PHYSICAL CHEMISTRY OF NANOSTRUCTURED SYSTEMS

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INTRODUCTION

Nanotechnology was born as a science very recently. It is one of the greatest discoveries for humanity and one of the most promising areas of modern science and technology with great economic and social impact.

The main purpose is to help humanity in its development.

INTRODUCTION

Advances for the industry:

- Materials with new properties not developed until now.
- Stronger materials than steel, but with 10% of its weight.
- Faster computer applications.
- Various medical applications.

INTRODUCTION

Richard Feynman was the first to refer the possibilities of nanoscience when in 1959 he gave a lecture entitled “There's Plenty of Room at the Bottom”

Questions are raised about its suitability and opens the possibility of transforming matter from the minimum to our benefit and today this is possible thanks to Nanotechnology.

OBJECTIVES

- To explain formation and development of Nanochemistry.
- To give an overview about Nanoparticle as a structural unit of new substances and materials with unusual properties.
- To organize nanoparticles according different criteria.
- To explain briefly properties of nanoparticles.

OUTLINE

1. Introduction.
2. Formation and development of Nanochemistry.
3. Nanoparticle as a structural unit of new substances.
4. Classification and properties of nanoparticles.

Formation and development of Nanochemistry

Nanoscience: study of phenomena and manipulation of materials at atomic, molecular and macromolecular scales, **where properties differ significantly from those at a larger scale**.

Nanotechnology: a device or machine, product or process, based upon individuals or multiple integrated nanoscale components.

Nanochemistry: is the utilization of synthetic chemistry to make nanoscale building blocks of different size and shape, composition and surface structure, charge and functionality.

Formation and development of Nanochemistry

Nanoparticles can be defined as particles with at least one of their three - dimensional sizes in the range of 1–~100 nm. This is between the size of atoms or molecules and bulk materials. Within this size range, they can usually consist of 10–10,000 atoms.

Also, nanoparticles can be in either an amorphous or crystalline state. If crystalline is considered: nanocrystal

Classification of nanoparticles

The US Environmental Agency:

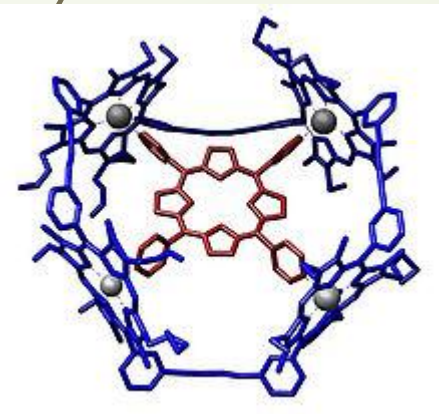
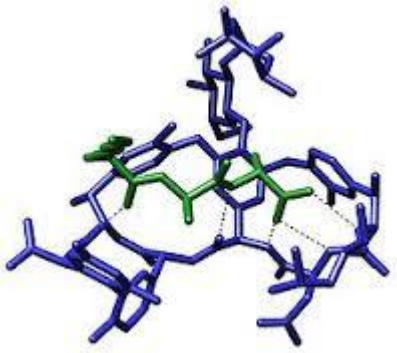
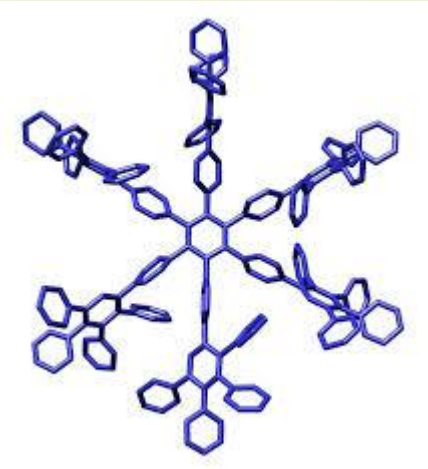
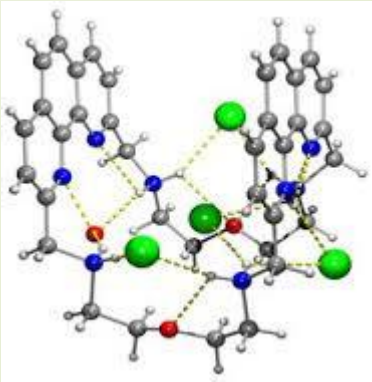
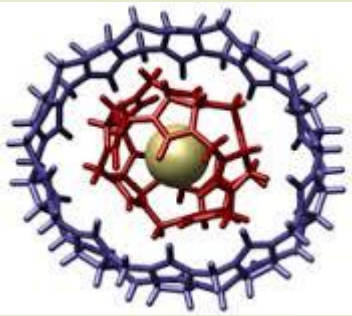
1. **Carbon based materials**: with spherical, ellipsoidal or tubular forms.

