Host molecules SAM for fabricating plasmonic nanocavities

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Photon emitters within an optical cavity experience a modified environment that influences their interaction with the surrounding light field. In the weak-coupling regime, light extraction from the emitter is enhanced. However, in the strong-coupling regime with single emitters, more significant effects emerge : mixed states are formed that are part light and part matter, possessing exotic properties. Traditionally, such cavities have been restricted to low temperatures and complex fabrication methods, limiting their practical applications. Recently, an easy method for their realization has been achieved using self-assembled monolayers of Cucurbituril molecules[1][2].

At LQNO-lab, we have ongoing projects employing the Cucurbituril strategy to fabricate nanocavities. This method involves two steps: first, we grow CB self-assembled monolayers (SAMs) on an ultra-flat gold surface; second, we drop-cast gold nanospheres on top to form the cavities. Cucurbiturils (CBs) are highly versatile, allowing us to trap various molecules (such as dyes, emitters, and non-linear molecules) on the surface and within the cavity. The guest molecules' transition dipole moments align correctly with the electric field due to the geometrical constraints of the CBs. This electric field is enhanced by plasmonic confinement, resulting in very strong coupling. Changing the guest molecules and the metal used can yield highly tunable optical properties.

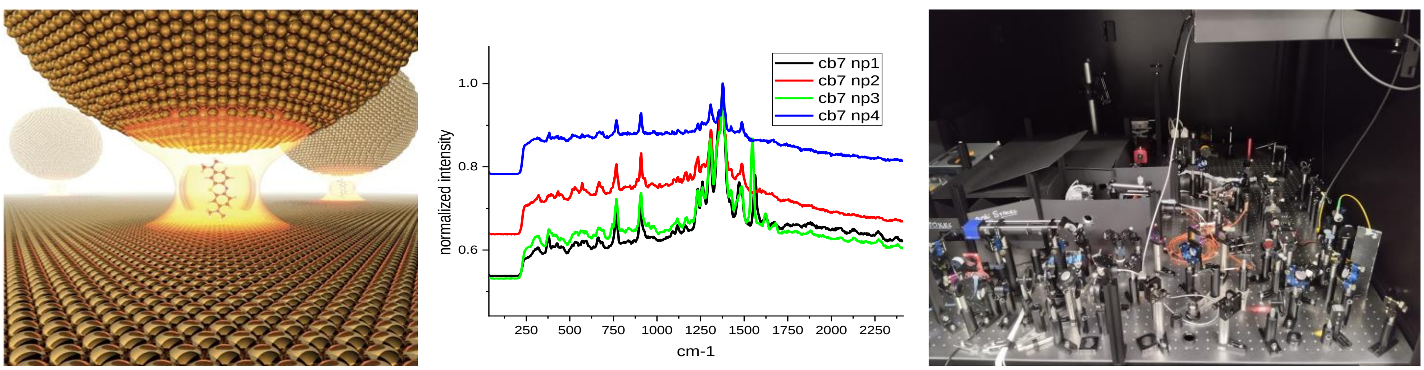

Fig.1 *Left: CB7 nanocavity [1]. Center: SERS of Au NPs on cucurbiturils SAM. Right: our Dark Field and Raman experimental setup.*

. The student will participate in SAM fabrication and explore different molecules to study various optical phenomena in the strong coupling regime, such as plasmonic nanocavity-enhanced emission. Additionally, the student will gain experience with various spectroscopic techniques, performing optical characterization of the synthesized samples, including:

- Polarized dark-field scattering
- SERS (surface-enhanced Raman spectroscopy)
- Confocal Raman spectroscopy
- Photoluminescence spectroscopy

Depending on the student's interests, there may also be opportunities to learn how to predict the optical properties of the guest molecules from quantum chemistry calculations.

This project offers students an immersive, hands-on experience with optical spectroscopies, while also providing an opportunity to delve into the fields of plasmonics, nonlinear optics and nanofabrication.

For more information, please don’t hesitate to contact us.

[1]Chikkaraddy, R. Single-molecule strong coupling at room temperature in plasmonic nanocavities. https://doi.org/10.1038/nature17974
[2]Liu, R. Deterministic positioning and alignment of a single-molecule exciton in plasmonic nanodimer for strong coupling. https://doi.org/10.1038/s41467-024-46831-6