



POLITECNICO DI MILANO

DIPARTIMENTO DI CHIMICA, MATERIALI ED INGEGNERIA CHIMICA "Giulio NATTA"

PhD Projects

Engineering gold nanomaterials: from nanoclusters to supraparticles

Gold nanomaterials have emerged as valuable tools in a variety of high-end applications. Proper tuning of their size and of their possible self-assembly into larger structures is essential to obtain custom morphological and functional features. Our work in this field is focused on the synthesis of differently sized and functionalized gold nanoparticles and on the design of self-assembly strategies to form hybrid superstructures with tailored properties and functionalities. We use custom peptides and naturally occurring proteins as templates for the self-assembly process and as functional units to confer responsiveness to our superstructures. The applications of our systems are not limited to a single field but mostly fall in the biomedical one and include drug delivery, biosensing and medical imaging.

References

A. Marchetti *et al.*, *Templated Out-of-Equilibrium Self-Assembly of Branched Au-Nanoshells*, *Small* **2023**, 19, 2206712.

C. Pigliacelli *et al.*, *In Situ Generation of Chiroptically-Active Peptide-Gold Superstructures Promoted by Iodination*, *ACS Nano* **2019**, 13, 2, 2158-2166.

C. Pigliacelli *et al.*, *Encapsulation of Fluorinated Drugs in the Confined Space of Water-Dispersible Fluorous Gold Supraparticles*, *Angewandte Chemie International Edition*, **2017**, 56, 16186-16190.

Short antimicrobial peptides

Antimicrobial peptides (AMPs) represent an emerging class of antimicrobials, as shown by the thousands of entries in the AMP databases. Despite the definition of design rules and the high number of AMPs discovered to date, the translation of their usage into clinics is still slow, and their high cost and proteolytic degradation hamper their affirmation as new therapeutics. Our work aims at designing new short AMP sequences endowed with tuned interfacial and self-assembly properties, features that are key for the interaction of AMPs with bacterial membrane and wall. Controlled assembly of AMPs has also been showed to impact on AMPs proteolytic stability as well as on their antimicrobial activity. The project is highly multidisciplinary, combining peptide and supramolecular chemistry with microbiology through the joined supervision of Dr. Claudia Pigliacelli and Dr. Nina Bono.

References

S. Chou *et al.*, *Synthetic peptides that form nanostructured micelles have potent antibiotic and antibiofilm activity against polymicrobial infections*, *PNAS* 2023 Vol. 120 No. 4 e221967912.

A. Marchetti *et al.*, *Fibril Structure Demonstrates the Role of Iodine Labelling on a Pentapeptide Self-Assembly*, *Chem. Eur. J.* 2022, 28, e202104089.

Pennetta C, Bono N *et al.*, *Multifunctional Neomycin-Triazine-Based Cationic Lipids for Gene Delivery with Antibacterial Properties*, *Bioconjugate Chem.* 2021, 32, 4, 690–701

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Fluorinated peptides

Peptides hold great promise as versatile platforms in the biomedical field, with applications ranging from drug delivery to medical imaging. Recently, fluoroalkylation of peptides has shown to be an effective strategy to improve their cytosolic uptake of as well as to modulate their stability towards proteases. In this project, we aim at designing new self-assembling conjugates composed of short peptide sequences and tailored fluorinated moieties. We will study the supramolecular behavior of the fluorinated peptides and probe their applications for intracellular delivery as well as imaging probes, exploiting ^{19}F atoms MRI and raman activity. The project is coordinated by Prof. Francesca Baldelli Bombelli and involves the collaboration with Dr. Claudia Pigliacelli.

References

Rong G. et al., *Fluoroalkylation promotes cytosolic peptide delivery*, Science Advances 2020, Vol. 3, 33.

C. Chirizzi et al., *A Bioorthogonal Probe for Multiscale Imaging by ^{19}F -MRI and Raman Microscopy: From Whole Body to Single Cells*, J. Am. Chem. Soc. 2021, 143, 31, 12253–12260.

B. Bona et al., *Multibranch-Based Fluorinated Materials: Tailor-Made Design of ^{19}F -MRI Probes*, Accounts of Chemical Research 2023, 4, 1, 71-85

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