
Green Photocatalytic Synthesis of Au and Ag Nanoparticles: Size and Shape Control

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Objectives

Green Chemistry

- Non-toxic chemicals/
solvents
- Atom efficiency
- Low energy
requirements
- Renewable/
degradable materials

Synthesis of NPs

- Control:
 - ▣ Size
 - ▣ Size dispersion
 - ▣ Morphology
 - ▣ Crystallinity
 - ▣ Surface chemistry
- Colloidal stability
- Facile modification of
surface composition

Current synthetic methods

Thermal methods

- ❑ High energy consumption
- ❑ Strong reducing agents
- ❑ Noxious organic solvents

Photochemical methods

- ❑ UV-light
- ❑ Slow reaction

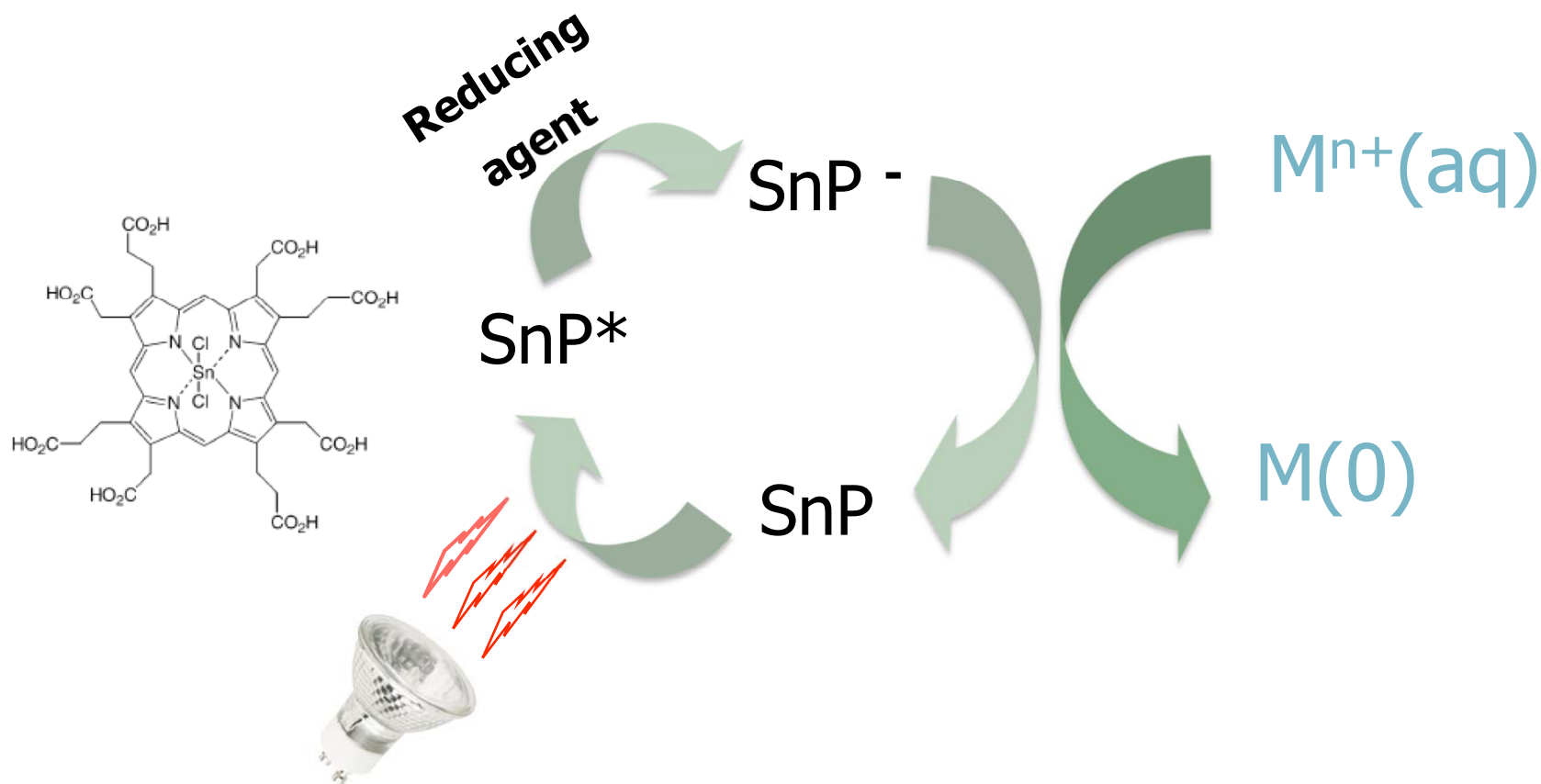
Improvements:

- ❑ Use of biological reducing agents
- ❑ Water as the solvent

Improvements:

