Title	**Producing and engineering enzymes for biocatalysis and bioremediation**
PI	BERGANTINO Elisabetta
Research Group	Synthetic Biology and Biotechnology - Department of Biology – DiBio
Curriculum	Scienze Chimiche
Contact	**web:**
	email: elisabetta.bergantino@unipd.it

Projects description:

The proposed **research activity**, focused on the study of enzymes, targets the specific fields of biocatalysis or bioremediation and will predictably proceed through the following step: (i) *in silico* identification and recombinant production of new enzymes; (ii) their biochemical and structural characterization (crystallization or modeling); (iii) bioinformatics analysis and engineering of the proteins (site-specific mutagenesis / rational design / directed evolution).

Chemical industry is increasingly interested in **biocatalysis** to assist synthesis of molecules with high added value. Enzymes can help in overcoming critical steps in organic synthesis by furnishing high chemo-, regio- and enantio-specificity and selectivity. The widespread application of biocatalysts has however to face the limited number of simultaneously synthetically useful and commercially available enzymes. Basic research is needed to uncover new enzymes and to improve their stability and substrate repertoire, as well as their capability of withstanding the harsh conditions often required in industrial reactors (non-aqueous solvents or extreme salinity, temperature, pH).

Pollution of freshwater by PFASs (Perfluoroalkyl Substances) is currently an emergence in Veneto. A possible approach for **bioremediation** consists in finding one or more enzymes (laccases, peroxidases and fluoroacetate dehalogenases) that can be used to remove PFAS or reduce their toxicity, after their expression in a microbial strain (such as the cyanobacterium *Synechocystis*) proven to be cultivated in real wastewaters.

Publications:

- Haudecoeur R, Carotti M, Gouron A, Maresca M, Buitrago E, Hardré R, Bergantino E, Jamet H, Belle C, Réglier M, Bubacco L, Boumendjel A (2017) 2-hydroxypyridine-N-oxide-embedded aurones as potent human tyrosinase inhibitors. ACS Med. Chem. Lett. 8: 55–60
- Fogal S, Beneventi E, Cendron L, Bergantino E (2015) Structural basis for double cofactor specificity in a new formate dehydrogenase from the acidobacterium Granulicella mallensis MP5ACTX8. Appl Microbiol Biotechnol, 99: 9541-54
- Beneventi E, Niero M, Motterle R, Fraaije M, Bergantino E (2013). Discovery of Baeyer-Villiger monooxygenases from photosynthetic eukaryotes. J Mol Calalysis B-Enzymatic, 98: 145-154

Collaborations/Network:

- Bruno Miroux, Laboratory of Physical and Chemical Biology of Membrane Proteins UMR 7099, Institute of Physico-Chemical Biology, Paris, France - University Paris Diderot;
- Marco Fraaije, Molecular Enzymology Group, University of Groningen, Groningen, The Netherlands;
- Melanie Hall, Department of Chemistry, University of Graz, Austria.

Research funding:

The project on biocatalysis has been supported by F.I.S.-Fabbrica Italiana Sintetici, Alte di Montecchio Maggiore (Vicenza), Italy.

Title	Provide a title for the research project
PI	COLLINI Elisabetta
Research Group	Multidimensional and Ultrafast Optical Spectroscopy Group (MUOS) – DiSC
Curriculum	Scienze Chimiche
Location	DiSC
Contact	**web:** www.chimica.unipd.it/elisabetta.collini
	email: elisabetta.collini@unipd.it

Project description:
Scientists across several disciplines have recently become interested in the possibility that quantum-mechanical phenomena may play a role in electronic energy transfer (EET). This is a photo-physical process that happens both in natural antenna complexes in photosynthetic organisms and in synthetic light-absorbing materials (e.g. conjugated polymers) used in optoelectronic devices. In multi-chromophoric systems, emerging experimental results have clarified that the energy transfer mechanism cannot be described simply by semiclassical models that invoke incoherent 'hopping' of excited-state populations along discrete energy levels, but that electronic energy transfer involves quantum coherent pathways. This discovery opened new exciting perspectives on the possibility of controlling the efficiency and the mechanism of EET through quantum-mechanics!
In the project the attention is focused in particular on the comprehension of which factors could be responsible of that phenomenon, such as structural elements, coupling with vibrational modes or plasmonic interactions. New ultrafast spectroscopic techniques, in particular 2D electronic spectroscopy, together with more conventional time-resolved optical techniques will be employed to obtain clear experimental proofs of these effects and shed light on their origin.
The attention will be focused on artificial biomimetic multichromophoric systems, biological antenna complexes and organic/inorganic hybrid nanostructured systems including functionalized metal nanoparticles and semiconductor nanocrystals.

Publications:
[1] E.Meneghin et al., Nat. Commun. 2018, 9, 3160.
[2] M.Righetto et al., PCCP 2018, 20, 18176
[3] Collini, E. Chem. Soc. Rev. 2013, 42, 4932.
[4] Collini, E.; et al. Nature 2010, 463, 644.

Collaborations/Network:
Prof. C. Ferrante (Padova) [spectroscopy]
Dr. M. Cordaro, Dr.ssa M. Castriciano (Messina) [supramolecular chemistry, organic synthesis]
Prof. F. Remacle (Liegi); Dr.ssa B. Fresch (Padova) [theory and modeling]
Prof. F.Mancin (Padova) [materials and synthesis]

Research funding:
PRIN 2015 n.2015XBZ5YA 'Towards quantum-photovoltaics: ultrafast energy and charge transport in hybrid nanomaterials'; PRIN2017 n.2017A4XRCA 'Physico-chemical Heuristic Approaches: Nanoscale Theory Of Molecular Spectroscopy'; H2020 FET OPEN 'Coherent Optical PArallel Computing' (COPAC, GA n. 766563)

Title	**Multiscale simulations of protein-surface and protein-nanoparticle interactions**
PI	CORNI Stefano
Research Group	Nanostructures & (Bio)molecules Modeling – DiSC
Curriculum	Scienze Chimiche
Contact	**web:** www.tame-plasmons.eu
	email: stefano.corni@unipd.it

Project description:

Protein-surface & protein-nanoparticle interactions are central to several material science and bio-oriented systems, such as enzymatic biofuel cells (electric power by organics fuels), guiding self-assembling at the nanoscale with material-specific proteins, nanoparticle effects on protein aggregation. The PhD project consists in extending the computational tools developed by our group, and/or to apply them to problems of biotechnological/material science relevance. A MSc background in Computational Chemistry or Physics is helpful but not mandatory.

Publications:

1. L. Bellucci, G. Bussi, R. Di Felice, S. Corni *Fibrillation-prone conformations of the amyloid-β-42 peptide at the gold/water interface* Nanoscale 9, 2279 (2017)
2. Ozboyaci, M., Kokh, D.B., Corni, S., Wade, R.C. *Modeling and simulation of protein-surface interactions: Achievements and challenges* Quart. Rev. Biophys. 49, e4 (2016)
3. L.B. Wright, J. P. Palafox-Hernandez, P.M. Rodger, S. Corni, T.R. Walsh, *Facet selectivity in gold binding peptides: exploiting interfacial water structure* Chem. Sci. 6, 5204 (2015)
4. G. Brancolini, A. Corazza, M. Vuano, F. Fogolari, M. C. Mimmi, V. Bellotti, M. Stoppini, S. Corni, G. Esposito, *Probing the Influence of Citrate-Capped Gold Nanoparticles on an Amyloidogenic Protein* ACS Nano 9, 2600 (2015)

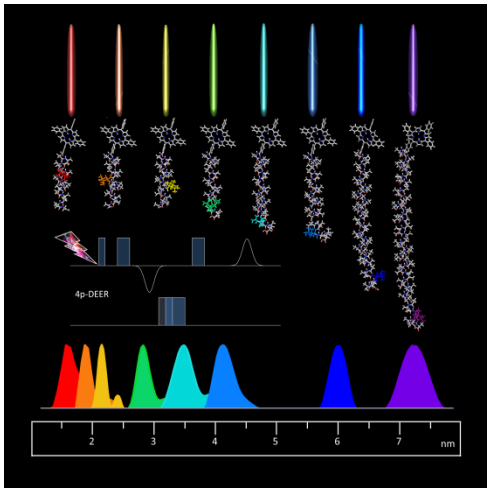
Collaborations/Network:

T. Walsh, Deakin University, AUS
R.C. Wade, Univ. Heidelberg & HITS, DE
G. Brancolini, CNR-NANO Modena, IT
G. Esposito, Univ. Udine, IT & NYU, Abu Dhabi, UAE
R. Di Felice, USC, Los Angeles, USA
M. Sarikaya, Univ. Washington, Seattle, USA

Title	**Innovative spin labels for high-sensitivity distance measurements in proteins by advanced EPR spectroscopy**
PI	Di Valentin Marilena
Research Group	EPR Spectroscopy/Biophysics – DiSC
Curriculum	Scienze Chimiche
Contact	**web:** http://www.chimica.unipd.it/biofisica/pubblica/personali/divalentin/index.html
	email: marilena.divalentin@unipd.it

Project description:

The aim of the research project is the application of Electron Paramagnetic Resonance (EPR) spectroscopy, using different advanced EPR techniques, as investigation tool for the study of biological systems, focusing on the resolution of structural and conformational problems and exploiting the triplet state as paramagnetic probe. The spectroscopic investigation, complemented by suitably tailored theoretical approaches, constitutes the basis for measuring nanometer distances in complex biological systems. The methodology is applied to paradigmatic proteins in which the chromophore probe is endogenously bound to different classes of proteins. Appropriate spin-labeling protocols can finally extend this novel strategy to any macromolecular system with a general impact in structural (bio)chemistry.



Publications:

Di Valentin, M., Albertini, M., Zurlo, E., Gobbo, M., Carbonera, D. Porphyrin triplet state as a potential spin label for nanometer distance measurements by PELDOR spectroscopy (2014) Journal of the American Chemical Society, 136, 6582.

Di Valentin, M., Albertini, M., Dal Farra, M.G., Zurlo, E., Orian, L., Polimeno, A., Gobbo, M., Carbonera, D. Light-induced porphyrin-based spectroscopic ruler for nanometer distance measurements (2016) Chemistry - A European Journal, 22, 17059.

Di Valentin, M., Dal Farra, M.G., Galazzo, L., Albertini, M., Schulte, T., Hofmann, E., Carbonera, D. Distance measurements in peridinin-chlorophyll a-protein by light-induced PELDOR spectroscopy. Analysis of triplet state localization (2016) Biochimica et Biophysica Acta - Bioenergetics, 1857, 1909.

Collaborations/Network:

Collaboration with experts in theoretical/computational chemistry (modeling and data analysis), in peptide synthesis and molecular biology (sample preparation and spin labeling protocols) have been established in the Departments of Chemical Sciences and Biology of the University of Padua.

Research funding:

Progetto di Ricerca di Ateneo 2014

Title	Towards the development of new radiopharmaceuticals based on thermodynamically strong and kinetically inert metal-ligand complexes.
PI	DI MARCO Valerio
Research Group	Analytical Chemistry – DiSC
Curriculum	Scienze Chimiche
Contact	**web:** http://www.chimica.unipd.it/analitica/
	email: valerio.dimarco@unipd.it

Project description:
The present research program aims to develop new radiopharmaceuticals for cancer therapy. Radiopharmaceuticals are constituted by a molecule bearing a targeting agent and a complexing moiety, and by a suitable radionuclide metal ion which represents the active (toxic) part of the drug. Complex stability and kinetical properties of the complex should guarantee that the radionuclide is firmly bound to the molecule, thus avoiding radionuclide releases outside the target site. The present project, named ISOLPHARM, involves the INFN of Legnaro (PD) (Istituto Nazionale di Fisica Nucleare), and the departments of Chemical Sciences (DISC) and Pharmaceutical Sciences (DSF) of the University of Padova.
Measurements aim to characterize the metal-ligand interactions from both a thermodynamic and kinetic point of view. Potentiometric, spectrophotometric, NMR and ESI mass measurements will be performed. As molecules are not commercially available, their synthesis will be performed at the department of Pharmaceutical Sciences. Periodic group meetings as well as short working periods will be scheduled also at the INFN.

Publications:
- F. Borgna, M. Ballan, C. Favaretto, M. Verona, M. Tosato, M. Caeran, S. Corradetti, A. Andrighetto, V. Di Marco, G. Marzaro, N. Realdon, Early Evaluation of Copper Radioisotope Production at ISOLPHARM, Molecules 2018, 23, 2437.
- V. Di Marco, M. Tosato, et al, complex formation between Ag(I) and a possible radiopharmaceutical, 2019, paper in preparation.

Collaborations/Network:
(other than INFN, DISC and DSF) Dr. Mattia Asti, S.S Radiochimica, Hospital of Reggio Emilia. Trento Institute of Fundamental Physics and Applications (TIFPA). Istituto Oncologico Veneto, Padova. Prof. Roger Schibli, Paul Scherrer Institute (PSI), Switzerland.

Research funding:
Ateneo, INFN

Title	**Platinum free electrocatalysts based on Fe-Nx modified mesoporous carbon as cathodic material in proton exchange membrane fuel cell**
PI	Durante Christian
Research Group	Electrocatalysis and Applied Electrochemistry Group– DiSC
Curriculum	Scienze Chimiche
Contact	**web:** www.chimica.unipd.it/electrochem
	email: christian.durante@unipd.it

Project description:

Proton exchange membrane fuel cell (PEMFC) wide spreading is still hindered by the bottleneck of the oxygen reduction reaction (ORR). Actually, large amounts of precious Pt metal are required to promote the sluggish kinetics, causing the PEMFCs to be economically uncompetitive with conventional technologies. The physical amount of platinum existing on the Earth is barely enough to cover the world demand in the next forty years for fuel cell vehicles. Nitrogen doped mesoporous carbons are emerging as a new class of Pt free materials for ORR. In particular, it was observed that doped carbons containing small amount of transition metals, such as Fe or Co, can catalyze the O_2 reduction to H_2O at overpotentials comparable to that of the most active Pt catalyst.

In this research project, nitrogen doped mesoporous carbons containing small amount of Fe and/or Co (M@N-MC,) will be prepared from 1D and 2D coordination polymer prepared by thermal or hydrothermal synthesis of suitable carbon and metal precursor. The synthesis involves the employment of nitrogen containing polydentate ligands able at complexing iron or other metals, affording a robust network, which, after pyrolysis at high temperature, yields a porous carbon structure functionalized with Fe-Nx sites. The electrochemical characterization will include activity test at rotating ring disk electrode and stability tests combined with Raman and XPS spectroscopies and TEM microscopy. The 1D and 2D coordination polymer properties will be tailored in order to obtain high surface area, high stability and catalytic activity towards oxygen reduction reaction.

Publications:

(1) Perazzolo, V.; Durante, C.; Pilot, R.; Paduano, A.; Zheng, J.; Rizzi, G. A.; Martucci, A.; Granozzi, G.; Gennaro, A. *Carbon* **2015**, 95, 949–963.

(2) Perazzolo, V.; Grądzka, E.; Durante, C.; Pilot, R.; Vicentini, N.; Rizzi, G. A.; Granozzi, G.; Gennaro, A. *Electrochim. Acta* **2016**, 197, 251–262.

(3) Perini, L.; Durante, C.; Favaro, M.; Perazzolo, V.; Agnoli, S.; Schneider, O.; Granozzi, G.; Gennaro, A. *ACS Appl. Mater. Interfaces* **2015**, 7, 1170–1179.

Collaborations

1) Toyota Motor Europe
2) Technische Universität Berlin

Research funding:

Toyota Motor Europe Agreement
Crescendo Project, (**H2020-JTI-FCH-2017-1** call) under evaluation

Title	**Dynamics of protein corona formation on inorganic nanoparticles investigated with time resolved fluorescence techniques in microfluidic devices**
PI	Camilla Ferrante
Research Group	Laser Spectroscopy and Nanophotonics– DiSC
Curriculum	Scienze Chimiche
Contact	**web:** www.chimica.unipd.it/camilla.ferrante
	email: camilla.ferrante@unipd.it

Project description:

Inorganic nanoparticles (NP) are widely used in biology and medicine as selective fluorescent labels as well as drug carriers to target specific sites. NP surface properties are fundamental in these application and a large part of the synthetic work in this field deals with an ad hoc functionalization of the surface. At the same time it is important to understand how the specifically engineered surface can be modified when the NP are exposed to biological fluids such as blood and serum. In particular the research project will focus on the study of protein adsorption on the NP surface, usually named protein corona formation. To this end frequency and time resolved fluorescence experimented will be carried out. In particular fluorescence correlation spectroscopy will allow monitoring the change in the hydrodynamic radius of the NP upon exposure to specific protein under physiological conditions. Fluorescence lifetime imaging will be used to observe and characterize the evolution of the protein corona when the NP and the protein are mixed inside a microfluidic device.

Publications:

Rossetto, N.; Fortunati, I.; Gellini, C.; Feis, A.; Ferrante, C; *An optofluidic light detector based on the photoacoustic effect,* SENSORS AND ACTUATORS. B, CHEMICAL, 2016, 233, 71-75, DOI: 10.1016/j.snb.2016.04.046;

Fede C; Fortunati I; Weber V; Rossetto N; Bertasi F; Petrelli L; Guidolin D; Signorini R; De Caro R; Albertin G; Ferrante C; Evaluation of gold nanoparticles toxicity towards human endothelial cells under static and flow conditions, MICROVASCULAR RESEARCH, 2015, 97, 147-155, DOI:10.1016/j.mvr.2014.10.010;

Ferrante, C.; Fortunati, I.; Molinaro, I. Weber, V.; *BSA adsorption on gold nanoparticles investigated under static and flow conditions*, International Conference on BioPhotonics, BioPhotonics, 2015, 7304040, DOI: 10.1109/BioPhotonics.2015.7304040.

Research funding:

PRAT2015, Title: “A model Study of protein corona formation on nanoparticles based on time resolved fluorescence and microfluidic devices”

Title	**Tumor-targeting peptidomimetics: synthesis and bio-medical applications**
PI	FORMAGGIO Fernando
Research Group	Bio Organic Chemistry group – DiSC
Curriculum	Scienze Chimiche
Contact	**web:** http://www.chimica.unipd.it/bocgroup/index.htm
	email: fernando.formaggio@unipd.it

Project description:

Peptides and peptidomimetics are privileged options to develop small molecules targeting tumor-specific antigens involved in protein-protein interactions (PPI). This approach poses a whole new set of challenges to chemists for the design and synthesis of molecules with the potential of being evolved in therapeutic and diagnostic tools in oncology. We are addressing a selected group of well-characterized targets, relevant in cancer biology, by using peptidomimetics or non-natural oligomers folding into well-defined structures (foldamers).

In addition to this approach, *i.e.* inhibiting dangerous PPI, we will explore an alternative path that allows us to control tumors via immune-modulation or peptide-membrane interactions. Indeed, this research group has a long standing experience with the peptaibiotics, natural peptides known to interact and to disrupt the phospholipid bilayers.

This type of research, that requires a variety of skills, can be successful only through the collaboration of different laboratories. Therefore, synthesis and spectroscopic analyses will be carried out in Padova, whereas computational modeling and biological assays will involve a collaborative Italian network.

In summary, with this research we aim at accomplishing the following strategic objectives:

1. identification of tumor targeting peptidomimetics and foldamers (PPI inhibitors);
2. synthesis of multimeric and nanoscaled systems for drug delivery and cancer imaging;
3. synthesis and study of peptides and foldamers controlling tumors via immune-modulation or peptide-membrane interactions.

