



CSIC

CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

Plasmónica: Detección molecular intensificada sobre nanoestructuras metálicas

Santiago Sanchez-Cortes

*Instituto de Estructura de la Materia. CSIC.
Serrano, 121. 28006-Madrid. Spain*

E-mail: s.sanchez.cortes@csic.es

Plasmónica: Interacción Luz-Metal

Aprovechamiento de la interacción luz-materia para:

Identificación y cuantificación de materiales

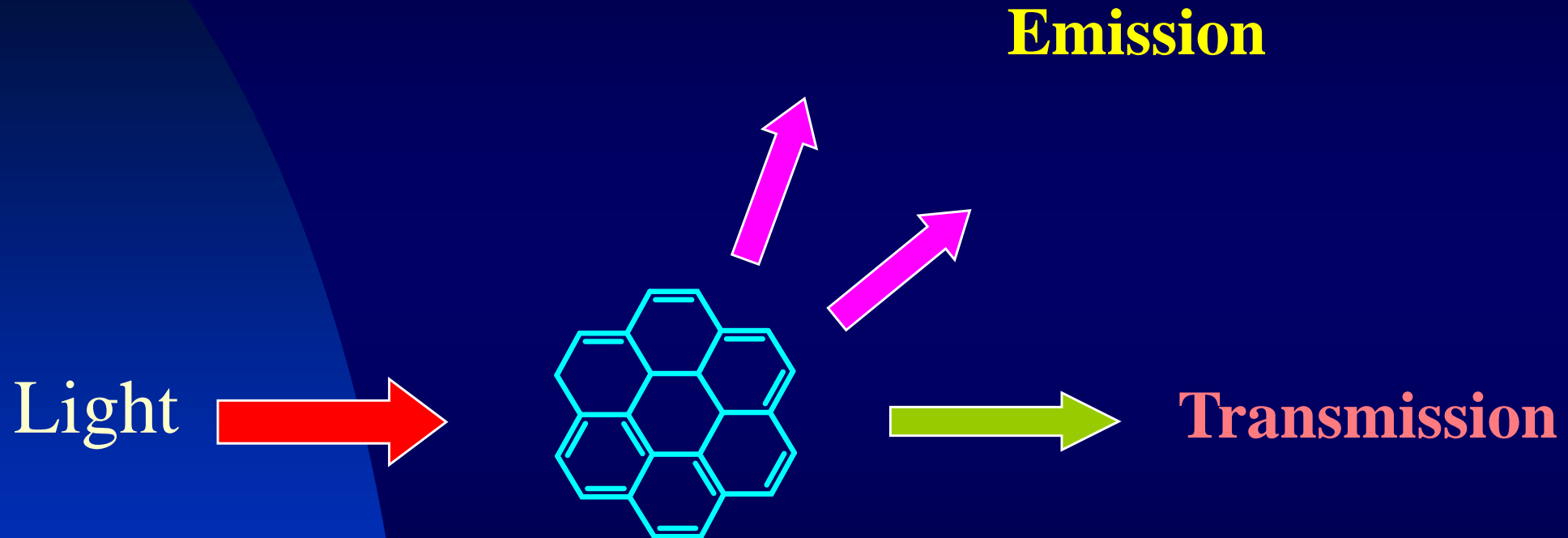
Confinamiento de energía: Hipertermia, células solares

Nanofabricación

Funcionalización

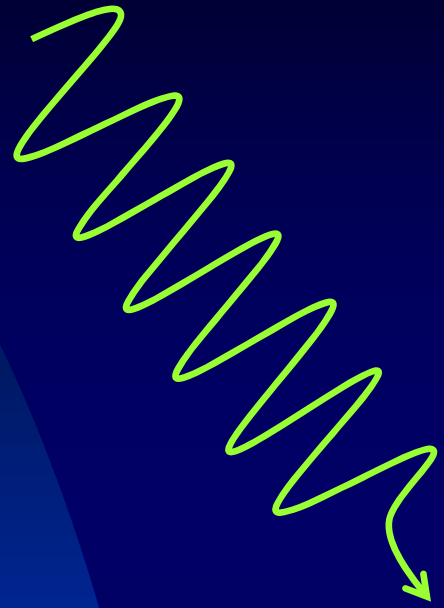
Aplicaciones: Detección, Biodiagnos, análisis del Patrimonio Histórico

Light-Matter Interaction: Molecules

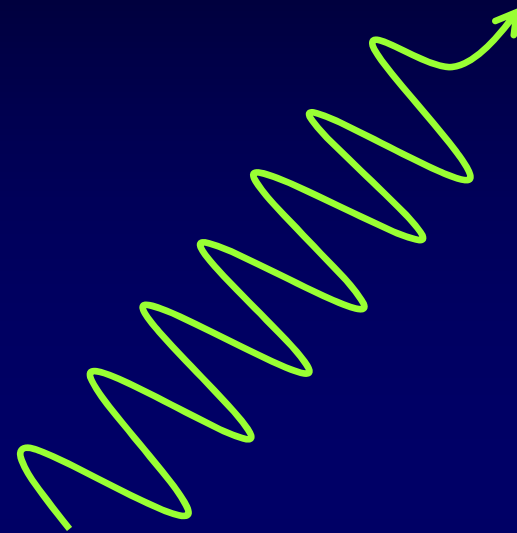


Radiation-Metal Interaction

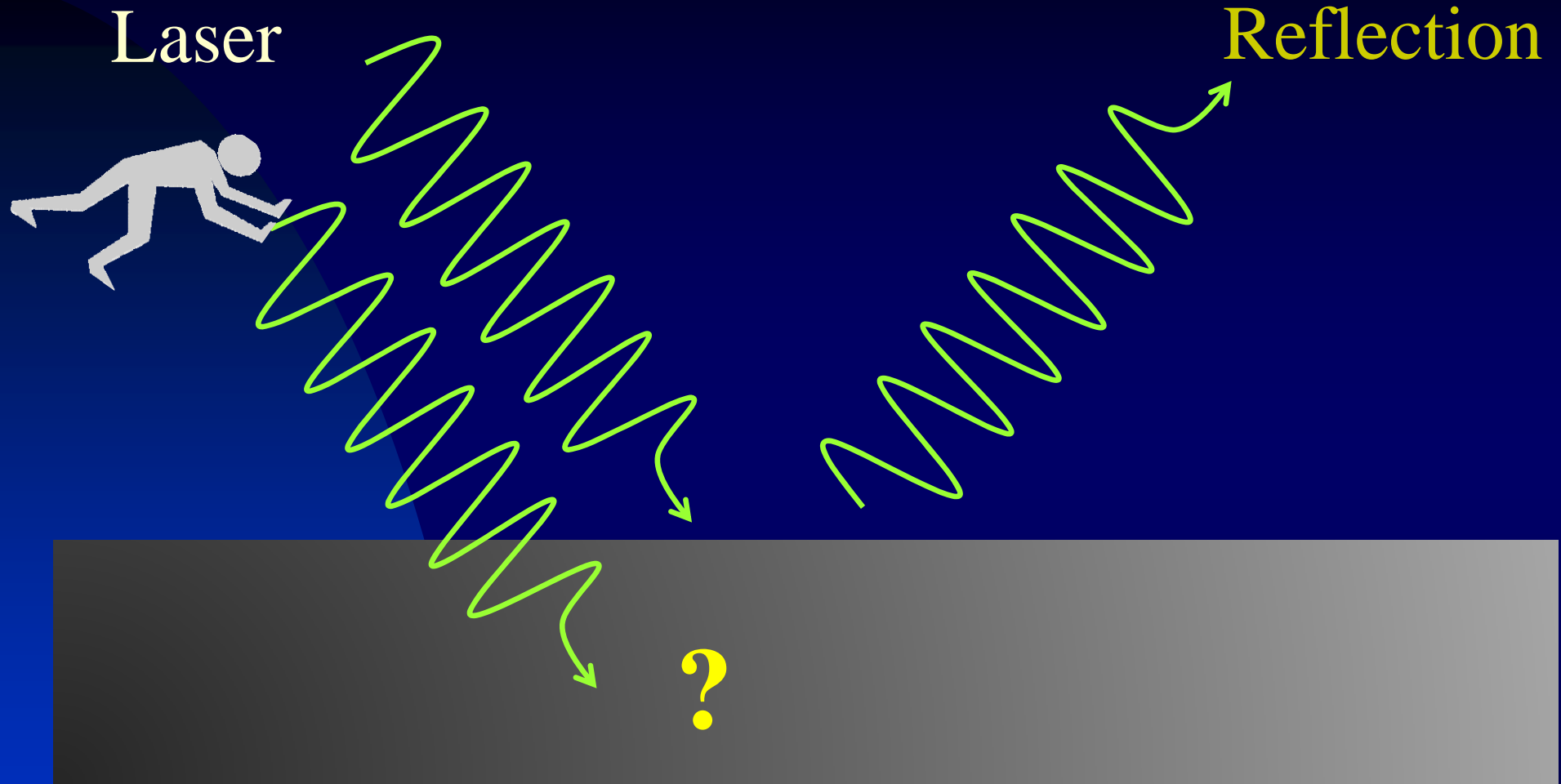
Light



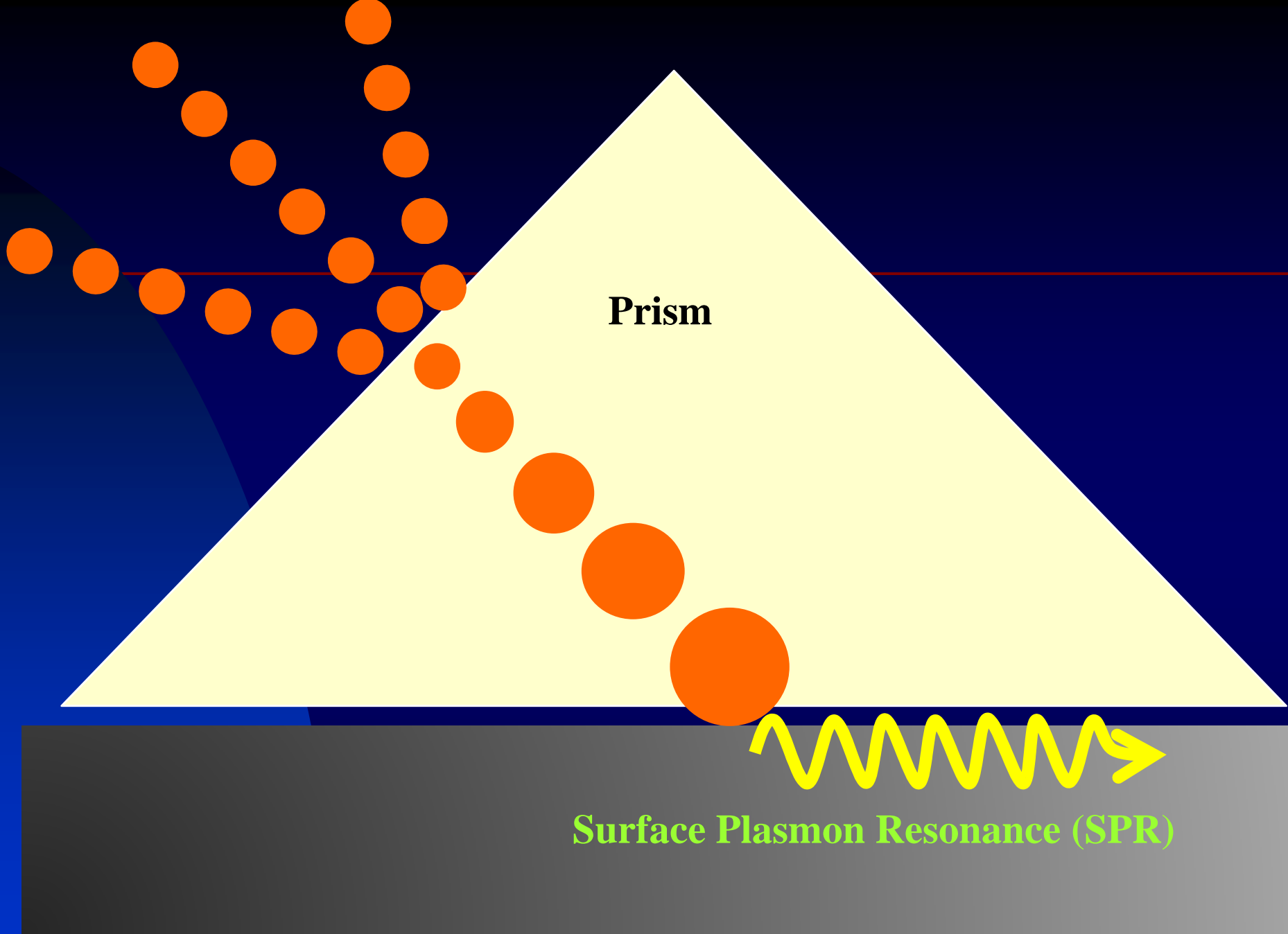
Reflection



Radiation-Metal Interaction



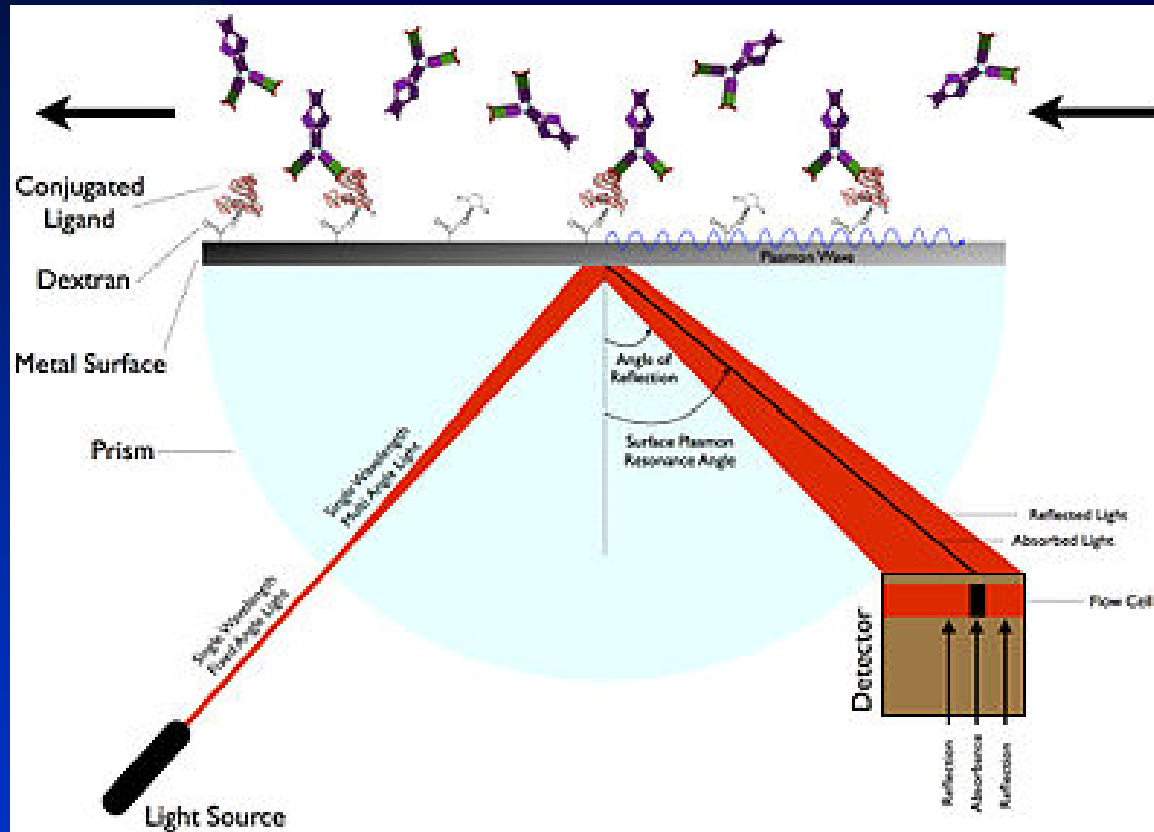
Coupling with free e^-
oscillations or Plasmons



Prism

Surface Plasmon Resonance (SPR)

SPR is sensitive to the adsorption of species on the metal



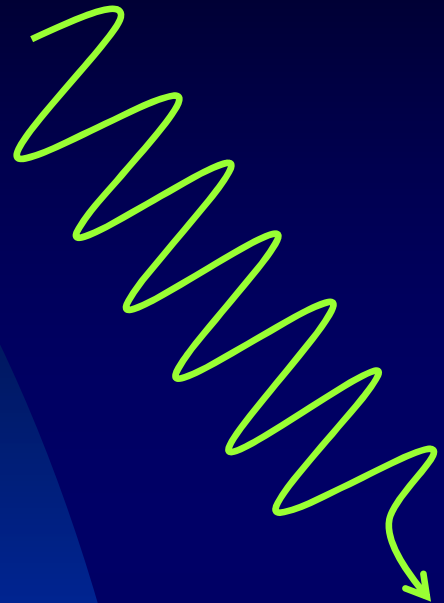
Detection of Proteins
related with:

Tumors

**Degenerative Diseases
(Alzheimer, Parkinson, etc.)**

Radiation-NanoMetals Interaction

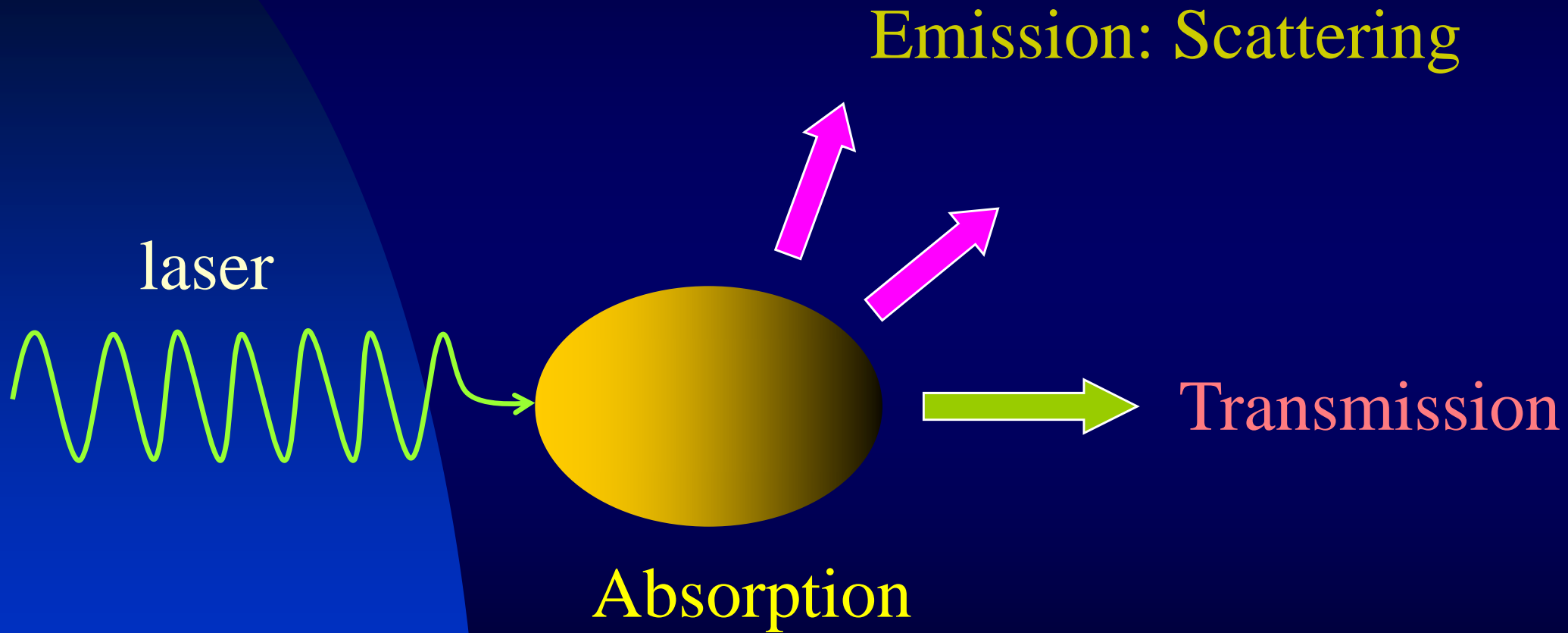
Laser



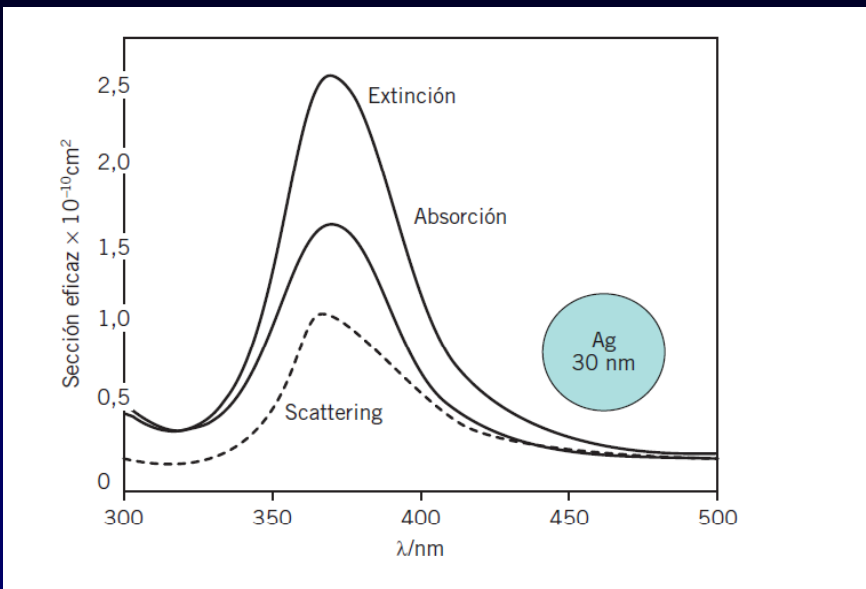
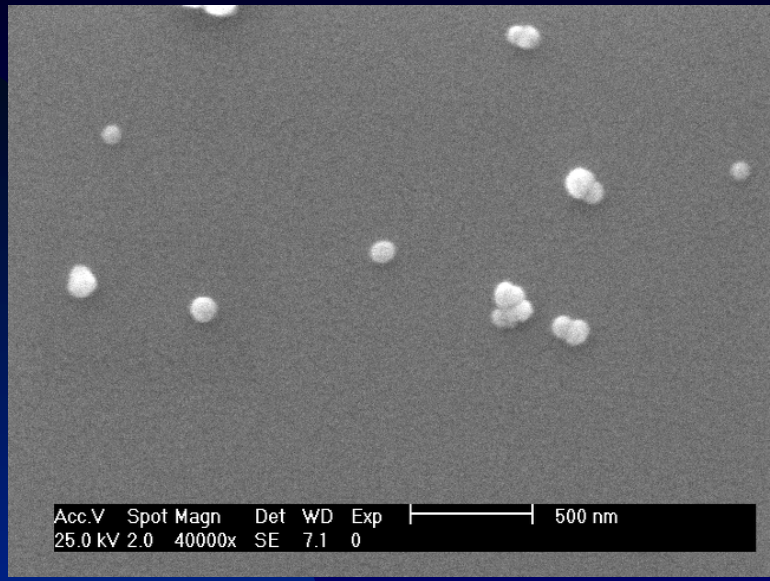
Nano-optics



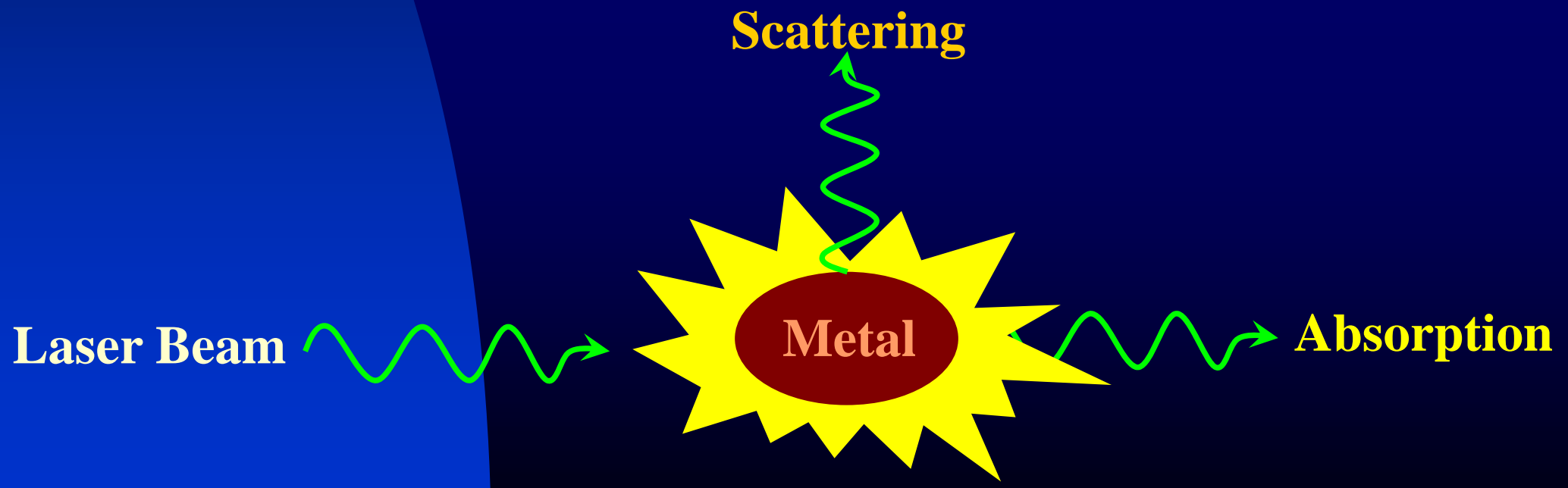
Radiation-NanoMetals Interaction



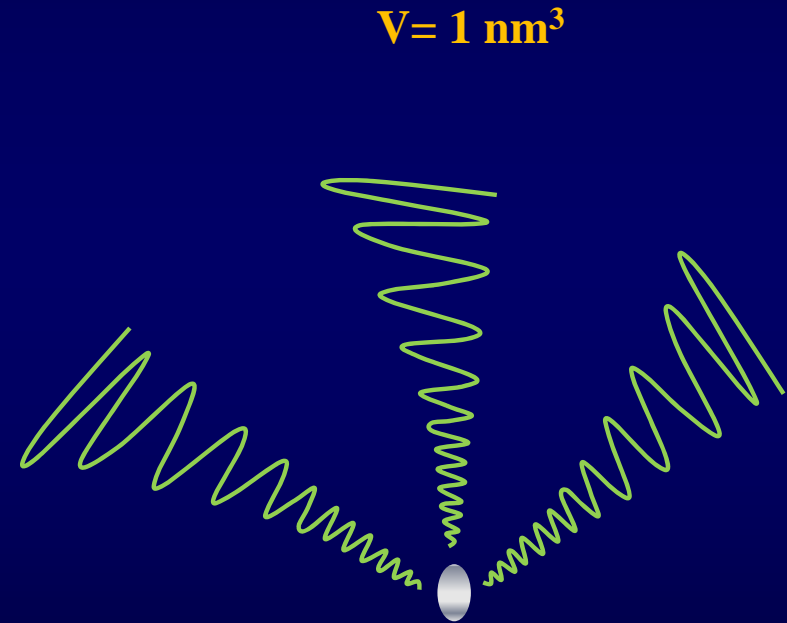
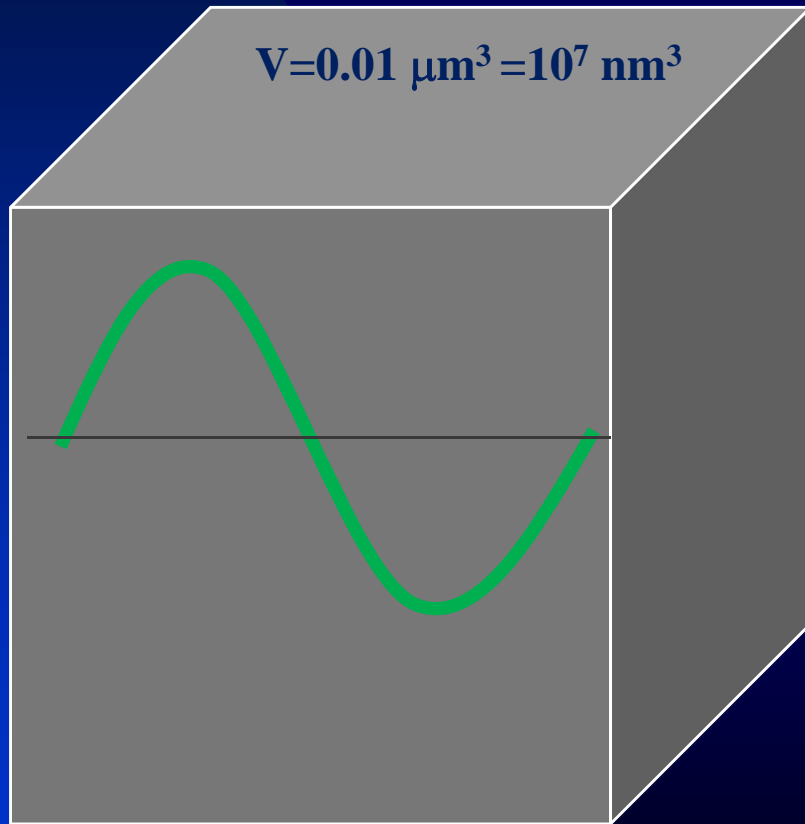
Optical properties of finely divided metals (M. Faraday)