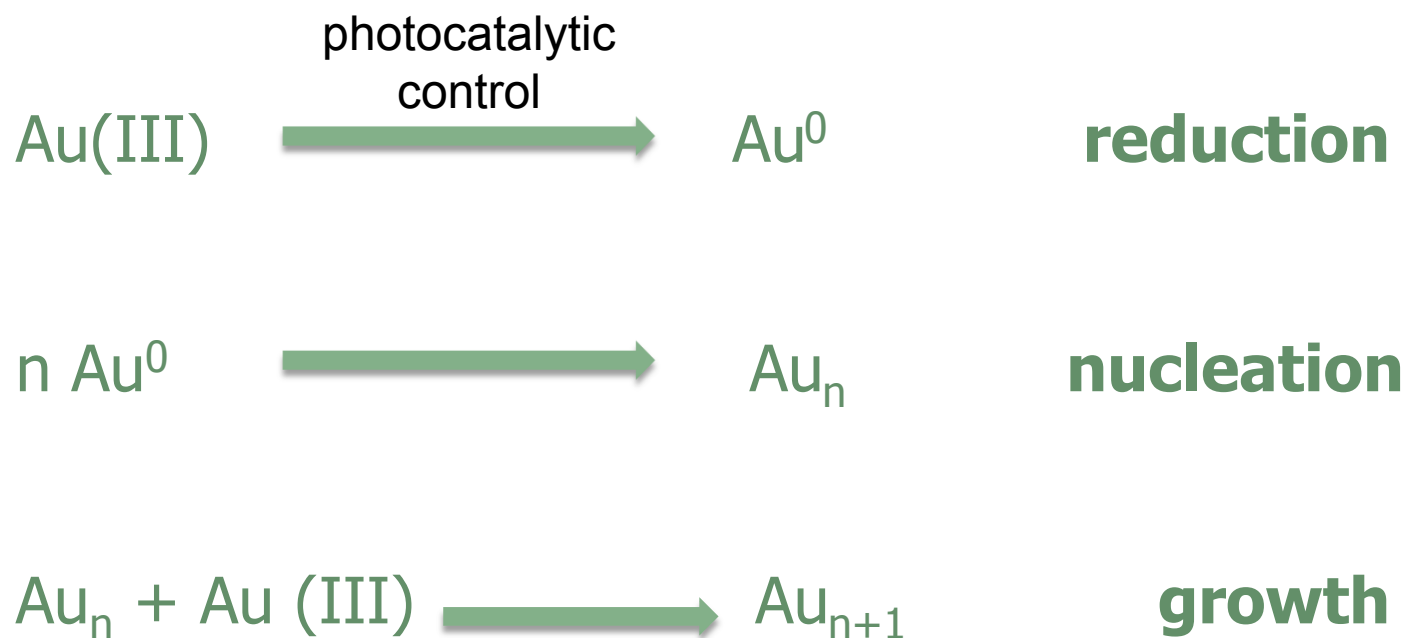
- ❑ Photocatalysts (visible light)

Photocatalytic method for the synthesis of NPs



Reducing agent = TEA, ascorbic acid, EDTA, etc.

Mechanism of NPs formation



Photocatalytic synthesis of Ag or Au NPs

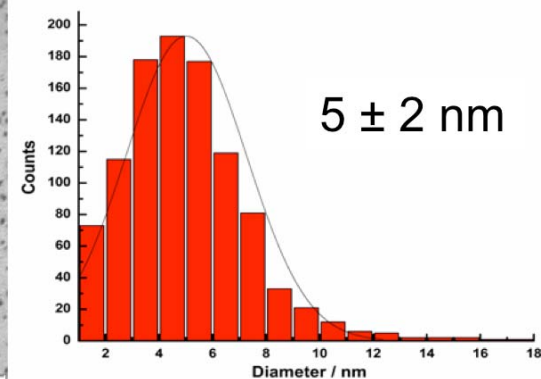
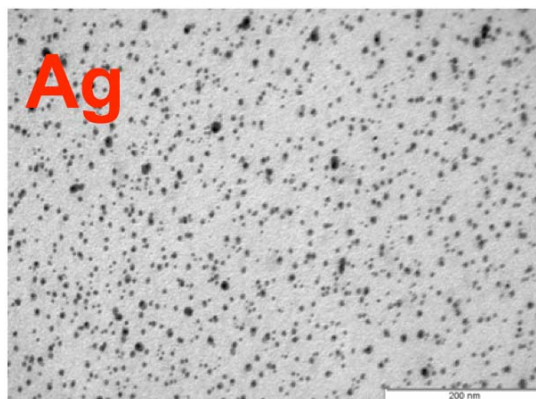
Reducing agent: TEA

Capping: PVP

Solvent: Water

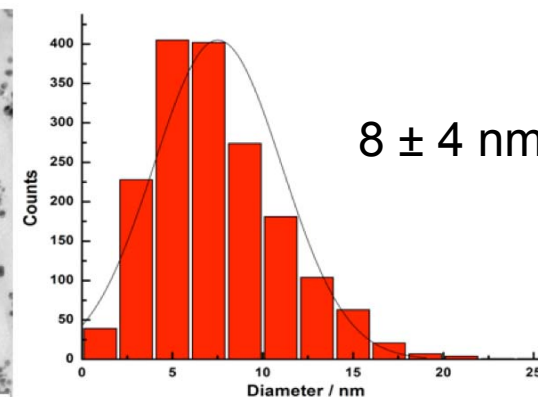
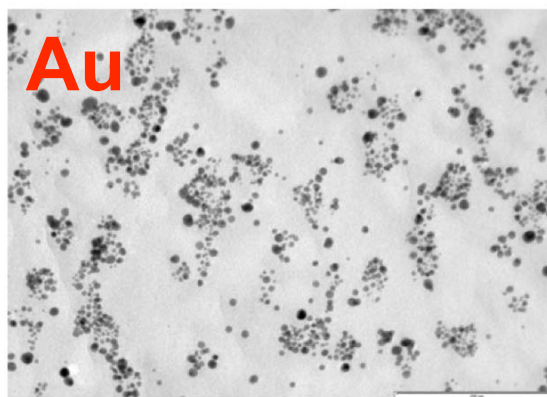
Room Temperature