Publications:

Org. Biomol. Chem. 10, 1285-1299, 2012; *Chem. Biodivers.* 11, 1163-1191, 2014; *Biochim. Biophys. Acta-Biomembr.* 1848, 134-144, 2015; *Biopolymers (Pept. Sci.)* 106, 6-24, 2016.

Collaborations/Network:

Prof. Emanuele Papini, University of Padova, Italy; Prof. Simona Oancea, University of Sibiu, Romania; Prof. Lorenzo Stella, University of Rome “Tor Vergata”, Italy; Prof. Cesare Gennari, University of Milan, Italy

Research funding: Italian Ministry of University, PRIN 20157WW5EH, project title: “Tumor-targeting peptidomimetics: synthesis and bio-medical applications”.

Title	**Electron Paramagnetic Resonance investigation on new generation organic and hybrid electronic materials.**
PI	Franco Lorenzo
Research Group	EPR spectroscopy Group – DiSC
Curriculum	Scienze Chimiche
Contact	**web:** http://www.chimica.unipd.it/lorenzo.franco/pubblica
	email: lorenzo.franco@unipd.it

Project description:

This research project is focused on the investigation of the photophysics of new materials for organic and hybrid organic-inorganic electronics and photovoltaics. The materials investigated include organic conjugated polymers, fullerene derivatives, organic dyes, carbon nanostructures, organic perovskites and composite materials obtained by blending the above materials with some inorganic semiconductors nanoparticles (TiO2, ZnO and others) in disordered or layered structures. The investigation will be carried out on bulk materials and on devices based on several different architectures (bulk heterojunction, multilayer, and others). The research work will be mainly carried out using spectroscopic methods, mainly electron magnetic resonance (EPR), aiming at the identification of the main species generated in the material under visible-ultraviolet light absorption (free radicals, charge carriers, excited states) and the processes and interactions between them. From the spectroscopic results, it is expected to obtain information on the structural and electronic factors influencing the photoresponse of the materials.
The research work is done in collaboration with other research groups or the DiSC and additional collaboration with other national and international institutions.
The expected knowledge to be acquired by the PhD student includes a good expertise in EPR spectroscopy, a detailed knowledge of the research field organic electronics.

Publications:

(1) Privitera, A.; Righetto, M.; Mosconi, D.; Lorandi, F.; Isse, A. A.; Moretto, A.; Bozio, R.; Ferrante, C.; Franco, L. Boosting Carbon Quantum Dots/fullerene Electron Transfer via Surface Group Engineering. *Phys. Chem. Chem. Phys.* **2016**, *18* (18), 31286–31295.
(2) Cristofani, M.; Menna, E.; Seri, M.; Muccini, M.; Prosa, M.; Antonello, S.; Mba, M.; Franco, L.; Maggini, M. Tuning the Electron-Acceptor Properties of [60]Fullerene by Tailored Functionalization for Application in Bulk Heterojunction Solar Cells. *Asian J. Org. Chem.* **2016**, *5* (5), 676–684.
(3) Grancini, G.; De Bastiani, M.; Martino, N.; Fazzi, D.; Egelhaaf, H.-J.; Sauermann, T.; Antognazza, M. R.; Lanzani, G.; Caironi, M.; Franco, L.; et al. The Critical Role of Interfacial Dynamics in the Stability of Organic Photovoltaic Devices. *Phys. Chem. Chem. Phys.* **2014**, *16* (18), 8294.
(4) Camaioni, N.; Tinti, F.; Franco, L.; Fabris, M.; Toffoletti, A.; Ruzzi, M.; Montanari, L.; Bonoldi, L.; Pellegrino, A.; Calabrese, A.; et al. Effect of Residual Catalyst on Solar Cells Made of a Fluorene-Thiophene-Benzothiadiazole Copolymer as Electron-Donor: A Combined Electrical and Photophysical Study. *Org. Electron.* **2012**, *13* (4), 550–559.

Title	**Reconstructing paleoenvironmental conditions form biogenic markers in ice cores**
PI	GIORIO Chiara
Research Group	Analytical Chemistry – DiSC
Curriculum	Scienze Chimiche
Location	DiSC, Padova
Contact	**web:** http://www.chimica.unipd.it/category/ruoli/personale-docente?key=54631E5DCFB79F50380CAC51246DBAA1
	email: chiara.giorio@unipd.it

Project description:

Ice cores provide exceptional time-resolved archives of data on Earth's climatic conditions on timescales ranging up to 800,000 years. Obtaining older records has been an ongoing challenge in the ice core community with the current Beyond EPICA (BE) project focussing on the retrieval of a 1.5 million year old Antarctic ice core. Most ice core data focusses on inorganic components in the ice (e.g. water isotopes, inorganic salts, or gases) due to their higher concentrations. However, it has long been recognised that additional climatic information resides in the organic compounds present in the ice. For example, the biosphere is the largest emitter of both primary organic aerosols and volatile organic compounds. Specific organic compounds in ice cores may therefore explain how the terrestrial biosphere has changed due to rapid climate changes and glacial-interglacial transitions or give an indication of the sea ice extent in past eras. The proposed project aims to combine the growing field of microfluidics with improvements to conventional mass spectrometry to allow for continuous analysis of ice cores, gradually melted in continuous on a melting-head, for the determination of terrestrial and marine biomarkers with high time resolution in the archive.

In the framework of this research project, the prospective PhD student will experience working in an international collaborative environment. The student will develop skills in microfluidics, ma ss spectrometry for analysis of organic in ultra-trace levels and advanced data analysis techniques.

Publications:

King A.C.F.*, Giorio C.*, et al. (**2019**) Direct injection liquid chromatography high-resolution mass spectrometry for determination of primary and secondary terrestrial and marine biomarkers in ice cores. Analytical Chemistry, doi: 10.1021/acs.analchem.8b05224.

Giorio C.*, Kehrwald N.*, et al. (**2018**) Prospects for reconstructing paleoenvironmental conditions from organic compounds in polar snow and ice. Quaternary Science Reviews, 183, 1-22.

Collaborations/Network:

Professor Carlo Barbante, Università Ca' Foscari, Venezia
Professor Eric Wolff, University of Cambridge (UK)
Dr. Liz Thomas, British Antarctic Survey (UK)

Research funding:

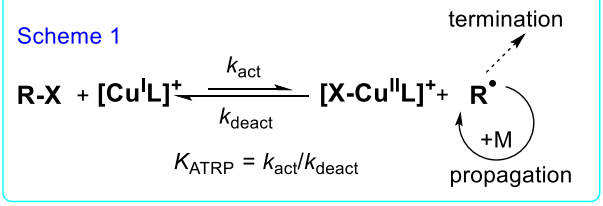
PRIN-AMICO

Title	Study of the activation process in atom transfer radical polymerization
PI	Abdirisak Ahmed Isse
Research Group	Electrocatalysis and Applied Electrochemistry Group– DiSC
Curriculum	Scienze Chimiche
Contact	**web:** www.chimica.unipd.it/electrochem
	email: abdirisak.ahmedisse@unipd.it

Project description:

Atom transfer radical polymerization (ATRP) is a powerful controlled radical polymerization technique, used to prepare polymers with well-defined architectures, predetermined molecular weights (MW), and low dispersities. The process is catalyzed by a copper−amine complex through a reversible equilibrium involving the activator and deactivator complexes, $[Cu^{I}L]^{+}$ and $[X\text{-}Cu^{II}L]^{+}$ (X = Cl, Br), respectively (Scheme 1). The success of the process relies on various parameters including the stability and reactivity of the catalyst toward initiator, dormant species and propagating radicals.

Scheme 1



The aim of the present research project is to determine kinetic and thermodynamic parameters of relevance to the activation step of ATRP, i.e., k_{act}, k_{deact}, K_{ATRP}, and stability and halidophilicity constants of catalyst complexes. These parameters strongly depend on the nature of the solvent and, above all, on the composition of solvent/monomer mixture. The study will therefore cover a wide range of solvents and monomers that are typically used in ATRP. The study will mainly employ various electrochemical and spectrophotometric techniques.

Publications:

Fantin, M.; Isse, A.A.; Matyjaszewski, K.; Gennaro, A. *Macromolecules*, **2017**, *50*, 2696-2705.
Fantin, M.; Isse, A.A.; Bortolamei, N.; Matyjaszewski, K.; Gennaro, A. *Electrochim. Acta*, **2016**, *222*, 393-401.
Fantin, M.; Isse, A.A.; Gennaro, A.; Matyjaszewski, K. *Macromolecules* **2015**, *48*, 6862-6875.
Bortolamei, N.; Isse, A.A.; Di Marco, V.B.; Gennaro, A.; Matyjaszewski, K. *Macromolecules* **2010**, *43*, 9257-9267.

Collaborations

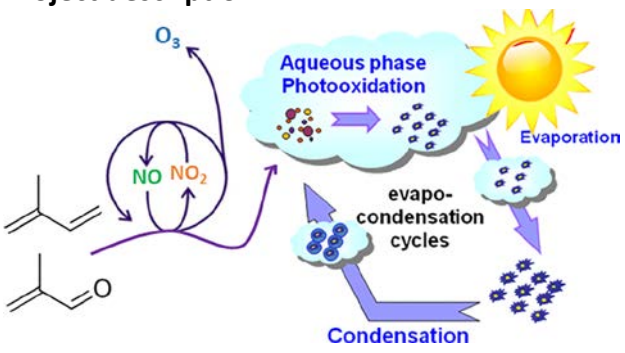
1) K. Matyjaszewski, Center for Molecular Engineering, Department of Chemistry, Carnegie Mellon University, 4400 Fifth Avenue, Pittsburgh, Pennsylvania 15213, United States.

Research funding:

Progetto Ateneo PRAT2015 - CPDA150001.

Title	**Cloud processing of atmospheric aerosol**
PI	GIORIO Chiara
Research Group	Analytical Chemistry – DiSC
Curriculum	Scienze Chimiche
Location	DiSC, Padova
Contact	**web:** http://www.chimica.unipd.it/category/ruoli/personale-docente?key=54631E5DCFB79F50380CAC51246DBAA1
	email: chiara.giorio@unipd.it

Project description:



Chemical processes in clouds have been suggested to contribute substantially to organic aerosol particle mass. However, considerable uncertainties exist, e.g. with regards to the nature of the resulting aerosol particles which might be metastable and loose at least part of their organic mass during the cloud droplet evaporation.
The project is aimed at the investigation of cloud processes which are able to process organic constituents and produce organic aerosol particle mass. The project will focus on the multiphase chemistry of atmospheric relevant polyfunctional precursors such as polyfunctional carbonyls and acids. With these precursors, a combination of aqueous-phase laboratory and smog chamber studies will be undertaken to examine the multiphase cloud processing. The planned chamber studies will use different seeds and oxidant precursors to examine the organic mass production under different environmental and diurnal conditions.
In the framework of this project, the prospective PhD student will experience working in an international collaborative environment, will gain experience in smog chamber studies, mass spectrometry and advanced techniques for data analysis.

Publications:

Giorio C.*, et al. (**2017**) Cloud processing of secondary organic aerosol from isoprene and methacrolein photooxidation. Journal of Physical Chemistry A, 121 (40), 7641–7654.

Giorio C.*, et al. (**2017**) Formation of metal-cyanide complexes in deliquescent airborne particles: a new possible sink for HCN in urban environment. Environmental Science and Technology, 51(24), 14107-14113.

Collaborations/Network:

Professor Jean-François Doussin, Université Paris-Est Créteil (France)
Professor Hartmut Herrmann, TROPOS - Leibniz-Institut für Troposphärenforschung (Germany)
Professor Anne Monod, Aix-Marseille Université (France)

Research funding:

ANR PARAMOUNT, Eurochamp2020

Title	**Targeted nanoprobes for imaging and dual mode therapy**
PI	GOBBO Marina
Research Group	Bio-organic Chemistry – DiSC
Curriculum	Scienze Chimiche
Contact	**web:** www.chimica.unipd.it/bocgroup
	email: marina.gobbo@unipd.it

Project description:

The combination of various therapeutic strategies to treat cancer is an important and promising strategy to improve therapeutic efficiency and overcome drug resistance. Gold nanoparticles represent an ideal platform on which integrating different therapeutic and diagnostic functions as well as target molecules. The objective of this PhD project will be the engineering of biocompatible plasmonic nanostructures functionalized with photosensitizing and targeting units to be used as biosensors in cancer theragnostics. The diagnostic moiety will be constituted by SERRS nanostructures which show a high efficiency in multiplexing measurements and a detection limit approaching the single molecule level. For therapy the photothermal properties of gold nanoparticles, irradiated with light of the correct wavelength to induce localized temperature increases, will be combined with a photosensitizing agent able to generate ROS under the laser condition used for detection. The nanostructure should be biocompatible to allow long circulation times in vivo and functionalized with targeting agents for selective delivery to tumor site. Throughout this interdisciplinary project the PhD student will be involved in synthetic aspects related to the coating of the nanoparticles, in the preparation and photophysical characterization of the nanostructures and in testing the SERRS and photodynamic properties of the nanoprobes.

Publications:

1) Moret, M. Gobbo, E. Reddi (2015) Conjugation of photosensitisers to antimicrobial peptides increases the efficiency of photodynamic therapy in cancer cells. *Photochem. Photobiol. Sci. 14,* 1238-1250.

2) R. Dosselli, R. Ruiz-González,. F. Moret,. V. Agnolon,. C. Compagnin, M. Mognato, V. Sella, M. Agut,. S. Nonell,. M. Gobbo, E. Reddi (2014*)* Synthesis, Spectroscopic, and Photophysical Characterization and Photosensitizing Activity toward Prokaryotic and Eukaryotic Cells of Porphyrin-Magainin and -Buforin Conjugates. *J. Medicinal Chem*., 57, 1403-1415.

3) G. Sciutto, L. Litti, C. Lofrumento, S. Prati, M. Ricci, M. Gobbo, A. Roda, E. Castellucci, M. Meneghetti, R. Mazzeo (2013) Alternative SERRS probes for the immunochemical localization of ovalbumin in paintings: an advanced mapping detection approach. *Analyst*, 138, 4532-4541.

Collaborations/Network:

The projet is in collaboration with the Department of Surgery Oncology and Gastroenterology, University of Padova (Prof. S. Mocellin) and the Department of Medicin University of Padova (Prof. P. Pontisso).

Research funding:

MIUR

Title	Crystallisation of inorganic nanostructures under confinement
PI	GROSS Silvia
Research Group	Wet Chemistry and Colloids groups – DiSC
Curriculum	Scienze Chimiche
Contact	**web:** http://www.chimica.unipd.it/silvia.gross/
	email: silvia.gross@unipd.it

Project description:

The reason why in many application fields **crystallisation** is sought after is not straightforward. Nowadays, instead of focusing only on structure-properties relationships, **functionality-oriented crystallisation** is pursued. As already outlined in a previous work by some of us,[1] crystallinity is in many case *conditio sine qua non* for the **achievement of particular functional properties** among which, *inter alia*, luminescence as well as catalytic, electronic, and magnetic properties. Crystallisation pathways in inorganic nanostructure can affect the final properties of the resulting materials since the evolution of the first seeds to the nuclei and eventually their growth may dictate also the occurrence of anisotropy and of not-spherical morphologies. Crystallisation can be dramatically altered by **nanometric confinement**, for instance pursued by nanosized pores or droplets. The topic of this PhD project will be to investigate the **nucleation/growth phenomena occurring in the confined volume of miniemulsion droplets**, where unusual behavior of solvent molecules, limited precursor concentrations, Laplace pressure and further experimental conditions can affect the crystal growth. In particular, the **objectives** of the PhD project will be to investigate the crystallisation pathways in the confined space of the droplets and to identify the most relevant experimental parameters ruling the structural evolution towards crystals. Skills that will be acquired by the PhD student encompass both the field of synthesis (miniemulsion process) as well as the *ex-situ* (XPS, XRD, TEM, SEM), *in situ* and time-resolved characterization, by synchtrotron-assisted methods (XRD, XAS, SAXS), of the inorganic nanostructures. Modeling activity is also envisioned.

Publications:

1. S. Gross*, A. Vittadini and N. Dengo, *Functionalisation of Colloidal Transition Metal Sulphides Nanocrystals: A Fascinating and Challenging Playground for the Chemist*, Crystals, **2017**, *7*, 110
2. A. Antonello, P. Dolcet, K. Landfester, R. Muñoz-Espí and S. Gross* et al, *Synergy of Miniemulsion and Solvothermal Conditions for the Low Temperature Crystallization of Magnetic Nanostructured Transition Metal Ferrites*, Chem. Mater., **2017**, *29*, 985–997
3. S. Diodati, P. Dolcet, M. Casarin and S. Gross*, *Pursuing the Crystallization of Mono- and Polymetallic Nanosized Crystalline Inorganic Compounds by Low-Temperature Wet-Chemistry and Colloidal Routes*, Chem. Rev., **2015**, *115*, 11449–11502

Collaborations/Network:

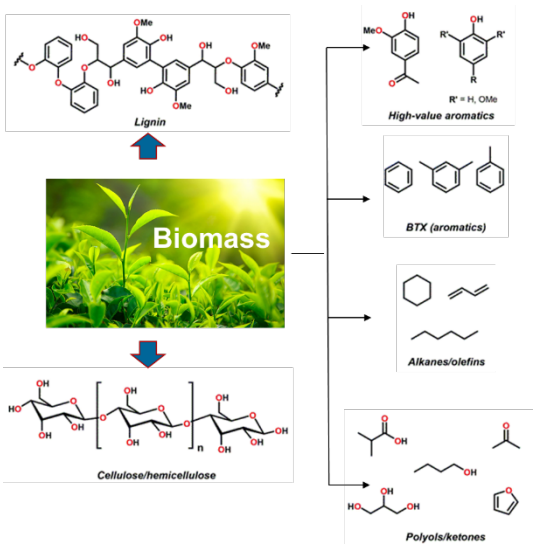
- Prof. B. Smarsly, Physikalisch-Chemisches Institut, Justus Liebig Universität Gießen, Germany
- Prof. K. Landfester, Max Planck Institut für Polymerforschung, Mainz, Germany
- Dr. R. Muñoz-Espí, University of Valencia, Valencia, Spain

Research funding: Bilateral project UCL-CNR ICMATE (mobility funded by RSC), Different industrial projects with Italian and European companies

[1] R. Muñoz-Espí, Y. Mastai, S. Gross and K. Landfester, Colloidal systems for crystallization processes from liquid phase (Invited), CrystEngComm, 2013, 15, 2175

Title	Catalyst Design for Innovative Sustainable Chemical Transformations
PI	LICINI Giulia
Research Group	Molecular Recognition and Catalysis
Curriculum	Scienze Chimiche
Contact	**web:** www.chimica.unipd.it/giulia.licini
	email: giulia.licini@unipd.it

Project description:



Catalysis is a Key Element to sustainability, which allows the efficient conversion of readably available starting materials into products for industry, health, environment, and nutrition, in high yields and avoiding unwanted by-products. In our group we developed homogeneous catalysts based on non-noble , Earth abundant transition metals and highly symmetric multidentate ligands, able to effectively perform oxidations (oxygen transfer processes and aerobic oxidative C-C bond cleavage) or activate small molecules (CO_2). Aim of this project will be the fine-tuning of these privileged ligands (ligand design, metal ion, additive) in order to explore even more challenging catalytic transformations. We intend to develop new catalysts for an effective biomass valorisation (aerobic oxidative lignin-cellulose and unsaturated fatty acids valorisation) and CO_2 fixation also taking advantage of non-conventional reaction conditions (micellar catalysis, IL, MW, catalyst anchoring on suitable supports, etc.) The elucidation of the reaction mechanism (characterization of the reactive species, spectroscopic, kinetic and computational studies) will be also a major goal for a deeper understanding of the system and a more rational optimization. The project will be carried out in the frame of COST Actions *FP1306. (http://www.cost.eu/COST_Actions/fps/Actions/FP1306)* and CM1402 Crystallize *(http://www.cost-crystallize.com/)*

