

Zero-Dimensional Nanostructures: Nanoparticles

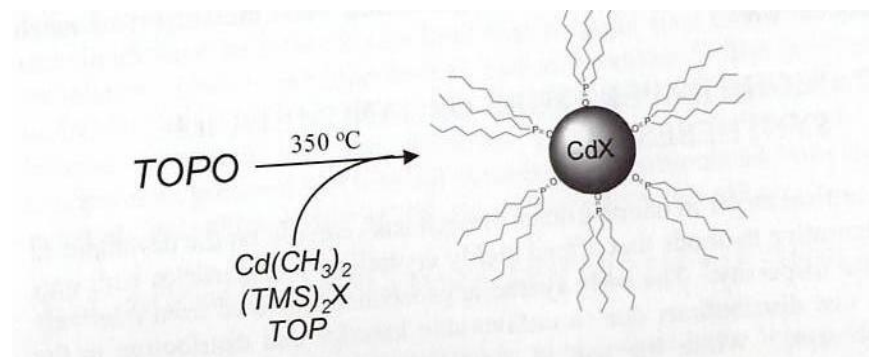
**Synthesis of Au, Ag and other
Nanoparticles**

Semana 7

Semiconductor Compound Nano Particles

High Temperature Organo-Metallic Methods are still the most popular for both III-V and II-VI compound.

- Thermal decomposition.
- Rapid injection of organometallic precursor means fast nucleation.
- The following growth can be controlled and terminated by adjusting temperature



<https://www.youtube.com/watch?v=bNuoYm7Su4o>

?

Au nanoparticles: Is it New?



“Labors of the Months” (Norwich, England, ca. 1480)
(The ruby color is probably due to gold nanoparticles.)

Au nanoparticles: Is it New?



Lycurgus Cup that was manufactured in the **5th to 4th century B.C.**

It is ruby red in transmitted light and green in reflected light, due to the presence of gold colloids.

Nano-sizing Causes Changes In Color

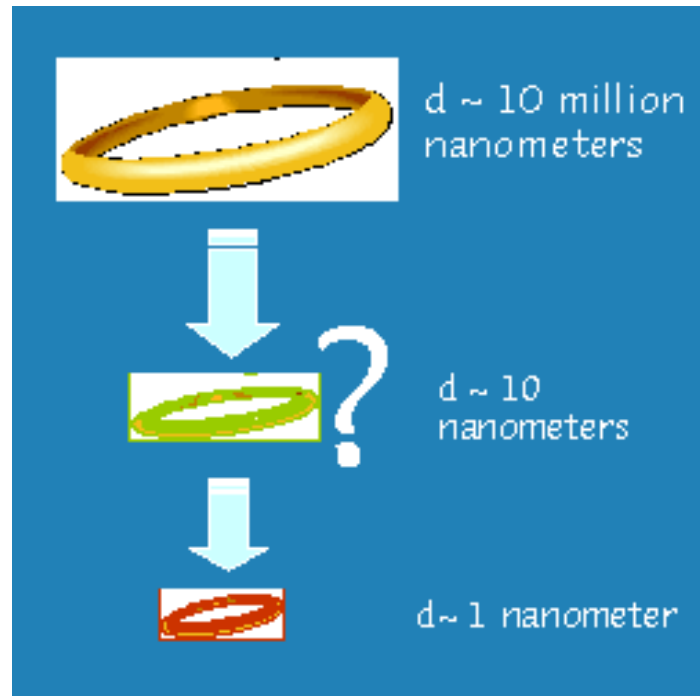
Macroscale vs. Nanoscale Gold



Why ?

Does something else changes?

Why Nano Gold Particles?

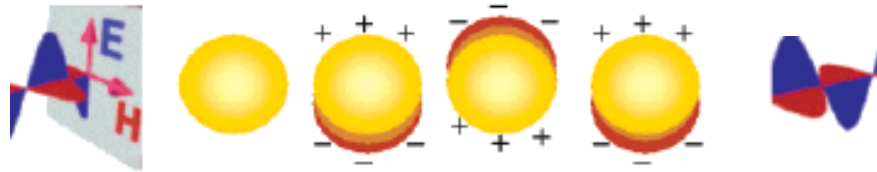


The optical applications of nano materials

Why different sizes “have” different colors?

