ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

INORGANIC CHEMISTRY AREA

CURRENT RESEARCH TOPICS

Dipartimento di Chimica Industriale
"Toso Montanari"

Research Groups

- CHINANOR Advanced Materials
- Metal Carbonyl Clusters
- Bioactive Ru-Complexes for Therapeutical Applications
- Molecular Catalysis for Sustainable Applications (MOLCAT)
- Photoactive Metal Complexes for Materials and Life Sciences
- Supramolecular Chemistry, Photochemistry and Nanoscience
- Hybrid Perovskite Semiconductors for Optoelectronic Applications

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CHINANOR
Advanced Material

Dipartimento di Chimica Industriale
"Toso Montanari"

CHINANOR Advanced Material

Department of Industrial Chemistry «Toso Montanari»

web site: https://chimica-industriale.unibo.it/it/ricerca/gruppi-di-ricerca/chinanor

Prof. Barbara Ballarin, Analytical Chemistry
barbara.ballarin@unibo.it
https://www.unibo.it/sitoweb/barbara.ballarin

Prof. Maria Cristina Cassani, Inorganic Chemistry
maria.cassani@unibo.it
https://www.unibo.it/sitoweb/maria.cassani

CHINANOR is a multidisciplinar group composed by researchers with expertise in the fields of Inorganic (Prof. Maria Cristina Cassani, maria.cassani@unibo.it) and Analytic Chemistry (Prof. Barbara Ballarin, barbara.ballarin@unibo.it).

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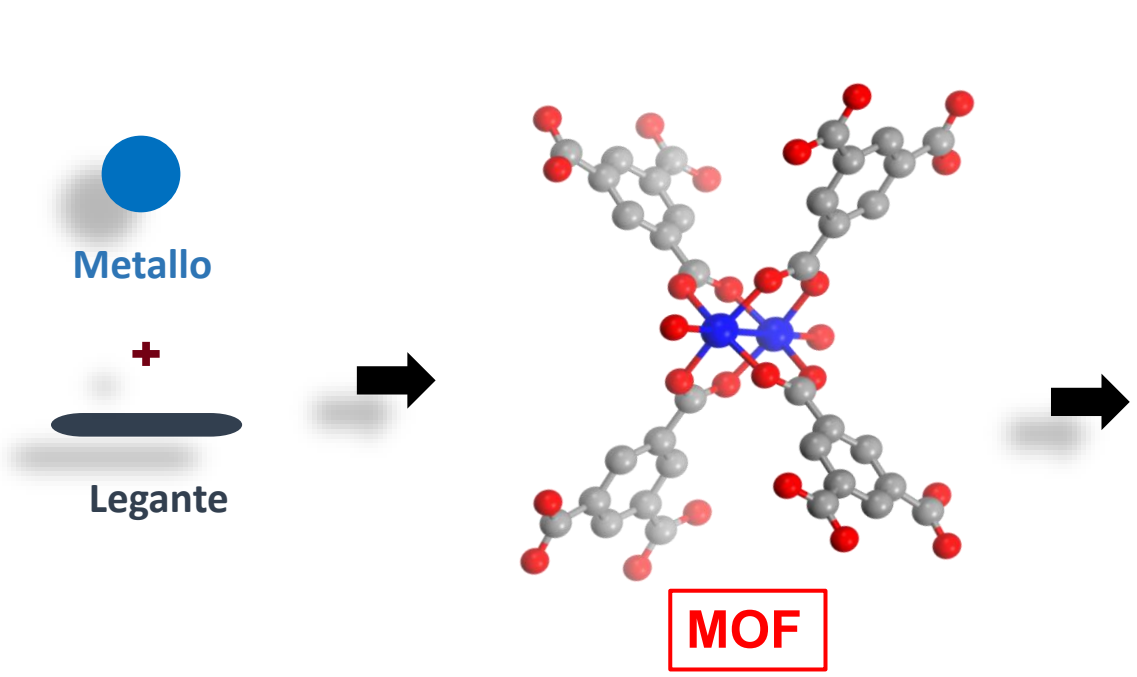
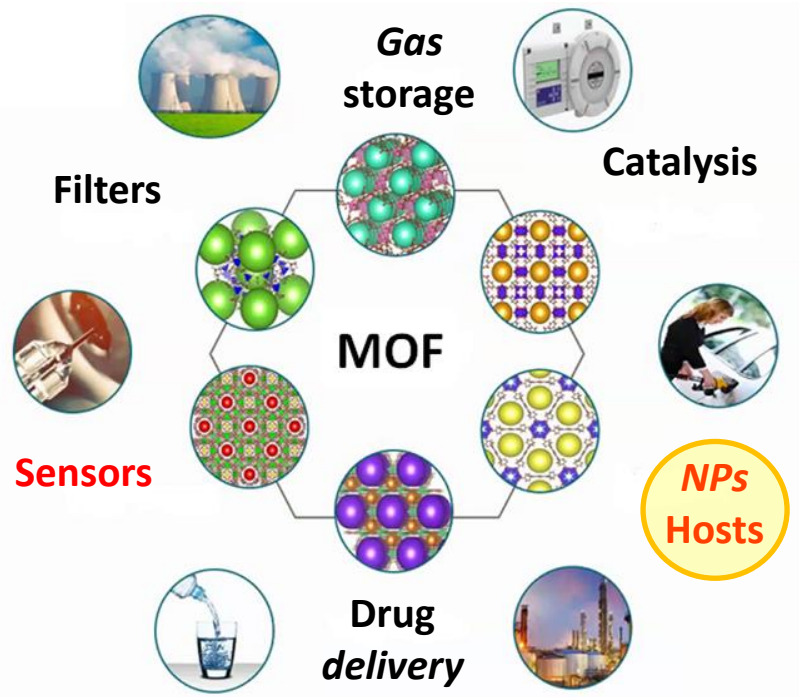
MOFs: Metal Organic Frameworks

Maria Cristina Cassani

I MOFs sono una classe di materiali cristallini con alta area superficiale. Rispetto ai tradizionali adsorbenti porosi, l'unicità della struttura cristallina dei MOFs permette di progettare strutture con dimensioni e proprietà chimico-fisiche della superficie interna dei pori predeterminate, per applicazioni specifiche.





Metal Organic Frameworks (MOFs)@work: FROM BIOMEDICAL APPLICATIONS TO CULTURAL HERITAGE

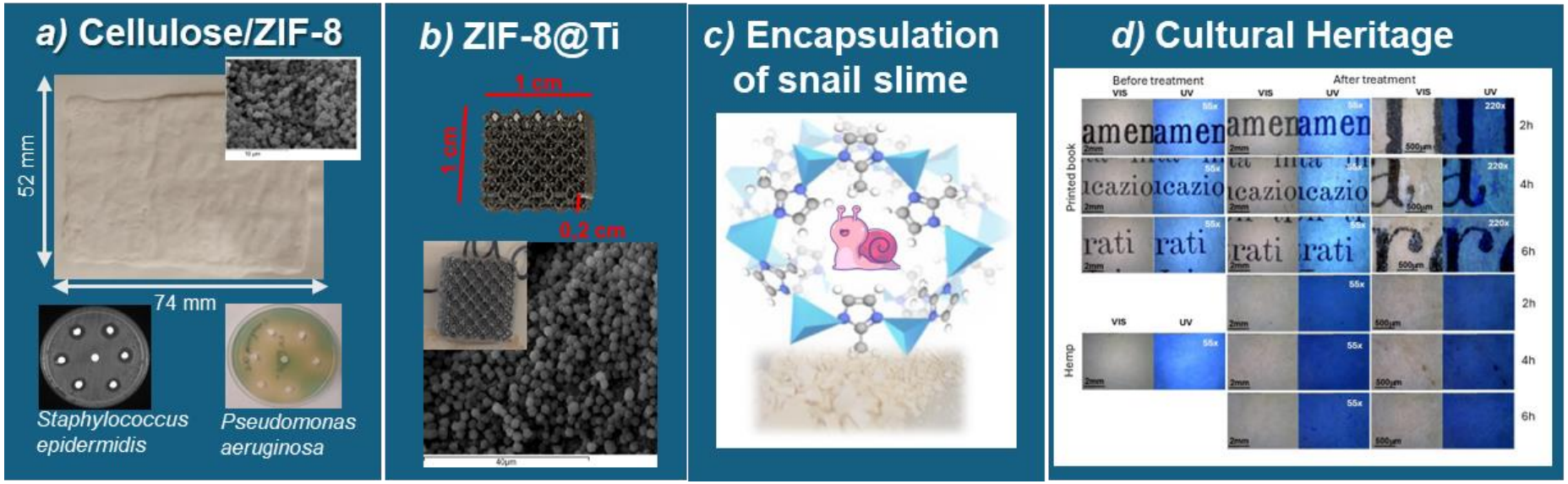


Figure 1. *a*, *b*, c) Biomedical applications of ZIF-8. *d*) Paper samples obtained for printed books and hemp observed via contact microscope before and after treatment with ZIF-8 solution 2h, 4h, and 6h under visible (VIS) and ultraviolet light (UV).

[***a***] V. Di Matteo, M.F. Di Filippo, B. Ballarin, G.A. Gentilomi, F. Bonvicini, S. Panzavolta, M.C. Cassani, *J. Funct. Biomater.* **2023**, 14, 472.

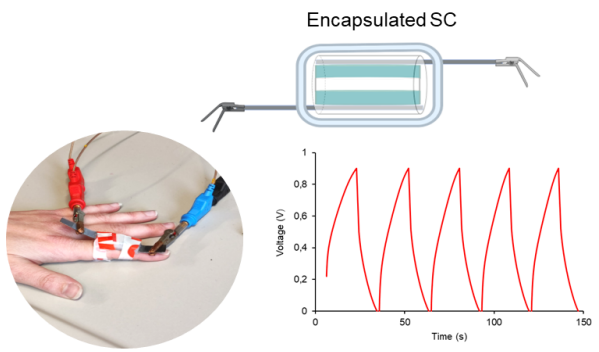
[***b***] V. Di Matteo, M.F. Di Filippo, B. Ballarin, F. Bonvicini, M.R. Iaquinta, S. Panzavolta, E. Mazzoni, M.C. Cassani, *Front. Chem*. **2024**, 12:1452670.

[***c***] M.F. Di Filippo, V. Di Matteo, L.S. Dolci, B. Albertini, B. Ballarin, M.C. Cassani, N. Passerini, F. Bonvicini, G. Gentilomi, S. Panzavolta, *Nanomaterials* **2022**, 12, 3447.

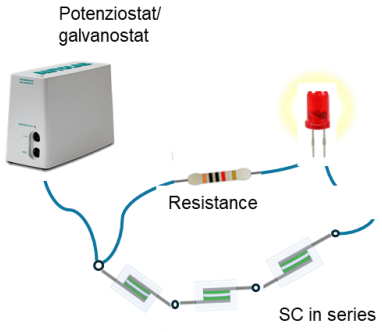
[***d***] E. Balliana, M. Marchand, V. Di Matteo, B. Ballarin, M.C. Cassani, S. Panzavolta, E. Zendri, *Polymers* **2025**,*17*, 1369.

Hydrogel: sintesi e applicazioni

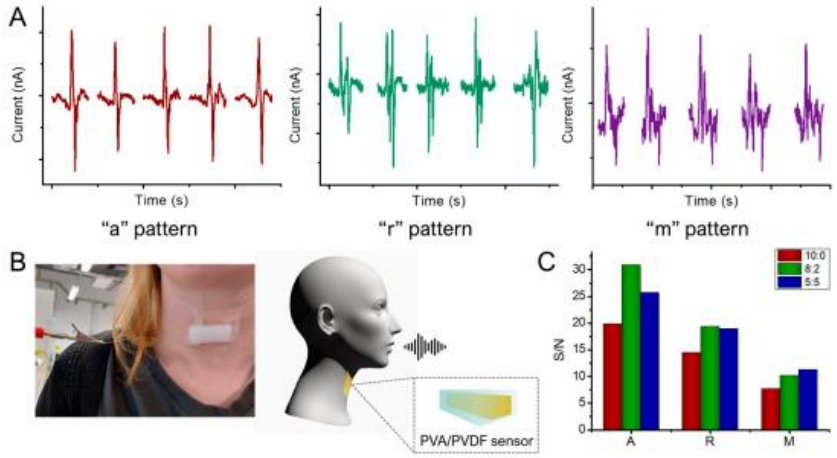
Barbara Ballarin



Wearable device



Energy storage device



Human voice sensor

ACS Omega, **2024**, 6391.
Gels **2024**, 10, 458
Gels **2025**, 11, 133

Gli hydrogel (o idrogel) sono materiali polimerici costituiti da una rete tridimensionale di macromolecole idrofile, cioè con affinità per l'acqua, legate tra loro tramite reticolazioni chimiche o fisiche. La loro caratteristica principale è la capacità di assorbire e trattenere grandi quantità di acqua o soluzioni acquose, arrivando a contenere dal 10-20% fino a migliaia di volte il proprio peso iniziale da asciutti, senza dissolversi nell'acqua stessa, e la capacità di rigenerarsi.
Grazie alla loro biocompatibilità, flessibilità e porosità, gli hydrogel trovano impiego in numerosi settori:

- Biomedicale: supporto per la crescita cellulare in ingegneria tissutale, medicazioni per ferite e ustioni, rilascio controllato di farmaci.
- Energia: sensori. supercapacitori e dispositivi diagnostici.
- Ambiente: assorbenti, rivestimenti.

