Biochemistry for the binding of bacterial cells with gold nanoparticles for Surface-Enhanced Raman Spectroscopy (SERS)

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Project type: Masters project

Context

Bacterial contamination of food products represents an ongoing public health hazard, results in a massive waste of food and costs hundreds of millions of francs to food companies every year.

At the heart of it is the fact that current bacterial detection and identification methods used in the food industry (and many other industries) are slow and can require up to a week to provide results.

At the Laboratory of Quantum and Nano-Optics (LQNO), we are looking to build the next generation of bacterial sensing technology, using Raman spectroscopy and its variants, combined with a solid understanding of biochemistry, microfluidics know-how and powerful machine learning techniques.

The project is extremely interdisciplinary and gives students the opportunity to familiarize themselves with a wide range of technologies, as well as gain experience in translating basic sciences to applied research.

Project overview

The working principle of our current method is illustrated in Figure 1. In order to detect and identify bacterial cells, they need to be enriched with gold nanoparticles, which allows us to obtain extremely strong signals due to an optical phenomenon known as Surface-Enhanced Raman Scattering (SERS) under a red or near-infrared laser beam. Binding gold nanoparticles to bacteria (Figure 2) in a non-specific way is a relatively unexplored scientific avenue and requires the judicious selection of binding agents, as well as careful control of parameters such as pH, temperature and incubation times. The aim of the project will be to develop and optimize protocols for bacteria-gold adsorption focused on cost-efficiency, sustainability and ease-of-use. Evaluation of these protocols will be achieved through optical microscopy, Transmission Electron Microscopy (TEM) and SERS, among other techniques.

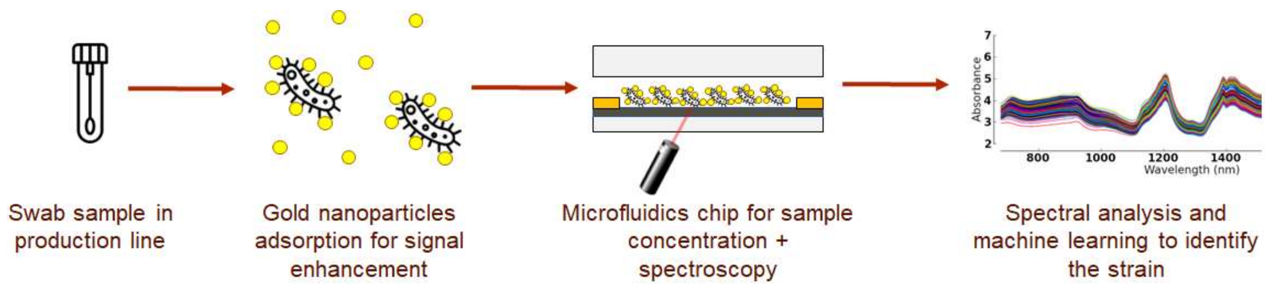

Figure 1. Current process flow: a liquid sample containing bacteria is enriched with gold nanoparticles and immobilized in a microfluidic chip. Then, the spectral signature of the bacteria-gold complexes is acquired and analysed with machine learning to identify the strain of bacteria.

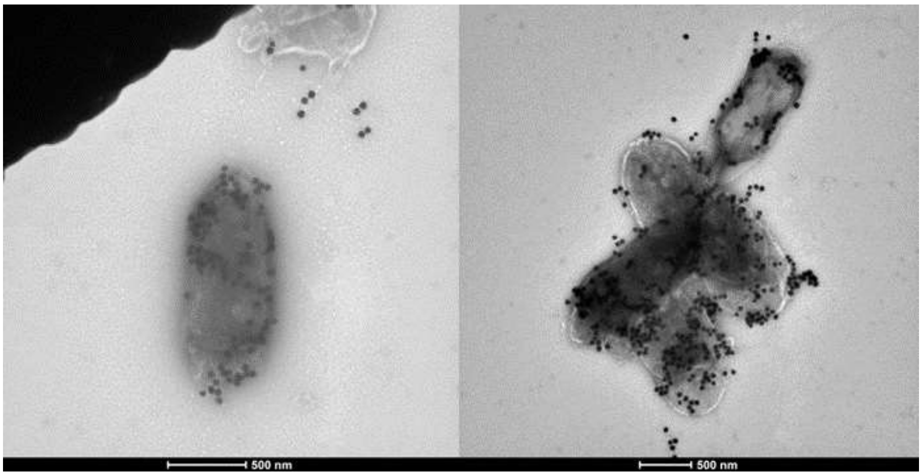

Figure 2. Bacterial cells covered with gold nanoparticles (black dots), seen under TEM.

What the student will do

Throughout the project, the student will work on chemically modifying gold nanoparticles in an attempt to increase their affinity to bacteria while maintaining the stability of gold nanoparticles in aqueous solutions. This work will include a wide array of chemical work and techniques from gold nanoparticles synthesis, surface functionalization and ligand exchange, spectroscopy measurements (SERS & UV/Vis), Zeta potential measurements, TEM, bacterial culture and sample preparation, etc. Depending on the progress of the project, opportunities for publication might arise, which the student will be encouraged to participate in if they wish.

Who we are looking for

We are looking for students pursuing a degree in chemistry, life sciences or related fields. Students from unrelated fields may also apply if they demonstrate prior experience or great interest and willingness to learn. Most importantly, we are looking for students who are motivated and able to work autonomously.

Interested? Get in touch to apply or learn more -> marwan.elchazli@epfl.ch