# CHEMISTRY DEPARTMENT UNIVERSITY OF FRIBOURG

## ACTIVITY REPORT

## 2020 - 2021

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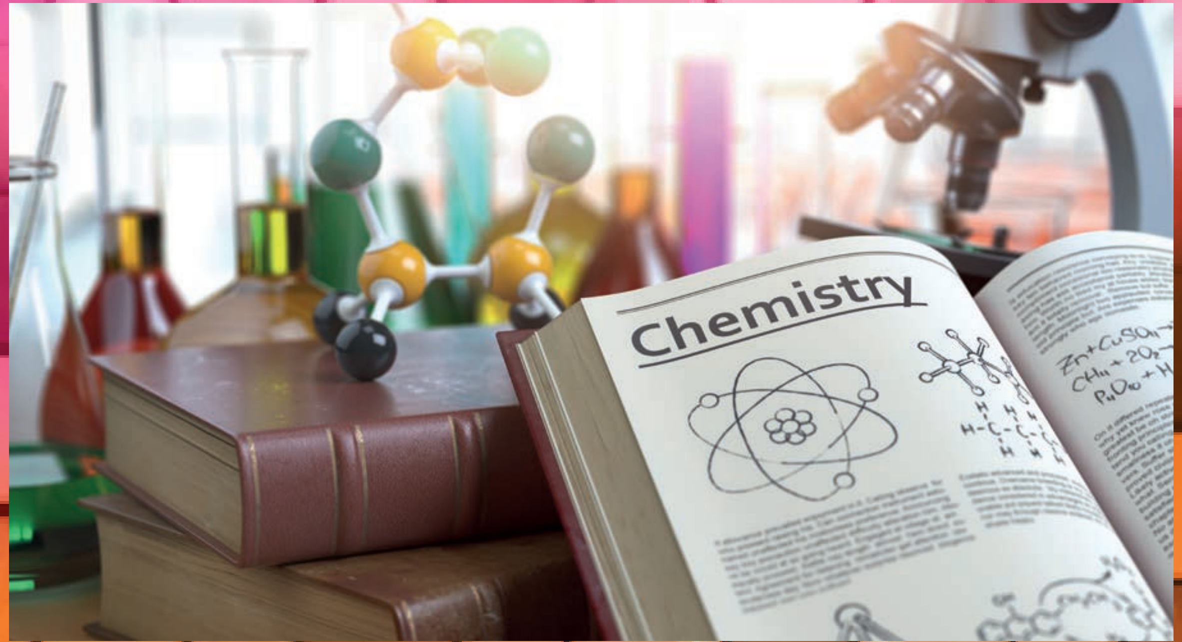
# ACTIVITY REPORT 2020 - 2021

## Our Contents





# From the President

## Transformative Research & Education

**Chemistry is playing an increasingly important role in modern society. Aware of the importance of this discipline in technology, we strive to create an international environment where, through research and teaching, both undergraduate and graduate students acquire not just the scientific knowledge, but also the skills that will help them to adapt to an ever-changing world. We hope to instill in them the passion for learning, which will last throughout their career, to teach them the importance of teamwork and foster their spirit of innovation and creativity.**

In the last two years, the successful hires both at junior and senior levels strengthen our research capabilities in catalysis and also in food sciences. The research activity of our department, with a focus on material science and biomedical research, is characterized by high interdisciplinarity, a highly stimulating research environment, a top-level infrastructure and excellent working conditions. The faculty, with the help of brilliant students from all over the world, seeks to solve problems of high fundamental and practical importance and promote a culture of innovation and collaboration. Nanotechnology, polymer science, organic and inorganic chemistry applied to novel drug synthesis, materials for energy-related applications are only some of the exciting research topics investigated in the department. We have also made significant infrastructure upgrades to support our research and teaching. Taken all together, the chemistry department is ready for the future and will continue to increase the quality of research and teaching. In the coming years, we will continue to adopt new strategies and technologies such as virtual reality to further improve our teaching activities.
Finally, I would like to thank all the members of our department for their strong commitment and support!

President of the Department of Chemistry
Prof. Dr. Ali Coskun

*Ali Coskun*

*The grand challenges of the 21st century are waiting for the next generation scientist - you!*
*Join us to discover the wonders of chemistry!*

**Department Head**

Prof. Dr. Ali Coskun

UNIVERSITY OF FRIBOURG | DEPARTMENT OF CHEMISTRY | 2021-2022

Teaching should be such that what is offered is perceived as a valuable gift and not as a hard duty

*Albert Einstein*

ORGANIC PHOTOCHEMISTRY

# Using light to create new substances

## Prof. Christian BOCHET

*The future of chemistry is bright*

**Organic synthesis is the science dedicated to the preparation of carbon-based substances in the laboratory. Photochemistry is the science studying how light can transform matter. Thus, organic photochemistry uses light to create new molecules.**

Our group's aim is to use light as a safe, inexpensive and environmentally friendly alternative to classical chemical reagents. To be able to reach this long-term goal, we approached the problem from two different sides at the same time:

a) finding new reactions promoted by light, giving new substances that are tested for their pharmaceutical properties and optimising existing reactions by replacing certain components by light, in collaboration with the chemical industry.

b) trying to understand the fundamentals of photochemistry, by designing model reactions to test the currently used hypotheses, and studying them both experimentally and by computer-assisted modelling.

