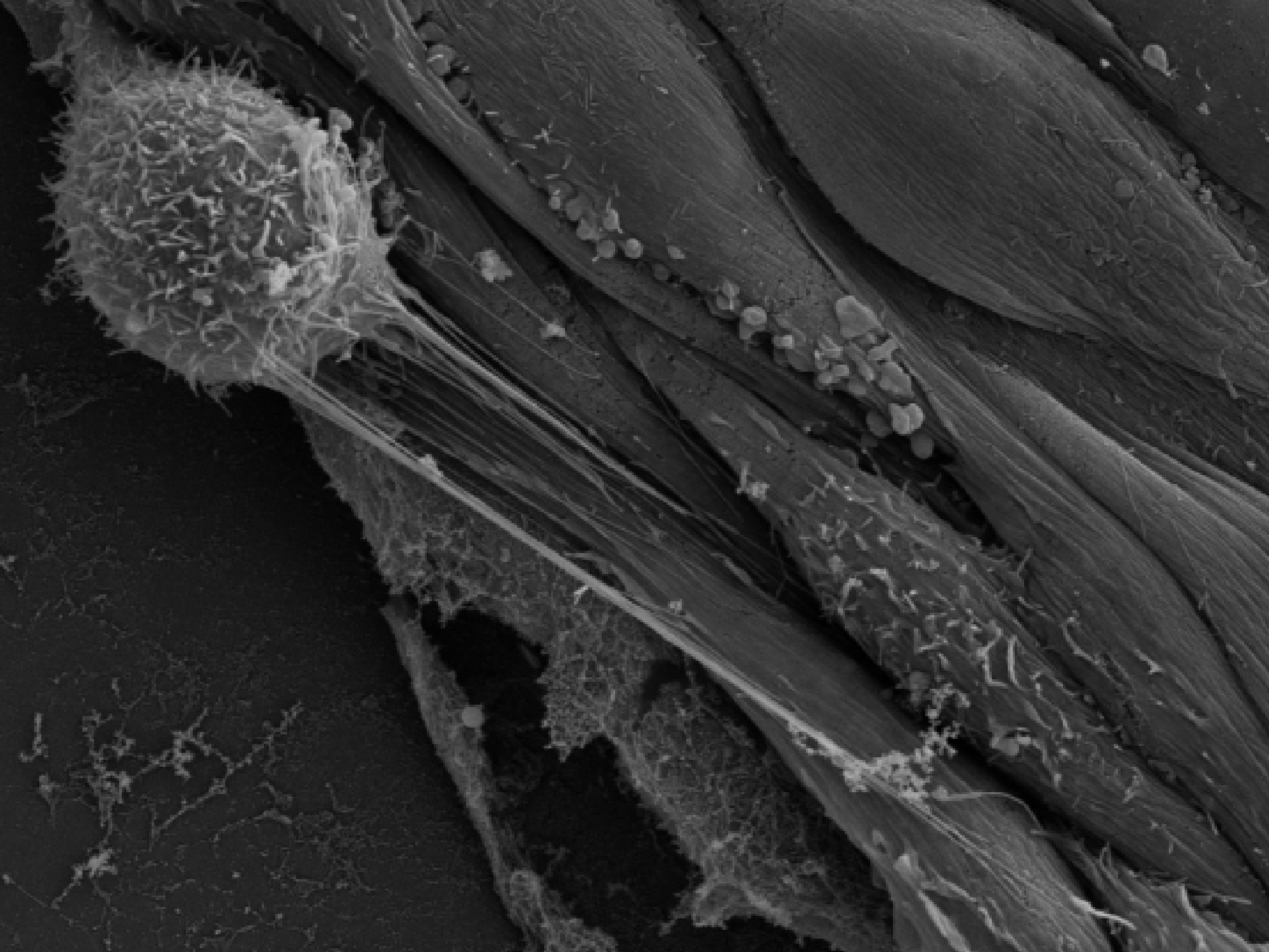
Bachelor Thesis 2016

Radiosensitization using gold nanoparticles

Lies Deceuninck en Hannelore Verhoeven

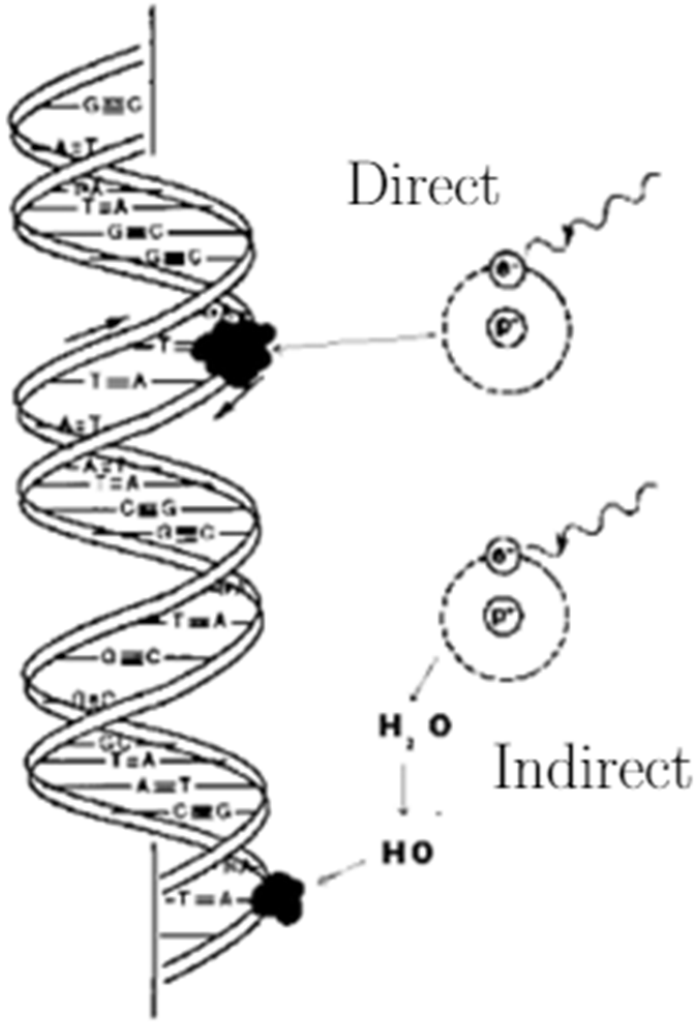
Assistents: Bert De Roo
Mattias Vervaele
Professor: Chris Van Haesendonck



DNA damage using ionizing radiation

- Chemotherapy
- Surgery
- **Radiation therapy**

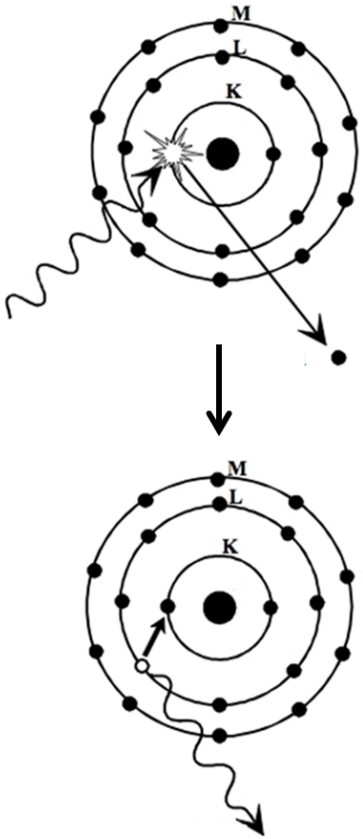
  Energy $\sim$ MeV



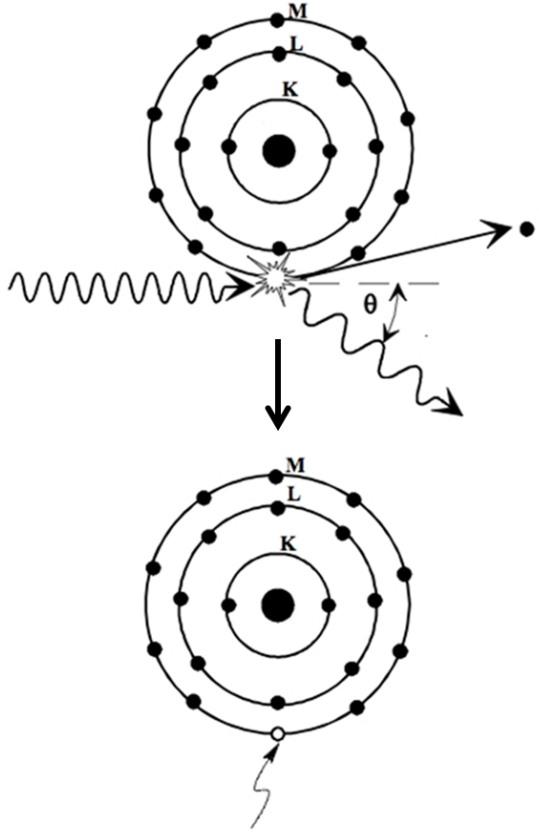
Source: https://chem.kuleuven.be/veiligheid/info/ioniserende-st.htm

