Abstracts of Papers of the American Chemical Society

Illuminating bacterial communities with plasmonic nanoantennas

Regina Ragan,William Thrift, Antony Cabuslay, Allon Hochbaum

PRESENTED AT ACS Fall (2019) – American Chemistry Society
August 25-29, 2019

Abstract

Nanotechnology-based biosensors offer the ability to leverage a vast numbers of sensing elements per unit area. When coupled with a smart readout mechanism they offer the ability to mimic sensitive olfactory systems that relies on an interplay between sensitive receptors and synaptic processing of olfactory information. Surface enhanced Raman scattering (SERS) can simultaneously sense large numbers of small molecules, which can be differentiated based on their vibrational signature; thus it doesn't require capture agents such as antibodies and aptamers. Yet, SERS spectra are complex and difficult to attribute to individual molecules in a complex mixture. We first will present how 2-dimensional physically activated chemical (2PAC) assembly uses electrohydrodynamic flow to enable controlled molecular cross-linking between nanospheres. It overcomes long-standing challenges in reproducible nanomanufacturing of plasmonic 'nanoantennas' serving as ultrasensitive receptors. 2PAC achieves uniform (<10% RDS) billion fold enhancements in elements spanning mm^2. Large datasets can thus be acquired from 2PAC fabricated sensors that are critical for reliable training data for machine-learning (ML).

The SERS+ML approach enables early detection of biofilm formation. For example, supernatent from a culture from the opportunistic pathogen *Pseudomonas aeruginosa* are flowed over SERS sensors in a microfluidic channel. SERS+ML is able to detect biofilm formation as early as 3 hours after inoculation. Bacteria exposed to a bactericidal antibiotic were differentially less susceptible after 10 h of growth, indicating that these devices are useful for early intervention of bacterial infection. Further, we present that the complex vibrational signature of metabolites after antibiotic exposure provides the ability to distinguish between antibiotic resistant and susceptible strains. The complex metabolite vibrational signatures are used to distinguish antibiotic resistant from antibiotic susceptible P. *aeruginosa*. This is achieved after just 30 minutes of antibiotic exposure at the minimum inhibitory concentrations using linear discriminant analysis of SERS spectra from bacterial lysate.