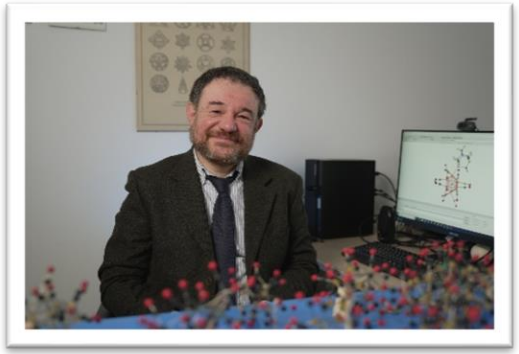
TRANSITION METAL CARBONYL CLUSTER COMPOUNDS

DESIGN, SYNTHESIS AND CHARACTERIZATION OF METAL CARBONYL CLUSTERS AS MOLECULAR METAL NANOPARTICLES

Area di Chimica Inorganica

Dipartimento di Chimica Industriale “Toso Montanari”

RESEARCH GROUP



Prof. Stefano Zacchini
stefano.zacchini@unibo.it

Prof.ssa Maria Carmela Iapalucci
maria.iapalucci@unibo.it

Prof.ssa Cristina Femoni
cristina.femoni@unibo.it

Dott.ssa Francesca Forti
francesca.forti7@unibo.it
(Post-doc)

Dott.ssa Cristiana Cesari
cristiana.cesari2@unibo.it

Dott.ssa Giorgia Scorzoni
giorgia.scorzoni3@unibo.it
(PhD)

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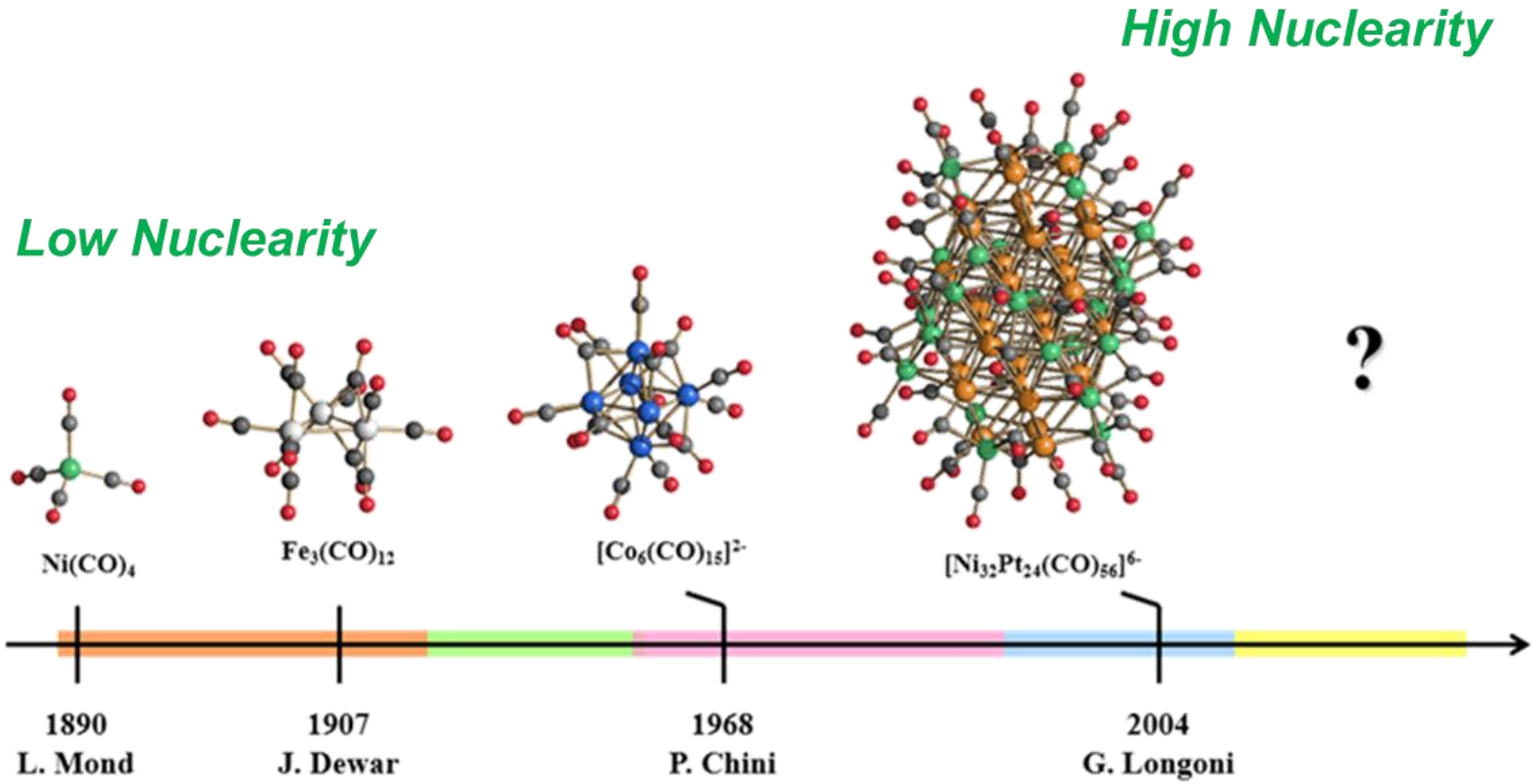
What is a cluster?

F. A. Cotton (1966): a metal cluster is a molecular species consisting of "*…a finite group of metal atoms held together mainly, or at least to a significant extent, by* ***metal-metal bonds.***"



Coord. Chem. Rev., **2018**, *335*, 27; *Eur. J. Inorg. Chem.*, **2018**, 3285, *Acc. Chem. Res.*, **2018**, *51*, 2748; Chem. Soc. Rev., **2021**, *50*, 9503; Dalton Trans., **2025**, *54*, 2224.

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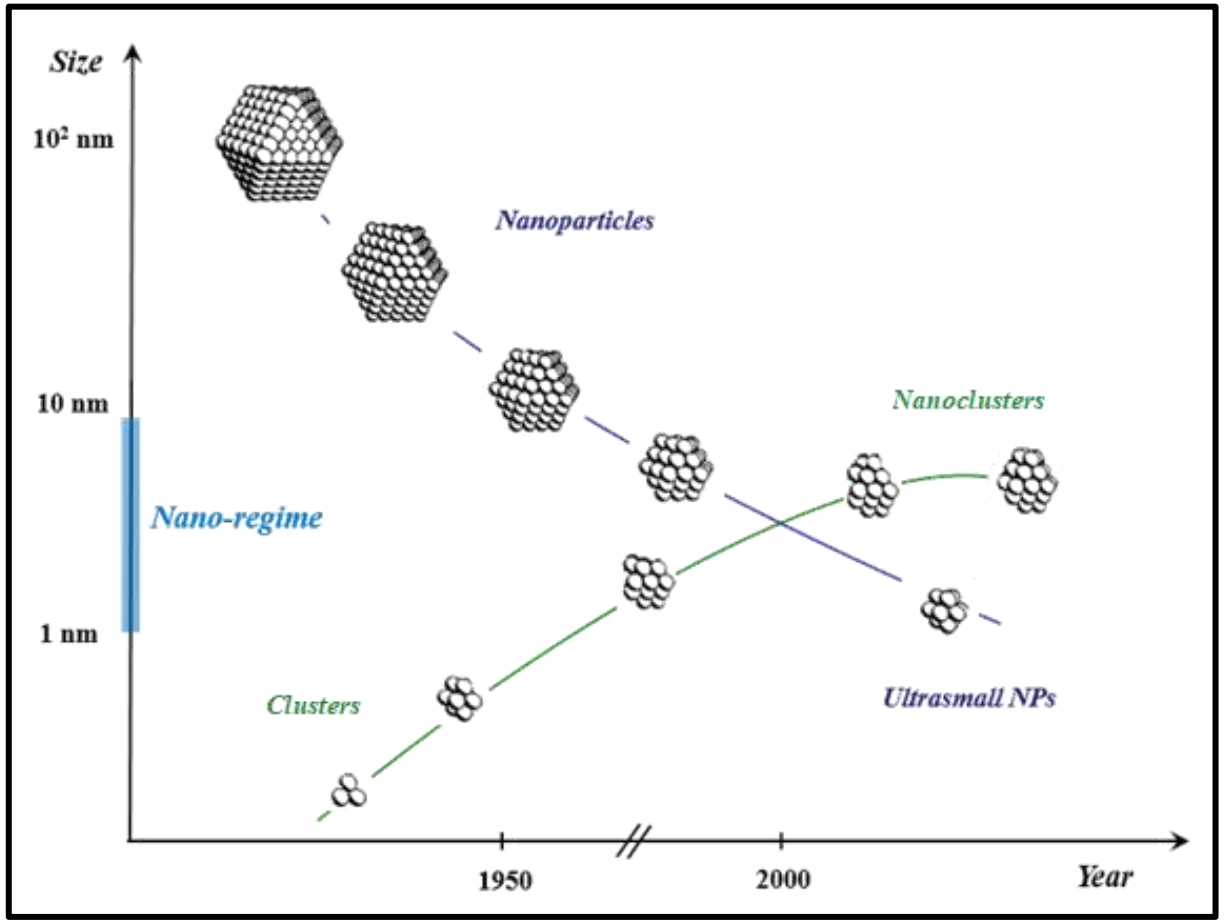
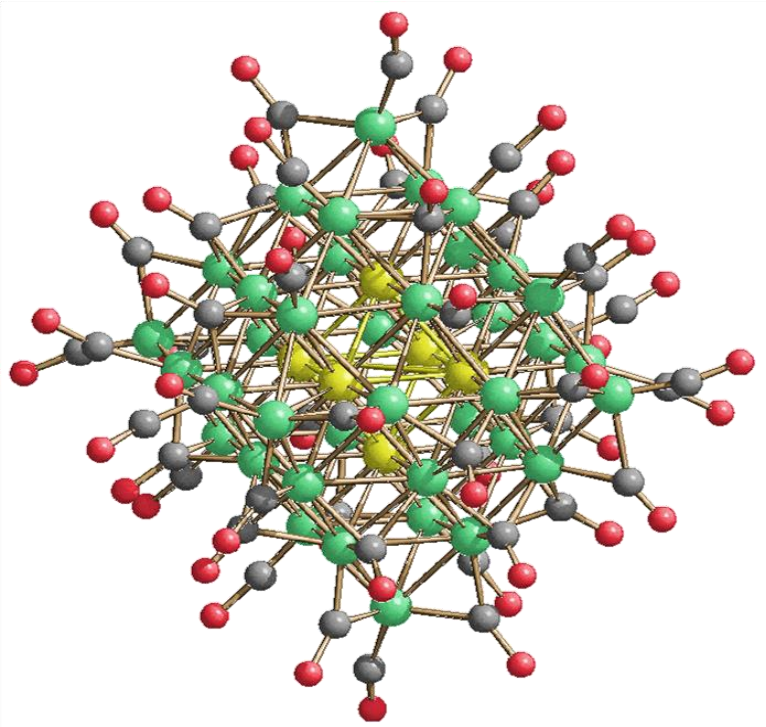
Metal Carbonyl Clusters

Metal Carbonyl Clusters (**MCCs**) are low valent clusters based on late transition metals and stabilized by carbon monoxide ligands.



High-nuclearity MCCs can be considered monodisperse, atomically precise metal nanoparticles.



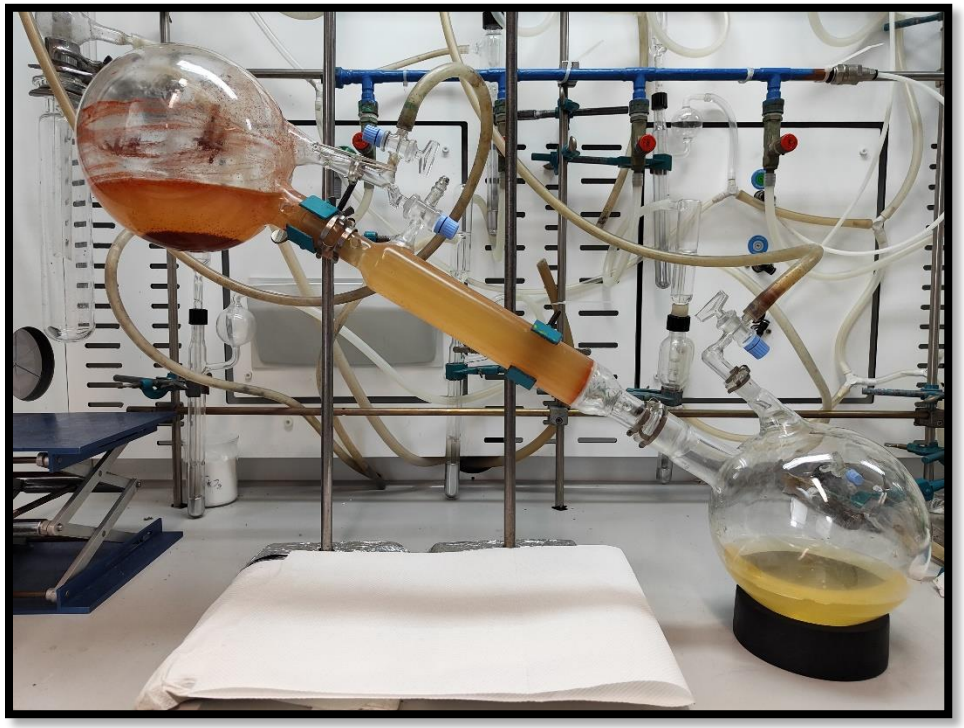
$[HNi_{38}Pt_6(CO)_{48}]^{5-}$
diameter: 1.9 nm

Longoni et al. *Angew. Chem. Int. Ed.* **1985**, *24*, 696

What we actually do in our lab?

