FROM RESEARCH TO INDUSTRY

nanoSAFE'16

SAFER-BY-DESIGN APPROACH TO IDENTIFY QUANTUM DOTS WITH REDUCED TOXICITY

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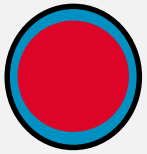
Serenade
Safe(r) Ecodesign Research and Education applied to nAnomaterial DEvelopment.

INTRODUCTION

Advantages

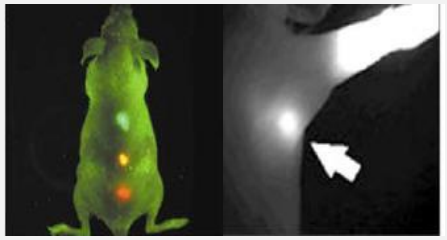
Fluorescent semiconductor nanocrystals

core  core/shell 

➡ **unique optical properties**

Optoelectronics (LED, photovoltaic cells)

Biology (imaging, biosensing)



Drawbacks

Contains Cadmium (mostly)

CdSe-CdTe QDs: *in vitro and in vivo* toxicity

- Cell mortality
- DNA damage
- Neurotoxicity …

➡ Alternative: indium-based QDs

OBJECTIVE

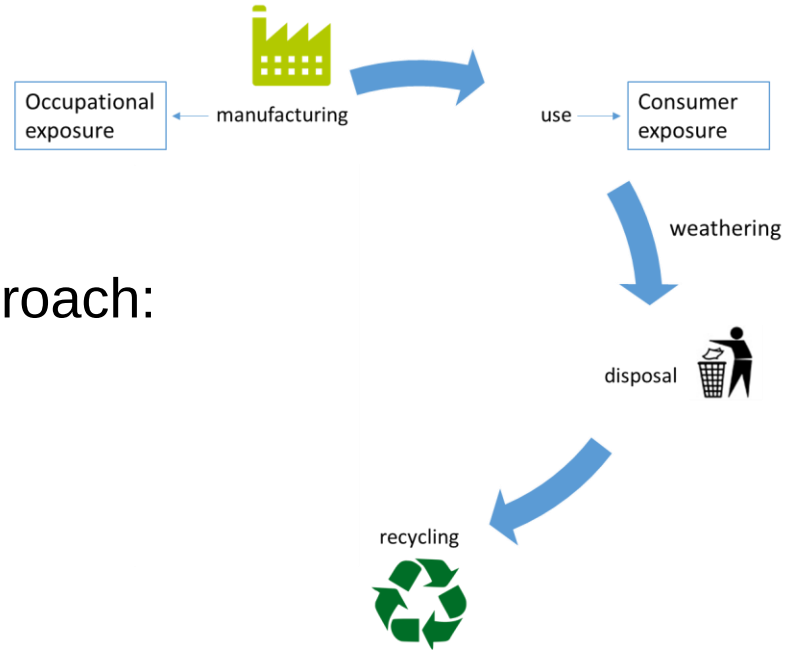
Design QDs which are **less toxic** for human health

Throughout the life cycle of the QDs

➡ impact of ageing?

By using a safer-by-design scientific approach:

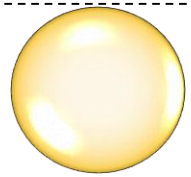
- Cd replaced by less toxic element (indium)
- Limited dissolution (double shell protection)
- Different types of surface ligands



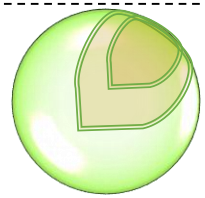
Toxicity assays using a human skin model: human primary keratinocytes

