Surface-Enhanced Raman Spectroscopy and Imaging with Tailor-Made Plasmonic Nanoparticles

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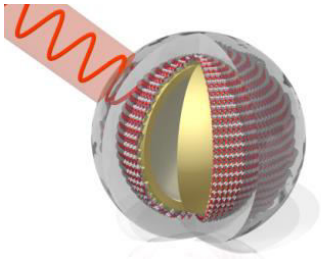
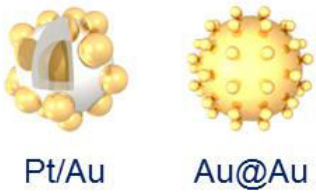
Surface-enhanced Raman scattering (SERS) has become a mature vibrational spectroscopic technique during the last decades and the number of applications in the chemical, material, and in particular life sciences is rapidly increasing.[1] In addition to normal Raman spectroscopy, SERS requires plasmonically active materials, for instance noble metal colloids, which support localized surface plasmon resonances.

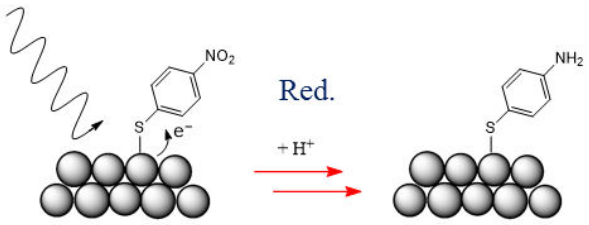
This talk gives an overview on the rational design and synthesis of molecularly functionalized noble metal colloids for chemical and bioanalytical applications of SERS. After a brief introduction on the theoretical foundations of SERS, two different topics from the chemical sciences with results from our group will be covered. In both cases plasmonic nanostructures with tailor-made physical and chemical properties play a key role.

Immuno-SERS microscopy (iSERS) for tissue-based cancer diagnostics employs target-specific colloidal SERS probes in combination with Raman microspectroscopy. SERS-labeled antibodies allow the selective and sensitive localization of the corresponding antigen in tissue specimens. The properties of the colloidal SERS probes[2] are crucial for the success of iSERS experiments. Signal brightness, stability and robustness as well as steric accessibility for bioconjugation are few very important aspects. For instance, small Raman reporter-functionalized clusters of noble metal nanoparticles (NPs) are very bright SERS labels due to plasmonic coupling. Small clusters of AuNPs were further used for iSERS imaging on prostate biopsies. Current work in our laboratories and future developments of this innovative iSERS imaging approach will be discussed.



The second part of the talk covers label-free monitoring of chemical reactions catalyzed by Pt, Au and Ag nanoparticles. Bifunctional nanoparticles exhibiting both high plasmonic and catalytic activity are required, but not routinely available. We designed and synthesized Au/Pt nanoraspberries as well as Au/Au and Ag/Ag core/satellite superstructures for this purpose.[3-5] Electron microscopy demonstrates the high uniformity of the particles. Computer simulations predict very high plasmonic activity due to plasmonic coupling, resulting in several hot spots. For proof-of-concept studies 4-nitrothiophenol, which is present as a monolayer on Au and Ag surfaces, was chosen. The reduction to 4-aminothiophenol can be achieved either by chemical hydride agents [3-4] or by a combination of hot electrons and protons.[5] Current work from our group on temperature-controlled microfluidics for kinetic reaction monitoring as well as future directions for the use of hot electrons for driving chemical reactions will be discussed.





References

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