Extinction = Absorption + Scattering

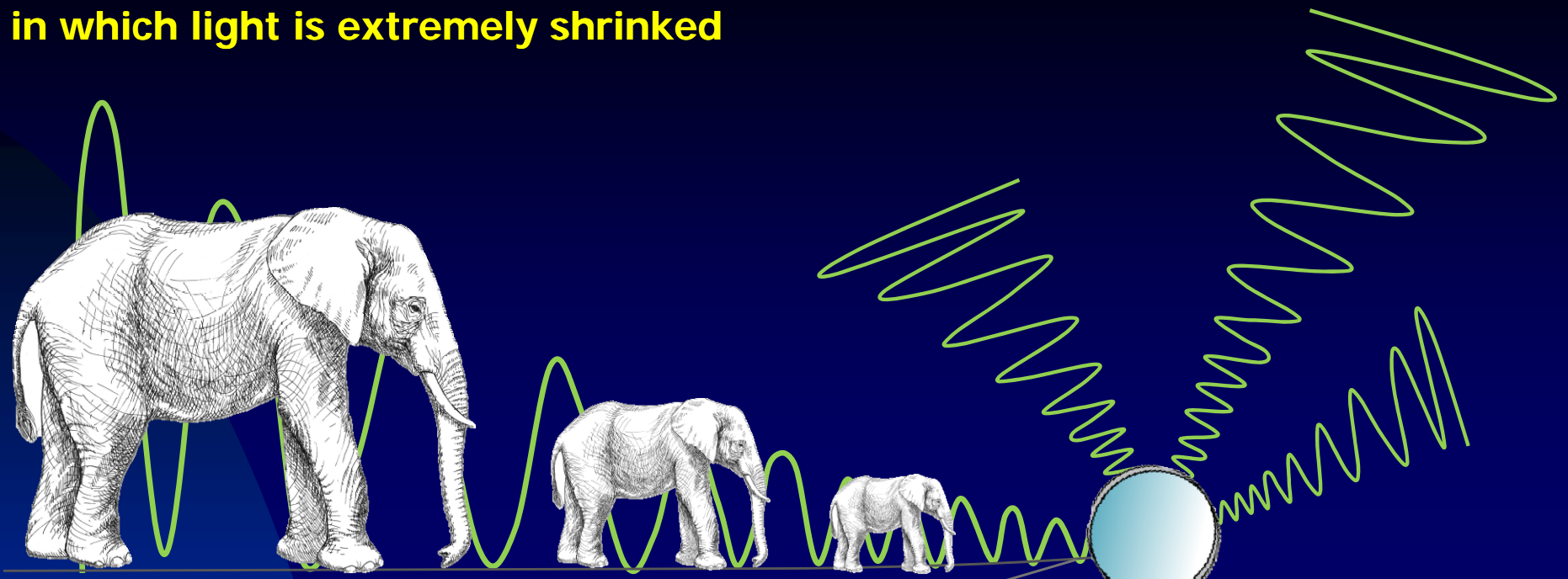


Localized Surface Plasmon Resonance: Confinement of light into a reduced volume

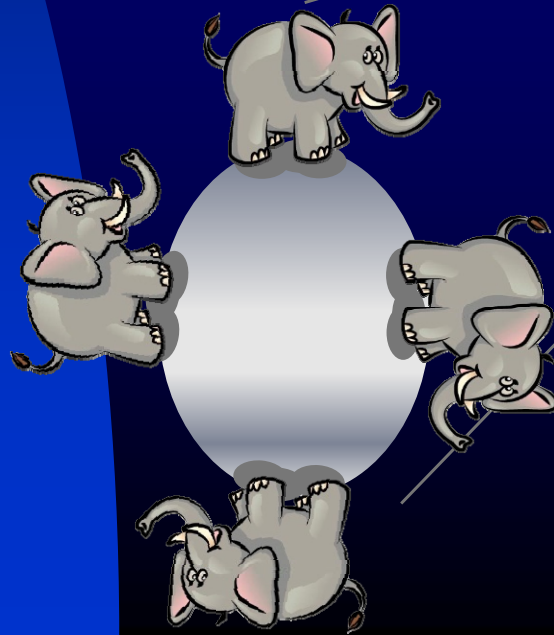


**Seven orders of
magnitude tighter!!**

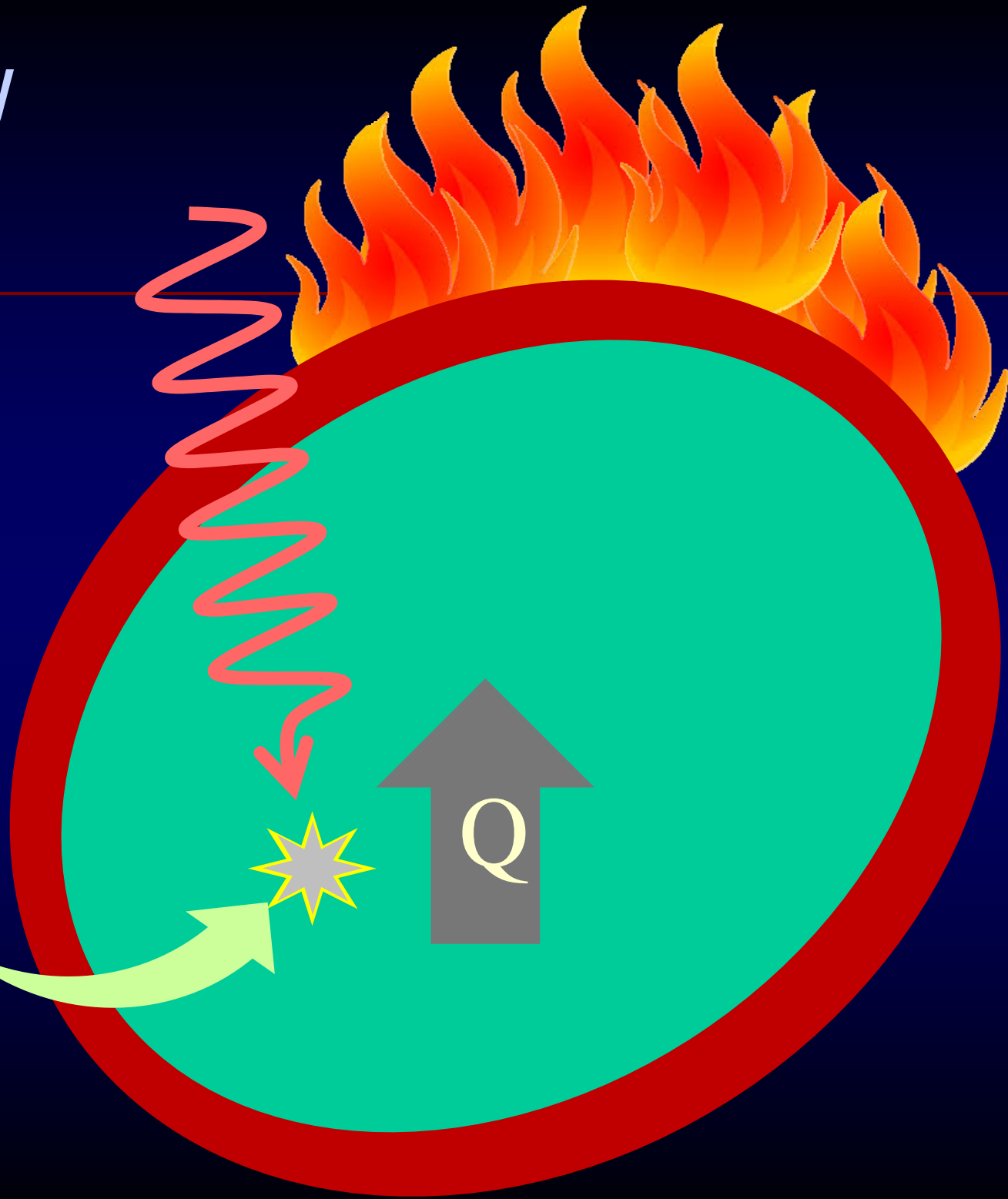
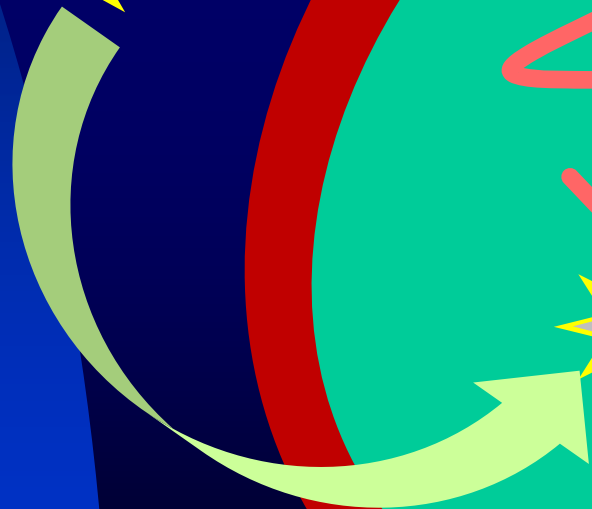
Nanoplasmonics: An incredible travel to the nanoworld in which light is extremely shrunk



Domestication of light!



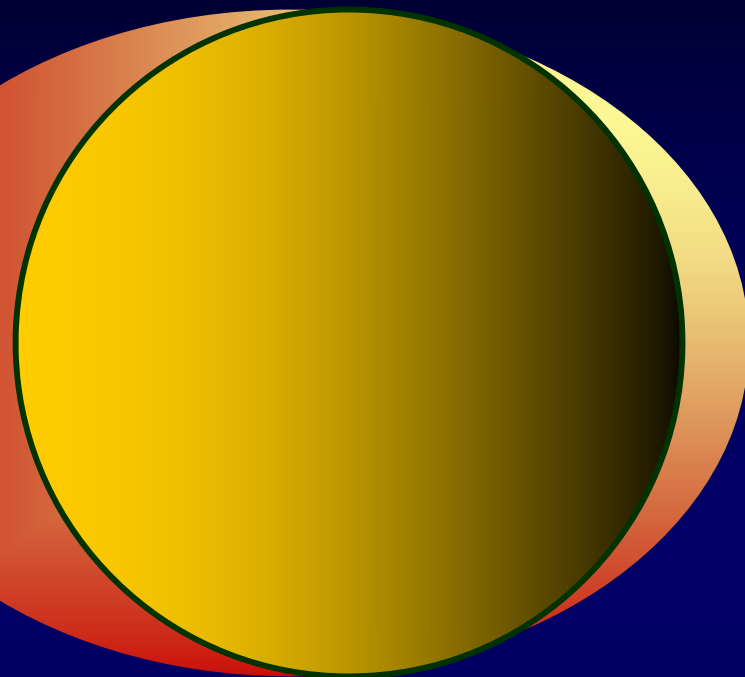
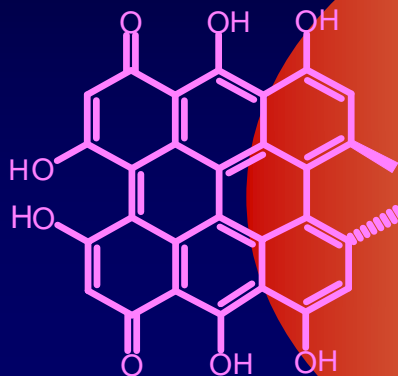
Thermotherapy



Spectroscopy on Metal Nanoparticles:

Molecule in the presence of Nanostructured Metals with LSPR

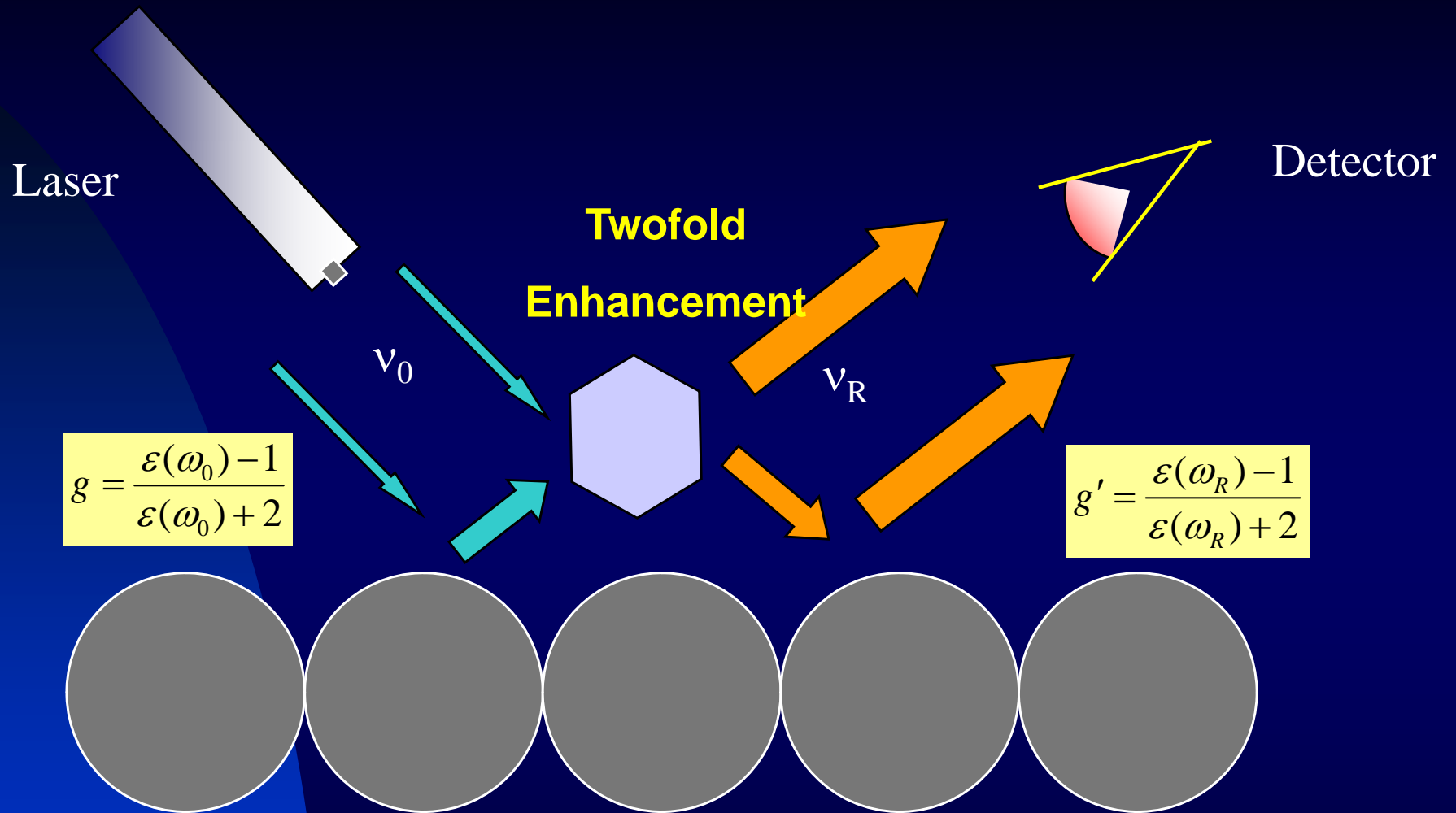
Laser beam



➤ Spectroscopic Applications:

- ❖ SERS (Surface-enhanced Raman Scattering)
- ❖ SEIRA (Surface-enhanced IR Absorption)
- ❖ SEF (Surface-enhanced Fluorescence) or SMF (Surface-Modified Fluorescence)

Emission Spectroscopy



G, Enhancement

$$G \cong 80 |gg'|^2 \cong 80 g^4 \approx 10^6$$

Important Factor:

$$g = \frac{\varepsilon(\omega) - 1}{\varepsilon(\omega) + 2}$$

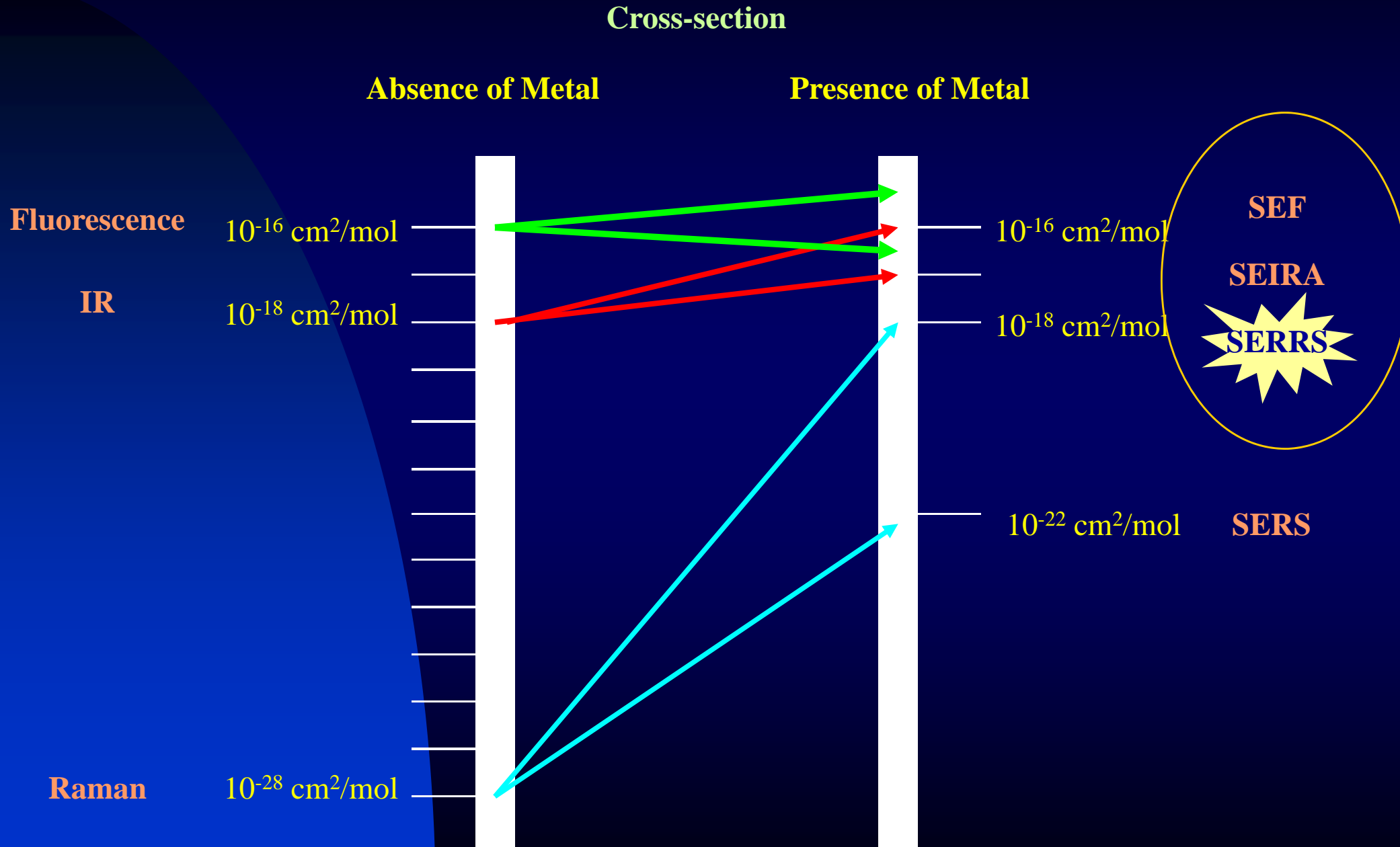
$$\varepsilon(\omega) = \text{Re}[\varepsilon(\omega)] + \text{Im}[\varepsilon(\omega)]i$$

Two main conditions of plasmonic materials:

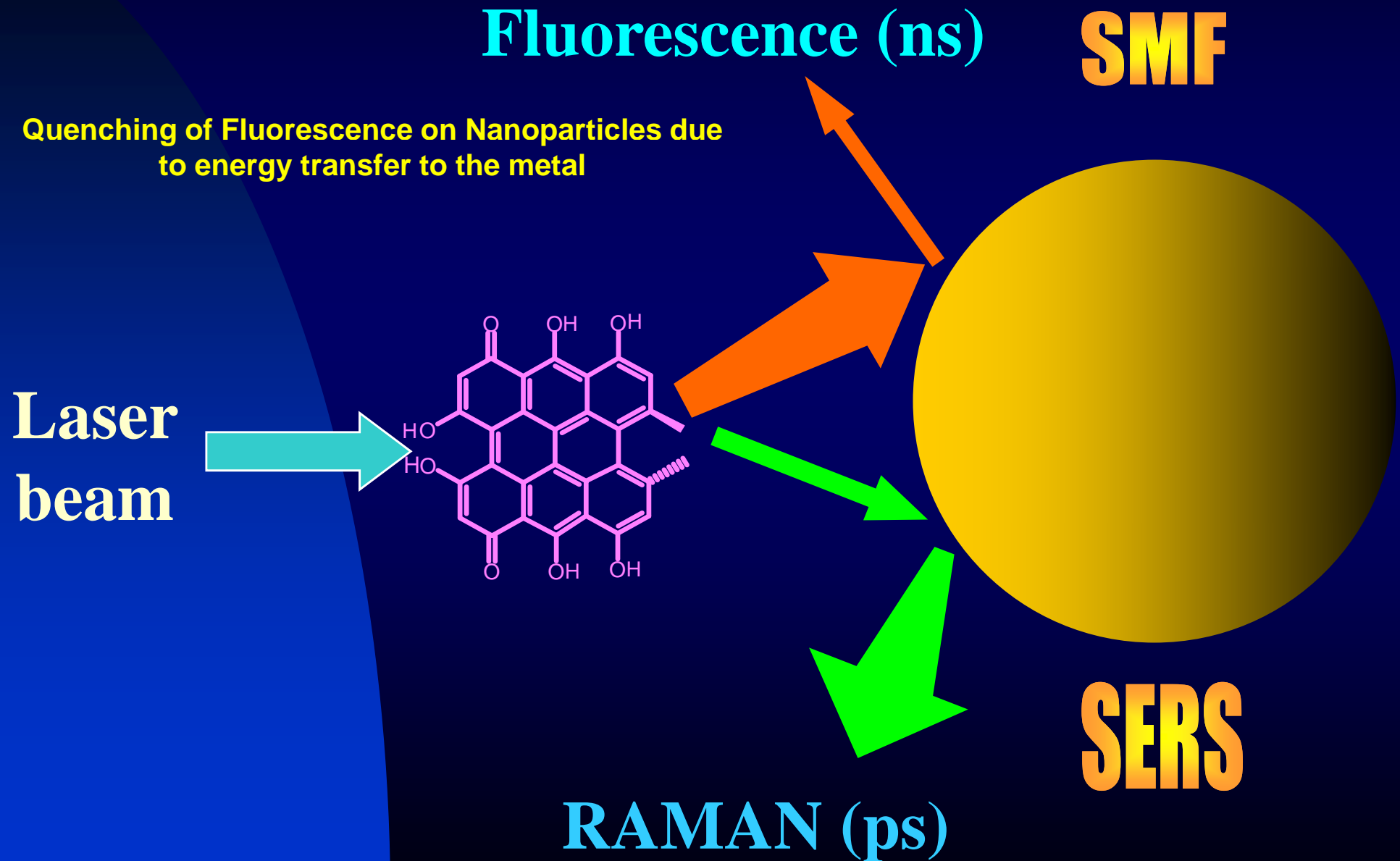
$$\begin{aligned} \text{Re}[\varepsilon(\omega)] \approx -2 &\Rightarrow \text{Plasmon Resonance} \\ \text{Im}[\varepsilon(\omega)] \rightarrow 0 &\Rightarrow \text{Minimum Resistivity} \end{aligned}$$