Surface Plasmon (SP) Resonance

Surface electromagnetic waves that propagate parallel along a metal interact with the electric field.



An SP is a natural oscillation of the electron (6s) gas inside a gold particle.

Surface plasmon is excited when a long-wavelength electromagnetic wave is incident on a metallic sphere.

SP frequency depends on the dielectric function of the gold, and the shape of the nanoparticle.

Surface Plasmon Resonance (SPR)

At an interface between two transparent media of different refractive index (glass and water), light coming from the side of higher refractive index is partly reflected and partly refracted. Above a certain critical angle of incidence, no light is refracted across the interface, and total internal reflection is observed.

While incident light is totally reflected the electromagnetic field component penetrates a short (tens of nanometers) distance into a medium of a lower refractive index creating an exponentially detenuating evanescent wave.

If the interface between the media is coated with a thin layer of metal (gold), and light is monochromatic and p-polarized, the intensity of the reflected light is reduced at a specific incident angle producing a sharp shadow (called surface plasmon resonance) due to the resonance energy transfer between evanescent wave and surface plasmons.

The resonance conditions are influenced by the material adsorbed onto the thin metal film. Satisfactory linear relationship is found between resonance energy and mass concentration of biochemically relevant molecules such as proteins, sugars and DNA.

The SPR signal which is expressed in resonance units is therefore a measure of mass concentration at the sensor chip surface. This means that the analyte and ligand association and dissociation can be observed and ultimately rate constants as well as equilibrium constants can be calculated.

Plasmonics: merging photonics and electronics at nanoscale dimensions.

Science. 2006 Jan 13;311(5758):189-93

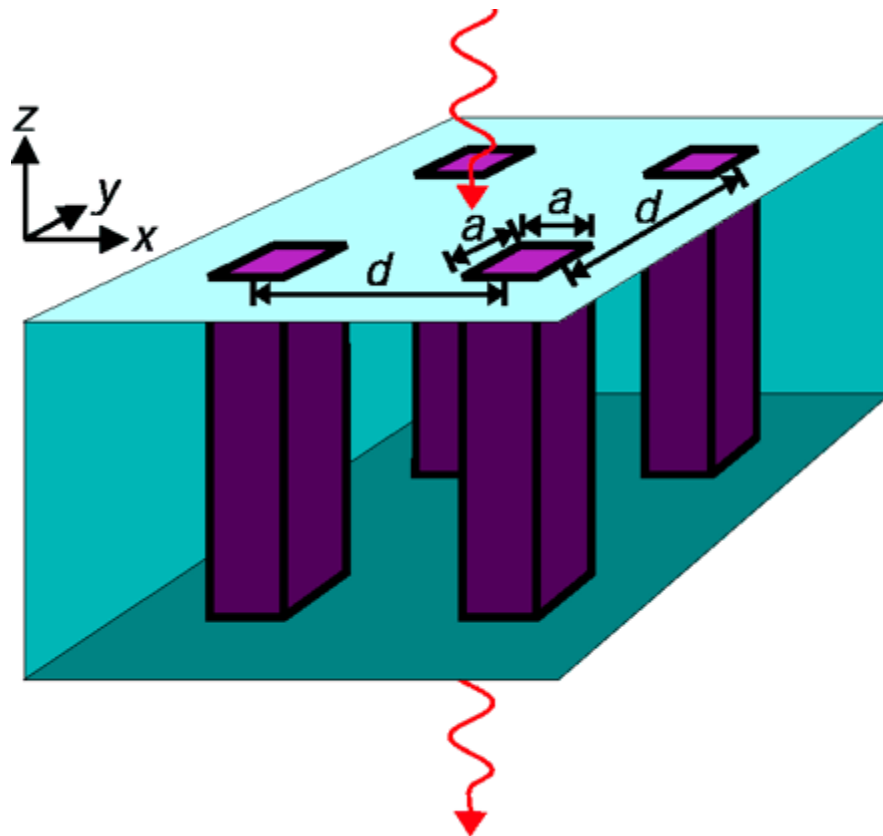
Ozbay E.

