In vitro Toxicity Study of Noble Metal Nanoparticles with Varied Size, Geometry and Surface Chemistry

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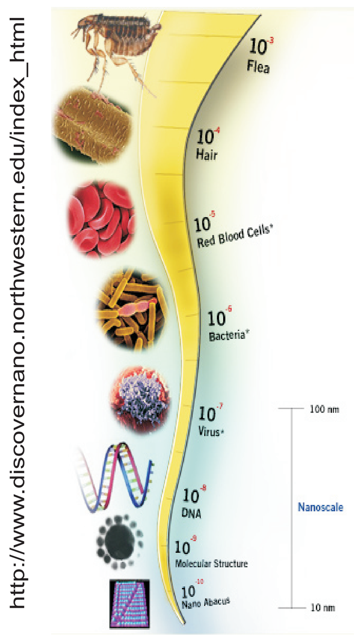
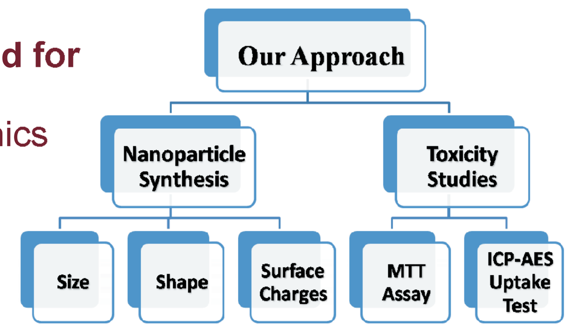
Why Study Nanoparticle Cytotoxicity?



Nanoscale materials are currently being used for applications in the following areas:

- -electronics
- -biomedical
- -cosmetic
- -catalysis
- -magnetics and optoelectronics
- -pharmaceutical
- -energy
- -materials

From the NIH Fact Sheet
"… the toxicology of nanoparticles is poorly understood as there is no regulatory requirement to test nanoparticles for health, safety and environmental impacts... Research is now showing that when harmless bulk materials are made into ultrafine particles, they tend to become toxic. Generally, the smaller the particles, the more reactive and toxic are their effects." http://www.niehs.nih.gov/oc/factsheets/nano.htm



Our Goal:
Develop a basic theory on how the size, shape and surfactants would affect the bio-toxicity of the nanopartilces.

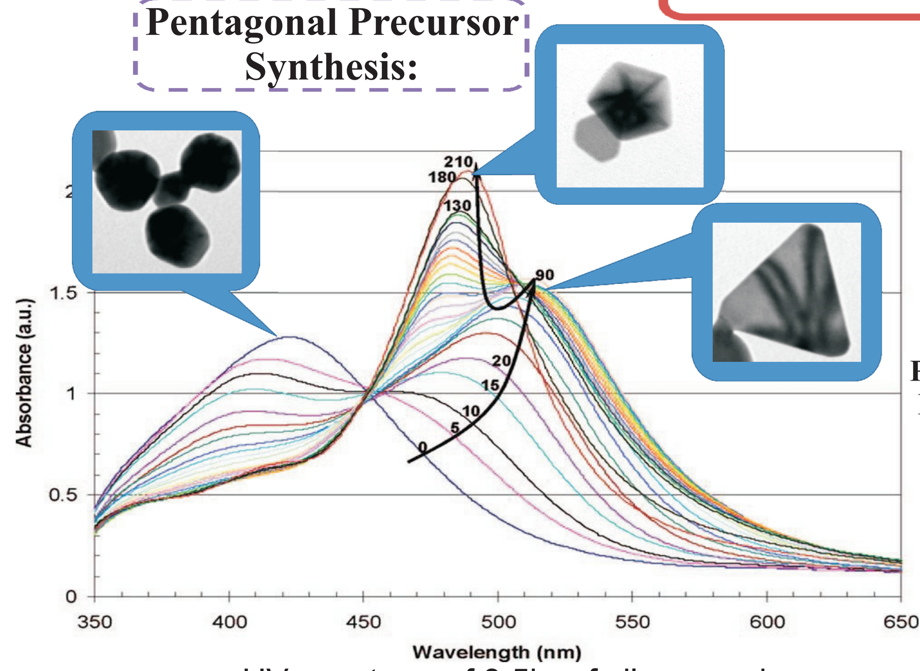
Size and Aspect Ratio Controlled Synthesis

Size Control:
The size of the nanoparticles are usually adjusted by varying the concentration of the reducing agent, for example, a lower $HAuCl_4$ to sodium citrate ratio would yield smaller gold nanoparticles.

Shape Control:
The synthesized nanoparticles are usually a mixture of spheres, prisms and nanorods without special control.
High ratio prisms are usually achieved by higher concentration of reducing agents, higher reacting temperature and fast cooling.