pH = 7



Reaction complete in 4 min

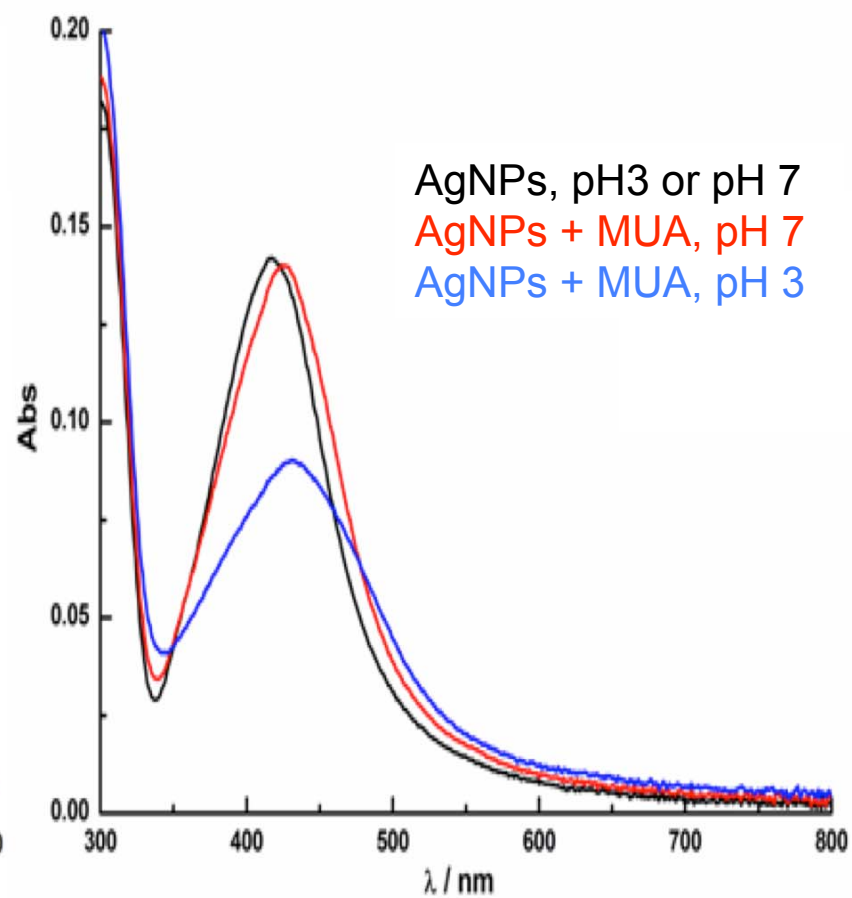
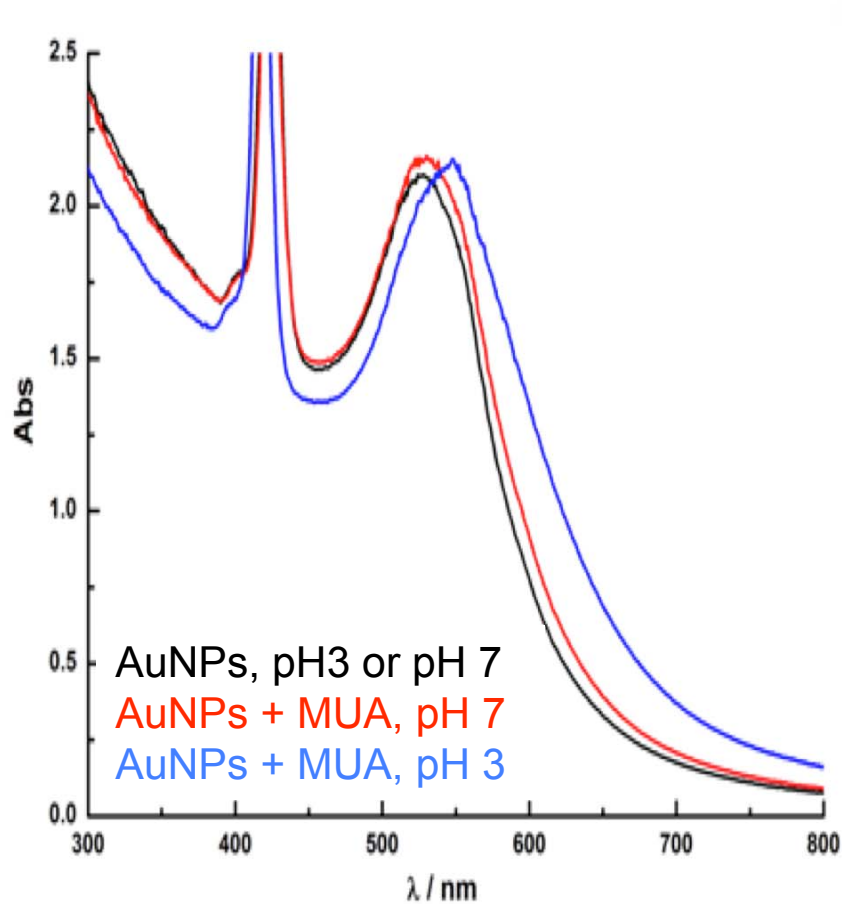
Metal concentration 1 mM