Metals which fulfill these conditions: Ag, Au, Cu

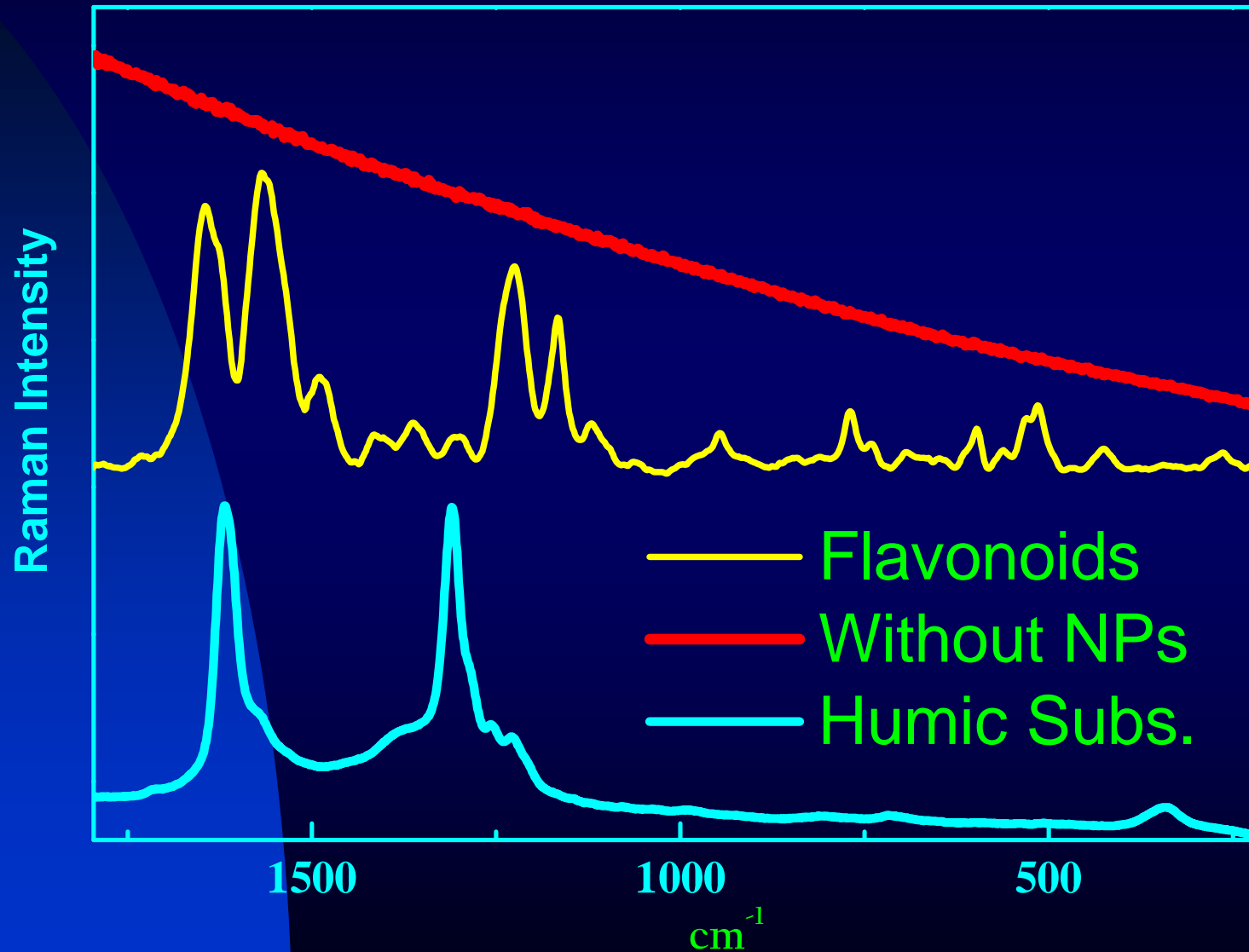
Spectroscopic signal gain



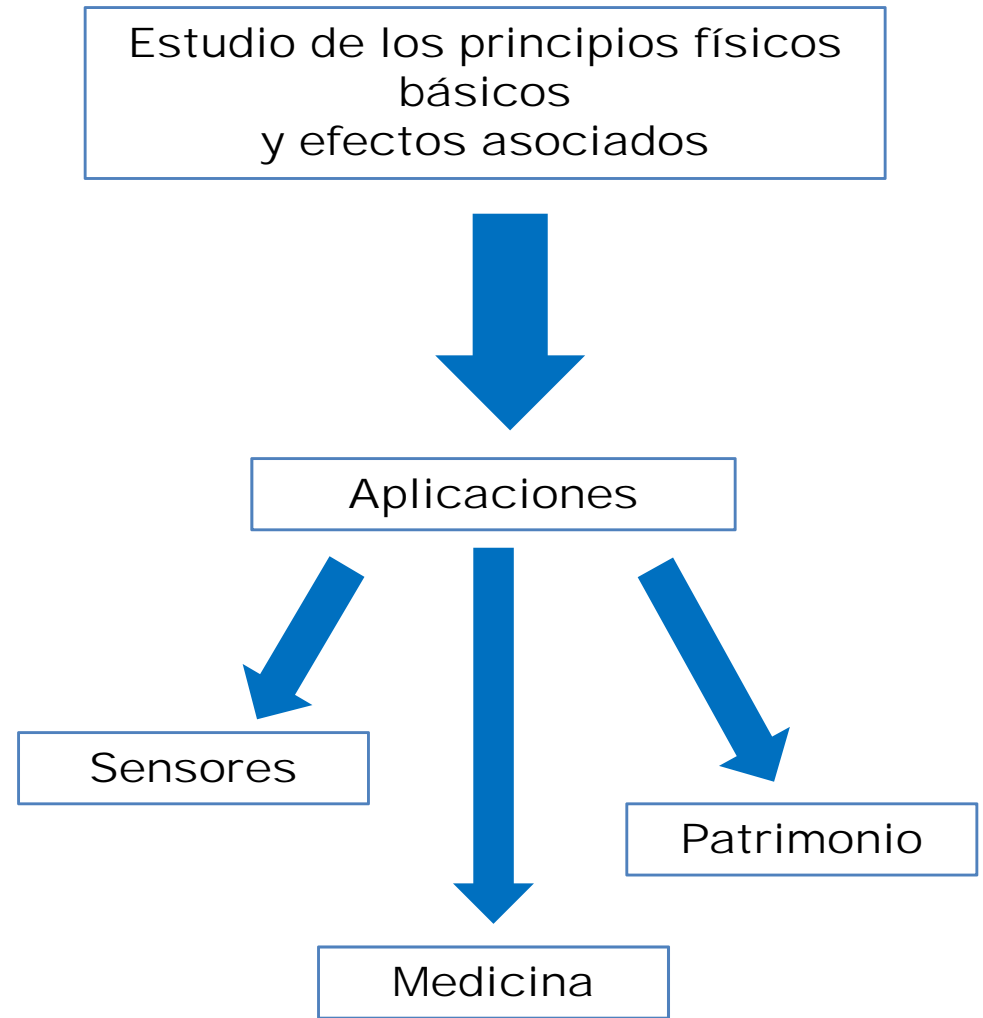
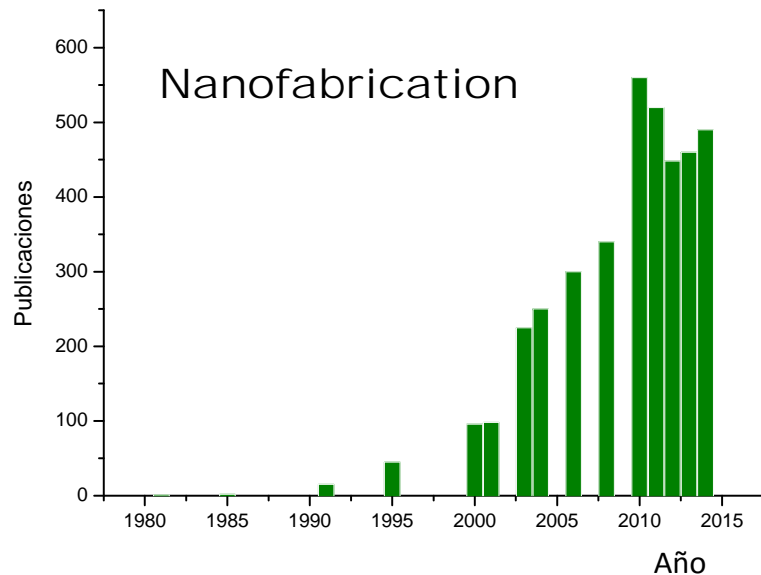
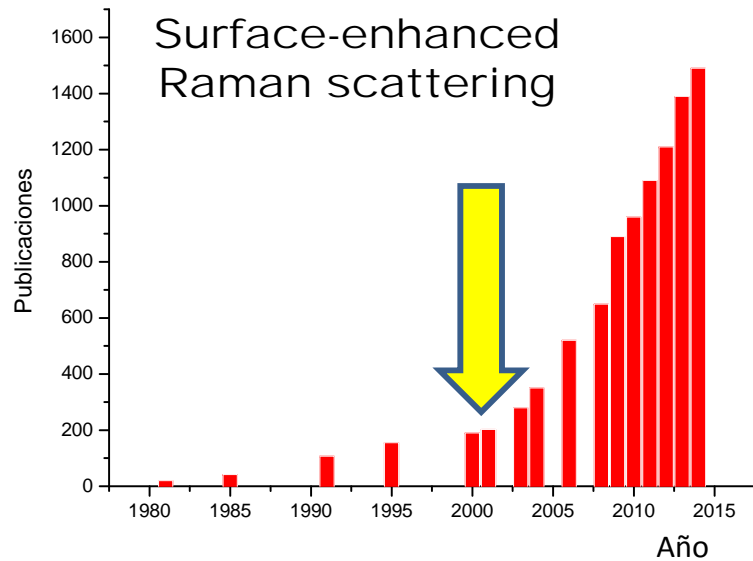
Emission Spectroscopy on Nanoparticles



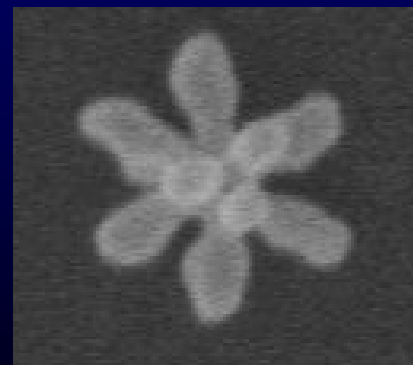
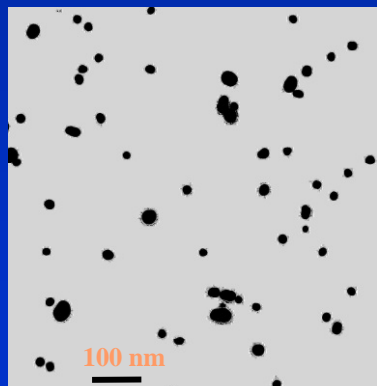
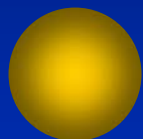
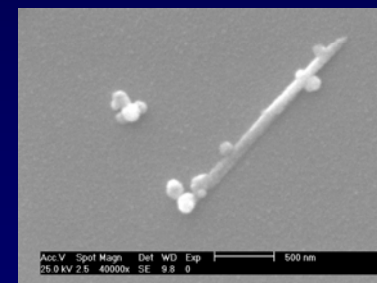
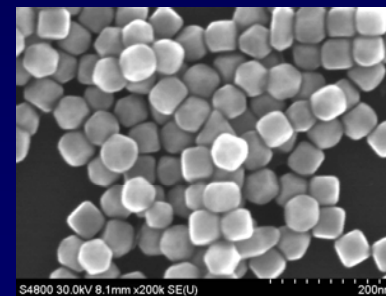
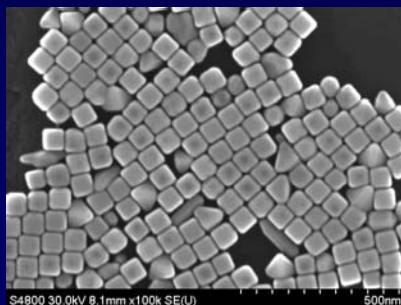
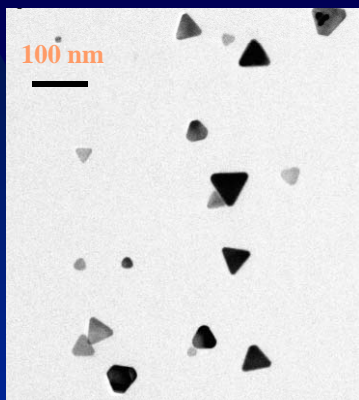
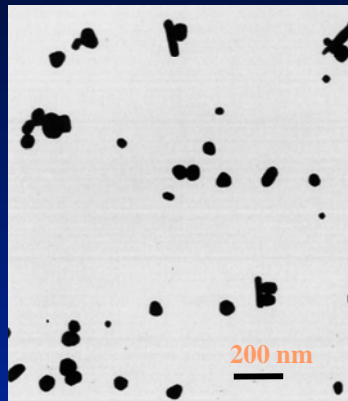
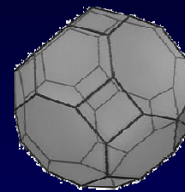
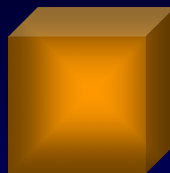
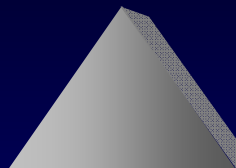
SERS: Intensity Enhancement and quenching of fluorescence



Publicaciones en el campo en los últimos 20 años y tendencias

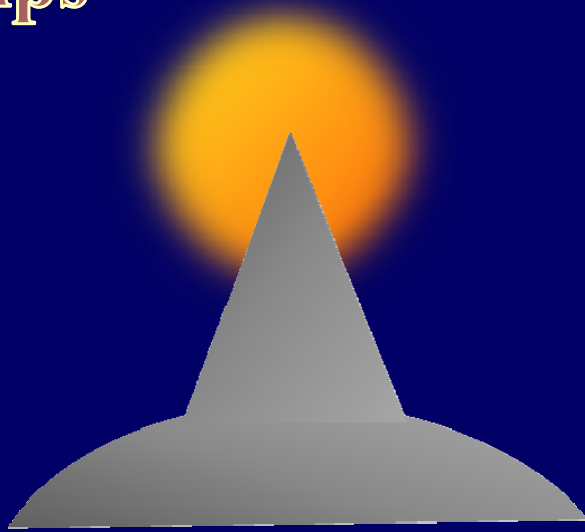


Tailoring the nanoparticle morphology

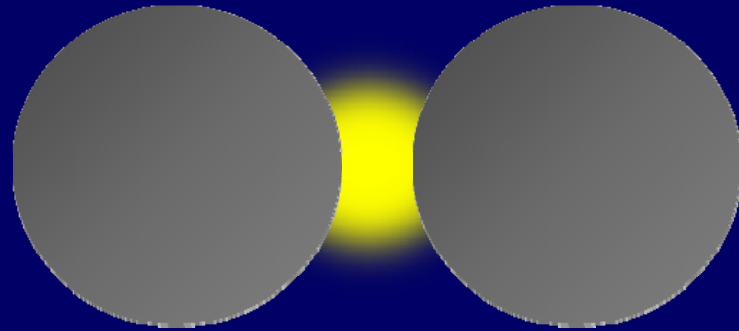


Hot Spots

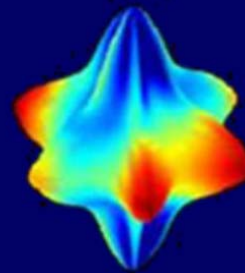
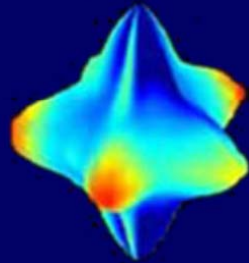
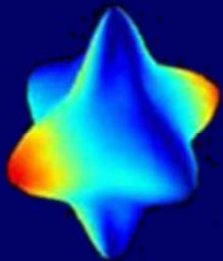
Tips