Publications:

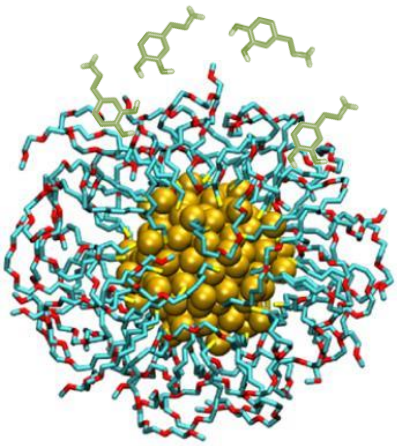
Amadio, E.; Di Lorenzo, R., Zonta, C. Licini. G. *Coord. Chem. Rev.,* **2015**, *255*, 2165– 2177; Badetti, E.; Romano, F.; Marchiò, L.; Taşkesenlioğlu, S.; Daştan, A.; Zonta, C.; Licini, G. *Dalton Trans.*, **2016**, *45*, 14603-14608; C. Miceli, J. Rintjema, E. Martin, E. C. Escudero-Adán, C. Zonta, G. Licini, A. W. Kleij *ACS Catal.,***2017**, *7*, 2367–2373

Collaborations/Network:

Arjan Kleij – ICIQ, Tarragona (Spain)
Kristin Bartik – ULB Bruxelles
Fabrizio Cavani – UNIBO, Bologna
Kari Rissanen, University of Jyväskylä, Jyväskylä, (Finland)

Title	**Rational design of nanoreceptors for sensing and molecular bio-trafficking**
PI	MANCIN Fabrizio
Research Group	Supramolecular Chemistry and Systems Chemistry – DiSC
Curriculum	Scienze Chimiche
Contact	**web:** www.chimica.unipd.it/fabrizio.mancin
	email: fabrizio.mancin@unipd.it

Project description:



The potential of macromolecular receptors is demonstrated by Nature. Proteins control almost any biological event using recognition to drive catalysis, signaling processes, ions translocation, etc. In the classic *supramolecular* approach, the receptor is a molecular entity designed following the principles of *complementarity* and *preorganization*. However, the complexity and specificity of natural receptors are still far from being reached. Monolayer Protected Gold Nanoparticles (MPGNs) offer an interesting shortcut to the development of macromolecular receptors by self-organization. Their coating can be considered as a three-dimensional array of organic molecules grafted to the particle surface. The functional groups implemented can provide the interactions for substrate recognition and the radial organization of the molecules on the particle surface multiply the number of interactions and provide some degree of preorganization. We have demonstrated that MPGNs can be turned into sensors and catalysts. Such an activity intrinsically implies the cooperative (or collective) recognition of substrate. However, the characterization and prediction of monolayer structure and activity are still challenging.

In this project, we aim at performing a deep investigation on the recognition properties of MPGNs. This will include synthesis of coating molecules and MPGNs, their structural characterization, the assessment of their binding properties, the investigation of their interactions with biological entities. The results obtained will be integrated with atomic molecular dynamic simulations (performed by our collaborators) to obtain a detailed picture. The **final goal will be the realization of nanoparticles with programmed molecular recognition** ability capable to detect **and translocate selected molecules in complex media**, including biological fluids and living organisms.

Publications:

B. Perrone, F. Rastrelli, F. Mancin et al. ***JACS*** 2013, *135*, 11768; M.-V. Salvia, F. Rastrelli, F. Mancin, et al. ***JACS*** 2015, *137*, 886; M.-V. Salvia, G. Salassa, F. Rastrelli, F. Mancin ***JACS*** 2015, *137*, 11399; L. Riccardi, L. Gabrielli, X. Sun, F. De Biasi, F. Rastrelli, F. Mancin, M. De Vivo ***Chem*** 2017, *accepted.*

Collaborations/Network:

Marco De Vivo, Istituto Italiano di Tecnologia, **Genova**; Monica Carril, CIG BIOMAguna, S. Sebastian, **Spagna**; Euan Kay, St. Andrew University, **UK**; Tomas Buergi, University of Geneve, **CH**.

Research funding:

MSCA-ITN MMBIO (International Training Network), Progetto Strategico di Ateneo NAMECA

Title	**Cold plasma activation of microalgal growth**
PI	MAROTTA Ester
Research Group	Organic Chemistry for the Environment and Health – DiSC
Curriculum	Scienze Chimiche
Contact	**web:** www.chimica.unipd.it/ester.marotta
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Project description:

State of the art: Plasmas at ambient conditions (*cold* plasmas) are becoming powerful tools to activate chemical processes including advanced oxidation for air and water decontamination, materials and biomaterials treatments and biomedical applications. New frontiers are opening up in the fields of agriculture and nutrition, for which the knowledge, intuition and skills of chemists are strongly needed.

Objectives and activity: Food shortage is one of humankind major problems. The project is a proof of principle study of the possibility of using cold plasma to stimulate the growth of edible microalgae. Spirulina (Arthrospira), a cyanobacterium rich in nutrients (proteins, lipids, carbohydrates, vitamins and minerals) will be used as model. Cold plasmas in air/water systems produce ROS which can stimulate growth mechanisms. The project will be carried out within an established network of interdisciplinary collaboration to provide the required competences in engineering, plasma physics and biology. The PhD student will be involved in the characterization of the plasma, based on spectroscopic and chemical analysis of major reactive species, including short lived molecular excited states, OH radicals and hydrogen peroxide, and in the chemical and biological characterization of the plasma treated microalgae to determine its content in proteins, sugars, lipids, vitamins, carotenoids, chlorophyll, to measure the biological activity of the enzymes and the photosynthetic activity of the microalgae.

Skills to be acquired and opportunities: The PhD student will use various analytical techniques, such as HPLC-UV/Vis and HPLC-mass spectrometry, optical emission spectroscopy, and develop skills in the analysis of complex matrixes and in the use of chemical and biochemical mechanistic and kinetic tools. The candidate will work in a stimulating multidisciplinary environment in Padova and will have the opportunity to spend a research stage abroad at one laboratory within an established international network.

Publications:

- S. Krishna, E. Ceriani, E. Marotta, A. Giardina, P. Špatenka, C. Paradisi. Products and mechanism of verapamil removal in water by air non-thermal plasma treatment, Chem. Eng. J. 2016, 292, 35-41.
- B. M. Cadorin, V. D. Tralli, E. Ceriani, L. O. Benetoli, E. Marotta, C. Ceretta, N.A. Debacher, C. Paradisi. Treatment of methyl orange by nitrogen non-thermal plasma in a corona reactor: The role of reactive nitrogen species, J. Hazard. Mater. 2015, 300, 754-764

Collaborations/Network:

Emilio Martines and Matteo Zuin, CNR Istituto Gas Ionizzati – Consorzio RFX, Padova
Paola Brun, Dipartimento di Medicina Molecolare, Università di Padova
Matteo Pavan, Microlife S.r.l.

Title	**Nano-carbon hybrid materials for renewable energy conversion and wastewater treatment**
PI	MENNA Enzo
Research Group	Organic Materials – DiSC
Curriculum	Scienze Chimiche
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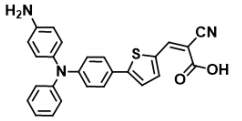
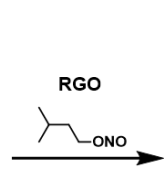
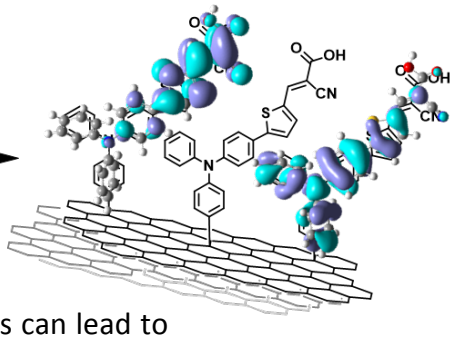
Project description:

The use of carbon nanostructures (CNSs) in energy related applications attracts large attention for different scopes. The combination of CNSs, such as fullerenes, carbon nano-tubes (CNTs) and graphene based materials (e.g. reduced graphene oxide, RGO), with π-conjugated organic molecules and polymers can lead to hybrid systems that are promising as active materials in energy related applications such as photovoltaic devices. Conjugated polymer-nanocomposites, based on functionalized CNTs and RGO, were used as hole transporting materials in perovskite solar cells (PSC). In the field of dye-sensitized solar cells (DSSC), grafting of photoactive molecules on RGO has led to novel photosensitizing agents. The focus of the project is the development of CNS based materials through the functionalization with organic dyes and other moieties, to improve efficiency and stability of non-conventional photovoltaic and photocatalytic devices. It will aim in particular at systematically investigating the use of CNS-organic dye hybrids for stable and performing solar devices using wastewater as electrolyte and source of hydrogen. Dye-Sensitized Photocatalytic and Photoelectrochemical cells for production of hydrogen fuel from wastewater, using graphene-organic dye hybrids as the innovative photoactive units, will be investigated. The PhD candidate will develop interdisciplinary skills such as the organic chemistry and characterization of materials, photophysical properties of organic materials, photocatalysis and degradation of water contaminants. The work will be carried on in strict collaboration with Italian and international research groups.







Publications:

Solar RRL **2018**, *2*, 1800013; *J. Mater. Chem. A* **2017**, *5*, 11882; *Nano Energy* **2017**, *41*, 84; *Carbon* **2017**, *115*, 746; *Adv. Funct. Mater.* **2016**, *26*, 7443.

Collaborations/Network:

M. A. Loi - Groningen University (The Netherlands). A. F. Nogueira -University of Campinas (Brazil). A. Abbotto - Università di Milano Bicocca.

Research funding:

Funding from Fondazione Cassa di Risparmio di Padova e Rovigo, Centro Studi di Economia e Tecnica dell'Energia Giorgio Levi Cases (OPERA)

Title	**Photo-flexible molecules to target neurodegenerative diseases [FlexMol]**
PI	MORETTO Alessandro
Research Group	Bio Organic Chemistry group – DiSC
Curriculum	Scienze Chimiche
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	email: alessandro.moretto.1@unipd.it

Project description:

As we age, our same metabolism together with some external factors conspire against us, resulting in the misfolding of proteins which are associated to degenerative diseases like Alzheimer's and Parkinson's. At the moment there is no treatment for any of the known degenerative diseases. However, there is hope. The increasing knowledge of the causes of incorrect proteins accumulation is beginning to pay off with possible pharmacological treatments. As the number of known incorrect proteins structures grows, scientists have more options to find common structures for the design of specific chemical inhibitors of aggregation. Although we are at risk of accumulating misfolded proteins every day we age, to function properly our cells must continually make proteins. Thus understanding misfolding will ultimately help protecting us from serious diseases. To do this, within this project we plan to develop a set of dynamical adapting foldamers, which are created chemically by following bio-inspired concepts, and aimed at powerfully interact with proteins thus to providing us new information on the very early stages of these incurable diseases. The first outcome of the FlexMol project will be the production of a large number of intrinsically photocontrollable foldamers which are to be considered as very innovative supra-molecules. Their rational studies will end up in a selection of a certain number of candidates to be applied on binding-interaction with alpha-synuclein (protein associated to Parkinson). The second outcome of the FlexMol project will be the studies of aggregation prone proteins associated to Parkinson disease in cells, in presence of the selected foldamers, prior and after photo-irradiation. Of course, cytotoxicity, cell-internalization and related distribution of foldamers will also be studied. The PhD student will acquire: (i) organic synthetic protocols, (ii) peptide synthesis, (iii) a varieties of characterization methodologies, (iii) bases of biochemical experiments.

Publications:
1. J. Am. Chem. Soc., **138**, 8007-8018 (2016). ***2.*** Soft Matter, **12**, 238-245 (2016). ***3.*** RSC Adv., **6**, 73650–73659 (2016)**.** ACS Nano, **9**, 4156-4164 (2015). Macromolecules, **47**, 7272–7283 (2014).

Collaborations/Network:
Biochemistry: Luigi Bubacco (Italy). Supramolecular Chemistry: Jonathan Clayden (UK).

Research funding:
PRIN, Ateneo.

Title	**Molecules and quantum pure states: statistical models of dynamics and thermodynamics at the nanoscale**
PI	MORO Giorgio
Research Group	Theoretical Chemistry
Curriculum	Scienze Chimiche
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	email: giorgio.moro@unipd.it

Project description:

The control over the preparation and the time evolution of quantum pure states (wave-functions) became a central challenge in recent years because of the growing interest in the emergence of novel technologies enabled by the quantum nature of matter. Beyond future potential applications, monitoring quantum evolution of small isolated system and single molecule offered an unprecedented view on fundamental aspects as the nature of equilibrium and thermodynamics at the nanoscale and the effect of structured environment on coherent and incoherent quantum dynamics. Most of the current understanding of these issues is based on mixed states as opposed to pure states. The PI and Barbara Fresch, who will collaborate to the project development, have developed original statistical tools for the treatment of quantum pure states evolving according to the Schroedinger equation.[1-4] The PhD project will push forward these investigations, by developing models for the statistical characterization of quantum pure states to provide a thermodynamically-grounded description of both equilibrium properties and quantum dynamics of a probe molecule whose states are controlled by the interactions with the environment. These general methods will be employed for the interpretation of spectroscopic observations and for the characterization of molecules as quantum systems whose properties can be tailored for specific applications in molecular logic and sensing.[5,6] The proposed research will allow the candidate to develop a deep understanding of quantum dynamics and to contribute to the growing scientific effort in envisioning quantum technologies with a special emphasis on the role of molecular systems.

Publications:

[1]B. Fresch, G.J. Moro, Beyond quantum microcanonical statistics, *J. Chem. Phys*. 134 (2011) 05451. [2]B. Fresch, G.J. Moro, Typical response of quantum pure states, *Eur. Phys. J.* B 86 (2013) 233-246. [3]F. Avanzini, B. Fresch, G.J. Moro, Pilot-wave quantum theory with a single Bohm's trajectory, *Found. of Phys.* 46 (2016) 575-605. [4]M. Coden, B. Fresch, G.J. Moro, Quantum Statistical Ensemble Resilient to Thermalization, *J. Phys. Chem. A* 120 (2016) 5074-5082. [5] B. Fresch, D. Hiluf, E. Collini, R. D. Levine, F. Remacle, Molecular decision trees realized by ultrafast electronic spectroscopy. *Proc. Natl. Acad. Sci. U.S.A.* 110, (2013) 17183-17188. [6] B. Fresch, J. Bocquel, S. Rogge, R. D. Levine, F. Remacle, A Probabilistic Finite State Logic Machine Realized Experimentally on a Single Dopant Atom. *Nano Letters* 17 (2017), 1846.

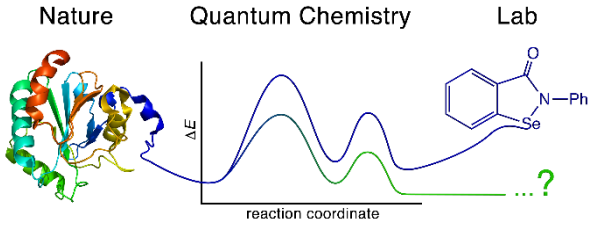
Collaborations/Network: Prof. Francoise Remacle-University of Liege (Belgium). Prof. Raphael D. Levine-The Hebrew University of Jerusalem (Israel). Prof. Sven Rogge (Centre for Quantum Computation and Communication Technology, The University of New South Wales, Australia)**.**

Research funding: Further funding opportunities for the same research line will be actively pursued at the national and international level.

Title	**REBEL (REdox state role in Bio-inspired ELementary reactions)**
PI	Laura Orian
Research Group	Theoretical Chemistry – DiSC
Curriculum	Scienze Chimiche
Contact	**web:** www.chimica.unipd.it/laura.orian
	email: laura.orian@unipd.it

Project description:

Computational methodologies are nowadays well consolidated in a multi-scale range, so that accurate *in silico experiments* can be carried out on molecules with tenths of atoms as well as on very large systems like biomolecules. An ambitious goal in computational chemistry is the design of functional molecules, i.e. drugs, devices, catalysts, and in most cases inspiration is searched in nature. A solid and rigorous approach to the design of bio-inspired molecules, i.e. catalysts, requires investigation of the natural systems as well as a bottom-up approach starting from small model molecules. These studies are intrinsically multi-scale and benefit of data from synthesis and measurements set up by collaborators. Systems of interest are anti-oxidant enzymes, such as GPx and PRx, proteins in which the chemistry of chalcogens (selenium and sulfur) is fundamental. In particular, the REDOX state of the catalytic center seems to play a key-role, still under debate. The mechanisms of oxidation phenomena will be studied in the enzymes as well as in model systems and molecular catalysts/drugs. The PhD student will gain experience with advanced computational methodologies, among which quantum chemistry and molecular dynamics approaches and his research tasks will certainly gain profit of the multiscale skills acquired in the years in the group of Theoretical Chemistry (from molecular level to continuum). In addition, he/she will learn and practice script/programming languages and abilities to work with supercomputers (local and national facilities). Requisites are chemical curiosity, passion for numerical problems and computers and inclination to apply consolidated chemistry background to solve problems.



Publications:

- Ribaudo, G.; Bellanda, M.; Menegazzo, I.; Wolters, L. P.; Bortoli, M.; Ferrer-Sueta, G.; Zagotto, G.; Orian, L. Mechanistic insight into the oxidation of organic phenylselenides by H_2O_2 *Chem. Eur. J.* **2017** *23*, 2405-2422.
- Bortoli, M.; Wolters, L.P.; Orian, L.; Bickelhaupt, F. M. *J. Chem. Th. Comp.* **2016** *12,* 2752-2761.
- Orian, L.; Toppo, S. Organochalcogen peroxidase mimetics as potential drugs: a long story of a promise still unfulfilled *Free Rad. Biol. Med.* **2014** *66,* 65-74

Collaborations/Network:

Theoretical Chemistry Group VU Amsterdam (The Netherlands) (Prof. F.M. Bickelhaupt and Prof. Célia Fonseca Guerra)

Research funding:

Title	**Development of new luminescent thermometers**
PI	Armelao Lidia
Research Group	*Functional Molecules and Inorganic Nanosystems* – DiSC and ICMATE-CNR
Curriculum	Scienze Chimiche
Contact	**web:** http://www.chimica.unipd.it/FMNLab/
	email: lidia.armelao@unipd.it

Project description:

Sensing and temperature measurements are crucial needs for countless scientific investigations and technological developments in a large variety of fields as electronic for optical devices, nano-medicine, micro-fluidics or optoelectronic. Since last few years, many efforts have been made in the synthesis of novel non-invasive, luminescence (PL) thermometers as organic, inorganic and hybrid systems that show a dependence of their PL properties on temperature. To this regards, particularly appealing are ratiometric, self-referencing temperature sensors based on the intensity ratios of two emission transitions.

The proposed research project will be focused on the development of new molecular thermometers based on luminescent d- and f-ion complexes. In particular, we will consider: *i)* coordination compounds and metallo-supramolecular architectures; *ii)* inorganic host-guest systems, where d- and f-ions are introduced as guests in suitable oxide based matrices; iii) hybrid materials where functional molecules are synergically coupled with inorganic substrates even as surface monolayers.

