Multifunctional Fe_3O_4@SiO_2-Au Nanostructure as SERS Substrate

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Plasmonic core-satellite structures have promoted the application of surface-enhanced Raman scattering (SERS) in chemical analysis [1]. However, most of these structures are limited to a single use or single function. Taking advantage of the explosive growth in nanofabrication, the exploitation of multifunctional nano-assemblies, including plasmonic core-satellite structures, has caused increasing interest in integrating novel optical, charge selective, and magnetic properties [2]. Nanofabrication of multifunctional SERS substrates is strongly desirable, but currently remains a challenge. The motivation of this study was to design such a substrate – a versatile core-satellite Fe_3O_4@SiO_2-Au (FA) hetero nanostructure – and demonstrate its use for charge-selective detection of food dye molecules as an exemplary application. Our experimental results and three-dimensional finite difference time domain (FDTD) simulation suggest that tuning the Au nanoparticle (NP) gap to sub-10 nm, which could be readily accomplished, substantially enhanced the Raman signals. Further layer-by-layer deposition of a charged polyelectrolyte on this magnetic SERS substrate induced active adsorption and selective detection of food dye molecules of opposite charge on the substrates. Molecular dynamics (MD) simulations suggest that the selective SERS enhancement could be attributed to the high affinity and close contact (within a 20 Å range) between the substrate and molecules. Density function theory (DFT) calculations confirm the charge transfer from food dye molecules to Au NPs via the polyelectrolytes. This multifunctional SERS platform provides easy separation and selective detection of charged molecules from complex chemical mixtures.

[1] Gandra *et al.* (2012) *Nano Lett.* **12**, 2645-2651.
[2] Yang *et al.* (2014) *RSC Adv.* **4**, 49635-49646.