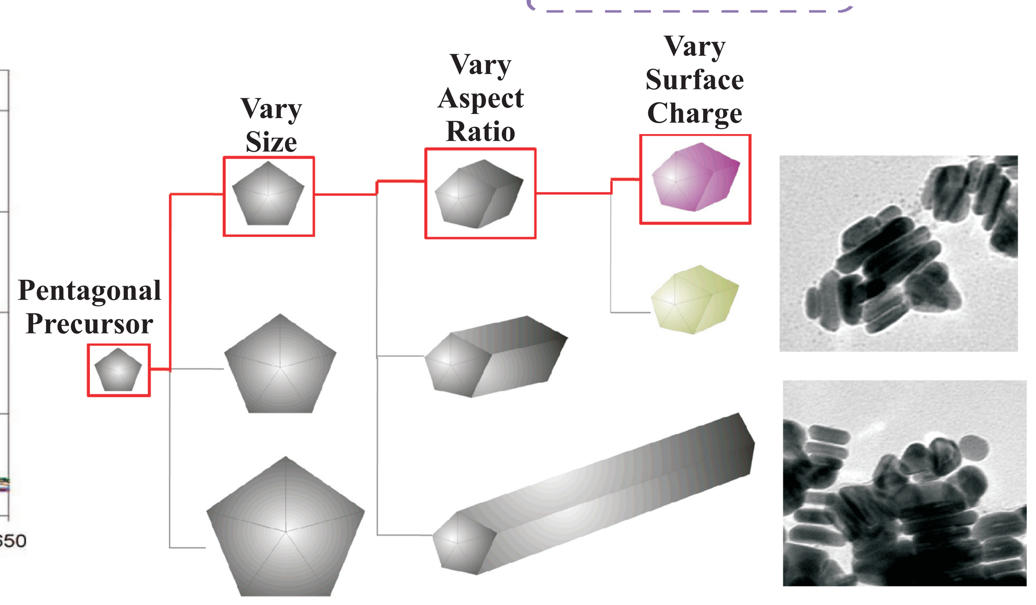
Silver Nano-rod Synthesis

Pentagonal Precursor Synthesis:



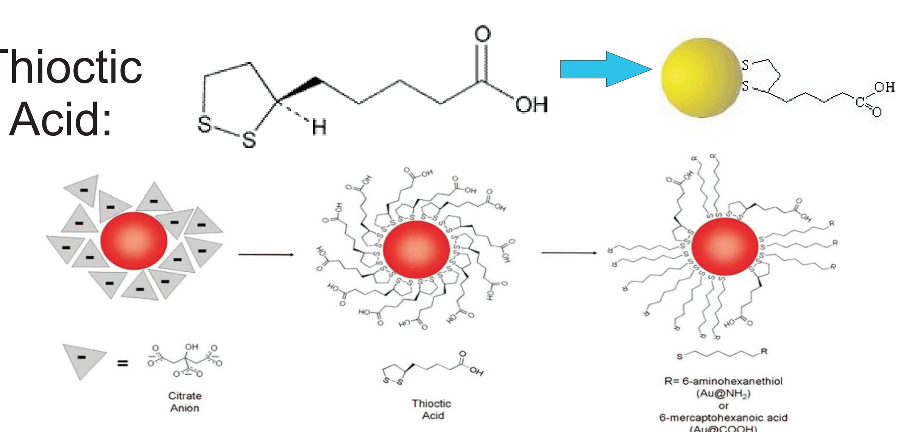
UV-spectrum of 3.5hr of silver seed solution exposed to metal-halid lamp

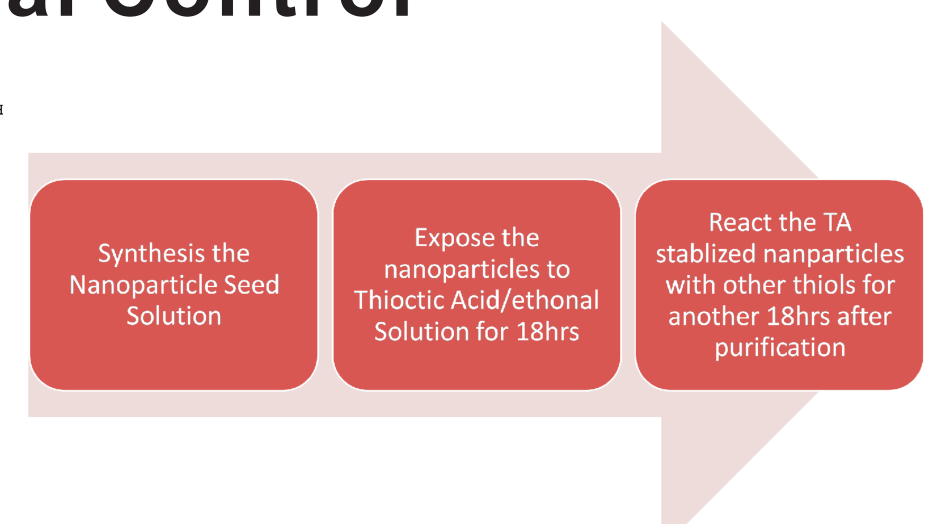
Regrowth:



Zeta-Potential Control

Thioctic Acid:





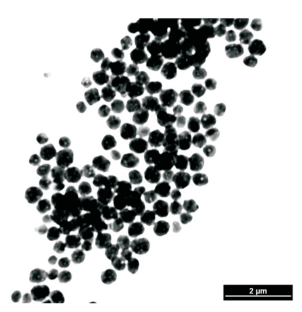
Ivanov, M., Bednar H., and Haes, A. ACS Nano, 3, 2, 2009

In Vitro Viability

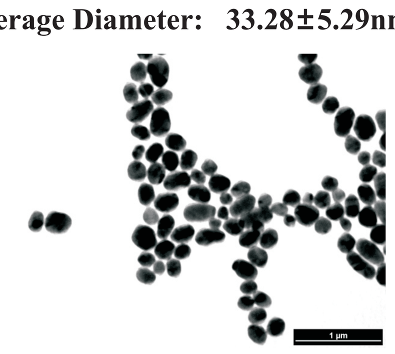
Nanoparticles We Studied:

For the MTT assay, we studied spherical gold and silver nanoparticles with diameters of ~30nm:

Gold Nanoparticles Reduced by Citrate
Average Diameter 26.48±3.98nm



Silver Nanoparticles Reduced by Citrate
Average Diameter: 33.28±5.29nm



Positively Charged Nanoparticles Stabilized by 11-Mercaptoundecylamine(11-MUAM)
Negatively Charged Nanoparticles Stabilized by 11-Mercaptoundecanoic Acid (11-MUDA)

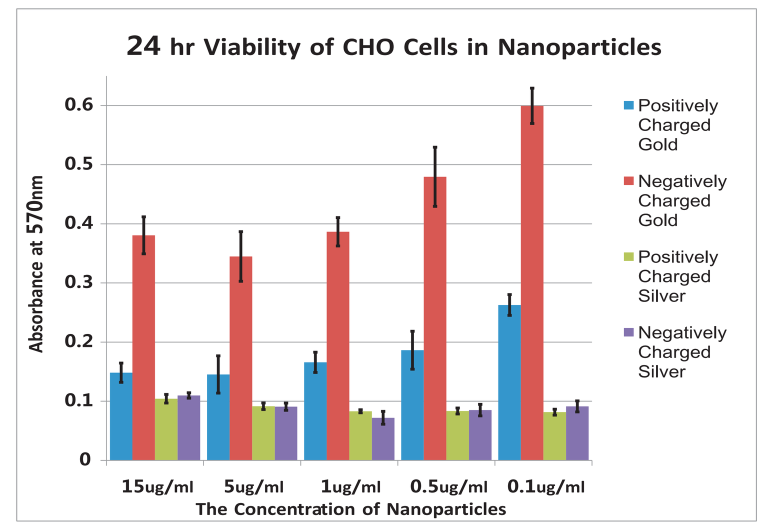
Zeta-potential Data

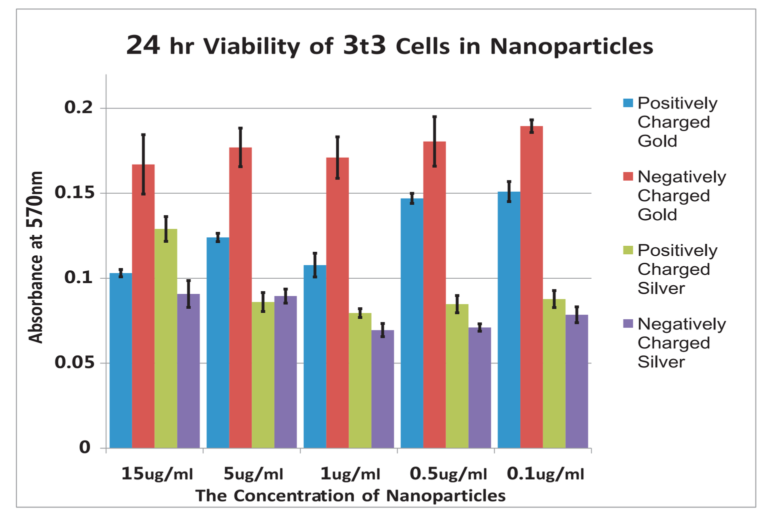
Au: +26.88 mV	Silver: +24.33mV
-25.04 mV	- 25.57mV

The out-come of the MTT assay of CHO and 3t3 cells are consistent with each other, which shows:

- Silver nanoparticles are more toxic than gold nanoparticles.
- For gold nanopartilces, the positively charged are more toxic than negatively charged. However, that difference is not obvious for silver nanoparticles.