- **<u>Synthesis</u> of inorganic compounds under controlled atmosphere:**

*Synthesis of **Ruthenium** carbonyl precursor in an **autoclave** (high-pressure reactor).*



*Synthesis of **Rhodium** carbonyl precursor under CO atmosphere (**Schlenk technique**).*

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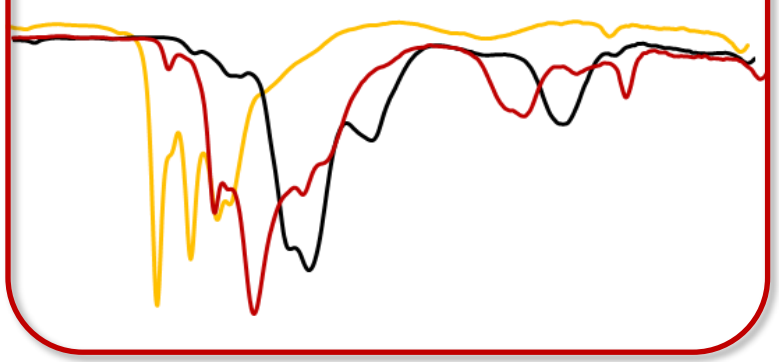
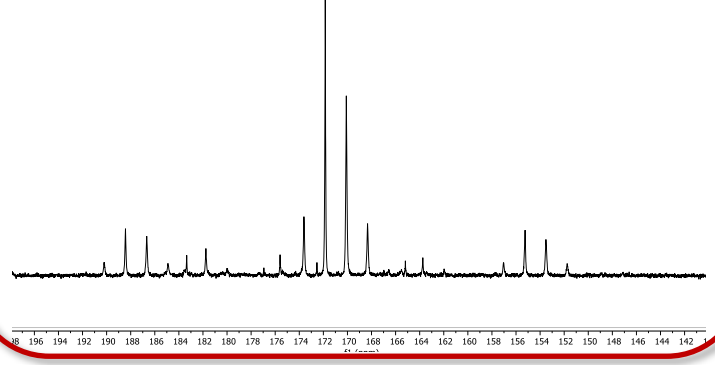
What we actually do in our lab?

- **Spectroscopic and Structural <u>Characterization:</u>**

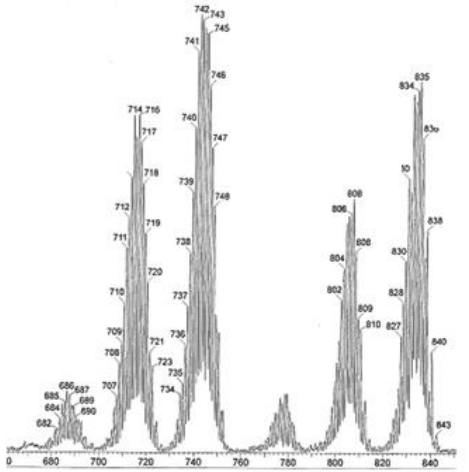
FT-IR



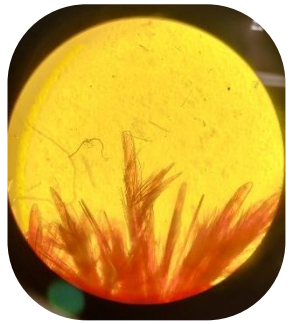
Multinuclear NMR



ESI-MS



SC-XRD



Double layer crystallization to obtain crystals suitable for SC-XRD

Single Crystal X-Ray Diffractometer (SC-XRD)

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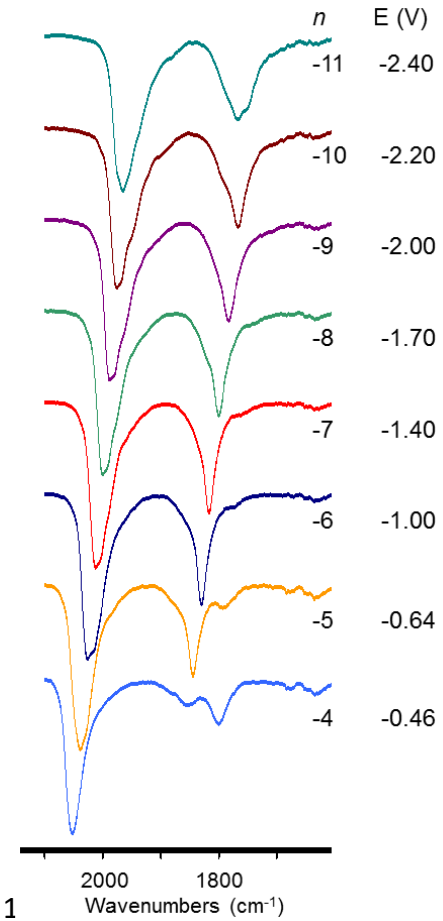
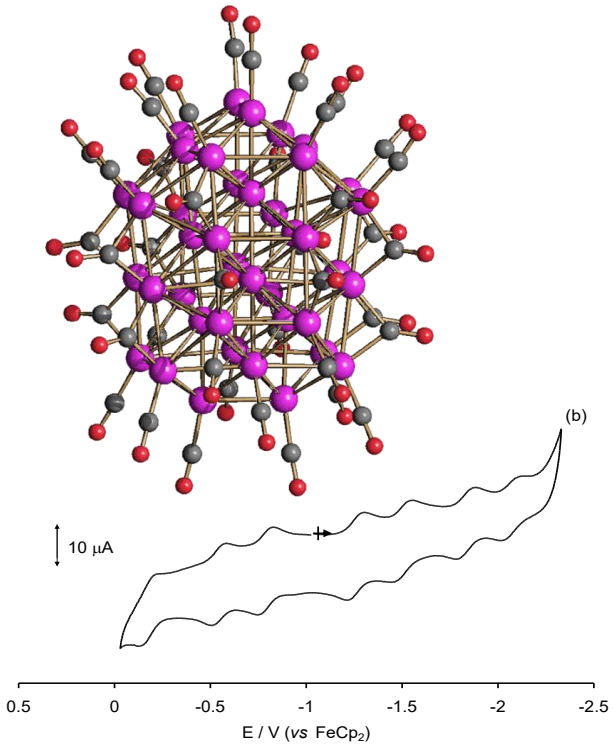
What we actually do in our lab?

➢ Applications in <u>Nanomaterials</u>

○ *Possible Molecular **Nanocapacitors***

$$[Pt_{19}(CO)_{22}]^{4-} \xrightarrow{+H^+} [Pt_{19}(CO)_{22}]^{3-} \xrightarrow{\text{time}} [Pt_{40}(CO)_{40}]^{6-}$$

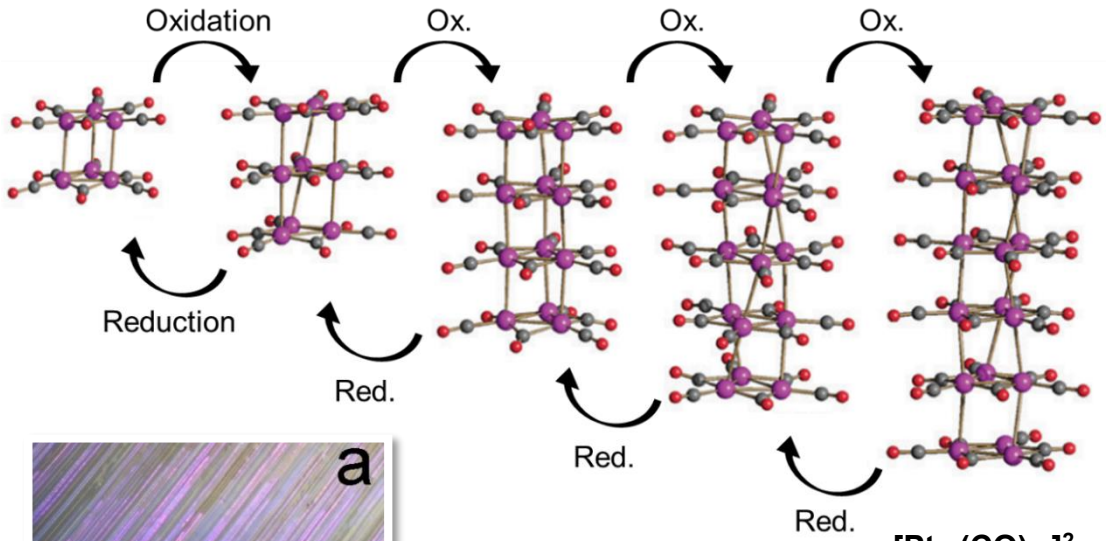


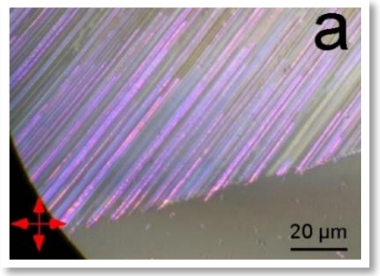


The cluster can accept and release electrons, functioning as an electron reservoir.

Inorg. Chem. **2016**, *55*, 6068

○ *Molecular Conductive Platinum **Nanowires***





Infinite Pt wires

Oxidation induces new inter-triangular Pt-Pt bonds formation, promoting self-assembly 1D structures upon crystallization.

Angew. Chem., Int. Ed., **2006**, *45*, 2060;
Inorg. Chem., **2010**, *49*, 5992-6004.

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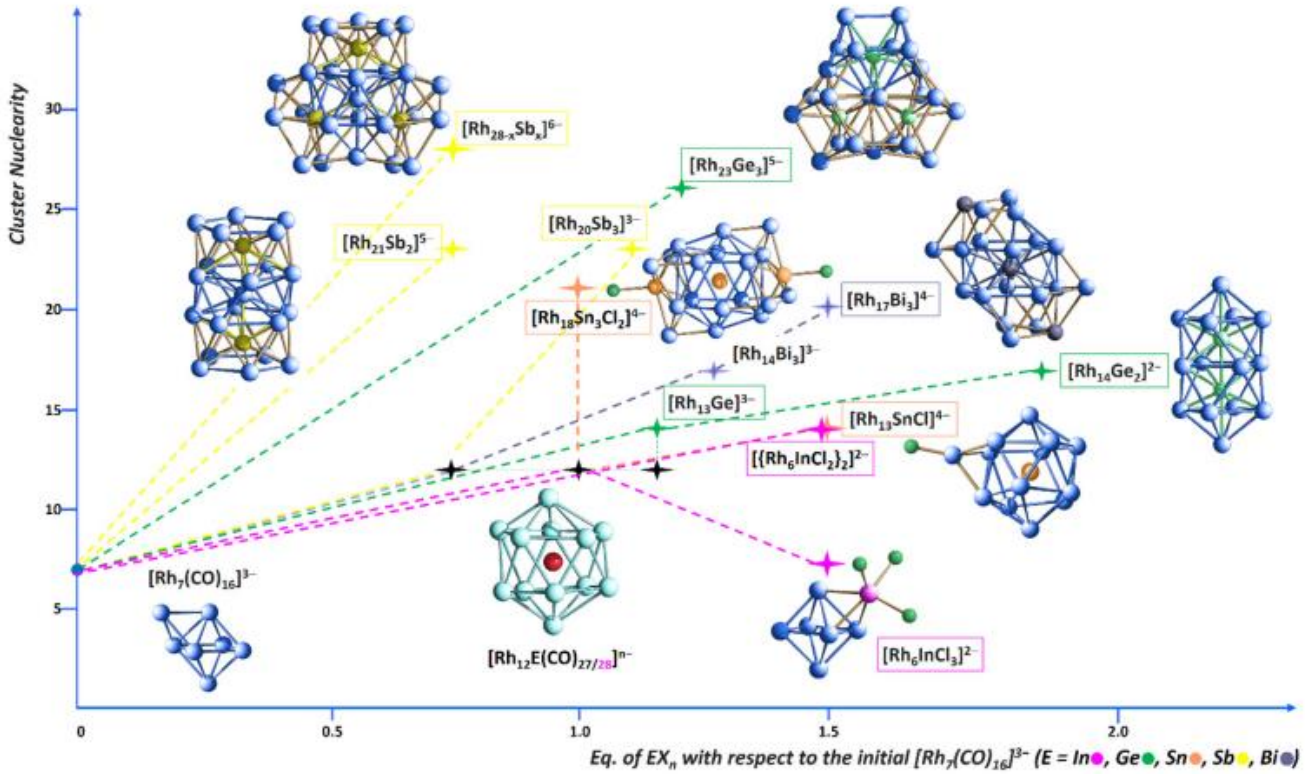
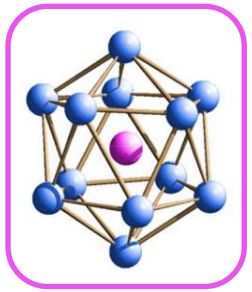
What we actually do in our lab?

➢ Applications in <u>Nanomaterials</u>

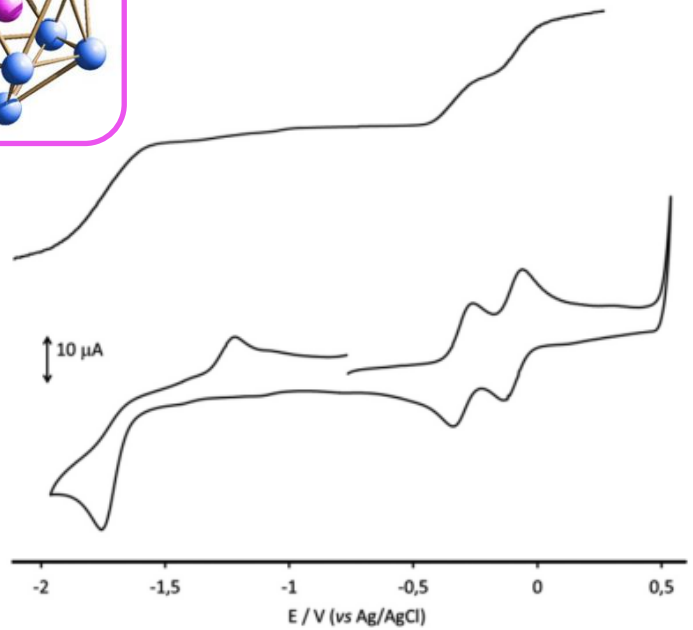
- ***Atomically precise Rhodium – Indium carbonyl nanoclusters***: *synthesis, characterization, crystal structure, and electron-sponge features.*



Growth trend of heterometallic carbonyl clusters for the various Rh – E systems as a function of the added equivalents of EXn (X = Cl, Br; n = 2-4).



