Quantum Plexcitonic Nanoprobes for Ultrasensitive SERS Biosensing

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Summary

The nanomedicine of the future requires novel nanoprobes with on demand properties for ultrasensitive biosensing. Surface enhanced Raman scattering (SERS) is an ultrasensitive technique which allows the detection of analytes in very low concentrations. This ultrasensitive technique mainly relies on the appropriate tuneability of the incident light and the strong local electric field generated by plasmonic NPs coupled with the vibrational modes of the molecule. However, often the intrinsic low analyte concentrations, lack of metal affinity or the complexity of matrices render direct SERS detection of the molecule of interest practically impossible. In these cases an indirect detection employing SERS tags is required. Thus, a SERS tag or SERS encoded nanoparticles is a probe system which combine a plasmonic nanoparticle and an active Raman reporter molecule that can be employed to label a target molecule and indirectly identify its presence and location [1].

Almost all the development on SERS tags has been done with optically active molecules weakly coupled to plasmonic nanoparticles. In this work we would like to exploit the extraordinary properties of quantum plexcitonic nanoparticles [2], where the active Raman reporter is strongly coupled to an open plasmonic cavity. This new range of ultrasensitive quantum SERS tags can open new exciting possibilities in photochemistry and enhanced spectroscopy exploiting the extraordinary properties of quantum hybrid matter as improved photostability [3] or harvested excitons [4].

Our quantum plexcitonic nanoprobes are formed by J-Aggregates strongly coupled to plasmonic hollow nanoparticles. These hybrid systems were prepared by galvanic replacement-seeded growth method [5], a novel synthetic route involving the transformation of Ag nanoparticles into closed hollow gold-silver nanoparticles in the presence of the J-Aggregates. Interestingly, the addition of J-aggregates at different concentrations during the synthesis, lead to its encapsulation within the inner void being isolated by the external chemical environment and maintaining stable their optical properties. Their optical properties evidence the achievement of strong coupling regime between hollow plasmonic nanoparticles and J-Aggregates. We have analyzed the optical properties of these plexcitonic nanoparticles as a function of the morphology and concentration of J-Aggregates in the reaction mixture. The SERS signal reveals that plexcitonic nanoparticles are one order of magnitude more efficient than weakly coupled J-aggregate/plasmonic SERS tags showing the potential use of this quantum nanoprobes por ultrasensitive biosensing.

References:

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