Multimethod Approach to Understand SERS Nanoprobes in Cells

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Understanding the behavior of SERS substrates in complex biosystems is of great interest for medical diagnostics, therapeutics, and in bioanalytical approaches. Based on the beneficial properties of the plasmonic gold and silver nanoparticles, uptake and processing of SERS substrates can be followed inside eukaryotic cells by complementary methods that enable characterization of their intracellular distribution in the cell ultrastructure and quantification, such as cryo X-ray tomography (cryo-XT) and mass spectrometry, respectively.

By SERS, we obtain information about the molecules interacting with the particle surface that could be biomolecules from inside the cell or extrinsic molecules, e.g., reporter molecules, pharmaceuticals (e.g., antidepressants), or components of the culture medium.[1-3] The SERS information on the molecular composition in the immediate environment of the nanostructures, allows to deduce transport mechanisms and molecular changes within the vesicles throughout a cell's lifetime[1-3]. The uptake and processing of the nanoparticles into cells differ strongly for different types of nanoparticles due to their different physico-chemical properties. Cryo-XT gives 3D information about the distribution and arrangement of metal nanoparticles in the cellular ultrastructure due to the high contrast of the particles in the biological environment. For silver nanoparticles, the X-ray tomograms prove the presence of 2D ring-like nanostructures in the cellular ultrastructure which can be correlated with the formation of a specific biomolecule corona investigated by SERS.[2] To analyze the quantitative uptake and distribution of nanoparticles in single cells, we used laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS). In a series of pulse-chase experiments the nanoparticle pathway from endocytotic uptake, intracellular processing, to cell division is monitored for 14 nm sized gold nanoparticles by combining SERS data with quantitative information from LA-ICP-MS.[1]

By the use of these complementary methods we are able to get insight into the biological reaction pathways of SERS substrates in live cells. The data indicate that particle properties, aggregate geometry, and surface modification of noble metal nanoparticles play a critical role for their use as efficient SERS nanoprobes.

References

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