

MASTER THESIS M2 CDM (5 months, Feb. - June) 2025-2026

Title of the project: Deciphering the mechanisms of gold nanoparticle networks formation and their optical and plasmonic properties induced (NET-AU)

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Location / Laboratory (Department /Team): Dijon / ICMUB (Catalysis) – ICB (Photonics)

Collaborations: Myrtil KAHN (Nanosciences, NOS LCC-Toulouse)

Summary: Nanoparticle (NP) synthesis and applications have attracted great interest since their properties (magnetic, optic, catalytic, etc.) bridge the gap between molecules and bulk materials [1]. While they are often constructed as isolated nanoobjects, the ability to assemble NPs with controllable sizes and shapes within networks is a current issue which concerns frontier areas of research in sensors, medical diagnostics, information storage, and metal catalysis [2]. Fairly sophisticated synthetic approaches to gold plasmonic dimers with controlled gap distance, symmetry, and capability of hosting guest molecules in hotspot regions have been described [3]. Our groups described also the facile synthesis of innovative networks of gold nanoparticle (**Fig. 1**) that were employable in very efficient organic synthesis for unique selectivity [4]. The formation of gold NP networks by our methods –*dense networks of small NPs of 2-3 nm size separated by rigid diamondoid linkers of 1-2 nm*– follow mechanisms that need to be deciphered to control the physical properties (shape of individual NPs, optical and plasmonic properties of the networks). This could be achieved *in situ* from DLS monitoring and associated laser-assisted methods. The training period will consist at ICMUB at the formation of individual NPs that would be associated as networks from ligand exchange in specially designed apparatus allowing multiple analysis developed at ICB. *In-situ* UV–visible spectroscopy and *ex-situ* electron microscopy analysis, as well as simulation [5], are accessible in relation with the excellence equipment SMARTLIGHT, while ultimately reshaping of NPs and networks may be studied by plasmonic resonances driven by femtosecond laser irradiation.

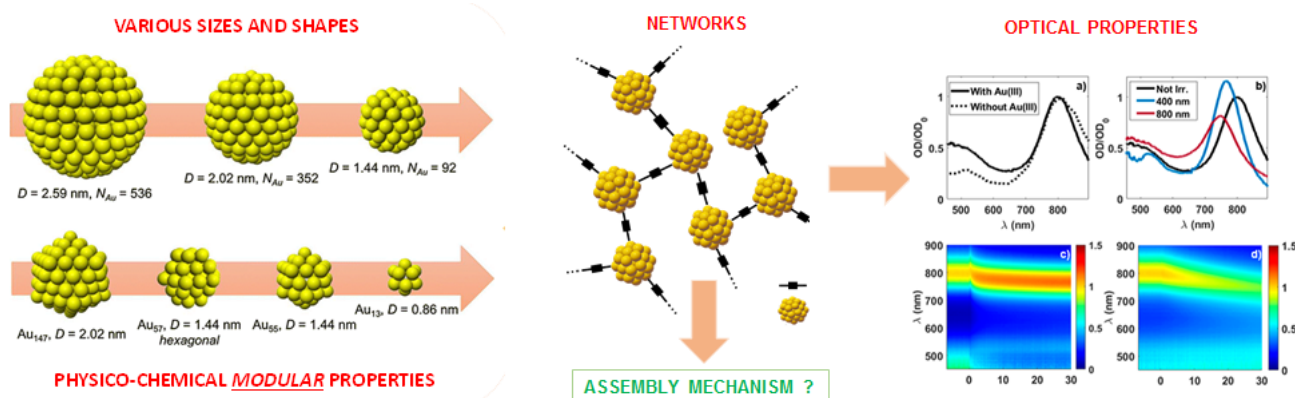


Fig 1. Au NPs of various nanosizing (left); novel networks of 2-3 nm size Au NPs separated by 1-2 nm (middle); Au NPs optical properties (right), B. Cluzel©, ICB.

References: [1] Astruc, D. et al. Gold nanoparticles: assembly, supramolecular chemistry, quantum-size-related properties, and applications toward biology, catalysis, and nanotechnology. *Chem. Rev.* **2004**, 104, 293. [2]. a) Rotello, V. M. et al. Self-assembly of nanoparticles into structured spherical and network aggregates. *Nature* **2000**, 404, 746. b) Rotello, V. M. et al. Controlled interparticle spacing through self-assembly of Au nanoparticles and poly(amidoamine) dendrimers. *J. Am. Chem. Soc.* **2002**, 124, 15146. c) Zhong, C.-J. et al. Novel spherical assembly of gold nanoparticles mediated by a tetradentate thioether. *J. Am. Chem. Soc.* **2002**, 124, 4958. d) Zhong, C.-J. et al. Molecularly mediated processing and assembly of nanoparticles: exploring the interparticle interactions and structures. *Acc. Chem. Res.* **2009**, 42, 798. [3] Li, G. et al. Rational Approach to Plasmonic Dimers with Controlled Gap Distance, Symmetry, and Capability of Precisely Hosting Guest Molecules in Hotspot Regions. *J. Am. Chem. Soc.* **2021**, 143, 8631. [4] Hierso, J.-C. et al. Nanocatalysts for High Selectivity Enyne Cyclization: Oxidative Surface Reorganization of Gold Sub-2-nm Nanoparticle Networks. *JACS Au*, **2021**, 1, 187. [5]. Cluzel, B. et al. Gold Nanorod Growth and Etching Activated by Femtosecond Irradiation and Surface Plasmon Resonance. *J. Phys. Chem. C* **2024**, 128, 3074.

Type of project (theory / experiment): Experiment: synthesis / plasmonic / photonic / nanosciences

Required skills: Basics in materials chemistry and in light-matter interaction in physics; interest for NPs synthesis in

solution; interest in experimental physics measurement; team spirit, curiosity and interest for transdisciplinary.

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