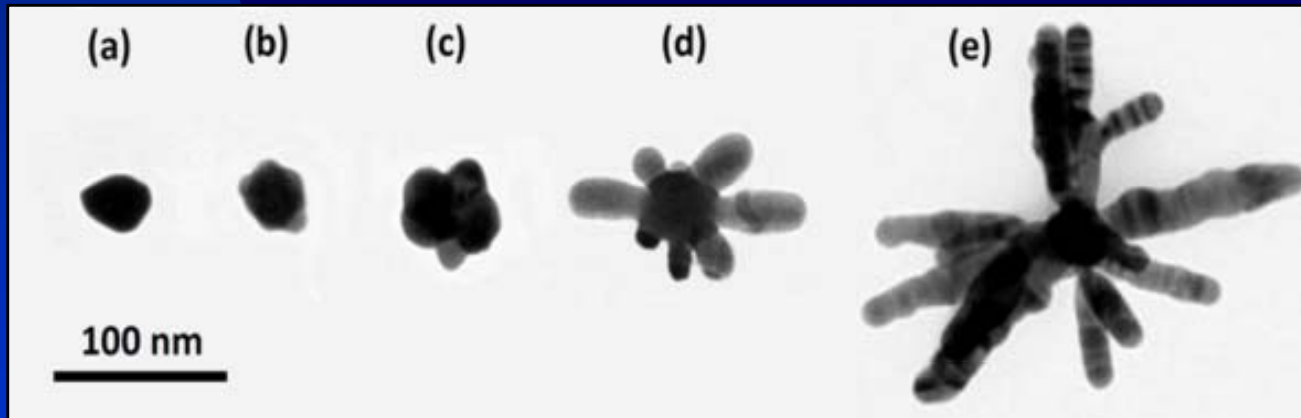
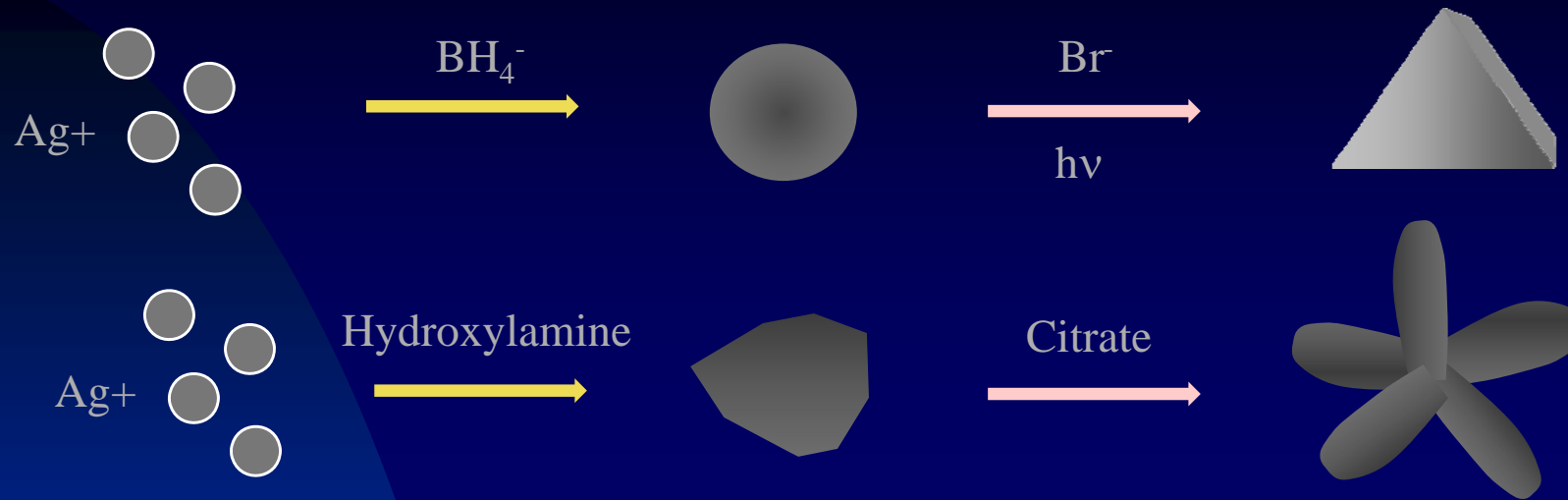
Gaps



Acoplamiento plasmónico



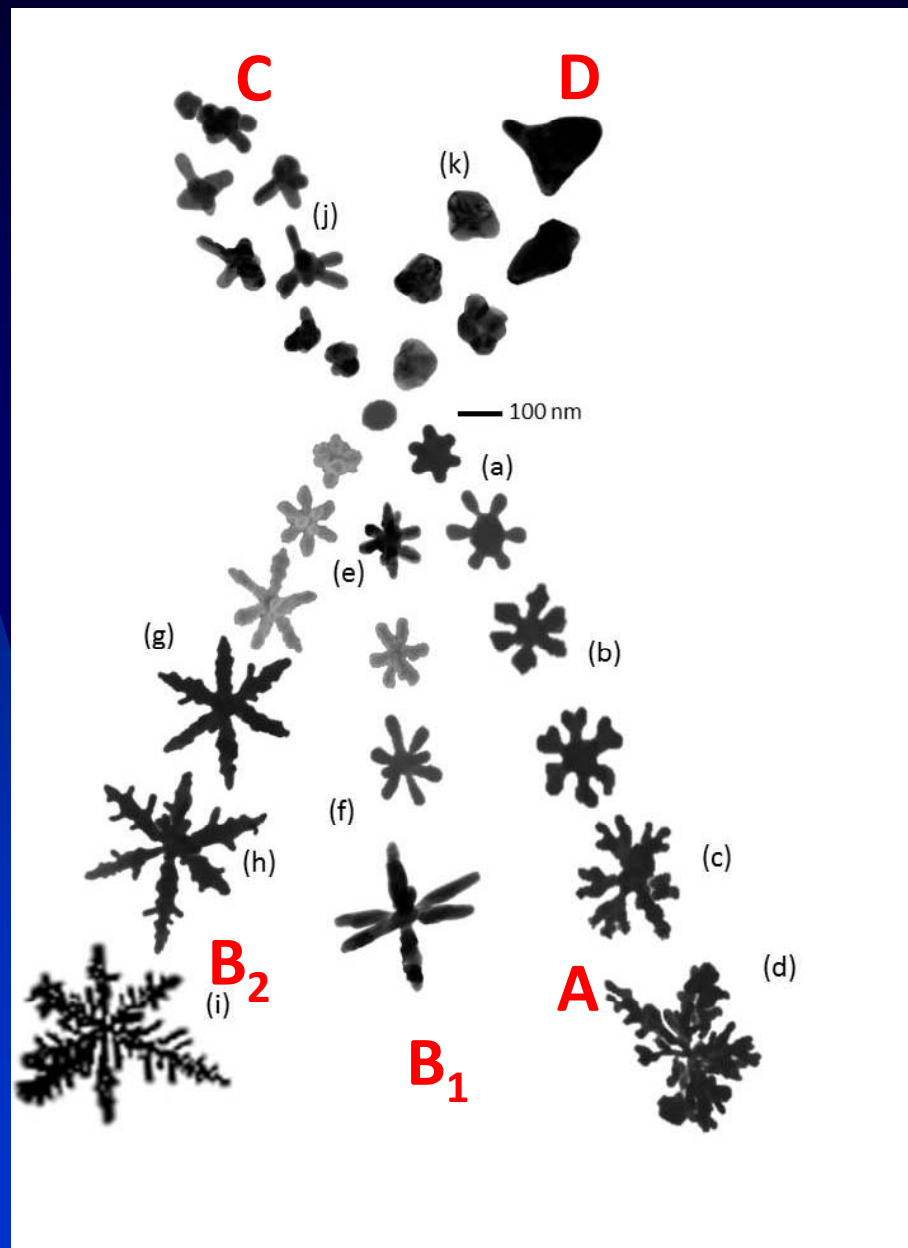
Anisotropic NPs: Two step growing



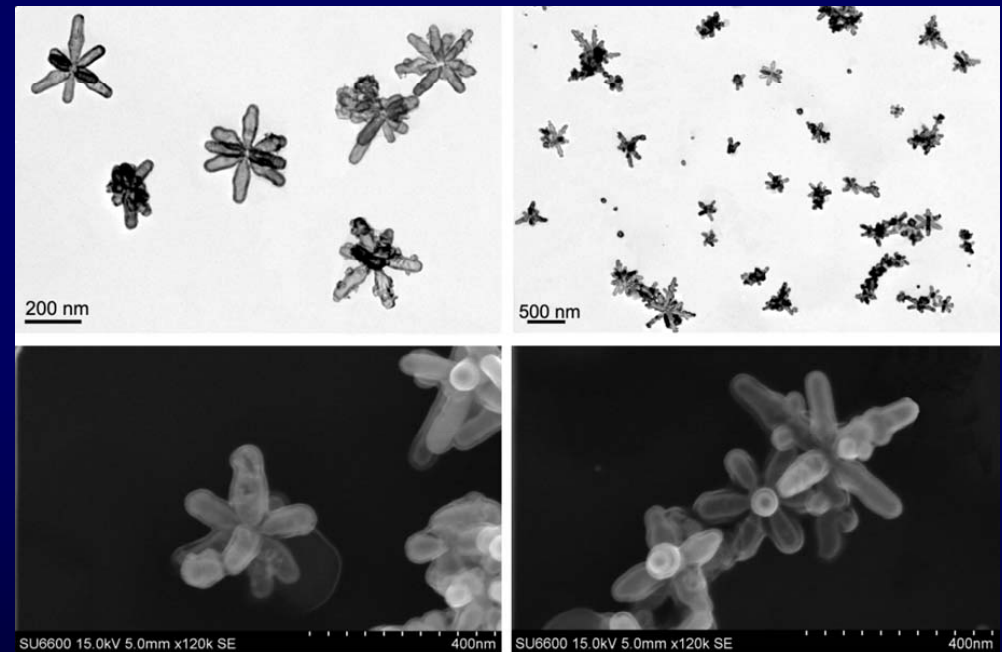
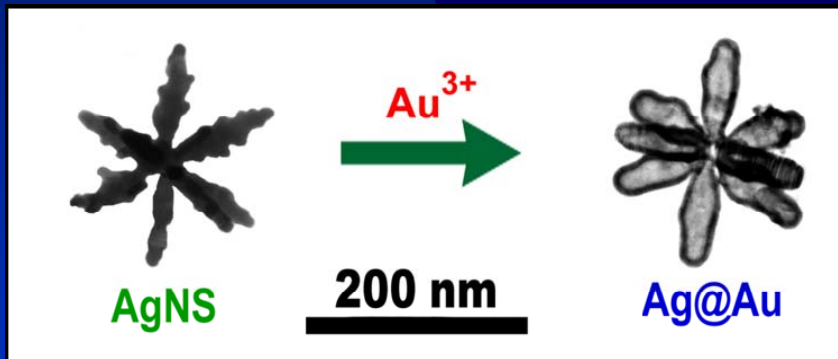
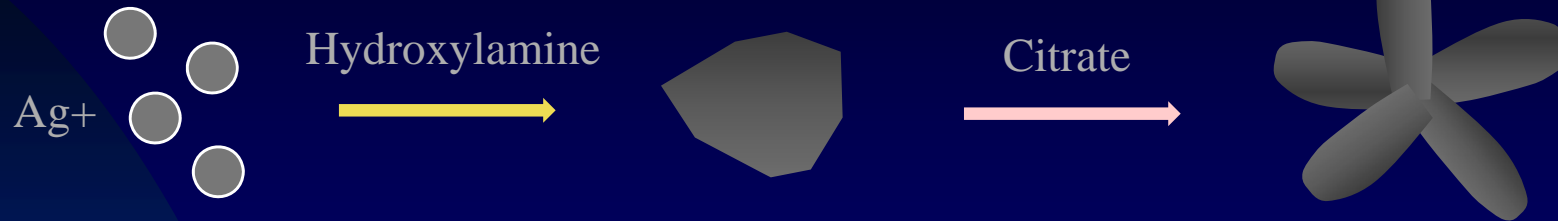
Izquierdo-Lorenzo et al *Langmuir* 28, 8891 (2012)

Garcia-Leis et al. *J. Phys. Chem. C* 117, 7791 (2013)

Growth Paths

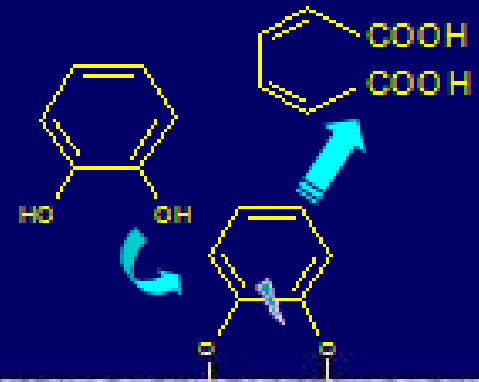
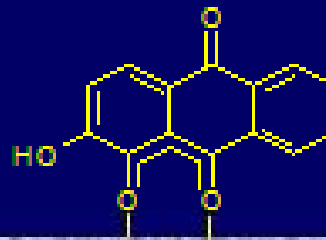
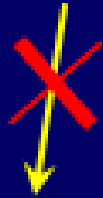
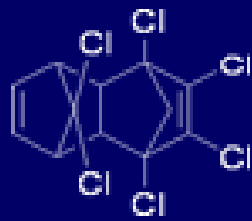
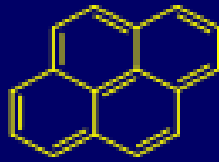