Radiosensitization of cancer cells with gold nanoparticles (GNP) E ~ keV

Photoelectric absorption

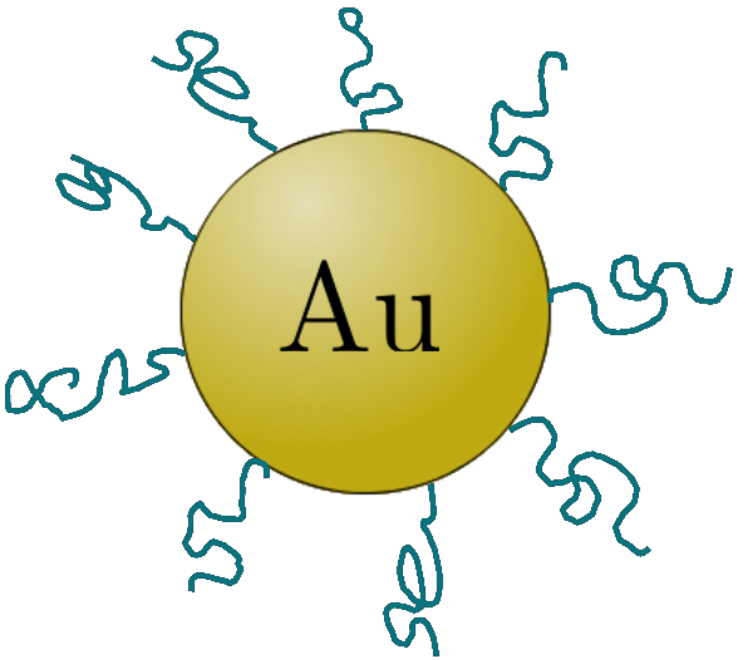


Compton effect

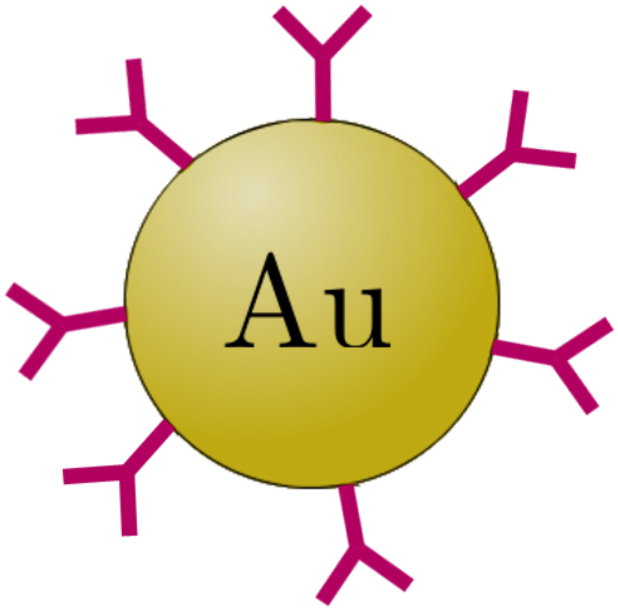


Targeting of the GNP to the tumor

Passive targeting
PEG coating



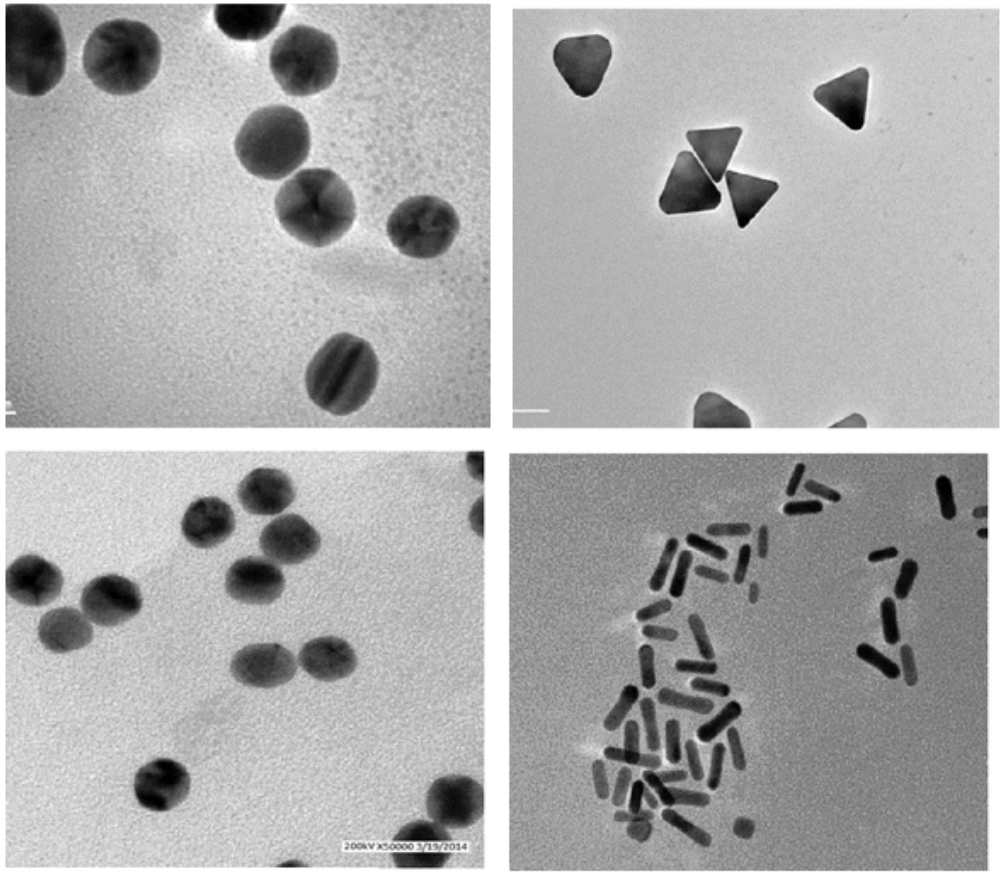
Active targeting
Antibodies



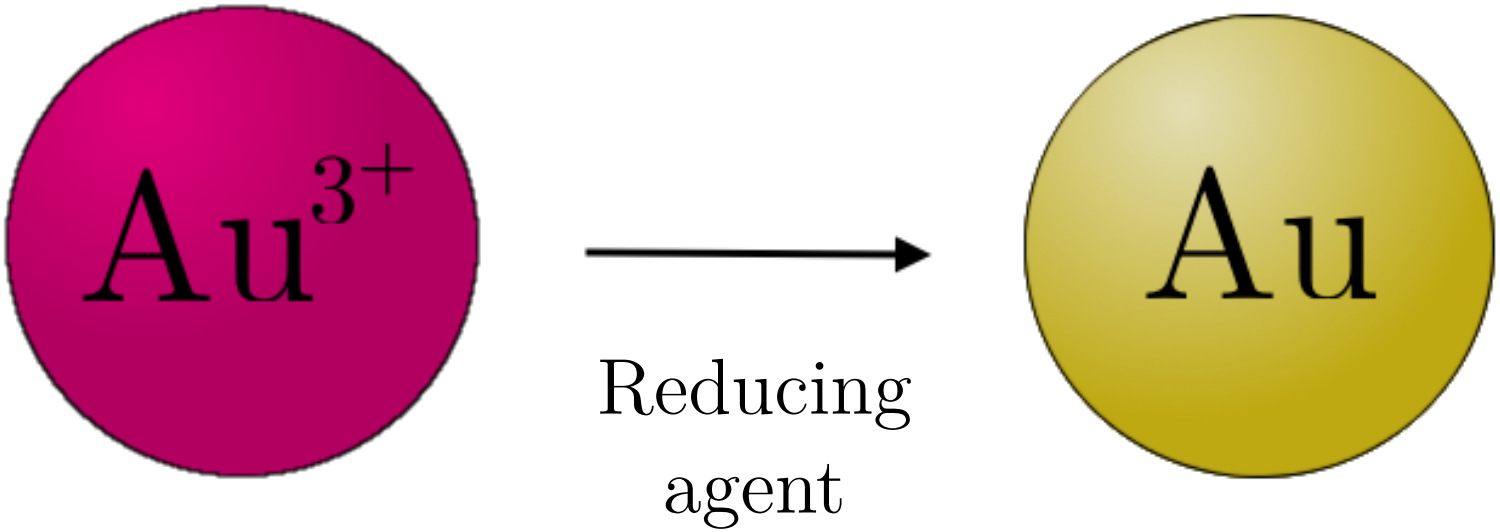
Overview Project