STRATEGY

SYNTHESIS

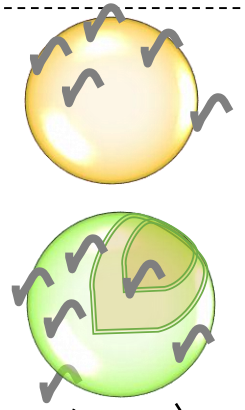


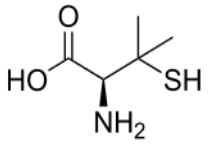
InPZnS
InPZn



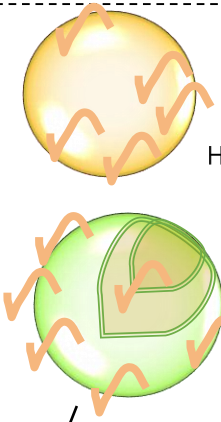
InPZnS@ZnSe/ZnS
InPZn@ZnSe/ZnS

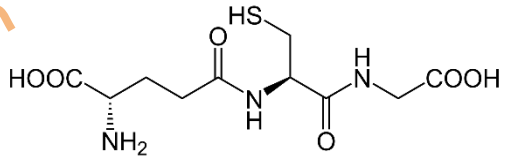
LIGAND EXCHANGE





Penicillamine





Glutathion

AGEING

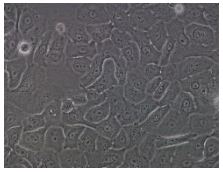
Pristine

Aged

Pristine

Aged

CELLULAR EXPERIMENTS



Primary human keratinocytes

AGEING UNDER A XENON TEST CHAMBER

Plateforme Hybriden (Collab. Clément Thomassé, Jérôme Faure-Vincent)

Model: QSUN Xe-1 BC with xenon arc lamp

Full spectrum sunlight

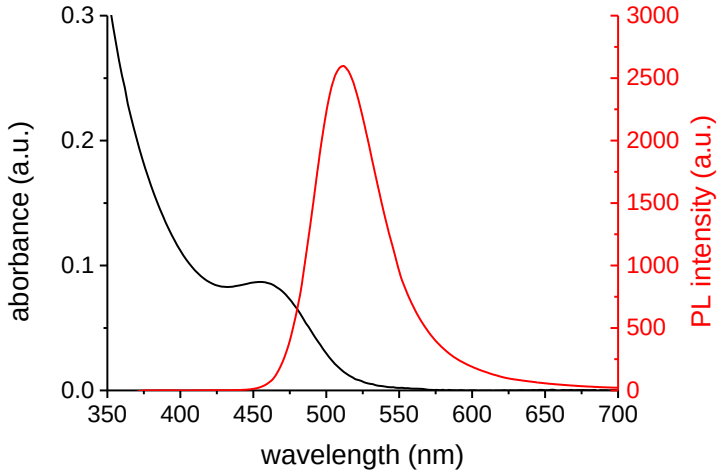
Temperature: 40°C
Irradiance: 1.44 W/m²
Duration of the ageing cycle: 64 h

