19CH201 – ENGINEERING CHEMISTRY FOR CIRCUIT BRANCHES
Unit-3 NANO CHEMISTRY

SIZE DEPENDENT PROPERTIES

Size-dependent properties are observed such as quantum confinement in semiconductor particles, surface plasma resonance in some metal particles and superparamagnetism in magnetic materials. The properties of materials

change as their size approaches the nanoscale and as the percentage of atoms at the surface of a material becomes significant.

For bulk materials larger than one micrometre the percentage of atoms at the surface is minuscule relative to the total number of atoms of the material.

The interesting and sometimes unexpected properties of nanoparticles are not partly due to the aspects of the surface of the material dominating the properties in lieu of the bulk properties. Nanoparticles exhibit a number of special properties relative to bulk material.

For example, the bending of bulk copper (wire, ribbon, etc.) occurs with movement of copper atoms/clusters at about the 50 nm scale. Copper nanoparticles smaller than 50 nm are considered super hard materials that do not exhibit the same malleability and ductility as bulk copper. The change in properties is not always desirable.

Ferroelectric materials smaller than 10 nm can switch their magnetisation direction using room temperature thermal energy, thus making them useless for memory storage.

Suspensions of nanoparticles are possible because the interaction of the particle surface with the solvent is strong enough to overcome differences in density, which usually result in a material either sinking or floating in a liquid.

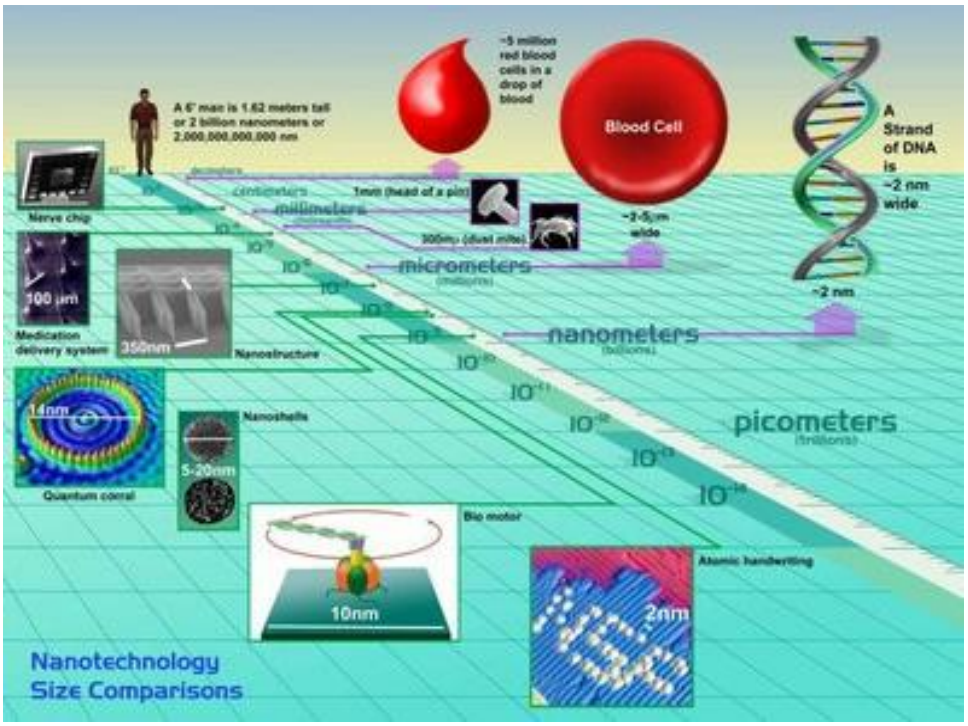
Nanoparticles often have unexpected visible properties because they are small enough to confine their electrons and produce quantum effects.

For example gold nanoparticles appear deep red to black in solution. Nanoparticles have a very high surface area to volume ratio.

This provides a tremendous driving force for diffusion, especially at elevated temperatures. Sintering can take place at lower temperatures, over shorter time scales than for larger particles.

This theoretically does not affect the density of the final product, though flow difficulties and the tendency of nanoparticles to agglomerate complicates matters.

The large surface area to volume ratio also reduces the incipient melting temperature of nanoparticle.



Nano particles size comparison

PROPERTIES OF NANOPARTICLES

Physical properties

Nanoparticles are unique because of their large surface area and this dominates the contributions made by the small bulk of the material. Zinc oxide particles have been found to have superior UV blocking properties compared to its bulk substitute. This is one of the

reasons why it is often used in the preparation of sunscreen lotions.

Other examples :

· Color – Nanoparticles of yellow gold and gray silicon are red in color

· Gold nanoparticles melt at much lower temperatures (~300 °C for 2.5 nm size) than the gold slabs (1064 °C)

Optical Properties

Nanoparticles also often possess unexpected optical properties as they are small enough to confine their electrons and produce quantum effects. One

example of this is that gold nanoparticles appear deep red to black in solution.

Formation of suspensions

An important physical property of nanoparticles is their ability to form suspensions. This is possible since the interaction of the particle surface with the solvent is strong enough to overcome density differences. In bulk materials this interactions usually result in a material either sinking or floating in a liquid.

Magnetization and other properties

Other properties unique among nanoparticles are quantum confinement in semiconductor particles, surface Plasma resonance in some metal particles and super-paramagnetism in magnetic materials.

For example, ferroelectric materials smaller than 10 nm can switch their magnetization direction using room temperature thermal energy, thus making them unsuitable for memory storage. Thus this property is not always desired in nanoparticles.

Diffusion Properties

At elevated temperatures especially, nanoparticles possess the property of diffusion. Sintering can take place at lower temperatures, over shorter time scales than for larger particles. Although this does not affect the density of the final product but there is a chance of agglomeration