Gold Nano-stars for Surface Enhanced Raman Scattering

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Advances in nanophotonics have shown the potential of colloidal metal particles with sharp tips, such as nanostars, to focalize the plasmonic electromagnetic fields.

SITUATION

Since the late seventies, SES (surface-enhanced spectroscopies) has been carried out on spheres, rods, cubes, octahedra, and various other geometries within a wide size range. However, a new family of colloidal structures, resembling a central sphere from which radial, acute tips branch out, has been recently reported to yield extraordinary field enhancements for SERS (surface-enhanced Raman scattering).

APPROACH

The central sphere of these structures, called nano-stars, acts as an electron reservoir while the tips are capable of focalizing the field at their apexes. Similar size nano-stars and nano-spheres are compared in this article.

RESULTS

The synthesis methods employed in this work yield highly monodisperse dispersions in size and shape for both nanospheres (47 +- 4 nm) and nanostars (41 +- 8 nm), as shown in Figure 1. In solution, the spherical nanoparticles present a surface plasmon band centered at 527 nm. In contrast, star-shaped colloids of comparable size present a strongly red-shifted surface plasmon resonance, with a maximum absorbance at 730 nm, in the near-infrared (NIR) region.

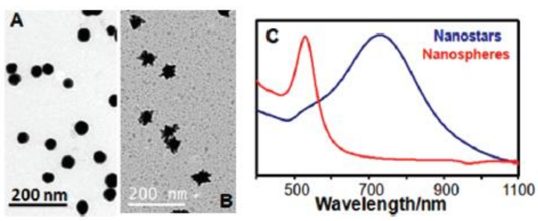

Figure 1_ TEM micrographs of nanospheres (A) and nanostars (B). (C) UV-vis-NIR spectra showing surface plasmon resonances of both types of nanoparticles in aqueous suspension.

The SERS enhancing properties of the nanostars were studied using a variety of analytes and compared to SERS enhancement with the same analytes on aggregated nanospheres, the most common and studied hot spots. The first choice was 1NAT (1-naphthalenethiol), which has often been used as a model SERS analyte, because it is a nonresonant molecule (electronic absorption is restricted to the UV) in the visible or the infrared, its surface-enhanced Raman spectrum is well established and has no remarkable chemical effects.

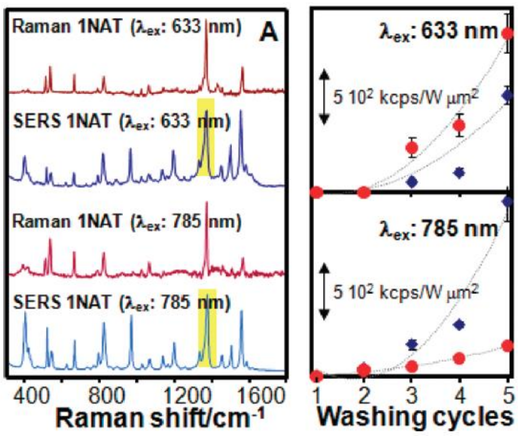

Figure 2_ Raman, resonance Raman, SERS, and SERRS spectra (left) and variation of the SERS/SERRS intensity as a function of the nanoparticle shape, washing cycles, and excitation laser line (right) for 1-naphthalenethiol.

Although when exciting with the red laser line (633 nm), a very similar enhancement was observed for both samples (slightly superior for nanospheres), upon excitation with the infrared laser (785 nm), the enhancement by nanostars was up to 6-fold more intense. The actual explanation for this additional enhancement was recently reported to arise from the field focalization at the apex of each tip of the nanostars.

Higher electromagnetic fields are reached by using nanostars as optical enhancers

Phone. +34 976 369 300 Email. info@nanoimmunotech.es