The understanding of energy transfer mechanisms determining thermal sensitivity is a current topic in the synthesis of molecular thermometers. This project will study the correlations between the thermal modulation of the d- and f- ions luminescence, the ligands coordinated to the metal center and the matrices.

During the three years PhD school, the skills that will be acquired are summarized as follows:

- Synthesis of organic compounds suitable for the coordination of the metal centers and able to generate highly luminescent complexes also exploiting sensitized emission;
- Synthesis of coordination driven systems based on d- and f-ions;
- Synthesis of hybrid materials mainly in form of thin films (dip-, spin- and spray-coating);
- Characterization of molecular systems and materials through: X-ray Diffraction (powder and single crystal), X-ray Photoelectron Spectroscopy, Scanning Electron Microscopy, Photoluminescence.

Collaborations/Network:

Prof. T.K. Sham, University of Western Ontario, Canada
Prof. D. Belli Dell'Amico, Prof. L. Labella, University of Pisa
Dr. R. Seraglia, ICMATE CNR

Title	*Design and synthesis of mitochondria-targeted molecular probes to report on or manipulate mitochondrial function and dysfunction*
PI	PARADISI Cristina
Research Group	Organic Chemistry for the Environment and Health – DiSC
Curriculum	Scienze Chimiche
Contact	**web:** www.chimica.unipd.it/cristina.paradisi
	email: cristina.paradisi@unipd.it

Project description:

State-of-the art: Mitochondria are the cell's power producers. Organic chemistry provides unique tools to probe and control mitochondrial function.

Objectives and activity: Mitochondria-targeted molecules will be designed and developed to either report on or manipulate aspects of mitochondrial function. Targeting is achieved by coupling the chemical entity of interest to the lipophilic triphenylphosphonium (TPP) cation which enables small molecules to pass through the phospholipid bilayers and selectively accumulate several hundred fold within the negatively charged mitochondrial matrix in cells and *in vivo*. Specifically, two lines of research are envisioned. One will involve the design, synthesis and characterization of new fluorescent indicators for sensing the mitochondrial concentration of metal cations and will contribute to our understanding of the role of these cations in physiological processes and under pathological conditions. The second will address the synthesis of mitochondria targeted bioactive compounds such as antioxidants, chemotherapeutics and other small molecules which can interact with mitochondria to prevent or treat diseases wherein mitochondrial functions are deregulated.

Skills to be acquired and opportunities: The graduate student will use up-to date procedures and tools for the synthesis and spectroscopic characterization of organic compounds; will have the opportunity to take part in tests of the synthesized compounds through a well established interdisciplinary network of collaborations at the University in Padova and the possibility to spend a stage abroad at some connected laboratories.

Publications:

- Leanza L., Romio M. et al. Direct pharmacological targeting of a mitochondrial ion channel selectively kills tumor cells *in vivo*. Cancer Cell. **2017**, 31, 516-531.
- Mattarei A. et al. Novel lipid-mimetic prodrugs delivering active compounds to adipose tissue. Eur J Med Chem. **2017**, 135, 77-88.
- Mattarei A. et al. Amino acid carbamates as prodrugs of resveratrol. Sci Rep. **2015**, 5, 15216.

Collaborations/Network:

CNR Institute of Neuroscience, Department of Biomedical Sciences, University of Padova
Department of Pharmaceutical and Pharmacological Sciences, University of Padova
Department of Biology, University of Padova

Research funding:

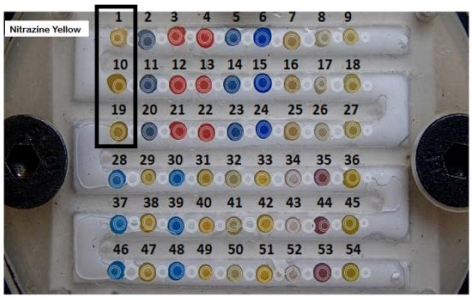
AIRC grant (PI I.Szabò, University of Padova)

Title	**optical pH sensors based on Ormosil matrix and supported in PVDF**
PI	Pastore Paolo
Research Group	Analytical Chemistry
Curriculum	Scienze Chimiche
Location	DiSC
Contact	web: http://www.chimica.unipd.it/analitica/ http://www.chimica.unipd.it/paolo.pastore/
	email: paolo.pastore@unipd.it

Project description:

Colorimetric sensor arrays (CSAs) utilize cross-responsive, chemically responsive dyes to generate a response unique to a given analyte that can be quantified by digital imaging. They are suitable for sensing wide range of organic and inorganic materials (such as H^+, metal ions, glucose, VOCs compounds , explosives, biogenic amines and gases like oxygen, carbon dioxide and sulfur dioxide). CSAs are interesting because they also can solve practical issues of cost and portability especially in connection to inexpensive technologies such as visual imaging (e.g., digital cameras and scanners).

Several optical sensor ("optodes"), have been designed to determine pH, but all suffer from limited measuring range. They have been long used in practical cases such as clinical analysis, environmental analysis, and process control. In the course of calibration, arrays produce large amounts of data and thus quantitative and qualitative information are mixed up. This type of data can be handled with mathematical and chemometrics methods. In addition, the development of new sensor technologies faces the dilemma of trying to create sensors that are both increasingly sensitive and increasingly robust (i.e., stable to exposure to analytes or the environment). In this context, the choice of the colour space plays an important role. The hue or H component of the hue, saturation, value (HSV) colour space, provide a robust and precise parameter to be correlated to the observable.



Publications:

research line just started

Collaborations/Network:

Not yet available.

Research funding:

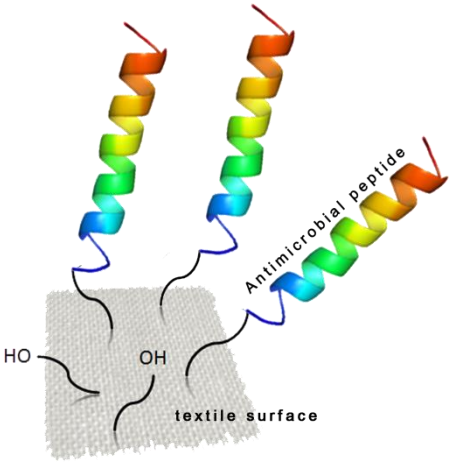
Financial support from the Analytical Chemistry group activities.

Title	Development of new therapeutic textiles through green chemical methods
PI	PEGGION Cristina
Research Group	Bio Organic Chemistry group – DiSC
Curriculum	Scienze Chimiche
Contact	**web:** www.chimica.unipd.it/cristina.peggion
	email: cristina.peggion@unipd.it

Project description:

The proposed PhD project has two main objectives:

- To develop therapeutic tissues that prevent bacterial and mycotic skin infections. The study should produce a biocompatible and well tolerated fabric, that must be and able to give relief and care for people suffering from skin diseases and allergies.
- To develop a general "green" protocol in the total respect of the environment to link a biological active peptide of interest on a biocompatible textile support.



To reach the objectives, we will use, as the protecting agents, natural antimicrobial peptides (AMP) that are normally produced by skin as first barrier against microbial and bacterial attack (*defensins, cethelicidins*…). For the textile, we will focus on natural abundant sources such as cotton and silk supports. Concerning the chemical linkage between the peptide and the textile, we will apply the known strategies of the chemoselective ligation that allows chemical reactions to be run in mild conditions with the use of water as the exclusive solvent. Textile samples will be analyzed for their antimicrobial activity against Gram positive and Gram negative bacteria.

With this work the PhD student will enrich his curriculum with cross-cutting skills ranging from the chemical synthesis of peptides to the material chemistry, passing through organic chemistry reaction tools. In addition, he will apply many spectroscopic techniques (FT-IR, XPS, UV-absorption) as well as different conformational analysis methods (NMR, Circular Dichroism).

Publications:

J. Am. Chem. Soc., 138, 8007–8018, 2016; *Biophys. J.,* 111, 2450-2459, 2016; *Biochim. Biophys. Acta-Biomembr.* 1848, 134-144, 2015; *J. Pept. Sci.* 20, 547-553, 2014; *Biopolymers (Pept. Sci.)* 100, 621-636, 2013.

Collaborations/Network:

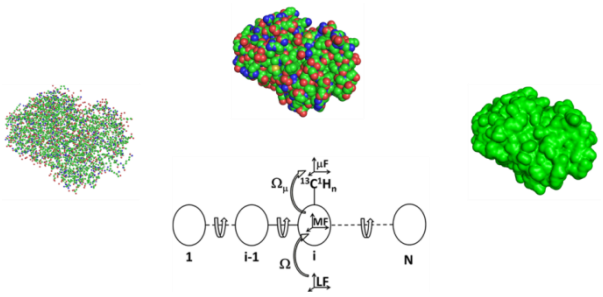
University of Innsbruck, Austria – Institute of Biochemistry (Prof. R. Schneider)
University of Sibiu, Romania – Faculty of Agricultural Sciences, Food Industry and Environmental Protection (Prof. S. Oancea)

Research funding: Funding: University of Padova, PRAT N° CPDA150532/15. Project title: "Innovative natural fibers functionalized with antimicrobial peptides". 50'000 euros.

Title	**Stochastic Approaches to LargE Molecules (SALEM)**
PI	POLIMENO Antonino, ZERBETTO Mirco
Research Group	Theoretical Chemistry Group (TCG) - DiSC
Curriculum	Scienze Chimiche
Contact	**web:** www.chimica.unipd.it/theochem
	email: antonino.polimeno@unipd.it

Project description:

Objectives - Biochemical patterns in living systems are based in several instances on mechanical events, resulting from proteins undergoing large amplitude motions (LAMs) triggered by chemical signals. This projects aims at 1) interpreting and simulating LAMs and their related spectroscopic signatures using advanced computational chemistry approaches, 2) describing at molecular level behaviors induced by localized structural changes due to chemical modifications, 3) extend this methodology to supramolecular systems



Background - Chemical and spectroscopic properties are affected by the rotational and internal dynamics in macromolecules and supramolecular constructs. In particular, spectroscopic observables can be used for monitoring of relaxation processes in macromolecules, including LAMs. Integration with advanced theoretical/computational methods proves to be particularly effective to acquire direct information on long-range relaxation processes, based on molecular dynamics, multiscale approaches and coarse-graining treatments. Together, the analysis of spectroscopic signatures and the integrated computational approach can provide a fundamental tool to understand the effect of biochemical changes on specific proteins, and contribute to the rational design of dedicated drugs. As such, a bottom-up approach based on the joint efforts of biochemists, spectroscopists and theoretical chemists is pursued in several advanced laboratories worldwide.

Project description - The roadmap will be as follows: 1) set up of computational interpretation of spectroscopic evidences based on in-silico evaluation of structural properties at atomistic level (obtained via mechanics/molecular mechanics), 2) short time scale dynamics (ps-ns scale, via molecular dynamics) 3) long time-scale dynamics (above ns scale, stochastic and coarse grained approaches); 4) classification, rationalization and prediction/simulation of the effects that chemical changes cause as perturbations of the molecular movements, 5) investigation of dynamic properties of supramolecular systems

Expected results - Basic science outcomes are expected: 1) the development of advanced *in-silico* tools (novel software packages) capable to reach predictive level relatively to the relation between structural changes and dynamics for triggered mechanics of macromolecules; 2) refined characterization tools bridging the gap between indirect spectroscopic observation of large amplitude motions and chemical properties of macromolecules; 3) rationalization of the effect of inter and intramolecular motility on the construction of self-assembling systems.

Publications:

- Flexibility at a glycosidic linkage revealed by molecular dynamics, stochastic modeling, and C-13 NMR spin relaxation: conformational preferences of alpha-L-Rhap-alpha-(1 -> 2)-alpha-L-Rhap-OMe in water and dimethyl sulfoxide solutions R. :Pendrill, R O. Engstrom, O A Volpato, M Zerbetto, M A Polimeno, G Widmalm, G Phys Chem Chem Phys , 18 (4) 3086-3096 DOI: 10.1039/c5cp06288h (2016)
- Decomposition of Proteins into Dynamic Units from Atomic Cross-Correlation Functions P. Calligari, Gerolin, D Abergel, A Polimeno J. Chem Theory and Computation, 13, 309-319 DOI: 10.1021/acs.jctc.6b00702 (2017)

Collaborations/Network:

Collaborations with French (École Normale Supérieure, Paris), American (Cornell University, Case Western Reserve University), Swedish (Stockholm University) groups will be carried on during this project, with the possibility of short (one months) or medium (up to twelve months) term secondments abroad for the students involved.

Research funding:

Fondi di ateneo (P-DISC) and European (COST) limited funds will be accessible.

Title	**Out-of-Equilibrium Self-Assembly driven by Chemical Fuels**
PI	PRINS Leonard
Research Group	Supramolecular Chemistry and Systems Chemistry – DiSC
Curriculum	Scienze Chimiche
Location	DiSC
Contact	**web:** www.chimica.unipd.it/leonard.prins
	email: leonard.prins@unipd.it

Project description:

Life is a non-equilibrium phenomenon and the necessity to consume energy is one of its most distinguishing features. On the molecular level, this characteristic is exemplified by energy-driven self-assembly which is extensively exploited by nature for the formation of high-energy materials able to perform work. An example is provided by microtubules, which form a dynamic network of filaments inside the cell that is responsible for controlling shape, movement and mechanical stiffness. Maintenance of the structural integrity of this material requires a constant supply of nutrients in the form of high-energy molecules, such as ATP. This gives the biomaterial the unique property to deform, adapt, and move in response to the availability of energy. Synthetic materials assembled following a similar process are endowed with unique properties that are unattainable for conventional 'static' materials. This enables innovative applications in the fields of materials science, catalysis and life sciences.

The **general objective** of the research in the Prins' group is to develop high-energy synthetic materials capable of converting and storing chemical energy that can adapt to external stimuli in a life-like manner. Materials will be assembled using chemical energy according to the same principles that guide the formation of microtubules. The project specifically aims at demonstrating how chemical energy can be converted and stored in synthetic materials and at studying their unique properties.

Publications

1. Ragazzon, G.; Prins, L.J. Energy Consumption in Chemical-Fuel Driven Self-Assembly *Nat. Nanotechnol.* **2018**, *13*, 882-889.
2. Del Grosso, E.; Amodio, A.; Ragazzon, G.; Prins, L.J.; Ricci, F. Dissipative Synthetic DNA-Based Receptors for the Transient Loading and Release of Molecular Cargo. *Angew. Chem. Int. Ed.* **2018**, *57*, 10489-10493.
3. Della Sala, F.; Maiti, S.; Bonanni, A.; Scrimin, P.; Prins, L.J. Fuel-Selective Transient Activation of Nanosystems for Signal Generation. *Angew. Chem. Int. Ed.* **2018**, *57*, 1611-1615.
4. Neri, S.; Martin, S.G.; Pezzato, C.; Prins, L.J. Photoswitchable Catalysis by a Nanozyme Mediated by a Light-Sensitive Cofactor *J.Am.Chem.Soc.* **2017**, *139*, 1794-1797.
5. Maiti, S.; Fortunati, I.; Ferrante, C.; Scrimin, P.; Prins, L.J. Dissipative self-assembly of vesicular nanoreactors, *Nat. Chem.* **2016**, *8*, 725-731.
6. Pezzato, C.; Prins, L.J., Transient Signal Generation in a Self-Assembled Nanosystem fueled by ATP. *Nat. Commun.* **2015**, *6*, 7790.

Collaborations/Network:

Francesco Ricci (Rome Tor Vergata), Camilla Ferrante (DiSC), Alberta Ferrarini (DiSC), Diego Frezzato (DiSC).

Research funding:

MIST, PRIN2018

Title	**Nanoparticle-assisted NMR spectroscopy**
PI	RASTRELLI Federico
Research Group	Supramolecular Chemistry and Systems Chemistry – DiSC
Curriculum	Scienze Chimiche
Location	Dipartimento di Scienze Chimiche (DiSC)
Contact	**web:** www.chimica.unipd.it/federico.rastrelli
	email: federico.rastrelli@unipd.it

Project description:

Gold nanoparticles (NPs) provide a convenient scaffold onto which molecular receptors can be grafted to form a protecting monolayer. By exploiting different kinds of non-covalent interactions (namely hydrophobic, ion pairing, and metal–ligand coordination) such receptors can in turn provide tailored binding sites for virtually any class of substrates. Remarkably, the variety of monolayers that can be potentially assembled endow a fine-tuning of these interactions not only in terms of selectivity, but also in terms of their strength.

The reduced translational and rotational diffusion rates resulting from the bulkiness of NPs offer a route to manipulate the magnetization of the receptor spins within the monolayer. We have shown how relaxation- and diffusion-based NMR techniques can be exploited to label and detect some interacting analytes either by magnetization transfer or by perturbation of their apparent diffusion coefficient. In particular, when the interaction is weak, the spins located on the NPs monolayer can be used as a source of magnetization that is transferred selectively to the interacting analytes via NOE.

While the intrinsic sensitivity of the first reported protocols was modest, we have recently found that water spins in long-lived association at the nanoparticle monolayer constitute an alternative source of magnetization that can deliver a remarkable boost of sensitivity, especially when combined with saturation transfer experiments. The approach is general and can be applied to analyte-nanoreceptor systems of different compositions, ultimately endowing selective analyte detection down to the micromolar range on standard instrumentation.

Publications:

F. De Biasi, D. Rosa-Gastaldo, X. Sun, F. Mancin, F. Rastrelli, *J. Am. Chem Soc.* 2019, **141**(12), 4870–4877.

B. Perrone, S. Springhetti, F. Ramadori, F. Rastrelli, and F. Mancin, *J. Am. Chem Soc*. 2013, **135**, 11768−11771.

Collaborations/Network:

Prof. Fabrizio Mancin, UniPD

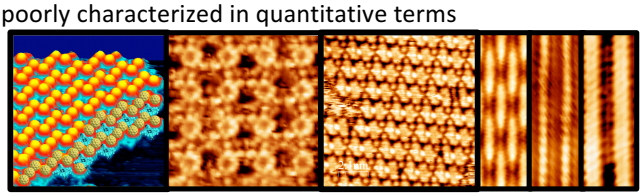
Dr. Marco deVivo, IIT Genova

Title	On-Surface Synthesis of Functional Nanomaterials
PI	SAMBI Mauro
Research Group	Surface Supramolecular Chemistry – DiSC
Curriculum	Scienze Chimiche
Contact	**web:** www.chimica.unipd.it/mauro.sambi
	email: mauro.sambi@unipd.it

Project description:

In recent years, direct **on-surface synthesis** (OSS) in ultra-high vacuum (UHV) has been exploited as a promising strategy to obtain thermally and chemically stable structures by covalent bonding of suitable precursors. So far, covalent linking of organic molecules onto metal, semiconducting and bulk insulator surfaces has been mostly carried out thermally: heat supplied to the system promotes the formation of covalent bonds between the monomeric building units either simultaneously with the surface diffusion phenomena it promotes (i.e. under dynamic bond-forming conditions) or as a trigger, after a pre-assembly step into a surface-supported supramolecular, non-covalent network. However, heat as a tool for OSS has the capacity to be beneficial and detrimental to the production and to the structural quality of the covalently-linked network at the same time. The close interplay between molecular surface diffusion, chemical reactivity and temperature, in fact, often hampers the possibility to independently control the reaction initiation and the surface mobility, ultimately leading to highly defective covalent networks, poorly ordered on the long range.

