Luminescent nanoparticle optical imaging for sensitive and portable detection of nucleic acids *in vitro* towards new generation diagnostic tests

The *in vitro* detection of pathogenic markers, either proteins or nucleic acids, is crucial for the diagnosis of numerous conditions, *e.g.* viral infectious diseases. Their efficiency relies on (i) their sensitivity, to identify pathogens at relevant concentrations, and (ii) their practicality, to allow their implementation possibly in context with limited logistics. However, these requirements are difficult to fulfill simultaneously, notably in the case of viral DNA or RNA. The detection of nucleic acid for medical purposes rely mostly on amplification-based, such as PCR or isothermal amplification, which –though sensitive (down to ≈10.000 cp/mL)- are costly and/or difficult to implement without specialized equipment and qualifications. We have developed the use of lanthanide-based nanoparticles (YVO_4:Eu) as reporter for biological imaging and, *in vivo*[1] or *in vitro*[2,3.45] The remarkable optical and chemical properties of these particles (high UV absorbance, larges Stokes shift, photostability, colloidal stability in aqueous buffers, and easy functionalization) qualifies them for the detection of biomolecules at high sensitivities. We thus have been designing optics based devices for the detection of proteins on strip-based immunoassays (Lateral Flow Assays or LFA, Figure) at high sensitivities.

During this Master 2 internship, we propose the demonstration of the feasibility of the amplification-free detection of DNA and RNA fragments on LFA. This work will thus involve (i) the development of optical detection and analysis of nanoparticle signal in LFA in complex media (i) the development of methodologies for DNA/RNA hybridization on strip and their integration in microsystems for multiplexed detection, (iii) evaluation and comparisons with conventional tests of the performances (sensitivity, concentration range, reproducibility) of the tests on model molecules DNA and RNA fragments. The next step will be the adaptation of this methods to physiological buffers in which actual test may be performed (blood, serum, urine or saliva) whose optical and chemical properties may hinder the test sensitivity, respectively due to the endogenous fluorescence and scattering and non-specific interactions. Altogether these results will aim at setting the basis for efficient fast *in vitro* diagnostic tests on strip, based on viral DNA/RNA detection. The internship is part of an interdisciplinary project, involving skills in biochemistry and biophysics, optics and imaging. It could be followed by a thesis project aiming at developing optical diagnosis tests, both for protein and nucleic acids detection and under LFA or ultra-sensitive detection modality for a use in a medical environment.

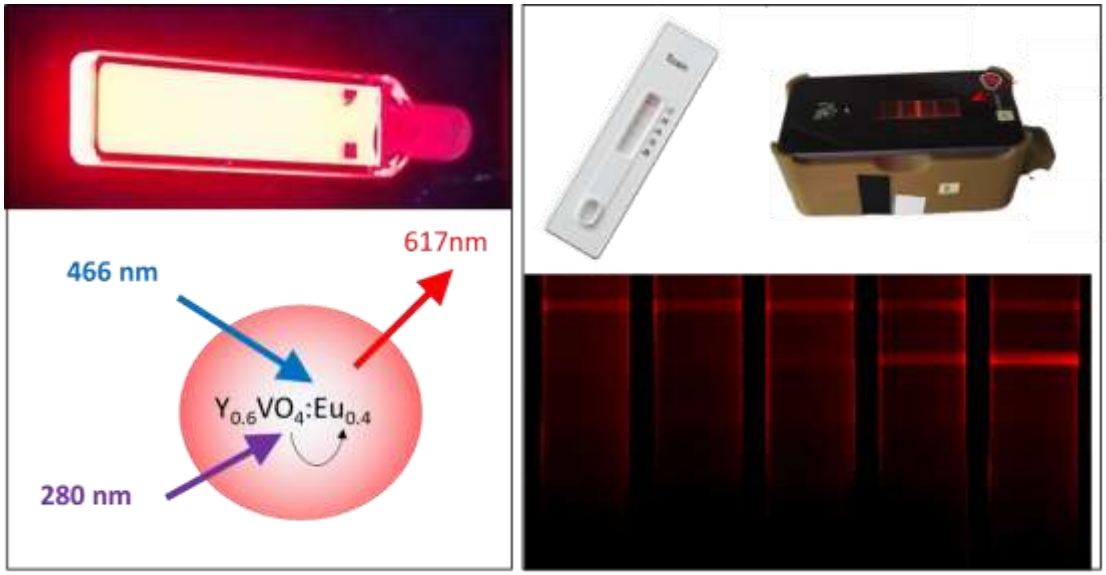

Figure 1. Leftt :nanoparticle luminescence under UV exctiation. Right : Typical LFA test and a portable UV reader (top) and typical images of proteins (toxins) detected with the reader.

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[1] Abdesselem et al. Biomed. Opt. Exp (2023)
[2] Mousseau et al. ACS Anal. Chem (2023)
[3] Mousseau et al. Nanoscale (2021)
[4] Preira et al. Patent WO2020/016308A1 (2020)
[5] Kuhner et al. biorXiv 10.1101/2025.06.03.657629 (2025)

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