- Pedro Quaresma, Leonor Soares, Livia Contar, Adelaide Miranda, Inês Osório, Patrícia A. Carvalho, Ricardo Franco and Eulalia Pereira *Green Chem.* 2009, DOI: 10.1039/b917203n

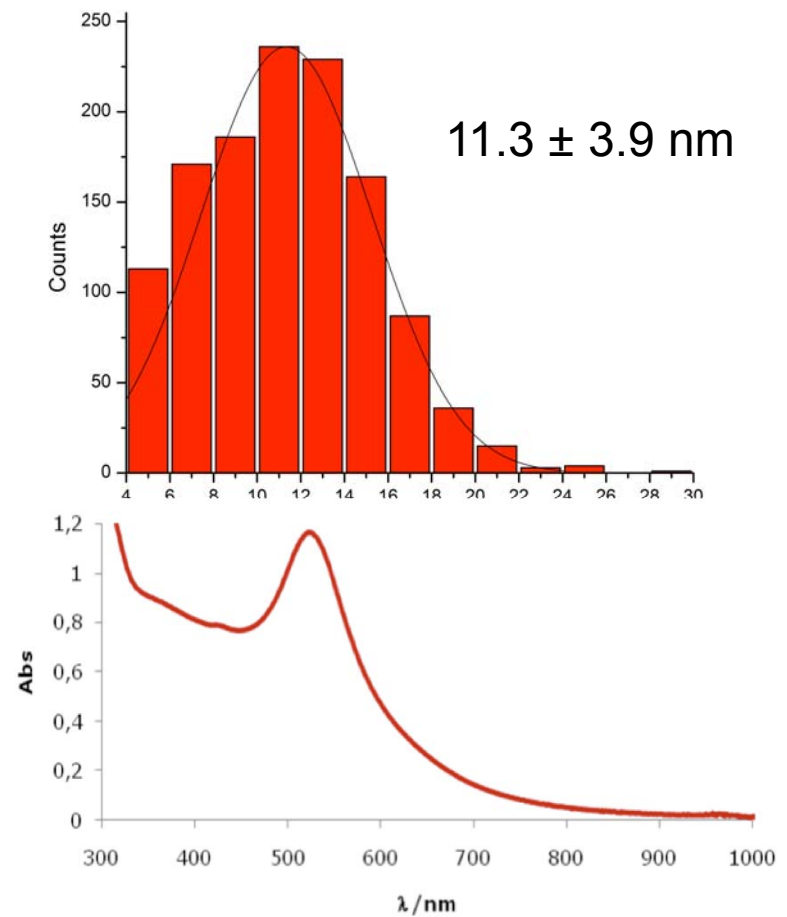
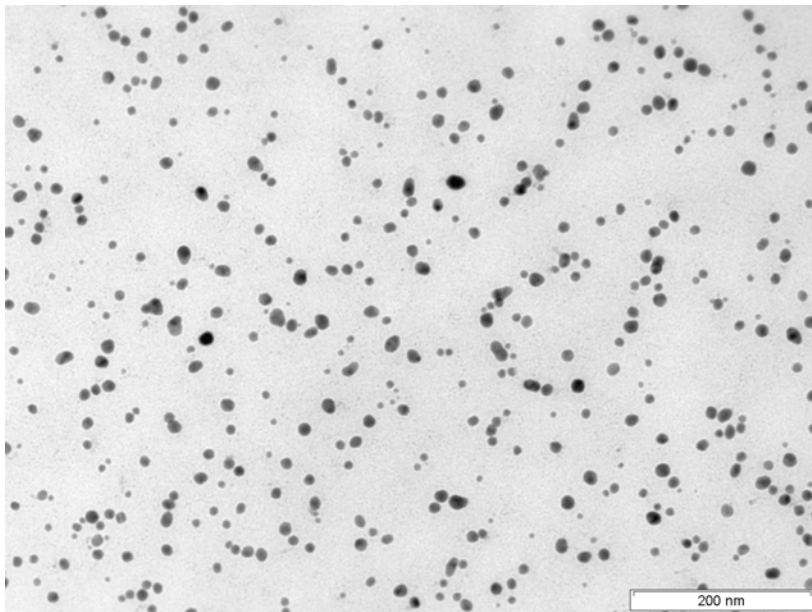
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Exchange of capping agent (MUA)