CORE-SHELL QUANTUM DOTS

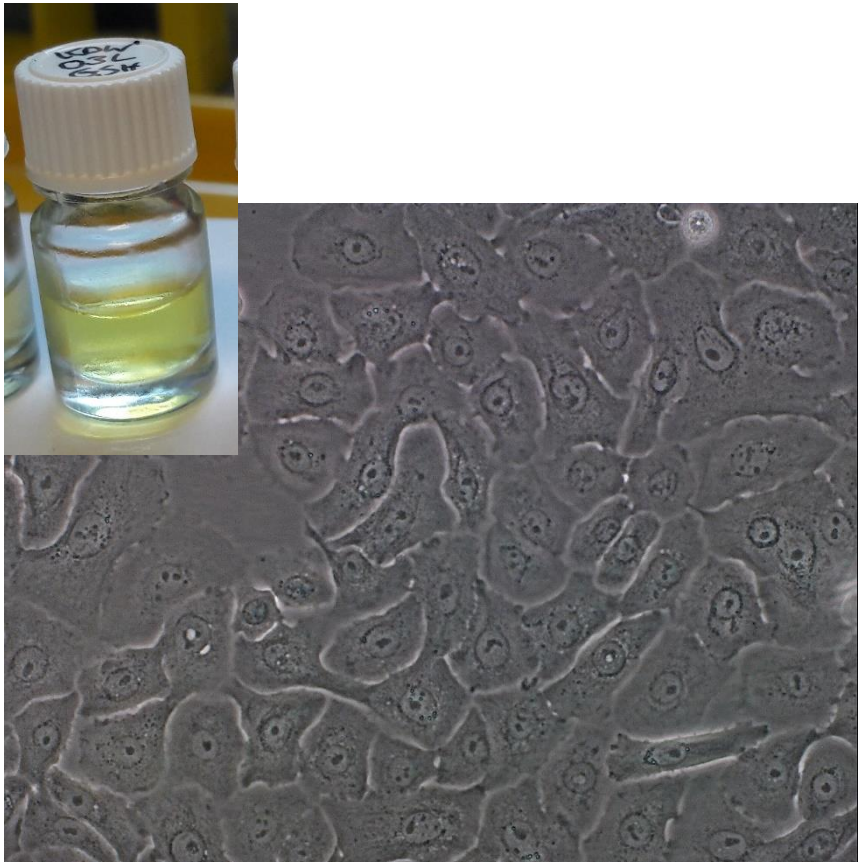
Collab. LEMOH (KD Wegner, L Mattera, C Lincheneau, P Reiss)

InPZnS@ZnSe/ZnS

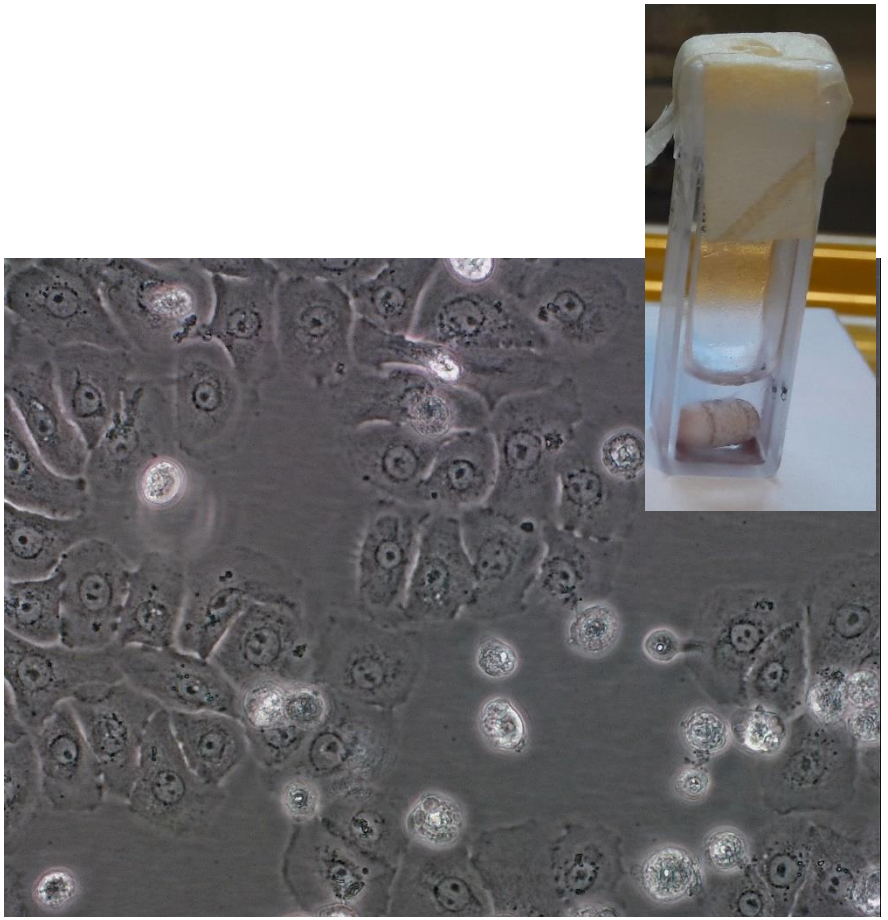
λem: 530 nm
QY: 22-25%
Primary size: 2 nm
Hydrodynamic diameter: 5 nm
Z pot (in PBS): -35 mV



