PhD PSL proposal at the ENSCP/ICLeHS-SEISAD team

Thesis project/ **Titre du projet de thèse**	**NIR-II Semiconductor Quantum Dots and Theranostics**
Supervisor / **Encadrant**	Dr. Zijun Wang (CPJ) E-mail: zijun.wang@chimieparistech.psl.eu
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Lab/ **Laboratoire**	Institute of Chemistry for Life and Health Sciences (i-CLeHS UMR 8060 Web: https://www.chimieparistech.psl.eu/recherche/les-laboratoires/i-clehs/
Team/ **Equipe**	Synthesis, Electrochemistry, Imaging and Analytical Systems for Diagnosis Team (SEISAD) Web: https://iclehs.fr/research/seisad/

Type of contract: 3-year full-time

Expected date of employment: 10/2026 — 9/2029

Funding: ANR

Remuneration: 2300 €

Keywords: Nanoparticle, Photoluminescence, NIR, Interface, Imaging, Theranostics, Physico-chemical characterization

1. Scientific context and problematic (Contexte scientifique et problématique)

Fluorescence imaging in the second near-infrared window (NIR-II, 1000–1700 nm) has recently emerged as a revolutionary tool in biomedical research. Compared to traditional visible and NIR-I imaging, NIR-II light experiences significantly reduced tissue scattering and minimal autofluorescence, enabling centimeter-deep tissue penetration with unprecedented spatial resolution adapted for biomedical applications.

To exploit this optical window, there is a massive demand for bright, stable, and biocompatible optical probes. Silver chalcogenide quantum dots stand out as highly promising candidates (ref 1). Unlike traditional lead- or cadmium-based quantum dots with severe toxicity concerns, silver chalcogenides are heavy-metal-free, suitable for *in vivo* bioimaging and clinical translation. However, a major challenge lies in low quantum efficiency due to the defects easily generated. These defects act as "traps" that capture electrons, causing energy to be lost as heat rather than emitted as NIR-II light.

To overcome these limitations, this PhD project will implement synthetic engineering for bright NIR-II quantum dots, surface engineering for biocompatibility, and preclinic validation in theranostics (Figure 1):

I. **Synthesis & Photophysics:** Developing and optimizing robust microwave-assisted protocols to synthesize quantum dot nanoparticles. Metal doping and shell structures will be used for brightness enhancement. The resulting products will be systematically characterized through XRD, TEM, DLS as well as photoluminescence spectroscopy. Physico-chemical characterization by capillary electrophoresis coupled to UV, fluo and other detectors will allow to synergistically optimize the synthesis in terms of impurities, size, polydispersity, etc (ref 2).

II. **Surface Functionalization:** As-synthesized nanoparticles are typically hydrophobic, the candidate will develop surface chemistries (ligand exchange or polymer encapsulation) to render the nanoparticles highly water-soluble, stable in biological media, and functionalized with targeting moieties (e.g., peptides or antibodies targeting cancer cells) and therapeutic photosensitizers. Physico-chemical characterization of the functionalized quantum dots will be undergone along with the studies of the nanoparticle interaction with plasmatic mimicking medium and their biotargets to optimize their biocompatibility and biodistribution properties (ref 3).

III. **Bioimaging and Therapy (Theranostics):** The functionalized nanoprobes will be evaluated *in vitro* and *in vivo* for toxicity and antitumoral activity. The optical probes will be used as deep-tissue NIR-II imaging contrast agents with MRI imaging as anatomic reference modality to validate preclinical performance. Furthermore, specific designed photosensitizers will be coupled on the nanoparticle surface to

enable photothermal or photodynamic therapy, which can locally kill cancer cells under light irradiation (ref 4).