Radiosensitization of cancer cells using gold nanoparticles

1. Synthesis
2. Characterization
3. Radiosensitization

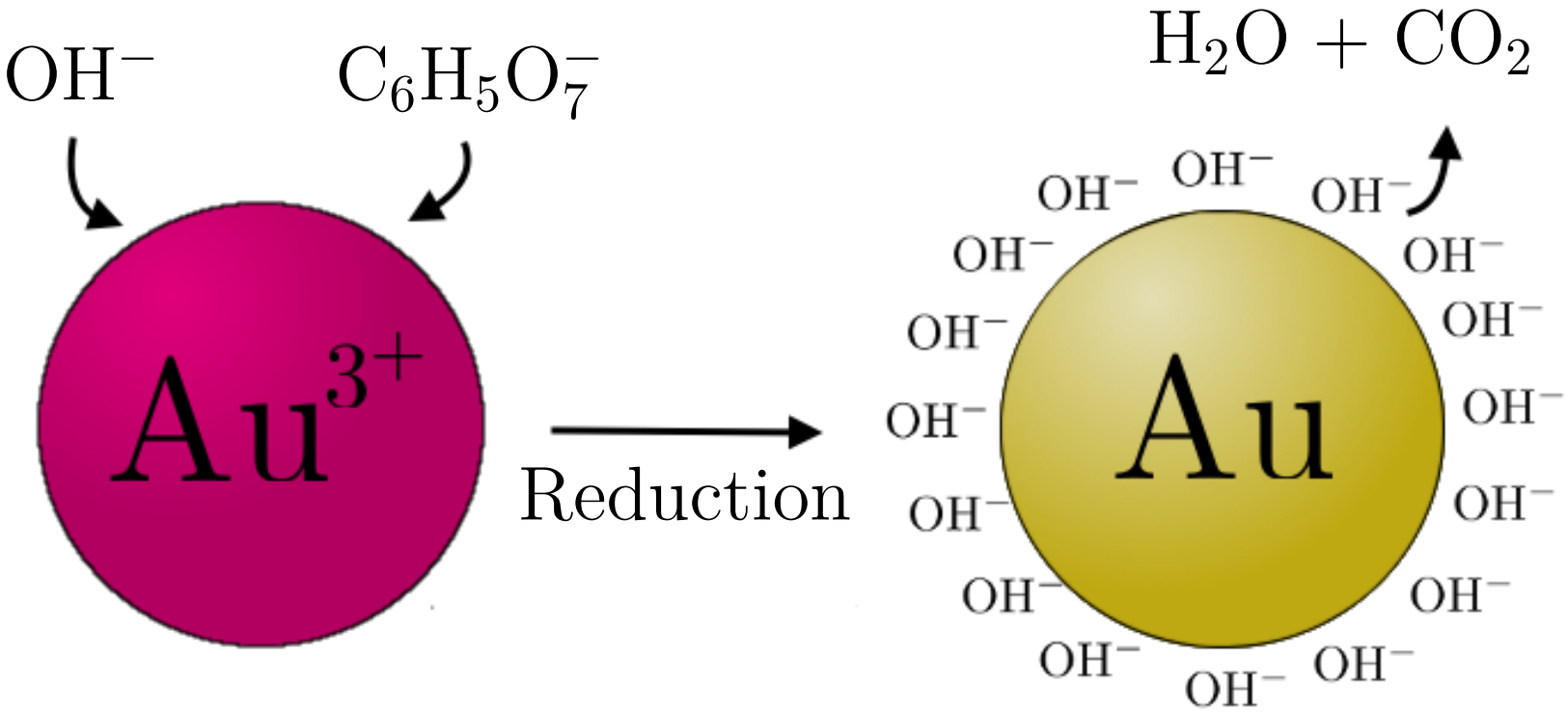


Reduction of gold ions to form GNP



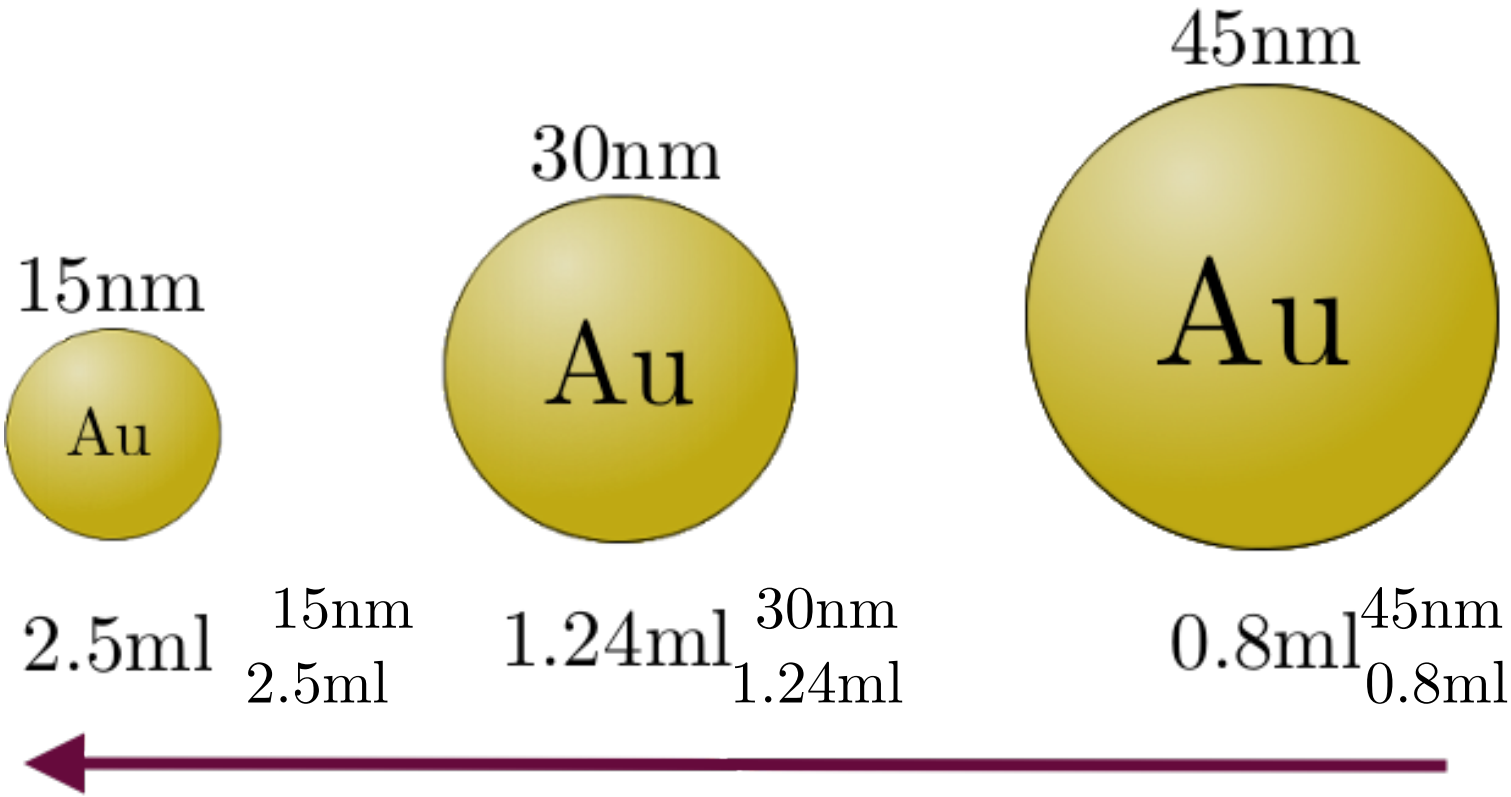
Gold ions: $HAuCl_4$ solution
Reducing agent: $Na_3C_6H_5O_7$

Reduction of gold ions to form GNP



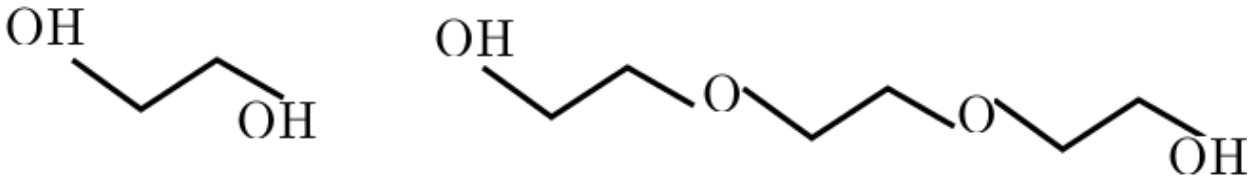
$$6Au^{3+} + C_6H_5O_7^{3-} + 15OH^- \rightarrow Au + 6CO_2 + 10H_2O$$