Metal skeleton of
$[Rh_{12}In(CO)_{28}]^{3-}$



Cyclic (bottom) and hydrodynamic (top) voltammetric responses recorded at a GC electrode in a CH_3CN solution of $[Rh_{12}In(CO)_{28}]^{3-}$ under CO atmosphere.

Nanoscale, **2024**, *16*, 17852–17867

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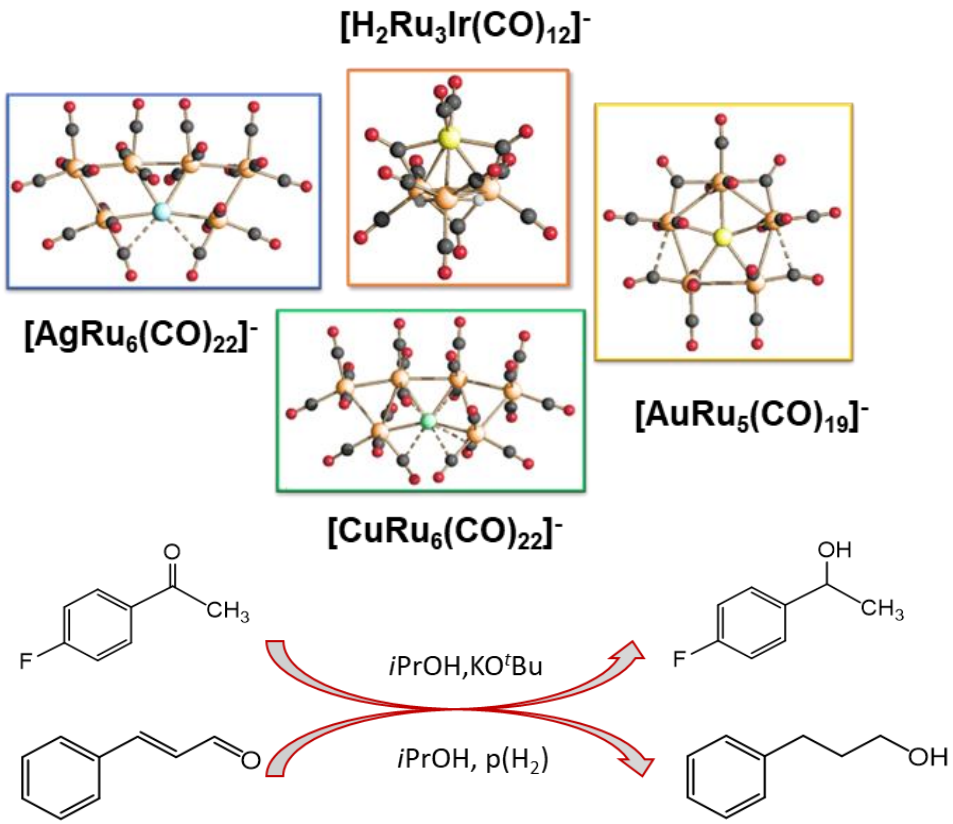
What we actually do in our lab?

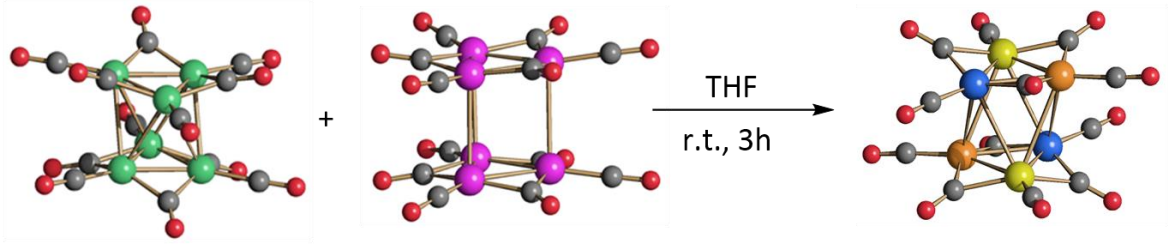
➢ Applications in <u>Catalysis</u>

- *Heterobimetallic **Ru-M** (M = Ag, Cu, Au, Ir) carbonyl clusters as **<u>homogeneous</u> pre-catalysts** in transfer hydrogenation and hydrogenation reactions.*

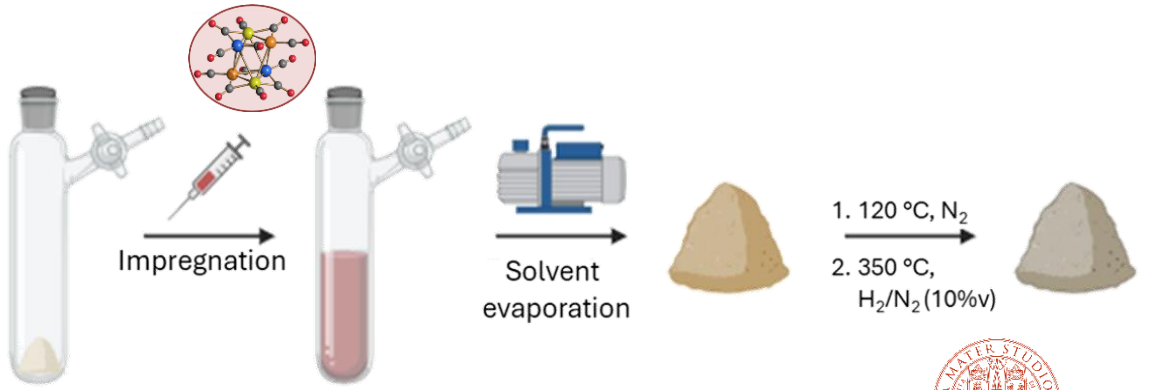


Inorg. Chem. **2022**, *61*, 14726–14741;
New J. Chem., **2023**, *47*, 19289

- *Metal carbonyl clusters as precursors for the preparation of **highly dispersed nanoparticles** over different supports.*

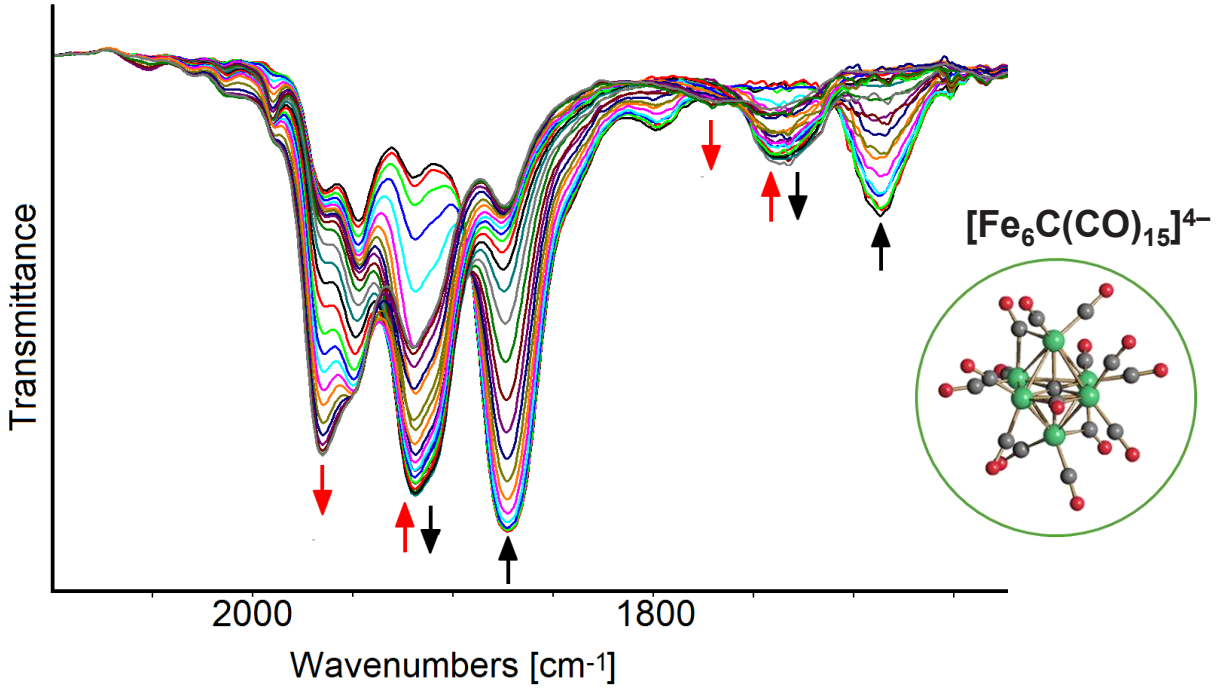


Inorg. Chem. **2021**, *60*, 8811; *Dalton Trans.*, **2023**, *52*, 3623



Who do we collaborate with?

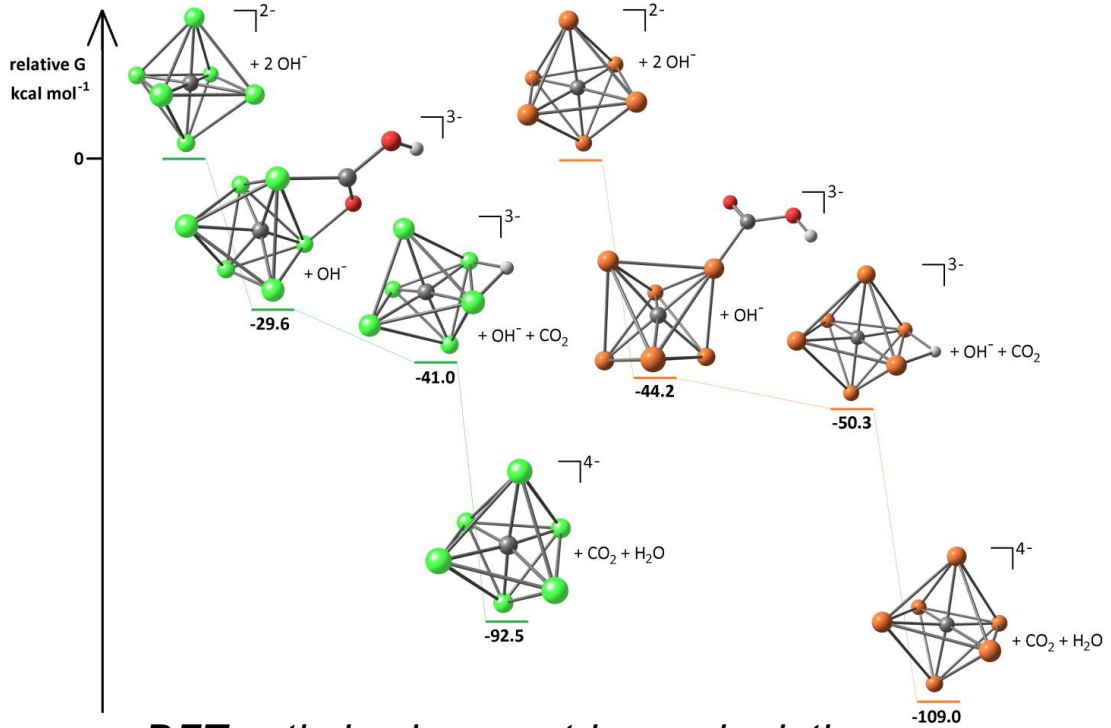
- **Electrochemical and spectrochemical** studies (**Prof. Tiziana Funaioli, Università di Pisa**).



The oxidation processes of $[Fe_6C(CO)_{15}]^{4-}$ were investigated by in situ IR-SEC in an optically transparent thin-layer electrochemical (OTTLE) cell

Inorg. Chem., **2025**, *64*, 9744

- **Computational studies** and DFT calculations (**Prof. Marco Bortoluzzi, Università di Venezia**).



DFT-optimized geometries and relative Gibbs energy values of $[M_6C(CO)_{16}]^{2-}$, $[M_6C(COOH)(CO)_{15}]^{3-}$, $[HM_6C(CO)_{15}]^{3-}$ and $[M_6C(CO)_{15}]^{4-}$ (M = Fe, Ru)

