Lanthanide Molecules and Nanomaterials able to Emit in the Near-infrared: from Fundamental Research to Applications in Optical Bioimaging

Due to their electronic structures, lanthanide cations possess very unique optical properties. We are interested to take advantage of their luminescence properties with a strong focus on near-infrared luminescence to address a broad range of requests in the fields of biological imaging, energy conversion and anti-counterfeit systems.

One of the specific aspects of our research lies in the design, synthesis, characterization of molecules and nanomaterials incorporating luminescent lanthanides taking into account the requirements of optical bioimaging (in cells, tissues and small animals). Fluorescence and luminescence-based detection techniques possess important advantages for bioanalytical applications and biologic imaging: high sensitivity, high cellular resolution, portability, versatility and low costs of instrumentation. A common characteristic of biologic analytes present in biological systems is their presence in small quantities among complex matrices such as blood, cells, tissue and organs. These matrices emit a significant background fluorescence (autofluorescence), limiting detection sensitivity.

The luminescence of lanthanide cations has several complementary advantages over the fluorescence of organic fluorophores and semiconductor nanocrystals, such as sharp emission bands for spectral discrimination from background emission, long luminescence lifetimes for temporal discrimination and strong resistance to photobleaching.

In addition, several lanthanides emit near-infrared (NIR) photons that can cross deeply tissues for non-invasive investigations and that result in improved detection sensitivity due to the absence of native NIR luminescence from tissues and cells (autofluorescence). The main requirement to benefit from lanthanide emission is to sensitize them with an appropriate chromophore (“antenna effect”). The choice of this antenna allows the tuning of the excitation wavelength of the resulting complexes.

We will discuss in this presentation different approaches to reach this goal from small molecules, macromolecules (metallacrowns and dendrimer complexes) to nanomaterials (MOFs).

We will compare and discuss the design, synthesis, characterization, spectroscopic properties and examples of optical imaging based on compounds obtained from different approaches.