Nanotechnology Research Center, Bilkent University, Bilkent, Ankara 06800 Turkey. ozbay@bilkent.edu.tr

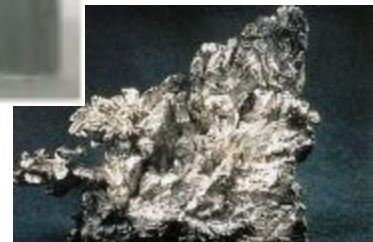
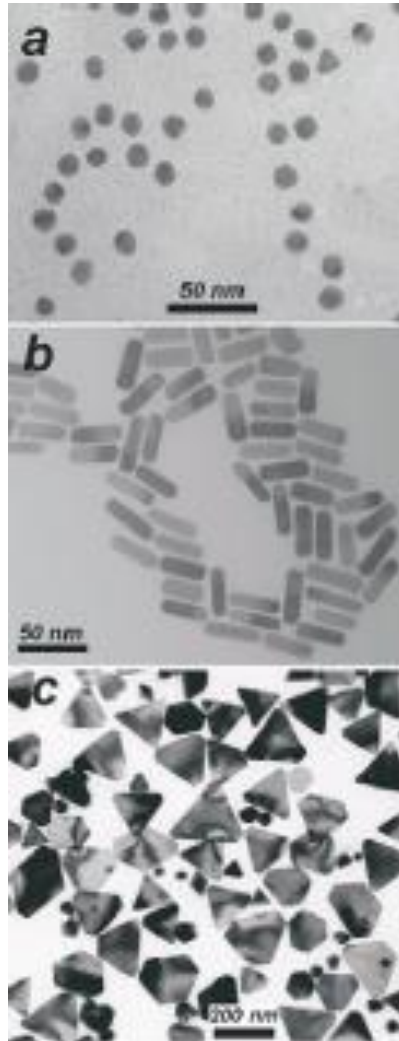
Electronic circuits provide us with the ability to control the transport and storage of electrons. However, the performance of electronic circuits is now becoming rather limited when digital information needs to be sent from one point to another. Photonics offers an effective solution to this problem by implementing optical communication systems based on optical fibers and photonic circuits. Unfortunately, the micrometer-scale bulky components of photonics have limited the integration of these components into electronic chips, which are now measured in nanometers. Surface plasmon-based circuits, which merge electronics and photonics at the nanoscale, may offer a solution to this size-compatibility problem. Here we review the current status and future prospects of plasmonics in various applications including plasmonic chips, light generation, and nanolithography.

PMID: 16410515 [PubMed]

Homework: Quantum Wells???

