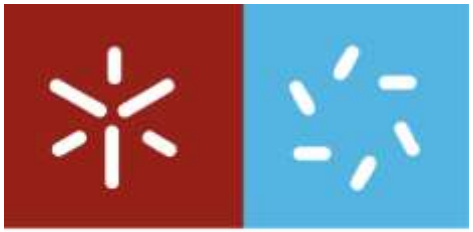
Ciência 2016

(Bio)nanosystems based on quantum dots, plasmonic or magnetic nanoparticles



Universidade do Minho

Paulo J. G. Coutinho

Departamento/Centro de Física

Escola de Ciências

Universidade do Minho

4 Julho 2016

OVERVIEW

Molecular engineering is continuously being enriched by the design and exploration of molecular materials at the **nanometer scale**

Detectable properties

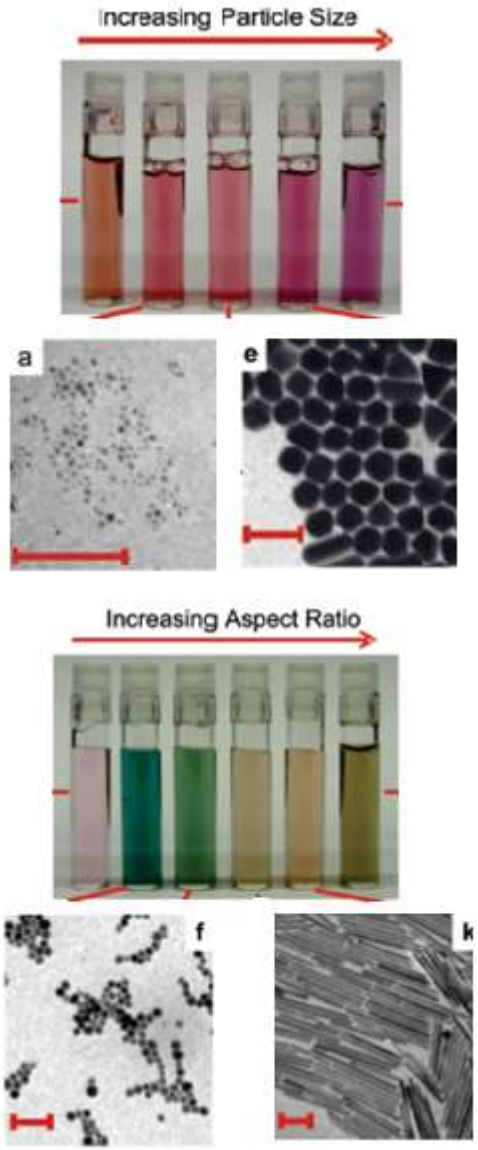
become tunable by simply controlling its **shape and size**

revolution in

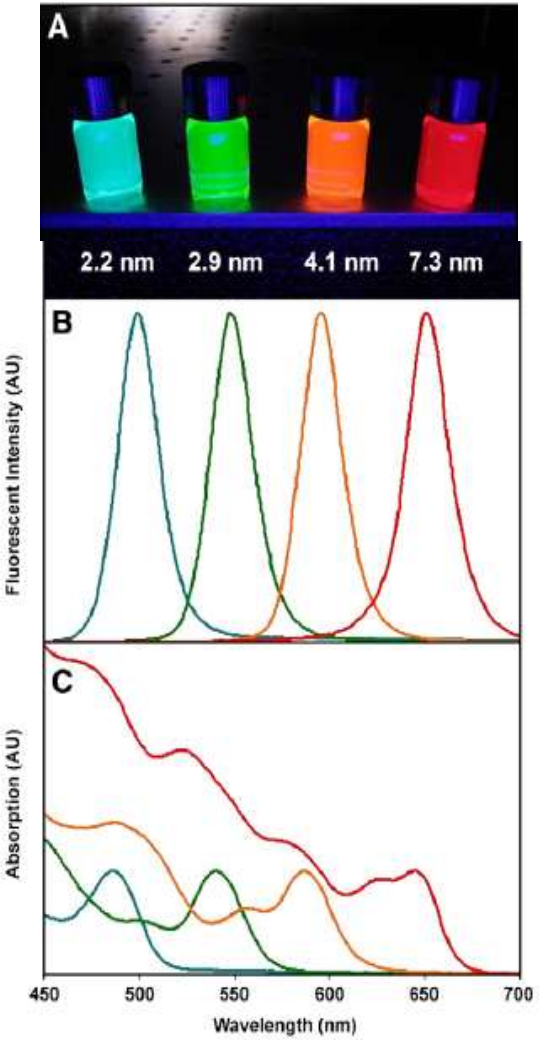
- device technology
- materials science

Nanoparticles

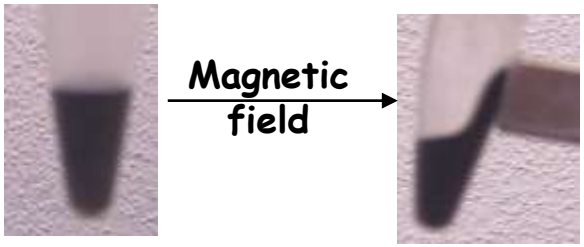
High electron density originating plasmonic effects (e.g. metal particles: Au, Ag, …)



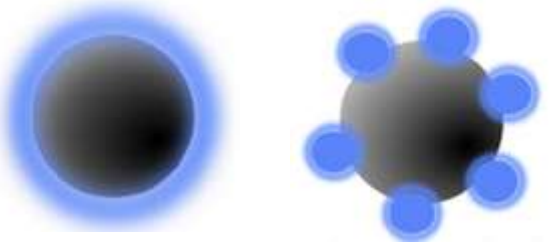
Efficient photoluminescence (semiconductor quantum dots, e.g. CdSe or CdTe)



High magnetic moment and superparamagnetism (e.g. iron oxide or ferrites)



These enhanced properties can even be combined by the use of hybrid nanostructures



core-shell

decorated

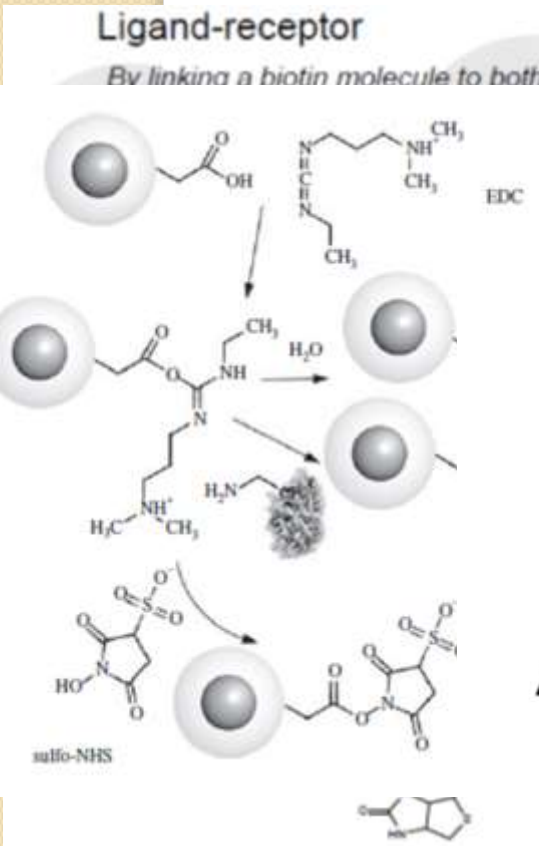
Nanoparticles Biocompatibilization and Biofunctionalization

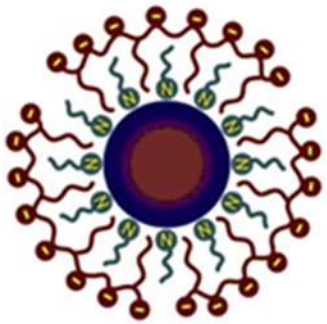
The conjugation of nanoparticles with biomolecules (bionanosystems) improves the biocompatibility and adds to the unique properties of inorganic nanoparticles the ability of biomolecules for highly specific binding by molecular recognition.