The amount of citrate controls the size

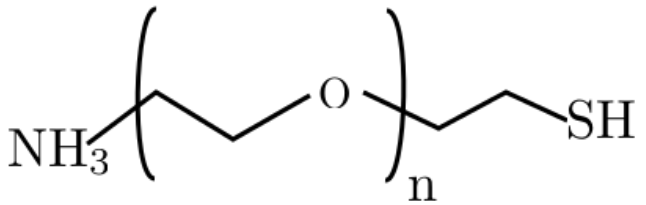


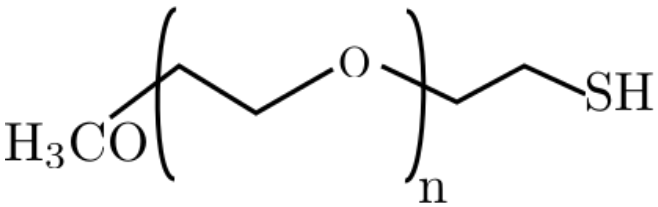
Citrate 1%
100ml $HAuCl_4$ 0.01%

PEG for targeting and stabilization

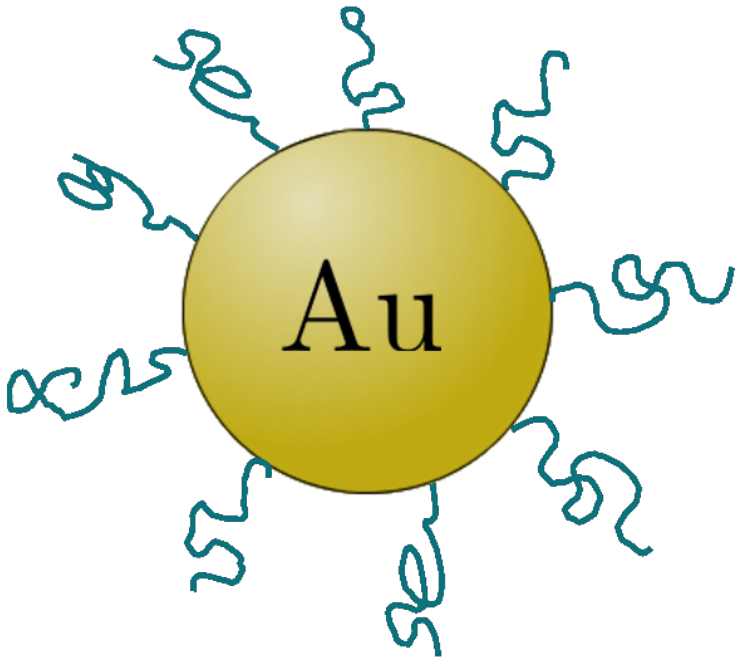


Ethylene glycol → Polyethylene glycol

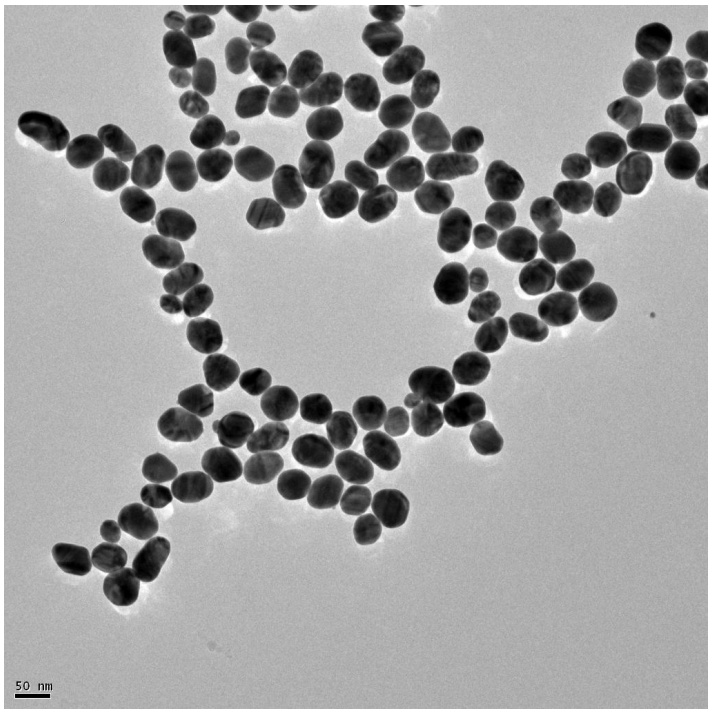


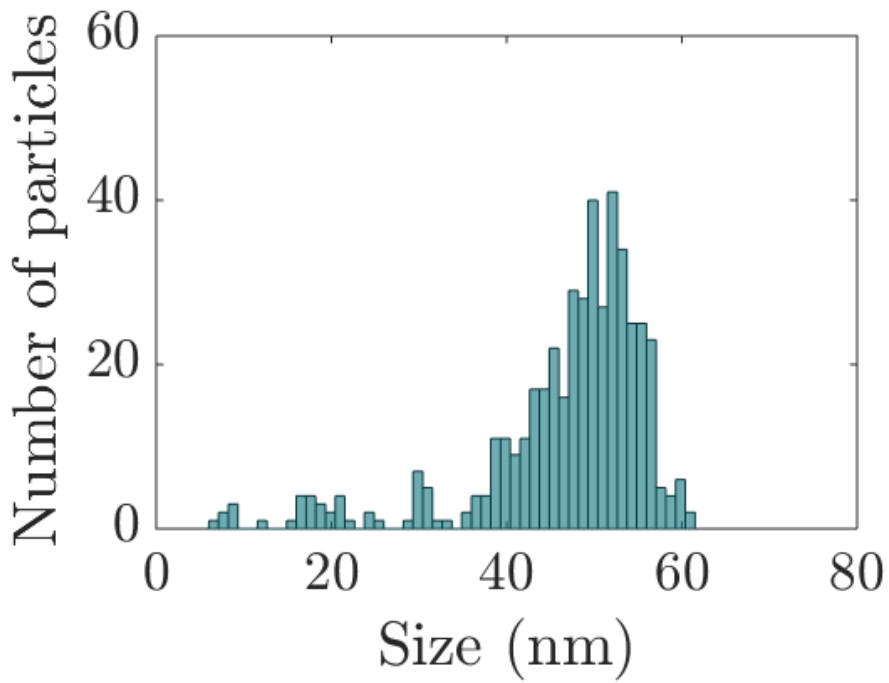


20k, 10k, 5k, 1k