Core@Shell Nanostars



Funcionalización de nanopartículas plasmónicas

Efecto de campo cercano: Adsorción molecular sobre interfases

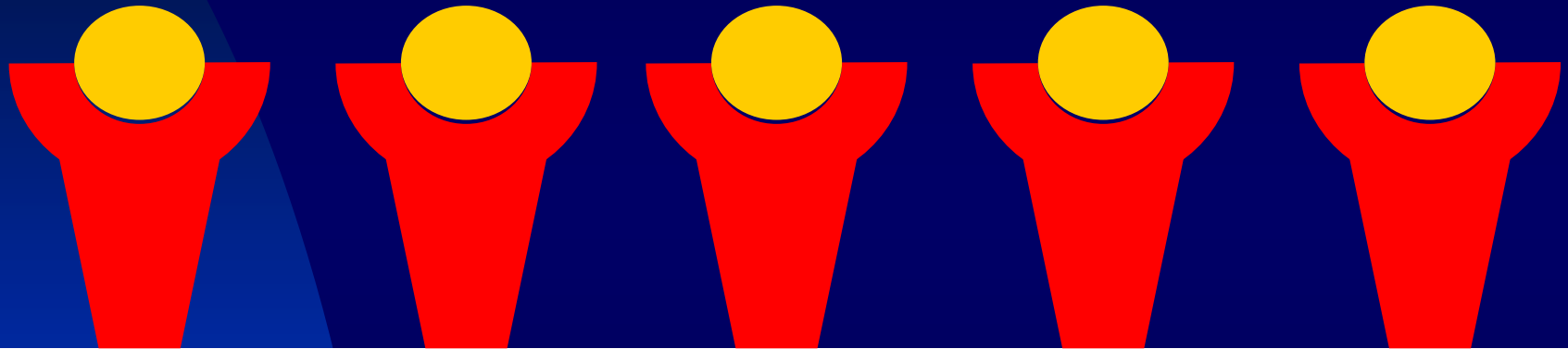


**A) Adsorción
imposible**

**B) Fisisorción o
quimisorción**

C) Catálisis

Funcionalización

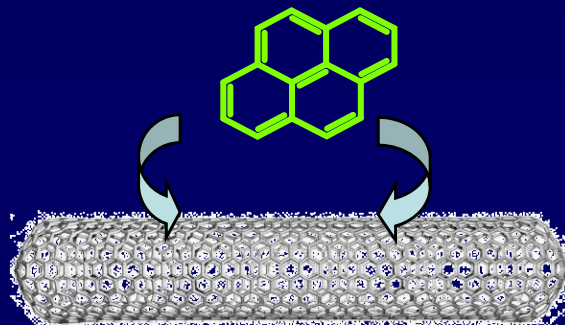


Funcionalización

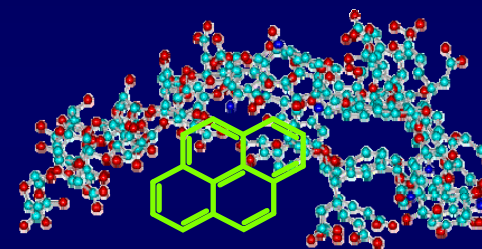
Inclusion



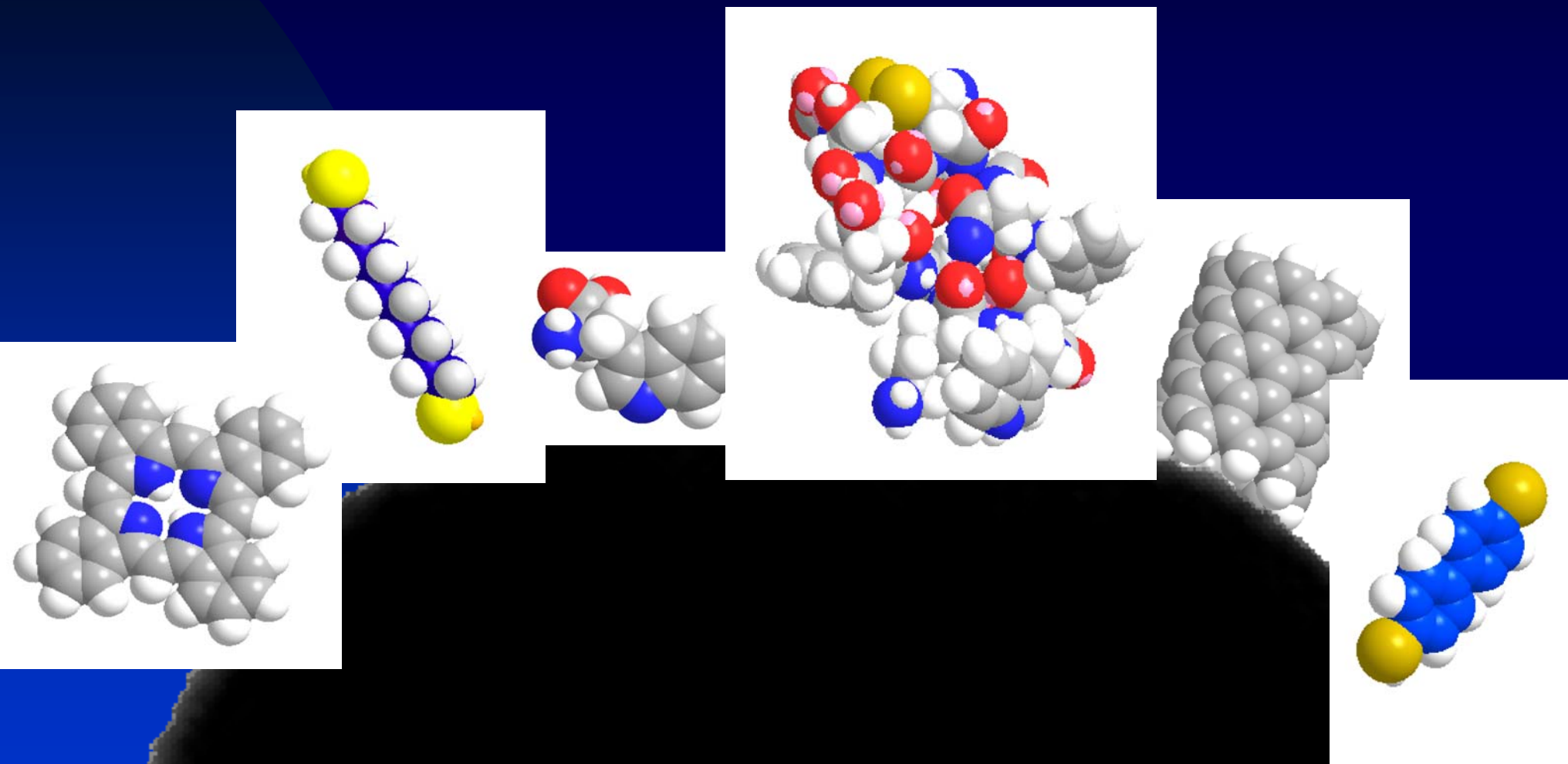
Contact



Occlusion

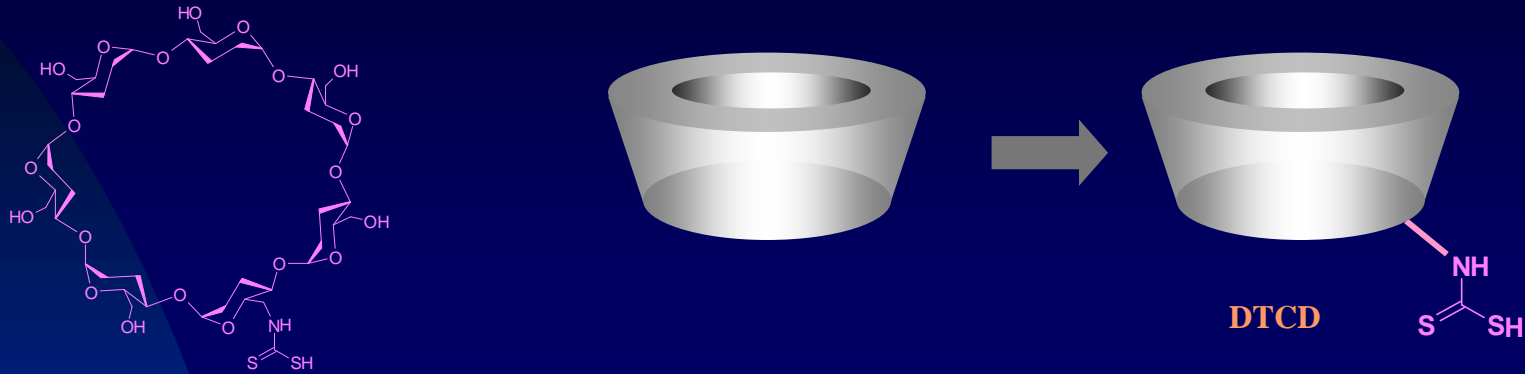


Nanoparticle Functionalization

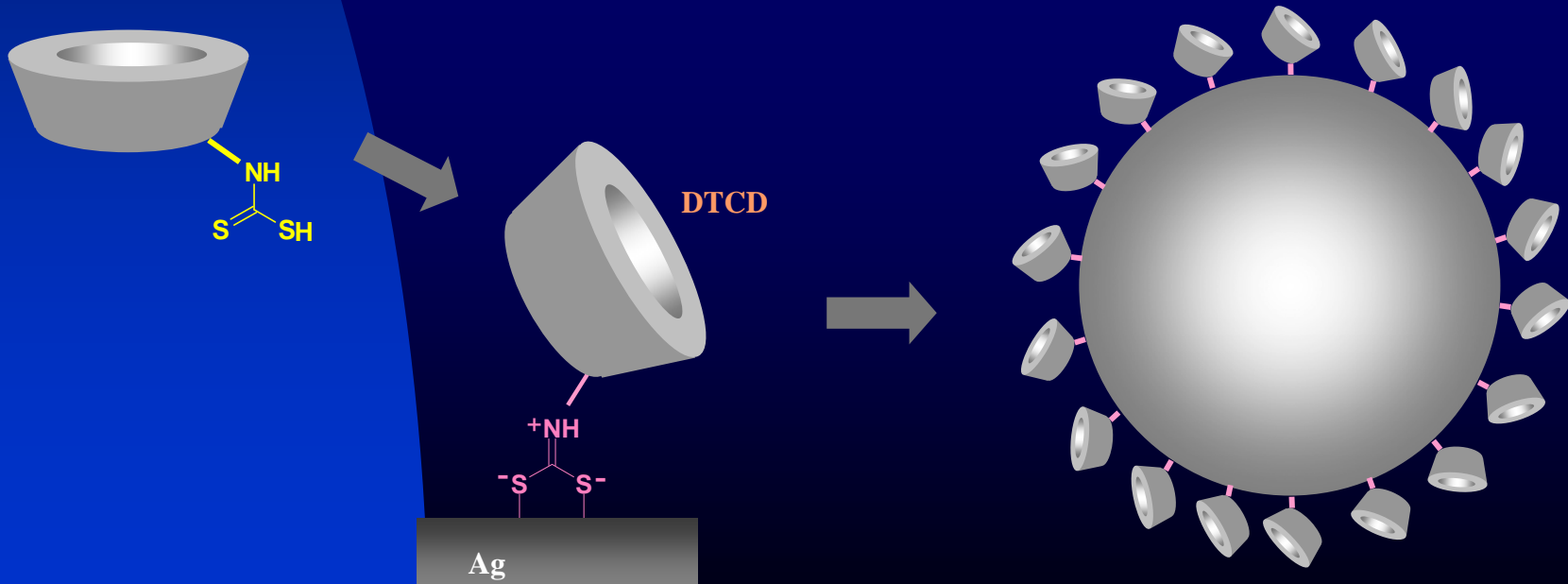


Surface Functionalization with Cyclodextrines

A) DTC derivatized Cyclodextrins

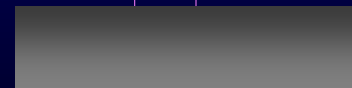
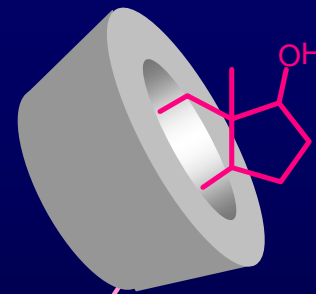
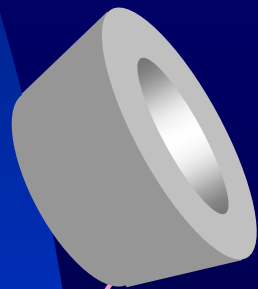
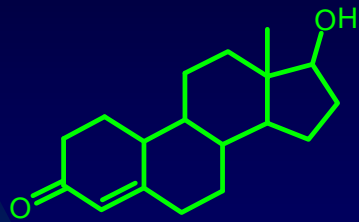