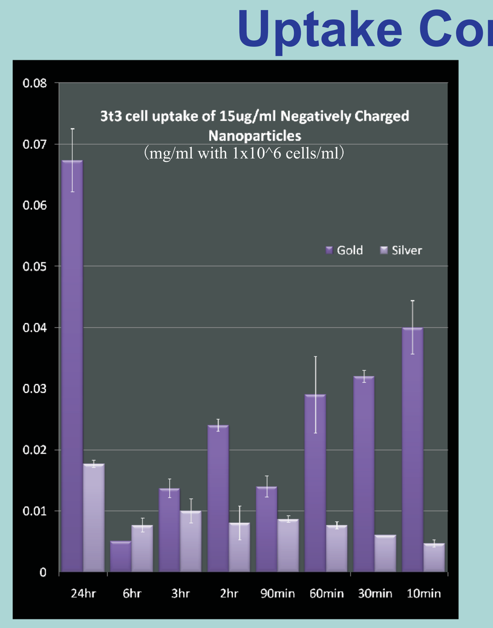
The MTT assay was carried out to compare the in vitro toxicity between different nanoparticle species (gold and silver), and between opposite surface charges.

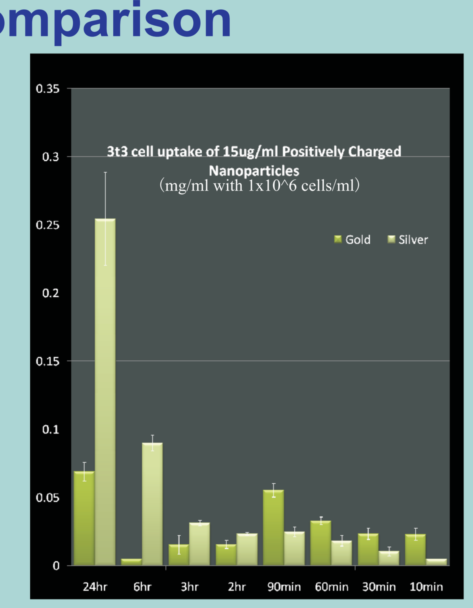




Cellular Uptake

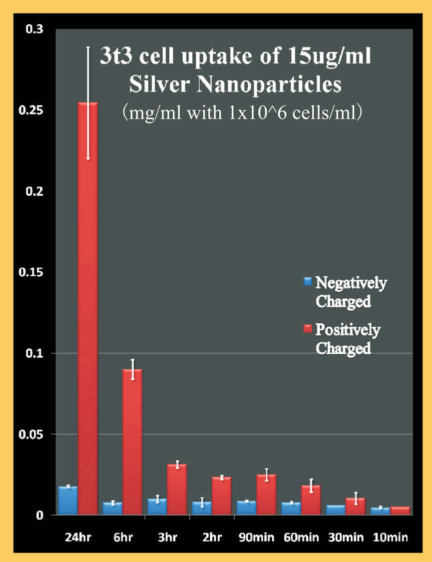
Gold and Silver Uptake Comparison

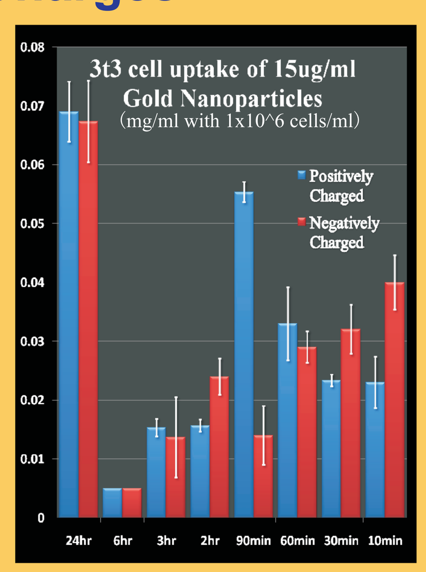




For the silver, the uptake of positively charged nanoparticles is much greater than that of negatively charged ones. However, the uptake disparity is not obvious for gold nanoparticles.

Uptake Comparison between Charges





Though silver nanopartilces of both charges demonstrate higher toxicity than gold nanopartilces, the uptake test shows the major cause for the difference is not the same.

With higher uptake, the toxicity of positively charged silver nanoparticles mainly come from the number of particles absorbed by the cells, and on the other hand, that of negatively charged ones is a result of higher toxicity of single nanopartilce demonstrated by a lower amount of uptake.

Funding:

National Science Foundation
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