Using non-covalent interactions

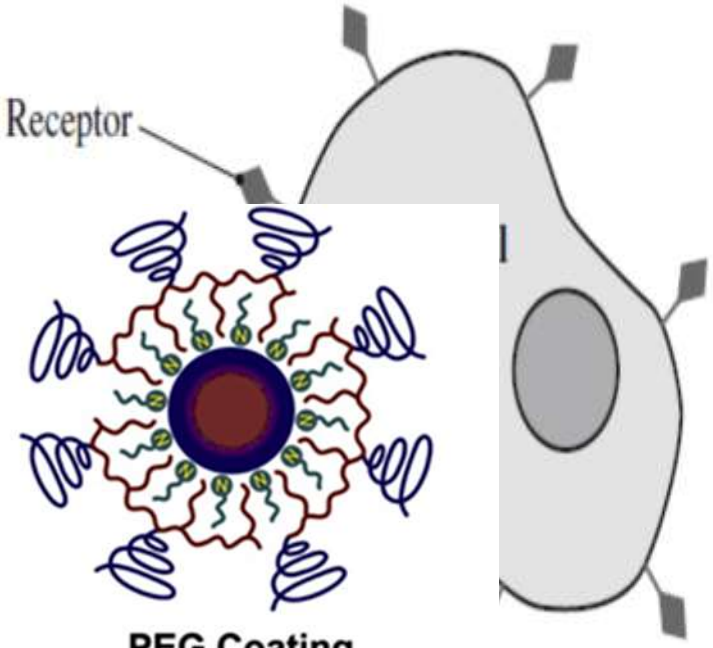
high affinity ligand-receptor plataforms or hydrophobic association

Building on the particle surface





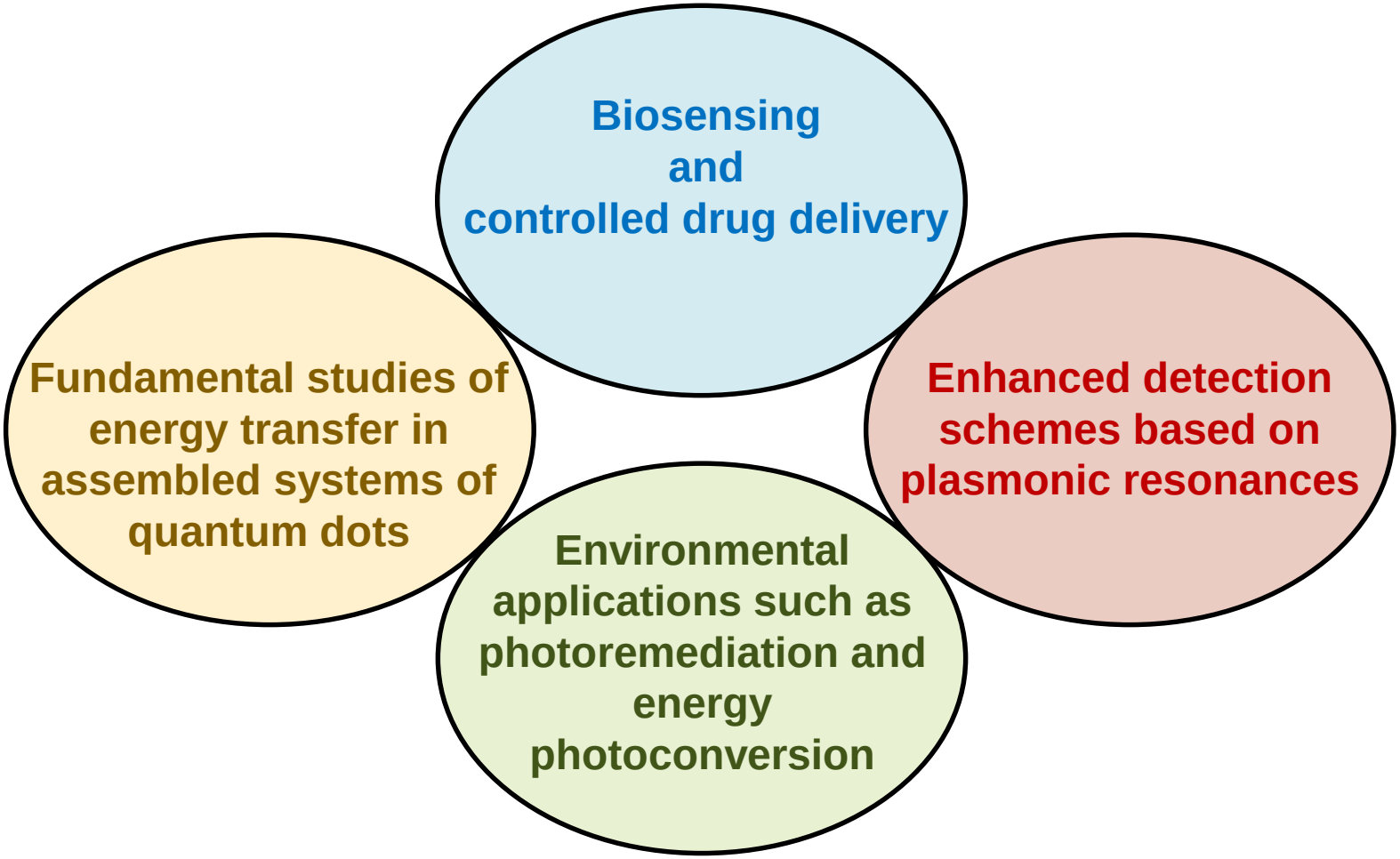
Amphiphilic Polymer Coating



PEG Coating

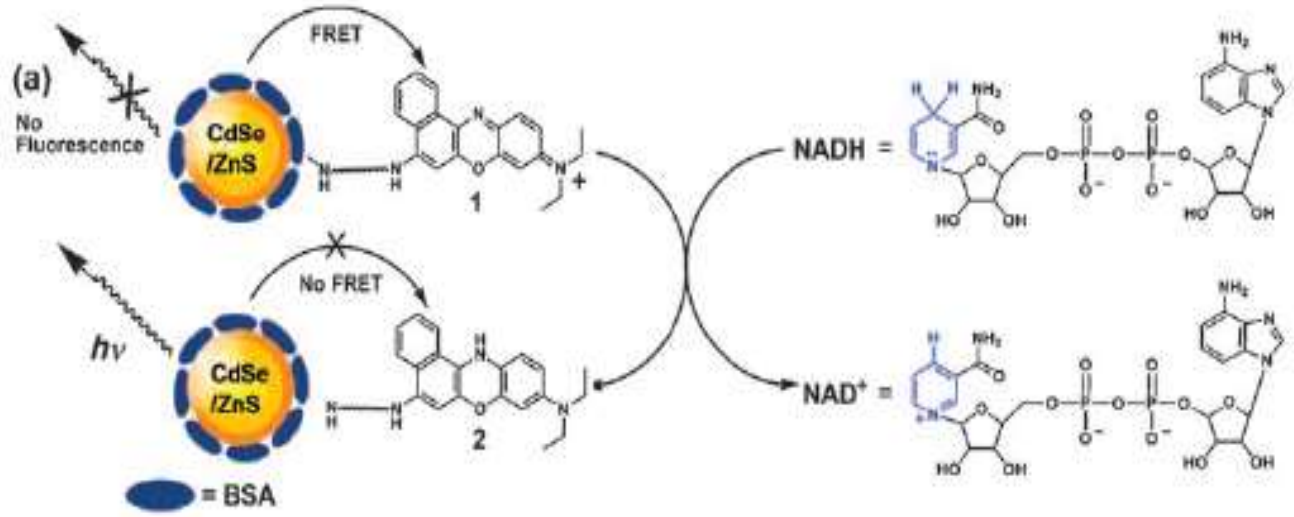
Main areas of application @ CFUM

The general objective is exploring the potential of **custom designed (bio)nanosystems** for