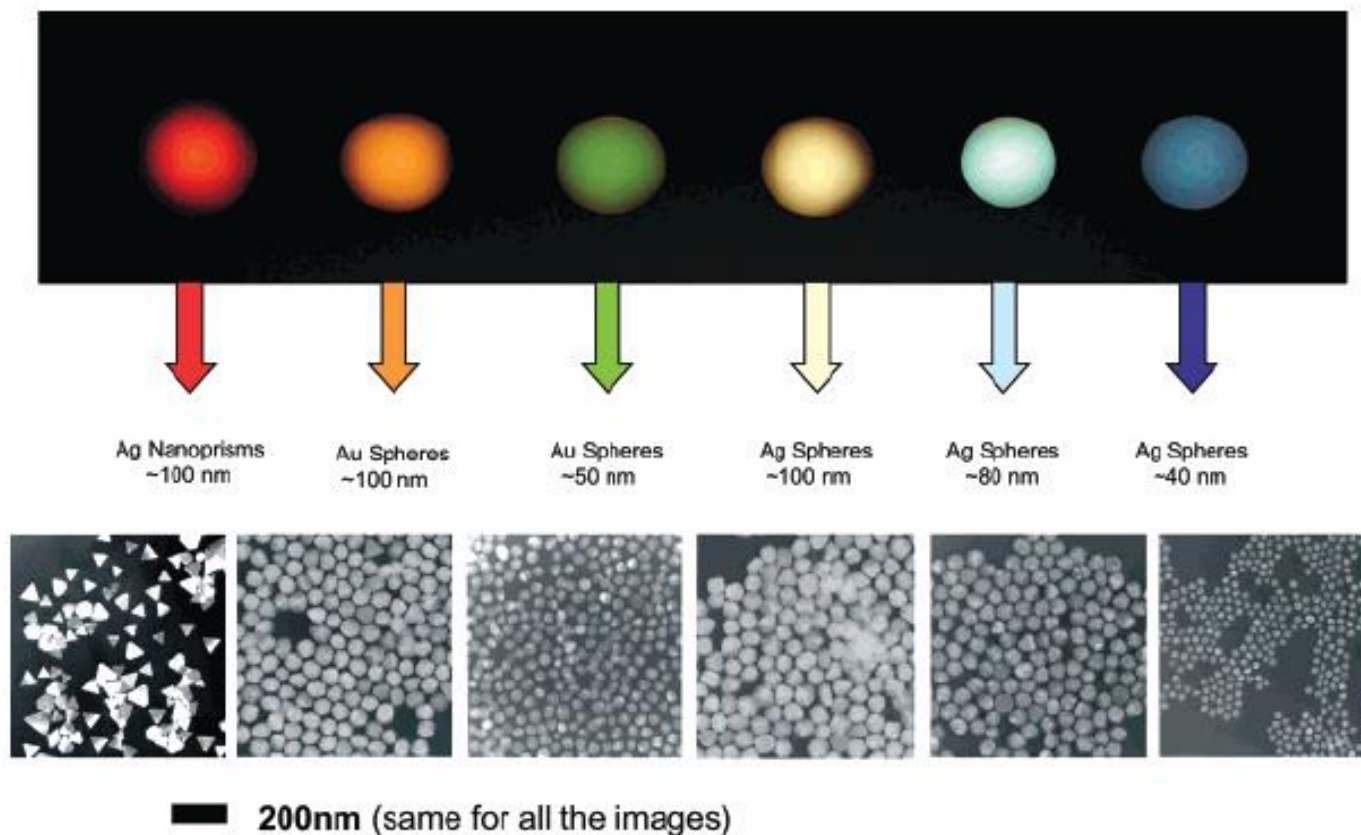


Metal Nanoparticles: Color depends on shape and size

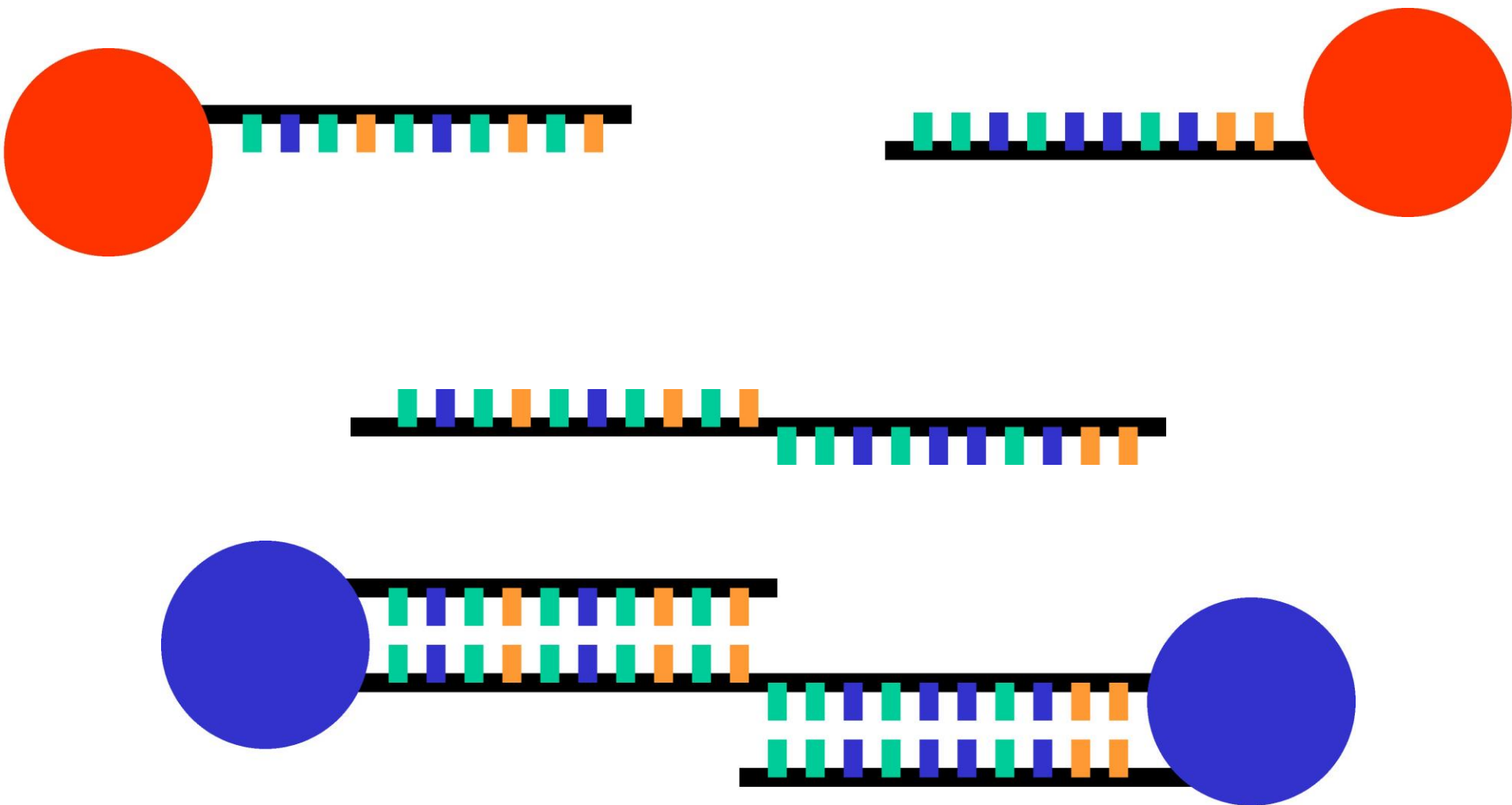


Luis M. Liz-Marzán, *Materials