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SERS-active arrays of gold- and silver-coated porous silicon nanowires for bacterial identification and antibiotic susceptibility testing

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Given the ever-growing threat of infectious diseases, it is crucial to respond promptly to bacterial contaminations. Although current microbiological methods for pathogen detection are reliable, they can be laborious and require laboratory equipment. Conversely, techniques utilizing the interaction of light with biomolecules offer the potential for ultrafast, specific, and reliable analysis.

Surface-enhanced Raman spectroscopy (SERS) is one such method that relies on the local surface plasmonic resonance generated by nanostructured noble metal surfaces like silver (Ag) and gold (Au). It is considered an alternative approach for biomolecule detection. Raman spectrometers can be designed to be portable, and conducting bacterial tests using this method is relatively simple.

Recently, numerous studies have focused on the application of surface-enhanced Raman spectroscopy (SERS) in biosensors. These studies have demonstrated the method's exceptional sensitivity in detecting both Gram-positive and Gram-negative bacterial strains, as well as their mutations. Furthermore, SERS has shown the potential to generate an optical signal from a single cell [1]. However, it has been observed that the choice of SERS-active substrate significantly affects the results, leading to ongoing debates regarding various enhancers of the SERS signal.

Porous silicon nanostructures, specifically porous silicon nanowires (pSi NWs), have immense potential in the advancement of SERS biosensors. These nanostructures have already demonstrated their capabilities in detecting bacterial metabolites [2], DNA [3], and various other molecules. The remarkable combination of a large surface area and high porosity in pSi NWs makes them highly suitable for functionalization with silver (Ag) and gold (Au) nanoparticles (AuAg@pSiNWs) for SERS applications. Furthermore, the porous structure of pSi NWs facilitates improved adsorption of bacterial samples onto the substrate, further enhancing the efficiency of the biosensor.

In this study, AuAg@pSi NWs substrates were developed for SERS diagnosis of *L. innocua* food bacteria (Fig. 1). It was shown that the bacteria were detected up to a concentration of 10^6 CFU/ml. It is shown that SERS with the developed substrates can be used for rapid analysis of bacteria antibiotic resistance: the characteristic scattering lines of bacteria disappeared after 1 hour of incubation with gentamicin. The results presented can make a significant contribution to the field of diagnostics and the development of effective strategies for combating antibiotic resistance.

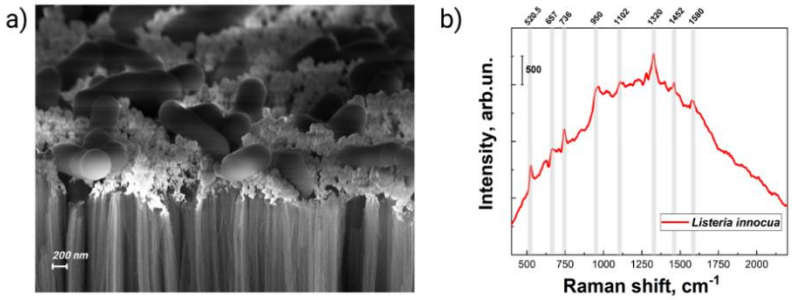

Fig. 1 a) SEM image of *L. Innocua* adsorbed onto AuAg@pSiNWs surface; b) SERS spectra of *L. Innocua* incubated with gentamycin.

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