Inorg. Chem., **2023**, *62*, 14590

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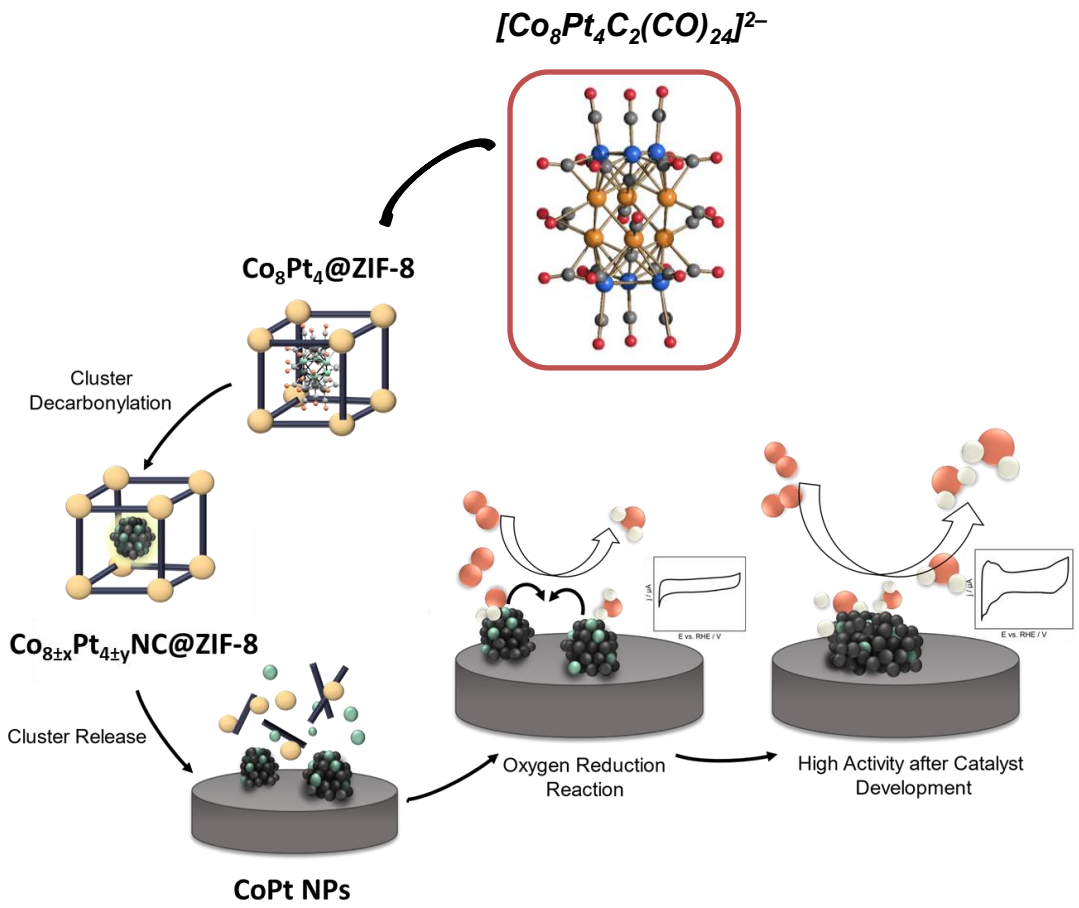
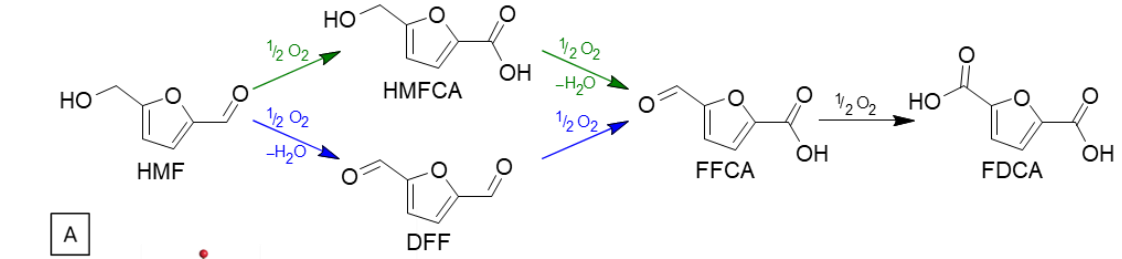
Who do we collaborate with?

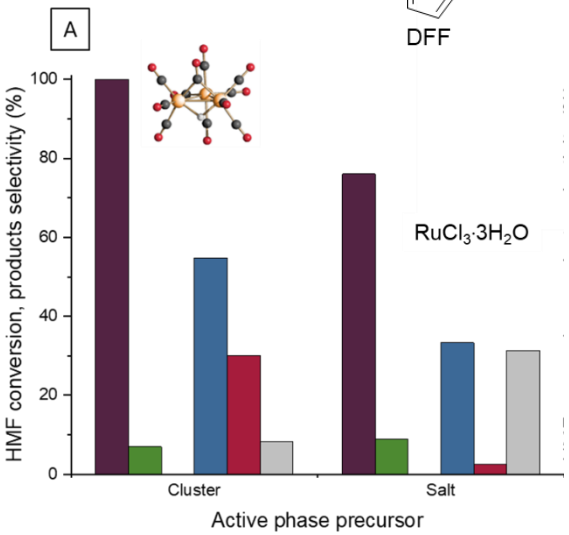
- Use of atom-precise nanoclusters **encapsulated in MOFs for Electrochemical applications** (**Prof. Roland A. Fischer, Technical University Munich**).



ChemElectroChem, **2024**, *11*, e202300476

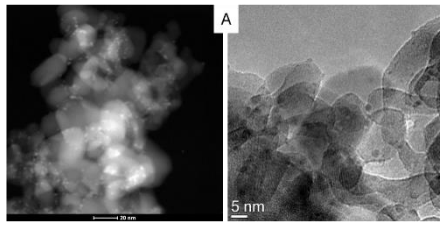
- Use of molecular clusters as precursors of **nanostructured catalytic materials** (**Prof.ssa S. Albonetti and F. Basile, Università di Bologna**).





Comparison of the catalytic activity of Ru/TiO_2 NPs prepared by cluster $[HRu_3(CO)_{11}]^-$ decomposition or salt ($RuCl_3 \cdot 3H_2O$) impregnation in the HMF oxidation reaction.

Catalyst	Mean particle size (nm)
Ru/TiO_2-Cluster	1.4 ± 0.4
Ru/TiO_2-Salt	1.8 ± 0.4



TEM/HAADF images of Ru/TiO_2 catalyst

Molecules, **2025**, *30*, 2120

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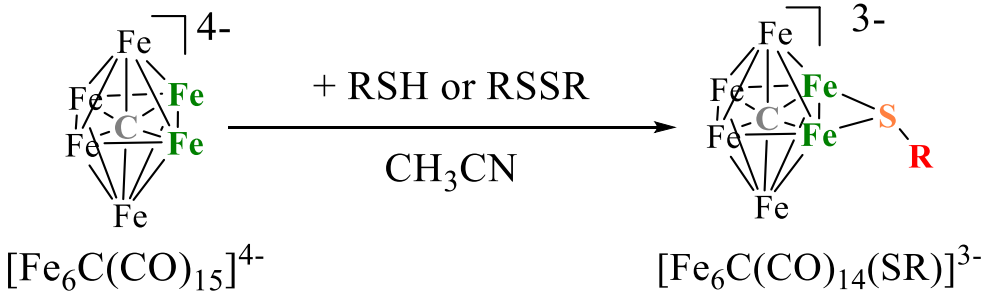
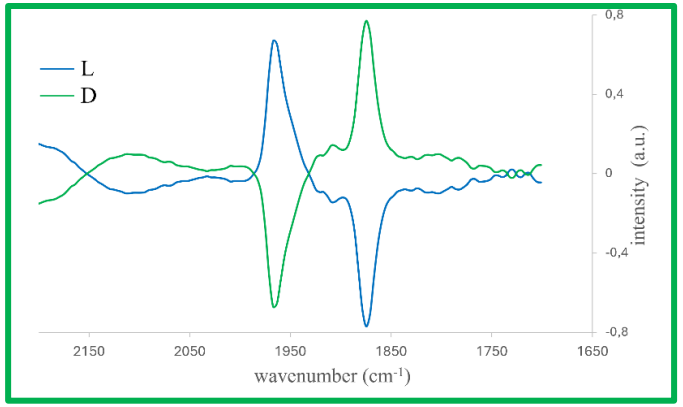
Some ongoing projects

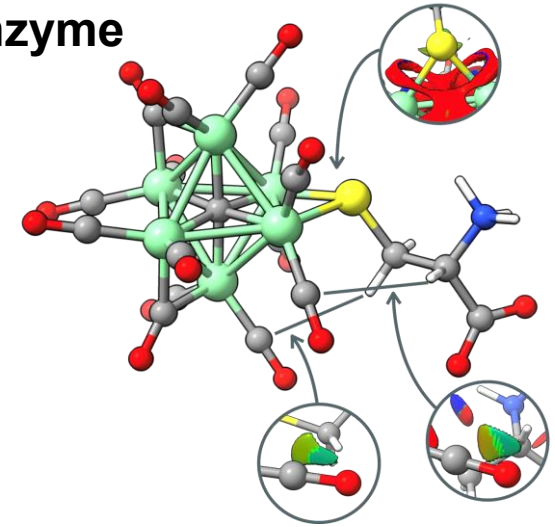
- Iron Carbide Carbonyl Clusters as **Models of the FeMoco Cofactor of Nitrogenase Enzyme**



$[Fe_6C(CO)_{15}]^{4-}$ $[Fe_6C(CO)_{14}(SR)]^{3-}$

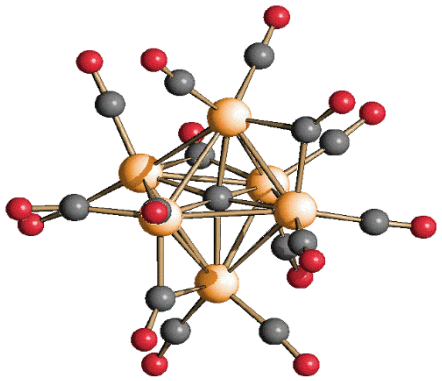


VCD spectra of $[Fe_6C(CO)_{14}$(L-cysteine)$]^{3-}$ and $[Fe_6C(CO)_{14}$(D-cysteine)$]^{3-}$ enantiomers.



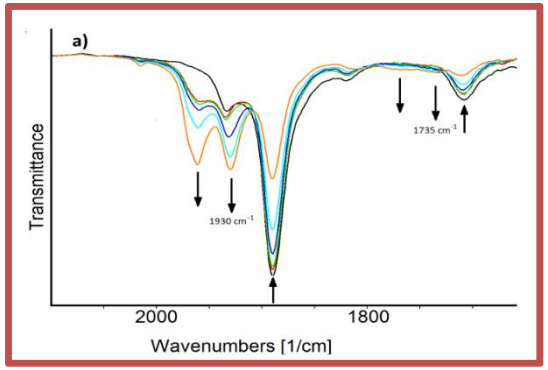
DFT-optimized structure of $[Fe_6C(CO)_{14}$(L-cysteine)$]^{3-}$ showing close contacts between the chiral organosulfur ligand and CO ligands.

- Comprehensive Study of **Highly Reduced Ruthenium Carbide Carbonyl Clusters**



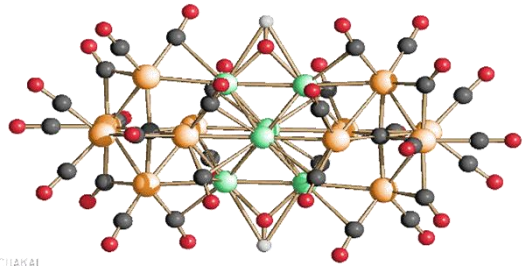
$[Ru_6C(CO)_{15}]^{4-}$

IR spectro-electrochemistry analysis



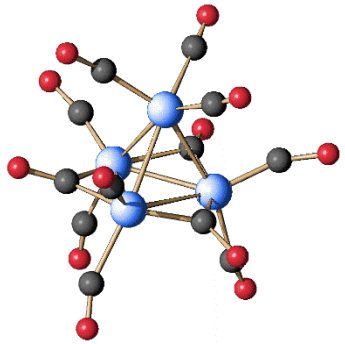
Cu(I)

$[Ru_{12}C_2(CO)_{30}Cu_6(OH)_2]^{4-}$

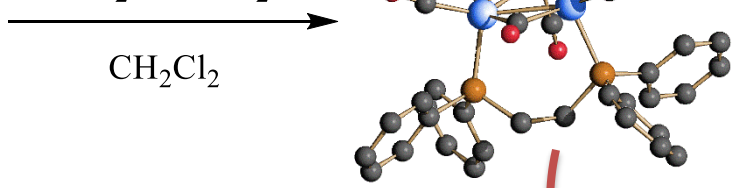


Some ongoing projects

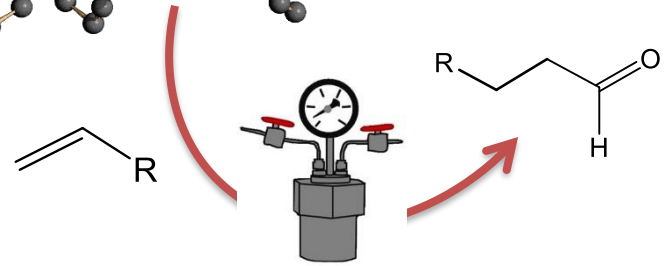
- Rhodium heteroleptic clusters as **Homogeneous pre-Catalyst**



$Rh_4(CO)_{12}$

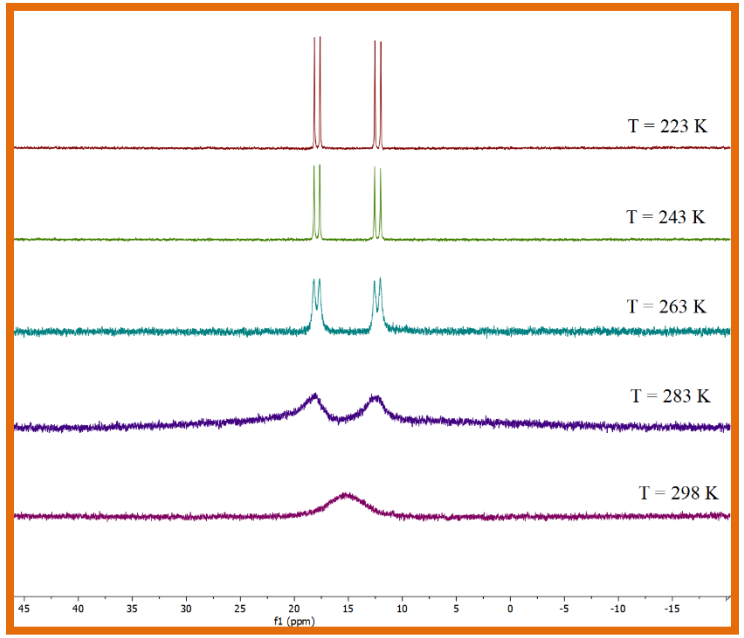


$Rh_4(CO)_{12-x}(L)_x$

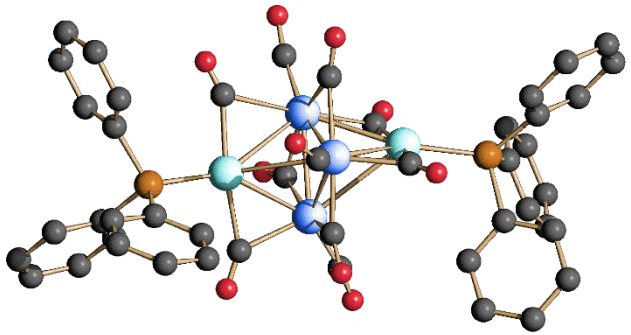


*Testing the new species as catalyst precursors for the **hydroformylation reactions** in homogeneous conditions*