B) Functionalization of Ag NPs with DTC-D

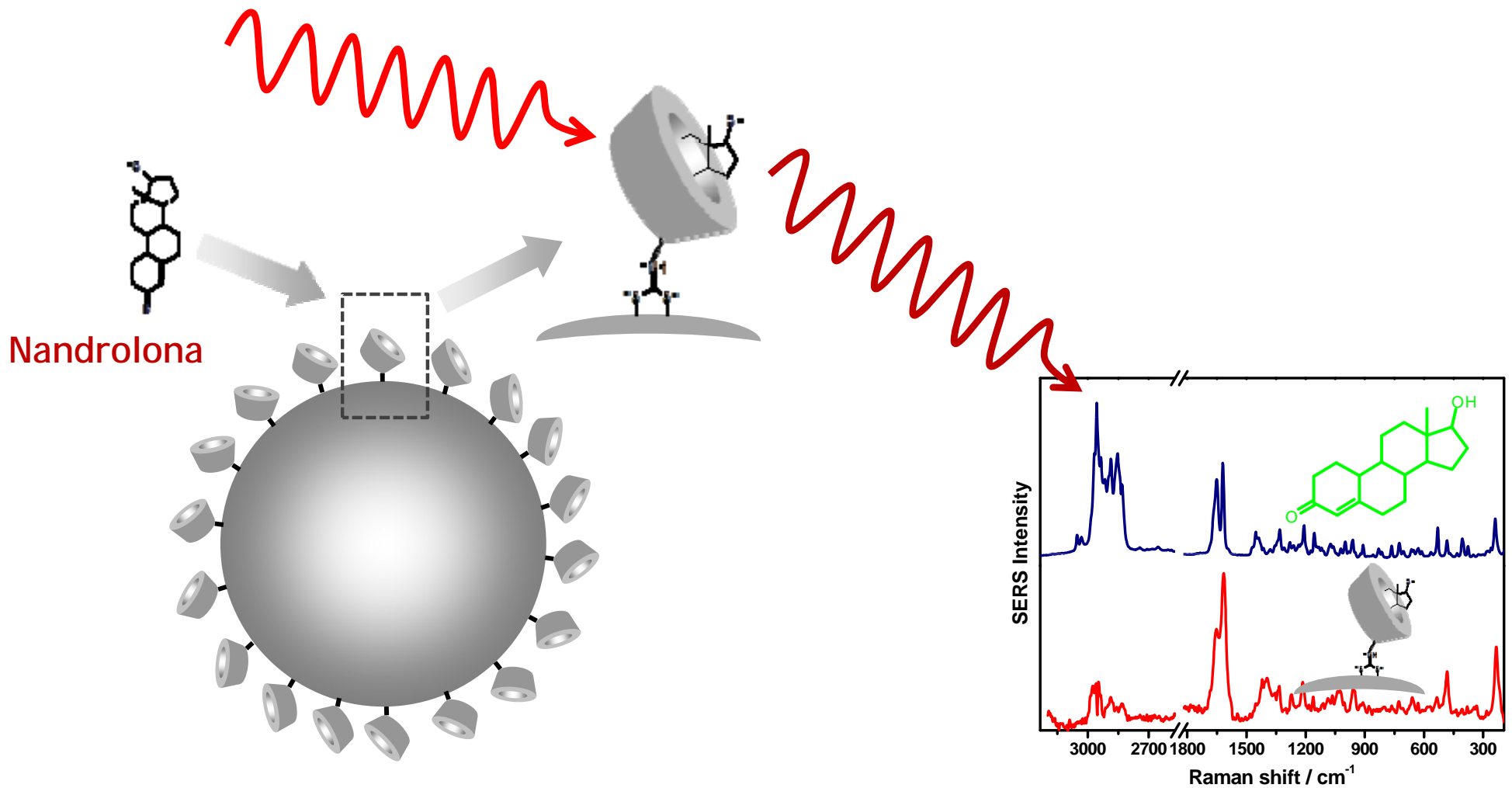


Encapsulation with DTCD

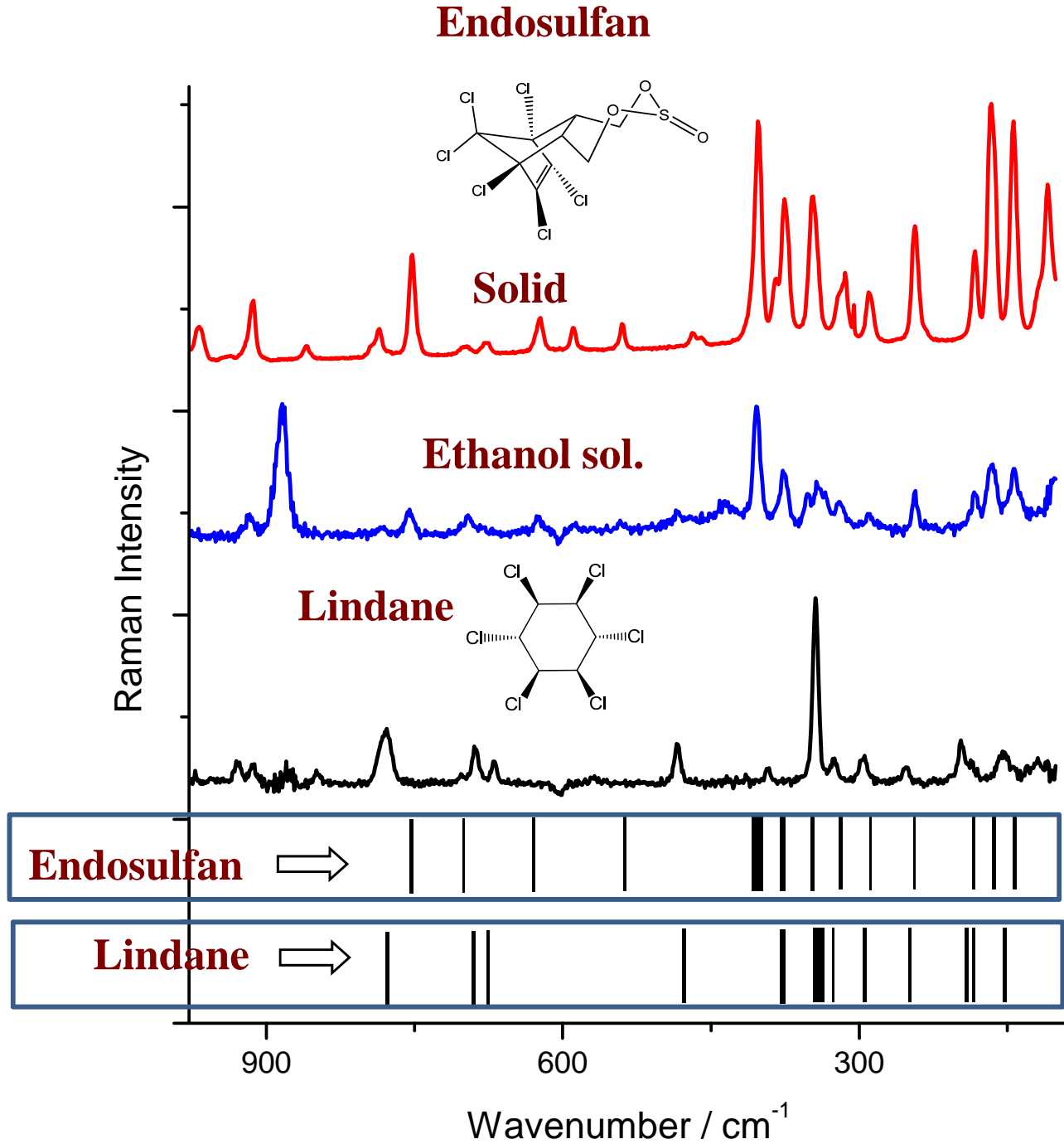
Encapsulation of Nandrolone



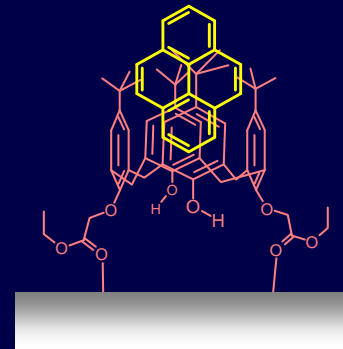
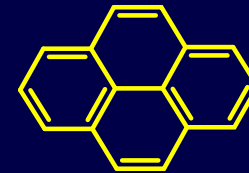
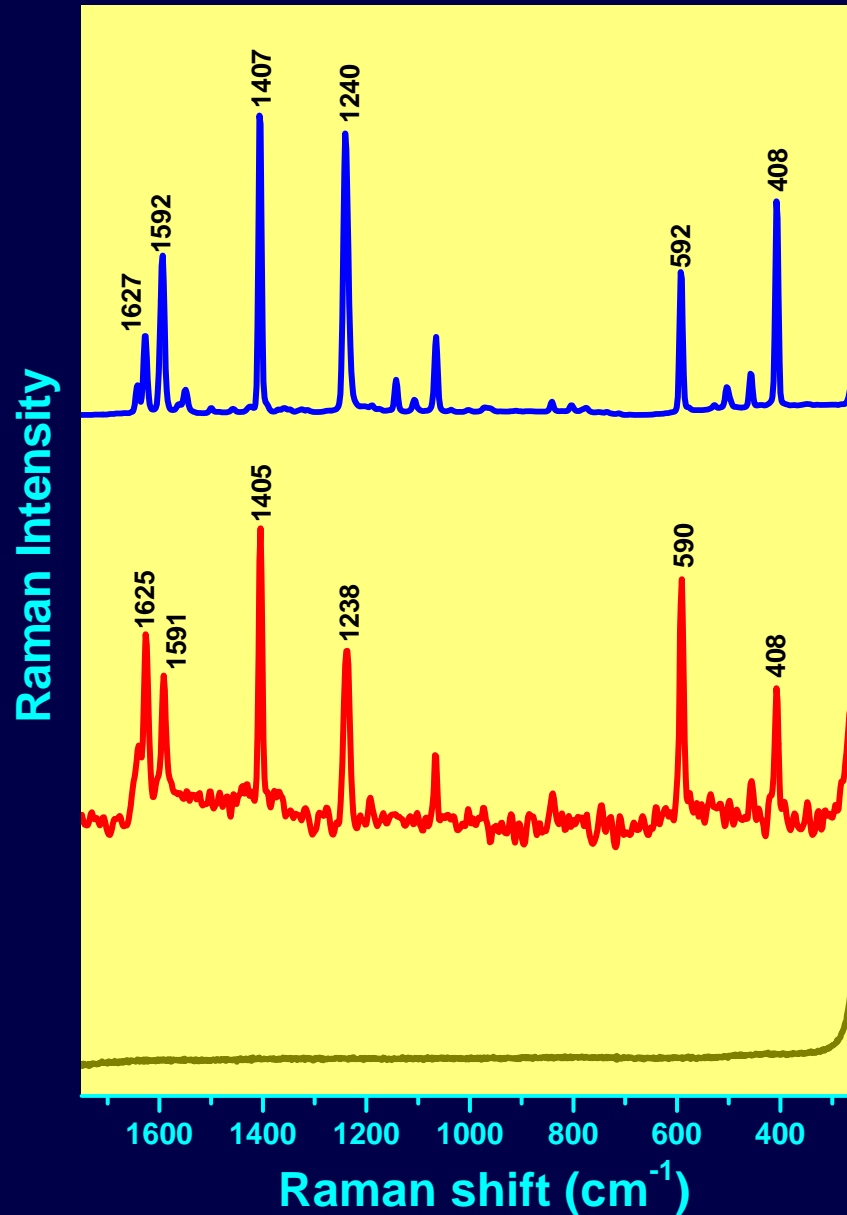
NANOPARTÍCULAS DE PLATA FUNCIONALIZADAS CON DITIOCARBAMATO DE CICLODEXTRINA, Y SU USO EN LA DETECCIÓN ULTRASENSIBLE DE NANDROLONA



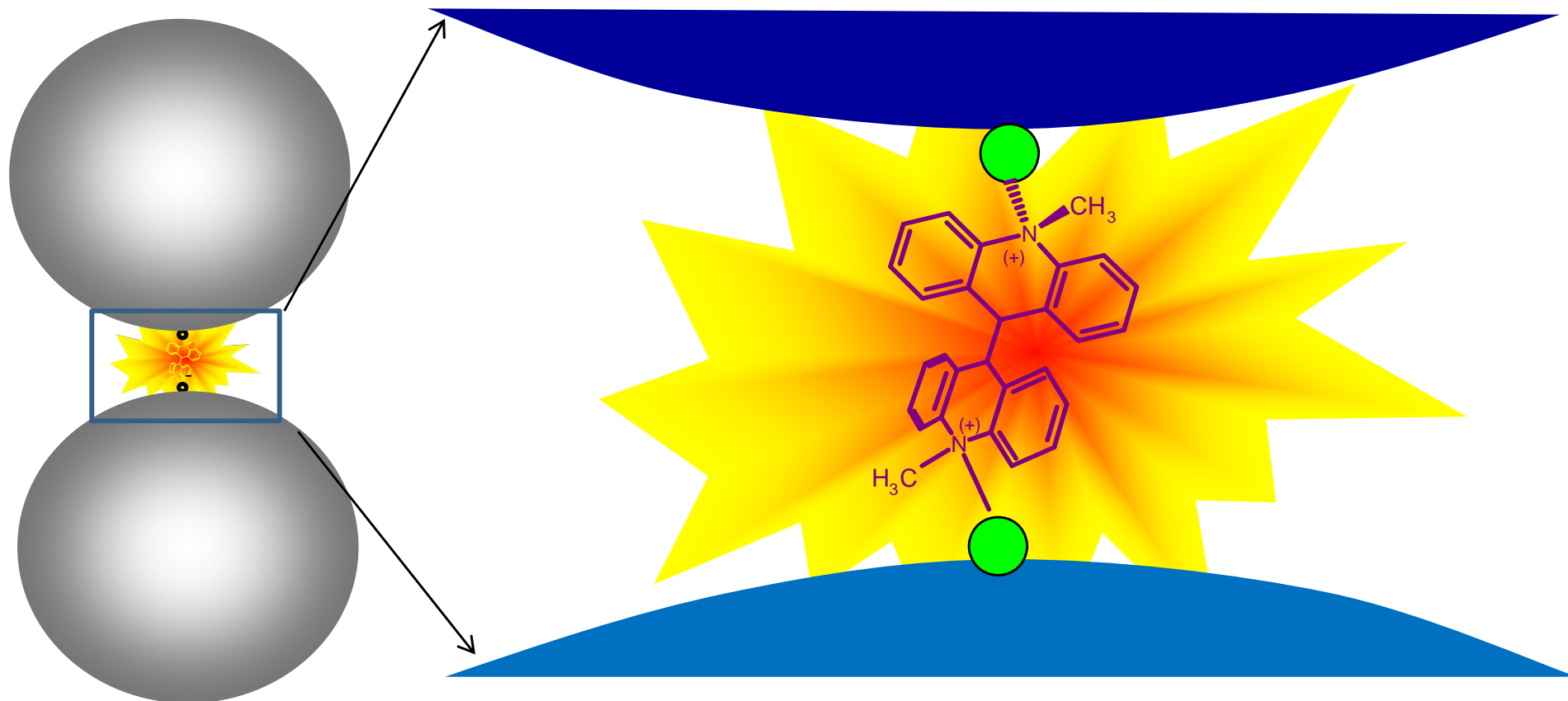
Selective detection of pollutants by Raman



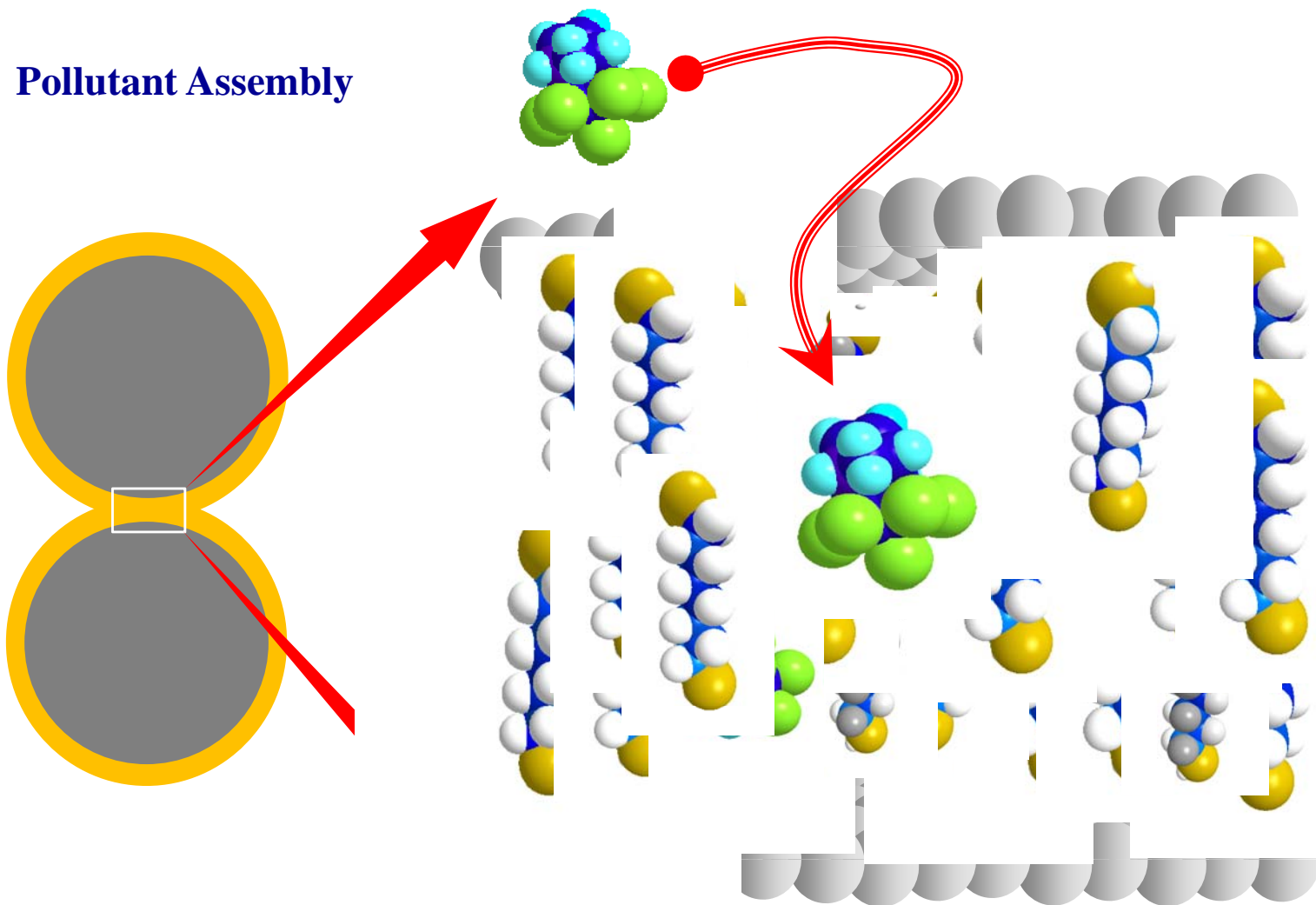
Detección de contaminantes con calixarenos



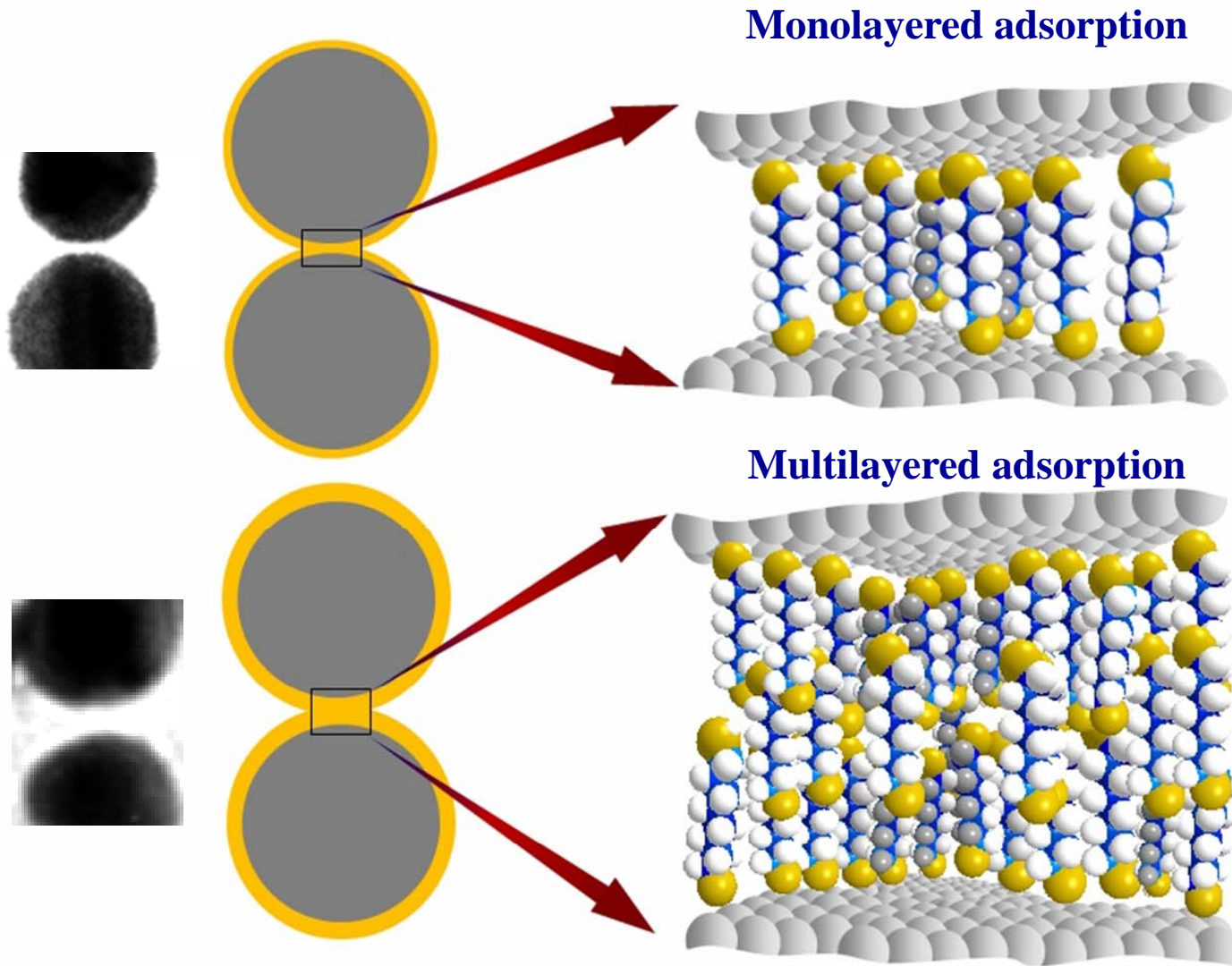
Construcción de espacios interpartícula o *gaps* mediante ensambladores moleculares bifuncionales



Dithiol-Functionalized Interparticle Spaces: Hot Spots + Pollutant Binding Sites

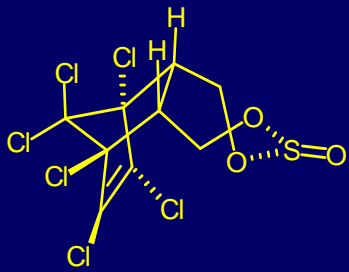


Interparticle Spaces: Hot Spots + Pollutant Binding Sites

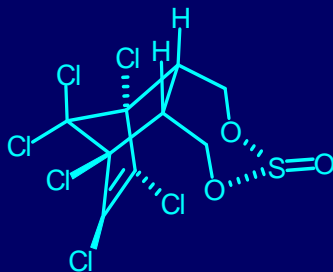


Aliphatic Linear Linkers: Molecular Detection

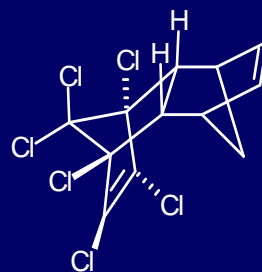
Chlorinated Pesticides Detected in this Work