Today*, **2004**, 26-31.

Metal Nanoparticles: Color depends on shape and size

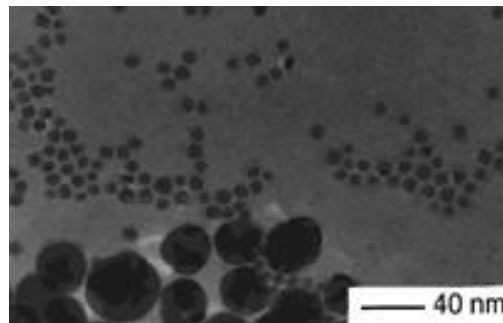
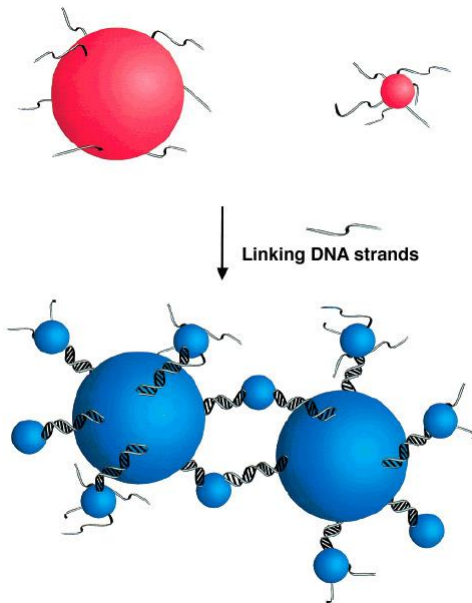