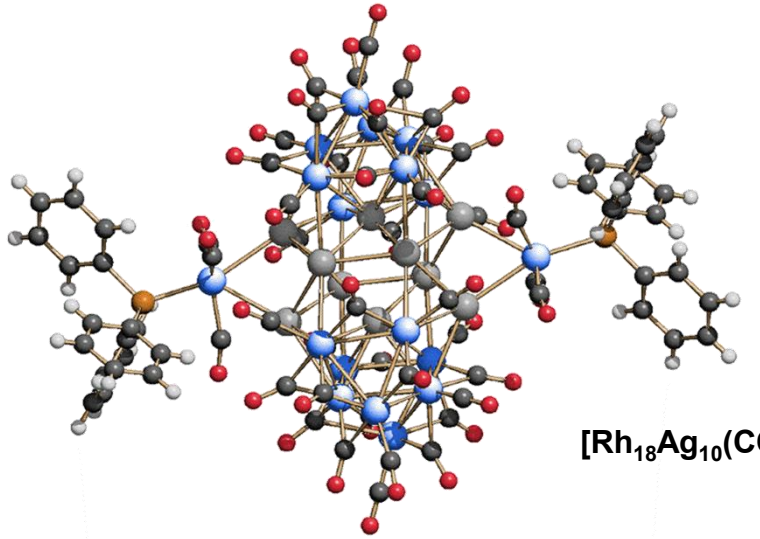
$^{31}P\{^1H\}$ NMR studies at variable temperature of $Rh_4(CO)_{12-x}(L)_x$



- Synthesis and characterization of **new Rh-M carbonyl clusters**



$[Rh_3Pt_2(CO)_{10}(PPh_3)_2]^-$



$[Rh_{18}Ag_{10}(CO)_{42}(PPh_3)_2]^{4-}$

and more…

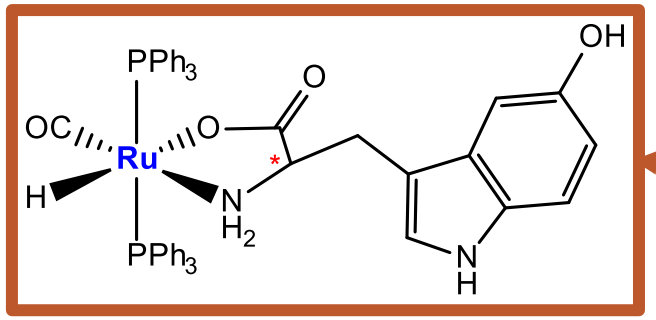
BIOACTIVE Ru-COMPLEXES FOR THERAPEUTICAL APPLICATIONS

Prof. Silvia Bordoni
E-mail: silvia.bordoni@unibo.it

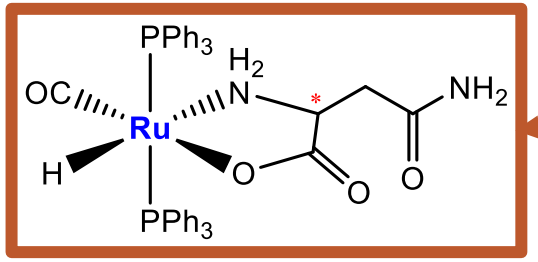
Dipartimento di Chimica Industriale "Toso Montanari"

Proposed thesis by Prof. Silvia Bordoni

Synthesis and characterization of Ruthenium complexes bearing bioactive aminoacidic ligands seeking novel therapeutic applications

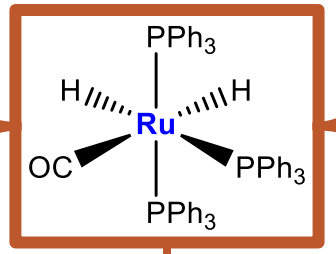


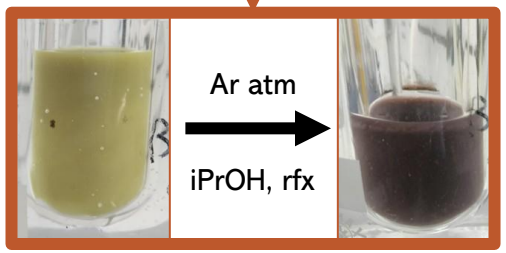
5-hydroxytryptophan
neuromodulator, antiobesity

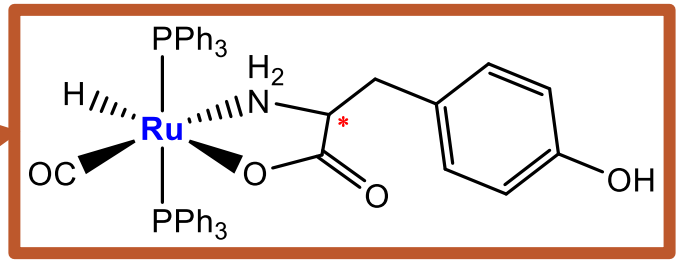


Asparagine - antiviral

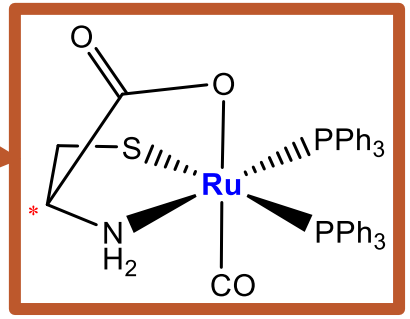
Dihydride Precursor



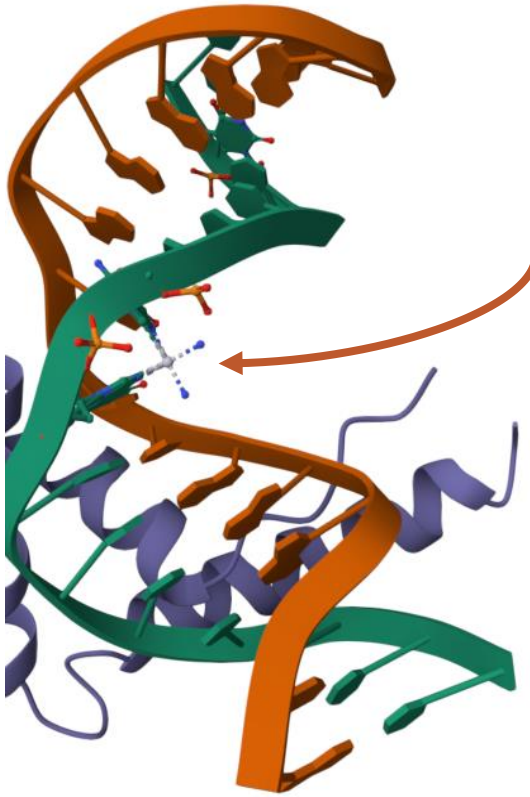




Tyrosine - neuromodulator



Cysteine - detox, biosynthesis, antioxidant



DNA helix

Organometallic Complex

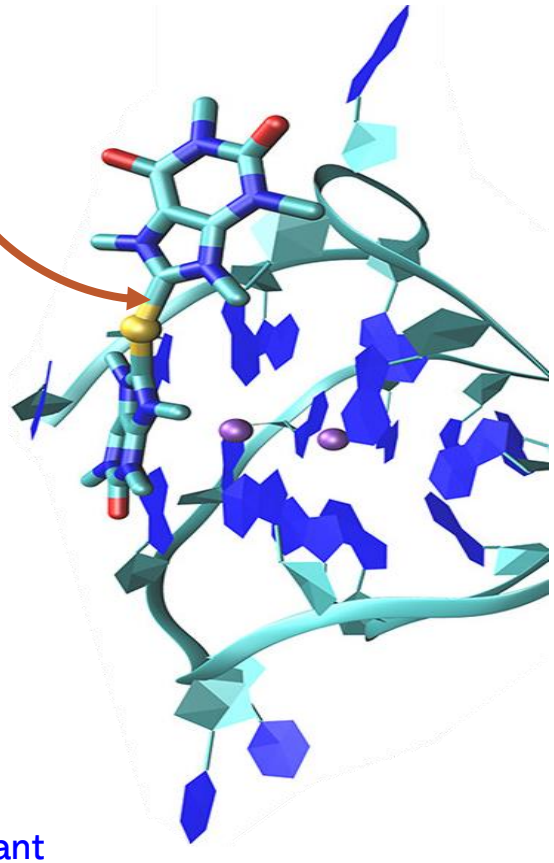
The question is:
Which receptor may interact with the Ru-organometallic bioactive species?

DNA or protein amino acids?

It is fundamental to study the MECHANISM (by DFT) and by isolating intermediates (X-ray)

Challenge: Ru-coordination of peculiar amino acids as proline or threonine

Protein chains



In collaboration with

Carola Parolin - Biological essays

Magda Monari - Crystallographic analyses

Carla Boga - Organic consultant

Riccardo Tarroni - DFT calculations

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UNIVERSITÀ DI BOLOGNA

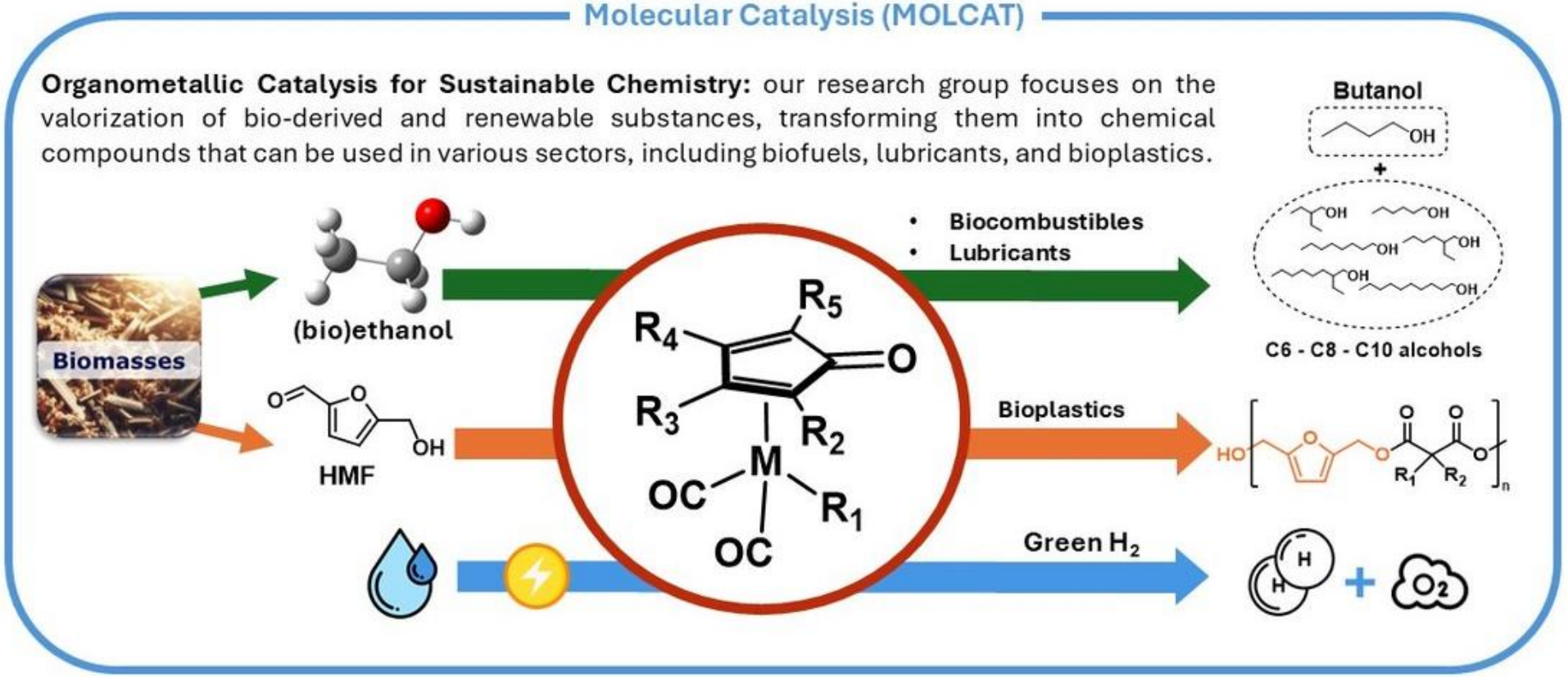
MOLCAT

Laboratory of Molecular Catalysis for Sustainable Applications (MOLCAT)

Prof.ssa Rita Mazzoni

Dipartimento di Chimica Industriale «Toso Montanari»

Overview



- Rational design of **homogeneous ruthenium based catalytic systems** for the development of innovative processes toward the **conversion of bio-based platform chemicals** (e.g. 2,5-hydroxymethyl furfural (HMF), 2,5-bis-hydroxymethylfurfural (BHMF), bio-ethanol from waste) to building blocks for green and energy transition (**second generation bio-fuel**) and for sustainable materials such as **bio-based polymers**.

- Design, synthesis and application of **Earth-abundant transition metal complexes** (e.g. Fe and Mn) which combine cyclopentadienone and N-heterocyclic carbene ligands for energy transition (**water oxidation, hydrogen production, acqueous phase reforming**).

Analysis techniques: NMR, FT-IR, GC, HPLC;
Lab techniques: Schlenk chemistry, Autoclave Reactors, MW reactions.