Photochemically activated reactions are a potentially powerful tool to stabilize self-organized structures without disrupting the long-range order. Yet, to date photo-initiated on-surface reactions are still rather uncommon, since the processes following light absorption are not completely understood and, in particular, the role of the substrate is still poorly characterized in quantitative terms



The proposed research activity is focused on the synthesis of gradually more complex and controlled mono- and two-dimensional (1D & 2D) molecular nanostructures by means of self-organization techniques on a solid surface in UHV, and their stabilization through intermolecular covalent bonds. Bond formation will be triggered by either thermal of photochemical means. The focus of the work will be put (i) on improving the long-range order and the monodispersity of the obtained nanostructures based on by now established reaction schemes; (ii) on exploring new reaction schemes based on organic synthesis know-how adapted to the in-vacuum and strictly bidimensional reaction conditions and (iii) on the detailed understanding of light-induced on-surface reactivity when the photochemical path is exploited.

The candidate will become familiar with a whole set of in situ preparation tools and surface science characterization techniques (scanning probe microscopy, photoemission, electron diffraction, x-ray absorption spectroscopy, etc) either in-house or at synchrotron radiation sources, and possibly in the laboratories of collaborating groups in Europe, as well as with different light sources, such as a monochromatic continuous diode lasers and a UV-Vis tunable pulsed laser in the nanosecond range for on-surface photochemistry.

Publications:

J. Am. Chem. Soc. **2016**, 138, 10151-10156; *ACS Nano* **2016**, 10, 2644-2651; *J. Am. Chem. Soc.* **2015**, 137, 1802-1808; *Chem. Commun.* **2015**, 51, 12593-12596; *Chem. Eur. J.* **2014**, 20, 14296-14304; *Nat. Mater.* **2012**, 11, 970-977.

Collaborations/Network:

F. Bartolomé, University of Saragoza, Spain; S. De Feyter, University of Leuven, Belgium; D. G. De Oteyza, Donostia International Physics Center, Spain; L. Floreano, IOM-CNR & Aloisa Beamline, Trieste, Italy; S. Pagliara, Catholic University, Brescia, Italy; Diego Peña, University of Santiago de Compostela, Spain; C. A. Pignedoli, EMPA, Dübendorf, Switzerland.

Research funding:

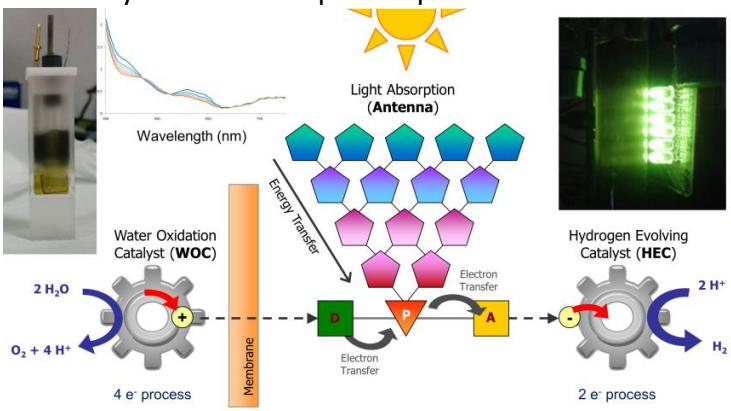
PRAT CPDA154322 "AMNES"; Piscopia - Marie Curie Fellowship Programme

Title	**Catalysis for artificial photosynthesis**
PI	SARTOREL Andrea
Research Group	Nano & Molecular catalysis Laboratory – DiSC
Curriculum	Scienze Chimiche
Location	DiSC
Contact	**twitter:** asartorel74
	email: andrea.sartorel@unipd.it

Project description:

Artificial photosynthesis is a promising strategy to capture and transform solar energy into renewable fuels or commodity chemicals, by photocatalytic processing of low cost and abundant resources such as water and carbon dioxide. Within such scheme, a key role is the development of suitable catalysts to conduct the redox reactions involved: proton reduction to hydrogen, water oxidation to oxygen, carbon dioxide reduction. The goal of the project is to develop synthetic transition metal cores capable of conducting the aforementioned reactions, by combining the design, synthesis and characterization of metal complexes, their application in electro- and photocatalysis; mechanistic evaluation by kinetic analysis, electrochemical and spectroscopic characterization of reaction intermediates, structure-reactivity correlations, isotopic labelling, DFT calculations, will provide fundamental information to address new systems with improved performance.

The student will acquire expertise in synthesis and characterization of ligands and of their metal complexes (mass spectrometry, NMR, UV-Vis, IR, electrochemical techniques including CV, spec-troelectrochemistry), and in electro- and photocatalysis. The student will also have the opportuni-ty to be part of international collaborations.



Publications:

Mechanistic Insights into Light-Activated Catalysis for Water Oxidation, M. Natali, F. Nastasi, F. Puntoriero, and A. Sartorel, VIP article in *Eur. J. Inorg. Chem.*, **2019**, in press.

Proton coupled electron transfer from Co3O4 nanoparticles to photogenerated Ru(bpy)33+: base catalysis and buffer effect, , G.A. Volpato, A. Bonetto, A. Marcomini, P, Mialane, M. Bonchio, M. Natali and Andrea Sartorel HOT article in Sust. Energy & Fuels **2018**, *2*, 1951.

Collaborations/Network:

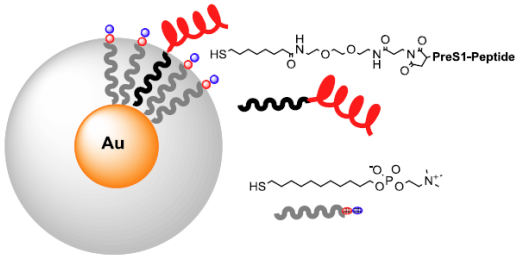
The project will be conducted within current collaborations with several Italian and International groups.

Research funding:

Funding from Ateneo (PDISC): PHOETRY artificial photooxygenase for light assisted selective oganic reactivity

Title	**Cooperative nanosystems: from catalysis to nanomedicine**
PI	SCRIMIN Paolo
Research Group	Supramolecular Chemistry and Systems Chemistry – DiSC
Curriculum	Scienze Chimiche
Contact	**web:** www.chimica.unipd.it/paolo.scrimin
	email: paolo.scrimin@unipd.it

Project description:



Whenever a chemist deals with collection of molecules she/he faces the problem: will they cooperate? Will cooperativity improve their properties or, even more, will it elicit new ones, totally unexpected? In biological systems cooperativity is a rule rather than the exception. Cooperativity governs cell-cell, protein-protein, protein-cell interactions, critical processes for the occurrence of life as we know it. In our group we are on the search of such cooperativity by using nanosystems by taking advantage of one important property they present: multivalency. Multivalency is the presence of several (not necessarily identical) functionality on a systems and our nanosystems are all multivalent. Starting from this basic concept we are currently developing: a) efficient catalysts for the cleavage of phosphate diesters (including those of RNA and DNA); b) fully synthetic nanovaccines against meningitides; c) nanodrugs for tumor targeting. The student will operate within one of these research lines and will follow the project from its design to its actual application. Accordingly, she/will acquire expertise in molecules and nanosystems preparation and characterization and will interact with research teams of other disciplines and from different countries. The laboratory will also provide a multicultural, stimulating environment for the presence of students and post-doc from different countries.

Publications:

1. Binding and Uptake into Human Hepatocellular Carcinoma Cells of Peptide-Functionalized Gold Nanoparticles. *Bioconjugate Chem*. **2017**, *28*, 222−229. (Research line c).
2. Hydrolytic Metallo-Nanozymes: From Micelles and Vesicles to Gold Nanoparticles. *Molecules* **2016**, *21*, 1014-1032. (Research line a).
3. Efficient Phosphodiester Cleaving Nanozymes Resulting from Multivalency and Local Medium Polarity Control. *J. Am. Chem. Soc.* **2014**, *136*, 1158-1161. (Research line a).
4. Factors affecting T cell responses induced by fully synthetic glyco-gold-nanoparticles. *Nanoscale*, **2013**, *5*, 392-402. (Research line b).

Collaborations/Network:

a) European Marie Curie Network – MMBio- Molecular Tools for Nucleic Acid Manipulation for Biological Intervention. Partners from UK, Germany, Sweden, Switzerland, Belgium and Finland.
b) Progetto di Rilevanza Nazionale (PRIN): Nanoplatforms for enhanced immune responses. Partners from the Universities of Florence, Siena, Rome, Milan, Novara, Naples and Italian Institute of Technology.
c) Strategic project of the University of Padova. Partners from the Departments of Medicine and Pharmacy.

Research funding:

a) MMBio network: 250.000 €; b) PRIN: 70.000 €; c) Strategic project: 100.000 €;

Title	Metal-ligand complexes in atmospheric particles: formation processes, properties and relevance for public health in urban environment
PI	TAPPARO Andrea
Research Group	Analytical Chemistry – DiSC
Curriculum	Scienze Chimiche
Contact	**web:** http://www.chimica.unipd.it/analitica/
	email: andrea.tapparo@unipd.it

Project description:
The present research program aims to contribute to a better assessment of the air quality with particular attention to the health effects in urban environments, by understanding how organic compounds in particulate matter (PM) can coordinate with, and therefore increase both the solubility and the bioavailability of, metals present in the aerosol itself or in atmospheric aqueous environments, in view of the possible correlation with toxic and environmental effects.
PM from the urban area of Padova will be sampled, and it will be characterized in its metal and ligand contents by ionic chromatography (IC), HPLC-MS, and ICP-MS. Metal-ligand complex formation will be evaluated experimentally, theoretically and statistically. Metabolic alterations and toxicity mechanisms associated with exposures with PM and with the metal-ligand complexes detected in PM will be investigated *in vitro* using selected cellular lines. An "omic" (metabolomic/proteomic/metallomic) approach will also be applied on cellular lines and real human tissues in order to detect PM markers.

Publications:
C. Giorio, A. Tapparo, M. Dall'Osto, D.C.S. Beddows, J.K. Gietl, R.M. Harrison. Local and regional components of aerosol in a heavily trafficked street canyon in central London derived from PMF and cluster analysis of single particle ATOFMS spectra. Environ. Sci. Tech. 49 (2015) 3330-3340.
C. Giorio, S. Campbell, M. Bruschi, F. Tampieri, A. Barbon, A. Toffoletti, A. Tapparo, C. Paijens, A.J. Wedlake, P. Grice, D.J. Howe and M. Kalberer. Online quantification of Criegee intermediates of α-pinene ozonolysis by stabilisation with spin traps and proton transfer reaction mass spectrometry detection. J. Am. Chem. Soc., 139-11 (2017) 3999–4008
P. Sellitto, C. Zanetel, A. Di Sarra, G. Salerno, A. Tapparo, D. Meloni, G. Pace, T. Caltabiano, P. Briole, B. Legras. The impact of Mount Etna sulfur emissions on the atmospheric composition and aerosol properties in the central Mediterranean: A statistical analysis over the period 2000–2013 based on observations and Lagrangian modelling. Atmos. Environ. 148 (2017) 77-88

Collaborations/Network:
Yoshio Takahashi, University of Tokyo, Japan; Jean-François Doussin, University Paris-Est Créteil, France; Markus Kalberer, University of Cambridge, UK; Andrea Trevisan, Padova University Hospital, Italy; Erich Cosmi, Padova University Hospital, Italy.

Research funding:
Ateneo

Title	**How a molecular motor works: deciphering the molecular bases of the hearing process in mammals.**
PI	BATTISTUTTA Roberto
Research Group	Biomolecular structures – DiSC
Curriculum	Scienze Chimiche
Contact	**web:** http://www.chimica.unipd.it/ricerca/gruppi-di-ricerca
	email: roberto.battistutta@unipd.it

Project description:

Prestin is a protein transporter that belongs to the SLC26 family of anion exchangers, found in the cochlear OHCs (outer hair cells), where it is densely packed in the basolateral membrane. OHCs in mammals have the ability to alter their cell length actively and quickly in response to changes in membrane potential triggered by incoming sound waves. This form of voltage-dependent cell movement, known as "electromotility", is provided by prestin. OHC electromotility is part of the mechanical sound amplification system responsible for increased hearing sensitivity and frequency selectivity in mammals. Hence prestin is a unique ATP- and Ca^{2+}-independent molecular motor with piezoelectric characteristic. We plan to combine structural and functional characterization of mammalian and non-mammalian prestin to provide a solid framework to comprehend electromotility and anion transport at atomic level, and how these events are regulated. To understand how this transporter function dynamically we will apply a modern "integrative structural biology" approach, merging methods that span different resolution scales and time frames, such as Xray crystallography, Bio-SAXS, NMR and SPR. Experimental results will be integrated and finalized by innovative computational approaches.

Publications:

1) Lolli G, Pasqualetto E, Costanzi E, Bonetto G, Battistutta R. (2016) The STAS domain of mammalian SLC26A5 prestin harbours an anion-binding site. Biochem J. 473, 365-370.
2) Gorbunov D, Sturlese, M, Nies, F, Kluge M, Bellanda M, Battistutta, R, Oliver, D. (2014) Molecular architecture and the structural basis for anion interaction in prestin and SLC26 transporters. Nat Comm, 5, 3622.
3) Lolli G, Ranchio A, Battistutta R. (2014) Active Form of the Protein Kinase CK2 α2β2 Holoenzyme Is a Strong Complex with Symmetric Architecture. ACS Chem Biol. 9:366-371
4) Lolli G, Pinna LA, Battistutta R (2012) Structural Determinants of Protein Kinase CK2 Regulation by Autoinhibitory Polymerization. ACS Chem Biol, 7, 1158-1163.
5) Pasqualetto E, Aiello R, Gesiot L, Bonetto G, Bellanda M, Battistutta R. (2010) Structure of the cytosolic portion of the motor protein prestin and functional role of the STAS domain in SLC26/SulP anion transporters. J Mol Biol. 16, 448-462.
6) Battistutta, R. (2009) Structural bases of protein kinase CK2 inhibition (Review). Cell. Mol. Life Sci. 66, 1868-1889.

Collaborations/Network:

Prof. Dominik Oliver, Department of Neurophysiology of the Philipps University in Marburg (D)
Prof. Gianluca Lattanzi, Physics Department of the University of Trento (I).
Dr. Graziano Lolli, Centre for Integrative Biology (CIBIO), University of Trento (I).

Title	**Gold(I,III) complexes with N-heterocyclic carbene ligands for catalytic, biomedical and luminescence applications**
PI	TUBARO Cristina
Research Group	Applied Organometallic Chemistry – DiSC
Curriculum	Scienze Chimiche
Location	DiSC
Contact	**email:** cristina.tubaro@unipd.it

Project description:
The compounds, that we want to develop in this program, are based on two symbiotic units (Au centers and N-heterocyclic carbene ligands) that, combined together, afford organometallic complexes with enhanced catalytic efficiency, antiproliferative activity and luminescence properties. The strong NHC-Au bond prevents the potential decomposition of the complex under catalytic or physiological conditions. A library of NHC-Au complexes with variable nuclearity, Au oxidation state, nature, charge and functionalization of the ligands and counteranions will be prepared. The performance of the complexes as catalysts in technologically relevant transformations involving activation of C-C multiple bonds will be evaluated. Their use as anticancer agents will be also assessed, within national and international collaborations. Finally, the luminescence properties of the complexes, mainly due to the so-called aurophilic interaction, will be investigated.
The PhD student will acquire experience in the above mentioned application fields as well as in the synthesis of organometallic compounds in inert atmosphere (Schlenk procedures, dry–box) and in the techniques for their characterization (NMR, MS, X-ray crystal structure solving, absorption and emission spectra).
Publications:
1. M. Monticelli, M. Baron, C. Tubaro, S. Bellemin-Laponnaz, C. Graiff, G. Bottaro, L. Armelao, L. Orian, ACS Omega 2019, 4, 4192-4205.
2. M. Baron, A. Dall'Anese, C. Tubaro, L. Orian, V. Di Marco, S. Bogialli, C. Graiff, M. Basato, Dalton Trans. 2018, 47, 935-945.
3. M. Baron, C. Tubaro, M. L. C. Cairoli, L. Orian, S. Bogialli, M. Basato, M. M. Natile, C. Graiff, Organometallics 2017, 36, 2285-2292.
4. M. Monticelli, S. Bellemin-Laponnaz, C. Tubaro, M. Rancan, Eur. J. Inorg. Chem. 2017, 2488-2495.
5. M. Monticelli, C. Tubaro, M. Baron, M. Basato, P. Sgarbossa, C. Graiff, G. Accorsi, T. P. Pell, D. J. D. Wilson, P. J. Barnard, Dalton Trans. 2016, 45, 9540–9552.
Collaborations/Network:
Prof. Claudia Graiff (University of Parma), Dr. Marzio Rancan (CNR-ICMATE Padova) – X-ray crystal structure determination
Dr. Stéphane Bellemin-Laponnaz (CNRS-University of Strasbourg) – Ligand design
Dr. Gianluca Accorsi (CNR-NANOTEC Lecce), Dr. Gregorio Bottaro (CNR-ICMATE Padova) – Luminescence properties
Research funding: DOR – University of Padova

Title	**Mesoporous polymer catalysts for heterogeneous catalysis**
PI	ZECCA Marco, CENTOMO Paolo
Research Group	Polymeric Materials for Catalytic Applications
Curriculum	Scienze Chimiche
Contact	**web:** www.chimica.unipd.it/marco.zecca
	email: marco.zecca@unipd.it

Project description:
It has been recently discovered that during the polymerization of vinyl monomers carried out at high monomers' dilution and with the molar fraction of the cross-linker is 50 % or more microsyneresis produces an unprecedented texture of the afforded resins (µ-resins), which combines high specific surface area, high pore volume and high pore diameter, and should be particularly fit to catalytic applications. We are currently investigating on their use as scaffolds for heterogeneous metal catalysts in the direct synthesis of H_2O_2 and in the oxidation of alcohols. These scaffolds can be chemically modified to tune their hydro-philic/phobic character to different reaction conditions. Engagement in this project will give to graduate students the chance to develop a wide array of skills which will be helpful not only in the field of heterogeneous catalysis, but also in solid state supported chemistry in general. In particular the work will range from the polymer synthesis, functionalization and characterization, to the preparation of the catalysts, the set-up of analytical methods for the analysis (GC, HPLC, NMR) of the reaction mixtures from catalytic experiments and to catalysts' testing. Both room-to-middle pressure batch autoclaves and flow reactors are available in our laboratory. Inverse Steric Exclusion Chromatography (ISEC) is also available: it is currently the most powerful tool for the characterization of the texture of organic polymeric materials in the swollen state, strictly relevant to the conditions of L-S catalysis, in which conventional dry-state techniques (e.g. gas physisorption) fail.

