

TFM 2025-26 | Ocular fluorophores tracking using nanoparticles enhanced fluorescence imaging

Different aspects of ocular tissue function are encoded at the biochemical level through intrinsically fluorescent metabolites fundamental to visual processing. The retina and nearby tissue, choroid and sclera, is rich with endogenous fluorophores^{1,2}, every single one of them characterized by its own excitation and emission spectrum and exhibits a unique fluorescence lifetime, which can be used as indicators for specific metabolic conditions of changes within the molecular micro-environment³. However, the damage threshold for in vivo application in the human eye is a significant drawback for imaging techniques (i.e. multiphoton microscopy), which requires working at very low radiation levels, where signals are not well generated⁴.

Functionalized nanoparticles (NPs) with controlled geometrical and optical properties are the subject of intensive studies and biomedical applications, including genomics, biosensors, immunoassays, clinical chemistry, laser phototherapy of cancer cells and tumors, the targeted delivery of drugs, DNA and antigens, optical bioimaging and the monitoring of cells and tissues with the use of state-of-the-art detection systems. In particular, Gold NPs allow individual enhancement of the fluorophores signals⁵, therefore enhancing our access to low intensity endogenous fluorophores.

In this collaborative project, between

- **BIOSIM - BIOphotonics & Smart IMaging Lab, Institute of Optics of the Spanish National Research Council (CSIC) | María Viñas Peña.** Development of novel imaging techniques and computational methods to investigate the visual system, with particular focus on adaptive optics, advanced optical coherence tomography, and multimodal functional imaging. BIOSIM works at the interface of photonics, neuroscience, and ophthalmology, translating high-resolution optical technologies into clinical tools for early diagnosis and personalised management of eye and vision-related neural diseases.
- **IORC - Instituto de Investigaciones Oftalmológicas Ramón Castroviejo, Universidad Complutense de Madrid (UCM) | Elena Salobar García Martín.** Clinical and experimental research in ophthalmology, addressing retinal neurodegeneration, aging, and the pathophysiology of neuro-ophthalmic disorders. IORC combines basic science, translational studies, and patient-oriented research to explore biomarkers, neuroprotective strategies, and innovative treatments for degenerative retinal and optic nerve diseases.
- **ICTP - Instituto de Ciencia y Tecnología de Polímeros, Spanish National Research Council (CSIC) | Mar Fernández Gutiérrez.** Design, synthesis, and characterization of advanced polymeric materials with biomedical and ophthalmic applications. ICTP develops functional polymers for drug delivery, tissue engineering, and biocompatible devices, enabling new solutions for sustained ocular therapies, implantable systems, and smart materials supporting clinical innovation.

the candidate will work in the development of a novel experimental procedure, nanoparticles-enhanced fluorescence imaging methods, to track specific ocular fluorophores using

- (1) novel immunohistochemistry methods,
- (2) metallic nanoparticles delivery methods, and
- (3) fluorescence imaging methods.

1 Dysli, C. et al. *Fluorescence lifetime imaging ophthalmoscopy*. *Progress in retinal and eye research* **60**, 120-143, (2017).

2 Tang, J. A. H. et al. *Adaptive optics fluorescence lifetime imaging ophthalmoscopy of in vivo human retinal pigment epithelium*. *Biomed Opt Express* **13**, 1737-1754, (2022).

3 Boguslawski, J. et al. *In vivo imaging of the human eye using a 2-photon-excited fluorescence scanning laser ophthalmoscope*. *The Journal of clinical investigation* **132**, (2022).

4 Vinas-Pena, M., et al. *Fluorescence lifetimes of scleral tissues after riboflavin-mediated crosslinking*. *Invest. Ophthalmol. Vis. Sci.* **64**, 3356-3356 (2023).

5 Li, G.-C. et al. *Light-induced symmetry breaking for enhancing second-harmonic generation from an ultrathin plasmonic nanocavity*. *Nature Communications* **12**, 4326, (2021).

Impact & opportunities. The candidate will have the opportunity to learn and practice different methodologies, working in an interdisciplinary and international environment, with great scientific, clinical and industrial impact, with opportunities for academic and business professional development.

Candidate's profile. We are looking for a candidate with an excellent academic record, motivation for experimental and multidisciplinary work, work capacity, and excellent communication skills (in English and Spanish). The selection process includes an in-person interview. Motivation to pursue a career in Optics and Photonics will be greatly valued.

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