio Service hearing aids from Germany's Institute of new materials. Advantage: better non-stick properties of coatings.

Industry	Applications on the market
Cosmetics and body care:	**Nucelle sunscreen using titanium dioxide nanoparticles from nanophase. Advantage: better absorption of UV-light.** **L'Oreal nano capsules in cosmetics. Advantages: Better skin moisturizing properties.**
Fashion	**Maui Jim sun glasses with nano coatings from Nanofilm. Advantages: Better antireflection properties.**
Medical equipment	**Eddie Bauer khaki pants using molecular textile coatings from Nano-tex. Advantages : For instance anti-wrinkle properties.** **Evidots (quantum dots) for medical imaging from evident technologies. Advantages: fluorescent biomarker with norrow, predictable emission band of light.**
Sports	**Babolat tennis rackets using Nano tubes. Advantages: Lighter but stronger rackets.** **Nano wax Derax ski wax from nano gate. Advantages: Hard and fast – gliding surface.**

❑Applications:

❖Health and medicine:

➢ **The current advancement in the field of medicine is the research and development of nanoparticles and nanotechnology for medicinal applications. Nanomedicine which is multidisciplinary field includes biology, chemistry, physics, engineering and material science. Nanomedicine may be defined as the monitoring, repair, construction and control of human biological systems at the molecular level, using engineered nanodevices and nanostructures.**

➢**By manipulating drugs and other materials at the nanometer scale, the fundamental properties and bioactivity of materials can bealtered. These tools can permit control over characteristics of drugs or agents such as solubility, blood pool retention times, controlled release over short or long durations.**

➢**By using nanometer-sized particles, the increased functional surface area per unit volume can be exploited in various ways. Integration of nanotechnology into complex biological systems lead to detection and prevention of disease at the earliest stages of its development.**

➢**Their applications to this field range widely from diagnosis, therapeutic applications, surgery and artificial implants.**

❖Food:

➢It is the source of mental and physical energy but it is not sure that many healthy ingredients that we consume reach the destination and if they reach, whether they function properly. The healthy food we consume should have both solubility and bioavailability and these ingredients are available in the body.

❖Diagnosis

➢Nanoparticles possessing unique optical, electronic and magnetic properties have been demonstrated by several researchers as possible probes to detect biological species. Not only the minute size of nanocrystals comparable to biologically functional molecules, but also the ability to tune their biochemical properties by modifying their size, shape and composition makes these materials useful and optimized for biomedical purposes. Nanotechnology has the potential to bring dramatic improvement in the field of biomedical science including detection, diagnosis and therapeutic systems.

❖Fluorescent NP for biosensors and biolabelling

➢**Surface Enhanced Raman Spectroscopy (SERS) relies on this signal magnification and serves as a tool for ultrasensitive monitoring of the intracellular distribution of these chemicals. Colloidal gold biofunctionalized nanomodules also have potential for use in enzyme multi-sensors. Gold nano particles coated with proteins have been used to detect conformation changes in the attached proteins via observation of color changes in the solution**

❖Quantum Dots(QDs):

➢**Quantum Dots (QDs) are one of the possible fluorescent nanoparticles for diagnostic applications. Quantum dots of semiconductor particles such as Cds and CdSe, whose electronic properties vary according to their particle size ,are used as biolables and biomarkers . Their water soluble nature and ability to conjugate with biological molecules make them a good choice as nanosensors.**

- **Dye doped silica nanoparticles have also been used in DNA microarrays which are used in genomics, drug discovery and clinical diagnosis. Nanoparticles have also been shown to determine the DNA quatitatively as the fluorescence signals reflected the amount of DNA on array. The nanoparticles can generate specific and high intensity fluorescent signals according to the antibody-antigen interaction, thus making it possible to detect bacterial or viral pathogens.**

- **Some class of organophosphorous (OP) neurotoxins is extremely toxic mammals and also they form chemical warfare agents. A method based on gold nanoparticles has been developed to detect the presence of OP compounds.**

- **Recently superparamagnetic iron oxide (SPIO) nanoparticles encapsulated within chitosan (polyglucosamine) were used to get the MRI images of kidney of New Zealand white rabbit. PEG (poly ethylene glycol) coated FeOOH nanoparticles were found to be potential material as tumor selective MRI contrast agents.**