KERATINOCYTES EXPOSED TO InPZnS CORE SHELL QDs



Pristine



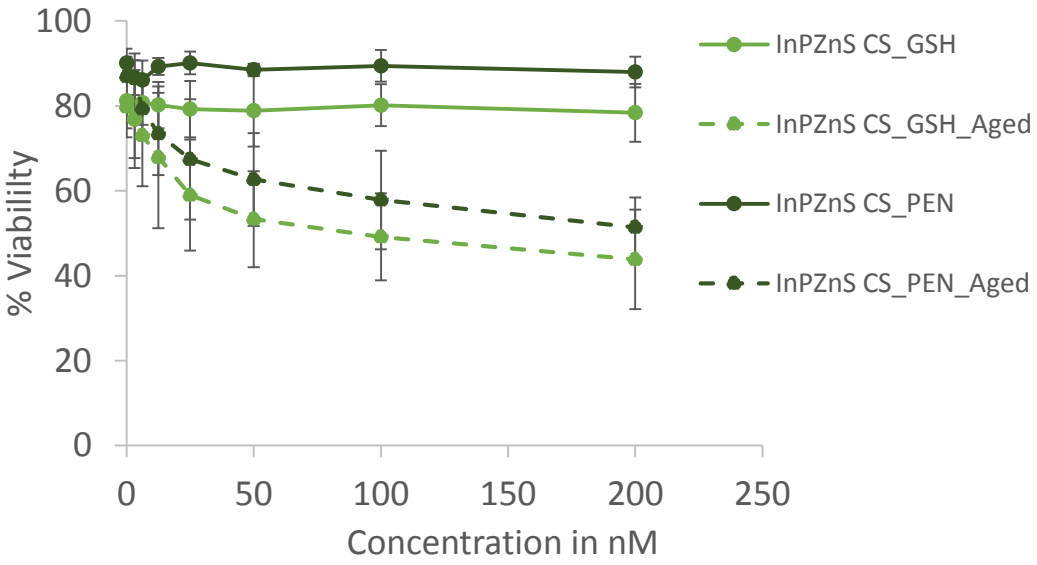
Aged

Exposure: 50 nM for 24h

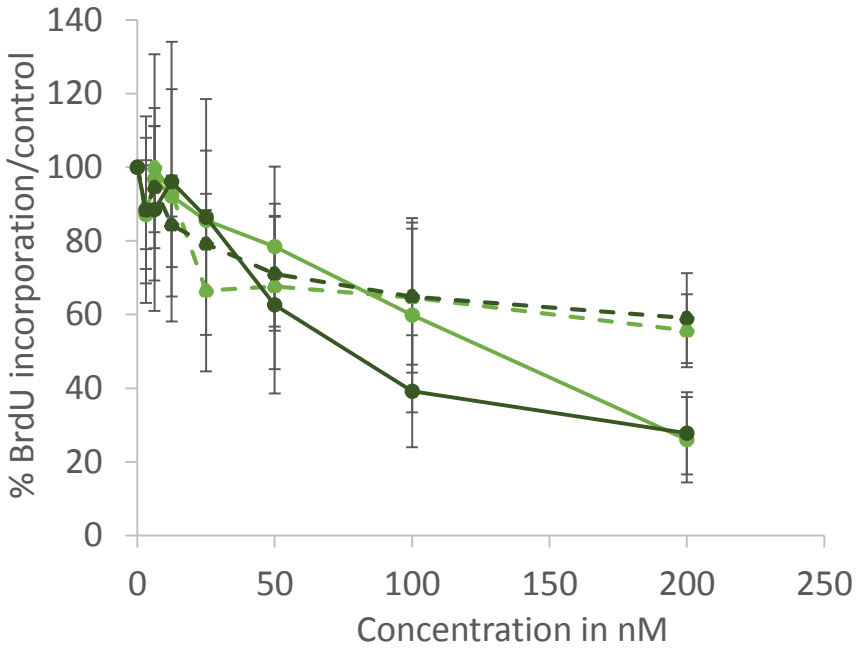
CELL VIABILITY AND PROLIFERATION

At 24h

CELL VIABILITY (LDH assay)



