Persistent luminescence nanoparticles for biosensors and bioimaging

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Persistent luminescence is controlled by a slow liberation of trapped charge carriers by a simple thermal de-excitation process. It can last for few minutes to hours after the removal of the excitation source. The persistent luminescence mechanisms can be envisioned either from physics or chemistry points of view, playing with the intrinsic defects and the optimization of the trapping by stoichiometric variation and thermal annealing. Several applications were envisioned with these materials such as emergency signing, luminous painting, etc. More recently this concept was also proposed for the development of *new optical imaging modalities*. At nanoscale, deep red and near-infrared persistent luminescence nanoparticles enable highly sensitive *in vivo* optical detection and complete avoidance of tissue autofluorescence. Development of nanosize persistent luminescent materials was initiated by our research team in Cr^{3+} doped zinc-gallate nanomaterials and requires perfect materials with high fluorescence intensity and careful control of the defects [1]. Lot of parameters of these nanoprobes can be adjusted, such as surface functionalization, composition for instance by using Sn^{4+} as dopant to improve the intensity *(Fig.1 left),* or wavelength of the optical stimulation/emission to favor multiple challenging *biomedical applications*. Bioimaging applications can be tuned when using probes emitting in various biological windows *(BW-I and BW-II Fig.1 center),* since this could allow better imaging of deeper tissues, but this is not that simple as in BW-II efficient SWIR camera are required [2].

New applications of the persistent luminescence nanophosphors include optical sensors in nanothermometry field or biological markers. A novel *in-vitro* strategy for biomolecule detection was introduced, leveraging the dose-dependent enhancement of persistent luminescence signal upon exposure to hydrogen peroxide (H_2O_2) [3] *(Fig.1 right).* This approach enables both quantitative and qualitative detection of H_2O_2, a product of various enzymatic reactions and an essential biomarker in numerous diseases, including diabetes and cancers. The development of sensitive, rapid, and user-friendly H_2O_2 sensors is therefore of great biomedical significance. A comprehensive analysis of material structure, surface chemistry and spectroscopic and electrochemical properties is proposed.

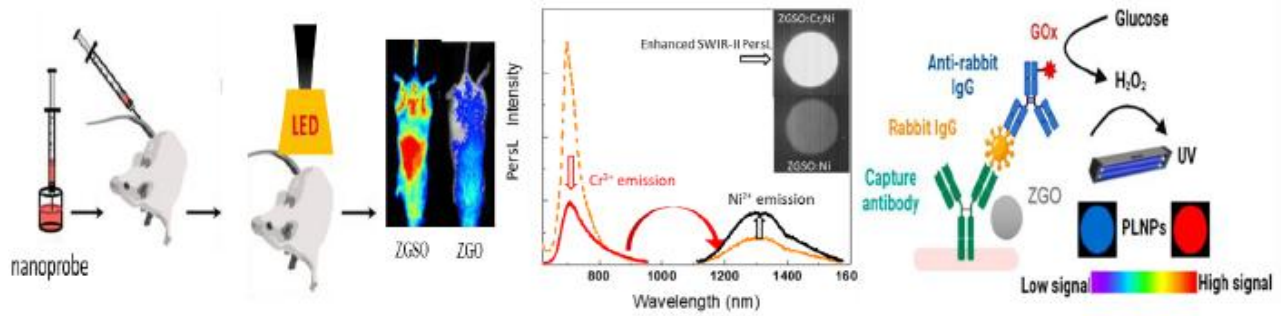

Fig.1. Persist. Lum. NPs with optimized: composition (left), dopant for SWIR bioimaging (center), and H_2O_2 nanosensors (right)

References

[1] B. Viana *et al*., in "NIR-persist. Lum. NPs for bioimaging, principle and perspectives" Book chapt. in Near Infrared-Emitting NPs for Biomedical Applications, Nature Springer, 163-197 **(2020)**, ed.: D. Jaque *et al*.
[2] G. Cai, B. Viana *et al*. Small 20 (51), 2406507 **(2024)** & Chemical Engineering Journal 490, 151643 **(2024)**
[3] Z. Ferjaoui, B. Viana *et al*. Adv. Opt. Mat. 13(4) 2402373 **(2025)**