

## DOCTORAL THESIS

### Biocompatible luminescent probes for imaging and inhibition of cancers

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*Date of Award:*  
2018

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## Biocompatible luminescent probes for imaging and inhibition of cancer

### Résumé

Cette thèse s'inscrit dans le cadre d'une collaboration entre Hong Kong Baptist University (Dr. Gary K-L Wong) et le Laboratoire d'Ingénierie Moléculaire Appliquée à l'Analyse (LIMAA - Dr. Loïc Charbonnière) financé par la région Alsace afin de synthétiser des nouvelles nanosondes pour la détection, l'imagerie et le traitement du cancer. Le premier travail a été de synthétiser des nouvelles nanoparticules ultrabrillantes hybrides. Elles ont été obtenues à partir d'un noyau  $\text{La}_{0,9}\text{Tb}_{0,1}\text{F}_3$  et recouvertes de différents ligands. Grâce au mécanisme d'effet d'antenne, la brillance des nanoparticules a été considérablement améliorée. Le deuxième travail a été de synthétiser un nouveau ligand pour photosensibiliser les nanoparticules  $\text{La}_{0,90}\text{Eu}_{0,1}\text{F}_3$  hydrosolubles afin d'améliorer l'émission de l'euporium. Un second ligand et des nouvelles nanoparticules hétérométalliques ont été synthétisées dans le but de favoriser le transfert d'énergie des ions  $\text{Tb(III)}$  à la surface des NPs vers les ions  $\text{Eu(III)}$  dans le noyau des nanoparticules pour obtenir des temps de vie très longs et un rendement quantique exceptionnel en solution aqueuse. Le dernier travail a été de fonctionnaliser des nanoparticules de g- $\text{C}_3\text{N}_4$  (graphitic-carbon nitride) par des porphyrines. Les porphyrines ont été synthétisées pour générer de l'oxygène singulet ( $^1\text{O}_2$ ), pour accueillir un ion  $\text{Ga}^{3+}$  dans sa cavité et deux espaceurs différents pour être couplés aux nanoparticules. Ce système a pour objectif d'être sensible au pH, être un agent théranostique pour l'imagerie TEP et la thérapie PDT.

**Mots-clés :** Cancer, nanoparticules, lanthanide (III), transfert d'énergie, imagerie, porphyrine

### Abstract

This joint PhD program is part of a collaboration between Hong Kong Baptist University (Dr. Gary K-L Wong) and Laboratoire d'Ingénierie Moléculaire Appliquée à l'Analyse (LIMAA - Dr. Loïc Charbonnière) funded by the Alsace region to synthesize new nanoprobes for sensing, imaging, and inhibiting cancer diseases. The first work was to synthesize new hybrid ultrabright nanoparticles. They have been obtained from a  $\text{La}_{0,9}\text{Tb}_{0,1}\text{F}_3$  core and coated by different ligands. Thanks to a mechanism of antenna effect, the brightness of the nanoparticles has been significantly improved. The second work was to synthesize a new ligand to photosensitize water-soluble  $\text{La}_{0,90}\text{Eu}_{0,1}\text{F}_3$  nanoparticles in order to improve the emission of europium. A second ligand and new heterometallic nanoparticles have been synthesized with the aim to promote the energy transfer from  $\text{Tb(III)}$  ions on the surface of the NPs to  $\text{Eu(III)}$  ions in the core of the nanoparticles and to get a very long excited-state lifetime and an exceptional quantum yield in aqueous solution. The last work was to functionalize water-soluble graphitic-carbon nitride (g- $\text{C}_3\text{N}_4$ ) nanoparticles by porphyrins. The porphyrins have been synthesized to generate singlet oxygen ( $^1\text{O}_2$ ), to host a  $\text{Ga}^{3+}$  ion inside their cavity and with two different linkers to be coupled to nanoparticles. This system aims to be a pH sensor, and a PDT and PET theranostic agent.

**Keywords:** Cancer, nanoparticles, lanthanide (III), energy transfer, imaging, porphyrin.

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