People:

Prof.ssa Rita Mazzoni
Supervisor

Andrea Masetti
Ph.D Student

Andrea Piazzi
Ph.D Student

Chiara Lenzi
Ph.D Student

Stefano Baratti
Research Fellow

For more

rita.mazzoni@unibo.it

Internal and External Collaborations:

Department of Industrial Chemistry - UNIBO
Department of Chemistry - UNIBO
Department of Pharmacy and Biotechnology - UNIBO
University of Calabria
Instituto de Tecnologia Quımica e Biologica da Universidade Nova de **Lisboa**
Department of Organic Chemistry of **Stockholm** University
Dept. of Chemistry and Biomolecular Sciences, **Ottawa**
Laboratorium für Anorganische Chemie of ETH **Zurich**
Department of Chemistry & Biochemistry of University of **Bern**
School of Chemistry of **Cardiff** University
Department of Pharmaceutical Sciences of **Tokushima** University
Department of Civil, Chemical, Environmental and Materials Engineering - UNIBO
University of Modena and Reggio Emilia (UNIMORE)

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UNIVERSITÀ DI BOLOGNA

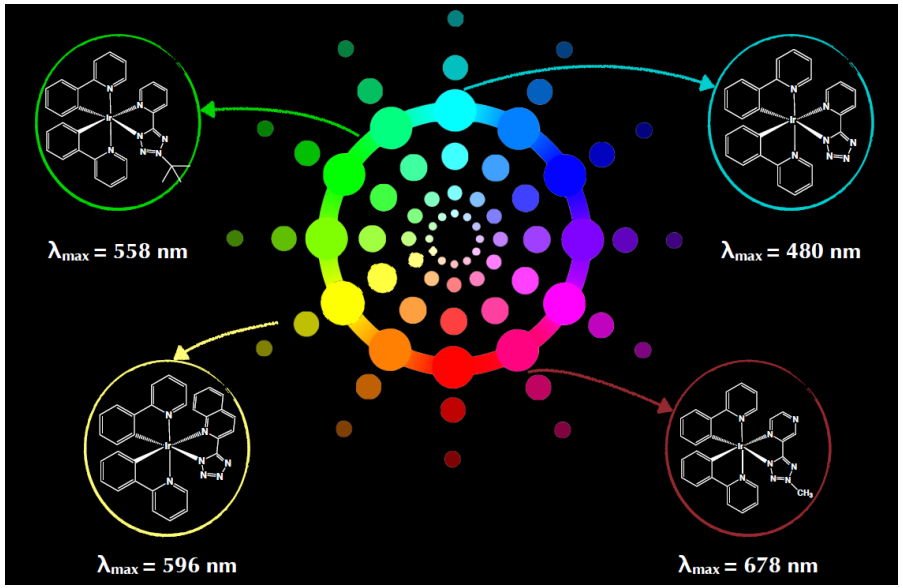
Photocative Metal Complexes for Materials and Life Sciences

Prof. Stefano Stagni
E-mail: stefano.stagni@unibo.it

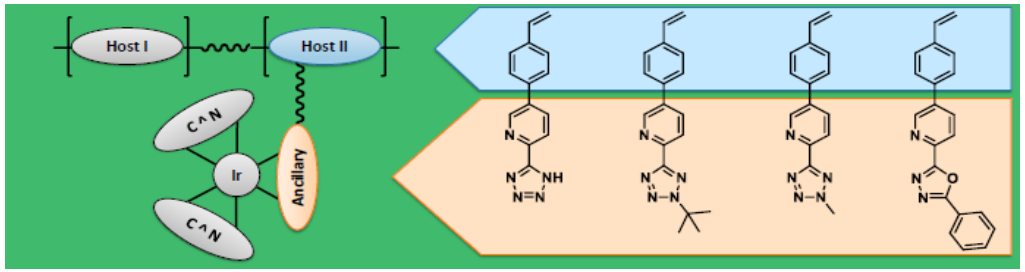
Dipartimento di Chimica Industriale "Toso Montanari"

Photoactive Metal Complexes for Materials Science

Organic molecules are combined with **transition metal ions** such as **Ir(III)**, **Re(I)**, **Ru(II)**, **Cu(I), Pt(II),** to prepare **coordination/organometallic complexes** that can efficiently **absorb visible light**, can display **bright luminescence,** are able to **transfer electrons** or, possibly, can do **all these things together**.



Luminescent Metal Complexes are designed for obtaining **a full-coloured palette** of emissive molecules and **Phosphorescent Metalla polymers** to be used in **photocatalysis**, **light emitting devices** (OLEDs, LEECs) and **luminescent solar concentrators**,.



Phosphorescent Metalla polymers

with Prof. **Andrea Pucci**@UniPI

20 years (and counting) collaboration with with Prof. **Max Massi**@Curtin University (AUS)

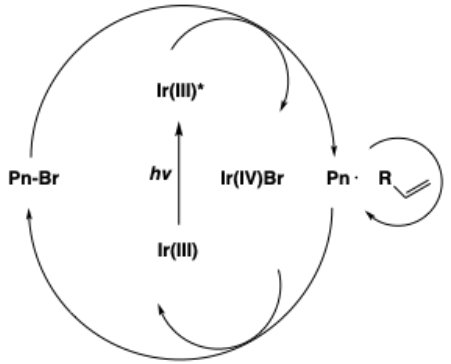


Photo-ATRP

Atom Transfer Radical Polymerization

with Prof. **Loris Giorgini** @UniBO

OLEDs..

Crew:
Eleonora Previati PhD
Anna De Carlonis (M.Sc. Student)

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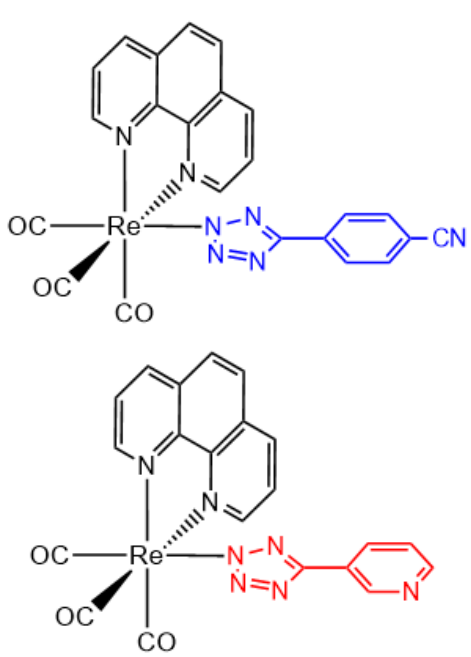
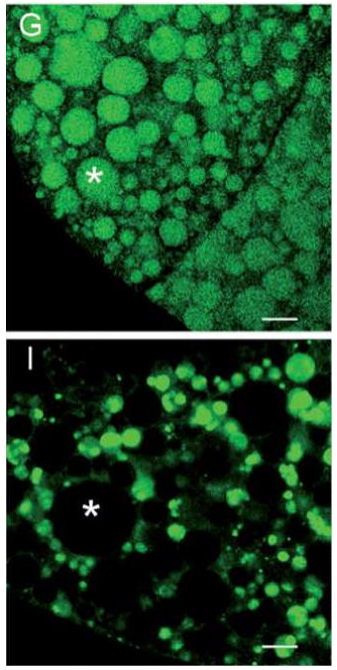
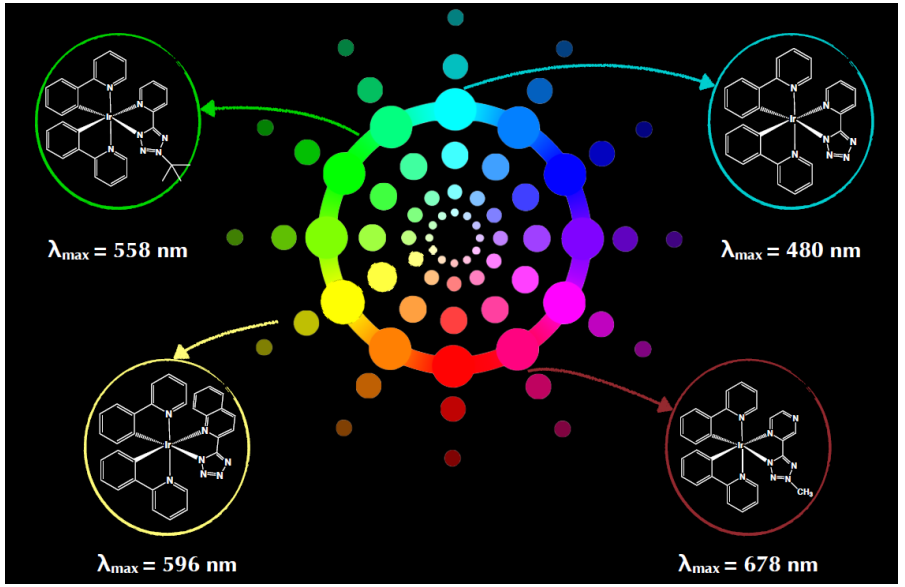
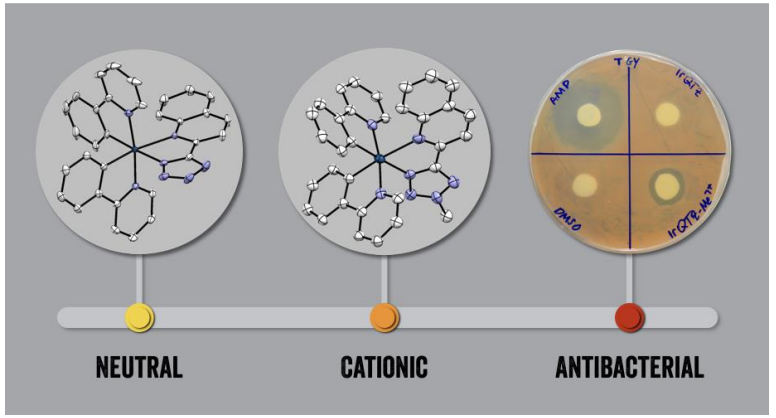
Photoactive Metal Complexes for Life Science **Luminescent metal complexes of Ir(III), Re(I), and Ru(II)**, are designed and synthesized for obtaining new **optical markers for live cells** and new classes of **selective antibacterials.**





Luminescent Imaging
of Live Eukaryotic Cells and Live Bacteria
with Prof. **Max Massi** @Curtin Uni. **Australia**





Metal complexes as new ANTIBACTERIALS
with Dr. **Alessandra Stefan** @UniBO
alessandra.stefan@unibo.it

Crew:
Eleonora Previati PhD
Anna De Carlonis (M.Sc. Student)

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UNIVERSITÀ DI BOLOGNA

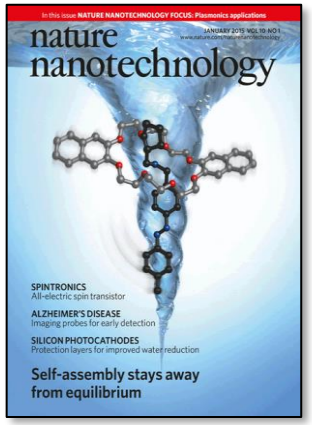
SUPRAMOLECULAR CHEMISTRY, PHOTOCHEMISTRY AND NANOSCIENCE

DESIGNING, MAKING AND OPERATING NANOSCALE DEVICES, MACHINES AND MATERIALS

Area di Chimica Inorganica

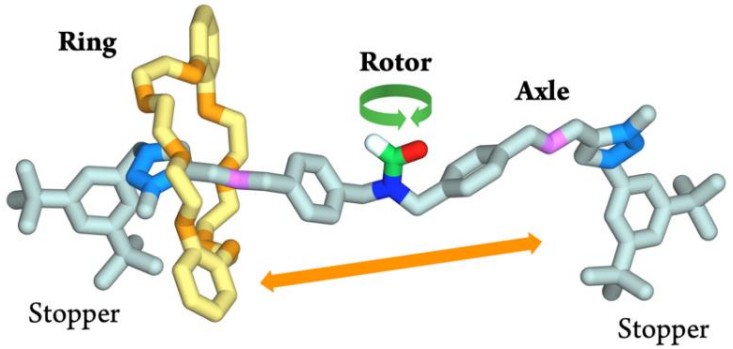
Dipartimento di Chimica Industriale "Toso Montanari"

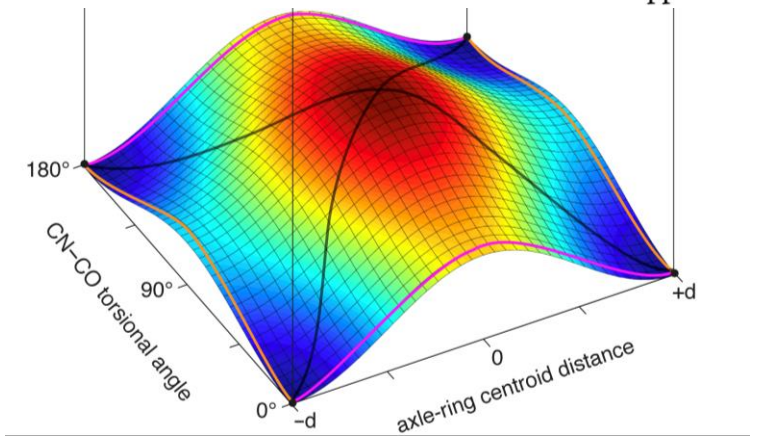
1. Artificial molecular machines and motors



CONTEXT

The realization of mechanical machines and motors of nanoscale size is a stimulating scientific challenge and a primary objective of nanotechnology, as demonstrated by the award of the Nobel Prize in Chemistry in 2016.



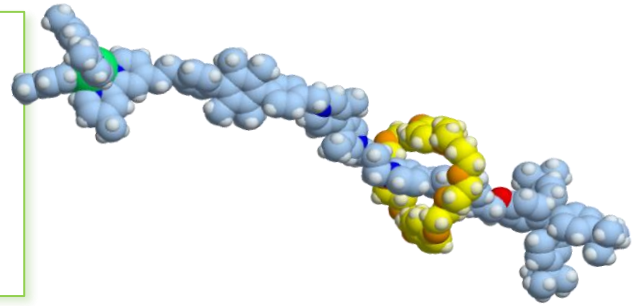


ACTIVITIES

Construction and investigation of **supramolecular complexes** and topologically nontrivial molecules (**rotaxanes**, **catenanes** and related species) that can perform controlled movements in response to light stimulation or other types of chemical or physical signals. Problems include the design of directed motion, its use to carry out tasks, autonomous operation away from equili-brium, and incorporation in complex matrices such as vesicles and polymers.

