SILVER NANOPARTICLES AND GOLD METALLODENDRIMERS: FROM MOLECULAR PRECURSORS TO NANOMATERIALS

Miguel Monge
GOLD(I) and SILVER(I) COMPLEXES

Organometallic precursor

SILVER NANOPARTICLES

Molecular building blocks

GOLD METALLODENDRIMERS
Synthesis of silver nanoparticles from organometallic precursors

ORGANOMETALLIC SILVER COMPOUNDS

MILD CONDITIONS

POLYMERS  LIGANDS  SiO$_2$
Organometallic precursor synthesis

\[ \text{NBu}_4[\text{Ag}(\text{C}_6\text{F}_5)_2] + \text{AgClO}_4 \xrightarrow{\text{Et}_2\text{O}} 2 \left[\text{Ag}(\text{C}_6\text{F}_5)\right] \]

\[ \text{[Ag}(\text{C}_6\text{F}_5)\text{][NH}_2-(\text{CH}_2)_n\text{-CH}_3] \xrightarrow{\text{Tolueno}} \text{[Ag}(\text{C}_6\text{F}_5)(\text{NH}_2-(\text{CH}_2)_n\text{-CH}_3)) \]

Silver nanoparticles synthesis

\[ \left[\text{Ag}(\text{C}_6\text{F}_5)(\text{NH}_2-(\text{CH}_2)_n\text{-CH}_3)) \right] \xrightarrow{\text{Tolueno, 7h reflux}} \text{Ag} \]

R = C\text{ }_6\text{F}_5
n = 15, 11, 8
Silver nanoparticles

UV-Vis spectrum of Ag NPs in toluene.

The band at 415 nm is a surface plasmon resonance band. The band energy is related to small and spherical Ag NPs.

X-ray powder diffraction pattern:

The peaks correspond to the 111, 200, 220 and 311 planes of the metallic silver fcc structure.

Nanoparticle size: 8-10 nm
Silver nanoparticles

9.8 ± 1.2 nm
### BACTERIOSTATIC AND BACTERICIDAL ACTIVITY OF Ag NPs

Minimal Inhibitory Concentration (MIC) and Minimal Bactericidal Concentration (MBC) of Ag NPs

<table>
<thead>
<tr>
<th>Bacterial Strain</th>
<th>MIC (µg/ml)</th>
<th>MBC (µg/ml)</th>
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<tbody>
<tr>
<td><em>E. coli</em> ATCC25922</td>
<td>12.5</td>
<td>12.5</td>
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<tr>
<td><em>S. aureus</em> ATCC25923</td>
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<td><em>L monocytogenes</em> CECT432</td>
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**Experiment: E. coli**

[Graph showing growth of *E. coli* over time with different concentrations of Ag NPs]

**Experiment: S. aureus**

[Graph showing growth of *S. aureus* over time with different concentrations of Ag NPs]
POLYMER STABILIZED SILVER NANOPARTICLES

CELLULOSE ACETATE (CA): textile applications

- Small size silver nanoparticles (ca. 5 nm).

- Slow solvent evaporation leads to cellulose acetate films loaded with Ag NPs.
POLYMER STABILIZED SILVER NANOPARTICLES

POLIVINILPIRROLIDONE (PVP): water soluble Ag NPs

\[ \text{[Ag(C}_6\text{F}_5\text{)] + } \quad \text{Toluene} \quad \text{reflux} \quad \rightarrow \quad \text{Ag-NPs@PVP} \]
POLYMER STABILIZED SILVER NANOPARTICLES

SILVER NANOPARTICLES STABILIZED WITH NANO-SILICA

\[ \text{Ag NPs@PVP} + \text{H}_2\text{N-Si-O-Si-O} + \text{Si-O-Si} \rightarrow \text{H}_2\text{O} \]

\[ \text{SiO}_2 \]

50 nm

20 nm
Au(I) Metalloendrimers

PPh$_2$-PPI-G1

PPh$_2$-PAMAM-G1

$X = \begin{array}{c} F \\ \hline F \end{array}$
GOLD(I) PHOSPHINO THIOLATE COMPLEXES

TETRANUCLEAR COMPLEXES

OCTANUCLEAR COMPLEXES (1ST GENERATION DENDRIMER)
X-RAY STRUCTURES
LUMINESCEENCE

Emission lifetimes

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<th>MeO</th>
<th>Me</th>
<th>F</th>
<th>NO₂</th>
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GOLD METALLODENDRÍMERS WITH 16, 32 AND 64 [Au(C₆F₅)] UNITS

PAMAM-\(\text{G1-PPh}_2-[\text{AuR}]_{16}\)  PAMAM-\(\text{G2-PPh}_2-[\text{AuR}]_{32}\)  PAMAM-\(\text{G3-PPh}_2-[\text{AuR}]_{64}\)
GOLD METALLODENDRIMER SIZE THROUGH PGSE-DOSY NMR

PGSE-DOSY NMR: determination of the translational self-diffusion coefficient ($D_t$)

Stokes-Einstein equation:

\[ D_t = \frac{k_B T}{c \pi \eta R_H} \]

$R_H = \text{Hydrodynamic radius}$

**Diameter size**

Au\(_{16}\) = 2.6 nm  
Au\(_{32}\) = 3.8 nm  
Au\(_{64}\) = 4.5 nm

1.9 nm  
2.6 nm  
3.6 nm
GOLD METALLODENDRIMERS AS PRECURSORS FOR Au NPs

Dendrimer stabilized Au nanoparticles (10 nm)
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Dr. Eduardo J. Fernández
Dr. José M. López de Luzuriaga
Dr. M. Elena Olmos
Eva Sanchez Forcada
Jorge García Barrasa

Prof. Antonio Laguna (UZ)

Prof. Carmen Torres

Dr. Bruno Chaudret (LCC-CNRS)
Dr. Katerina Soulantica (LPCNO-INSA)