2. **Metallic based materials**: they can be quantum dots (quantum dots or transistors of a single electron) or nanoparticles of gold, silver42 or of reactive metals like titanium dioxide.

Classification of nanoparticles

The US Environmental Agency:

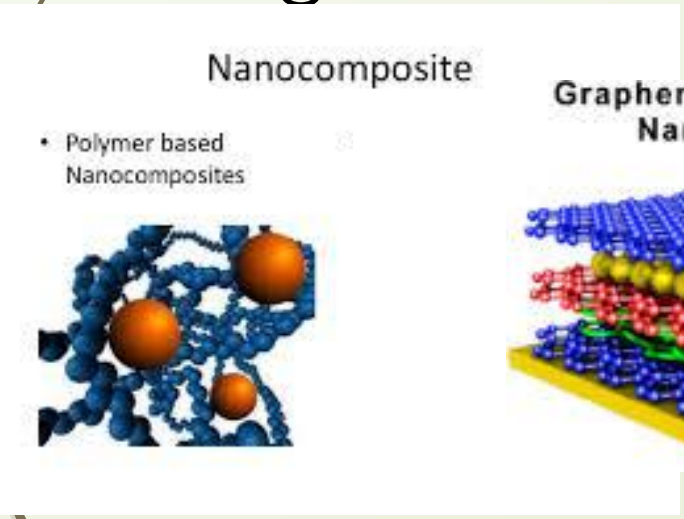
3. **Dendrimers**: are highly branched macromolecules with the dimensions nanometer-scale. The surface of a dendrimer possess numerous chain which can be modified to perform specific chemical functions.

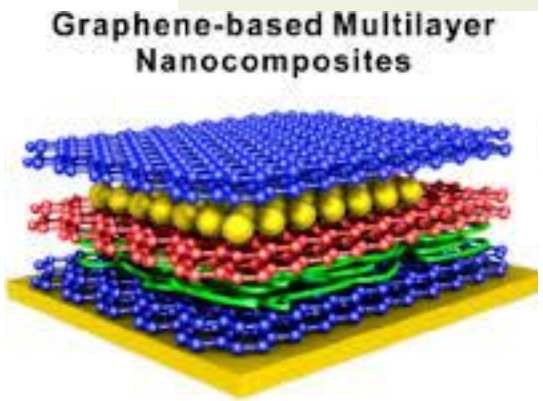






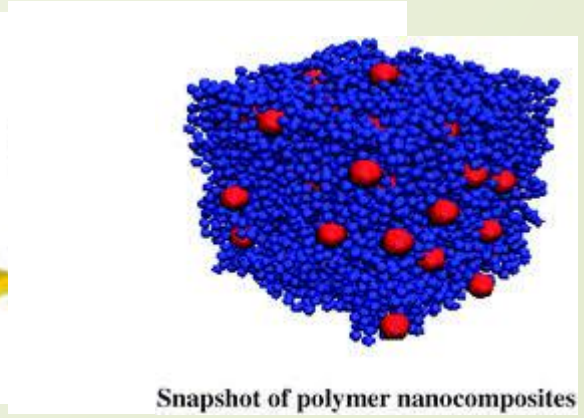
Classification of nanoparticles

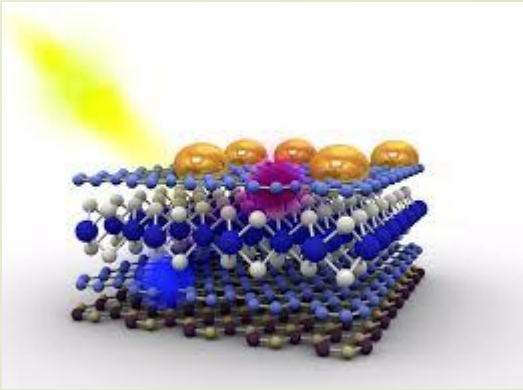
The US Environmental Agency:

4. Composites: Nanocomposite can be described as a multiphase solid material where at least one of the phases has one, two or three dimensions in nanoscale. The most common examples of these materials are colloids, gels and copolymers.









