LABORATOIRE DE CHIMIE

PhD offer in Organic Chemistry and Fluorescence Spectroscopy

Fluorescent organic dyes and dye-nanoparticles for thermal imaging

Colorants et nanoparticules organiques fluorescents pour l'imagerie thermique

Context: Temperature is one of the most important physical parameters in science, technology, physiology and everyday life. Yet, accessing temperature variations at small length and time scales remains technically challenging. Conventional thermometry techniques generally lack the spatial resolution and responsiveness required to detect local, transient thermal heterogeneities, particularly in complex or heterogeneous environments such as soft matter, microstructured systems, or biological samples. Among the numerous temperature sensing methods fluorescence detection is one of the most efficient due to its fast response and scalable spatial resolution down to microscopic levels. Our general research objective is to establish highly sensitive fluorescence imaging methods for temperature sensing with high spatial resolution. Despite several recent report on this topic, temperature-dependent fluorescence sensing is still relatively poorly explored. [1] Therefore, we aim to investigate the different photophysical mechanisms responsible for temperature dependent emission and establish **molecular and material engineering strategies** to obtain **dyes exhibiting strong temperature dependent fluorescence.**

Research objectives: Several photophysical mechanism have been explored to enable temperature monitoring via fluorescence detection. Polarity sensitive **donor-π-acceptor** (D-π-A) **dyes** have recently emerged as promising candidates as fluorescence thermometers. However, the underlying photophysical mechanism of their fluorescence is not yet understood. The first objective will be to uncover the structure-property relationships resulting in the photophysical mechanism of these dyes and further engineer the molecular architectures for highly sensitive temperature sensing using small organic molecules.

An alternative strategy is to employ **nanoparticles** containing poorly-emissive dyes that become fluorescent upon aggregation (**aggregation induced emission**, AIE). The advantage of these AIE-type organic nanoparticles is that they can be easily formulated from D-π-A dyes and they can be highly emissive in biological environment. The temperature dependent fluorescent feature of AIE nanoparticles has been demonstrated very recently. The second objective of the thesis will be, therefore, to explore the conditions of nanoparticle formulation and establish the design rules for temperature monitoring using fluorescent organic nanoparticles.

The photophysical properties of the developed fluorescent dyes and nanoparticles will be thoroughly characterized by steady-state and time-resolved **fluorescence spectroscopy as a function of the temperature** in various sample environments. Furthermore, their **two-photon absorption** cross sections will be characterized with the objective to employ the developed compounds in fluorescence imaging.

The ultimate objective is to construct a diversified library of organic dyes suitable for two-photon-induced fluorescence thermometry. The development of these new fluorophores opens the door to novel analytical coupling strategies in chemistry, where temperature-sensitive fluorescence can be combined with other spectroscopic or imaging modalities.

Lab and environment: The thesis will take place at the Chemistry Laboratory in ENS Lyon (UMR 5182). The laboratory has all the necessary equipment to carry out the project, including the synthesis of the dyes, the formulation of the nanoparticles, as well as their spectroscopic studies in solution and in the solid-state.

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Candidate Profile: To successfully undertake this project, we seek a motivated and autonomous student with a Master's degree in Chemistry, with experience in organic chemistry and physical chemistry. An interest in biological applications and imaging would be a plus. The ideal candidate will possess excellent problem-solving skills, a keen scientific curiosity, and the ability to work independently.

How to apply: Interested persons are requested to send a detailed CV with a covering letter and the marks and rank obtained in Master 2. Letter of recommendation or contact to a person who can provide it would be a welcome addition.

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References:

[1] Li, S. et al. Response strategies and biological applications of organic fluorescent thermometry: cell- and mitochondrion-level detection, *Anal. Methods*, **2024**, 16, 1968–1984. 10.1039/d4ay00117f

[2] Rémond, M. et al. 4,5,5-Trimethyl-2,5-Dihydrofuran-Based Electron-Withdrawing Groups for NIR-Emitting Push-Pull Dipolar Fluorophores. *J. Org. Chem.*, **2019**, 84 (16), 9965–9974. 10.1021/acs.joc.9b01120.

[3] Akl, D. et al. Comprehensive Photophysical and Nonlinear Spectroscopic Study of Thioanisolyl-Picolinate Triazacyclononane Lanthanide Complexes, *Eur. J. Inorg. Chem.*, **2024**, e202300785. 10.1002/ejic.202300785