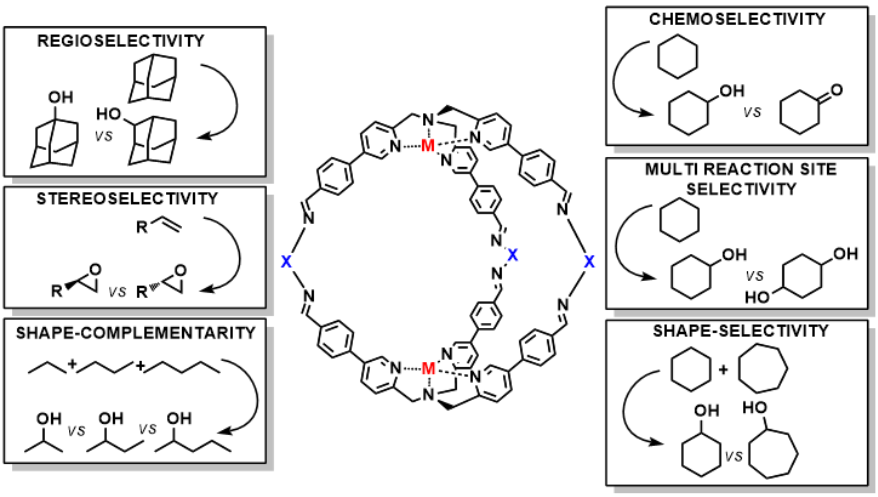
Publications:
P. Biasi, J.-P. Mikkola, S. Sterchele, T. Salmi, N. Gemo, A. Shchukarev, P. Centomo, M. Zecca, P. Canu, A.-R. Rautio, K. Kordàs, AIChE J. 63 (2017) 32–42.
S. Sterchele, P. Biasi, P. Centomo, A. Shchukarev, K. Kordás, A.-R. Rautio, J.-P. Mikkola, T. Salmi, P. Canton, M. Zecca, ChemCatChem 8 (2016) 1564–1574.
S. Martinuzzi, D. Cozzula, P. Centomo, M. Zecca, T.E. Müller, RSC Adv. 5 (2015) 56181–56188.
N. Gemo, S. Sterchele, P. Biasi, P. Centomo, P. Canu, M. Zecca, A. Shchukarev, K. Kordás, T.O. Salmi, J.-P. Mikkola, Catal. Sci. Technol. 5 (2015) 3545–3555.
P. Centomo, C. Meneghini, S. Sterchele, A. Trapananti, G. Aquilanti, M. Zecca, ChemCatChem 7 (2015) 3712–3718.
S. Sterchele, P. Centomo, M. Zecca, L. Hanková, K. Jeřábek, Microp. Mesop. Mat. 185 (2014) 26–29.

Collaborations/Network:
Dr. K. Jeřábek - Academy of Science of the Czech Republic, Prague, expert of textural analysis of polymeric materials (Including ISEC) and of their application in catalysis.

Research funding:
The project is partially funded by the “Progetto di Ateneo” P-Disc2016.

Title	**Supramolecular Catalysis within Confined Systems**
PI	ZONTA Cristiano
Research Group	Molecular Recognition and Catalysis
Curriculum	Scienze Chimiche
Contact	**web:** www.chimica.unipd.it/cristiano.zonta
	email: cristiano.zonta@unipd.it

Project description:



In the last years we have been interested in the application of TPMA metal complexes in catalysis and molecular recognition. TPMA are an important class of chelating ligands in coordination chemistry. These ligands are highly modular tetradentate molecules that effectively coordinate to transition metals, main group elements and lanthanides. Depending on the associated metals, different applications have been reported: catalysis (hydrolysis, oxidation, polymerization,…), molecular recognition, sensing, imaging and oxygen binding. Very recently, PI's group developed a novel supramolecular cage built from the self-assembly of tris(2-pyridylmethyl)amine TPMA zinc complexes through imine condensation chemistry. The research programme will result in the use of these novel system with the final goal to translate molecular confinement into the molecular: In particular the PhD will examine the catalytic properties of cages formed by linking two tris[(2-pyridyl)methyl]amine (TPMA) metal complexes, to take advantage of the properties strictly related to confined spaces and exploiting the presence of active metal sites inside the cavity. This allows to perform catalysis on the basis of: shape (catalysis by confinement), the nature of the metal centres (metal catalysis) and the presence of multiple metal sites (multimetal catalysis). The cages will be tested in oxidation catalysis. Nanocages will display enhanced catalytic properties due to the selectivities typical of homogeneous catalysis such as regio, stereo and chemoselectivity, combined with new selectivities exclusively associated with the confinement of metals in a cavity such as selectivity by shape complementarity and size exclusion. We are expected to find novel selectivties

Publications:

E. Badetti, K. Wurst, G. Licini, C. Zonta *Chem. Eur. J.* **2016**, *22*, 6515. R. Berardozzi, E. Badetti, N.A. Carmo dos Santos, K. Wurst, G. Licini, G. Pescitelli, C. Zonta, L. Di Bari *Chem. Commun.* **2016**, *52*, 8428. F. A. Scaramuzzo, E. Badetti, G. Licini, C. Zonta *Eur. J. Org. Chem.* **2017**, 1438. C. Bravin, E. Badetti, F.A. Scaramuzzo, G. Licini, C. Zonta *J. Am. Chem. Soc.* **2017**, *139*, 6456.

Collaborations/Network:

Miquel Costas – University of Girona (Spain)

Title	**Transition metal catalysis in unconventional media**
PI	BIFFIS Andrea (PI)
Research Group	Applied Organometallic Chemistry – DiSC
Curriculum	Scienze Chimiche
Location	DiSC
Contact	**web:** https://www.researchgate.net/profile/Andrea_Biffis
	email: andrea.biffis@unipd.it

Project description:

The group of Prof. Biffis has an ongoing interest in the development and application of catalytic systems based on late transition metals and able to operate in peculiar media/microenvironments leading to catalytic reactions with improved performance. Currently ongoing research of this topic includes:

- Use of ionic liquids as solvents in gold(I)-catalyzed alkyne hydrofunctionalization reactions;
- Solventless reactions: photocatalysts for the curing of silicone rubber formulations;
- Hierarchical assemblies of metal/metal oxide/crosslinked polymer nanoparticles for aerobic oxidations in water and under gas-solid conditions.

The PhD student will practice catalyst preparation (organometallic complexes of late transition metals, inorganic/hybrid assemblies containing noble metal nanoclusters), characterization by combined techniques (optical, vibrational, magnetic and mass spectroscopies, diffraction techniques, thermal analyses, electron microscopy) and catalyst testing under different conditions with in situ and ex situ reaction monitoring. Both model reactions and reactions of immediate technological relevance will be considered.

Publications:

D. Franco, A. Marchenko, G. Koidan, A. N. Hurieva, A. Kostyuk, A. Biffis, Palladium(II) Complexes with N-Phosphanyl-N-heterocyclic Carbenes as Catalysts for Intermolecular Alkyne Hydroaminations, *ACS Omega* **2018**, *12*, 17888-17894.

A. Biffis, P. Centomo, A. Del Zotto, M. Zecca, Pd Metal Catalysts for Cross-Couplings and Related Reactions in the 21st Century: A Critical Review, *Chem. Rev.* **2018**, *118*, 2249-2295.

M. Baron, E. Battistel, C. Tubaro, A. Biffis, L. Armelao, M. Rancan, C. Graiff, Single-Step Synthesis of Dinuclear Neutral Gold(I) Complexes with Bridging Di(N-heterocyclic carbene) Ligands and Their Catalytic Performance in Cross Coupling Reactions and Alkyne Hydroamination, *Organometallics* **2018**, *37*, 4213-4223.

Collaborations/Network:

ICMATE-CNR (Dr. Marzio Rancan, Dr. Marta Maria Natile) – XPS, XRD characterizations
ISTM-CNR (Dr. Claudio Evangelisti) – TEM microscopy
Academy of Sciences of Ukraine (Prof. Aleksandr Kostyuk) – Ligand synthesis
University of Muenster (Prof. F. Ekkehardt Hahn) – Ligand synthesis

Research funding:

DOR, P-DiSC 2017 “ENHCHANT”, UNI-IMPRESA project 2018 “PHOTOSIL”

Title	Toxic algal metabolites in the North Adriatic Sea: identification, risk assessment and early warning systems
PI	BOGIALLI Sara
Research Group	Analytical Chemistry – DiSC
Curriculum	Scienze Chimiche
Contact	**web:** http://www.chimica.unipd.it/analitica/; http://www.chimica.unipd.it/sara.bogialli/
	email: sara.bogialli@unipd.it

Project description:

Estuarine, marine, or freshwater phytoplankton species can cause extensive blooms also called 'red tides'. Sometimes, red tides are associated with the production of secondary metabolites, designated as toxins, and for this reason generally described as ''harmful algal blooms'' (HABs). HABs can affect public health and ecosystems in different ways. A comprehensive risk management on human exposure to toxic algal metabolites, whose production is actually unpredictable, is limited by reliable analytical tools for monitoring as many toxic algal metabolites as possible.

Objective/skills: Identification of target and non-target microalgal metabolites in algal cultures, marine waters and sediments, air and aerosol, and fisheries products by liquid chromatography coupled to high resolution mass spectrometry (LC-HRMS).

Publications:

1. Liquid chromatography-high resolution mass spectrometric methods for the surveillance monitoring of cyanotoxins in freshwaters **Sara Bogialli**, Claudio Bortolini, Iole Maria Di Gangi, Federica Nigro Di Gregorio, Luca Lucentini, Gabriella Favaro, Paolo Pastore. Talanta **2017**, 170, 332-330**.** DOI: 10.1016/j.talanta.2017.04.033.
2. First evidence of MC-HtyR associated to a Plankthothrix rubescens blooming in an Italian lake based on a LC-MS method for routinely analysis of twelve microcystins in freshwaters. F. Nigro Di Gregorio, **S. Bogialli**, E. Ferretti, L. Lucentini, Microchem. J. **2017**, 130, 329-335. DOI: 10.1016/j.microc.2016.10.012.
3. Non-target screening with high-resolution mass spectrometry: critical review using a collaborative trial on water analysis Emma L. Schymanski et al. Anal Bioanal Chem, **2015,** 407 (21), 6237-6255. DOI: 10.1007/s00216-015-8681-7.
4. Management of a Toxic Cyanobacterium Bloom (Planktothrix rubescens) Affecting an Italian Drinking Water Basin: A Case Study. **Sara Bogialli**, Federica Nigro di Gregorio, Luca Lucentini, Emanuele Ferretti, Massimo Ottaviani, Nicola Ungaro, Pier Paolo Abis, Matteo Cannarozzi de Grazia, Environ. Sci. Technol., **2013,** 47, 574-583. DOI: 10.1021/es302260p.

Collaborations/Network:

Department of Biology, University of Padua; Department of Chemical and Pharmaceutical Sciences-University of Ferrara; Italian National Health Institute; Marine Centre of Cesenatico.

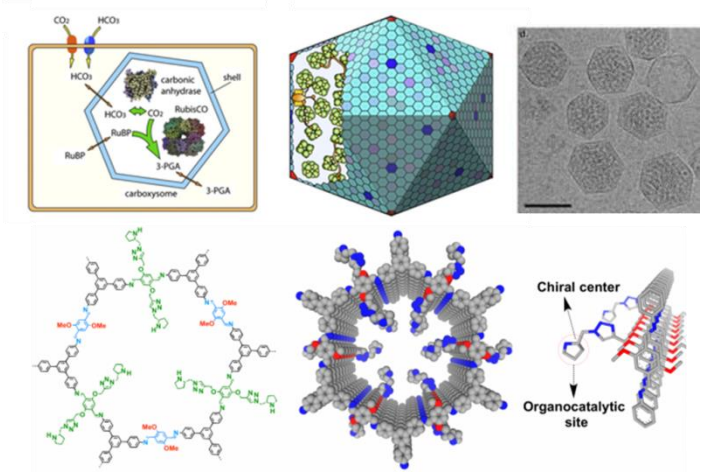
Research funding:

Private agreement

Title	**Bio-inspired Frameworks for CO_2 FIXATION**
PI	BONCHIO Marcella
Research Group	Nano and Molecular Catalysis (NanoMolCat) – DiSC
Curriculum	Scienze Chimiche
Location	DiSC
Contact	**web:** https://nanomolcat.wixsite.com/nanomolcat#
	email: marcella.bonchio@unipd.it

Project description:

Photosynthetic CO_2 fixation can win over the anthropogenic carbon emissions (ca. 120 Pg yr^{-1} vs. 7 Pg yr^{-1}; 1 Pg = 1 petagram = 1 billion tonnes = 10^{15} grams), however the key player for carbon-fixation i.e. the RuBisCO enzyme, is highly inefficient in terms of reaction kinetics (few Turnovers per hour) and selectivity (O_2 vs CO_2 processing). To overcome these limitations, most biological photosynthesizers adopt a combined strategy of spatial organization and separation of functions with cascade catalysis principles. One prominent example is found in the structure and multiple functions of the natural carboxysomes, i.e. microcompartments made by a self-assembling porous shell that encapsulates the RuBisCO catalyst in a confined, space. In this asset, the carboxysome allows for an efficient capture and activation of CO_2 while facilitating its fixation by feeding the catalyst with an increased local concentration of CO_2, boosting rates and controlling selectivity. The artificial replica of carboxysomes is still waiting for a groundbreaking molecular approach. The project will focus on the design of multi-functional molecular systems for CO_2 fixation, based on bio-inspired guidelines, including: (i) porous covalent organic frameworks (COF) using well established reversible condensation reactions and linkers; (ii) molecular organocatalysis; (iii) photo-redox cascade mechanisms. The PhD student will be trained on state-of-the art synthetic methods, solution and solid state characterization analysis (FT-IR, X-Ray techniques, NMR spectroscopy, mass spectrometry, chromatography and HPLC, circular dichroism) and advanced technology as micro-wave assisted protocols and photo-fluidic apparatus.



Publications:

M. Bonchio, et al. “Efficient water oxidation at carbon nanotube–polyoxometalate electrocatalytic interfaces” *Nature Chemistry 2*, 826–831 (2010); M. Bonchio, et al. “Hierarchical organization of perylene bisimides and polyoxometalates for photo-assisted water oxidation”. *Nature Chemistry 11*, 146–153 (2019); Cherubini-Celli, A.; Mateos, J.; Bonchio, M.; Dell'amico, L.; Companyò, X. "Transition-metal-free CO_2 fixation into new carbon-carbon bonds" *ChemSusChem* (2018), DOI: 10.1002/cssc.201801063.

Collaborations/Network:

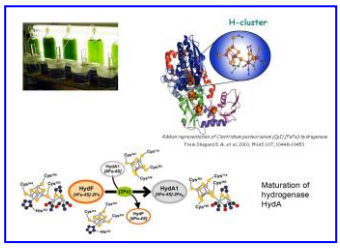
See national and international collaborations in recent publications.

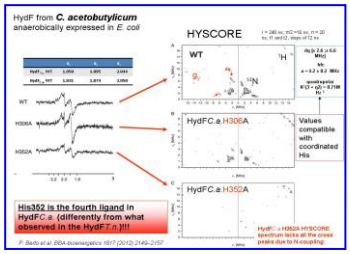
Research funding:

PRIN 2017 - 2017PBXPN4, CNR DCM.AD002.270 PROME

Title	**Hydrogenases, key enzymes in the production of bio-hydrogen**
PI	CARBONERA Donatella
Research Group	EPR spectroscopy/Biophysics– DiSC
Curriculum	Scienze Chimiche
Contact	**web:** www.chimica.unipd.it/donatella.carbonera
	email: donatella.carbonera@unipd.it

Project description: [FeFe]-hydrogenases are key enzymes for bioproduction of molecular hydrogen. Several efforts are currently underway to understand how their active site is assembled, and to improve the development of bioinspired hydrogenase analogs in renewable energy applications. Hydrogenases are metalloenzymes which are able to produce molecular hydrogen starting from protons and electrons provided by reduced substrates. Interestingly in green algae this reaction can be coupled to photosynthesis. [Fe-Fe]-hydrogenases are the most efficient enzymes in H_2 production, however they are rapidly inactivated by oxygen and the maturation of these enzymes is a complex process which requires the action of several other proteins. Both hydrogenase and maturation proteins are under investigation in our group, in collaboration with Dr. Paola Costantini, Department of Biology, University of Padova. A deeper understanding of H-cluster synthesis will facilitate the engineering of biotechnologies that use hydrogenases or synthetic catalysts inspired by them. Advanced EPR techniques and Fluorescence Resonance Energy Transfer (FRET) will be used to get information on the structure-function relationship in these metalloenzymes.





Publications:

1. Galazzo, L; Maso, L; De Rosa, E; Bortolus, M; Doni, D; Acquasaliente, L; De Filippis, V; Carbonera, D. Identifying conformational changes with site-directed spin labeling reveals that the GTPase domain of HydF is a molecular switch. (2017) *Scientific Reports* 7, 2045-2322

2. Di Valentin, M., Dal Farra, MG., Galazzo, L., Albertini, M., Schulte, T., Hofmann, E., Carbonera, D., Distance measurements in peridinin-chlorophyll a-protein by light-induced PELDOR spectroscopy. Analysis of triplet state localization (2016) *Biochimica et Biophysica Acta - Bioenergetics* 1857, 1909-1916

3. Di Valentin, M., Albertini, M., Zurlo, E., Gobbo, M., Carbonera, D. Porphyrin triplet state as a potential Spin label for nanometer distance measurements by peldor spectroscopy (2014) *Journal of the American Chemical Society*, 136 (18), pp. 6582-6585.

4. Albertini, M., Vallese, F., Di Valentin, M., Berto, P., Giacometti, G.M., Costantini, P., Carbonera, D. The proton iron-sulfur cluster environment of the [FeFe]-hydrogenase maturation protein HydF from Thermotoga neapolitana (2014) International *Journal of Hydrogen Energy*, 39 (32), pp. 18574-1858

5. Berto, P., Di Valentin, M., Cendron, L., Vallese, F., Albertini, M., Salvadori, E., Giacometti, G.M., Carbonera, D., Costantini, P. The [4Fe-4S]-cluster coordination of [FeFe]-hydrogenase maturation protein HydF as revealed by EPR and HYSCORE spectroscopies (2012) *Biochimica et Biophysica Acta - Bioenergetics*, 1817 (12), pp. 2149-2157

Research funding:

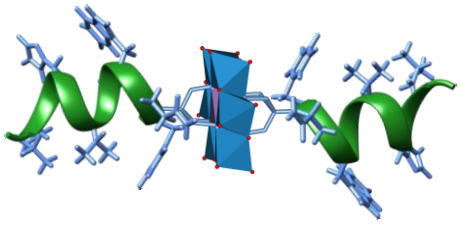
Cariparo Starting grants 2015

Title	**Synthesis of polyometalates-based bio-inorganic drugs**
PI	CARRARO Mauro
Research Group	Nano and Molecular Catalysis (NanoMolCat) – DiSC
Curriculum	Scienze Chimiche
Location	DiSC
Contact	**web:** http://wwwdisc.chimica.unipd.it/mauro.carraro
	email: mauro.carraro@unipd.it

Project description:

Polyoxometalates (POMs) are a class of transition metal compounds such as Mo, W, V in their highest oxidation state, bound together by oxygen bridge bonds. In recent years, an increasing number of potential POM applications in medicine has been reported in the literature. Many articles treat their activity as antibacterial, antiviral and anti-tumor agents, as they are able to interfere with the cellular / bacterial redox processes and to interact with biological macromolecules involved in various diseases. The polyanionic nature of POMs, associated with their nanometric size and rigidity, can be indeed exploited to favor the interaction with different biological macromolecules, such as the enzymes responsible for the development of tumor cells, or neurotoxic peptides, which can therefore be inhibited. Today there are several reproducible methods to synthesize POM functionalized with organic groups, characterized by greater stability in the physiological environment, reduced toxicity and greater selectivity. The preparation of organic-inorganic hybrid POMs, decorated with molecules of biochemical interest, will therefore be studied as a possible strategy to develop non conventional drugs with increased selectivity towards biological targets. In particular, we will study the possibility of functionalizing the Anderson polyoxomolybdates $[(C_4H_9)_4N]_3[MnMo_6O_{18}\{(OCH_2)_3CNH_2\}_2]$, with selected peptides (see Figure) or with small biomolecules (e.g. monosaccarides), for the recognition of tumor cells and /or for the inhibition of enzymes involved in tumor cells development, such as CK2.

The compounds will be characterized by techniques such as bidimensional NMR, UV-vis, CD, FT-IR, ESI-MS. Their tendency to assemble will be studied by DLS and TEM. In this way, both intramolecular interactions between the different domains and intermolecular interactions will be verified, to confirm the accessibility of the peptides and the availability towards the protein targets.