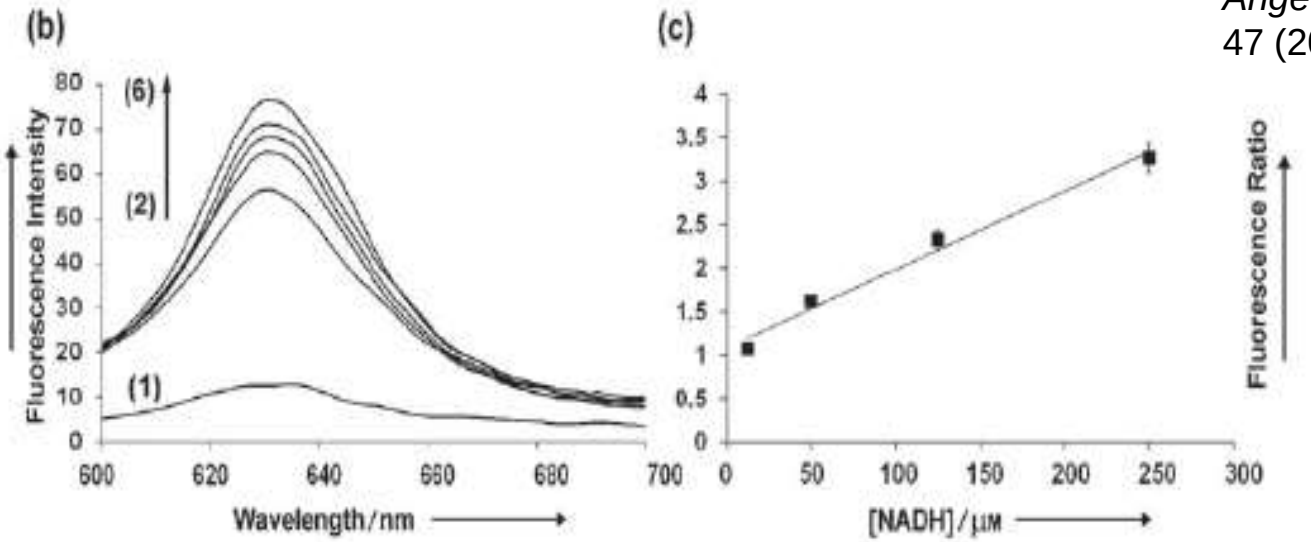


Quantum dot based biosensor

Sensing of NADH by Nile-blue-functionalized CdSe/ZnS QDs



Angew. Chem. Int. Ed. 47 (2008) 1-6

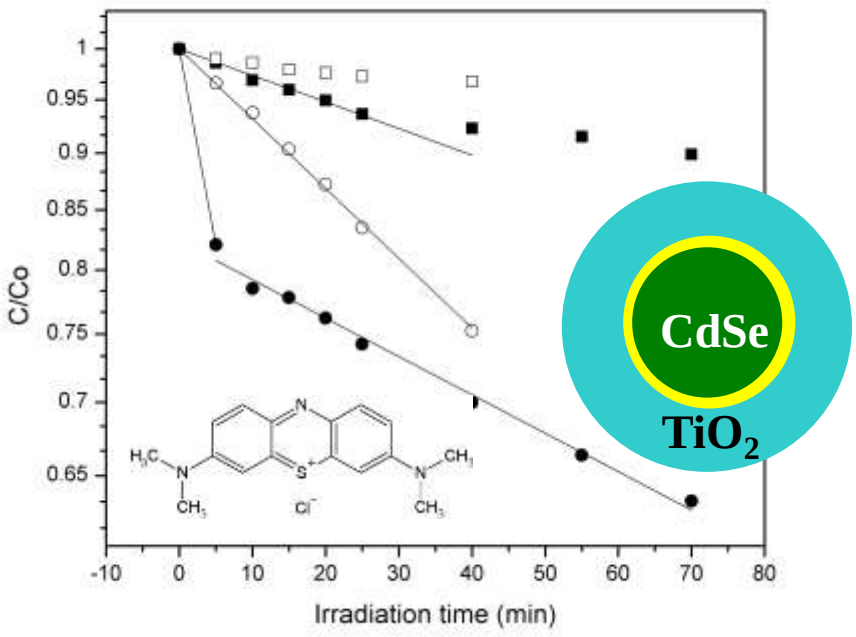


Time dependent fluorescence changes as a result of the interaction of functionalized QDs with 0.5 mM NADH:

(1) before addition of NADH; (2) to (6) after successive time intervals of 3 min.

Quantum dots @ CFUM

Photodegradation



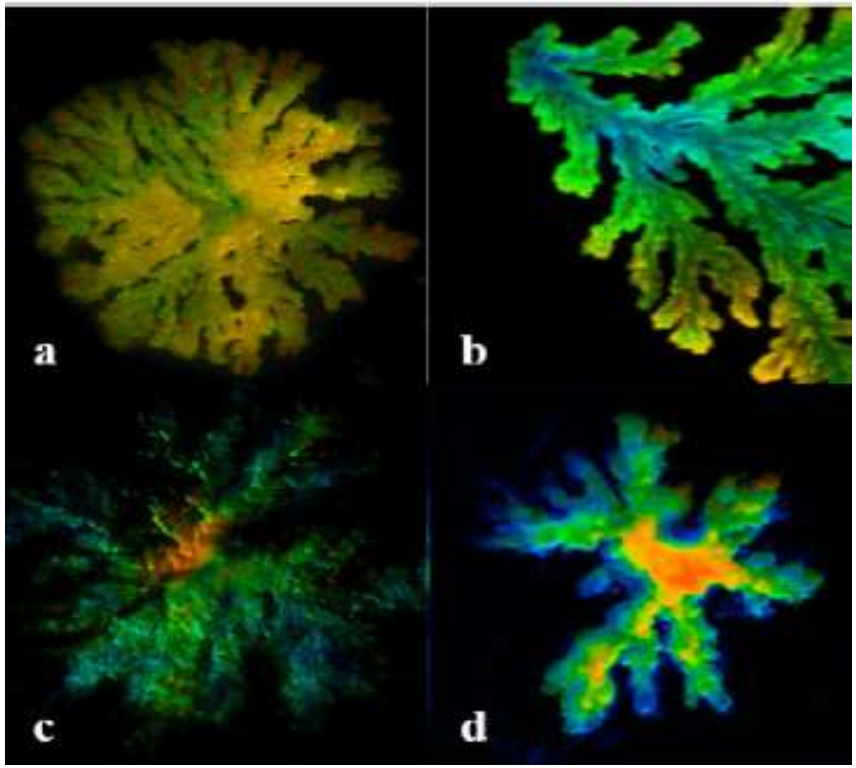
Photodegradation kinetics:

Degussa TiO_2 at 340 nm (○) and 405 nm (□); CdSe/TiO_2 core/shell nanoparticles at 340 nm (●) and 405 nm (■).

