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

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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
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
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 platforms or hydrophobic association
Building on the particle surface
The general objective is exploring the potential of custom designed (bio)nanosystems for main areas of application at CFUM.

- **Biosensing and controlled drug delivery**
- **Environmental applications such as photoremediation and energy photoconversion**
- **Enhanced detection schemes based on plasmonic resonances**
- **Fundamental studies of energy transfer in assembled systems of quantum dots**
Quantum dot based biosensor

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

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.

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

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).


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
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.

Labeling samples with magnetic nanoparticles

Collect samples of interest after separation
Magnetic nanoparticles cluster covered by a lipid bilayer

Magnetoliposomes: \( \text{MnFe}_2\text{O}_4 \text{ MNPs} \)

Aqueous media

Magnetic nanoparticles

Solid Magnetoliposomes (SMLs)

Cluster of \( \text{NiFe}_2\text{O}_4 \text{ SMLs} \) (negative staining)
Magnetoliposomes @ CFUM

Fusion of magnetoliposomes of Ni/SiO₂ NPs with biological membrane models

Research area evolution @ PT

Accumulated number of scientific articles

Magnetic Nanoparticles

- Total
- Portugal

Accumulated number of scientific articles

Magnetic Nanoparticles + bio, + conjugat*, + functional*


More details in poster “Magnetic liposome-based nanocarriers for dual cancer therapy”, by A. R. O. Rodrigues
Plasmonic nanoparticles

Gold nanoparticles with silica shell

(a) shell = 0 nm  (c) shell = 4.6 nm  (e) shell = 12.5 nm
(size of Au core is 13.2 nm)

Detection of a specific DNA sequence

Metallic Surface Plasmon Enhanced Fluorescence


Plasmonic nanoparticles
Surface Enhanced Raman Scattering

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.


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

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