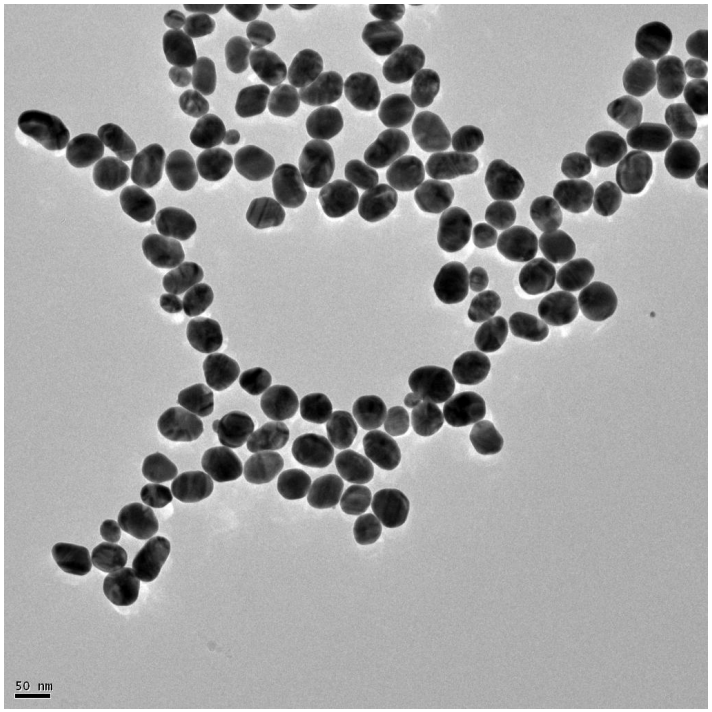


TEM image analysis to determine the core diameter





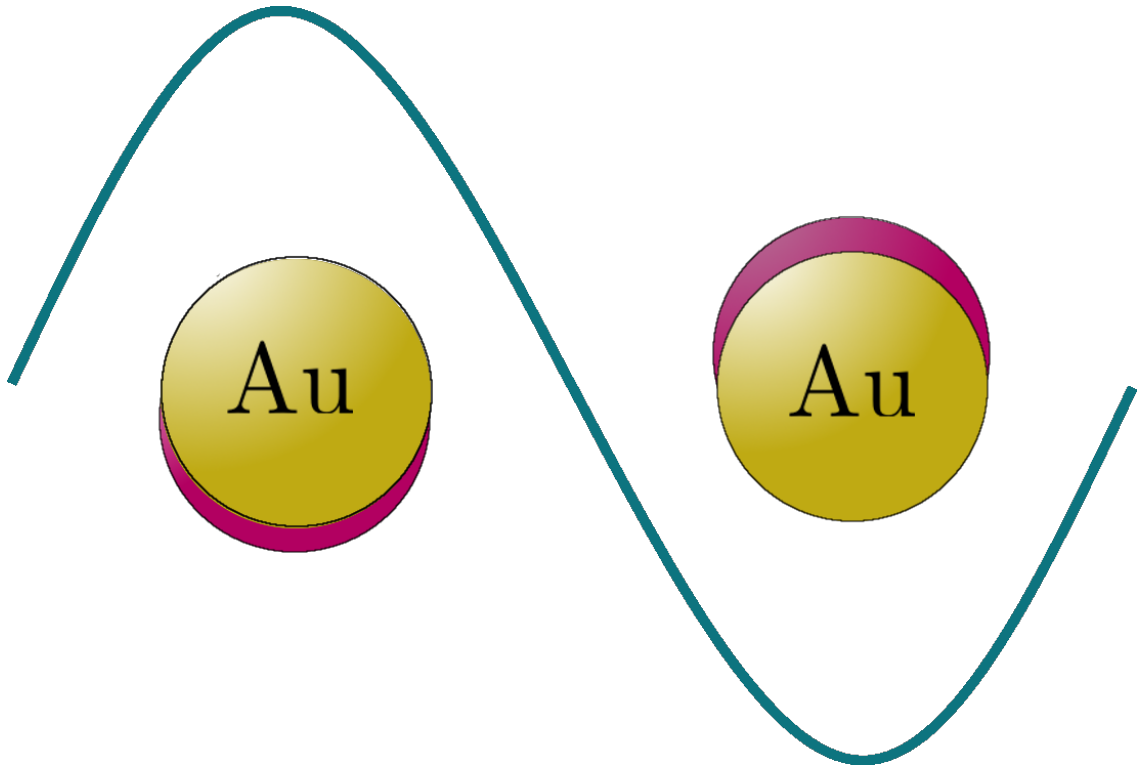
TEM image analysis to determine the core diameter



Exp. Size (nm)	Size (nm)
15	12.98 ± 0.23
	2.99 ± 0.16
30	18.29 ± 0.23
45	46.75 ± 0.47

UV-Vis spectroscopy

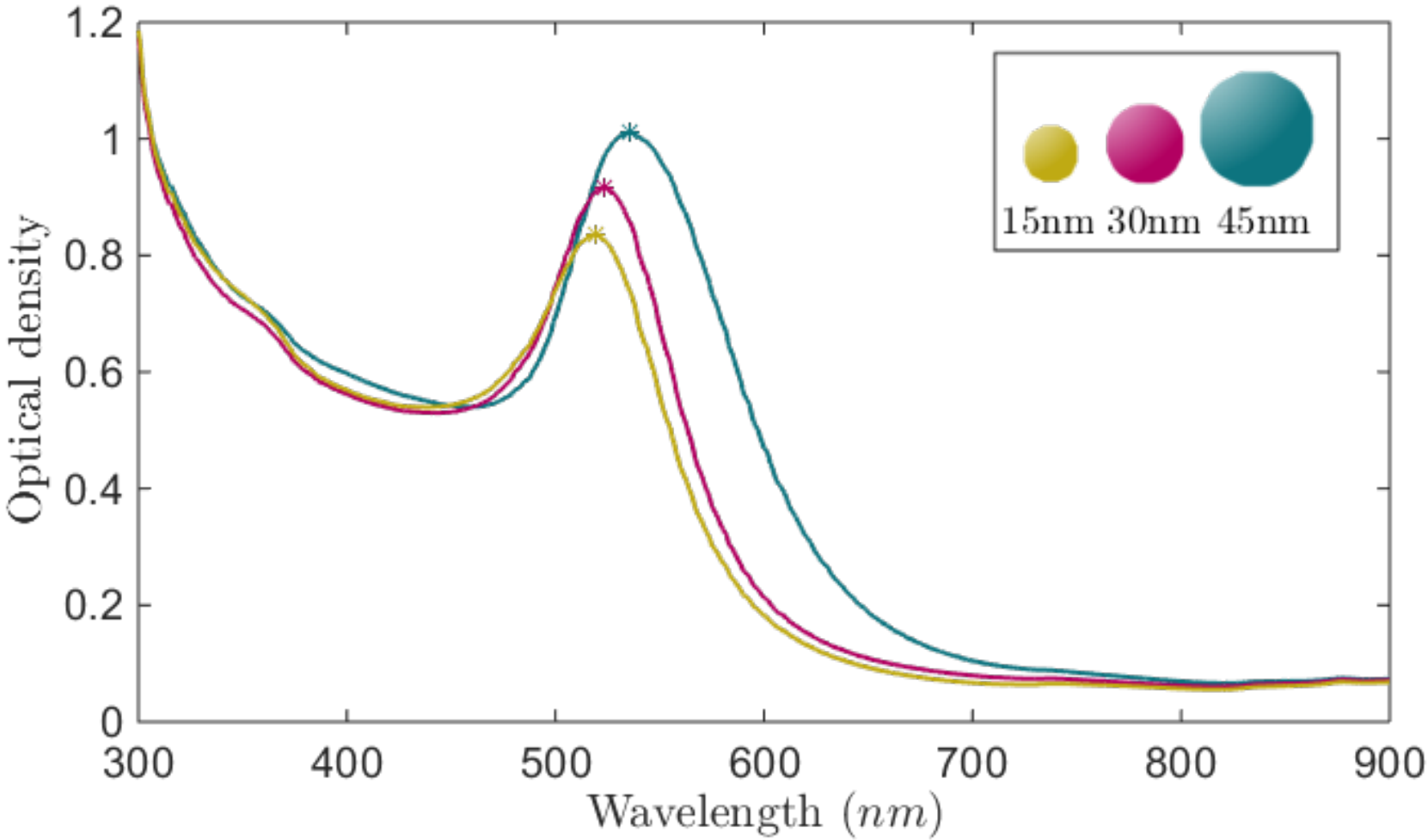
1. Add PEG
2. Size GNP
3. Add NaCl
4. Size GNP