The lines represent first order exponential kinetics.

A. Fontes-Garcia *et al., Nanoscale Res. Lett.* 6 (2011) 426

Energy transport



FLIM images of four representative superstructures obtained from CdSe/ZnS (a, b) and CdTe (c, d) QDs capped with thioglycolic acid, deposited on glass coated with polylysine. The color scale ranges from low (blue) to high lifetime values (red).

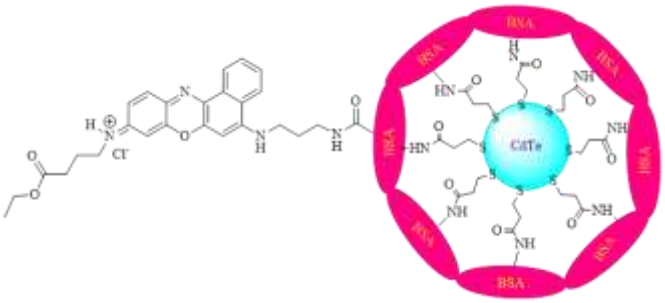
C. Bernardo *et al.*, *J. Phys. Chem. C* 118 (2014) 4982.

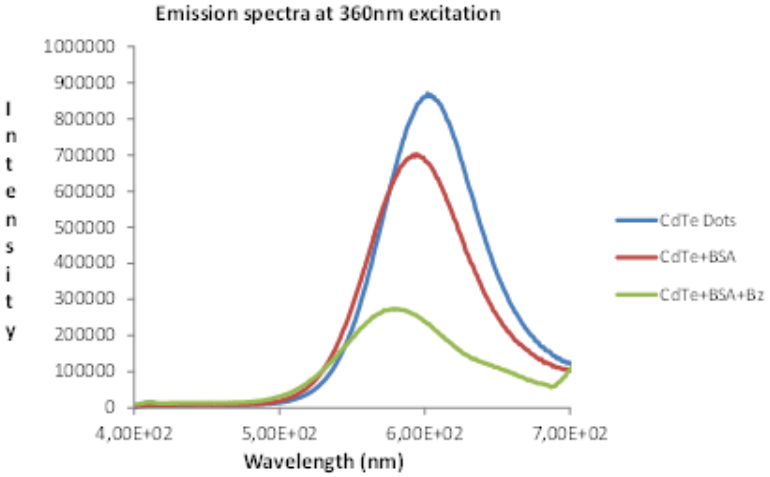
More details in poster "*Energy transfer via exciton transport in quantum dot based self-assembled superstructures*", by C. Bernardo