Classification of nanoparticles

Typical examples of various nanoparticles:

Composition	**Nanoparticles**
Pure metal	Au, Ag, Pd, Pt, Cu, Co, Ni, Ru
Bimetal	Fe-Co, Co-Ni, Pd-Au
Alloy	FePt, CoPt, PdNi, PtRu
Semiconductor	GaAs, CdTe, CdSe, CdS, ZnSe, AgBr
Oxide	SiO_2, Al_2O_3, TiO_2, CeO_2, Fe_3O_4, ZrO_2

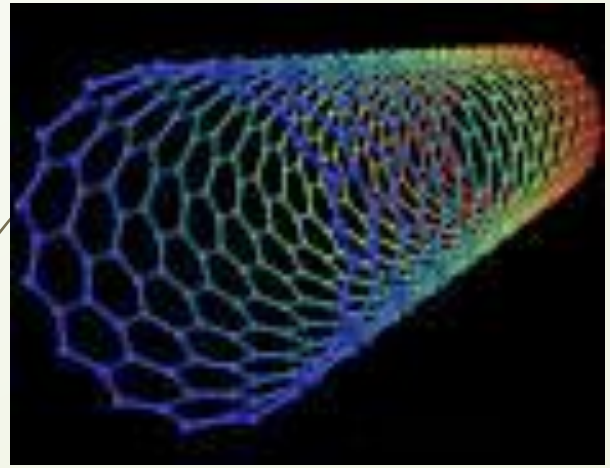
Classification of nanoparticles

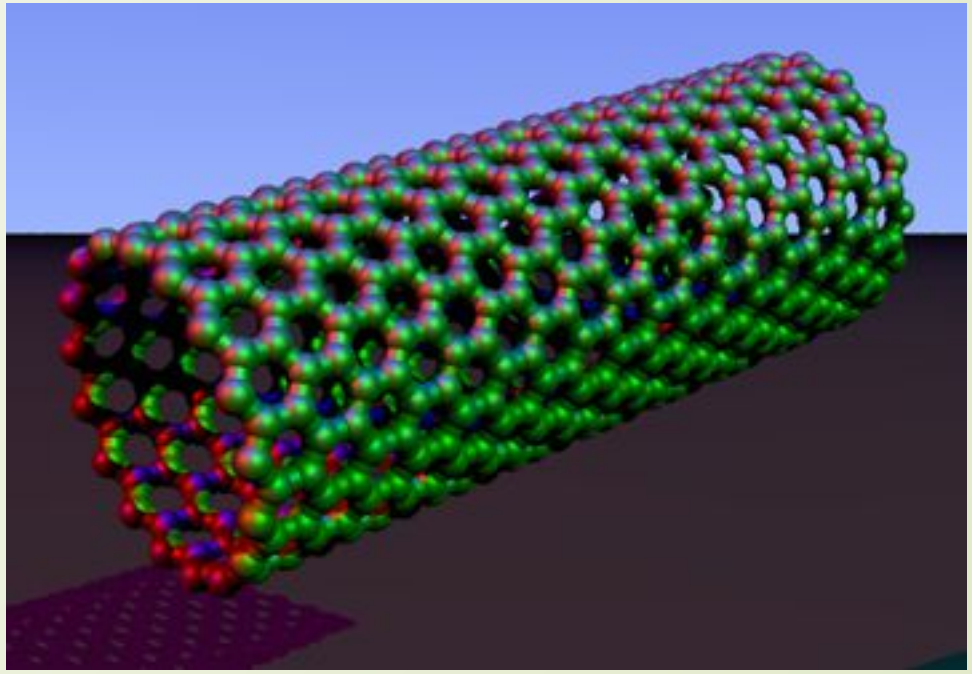
Different shapes of nanoparticles :

sphere prism cube tetrapod

Classification of nanoparticles

Examples of tube-type nanoparticles:

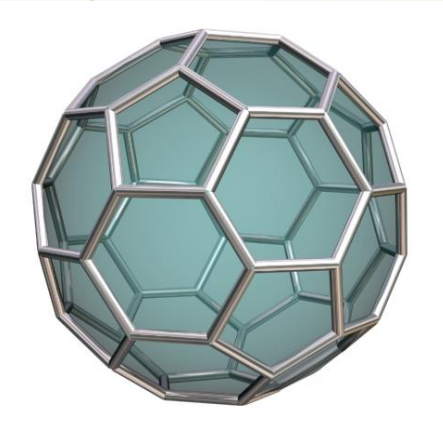


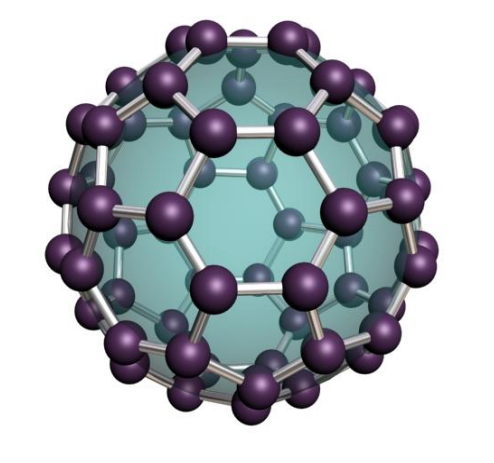


Carbon nanotubes

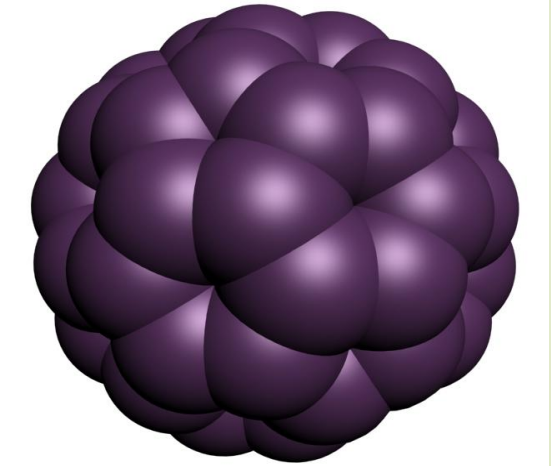
Classification of nanoparticles

Examples of hollow sphere nanoparticles:



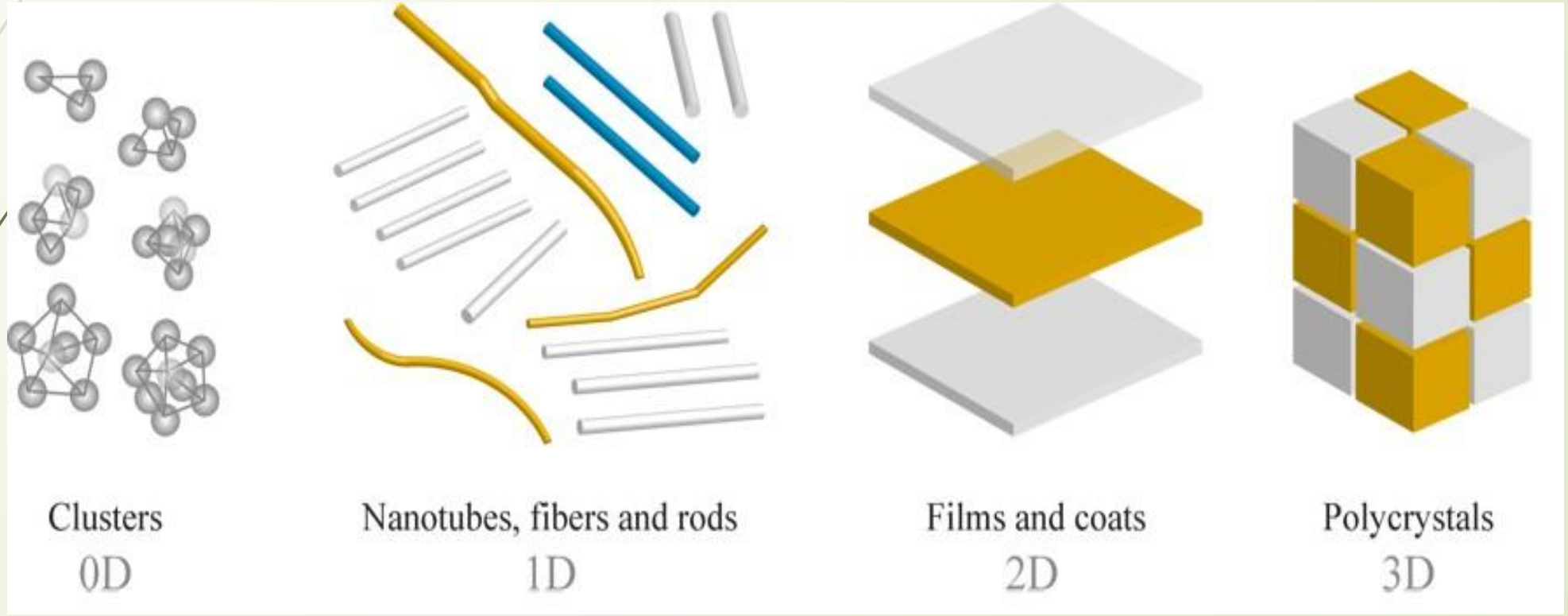


Fullerenes



Classification of nanoparticles

Different nanoparticles according to the spatial dimensions:



Classification of nanoparticles

Different nanoparticles according to the spatial dimensions:

- Zero dimensional(0-D): These nanomaterials have Nano-dimensions in all the three directions. Diameter of particles: 1-50 nm. Most of these are spherical. Examples: clusters.

- One dimensional(1-D): one dimension of the nanostructure will be outside the nanometer range. Examples: nanotubes, fibers and rods).

Classification of nanoparticles

Different nanoparticles according to the spatial dimensions:

- Two dimensional(2-D): In this type of nanomaterials, two dimensions are outside the nanometer range. Examples: nano films, nano sheets.

- Three Dimensional(3-D): All dimensions of these are outside the nano meter range. Examples: nanocrystals.

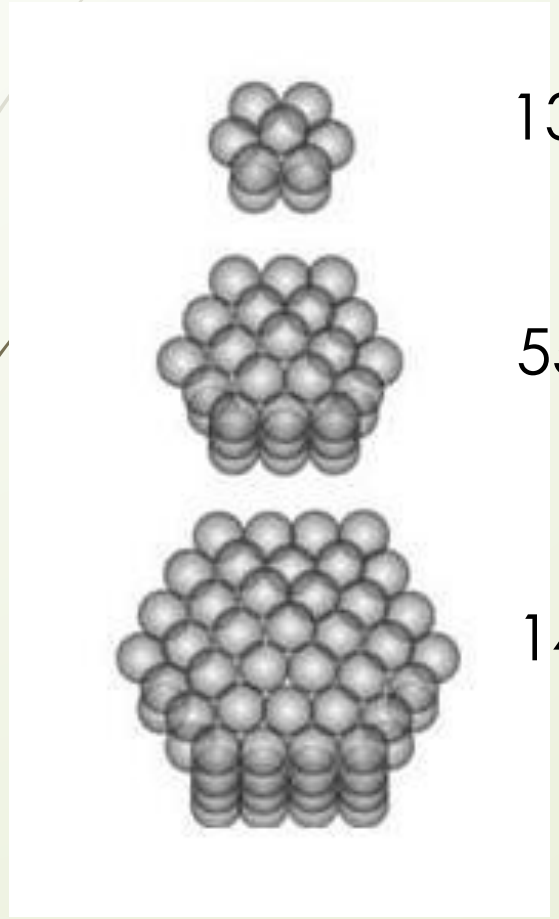
Properties of nanoparticles

The causes of these behavioral differences in their properties are mainly two:

- The large increase in the surface area of the nanoparticle.
- The quantum confinement of the electrons inside the nanoparticle (new quantum effect).

Properties of nanoparticles

Variation of the surface area



13 atoms (12 on the surface) 92%

55 atoms (45 on the surface) 76%

147 atoms (93 on the surface) 63%

Properties of nanoparticles

- Physical properties:
  - ✔ The melting point
  - ✔ Electrical and thermal conductivity
- Chemical properties
- Mechanical properties:
  - ✔ Hardness
  - ✔ Strength
  - ✔ capacity of tensile deformation

Conclusions

- A nanomaterial differs from a conventional polycrystalline material not only because of the size of its structures, but also in the way we can use it.
- The electronic, optical, magnetic, chemical, and mechanical properties are substantially affected by the scale of a material's features.

THANK YOU FOR YOUR ATTENTION!