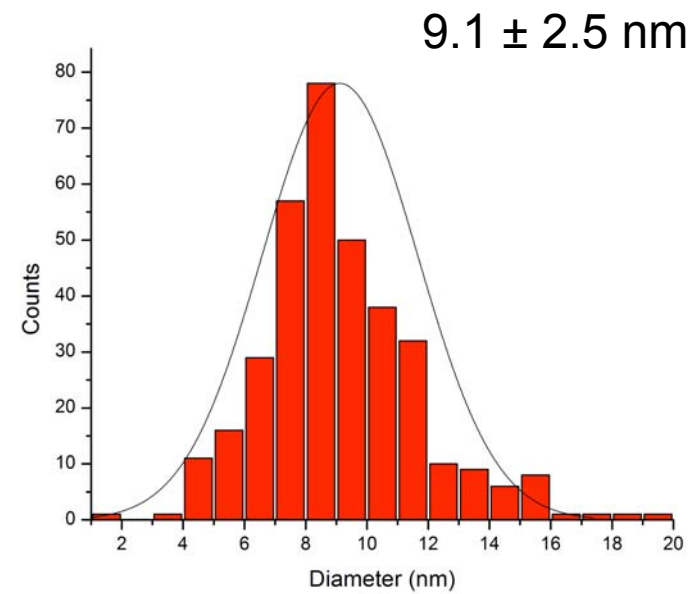
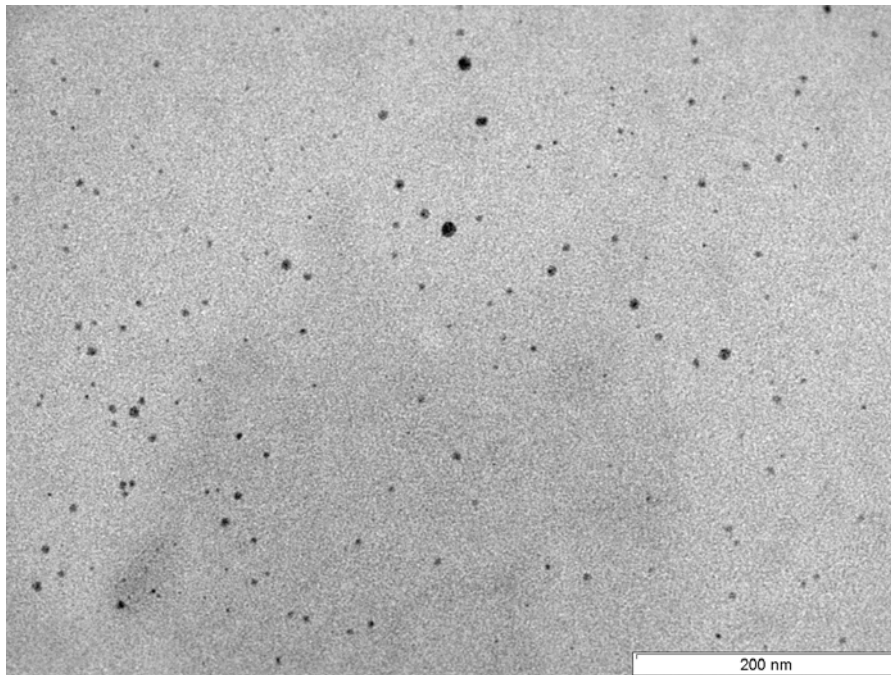
Photocatalytic synthesis with greener capping agents

Au/acacia gum



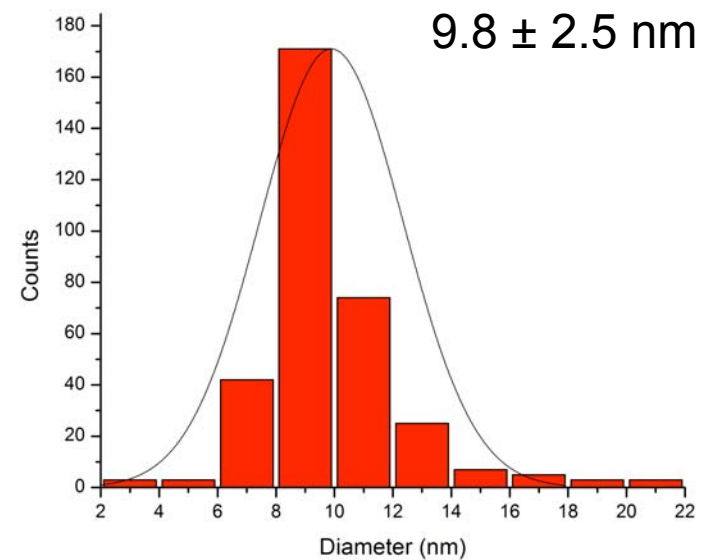
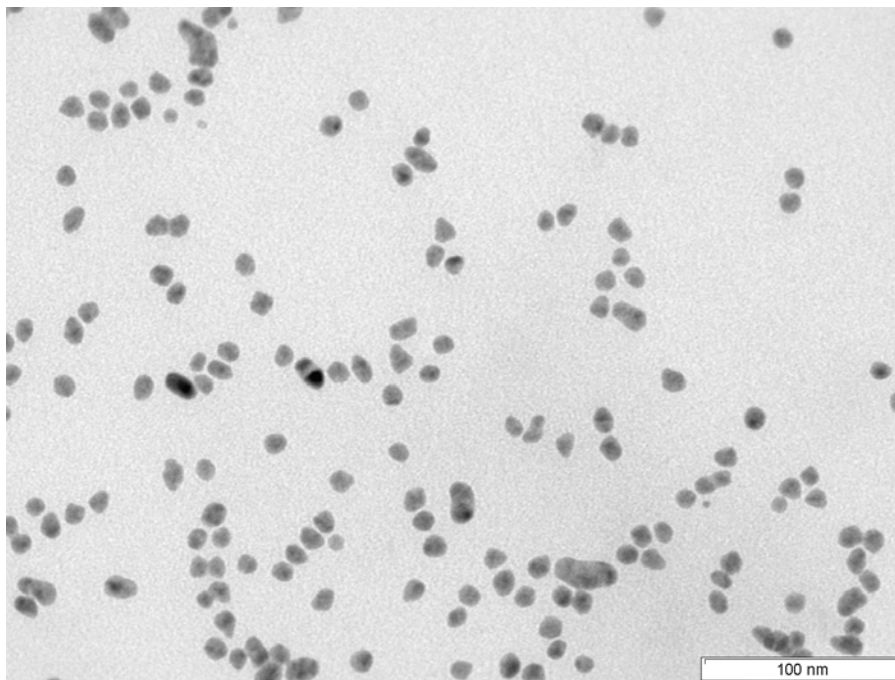
Photocatalytic synthesis with greener capping agents