Quantum dots

Bionanoconjugates @ CFUM

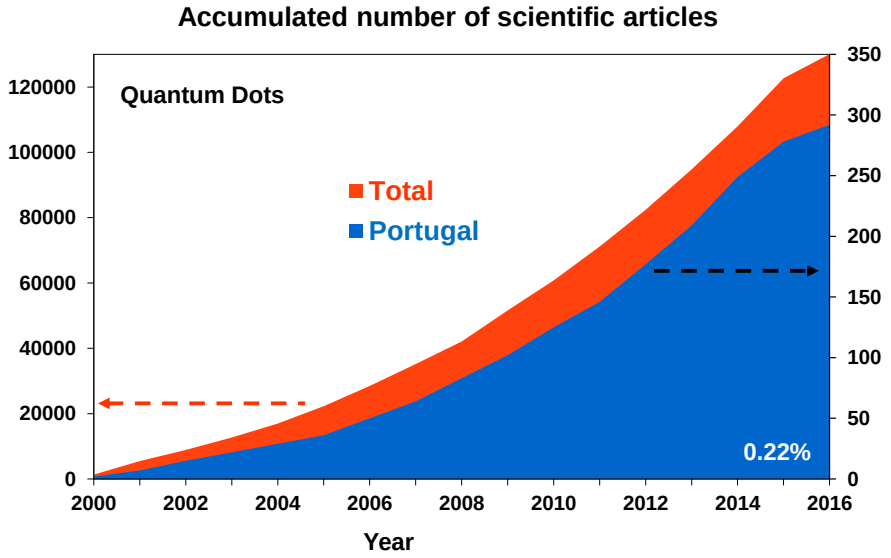
CdTe/BSA/Dye bionanoconjugate

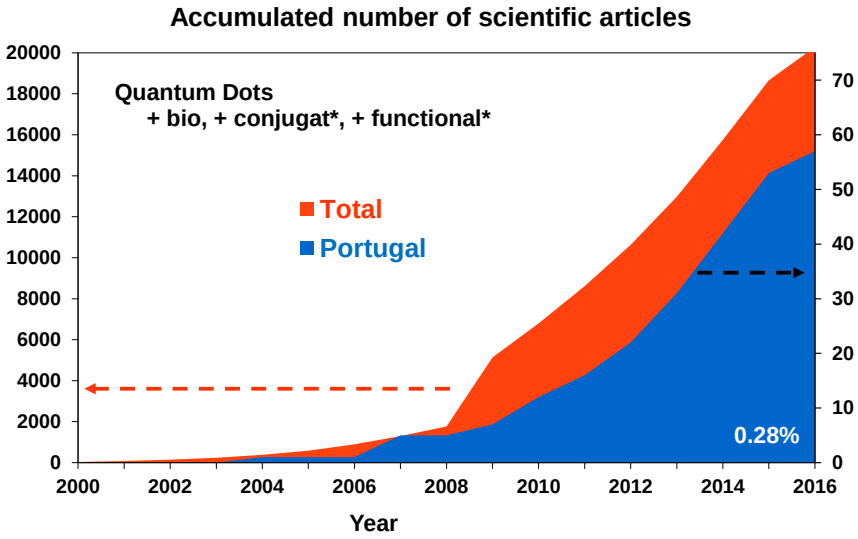




B. Raju *et al., Dyes Pigments* 110 (2014) 203

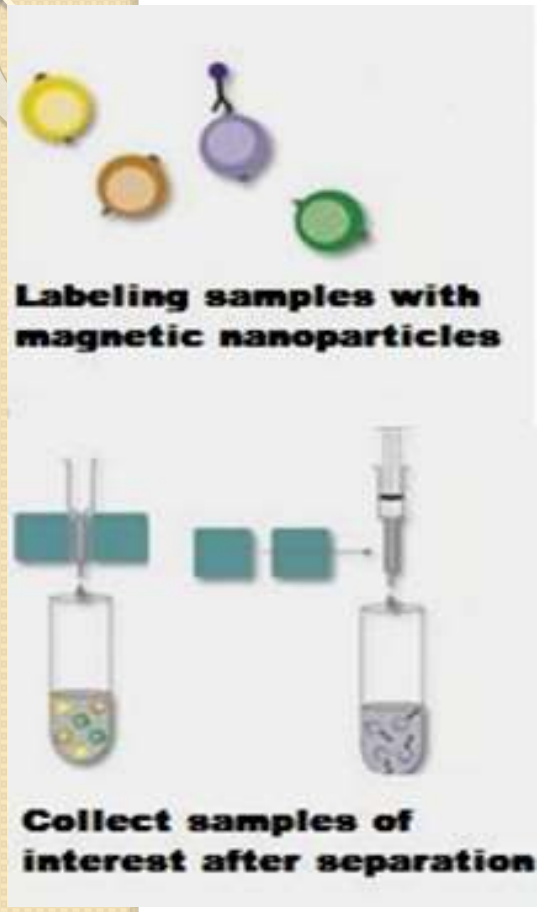
Research area evolution @ PT





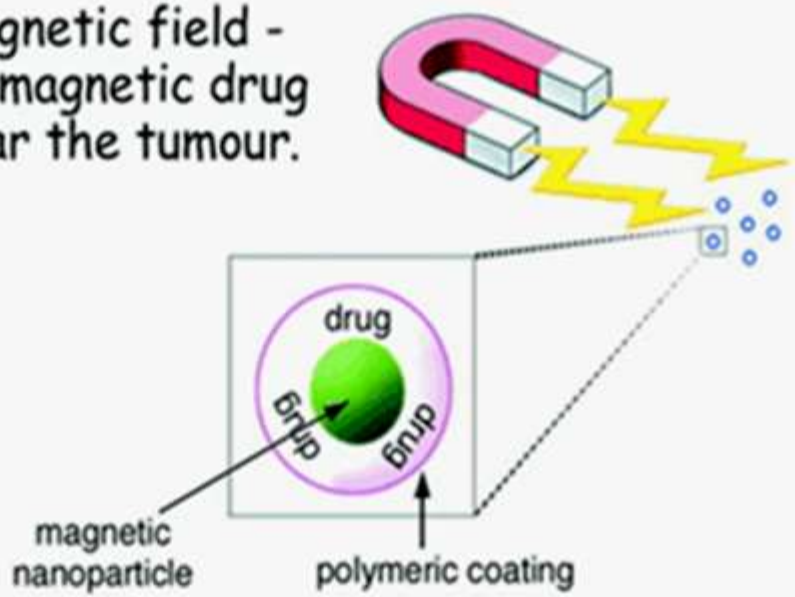
Magnetic nanoparticles

Biomagnetic separations of DNA, proteins, etc.

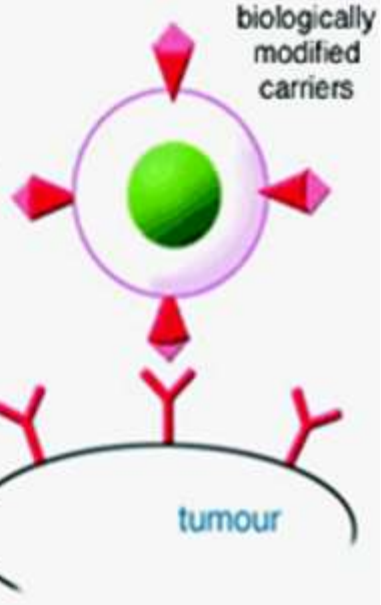


Targeted drug delivery in vivo

1. External magnetic field - guiding the magnetic drug carriers near the tumour.

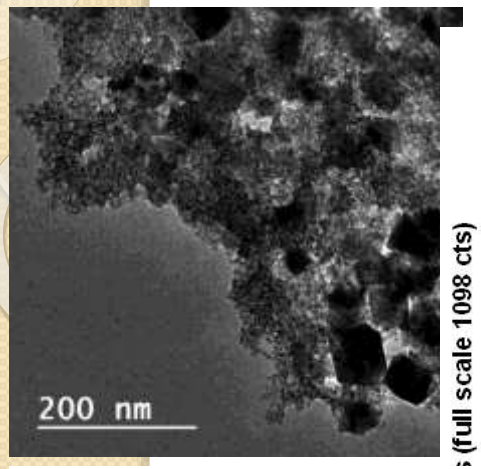


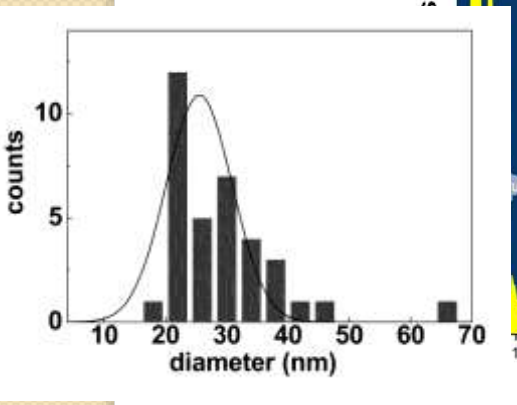
2. Surface antigen recognition - attaching the carriers to the tumour for drug release on site.

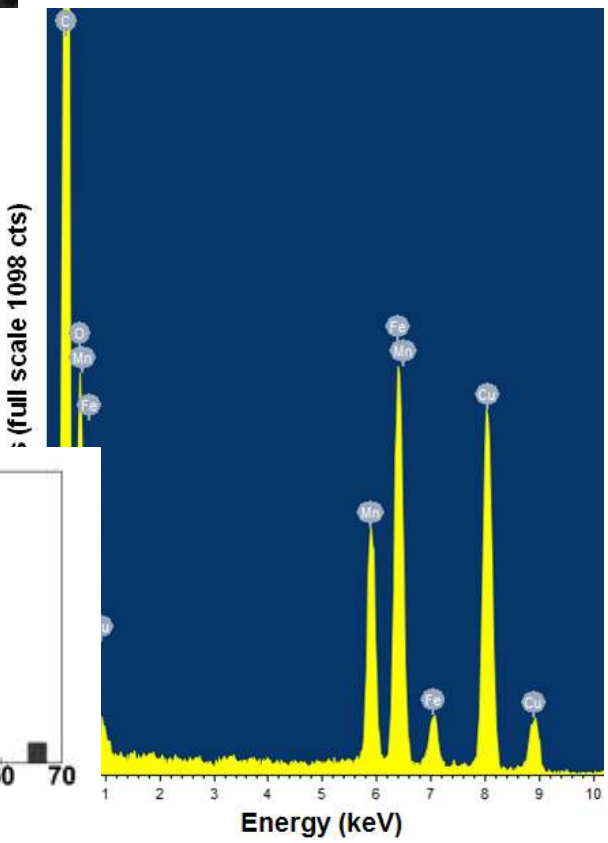


Magnetoliposomes @ CFUM

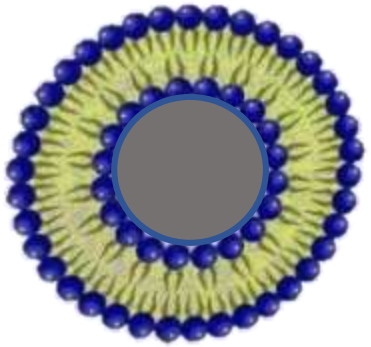
$MnFe_2O_4$ MNPs





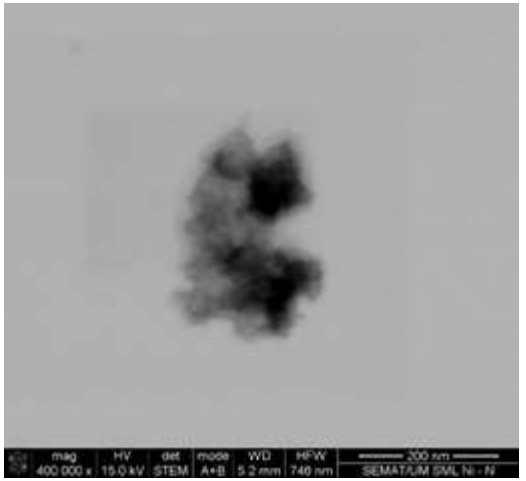


Solid Magnetoliposomes (SMLs)



Magnetic nanoparticles cluster covered by a lipid bilayer

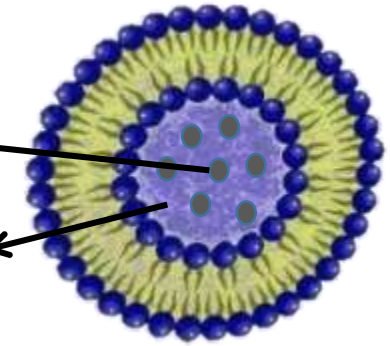
Cluster of $NiFe_2O_4$ SMLs (negative staining)