bigger size → too little PEG
same size → enough PEG

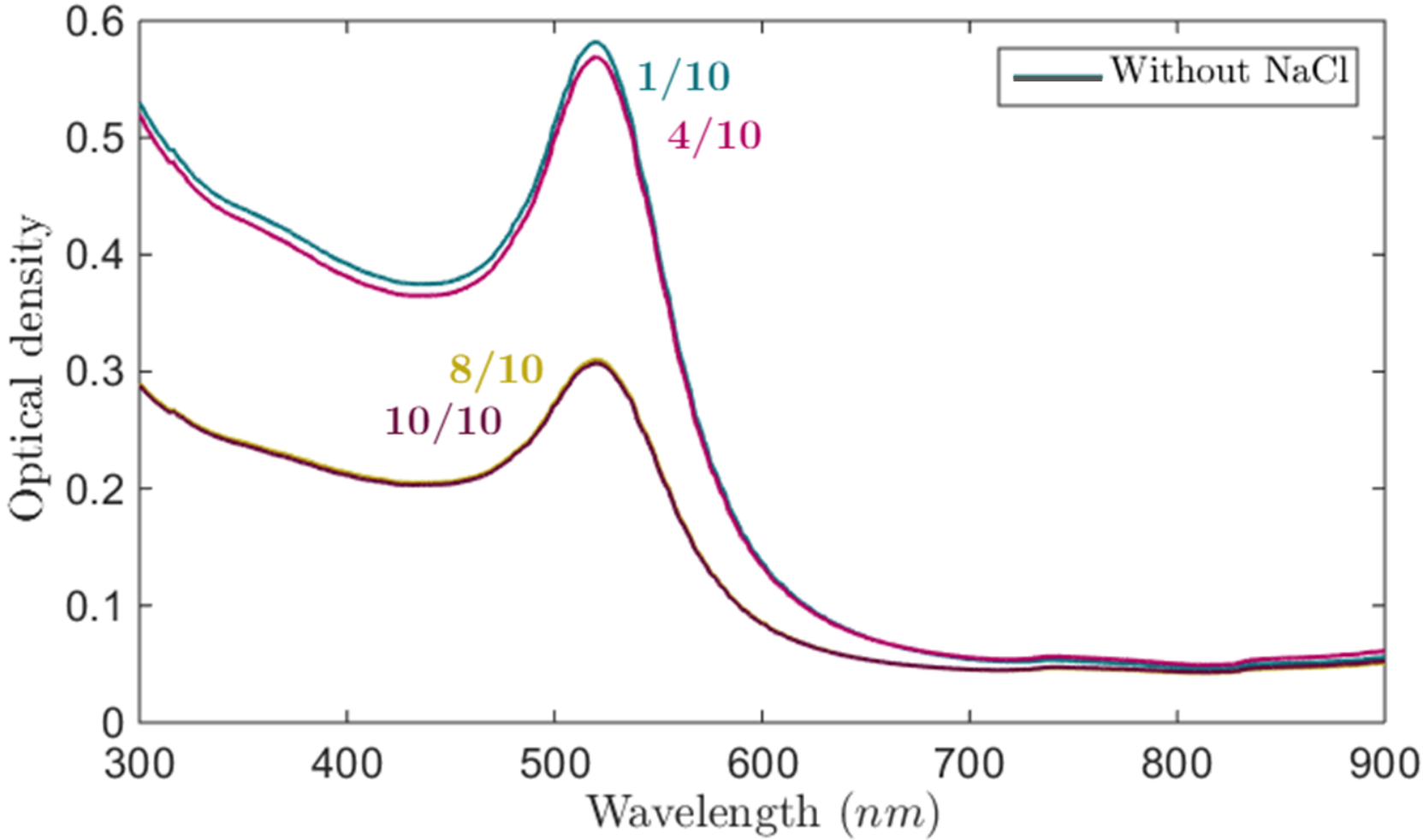
Results

GNP no PEG



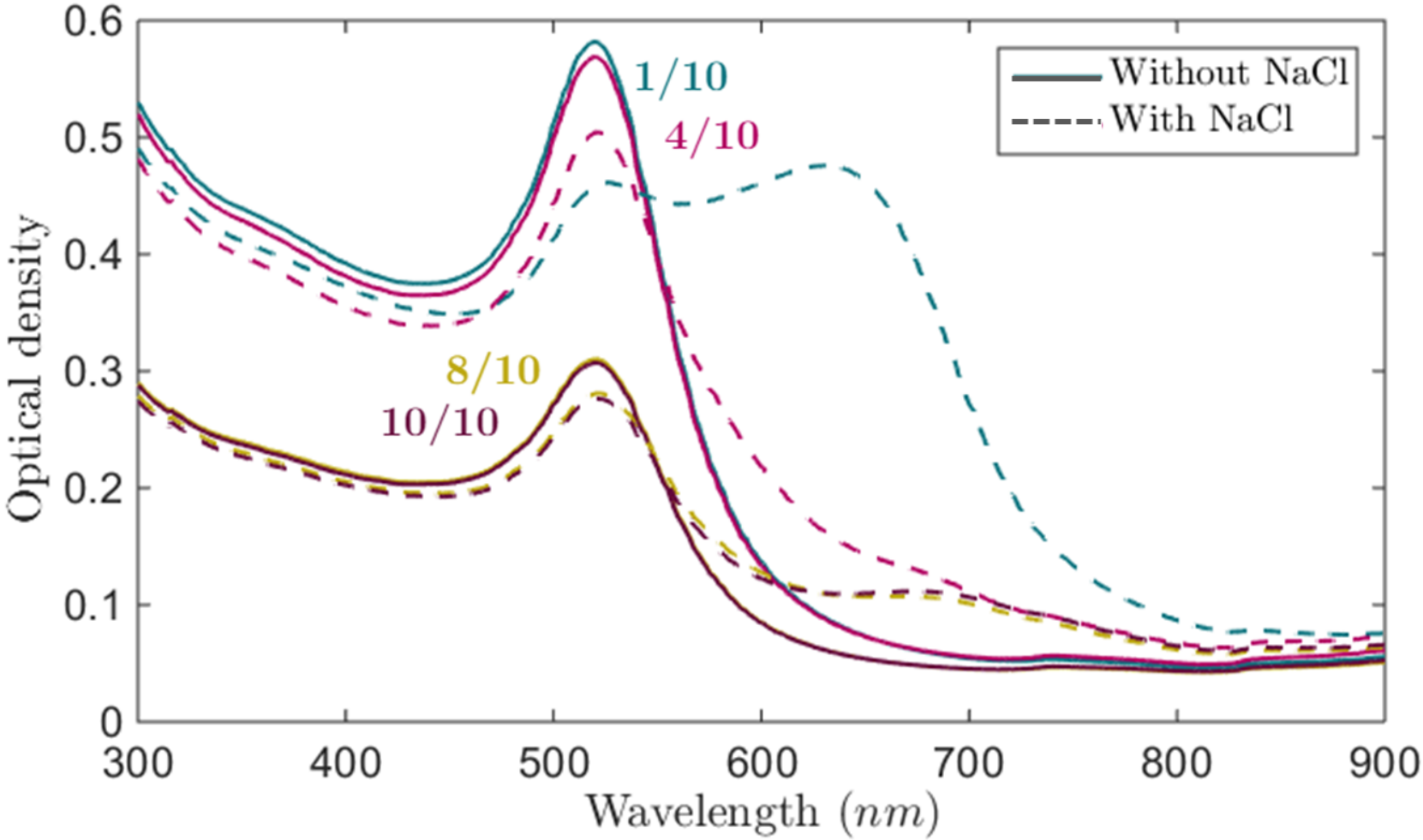
Results

15nm GNP 20k PEG for different PEG/GNP



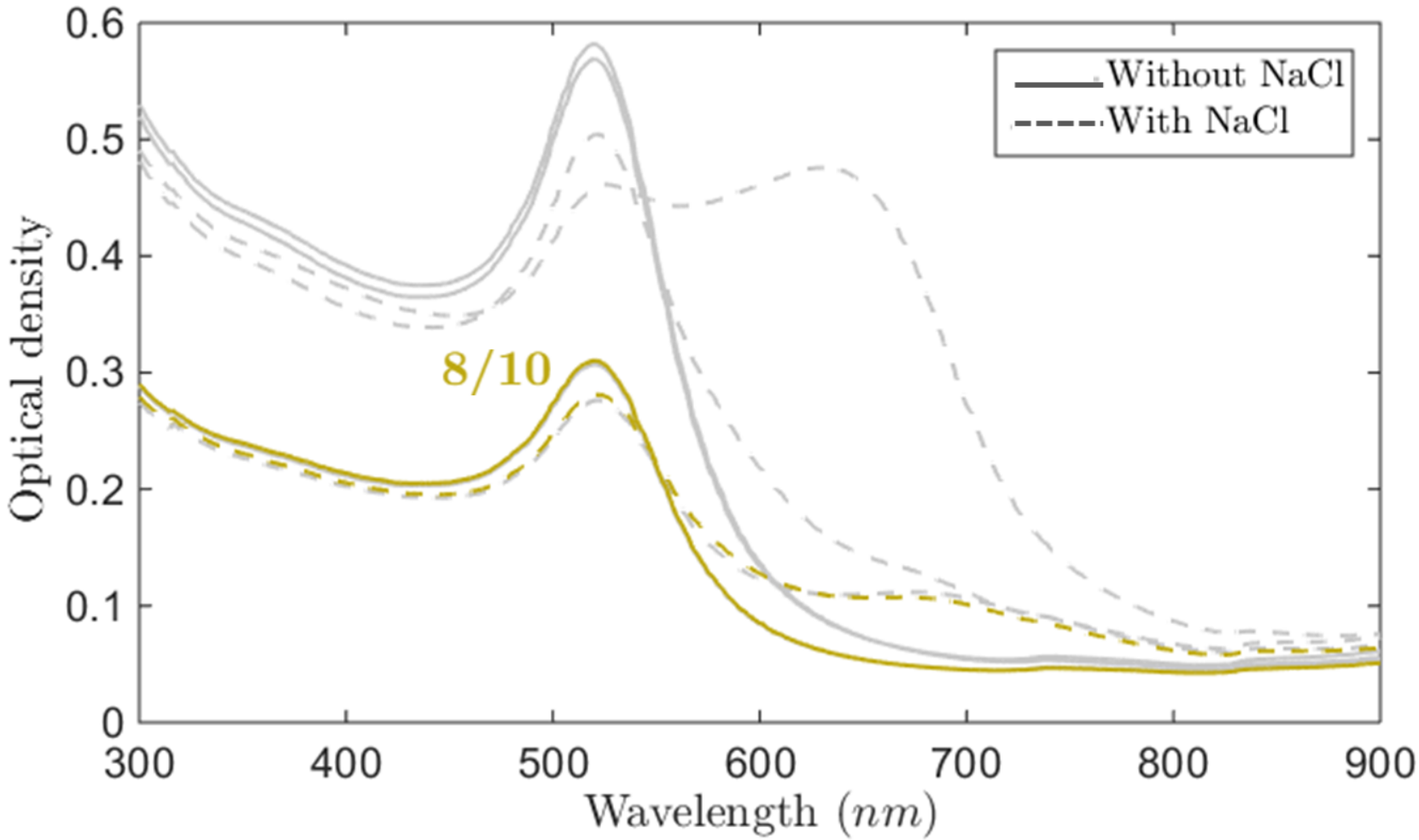
Results

15nm GNP 20k PEG for different PEG/GNP



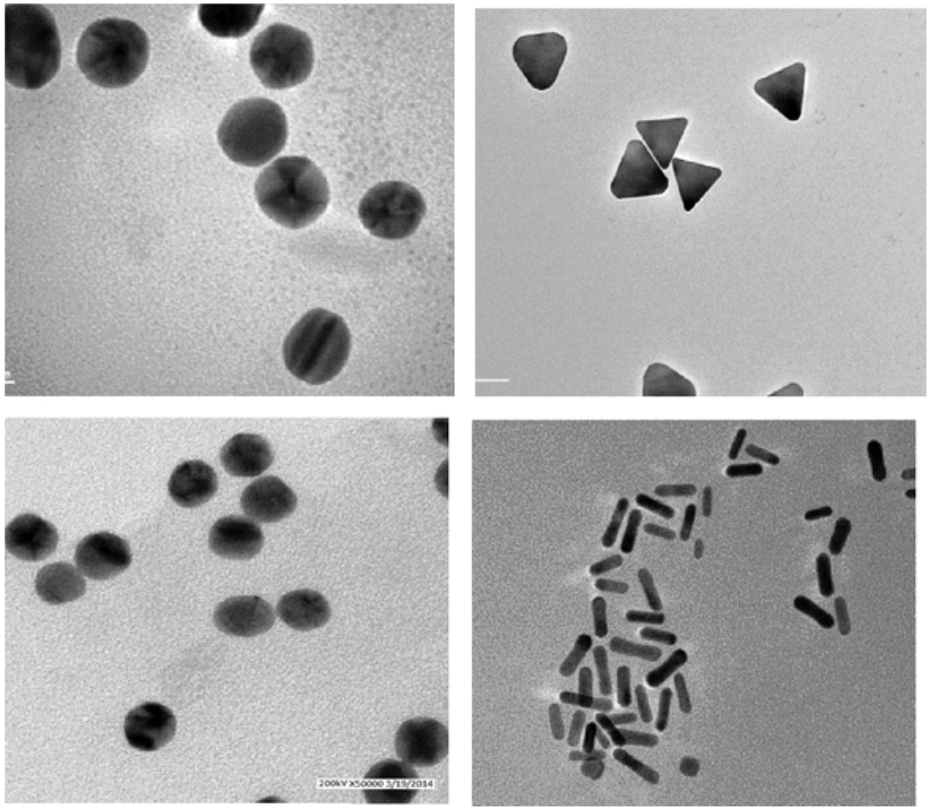
Results

15nm GNP 20k PEG for different PEG/GNP



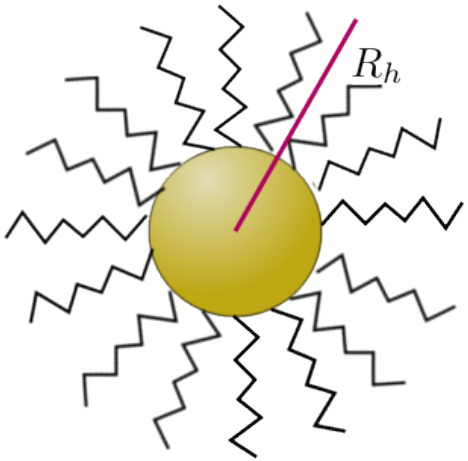
Overview

- Introduction
- Synthesis GNP
  - Chemical Protocol
  - Size GNP