Ag/starch

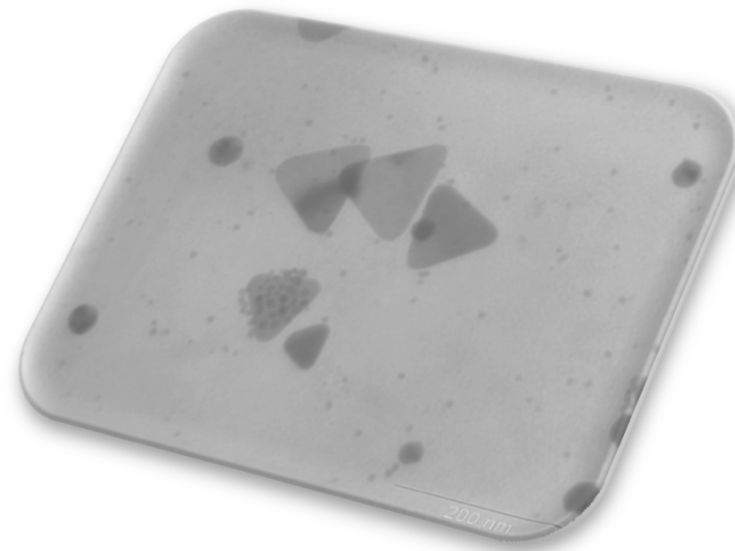


Photocatalytic synthesis with greener capping agents

Mixed Ag-Au/acacia gum

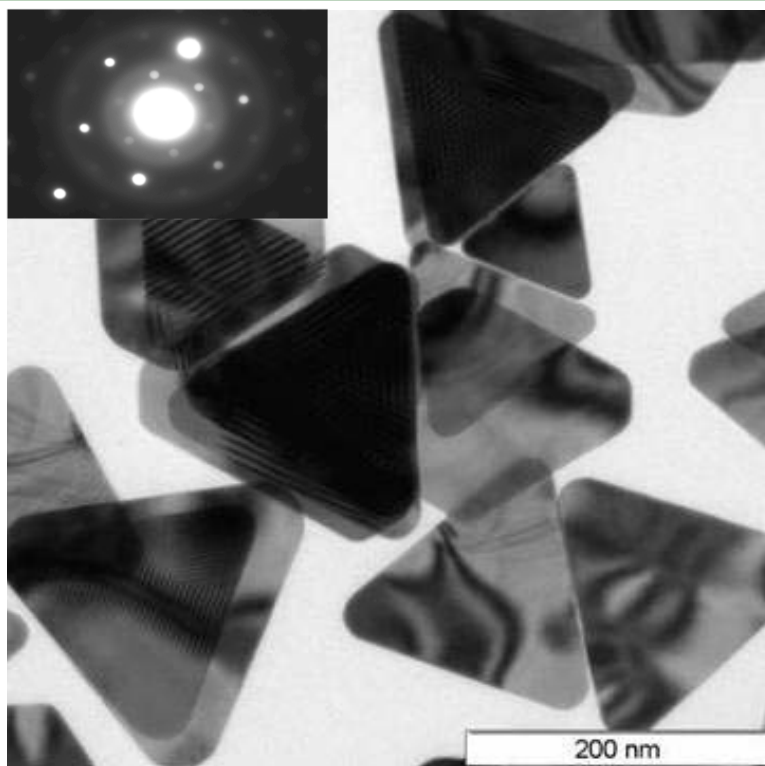


GOLD NANOTRIANGLES

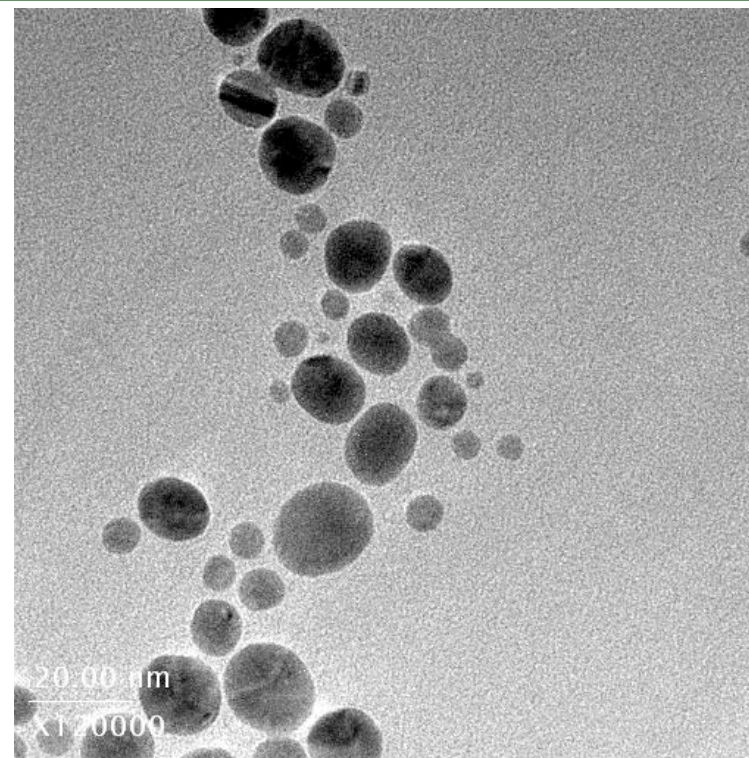


Photocatalyst concentration

[SntMepyP] = 1 nM



[SntMepyP] = 1 mM

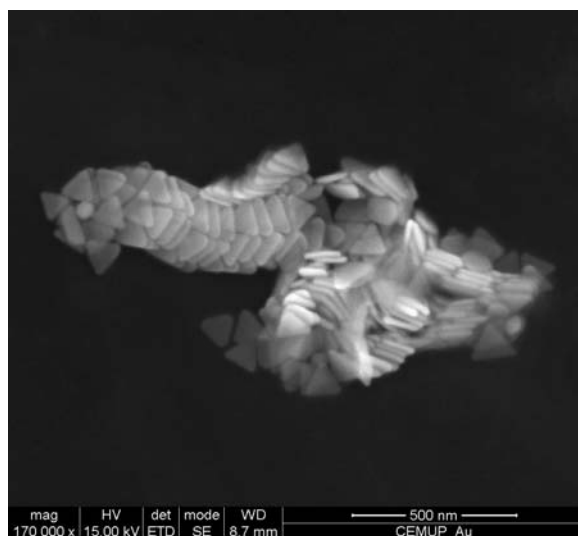
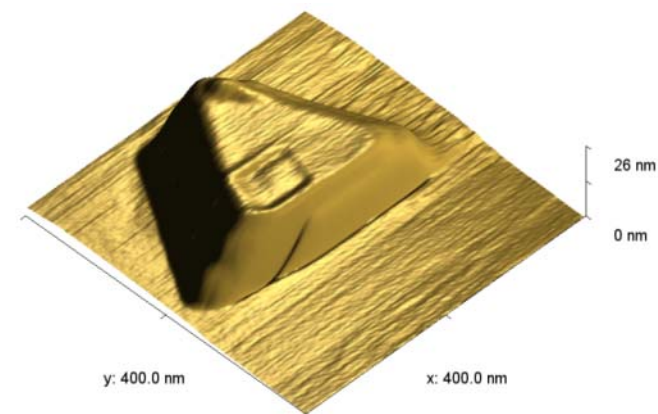