Aqueous Magnetoliposomes (AMLs)

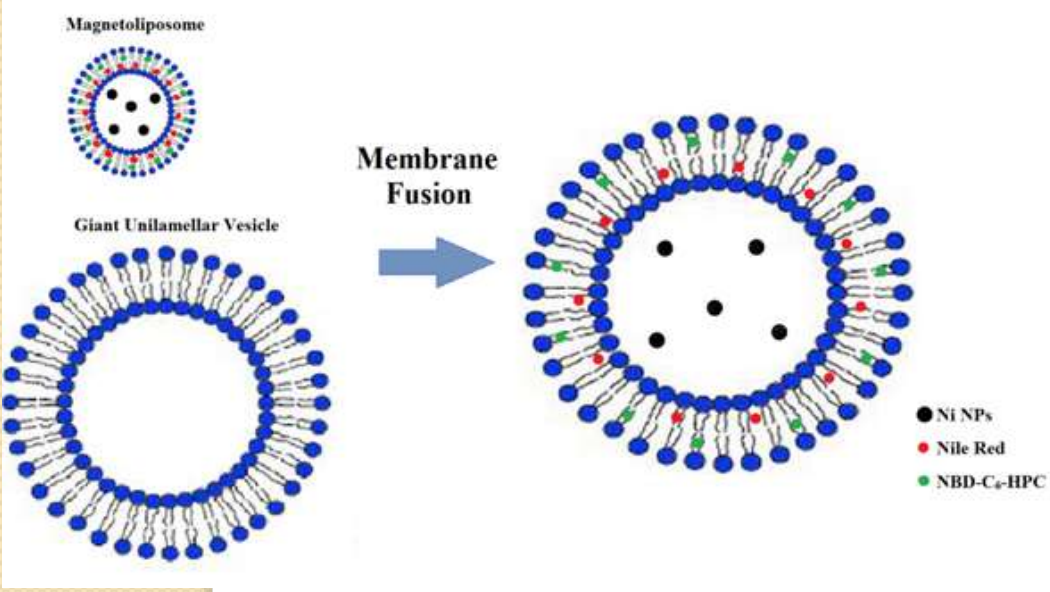
Magnetic nanoparticles

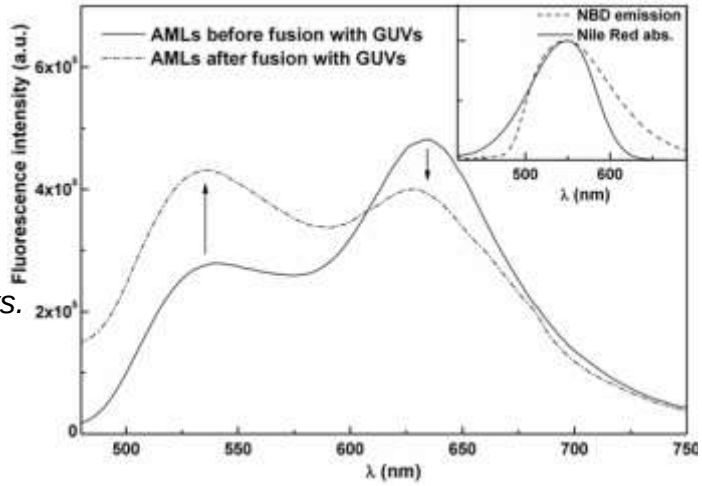
Aqueous media



Magnetoliposomes @ CFUM

Fusion of magnetoliposomes of Ni/SiO_2 NPs with biological membrane models





A.R.O. Rodrigues *et al*., *Mat. Chem. Phys.* 148 (2014) 978.

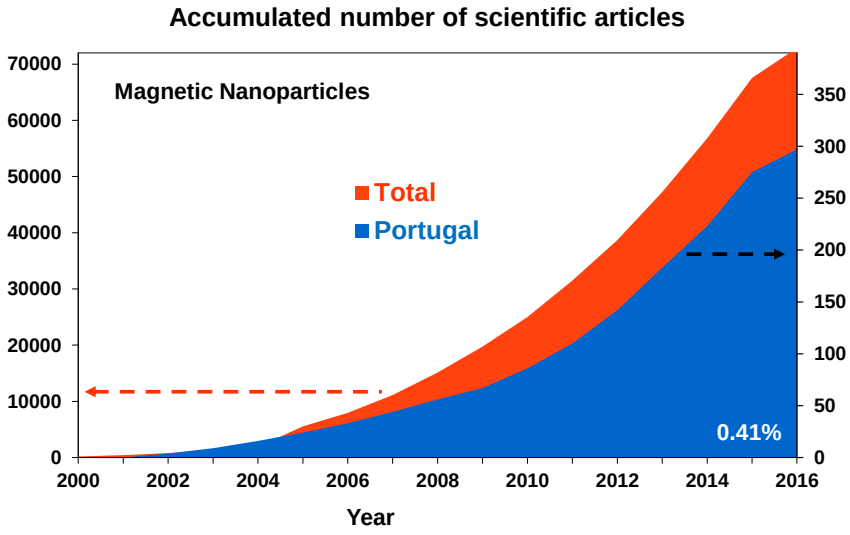
A.R.O. Rodrigues *et al*., *Phys. Chem. Chem. Phys.* 17 (2015) 18011.

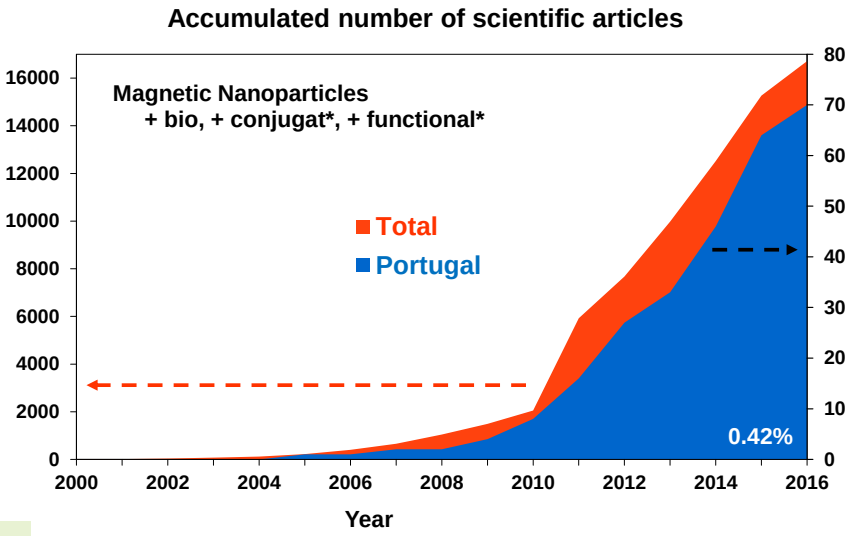
A.R.O. Rodrigues *et al*., *RSC Advances* 6 (2016) 17302.

