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Core-Shell Nanoparticle-Based Plasmon-Enhanced Molecule Spectroscopies: from methodology to theory

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To break through the bottleneck of SERS development in the surface analysis of a great variety of non-SERS active materials and atomically flat single-crystals, we invented shell-isolated nanoparticle-enhanced Raman spectroscopy (SHINERS) in 2010 [1]. The shell-isolated nanoparticle-enhanced mode is capable of characterizing the surface water, reaction intermediate species in many important electrocatalytic or photo-electrocatalytic systems, and interfacial structures of the solid electrolyte film [2]. The strategy of using shell-isolated nanoparticles is grossly extendable to other surface spectroscopies, like surface-enhanced fluorescence spectroscopy [3], surface-enhanced second-harmonic generation [4], sum-frequency vibrational spectroscopy, and tip-enhanced spectroscopies [5], to improve the enhancement factor (up to 10^5) or spatial resolution (down to 10 nm). It will attract more attention if these techniques are applied to in-situ monitor the actual catalytic reaction systems, e.g., at single atoms or a single molecule. In the aspect of fundamental understanding of SHINERS, New plasmonic nanostructures and relevant instrumentation and theory for pushing sensitivity to the limit will be discussed in details [6]. Finally, we would like to explore on the radiation enhancement that cannot be easily predicted by the local field enhancement in the presence of plane-wave illumination at the Raman scattered wavelength in the case of nanoparticle-on-mirror substrate. The mismatch could be understood by the radiation enhancement of the optical antenna in the reaction near-field region instead of the far-field region [7].

Keywords: SERS, SHINERS, Molecule spectroscopies, Shell-isolated nanoparticles, Plasmonic nanostructures, Radiation enhancement

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