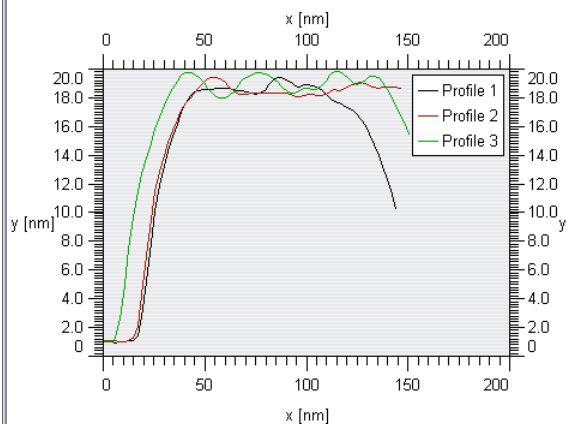
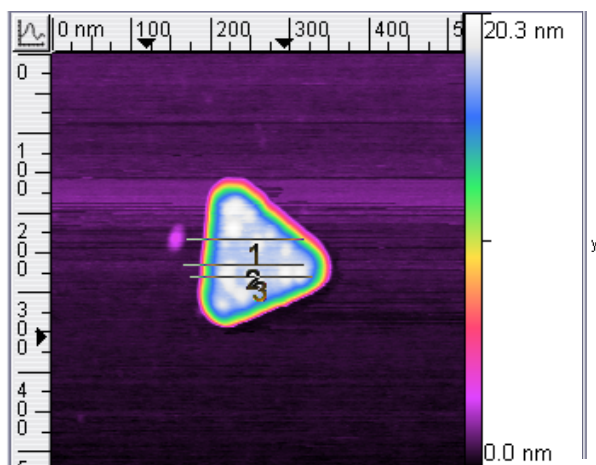


[AuCl₄]⁻/Sn(tMepyP)/TEA/HCl/CTAB (pH ≈ 7)

A. Miranda, E. Malheiro, E. Skiba, P. Quaresma, P. A. Carvalho, P. Eaton, B. de Castro, J. A. Shelnutt, and E. Pereira *Nanoscale*, **2010**, DOI: 10.1039/C0NR00337A

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AFM/XPS/SEM characterization