More details in poster "*Magnetic liposome-based nanocarriers for dual cancer therapy*", by A. R. O. Rodrigues

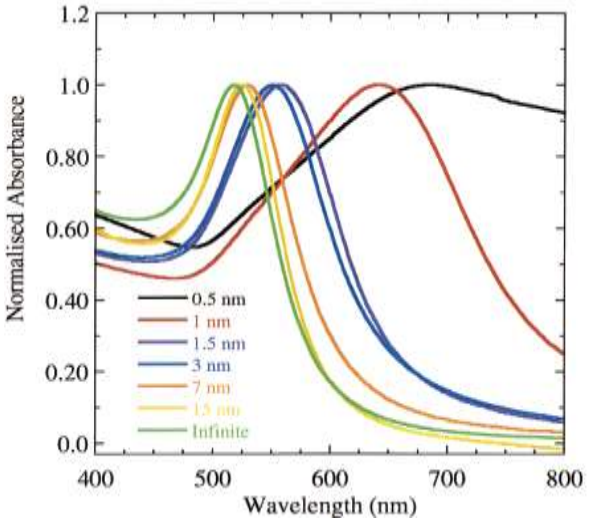
Magnetic Nanoparticles

Research area evolution @ PT

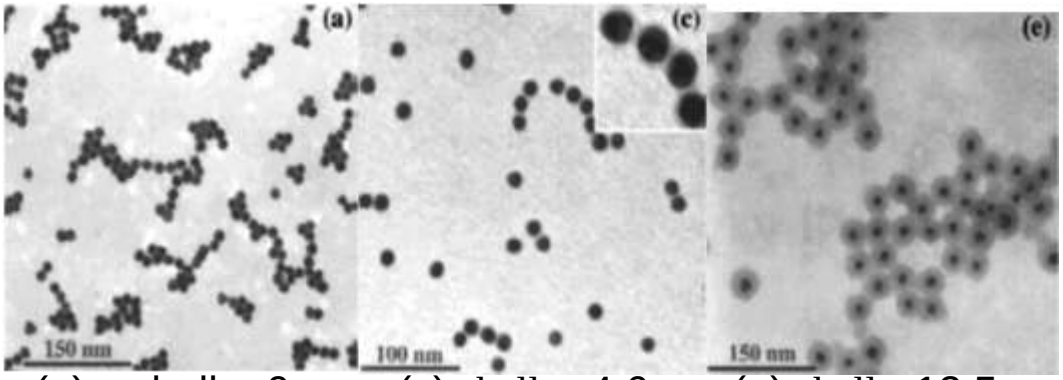




Plasmonic nanoparticles



Gold nanoparticles with silica shell

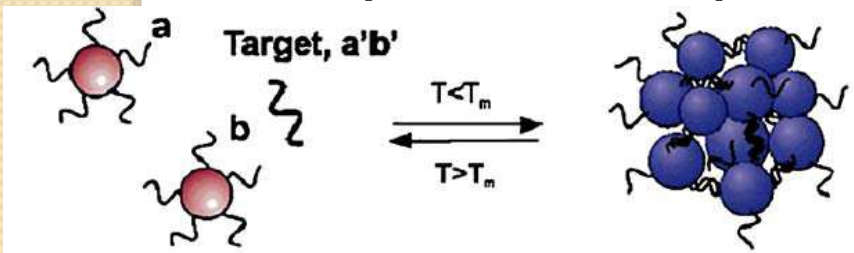


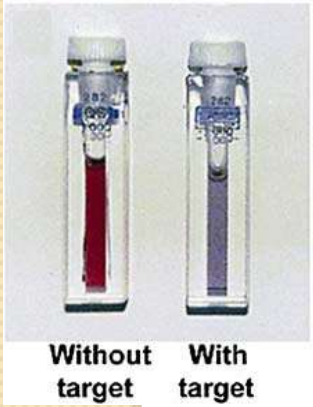
(a) shell = 0 nm (c) shell = 4.6nm (e) shell =12.5nm

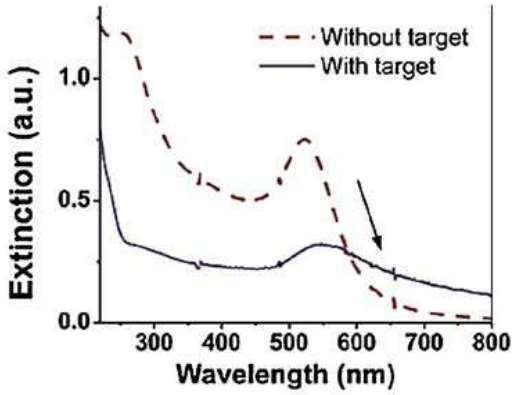
(size of Au core is 13.2 nm)

J. Phys. Chem. B 105 (2001) 3441-3452

Detection of a specific DNA sequence

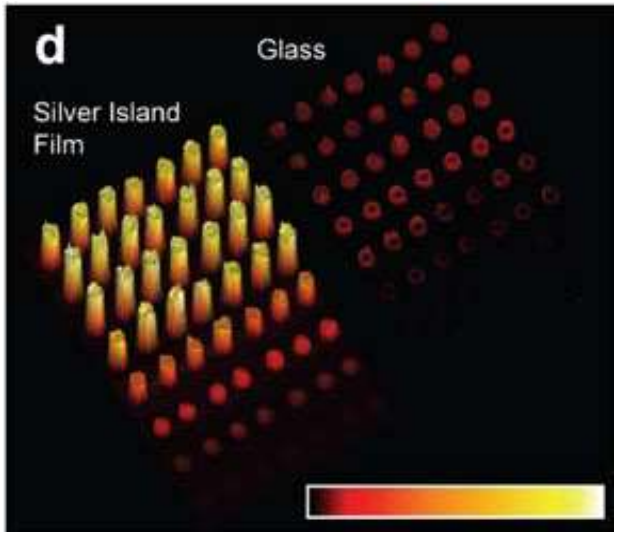






J. Am. Chem. Soc. 125 (2003) 1643–1654

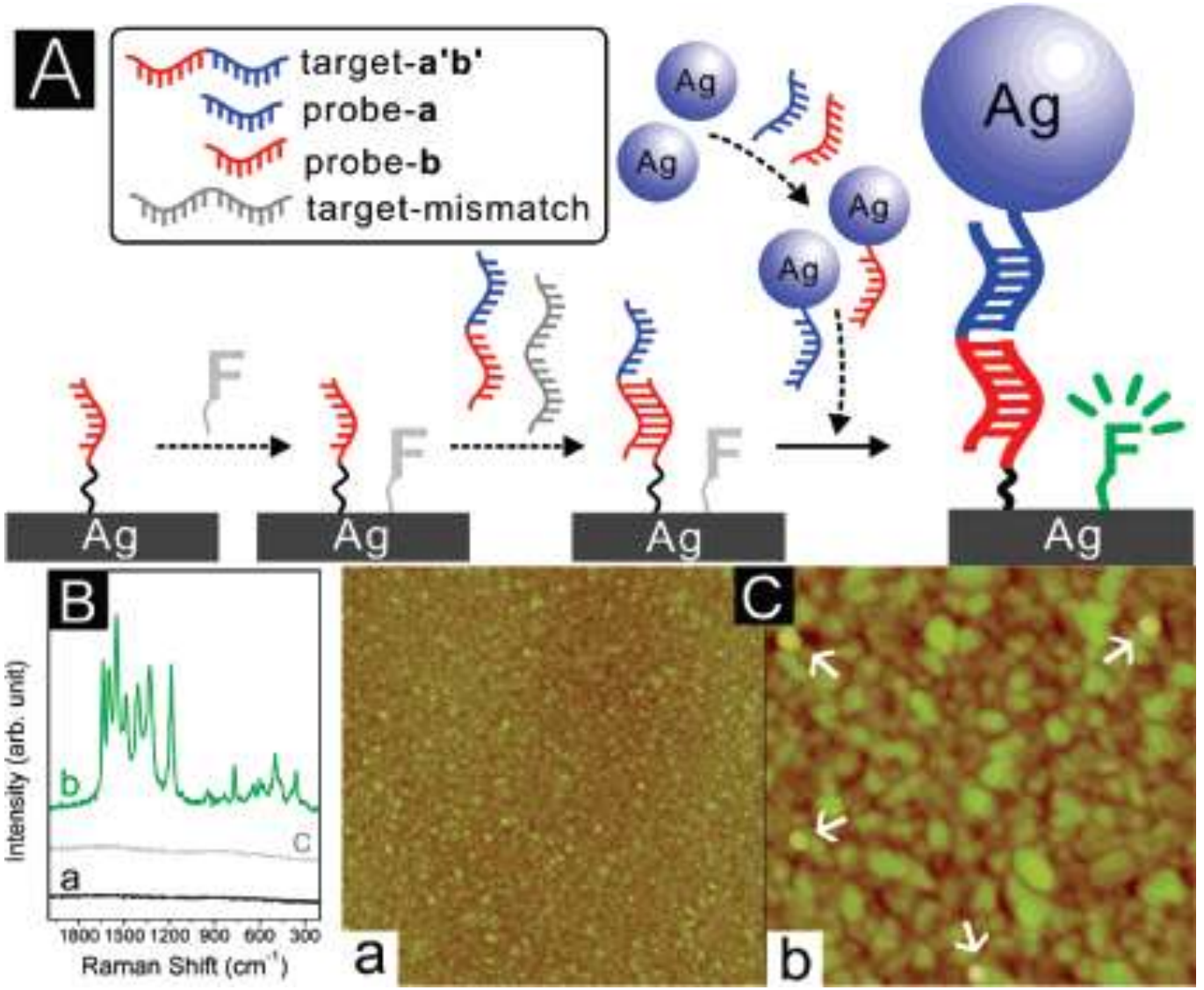
Metallic Surface Plasmon **E**nhanced **F**luorescence



