Gold Nano-assemblies as SERS–NIR–PTT theranostic agent: Tentacles more powerful than Satellites

Priyanka Dey[a]
Marzieh Salimi[a], Sara Mosca[b], Francesca Palombo[a], Pavel Matousek[b], and Nick Stone[a]
[a]*School of Physics and Astronomy, University of Exeter, Exeter EX4 4Q, United Kingdom.*
[b]*Central Laser Facility, STFC Rutherford Appleton Laboratory, Oxford OX11 0QX, United Kingdom.*
Contact@ p.dey@exeter.ac.uk

Theranostics has been a key research area in the past decade and is growing in importance as researchers around the world are able to effectively bridge diagnostic and therapeutic strategies. Light-mediated optical theranostic i.e., diagnostic and therapeutic agents based on gold nanostructures have become increasingly popular.[1] Thus, designing gold nano-assemblies for efficient surface-enhanced Raman (SERS) detection and high light-to-heat conversion for photothermal therapy (PTT) is crucial towards realizing the goal of optical theranostics. Multi-branched polymeric linkers have been effective in controlling gold nano-assembly morphologies.[2]

Here we report on low plasmon enhancers such as 15 nm and 5 nm spherical gold nanoparticles (NPs) fashioned into a unique colloidal gold nano-assembly morphology that features intensive NIR plasmon coupling. The developed nano-assembly morphology mimics multiple tentacles, each composed of multiple 5 nm NPs, anchored randomly onto a 15 nm core that is held together by a flexible branched polymeric linker (fig 1, left). We show that this morphology is the key to such continuum near-infrared (NIR) broadband localized surface plasmon resonance (LSPR) profile. The LSPR extends into the tissue transparency region and surpasses the plasmon behaviour of a typical core satellite nano-assembly made from the same building blocks (fig 1, right).[3] Furthermore, its approximate size of 70 nm, composition of nano-gold and polyethylene glycol polymer, and demonstrated biocompatibility towards human non-cancerous cell line Wi-38 makes it an ideal candidate for in vivo nanomedicine applications. SERS (830 nm laser excitation) of labelled core multi-tentacle nano-assemblies could be detected with the SERS label concentration below 50 nM with high SNR (comparable to larger 100–200 nm gold nanostars which have limited in vivo use), as well as having enhanced photothermal heat conversion. Thus, the high SERS amplification of the multi-tentacle nano-assemblies, coupled with its improved PTT potential and lower toxicity towards human cancerous cell line MCF7, suggests its potential as an optical NIR–SERS–PTT theranostic agent.

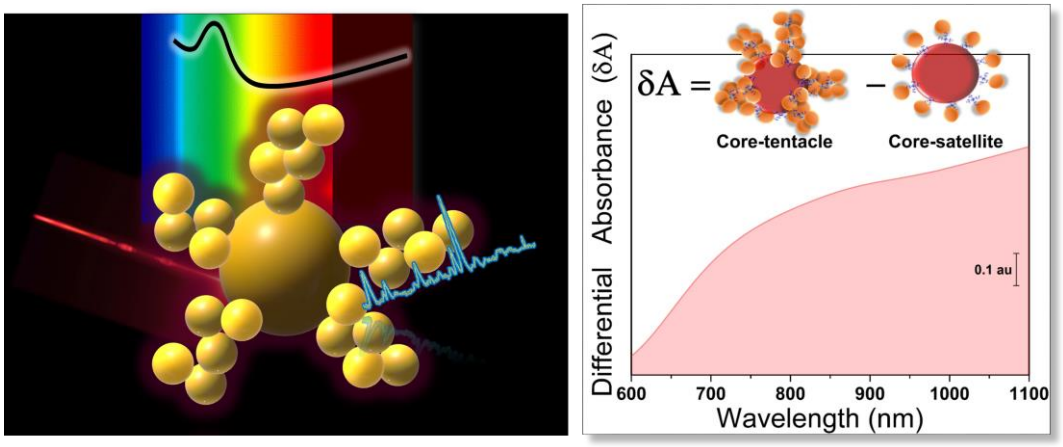

Figure 1: (Left) Cartoon depiction of core multi-tentacle gold nano-assemblies and (Right) the boost in NIR plasmon coupling of tentacles as compared to satellites, resulting in improved SERS and PTT performance.

REFERENCES

[1] T. A Tabish, P. Dey, S. Mosca, M. Salimi, F. Palombo, P. Matousek, N. Stone, *Advanced Science* (2020); 1903441.
[2] P. Dey, I. Blakey, K.J Thurecht, P. M Fredericks*, Langmuir* (2013); **29,** 523.
[3] P. Dey, T. A Tabish, S. Mosca, F. Palombo, P. Matousek, N. Stone*., Small* (2020); 1906780.