- Stabilization
- Characterization
  - Size GNP
    - Chemical Protocol
    - UV-VIS
    - TEM
  - Hydrodynamic Radius
    - DLS



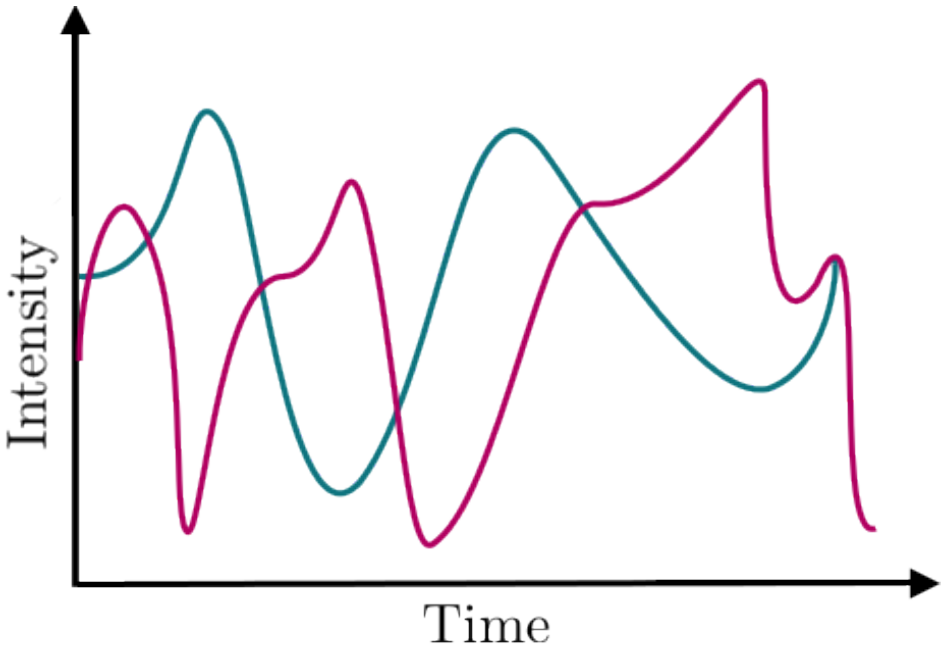
Source: A. Chaudhary , A. Gupta , S. Khan and C. Kanti Nandi *Phys. Chem. Chem. Phys.*, 2014 **16**

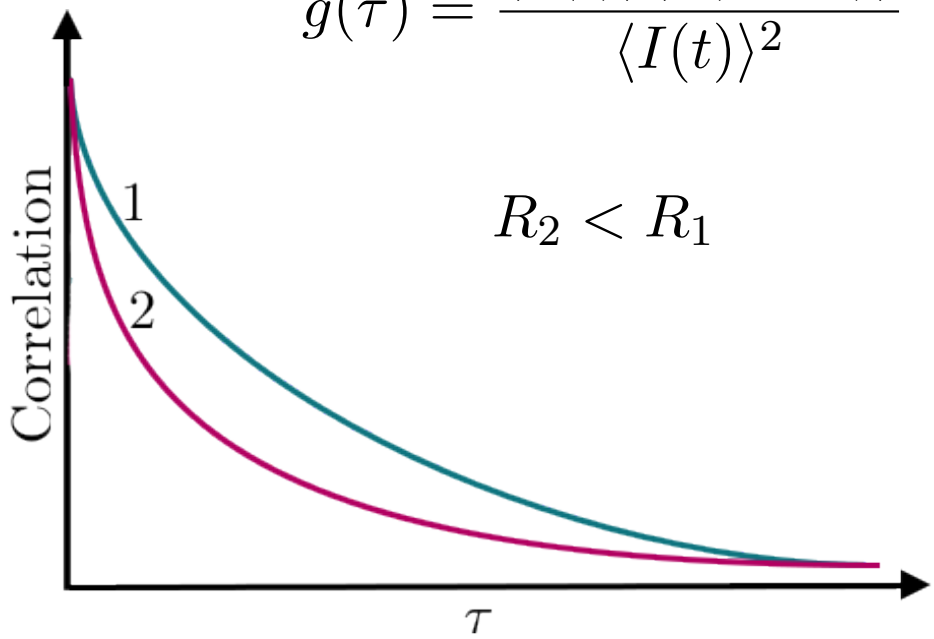
Dynamic light scattering (DLS)



Hydrodynamic radius (R_h)
$\rightarrow$ Rayleigh scattering

$$g(\tau) = \frac{\langle I(t)\rangle\langle I(t+\tau)\rangle}{\langle I(t)\rangle^2}$$