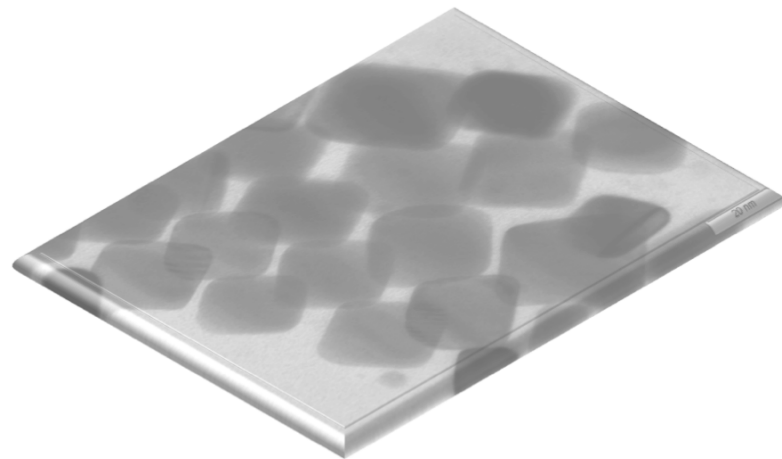


Element	BE (eV)	Abundance
Au	84.0; 87.7	1.00
N	400.2; 403.0	1.01
Cl	197.3	0.35
Br	68.3	0.45

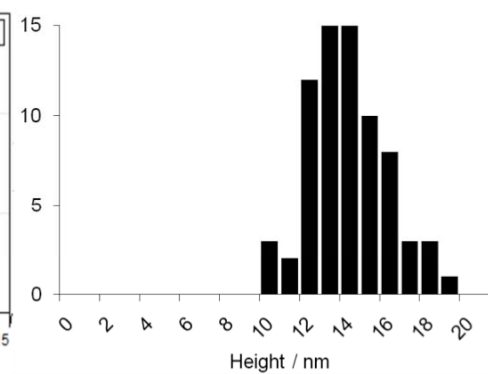
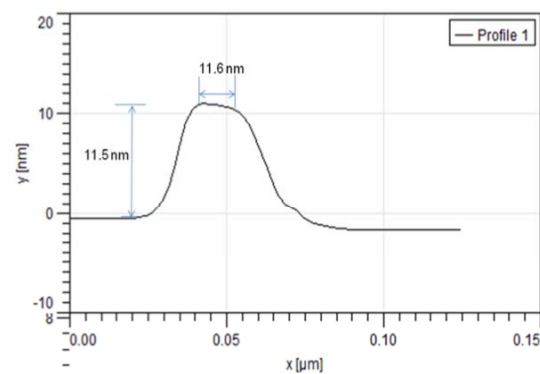
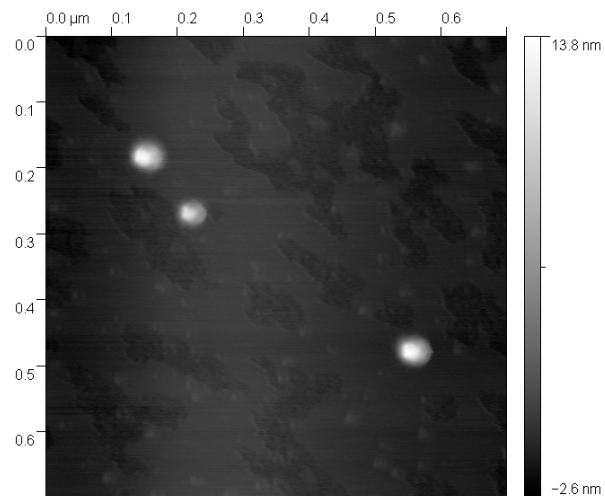
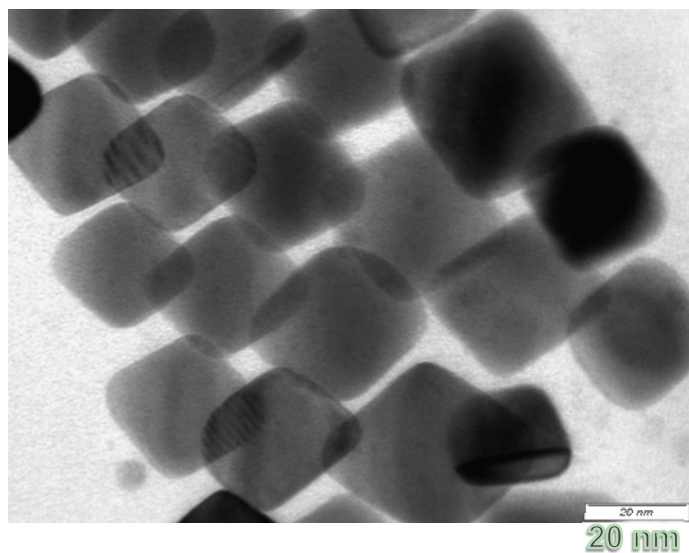
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GOLD NANOCUBES



Nanocubes



[AuCl₄]⁻/Sn(tMepyP)/TEA/HBr/CTAB (pH \approx 7)

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Conclusions

- Green Chemistry
 - Water as the solvent
 - Non-toxic/renewable reagents
 - Low energy consumption
 - Fast reaction
 - Low cost
- Nanochemistry
 - Good size control
 - High colloidal stability
 - Versatility
 - Morphology control

Lab Team

- Peter Eaton
- Adelaide Miranda
- Pedro Quaresma
- Leonor Soares
- Eliana Malheiro
- Armando Silva
- Cristina Neves
- Lívia Contar
- José Carlos Costa
- Vânia Vieira
- Catarina Loureiro

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