OBJECTIVES

Realization of innovative systems and intelligent materials for *catalysis, robotics, medicine, information technology and solar enery conversion.*



REFERENCES

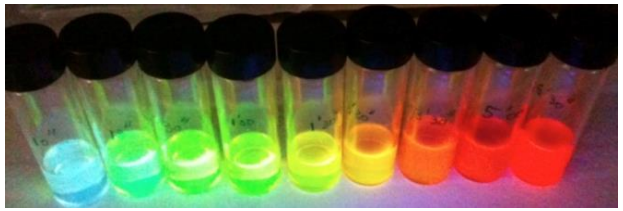
Molecular machines. Available at www.1088press.it
Nature Nanotech. **2015**, *10*, 70
Chem. Rev. **2020**, *120*, 200
Chem **2021**, *7*, 2137
J. Am. Chem. Soc. **2022**, *144*, 10180
Nature Nanotech. **2022**, *17*, 746
Chem **2025**, *11*, 102375

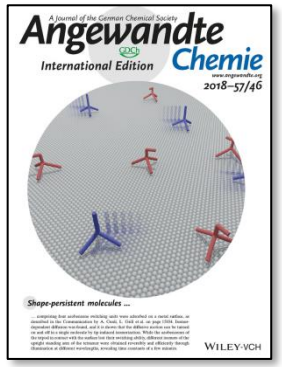
centr ibo.it/clan
alber credi@unibo.it

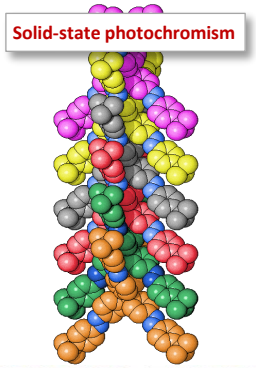
2. Stimuli-responsive molecules and materials

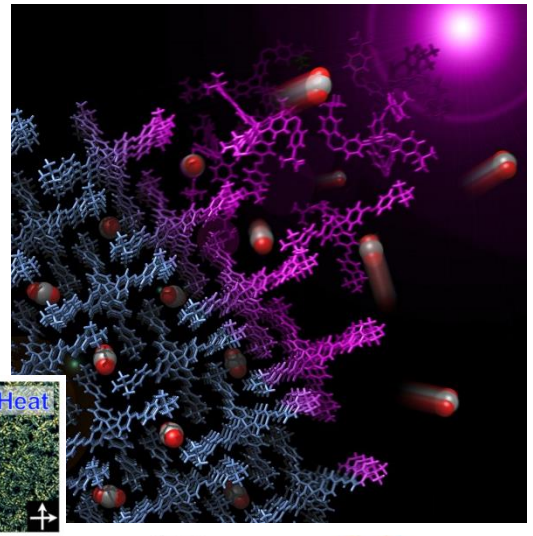
CONTEXT

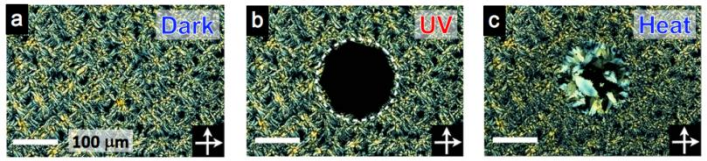
(Supra)molecular-based systems and materials that can perform predetermined functions in response to light or electrical stimulation are highly interesting for the inherent scientific value related to a bottom-up approach to functional nanostructures, and for the prospective applications in diverse fields of technology and medicine.











ACTIVITIES

Synthesis and characterization of **luminescent** and/or **photoreactive** species and related phenomena, including: molecular photoswitches, photochromism in solution and in the solid state, luminescent molecules and nanocrystal quantum dots, solid-state emission.

OBJECTIVES

Development of molecules and nanostructured materials suitable for applications in *analytical sciences, bioimaging, mechanical actuation, photopharmacology, gas adsorption, modification of surfaces, photocatalysis and solar energy conversion*.

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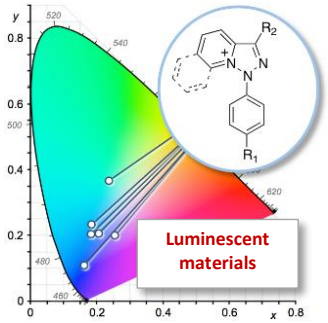
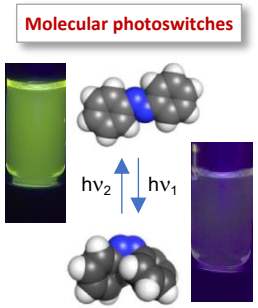
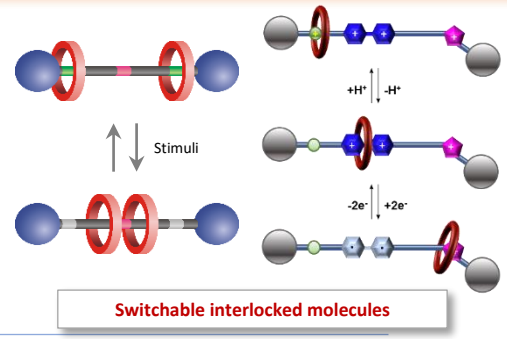
J. Am. Chem. Soc. **2019**, *141*, 9129
J. Am. Chem. Soc. **2021**, *143*, 7046
Chem. Commun. **2022**, *58*, 11236
Chem. Eur. J. **2023**, *29*, e202203472
Angew. Chem. Int. Ed. **2025**, *64*, e202414609







The research team, laboratories and equipment

PI | Prof **Alberto Credi** Dipartimento di Chimica Industriale “Toso Montanari”

Staff | Prof **Serena Silvi** Dipartimento di Chimica “G. Ciamician”
Prof **Massimo Baroncini** Dipartimento di Scienze e Tecnologie Agro-alimentari
Dr **Jessica Groppi** ISOF-CNR | Prof **Stefano Corrà**, Prof **Massimiliano Curcio** Dipartimento di Chimica Industriale “Toso Montanari”

Post-doc | Dr **Leonardo Andreoni**, Dr **Chiara Taticchi**, Dr **Brian Sachini**

Collaborations | Luigi Cavallo Kaust-Saudi Arabia | Stefan Diez Technische Universitaat Dresden-Germany | Massimiliano Esposito Université de Luxembourg | Ettore Fois Università dell’Insubria | Antonella Fontana Università di Chieti | Marco Garavelli Università di Bologna | Nicolas Giuseppone CNRS, Université de Strasbourg-France | Leonhard Grill Universitaat Graz-Austria | Marco Lucarini Università di Bologna | Giulio Ragazzon Université de Strasbourg-France | Andrea Secchi Università di Parma

CLAN CENTER FOR LIGHT ACTIVATED NANOSTRUCTURES

All activities are carried out in the Center for Light Activated Nanostructures (Clan), a joint laboratory between the University of Bologna and Cnr, located in the Bologna campus of Cnr – just across the street to the new ChimInd building. The laboratory has cutting-edge skills and equipment, and is funded by European and national grants.






European Research Council | European Commission | MINISTERO DELL'ISTRUZIONE, DELL'UNIVERSITÀ E DELLA RICERCA | Ministero degli Affari Esteri | UNIVERSITÀ ITALO FRANCESE | Regione Emilia Romagna | ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA | Consiglio Nazionale delle Ricerche

centri.unibo.it/clan

alberto.credi@unibo.it

Hybrid perovskite semiconductors for optoelectronic applications

Area di Chimica Inorganica

Dipartimento di Chimica Industriale “Toso Montanari”

CHYMERA Group
funCtional Hybrid MatERiAls

We develop advanced **metal halide perovskite semiconductors** for the next generation of **optoelectronic devices**, with applications ranging from photovoltaic to light-emitting diodes, photodetectors and scintillators.

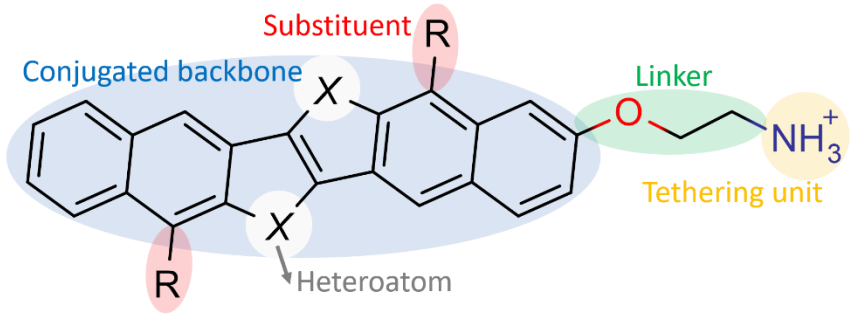
*We are currently running the ambitious European project (ERC) **SUPER**, Supramolecularly Engineered perovskite quantum wells.*
(https://cordis.europa.eu/project/id/101040681)

SUPER
Supramolecularly Engineered Functional Perovskite Quantum Wells

European Research Council
Established by the European Commission

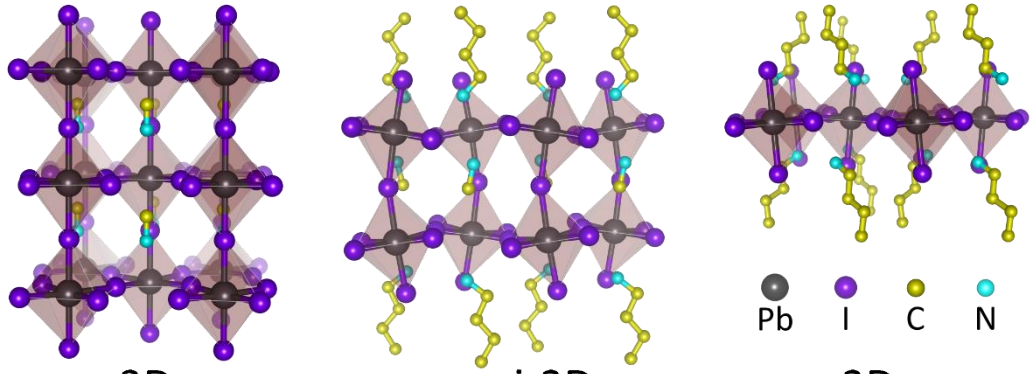
Research Activities

Development of functional organic semiconductors for integration in low-dimensional perovskites.



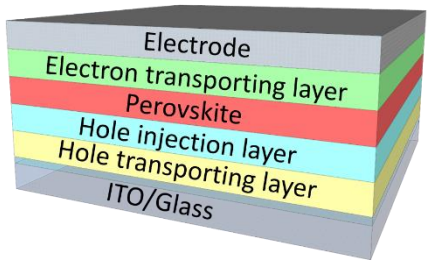
Molecular rod semiconductors

Perovskite self-assembly and investigation of local coordination environments via solid state NMR (ssNMR).

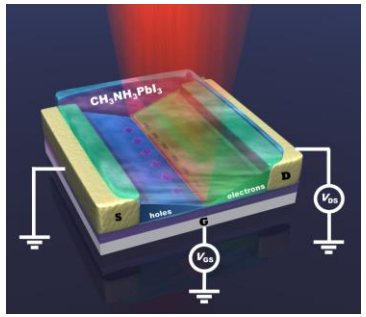


3D ·····→ quasi-2D ——→ 2D

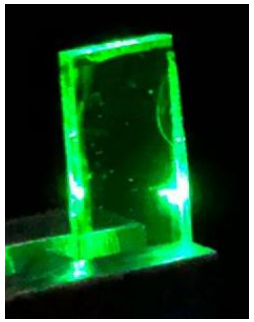
Fabrication and characterization of perovskite-based light-emitting devices.



Light emitting diodes

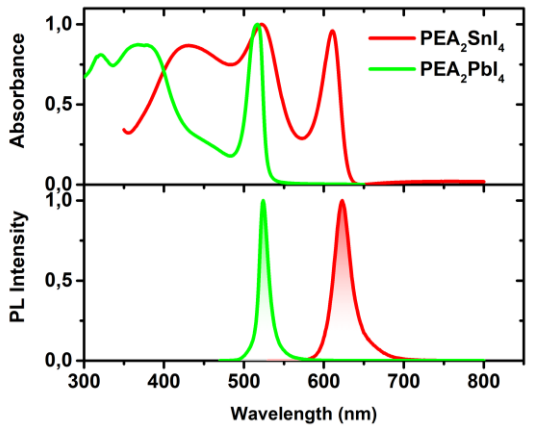


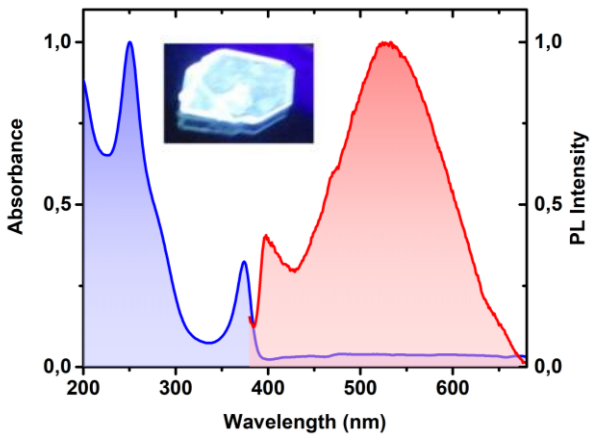
Light emitting FETs



Lasers

Photophysical characterization.





CHYMERA Group and Labs

Team Leader
Prof. Daniele Cortecchia
(https://www.unibo.it/sitoweb/daniele.cortecchia2)

Team Members
Ranita Samanta (Post Doc)
Giulia Luovisi (PhD Student)
Nurgul Sarsembekova (PhD Student)
Francesca Canestra (Research Assistant)

Undergraduate students (current): Martina Santarelli, Andreas Mercenier, Irene Carnevali, Alice Rizzoli