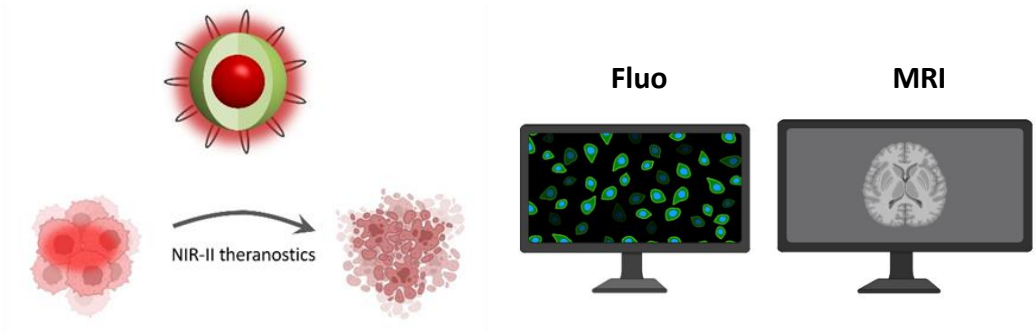

Figure 1. Workflow in the project including nanoparticle development and multimodal theranostic validation.

2. Expected outcomes (Retombées attendues)

- Development of a fast and reproducible synthetic route for NIR-II emitting nanomaterials.
- Highly bright NIR-II emitting silver chalcogenide nanoprobes with biocompatible interfaces.
- *In vitro* and *in vivo* proof-of-concepts demonstrating the superiority of these probes for multimodal imaging and therapeutic function in cancer theranostics.

3. Candidate profile (Profil du candidat souhaité)

- **Education:** Master's degree (or equivalent engineering degree) related to Chemistry, Materials Science, Biomedical Engineering or Bioimaging.
- **Hard Skills:** Strong background in colloidal chemistry and synthesis. Previous experience with nanoparticle synthesis, optical spectroscopy (UV-Vis, photoluminescence), surface functionalization, biomedicine, structural and chemical characterization (TEM, XRD, analytical methods) is highly desirable.
- **Interests:** A strong motivation to work at the interface of chemistry and biology, in multidisciplinary domains. While biological experiments will be done in collaboration, the candidate must be eager to learn cell culture, *in vitro* assay techniques, analytical methods, and bioimaging.
- **Soft Skills:** Scientific rigor, critical thinking, autonomy, and good communication skills in English (written and spoken).

4. Application documents (Documents de candidature)

To apply, please submit the following items to Dr. Bich-Thuy Doan and Dr. Zijun Wang by 31 May 2026.

- Cover letter;
- Curriculum Vitae;
- 2 reference letters (to be submitted by the reference writers).

5. References

1. Du, Kaimin, Liying Ma, Kun Liu, Pengpeng Lei, and Hongjie Zhang. Near-infrared-II Ag-based quantum dots for fluorescence imaging. *Materials Today Bio* (2025) 35, 102611.
2. Wang, Zijun, Jeongmo Kim, Lilian Magermans, Francesca Corbella, Ileana Florea, Eric Larquet, Jongwook Kim, and Thierry Gacoin. Monazite $LaPO_4$: Eu^{3+} nanorods as strongly polarized nano-emitters. *Nanoscale* (2021) 13, 16968.
3. Gonzalo Ramirez-Garcia, Fanny d'Orlyé, Silvia Gutierrez-Granados, Minerva Martinez-Alfaro, Nathalie Mignet, Cyril Richard, Anne Varenne. Electrokinetic Hummel-Dreyer characterization of nanoparticle-plasma protein corona: the non-specific interactions between PEG-modified persistent luminescence nanoparticles and albumin. *Colloids and Surfaces B: Biointerfaces* (2017) 159, 437.
4. Sarah Boumati, Angélique Sour, Valérie Heitz, Johanne Seguin, Gautier Beitz, Yusuke Kaga, Marta Jakubaszek, Johannes Karges, Gilles Gasser, Nathalie Mignet, Bich-Thuy Doan. Three in one: in vitro and in vivo evaluation of anticancer activity of a theranostic agent that combines magnetic resonance imaging, optical bioimaging, and photodynamic therapy capabilities. *ACS Applied Bio Materials* (2023) 6, 4791.