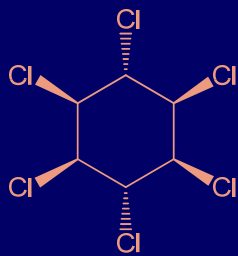
α -Endosulfan



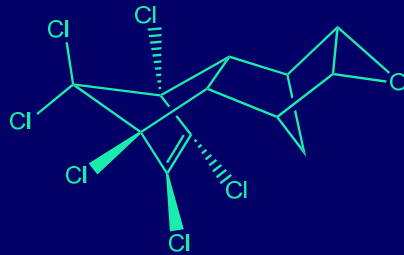
β -Endosulfan



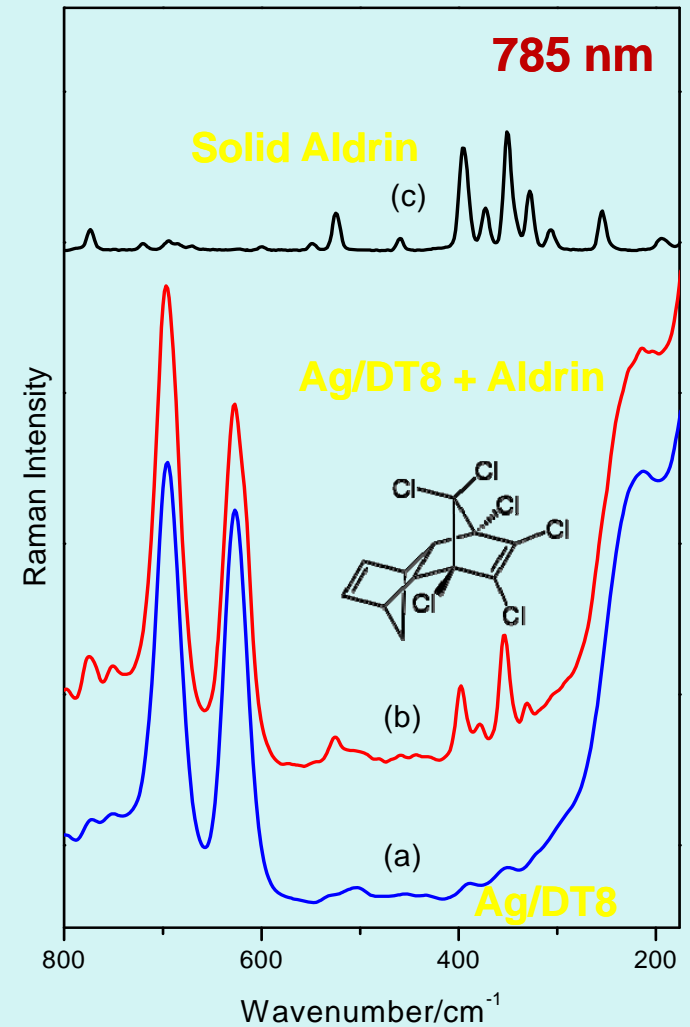
Aldrin



Lindane



Dieldrin



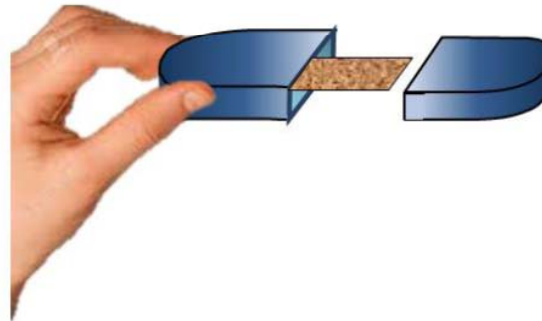
[Aldrin] = 50 μ M [DT8] = 50 μ M

Transferencia de Tecnología

Sensores basados en SERS

NanoScreen

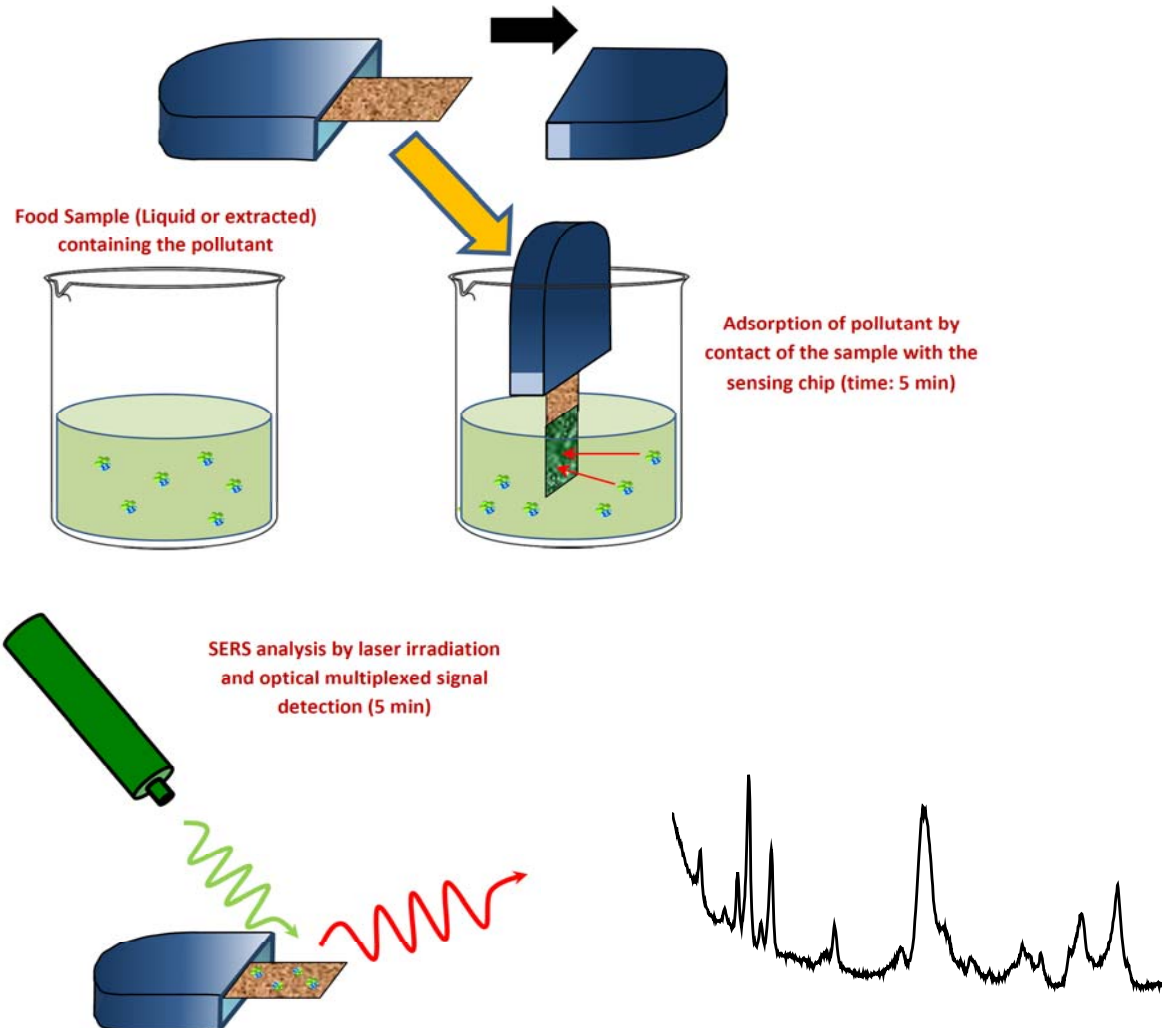
Disruptive portable device for pre-screening of Persistent Organic Pollutants –POPs- in food products and water



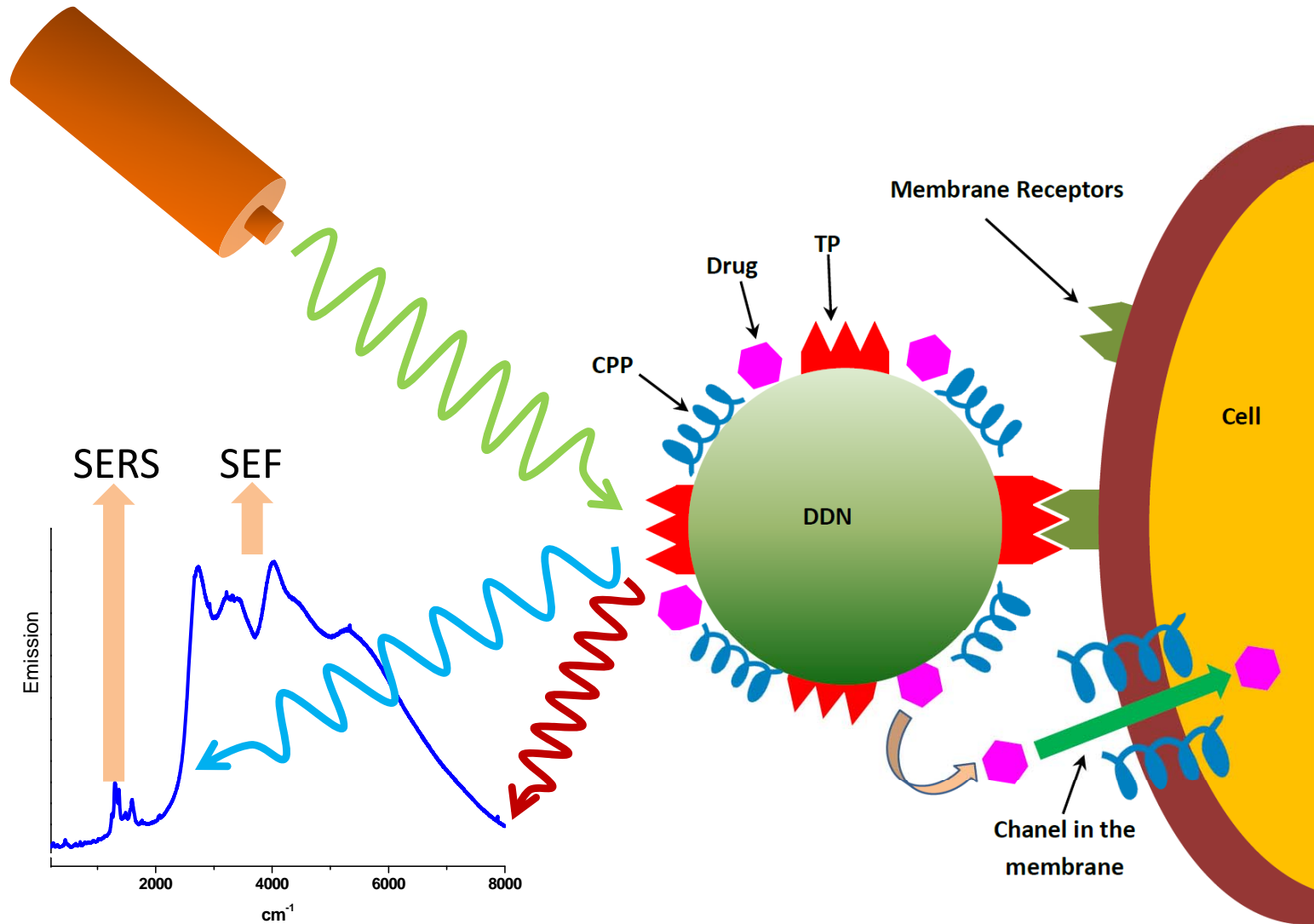
SFS-08-2015: Resource-efficient eco-innovative food production and processing

Sensores basados en SERS: SME Instrument project

Analysis of sample with NanoScreen Prototype

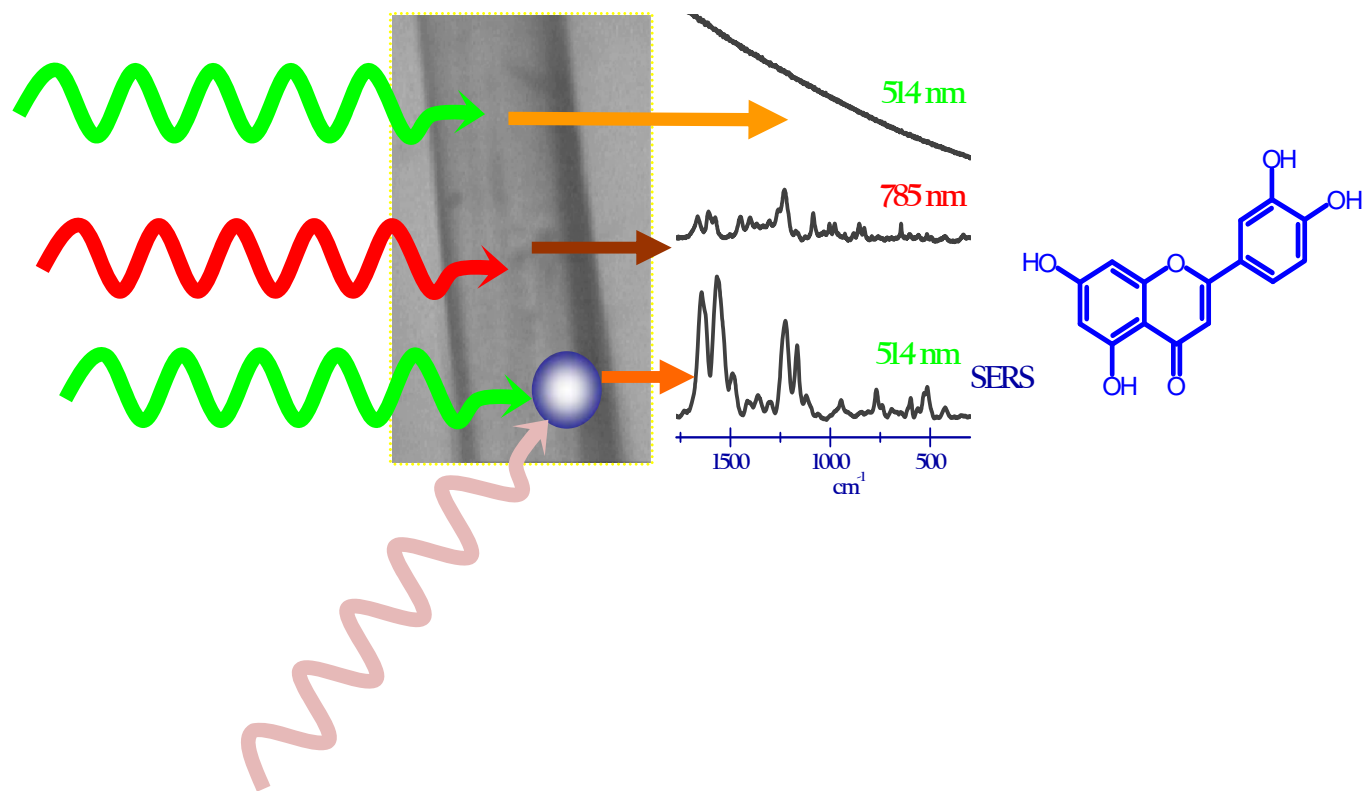


Biofuncionalización: Teranóstica

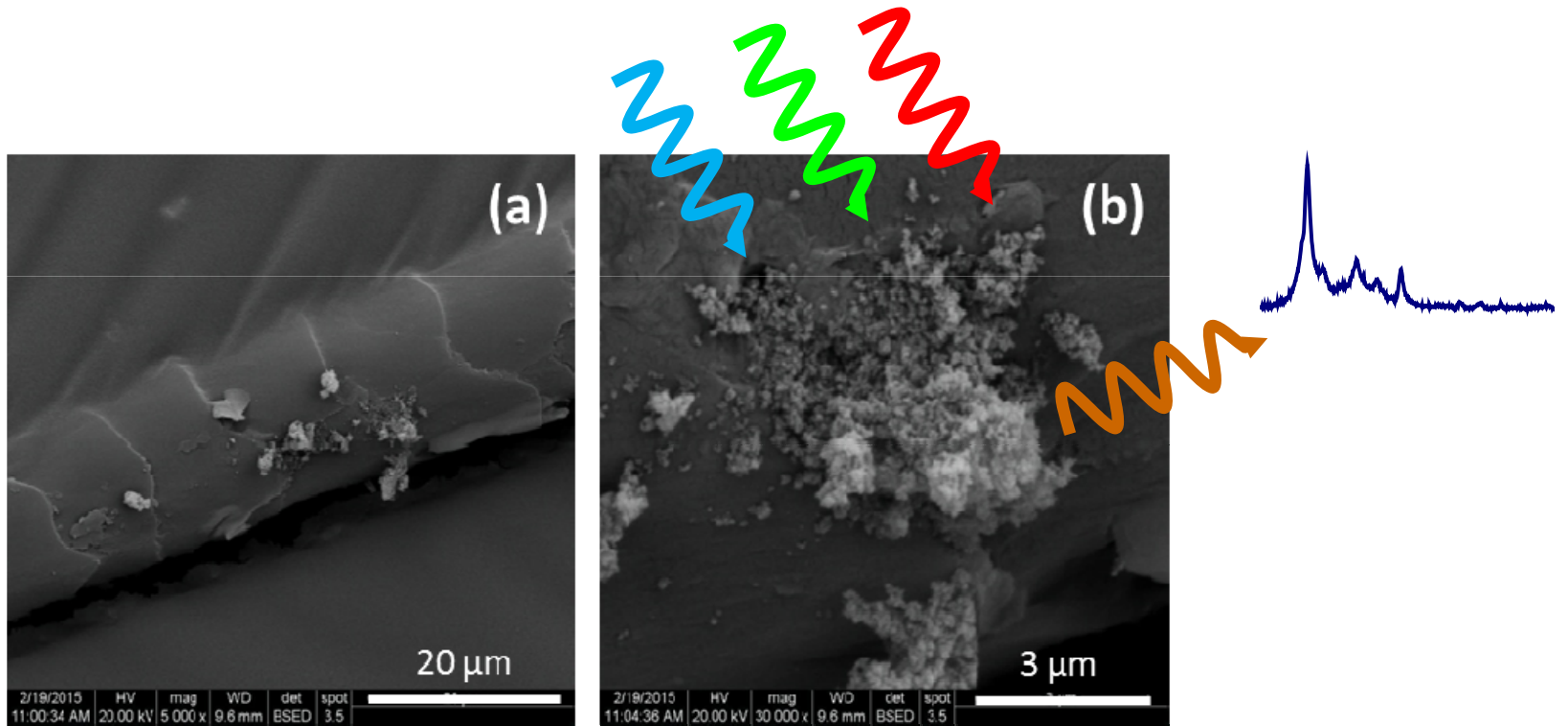


Aplicaciones en el Patrimonio

Análisis diferencial de tejidos históricos mediante SERS



Nanopartículas de plata inducidas sobre fibras de tejidos



Posibilidades de Trabajo e Internacionalización

- a) Proyectos de colaboración e intercambio de investigadores (CSIC, Mineco, MAE)
- b) Proyectos ligados a la Transferencia de Tecnología (UE): **Desarrollo de Nanosensores**
- c) Proyecto Marie Skłodowska Curie (MSC) **European Training Network in Interdisciplinary Biosciences**