CELL PROLIFERATION (BrdU assay)



↓ in the cell viability following exposure to the aged QDs

↓ in the cell proliferation pristine InPZnS CS> aged InPZnS CS at the highest dose

XAS ANALYSIS OF InPZnS CS (In K-EDGE)

Collab. Géraldine Sarret

EXAFS analysis of:

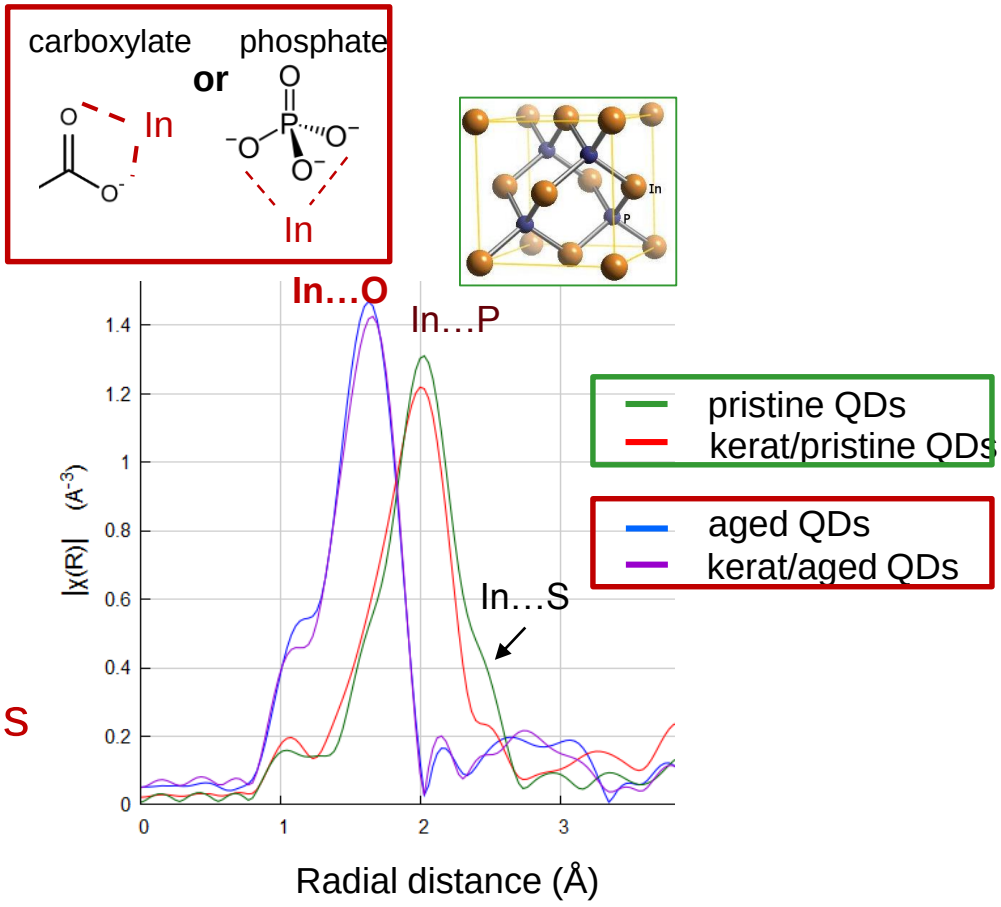
Core: InPZnS or InPZn
Shell: ZnSe/ZnS
Ligand: penicillamine or glutathione