Au nanoparticles: Applications

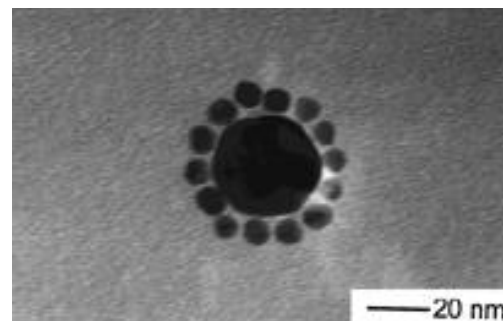


Au nanoparticles: Applications

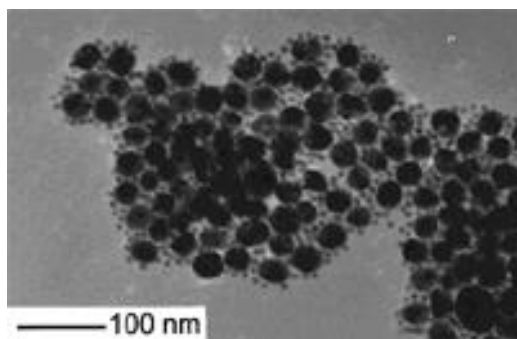
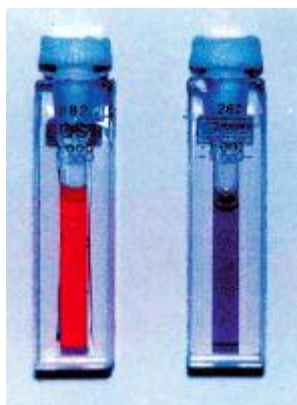
14



8 and 30 nm
gold particles,
no DNA link



8 nm and
excess 30 nm
gold particles,
DNA link



8 and 30 nm
gold particles,
DNA link

Ag nanoparticles: Applications

15



Silver Wash, as the name implies, uses real silver. Microscopic bits of electrolyzed silver (about 400 billion silver particulates) are dispersed and dissolved into the wash water, where they infiltrate fabrics on an almost molecular level. The silver nanoparticles kill 99.9% of bacteria and fungi, says the manufacturer.



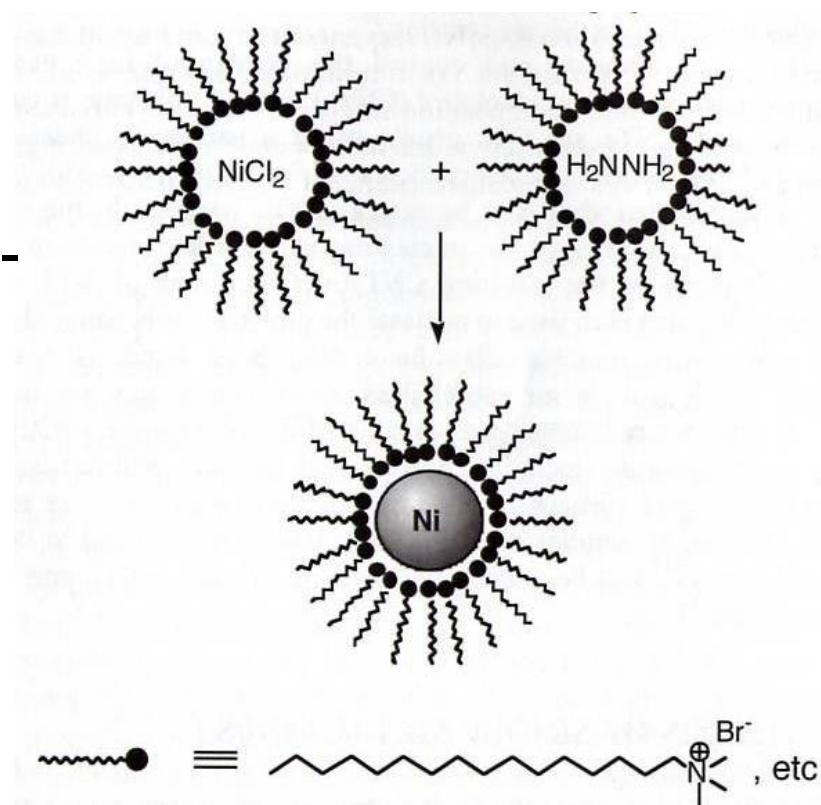
The silver nanoparticles in Fresh Box containers naturally kill bacteria and limit mold growth without toxins.



Synthesis of Single Metal MNP

-- Method I: The Reduction of Metal Salts

- Size control: conducting the reaction in a confined reactor
- Nano confined reactor such as water-in-oil or oil-in-water micro-emulsion system
- Size of confined space can be defined by varying amount of both surfactant and solvent
- Successful examples included Fe, Ni and Co particles