Publications:

V. A. Zamolo, G. Modugno, E. Lubian, A. Cazzolaro, F. Mancin, L. Giotta, D. Mastrogiacomo, L. Valli, A. Saccani, S. Krol, M. Carraro, M. Bonchio "Selective targeting of proteins by hybrid polyoxometalates: interaction between a bis-biotinylated hybrid conjugate and avidin" Front. Chem. 2018, 6, 278.

D. Ventura, A. Calderan, C. Honisch, S. Krol, S. Serratì, M. Bonchio, M. Carraro, P. Ruzza "Synthesis and biological activity of an Anderson polyoxometalate bis-functionalized with a bombesin-analogue peptide" Peptide Sci. 2018, e24047.

Collaborations:

M. Ruzzene (Biology Department, UNIPD), P. Ruzza (ICB-CNR).

Title	Smart nanocarriers for oligonucleotide delivery
PI	Paolo Caliceti
Research Group	Drug Delivery research Unit – DSF
Curriculum	Scienze Farmaceutiche
Contact	**web:** http://www.dsfarm.unipd.it/paolo-caliceti?key=FCC15E90D3F0134C4C25E8053AEE3AAE
	email: paolo.caliceti@unipd.it

Project description:

In the last decades, large efforts have been dedicated for the exploitation of therapeutic oligonucleotides (tON). Indeed, this class of macromolecules has shown a remarkable effect on the treatment of several diseases such as cystic fibrosis, ischemia, neurodegenerative diseases, wound healing and cancer. While oligonucleotide can be designed with high molecular selectivity, they suffer from instability, rapid enzymatic degradation, negligible circulation half-life. Thus, the use of dedicated delivery strategies is mandatory. The use of nanocarriers, in particular, has raised large interest in the scientific community to ensure the delivery of these macromolecules to the site of action. One of the most promising methods for the tON delivery relies on their assembly with polymers, which yields systems named “polyplexes”. We aim here to investigate a new class of cationic polymers with novel structural features that ensure efficient complexation of tONs through coulombic interactions. We expect that this will efficiently prevent their degradation in the blood stream, ameliorate the biopharmaceutical features (i.e. pharmacokinetic and biodistribution profiles). The cationic polymer will be designed to promote also the intracellular access of the tON. A set of star-like shape poly-cationic derivatives will be developed. These derivatives will be conjugated to different natural and biocompatible polysaccharides or polyaminioacid chains to tailor the features of the oligocationic moieties while end functionalization with targeting agents will enhance cancer selectivity.

The ability to condense, protect from enzymatic degradation and release oligonucleotides will be assessed by suitable analytical techniques. To further improve the efficacy of the nano-polyplexes, the co-delivery of oligonucleotides and anticancer drugs will be explored to seek a synergistic effect. Cleavable linkers will be used to conjugate the anticancer drugs to achieve in situ controlled release. I*n vitro* studies will be performed to evaluate the silencing of an intracellular target protein expressed by cancer cells. Nanotoxicity studies will be undertaken with the resulting nano-polyplexes. Finally, the *in vivo* efficacy to induce tumor regression will be performed using appropriate mice tumor models.

The PhD fellow involved in this project will acquired state-of-the-art skills in advanced drug delivery, nanotechnology, bioconjugation/polymer chemistry, in vitro and in vivo screening of novel therapeutic systems. The student will learn the most updated physico-chemical and biophysical techniques for colloid characterization.

This project lays at the interface between material science and biomedicine since the concepts behind the design of these systems stems from the combined knowledge of the physico-chemical features of novel materials and of the physiology of either the tumor tissue and the whole body.

Publications

1. Balasso, A.; et al. (2017) *European Journal of Pharmaceutical Sciences* 103:104-115.
2. Gallon E., et al (2015) *Biomacromolecules* **16**: 1924–1937.

Collaborations/Network

University of Tel Aviv (Israel)

Research funding

The project will be supported by dedicated commercial funds.

Title	**Provide a title for the research project**
PI	PASUT Gianfranco
Research Group	Protein and drug delivery – DSF
Curriculum	Scienze Farmaceutiche
Location	DSF
Contact	**web:** http://pasutlab.altervista.org/Pasutlab/Home.html
	email: gianfranco.pasut@unipd.it

Project description:
Polymer conjugation is an important technique useful to improve therapeutic properties of peptides, proteins, small molecules or oligonucleotides. Polymer conjugated drugs generally exhibit prolonged half-life, higher stability, water solubility, lower immunogenicity and antigenicity and often also specific targeting to tissues or cells. The approaches of conjugation are based on chemical or enzymatic methods and this important know-how can be exploited for the preparation also of next generation Antibody-Drug Conjugates (ADCs). ADCs are a broad class of molecules obtained by coupling a potent cytotoxic agent to a monoclonal antibody (MAb), through a chemical linker. The advantage of ADCs is the selective targeting of highly effective anticancer agents towards cells expressing specific tumor antigens, which are recognized by the selected MAb. The main challenges for the development of ADCs are related to the chemistry of drug conjugation (the drug has to be released to perform its cytotoxicity), the drug payload (usually several copies of an antitumor agent have to be coupled per MAb unit), and the site of drug conjugation [(mainly involving MAb's Lys(s) or Cys(s)]. The project aims to study the development of new approach for the targeted delivery of anticancer drugs by antibody. Studies will be directed to develop complexes between a MAb and a protein delivering the drug, or a MAb and a liposome entrapping the drug.

Publications:
Montagner IM, Merlo A, Carpanese D, Dalla Pietà A, Mero A, Grigoletto A, Loregian A, Renier D, Campisi M, Zanovello P, Pasut G, Rosato A. (2016). J CONTROL REL, 236:79-89
Grigoletto A, Mero A, Zanusso I, Schiavon O, Pasut G. (2016). MACROMOL BIOSCI, 16:50-56
Mero A, Grigoletto A, Maso K, Yoshioka H, Rosato A, Pasut G. (2016). POLYM CHEM, 7:6545-6553
Mero A, Campisi M, Favero M, Barbera C, Secchieri C, Dayer JM, Goldring MB, Goldring SR, Pasut G. (2014). J CONTROL REL, 187:30-38
Pasut G, Paolino D, Celia C, Mero A, Joseph AS, Wolfram J, Cosco D, Schiavon O, Shen H, Fresta M. (2014). J CONTROL REL, 199:106-113

Collaborations/Network:
- Dr. M.J. Vicent, Centro de Investigation Principe Felipe (E);
- Prof. R. Satchi-Fainaro, Sackler School of Medicine, Tel Aviv University (IL)
- Prof Silvia Muro, University of Meryland (US).

Research funding:
The project is financed in part by AIRC, Italian Ministry of Health

Title	Provide a title for the research project
PI	POLVERINO DE LAURETO Patrizia
Research Group	Protein Chemistry
Curriculum	Scienze Farmaceutiche
Contact	**web:** http://www.dsfarm.unipd.it/patrizia-polverino-de-laureto-0
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Molecular basis of the interaction between α-synuclein and compounds with anti-fibrillogenic properties

Project description:

- The research activity of our lab focuses on protein folding and misfolding studies and issues related to protein aggregation. Systematic studies are carried out with the aim of clarifying at the molecular level the protein amyloid aggregation mechanism using spectroscopic (circular dichroism, fluorescence, Fourier transform infrared, dynamic light scattering), biochemical (limited proteolysis) and morphological (electronic microscopy) techniques. A topic of current interest concerns the study of aggregated states of human alpha-synuclein, a protein involved in Parkinson's disease. Considering that this protein is present in free brain districts or presynaptic terminals, interaction studies with synthetic membranes and fatty acids are ongoing. Actually we are involved in a project focused on the study of the molecular interaction between the protein and small molecules of natural origin able to inhibit its amyloid aggregation process. These investigations into the structure–activity relationships of natural products may guide the design of novel therapeutic drugs in Parkinson's disease with enhanced properties.

Publications:

1. E. Frare, M. F. Mossuto, P. Polverino de Laureto, M. Dumoulin, C. M. Dobson and A. Fontana. Identification of the Core Structure of Lysozyme Amyloid Fibrils by Proteolysis. *J.Mol.Biol.* 361, 551–561 (2006).
2. P. Picotti, G. De Franceschi, E. Frare, B. Spolaore, M. Zambonin, F. Chiti, P. Polverino de Laureto, A. Fontana. Amyloid Fibril Formation and Disaggregation of Fragment 1-29 of Apomyoglobin: Insight into the effect of pH on Protein Fibrillogenesis. *J.Mol.Biol.* 367, 1237–1245 (2007).
3. G. De Franceschi, E. Frare, L. Bubacco, S. Mammi, A. Fontana, and P. Polverino de Laureto. Molecular Insights into the Interaction between alpha-Synuclein and Docosahexaenoic Acid. *J. Mol Biol*. 394, 94–107 (2009).
4. M.F. Mossuto, A. Dhulesia, G. Devlin, E. Frare, Kumita Jr, P. Polverino De Laureto, M. Dumoulin, A. Fontana, C.M. Dobson, X. Salvatella. The Non-core Regions of Human Lysozyme Amyloid Fibrils Give Rise to Cytotoxicity. *J. Mol Biol*. 402, 783–796 (2010).
5. G. De Franceschi, E. Frare, M. Pivato, A. Relini, A. Penco, E. Greggio, L. Bubacco, P. Polverino de Laureto. Structural and morphological characterization of aggregated species of alpha-synuclein induced by docosahexaenoic acid. *J.Biol.Chem.*, 286, 22262–22274 (2011).
6. M. Pivato, G. De Franceschi, L. Tosatto, E. Frare, D. Kumar, D. Aioanei, M. Brucale, I. Tessari, M. Bisaglia, B. Samorì, P. Polverino de Laureto, L. Bubacco. Covalent α-synuclein dimers: chemico-physical and aggregation properties. *PLoS One* 7(12). doi: 10.1371/journal.pone.0050027 (2012).
7. C. Fecchio, G. De Franceschi, A. Relini, E. Greggio, M. Dalla Serra, L. Bubacco, P. Polverino de Laureto. α-Synuclein oligomers induced by docosahexaenoic acid affect membrane integrity. *PLoS One*. 8(11), e82732. doi:10.1371/journal.pone.0082732. (2013).
8. Y. Feng, G. De Franceschi, A. Kahraman, M. Soste, A. Melnik, P. Boersema, P. Polverino de Laureto, Y. Nikolaev, A. P. Oliveira and P. Picotti. Probing protein structural transitions in complex biological backgrounds. *Nature Biotechnology* 32, *1036–1044,* doi:10.1038/nbt.2999 (2014).
9. J. R. da Palma, D. J. Burri, J. Oppliger, M. Salamina, L. Cendron, P. Polverino de Laureto, N. G. Seidah, S. Kunz, A. Pasquato. Zymogen Activation and Subcellular Activity of Subtilisin Kexin Isozyme-1/Site-1 Protease. *J.Biol.Chem.* 289*, 35743–35756,* doi: 10.1074/jbc.M114.588525 (2014).

10. G. De Franceschi, C. Fecchio, R. Sharon, A.H. Schapira, C. Proukakis, V. Bellotti, P. Polverino de Laureto. α-Synuclein Structural Features Inhibit Harmful Polyunsaturated Fatty Acids Oxidation, Suggesting Roles in Neuroprotection. *J.Biol.Chem.* 292(17):6927-6937 (2017).

Collaborations/Network:
University of Florence
University of Tuscia (Viterbo)
University College of London
Lausanne University Hospital

Title	**Programmed drug nanovehicles for enhanced site-selective anticancer therapy**
PI	STEFANO SALMASO
Research Group	Drug Delivery research Unit – DSF
Curriculum	Scienze Farmaceutiche
Location	DSF, Padova
Contact	**web:** https://www.dsfarm.unipd.it/stefano-salmaso-1
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Project description:

Cancer is one of the major causes of death worldwide accounting for about 13% of all deaths in 2015 (source: WHO Fact, February 2017). However there is a lack of ultimate solution to this fatal disease. In the last decades, several new active and selective anticancer drugs have been developed. However, poor pharmacokinetic (PK) profiles, limited biodistribution in the tumor tissue and high off-target toxicity have often hampered the clinical development of new promising molecules. Drug delivery approaches based on the use of nanosized carriers encapsulating drugs have been developed to reduce drug side effects and ultimately provide suitable therapeutic efficacy.

We aim here to improve drug nanovehicle performances by programming their functions that will be activated where and when required, including, but not limited to, drug delivery and release. While passive accumulation can promote biodistribution of drug nanocarriers in the tumor, our delivery systems are instructed to be activated in contact with target tissue and cells or when external stimuli are applied resulting in enhanced nonvehicle tropism for the tumor and locally restricted therapeutic activity.

This project aims at developing organic/inorganic colloidal vehicles as a “nano-machines” for cancer therapy. We will develop carriers for very potent and selective new anticancer molecules with poor biopharmaceutical features not yet on the market, and for existing anticancer drugs whose activity can be enhanced by combination therapy or by exploiting their sensitizing properties. The carriers developed will be decorated with functional components that provide for: sensing of the tumor local environment, biorecognition of specific molecular targets, site-activated drug release and cancer tissue hypersensitization to externally applied physical stimuli. When possible, novel microfluidic approaches will be exploited for the assembly of the nanocarriers.

The PhD fellow involved in this project will acquired state-of-the-art skills in advanced drug delivery, nanotechnology, bioconjugation/polymer chemistry, in vitro and in vivo characterization of novel therapeutic systems. The student will learn the most updated physico-chemical and biophysical techniques for colloid characterization. He/she will be trained at the interface between material science / pharmacy / nanotechnology / biomedicine since the concepts behind the design of these systems stems from a background knowledge of the novel material features and of the physiology of either the tumor tissue and the whole body.

Publications:

1. M. Barattin, et al. (2018) *Appl. Mater. Interfaces* 10: 17646–17661
2. Ambrosio E., et al. (2016) *J. Control Release.* 226: 35-46.
3. Brazzale C., et al. (2016) *Nanomedicine (Lond.)*, 11: 3053-3070.

Collaborations/Network:

University La Sapienza (IT), University of Nottingham (UK), University of Turin (IT), Ben-Gurion University of the Negev (Israel).

Research funding

The project will be supported by “PRIN grant” from the Ministry of University and Reseacrh – MIUR (Italy).

Title	**Non-canonical nucleic acid structure: foldings, functions and small molecule targeting**
PI	Sissi Claudia
Research Group	Biophysical Medicinal Chemistry Section– DSF
Curriculum	Scienze Farmaceutiche
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Project description:
The formation of non-canonical DNA structures in promoters is a recently explored mechanism to control the activity of the transcriptional machinery. In particular, their stabilization by small molecules has been widely investigated to suppress oncogene expression but, at present, none reached the clinic. Starting from available data, we identified main points that are rationally connected to this poor outcome: 1) the description of promoter structural organization cannot safely derive from studies on an isolated DNA structural motif. Indeed, we start to collect solid evidences of functional interactions among different nucleic acid structural domains; 2) DNA accessibility (topological state, hystone deposition), DNA modifications (iper- or ipo- methylation, oxidation) and DNA-protein complexes (transcription factors) make the system a different target for a small molecule 3) only a limited knowledge of a potential crosstalk between oncogene pathways is available. This makes difficult to properly evaluate the modulation of cellular pathways deriving from the silencing of a single oncogene.
From these assumptions, we are working to provide an in-deep comparison of the structural and functional role of the supramolecular organization of oncogene promoters and to dissect the consequence of the binding of small molecules on their transcriptionally active architecture.
This work explore the affected pathways by integrating distinct competences on biopharmaceutics, biophysics and cellular biology G4 ligands and unveil possible relationships between interconnected oncogenic pathways at structural, biological and functional level. it will provide the biological rationale for the design of novel therapeutic strategies and targets with more favorable outcome for patients.
Publications:
Rigo, R., Palumbo, M. and Sissi, C.* (2016) G-quadruplexes in human promoters: a challenge for therapeutic applications, BBA, bbagen.2016.12.024
Da Ros, S., Zorzan, E., Giantin, M., Zorro Shahidian, L., Palumbo, M., Dacasto, M. and Sissi, C. (2014) Sequencing and G-quadruplex folding of the canine proto-oncogene KIT promoter region: might dog be used as a model for human disease?, PLoS One, 9, e103876
Bianco, S., Musetti, C., Krapcho, A. P., Palumbo, M. and Sissi, C. (2013) Ni2+ and Cu2+ complexes of a phenanthroline-based ligand bind to G-quadruplexes at non-overlapping sites, Chem Commun (Camb), 49, 8057
Collaborations/Network:
Prof. J. Plavec, University of Lubiana; Prof. J. Chaires, University of Louisville, USA; Prof. Alcaro, University of Catanzaro; Prof. Randazzo, University of Naple. Dr. N. Zaffaroni, Istituto Tumori Milano, Dr, M. De Vivo, IIT, Genova.
Research funding: Ateneo

Title	**New generation trimethylangelicin (TMA) analogues for selective modulation of defective CFTR or inflammation**
PI	CHILIN Adriana
Research Group	Medicinal Chemistry – DSF
Curriculum	Scienze Farmaceutiche
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	email: adriana.chilin@unipd.it

Project description:
TMA was recently identified as a promising anti-inflammatory molecule for CF lung disease, with additional properties as potentiator and corrector of mutated F508del CFTR protein.
The major objective is to synthesize TMA analogs with the aim to find new antinflammatory agents (with NF-kB inhibitory activity) and/or CFTR function modulators, useful for CF lung disease, with equal or higher activity in the respect to the parent TMA, but with low or absent DNA photobinding properties. Hence, the goals of the project can be outlined in: 1) design and synthesis of a library of TMA analogs to identify a lead compound with optimized properties, 2) test of photoreactivity, 3) test of the anti-inflammatory activity and of the effects as CFTR function modulators, 4) derivation of structure-activity relationships to rationalize the structural determinants required to obtain selective anti-inflammatory properties, selective CFTR modulatory properties and dual anti-inflammatory/CFTR modulatory activity.
Expected results. Identification of novel candidates with improved anti-inflammatory and/or CFTR function modulating properties with reduced photoreactivity for the treatment of the chronic lung pathology of patients affected by CF.

Recent Publications in the specific field:
M Borgatti, A Chilin, et al. *Eur. J. Med. Chem*., **46**, 4870-7 (2011) DOI: 10.1016/j.ejmech.2011.07.032
G Marzaro, … A Chilin, *J. Med. Chem*. **67**, 373-83 (2013) DOI: 10.1021/jm3009647
G Marzaro, … A Chilin, *Molecular Diversity* **19**, 551-61 (2015) DOI: 10.1007/s11030-015-9586-2
I. Lampronti, …. A Chilin, *Mediators of inflammation*, 2017, submitted.

Collaborations/Network:
Dr. GIULIO CABRINI and Dr. MARIA CRISTINA DECHECCHI - Laboratory of Molecular Pathology - University Hospital of Verona (for testing analogues on rescue and potentiation of defective CFTR and for immune response).
Prof. ROBERTO GAMBARI - Department of Life Sciences and Biotechnology, Laboratory of Biochemistry and Molecular Biology, University of Ferrara (for testing analogues on the anti-inflammatory properties).

Research funding:
FFC#1/2016 project "New generation trimethylangelicin (TMA) analogues for selective modulation of defective CFTR or inflammation" funded by Fondazione Ricerca Fibrosi Cistica in 2016 – Two years project.

