**Classifications of Nanomaterials**

**1.5 Quantum dots**

A quantum dot is a semiconductor nanostructure that limits the motion of

valence band holes, conduction band electrons, or excitations in all three spatial

**4**

**Classifications of nanomaterials**

directions. The confinement can be due to electrostatic potentials (generated by

external electrodes, doping, strain, impurities), the presence of an interface between

different semiconductor materials (e.g. in core-shell nanocrystal systems), the

presence of the semiconductor surface (e.g. semiconductor nanocrystal), or a

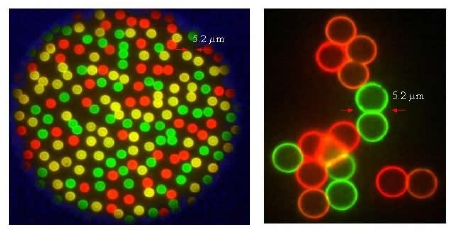
combination of these. A quantum dot has a discrete quantized energy spectrum. The

corresponding wave functions are spatially localized within the quantum dot, but

extend over many periods of the crystal lattice. A quantum dot contains a small finite

number (of the order of 1-100) of conduction band electrons, valence band holes, or

excitons(the combination of an [electron](https://www.britannica.com/science/electron) and a positive [hole](https://www.britannica.com/science/hole-solid-state-physics)), i.e., a finite number of elementary electric charges. Small quantum dots, such as colloidal semiconductor nanocrystals, can be as small as 2 to 10 nanometres, corresponding to 10 to 50 atoms in diameter and a total of 100 to 100,000 atoms within the quantum dot volume [20].



**Fig.5:** A figure showing typical quantum dots for anti-counterfeiting

**1.6 Nanostructures**

A nanostructure is a structure of intermediate size between microscopic and

molecular structures. Nanostructural detail is microstructure at nanoscale. In

describing nanostructures it is necessary to differentiate between the numbers of

dimensions on the nanoscale. Nano textured surfaces have one dimension on the

nanoscale, i.e., only the thickness of the surface of an object is between 0.1 and 100

nm. Nanotubes have two dimensions on the nanoscale, i.e., the diameter of the tube

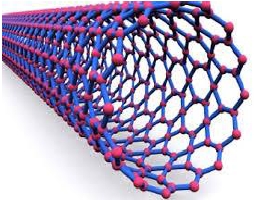
is between 0.1 and 100 nm; its length could be much greater. Finally, spherical

nanoparticles have three dimensions on the nanoscale, i.e., the particle is between

0.1 and 100 nm in each spatial dimension [21].

**5**

**Classifications of nanomaterials**



**Fig. 6:** Single walled carbon nanostructures

**1.7 Nanopores**

A nanopore is a tiny hole in a thin membrane, typically just big enough to

allow a single molecule of DNA to pass through. They are powerful sensors of

molecules and ions and have potential applications in many areas of

technology.When a nanopore is present in an electrically insulating membrane, it

can be used as a single-molecule detector. It can be a biological protein channel in a

high electrical resistance lipid bilayer, a pore in a solid-state membrane or a hybrid

of these - a protein channel set in a synthetic membrane. The detection principle is

based on monitoring the ionic current passing through the nanopore as a voltage is

applied across the membrane. When the nanopore is of molecular dimensions,

passage of molecules (e.g., DNA) cause interruptions of the "open" current level,

leading to a "translocation event" signal. The passage of RNA or single-stranded

DNA molecules through the membrane-embedded alpha-hemolysin channel (1.5 nm

diameter), for example, causes a ~90% blockage of the current (measured at 1 M

KCl solution [22].

**6**

**Classifications of nanomaterials- Types of nanoparticles**

**Fig. 7:** A biased nanopore in an insulating membrane that separates two ionic

solution-filled compartments translocate DNA molecules in sequential nucleotide

order

**2. Types of nanoparticles**

Since, we have objected to study the catalytic efficiency of metal oxide

nanoparticles in organic transformations. Further, we mainly concentrate our

attention on metal oxide nanoparticles. Based on the sources used, there are mainly

four types of nanoparticles given as follows:

2.1 Metallic nanoparticles

2.2 Polymeric nanoparticles

2.3 Carbon based nanostructures

2.4 Metal oxide nanoparticles

**2.1 Metallic nanoparticles**

The metallic nanoparticles are used to define Nano sized metals with

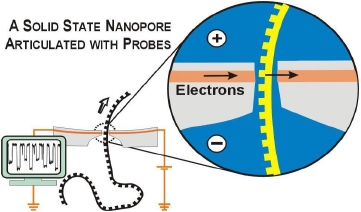
dimensions such as thickness, width or length within the size rang 1-100 nm. The

metallic nanoparticles have large surface-area-to-volume ratio as compared other

bulk materials. They have large surface energy and number of low-co-ordination

sites such as corners and edges. There are several types of metal nanoparticle are

**7**



**Types of nanoparticles**

synthesized by different chemical methods and co-precipitation methods like Cu,

Ag, Au, Ni, Zn, Mg, Fe, Si nanoparticles etc. [23].

**2.2 Polymeric nanoparticles**

The polymeric nanoparticles are defined as particulate dispersion and solid

particles with size in range of 10-1000 nm. The polymeric nanoparticles have been

extensively studied as particulate carriers in various fields such as pharmaceutical

and medical fields. They are also used for drug delivery system. The several

polymeric nanoparticles are synthesized from biodegradable and biocompatible

polymers. The several types of drugs are dissolved in polymeric nanoparticles. They

increase stability of any volatile pharmaceuticals agents. They are also used in

cancer therapy and delivery of vaccines [24].

**2.3 Carbon based nanostructure**

The carbon based nanostructures are important types of nanoparticles and

having different types such as graphene, diamond, nanotube and nanofibers. They

have high surface area for the deposition of conducting polymer and metal oxide

nanoparticles and which fascilate the efficient ion diffusion phenomenon and

contribute towards higher specific capacitance of carbon based composite material

with excellent cyclic stability. They have small dimensions, high chemical stability,

high thermal conductivity and low resistivity [25].

**2.4 metal oxide nanoparticles**

Currently, several types of metal oxides nanoparticles play a very important role in numerous areas of Physics, Chemistry and in Materials science. The numbers of metals are able to form a large miscellany of metal oxides. They involves the structural geometries with an electronic structure that can reveal semiconductor, metallic or insulator character. In technological applications, metal oxide nanoparticles are used in the optoelectronics, in fabrication of microelectronic circuits, sensors, fuel cells, piezoelectric devices. There are several types of metal oxide nanoparticles such as ZnO, CuO, TiO2, MgO, NiO, ZrO2 nanoparticles etc.[26-27].

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**11**