Anal. Bioanal. Chem. 394 (2009) 47-59

Plasmonic nanoparticles

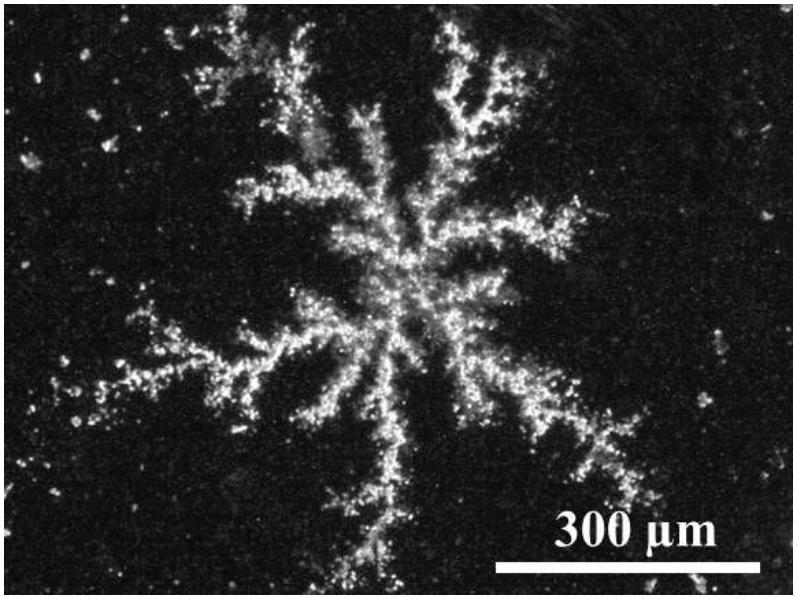
Surface Enhanced Raman Scattering



J. Am. Chem. Soc. 129 (2007) 6378

Plasmonic nanoparticles

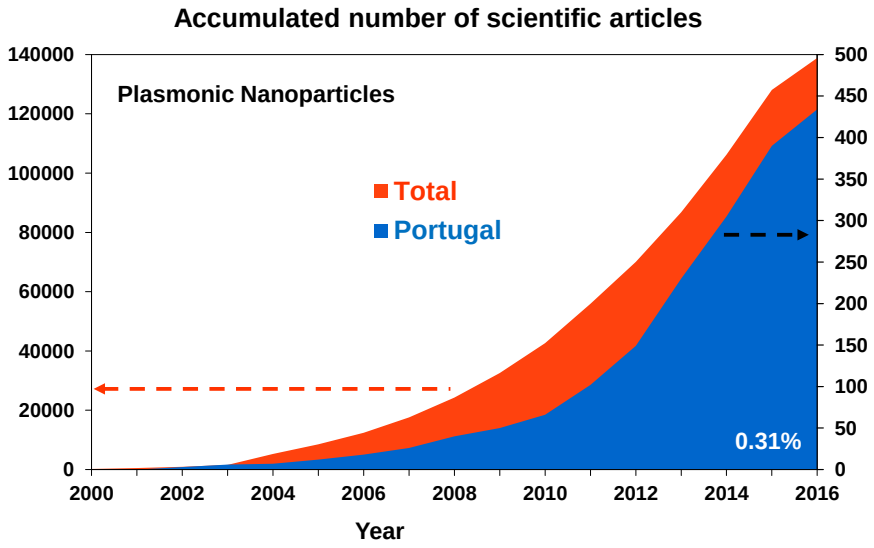
Ag fractals on top of TiO_2 matrix @ CFUM

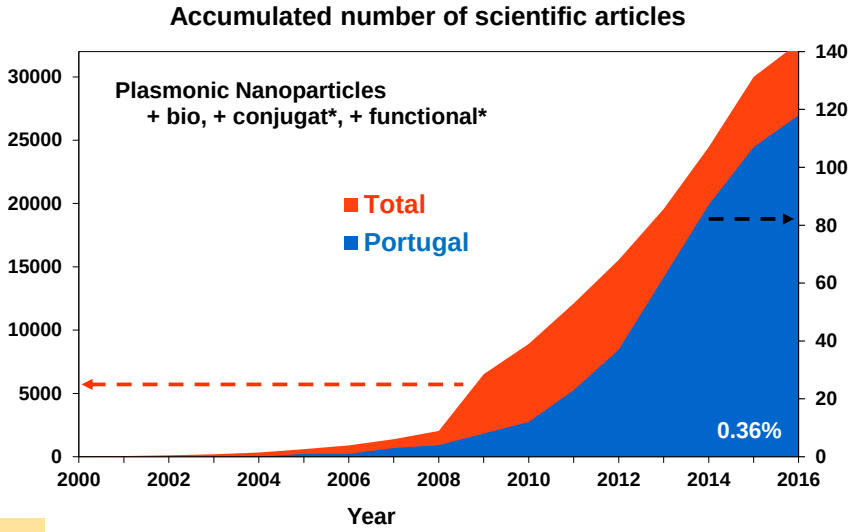


The dendrite-type objects emerged from a homogeneous and highly transparent Ag:TiO2 nanocomposite, via the mechanism of diffusion-limited-aggregation (DLA) of Ag atoms, during heat-treatment at 500 °C.

J. Borges *et al.*, *Phys. Status Solidi RRL* (2016) (DOI: 10.1002/pssr.201600131)

Research area evolution @ PT

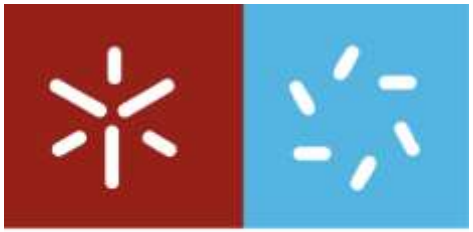




More details in poster “Nanoplasmonic thin films for LSPR-(Bio)sensing applications”, by J. Borges

Ciência 2016

Thanks for your attention



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4 Julho 2016