Pristine or aged

QDs or keratinocytes exposed to QDs

→ transformation after ageing,
→ no tranformations into the cells

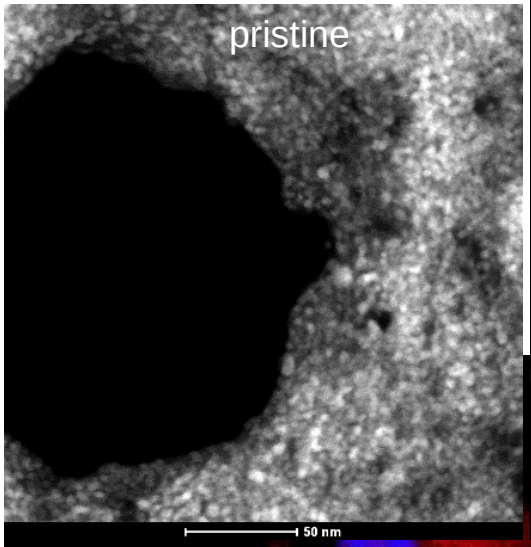
Exception: InPZn core only

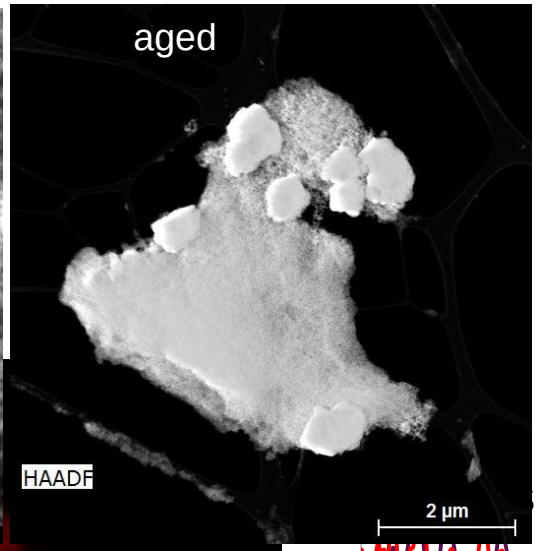


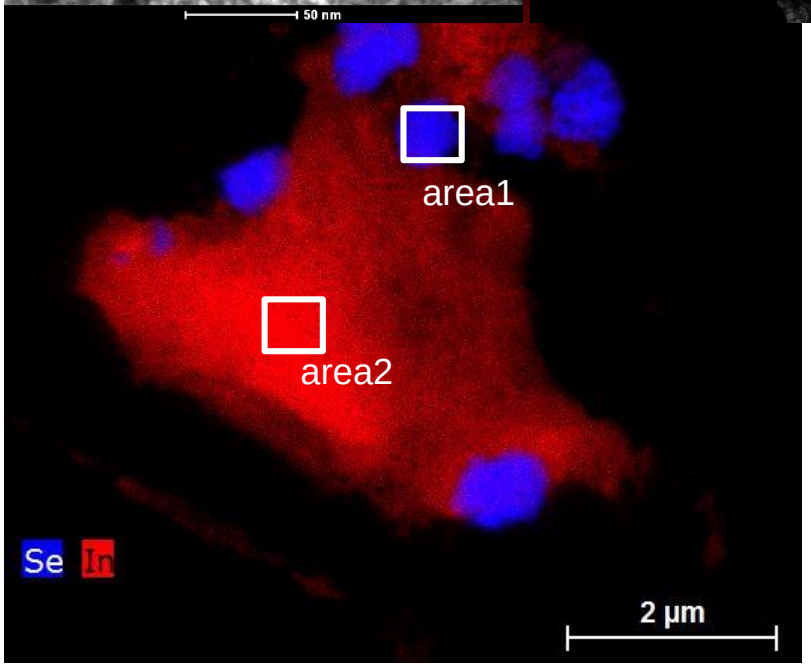
Cell exposure: 50 nM for 24h

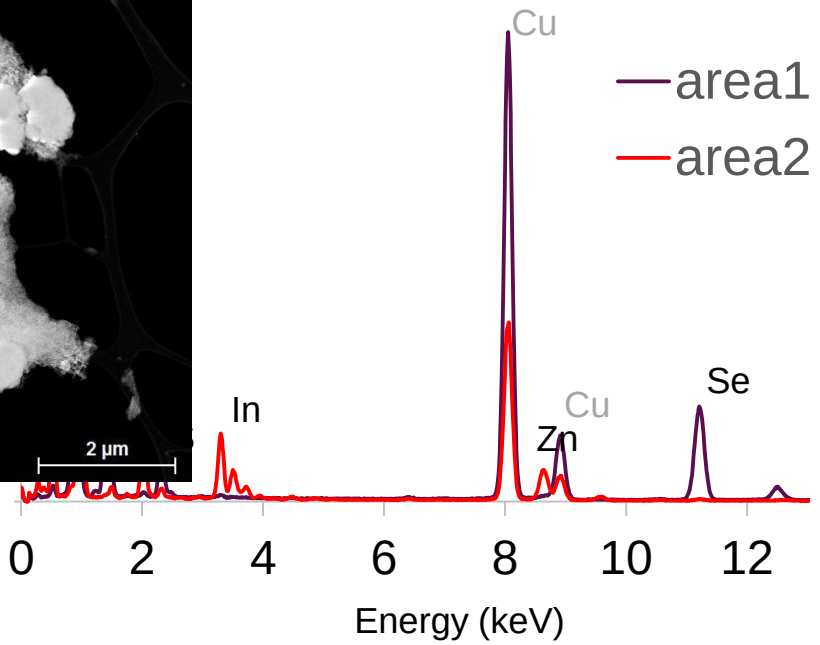
STEM/EDX ANALYSIS OF InPZnS QDs

Collab. Romain Soulas





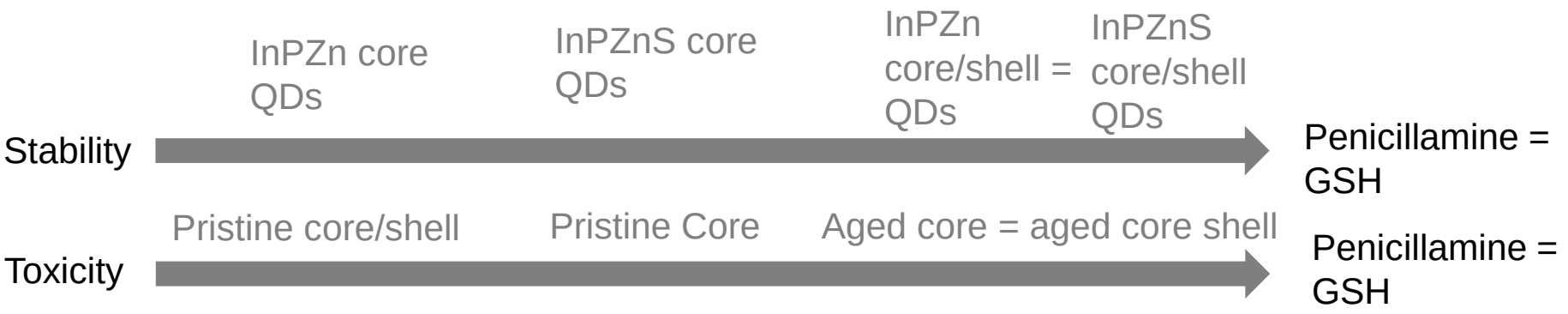




→ area1 = Se, S
→ area2 = In, P, O, Zn

Selenium sulfide

CONCLUSIONS & PERSPECTIVES



SAFER-BY-DESIGN STRATEGY

In > Cd
Core-shell > core only
InPZnS > InPZn
Penicillamine = GSH

dissolution and toxicity following ageing

Necessity to test other types of ligands

AKNOWLEDGMENT

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Muriel Dubosson

LR2N
Delphine Boutry
Romain Soulas

Serenade
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Thank you for your attention!