Title	**Novel anticancer strategies to fight drug resistance**
PI	DALLA VIA Lisa
Research Group	Medicinal Chemistry - Molecular Mechanisms of Drug Action – DSF
Curriculum	Scienze Farmaceutiche
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	email: lisa.dallavia@unipd.it

Project description:
Targeted chemotherapy, one of the principal modes of treatment for cancer, has revolutionized cancer treatment. Nevertheless, its effectiveness is quite often offset by drug resistance, one of the most challenging problems facing cancer research today. A diverse range of molecular alterations has been implicated in drug resistance. These include increased rates of drug efflux, alterations in drug metabolism, changes in the tumor environment and mutation of drug targets, among others. Moreover, tumors are highly adaptable, and the activation of survival signaling pathways and the inactivation of downstream death signaling pathways can also lead to drug resistance. To complicate matters, many of these factors can be at play simultaneously in a single tumor. Thus, much effort is needed to design more effective drugs and/or strategies toward which resistance does not develop. An interesting strategy involves combining two active drugs functionalized with a lipophilic tail and a suitable linker into a single supramolecular structure (nanoparticle) that can interact with two relevant components of cancer process. A further approach is the design of dual ligands, i.e. single chemical entities acting on two biomolecular targets. The project aims at the biological evaluation of novel dual ligands and nanoparticles, allowing the selection of few leads endowed with an optimal antiproliferative activity on resistant cancer cells. The involved intracellular molecular target(s) will be also assessed. A full characterization of the molecular mechanism(s) of the selected most promising hits, leading to the cytotoxic effect on resistant cells, is the main goal of the research project. The PhD student will mainly focus on the field of cell and macromolecular biology. A wide range of techniques should be employed, ranging from cell manipulation to spectroscopic and electrophoretic methods, applied to molecular biology.

Publications:
L. Dalla Via*, M. Mejia, A. N. García-Argáez, A. Braga, A. Toninello, M. Martínez-Vázquez, Anti-inflammatory and antiproliferative evaluation of 4β-cinnamoyloxy,1β,3α-dihydroxyeudesm-7,8-ene from *Verbesina persicifolia* and derivatives *Bioorg. Med. Chem.* 23, 5816-5828 (2015). **L. Dalla Via***, A. N. García-Argáez, E. Agostinelli, D. Belli Dell'Amico, L. Labella, S. Samaritani, New *trans* dichloro (triphenylphosphine)platinum(II) complexes containing N-(butyl),N-(arylmethyl)amino ligands: Synthesis, cytotoxicity and mechanism of action *Bioorg. Med. Chem.* 24, 2929-2937 (2016). G. Fumagalli, M. S. Christodoulou, B. Riva, I. Revuelta, C. Marucci, V. Collico, D. Prosperi, S. Riva, D. Perdicchia, I. Bassanini, A. García-Argáez, **Lisa Dalla Via**, D. Passarella, Self-assembled 4-(1,2-diphenylbut-1-en-1-yl) aniline based nanoparticles: podophyllotoxin and aloin as building blocks *Org. Biomol. Chem.* 15, 1106-1109 (2017).

Collaborations/Network: National: Universities of Ferrara, Milano, Pisa, Palermo and Roma "La Sapienza". International: Universidad Nacional Autónoma de México (UNAM), Universidad de Colima.

Title	**Extraction of bioactive products as pest control agents**
PI	Dall'Acqua Stefano
Research Group	Natural Product Lab
Curriculum	Scienze Farmaceutiche
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Project description:

The search for new pest control active agents which exhibit efficient activity as well as increased safety, is urgent and in the recent time is the extremely rich resource of natural products have been studied in this field. Thanks to the established collaboration with international group working in the field of pest control agents and antiparasitic compounds the project will be focused on the the discovery, identification, or study of the molecular mode of action of active natural agents as bi-opesticide and antiprotozoal agents. Extraction of compounds separation using state of the art thecniques and analytical hyphenated approach (LC-MS, GC-MS) will be used furthermore the most active compounds will be isolated and describing in detail the chemical structures by the means of MS and NMR approaches.

Publications specific to the aim of the project:

Benelli, G., Pavela, R., Petrelli, R., Cappellacci, L., Santini, G., Fiorini, D., Sut, S., Dall'Acqua, S., Canale, A., Maggi, F. The essential oil from industrial hemp (Cannabis sativa L.) by-products as an effective tool for insect pest management in organic crops (2018) Industrial Crops and Products, 122, pp. 308-315.

Sut, S., Dall'Acqua, S., Baldan, V., Ngahang Kamte, S.L., Ranjbarian, F., Biapa Nya, P.C., Vittori, S., Benelli, G., Maggi, F., Cappellacci, L., Hofer, A., Petrelli, R. Identification of tagitinin C from Tithonia diversifolia as antitrypanosomal compound using bioactivity-guided fractionation (2018) Fitoterapia, 124, pp. 145-151.

Sut, S., Pavela, R., Kolarčik, V., Lupidi, G., Maggi, F., Dall'Acqua, S., Benelli, G.Isobutyrylshikonin and isovalerylshikonin from the roots of Onosma visianii inhibit larval growth of the tobacco cutworm Spodoptera littoralis (2017) Industrial Crops and Products, 109, pp. 266-273.

Sut, S., Pavela, R., Kolarcik, V., Cappellacci, L., Petrelli, R., Maggi, F., Dall'Acqua, S., Benelli, G. Identification of onosma visianii roots extract and purified shikonin derivatives as potential acaricidal agents against tetranychus urticae (2017) Molecules, 22 (6), art. no. 1002.

Collaborations/Network:

University of Camerino, University of Pisa, Crop Research Institute of Prague, Umea University, for test on parasites and pest agents.

Research funding:

NPL lab have active research project (Unimpresa) and several funding from Industries.

Title	**Metal-based Radiopharmaceuticals**
PI	DOLMELLA Alessandro
Research Group	Medicinal Chemistry, Drug Design and Synthesis – DSF
Curriculum	Scienze Farmaceutiche
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Project description:
Radiodrugs (RDs) are compounds harboring a radioactive element to be used either in diagnosis and/or treatment of diseases. The paradigmatic leading nuclide in SPECT imaging is Tc-99m; new metals (Cu-64, Ga-67, Lu-177, others) have recently gained momentum, especially in the theranostic selective targeted delivery of radio-drug to the tumor site and simultaneous scintigraphic monitoring of the delivery itself. Our research concerns the recognition, development and optimization of new metal-based radiopharmaceuticals to be used in SPECT/PET diagnosis as well as in therapy. As a viable example of our approach to the developement of new RPs we remind the strategy of the indirect labelling (optimised for Tc-99m RDs), performed using the [M(N)(PNP)]2+ technology within the classical BFCA approach. Selected BFCAs such as Cys or DOTA/NOTA ligands can be conjugated by chemical methods to a suitable biological vector (e.g., peptides) and then inciubated with the selected radionuclide (interested readers will find in literature examples describing this paradigm with respect to, for example, In-111 or Ga-68). Obtained derivatives are then investigated by ESI-MS to identify the modification sites, whereas to optimize radiochemical yield the influence of the manifold reaction parameters, such as reagent concentrations, reaction time, pH and temperature are investigated. Radiochemical purity of products will be determined using HPLC analysis. In vitro stability cxan also be assessed by HPLC methods after incubation at 37 °C with fresh human serum, cysteine, glutathione or EDTA solutions at time points ranging from 0.5 to 24 h. Chemical identity of desired products will be ascertained using cold analogues in the solid state by X-ray diffraction techniques.

Publications:
Baron, Marco; Tubaro, Cristina; Basato, Marino; Ahmed Isse, Abdirisak; Gennaro, Armando; Cavallo, Luigi; Graiff, Claudia; **Dolmella, Alessandro**; Falivene, Laura; Caporaso, Lucia (2016). Insights into the Halogen Oxidative Addition Reaction to Dinuclear Gold(I) Di(NHC) Complexes. CHEMISTRY-A EUROPEAN JOURNAL, Vol. 22, p. 10211-10224, doi:

Nicola Salvarese, **Alessandro Dolmella**, Fiorenzo Refosco, Cristina Bolzati (2015). Reactivity of the [M(PS)2]+Building Block (M = ReIIIand99mTcIII; PS = Phosphinothiolate) toward Isopropylxanthate and Pyridine-2-thiolate. INORGANIC CHEMISTRY, vol. 54, p. 1634-1644, ISSN: 0020-1669, doi: 10.1021/ic502632h -Impact Factor 4.794

Collaborations/Network:
Dr. Cristina Bolzati, ICMATE-CNR, Padova; PhD Nicola Salvarese, ICMATE-CNR, Padova; PhD Laura Melendez-Alafort, DISCOG, Padova; Prof. Antonio Rosato, DISCOG, Padova.

Research funding: =

Title	**Development of target-specific metallodrugs**
PI	GANDIN Valentina
Research Group	Medicinal Chemistry - Molecular Mechanisms of Drug Action
Curriculum	Scienze Farmaceutiche
Contact	**web:** www.dsfarm.unipd.it/valentina-gandin
	email: valentina.gandin@unipd.it

Project description:

Although highly effective toward a number of solid tumors, platinum anticancer drugs cause severe toxic effects on normal tissues and induce the appearance of resistance phenomena. These drawbacks have stimulated an extensive search to develop alternative metal-based drugs with improved pharmacological properties and targeting different tumor-specific biomolecules (besides DNA).

By taking into consideration that the unique electronic structure of transition metals offers great versatility in tuning the properties of a given target-specific ligand, this project aim at the development of transition metal-based compounds able to target specific proteins that are overexpressed or even unique to selected cancer cell types as well as able to target specific abnormalities of certain tumor types.

The project will encompass the following steps: i) Design, synthesis and characterization of new metal-based derivatives; ii) Evaluation of target interaction at molecular level; iii) Assessment of target modulating activity and in vitro antitumor potential in selected cancer cells; iv) Investigation on cancer cell effects and signaling; v) Preliminary evaluation of the in vivo antitumor activity.

Besides primarily aimed at identifying structure-activity relationships (SARs) and selecting Lead compounds, these studies also provide mechanistic investigations for the recognition of biological and molecular determinants accounting for their antitumor activity.

Publications:

1 Montagner D., Fresch B., Browne K., Gandin V., Erxleben A. (2016) A Cu(II) complex targeting the translocator protein: in vitro and in vivo antitumor potential and mechanistic insights. Chem Commun (Camb)., 53, 134-137.

2 Raveendran R., Braude J.P., Wexselblatt E., Novohradsky V., Stuchlikova O., Brabec V., Gandin V., Gibson D. (2016) Pt(IV) derivatives of cisplatin and oxaliplatin with phenylbutyrate axial ligands are potent cytotoxic agents that act by several mechanisms of action. Chem Science, 7, 2381-2391.

3 Harper B.W.J., Petruzzella E., Sirota R., Faccioli F.F., Aldrich-Wright J.R., Gandin V., Gibson D. (2017) Synthesis, characterization and in vitro and in vivo anticancer activity of Pt(IV) derivatives of [Pt(1S,2S-DACH)(5,6-dimethyl-1,10-phenanthroline)]. Dalton Trans., DOI: 10.1039/C7DT01054K.

Collaborations/Network:

- Dr D.Montagner, Dept. of Chemistry, National University of Ireland, Maynooth, Ireland;
- Prof. D.Gibson, The Hebrew University of Jerusalem, School of Pharmacy- Institute for Drug Research;

Title	Nucleic Acids Alkylation by Mono and Bis-chloropiperidines
PI	Gatto Barbara
Research Group	Molecular Mechanism of Action of Drugs - Barbara Gatto - DSF
Curriculum	Scienze Farmaceutiche
Contact	**web:** http://www.dsfarm.unipd.it/barbara-gatto-0
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Project description:

This project aims to exploit the potentialities in drug development of easily accessible small molecules while building an interdisciplinary and international network. Mono and Bis-chloro-piperidines (M-CePS and B-CePS) are simplified analogues of natural products with potential therapeutic activity. They can be considered as piperidine-based analogues of nitrogen mustards, old drugs with valuable therapeutic activity despite severe side effects. In collaboration with the group of Prof. Dr. Goettlich at JLU - Giessen, we recently synthesized a large set of chloropiperidine derivatives intended to react covalently with nucleophilic sites on DNA, exploring the chemical space of B-CePS, elucidating their molecular mechanism of action (MMOA) and evaluating their potential as base alkylators in inducing cell death (1-3).
Beyond their ability to induce DNA damage, B-CePS derivatives exhibited the peculiar skill to differently react with RNA molecules inducing cross-linking of RNA strands. Opening new perspectives in the development of innovative antiviral agents targeting viral RNA structures, we aim to explore bis-chloropiperidines potential in inducing anti-HIV effects in vitro; and to elucidate their molecular mechanism of action by means of modern spectroscopic, electrophoretic and spectrometric methods.

Publications:

1. Zuravka, I., R. Roesmann, A. Sosic, W. Wende, A. Pingoud, B. Gatto and R. Gottlich (2014). "Synthesis and DNA cleavage activity of Bis-3-chloropiperidines as alkylating agents." ChemMedChem 9(9): 2178-2185.
2. Sosic, I. Zuravka, N.K. Schmitt, A. Miola, R. Göttlich, D. Fabris, and B. Gatto. “Direct and Topoisomerase II Mediated DNA Damage by Bis-3-chloropiperidines: The Importance of Being an Earnest G”. ChemMedChem, 2017, 12, 1471 – 1479.
3. Carraro, A. Francke, A. Sosic, F. Kohl, T. Helbing, M. De Franco, D. Fabris, R. Göttlich, and B. Gatto. “Behind the Mirror: Chirality Tunes the Reactivity and Cytotoxicity of Chloropiperidines as Potential Anticancer Agents”, ACS Med. Chem. Lett. DOI: 10.1021/acsmedchemlett.8b00580.

Collaborations/Network:
The international partners of the BICePs network are Prof. Dr. Richard Goettlich, Institute of Organic Chemistry, Justus Liebig University (JLU) Giessen, Germany and Prof. Dan Fabris, The RNA Institute and Department of Chemistry, University at Albany, Albany, NY, USA.

Research funding:
Marie Sklodowska Curie - Individual Fellowship (Beneficiary: Dott. Alice Sosic, Supervisor: Prof. Barbara Gatto)
Progetti di Ricerca di Interesse Dipartiementale (PRID) 2017

Title	**Dual kinase/HDAC inhibitors for cancer treatment**
PI	MARZARO Giovanni
Research Group	Drug Synthesis Lab – DSF
Curriculum	Scienze Farmaceutiche
Contact	**web:** www.dsfarm.unipd.it/giovanni-marzaro-0?key=B4466AE22F1E04234176B8A857CA80BE
	email: giovanni.marzaro@unipd.it

Project description:

The research on anti-cancer drugs is constantly moving towards the targeted therapy, that relies on inhibiting specific biomolecules fundamental for cancer growth. Ideal biological targets are the tyrosine kinases (TKs) and the histone deacetylases (HDACs). Recent findings have highlighted the importance of a multi-target approach: the simultaneous blockade of different pathways involved in the cancer growth leads to a more effective therapy, with reduced drug resistance phenomena onset. The co-administration of a TK inhibitor and of an HDAC inhibitor is largely more effective than the administration of a single drug. The multi-target approach can be pursued also through a single agent endowed with multiple potency (*i.e.* a single compound able to inhibit more targets), leading to higher potency and lower side effects when compared with the co-administration of different target-selective agents. The present project relies on the synthesis and the biological evaluation of novel anticancer multi-target compounds able to inhibit: 1) at least one tyrosine kinase and 2) one of the HDAC isoforms. The expected results of the project will be: 1) the development of novel compounds of pharmaceutical interest; 2) the improvement of the knowledge on dual inhibitors; 3) the improvement of the knowledge regarding the intercommunication between the TKs-mediated pathways and the HDACs-mediated pathways. The PhD student will deal with both classical and advanced organic synthesis techniques. Once new lead compound(s) will be identified, small libraries of analogues will be prepared by using the late stage functionalization techniques recently developed for the fast identification of pharmaceutically promising compounds characterized by improved solubility and catabolic stability.

Publications:

- Carbajales C., et al., *ACS Comb Sci*, 19, 153-160, **2017**
- Marzaro G., et al., *Eur J Med Chem*, 115, 416-425, **2016**
- Gandin V., et al., *Sci Rep*, 5, 16750, **2015**
- Marzaro G., et al., *J Med Chem*, 57, 4598-4605, **2014**
- Conconi M.T., et al., *Eur J Med Chem*, 67, 373-383, **2013**

Collaborations/Network:

Internal collaborators: Prof. Adriana Chilin (DSF); Dr. Valentina Gandin (DSF); Dr. Andrea Mattarei (DSF). External collaborators: Prof. Matthew B. Soellner (University of Michigan, USA; pharmacy.umich.edu/people/soellner); Prof. Ke Ding (Guangzhou University, China; english.gibh.cas.cn/iocb/rp/DingKe/); Prof. Alberto Coelho Coton (University of Santiago de Compostela, Spain; www.researchgate.net/profile/Alberto_Coelho)

Research funding:

The research will be supported by the University of Padova (PRID 2016)

Title	Provide a title for the research project
PI	MORO Stefano
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Curriculum	Scienze Farmaceutiche
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Project description:

Title: New computational methodologies in inspecting ligand-receptor recognition pathways: a valuable strategy to speed up the identification of drug candidates.

State of art: One of the most challenging issues for the future of drug discovery is the capability to understand the receptor-ligand recognition pathway with the aim to facilitate the development of drug candidates with more favorable phamacodynamic profiles. Unfortunately, the recognition process between a ligand and its receptor is a very rare event to describe at the molecular level, and even with the recent GPU-based computing resources, it is necessary to carry out classical molecular dynamics (MD) experiments in a long microsecond time scale. In order to overcome this limiting factor, we have implemented an alternative MD approach, named supervised molecular dynamics (SuMD), that enables us to follow receptor-ligand approaching process within a time scale reduced up to 3 orders of magnitude compared to classical MD. SuMD enables the investigation of ligand-receptor binding events independently from the starting position, chemical structure of the ligand, and also from its receptor binding affinity.

Objectives: Theme A – Application of SuMD technology in different hot therapeutic area such as oncology, inflammation and immunology. Theme B – Extending and improving the development of SuMD methods, in particular implanting novel approach to predict the free energy of binding and the corresponding binding kinetic parameters.

Skills of the candidate: Theme A – Background in Chemistry, Medicinal Chemistry, Pharmacy and Biotechnologies with a basic knowledge in informatics. Theme B – Background in Chemistry or Medicinal Chemistry with a good knowledge in informatics (linux environments) and solid skills in programming.

Publications:

Salmaso V, Sturlese M, Cuzzolin A, Moro S. "Exploring Protein-Peptide Recognition Pathways Using a Supervised Molecular Dynamics Approach." Structure 25, 655-662 (2017)

Cuzzolin A, Sturlese M, Deganutti G, Salmaso V, Sabbadin D, Ciancetta A, Moro S. "Deciphering the Complexity of Ligand-protein Recognition Pathways using Supervised Molecular Dynamics (SuMD) Simulations." J Chem Inf Model 56, 687-705 (2016)

Ciancetta A, Sabbadin D, Federico S, Spalluto G, Moro S. "Advances in Computational Techniques to Study GPCR-Ligand Recognition." Trends Pharmacol Sci. 36, 878-890 (2015)

Collaborations/Network:

Dr. Kenneth A. Jacobson, National Institutes of Health (NIH), Bethesda – USA
Dr. Jon Manson, Heptares Therapeutics, Hertfordshire – UK
Prof. Ajith A. Welihinda, Molecular Medicine Research Institute, Sunnyvale – USA

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