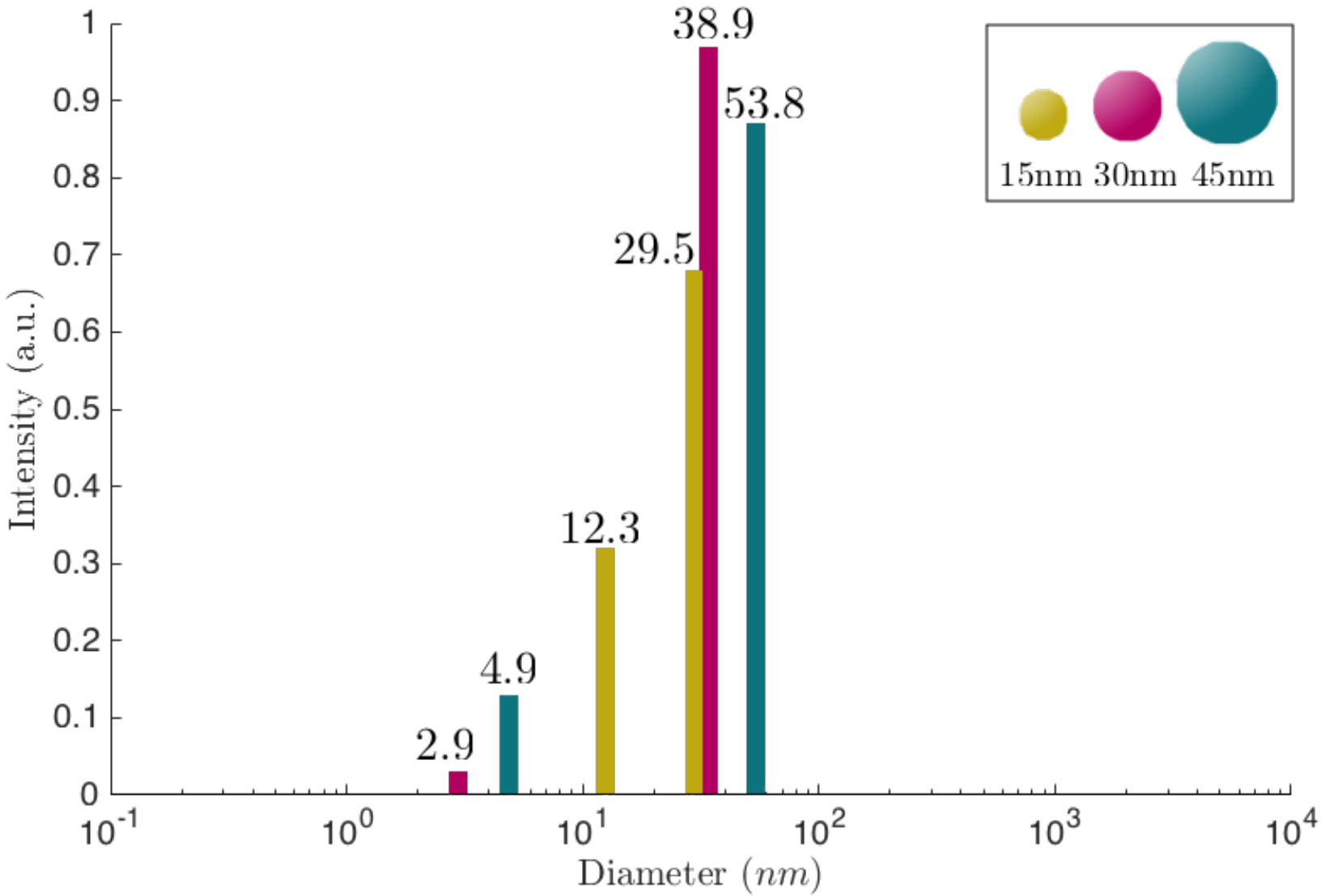




$R_2 < R_1$

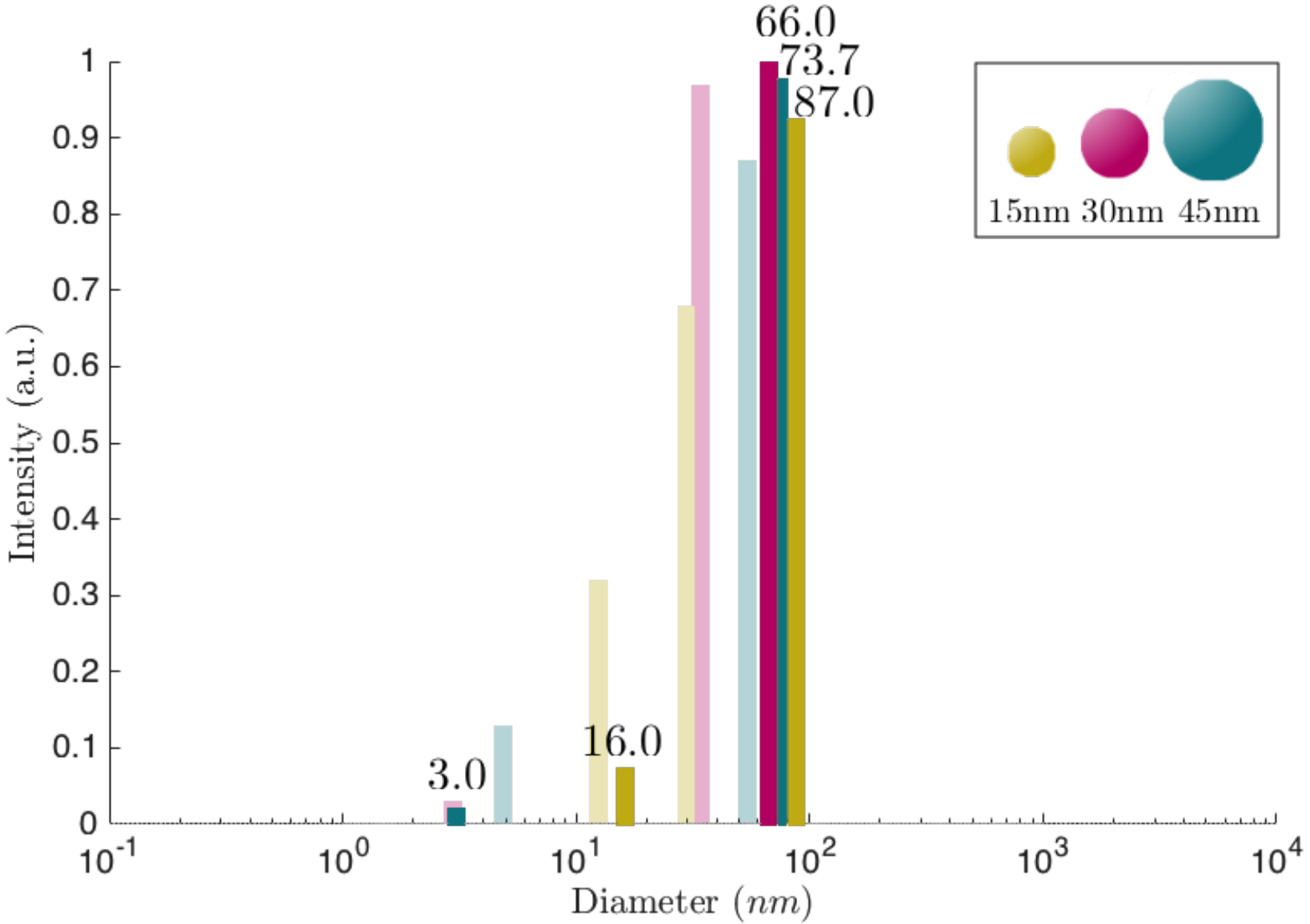
Results

Functionalisation no PEG



Results

Functionalisation 20k PEG

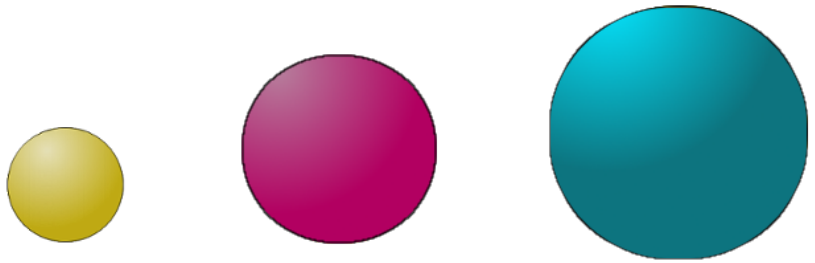


Results

Functionalization 15nm 20k PEG

Proportion (PEG/GNP)	**Average**
5/10	51.93 ± 2.76
6/10	80.89 ± 14.64
7/10	65.24 ± 14.32
8/10	83.91 ± 18.42
9/10	

Original functionalization 20k (8/10)



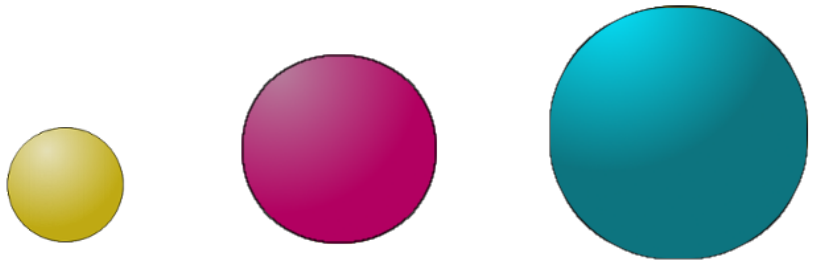
	15nm	30nm	45nm
PEG	87.0nm	66.0nm	73.7nm

Results

Functionalization 15nm 20k PEG

Proportion (PEG/GNP)	**Average**	**Average** (centrifuge)
5/10	51.93 ± 2.76	68.70 ± 7.99
6/10	80.89 ± 14.64	65.16 ± 11.61
7/10	65.24 ± 14.32	57.73 ± 7.72
8/10	83.91 ± 18.42	72.36 ± 10.44
9/10		56.54 ± 3.91

Original functionalization 20k (8/10)



	15nm	30nm	45nm
PEG	87.0nm	66.0nm	73.7nm

Conclusion

- Synthesis of GNP
- Characterization
- Stabilization with neutral PEG
- Stabilization with positively charged PEG
- X-Rays
- Analyze effect on DNA
- Solve problem with DLS