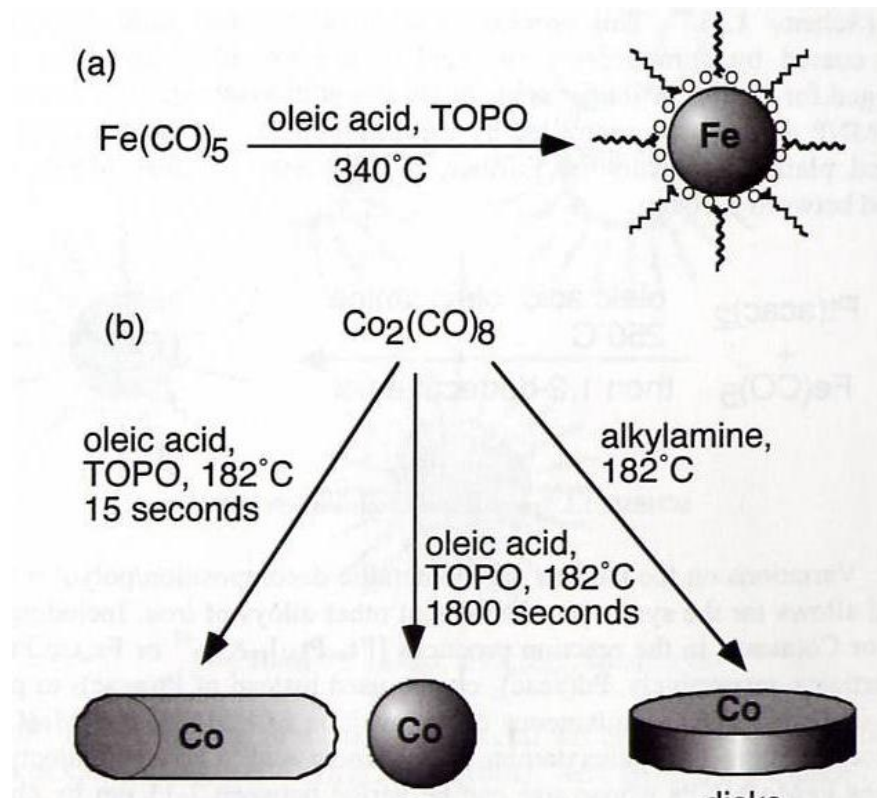


Courtesy from Vincent Rotello, Nanoparticles

Synthesis of Single Metal MNP

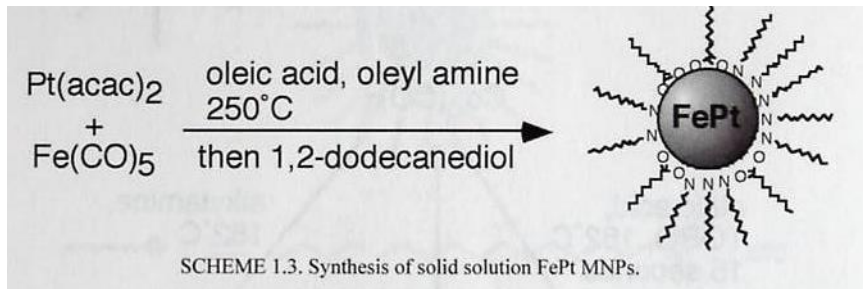
-- Method II: Thermal Decomposition

- Thermal Decomposition of organo-metallic complexes can produce highly mono-disperse nano particles.
- Size and dispersity control is attained through high reaction temperature.
- Capping ligands (e.g. Oleic Acid) can also mediate the particle growth by forming a monolayer of nano particles
- Most common precursors: Metal Carbonyl complexes.
- Morphology can also be controlled through various capping ligands

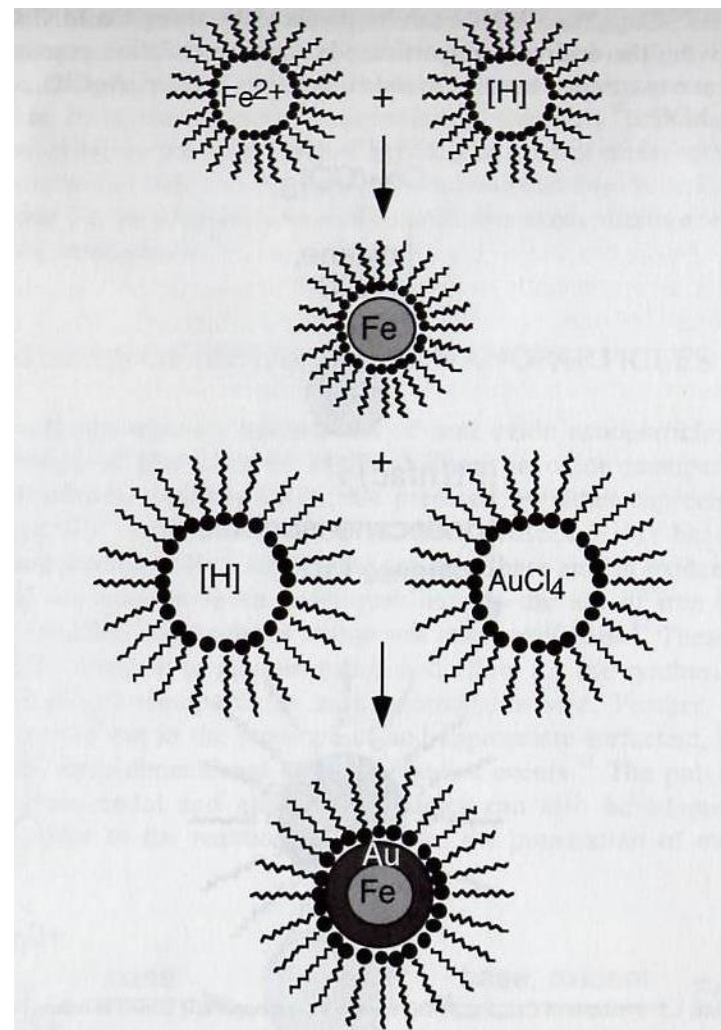


Courtesy from Vincent Rotello, Nanoparticles

Alloyed Metal Nano Particles

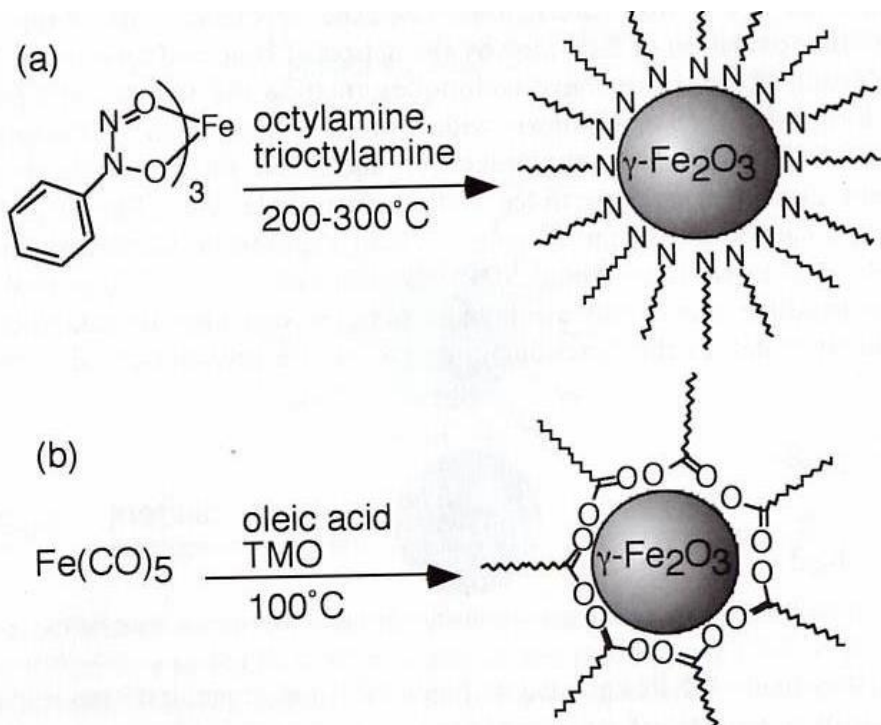


- Solid-solution alloyed metallic nano particles can be attained through simultaneous thermal decomposition
 - Core-shell alloyed nano particles are produced by a stepwise reduction process where each successive step uses larger diameter water droplet to yield the alloyed core-shell particles



Courtesy from Vincent Rotello, Nanoparticles

Metal Oxide Nano Particles



- Thermal decomposition of metal organic precursors on a hot surface.
- The size of the nano particles can be controlled by reaction temperature and / or the ratios of precursor verse capping ligands