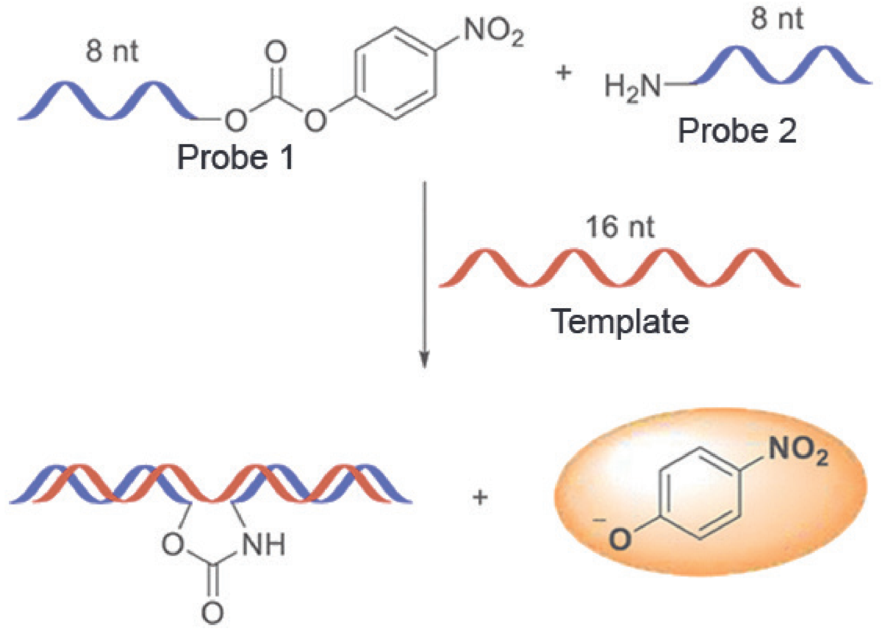
In parallel to these studies, we are also interested in the development of new techniques to detect and identify short DNA and RNA fragments. We have successfully prepared a very fast sensor for such fragments, that is now being tested for the identification of pathogens, such as Listeria or other bacterial strains.

Finally, our group has a long-time collaboration with the University of Yaoundé, Cameroon, for the isolation of pharmaceutically active substances from local plants. Starting from raw extracts, several new substances were found, some of them with promising therapeutic effects.

With the rarefaction of many raw materials, it is increasingly important to be able to use light, the only energy source reaching our planet, in all possible types of applications. After all, Nature is able to produce very large molecules with incredible precision by just combining carbon dioxide and water with the help of light. The future of chemistry is linked to the ability of scientist to do just the same !






The detection of a DNA fragment (template, in red) is based on the reaction between two shorter probes (in blue), releasing a colored indicator.

# BOCHET

## Group


**Recent publications:**

**Development and Scale-Up of a Novel Photochemical C–N Oxidative Coupling**
Robinson, A.; Dieckmann, M.; Krieger, J.-P.; Vent-Schmidt, T.; Marantelli, D.; Kohlbrenner, R.; Gribkov, D.; Simon, L. L.; Austrup, D.; Rod, A.; Bochet, C. G. . Org. Process Res. Dev. 2021, acs.oprd.1c00244. https://doi.org/10/gmt9r8.

**Aryl-Substituted Pyrimidones as Inhibitors of 3-Mercaptopyruvate Sulfurtransferase with Antiproliferative Efficacy in Colon Cancer**
Bantzi, M.; Augsburger, F.; Loup, J.; Berset, Y.; Vasilakaki, S.; Myrianthopoulos, V.; Mikros, E.; Szabo, C.; Bochet; C. G. Novel. J. Med. Chem. 2021, 64(9), 6221-6240.

**Is there a Photochemical Hammond Postulate?**
Harvey, F.M.; Bochet, C.G.;, Chem. Sci, 2021, 15, 599-605.

**Stereospecific hydrogenolysis of benzylic alcohols over Pd/C**
Harvey, F.M.; Bochet, C.G.;, J. Org. Chem. 2020, 85, 7611-7619.

**A Simple Reaction for DNA Sensing and Chemical Delivery**
Janett, E.; Diep, K.L.; Fromm, K.M.; Bochet, C.G.;, ACS Sensors 2020, 5(8), 2338-2343.

**Contortamide, a new anti-colon cancer cerebroside and other constituents from Tabernaemontana contorta Stapf (Apocynaceae)**
Ebede, G.R.; Ndongo, J.T.; Mbing, J.N.; Kenfack, H.C.M.; Pegnyemb, D.E; Bochet, C.G.;, Nat. Prod. Res. 2019, 1-9.

LABORATORY OF FUNCTIONAL MATERIALS

# Exploring new materials approaches for energy and environmental challenges

## Prof. Ali COSKUN

*Renewable Energy for a better tomorrow*

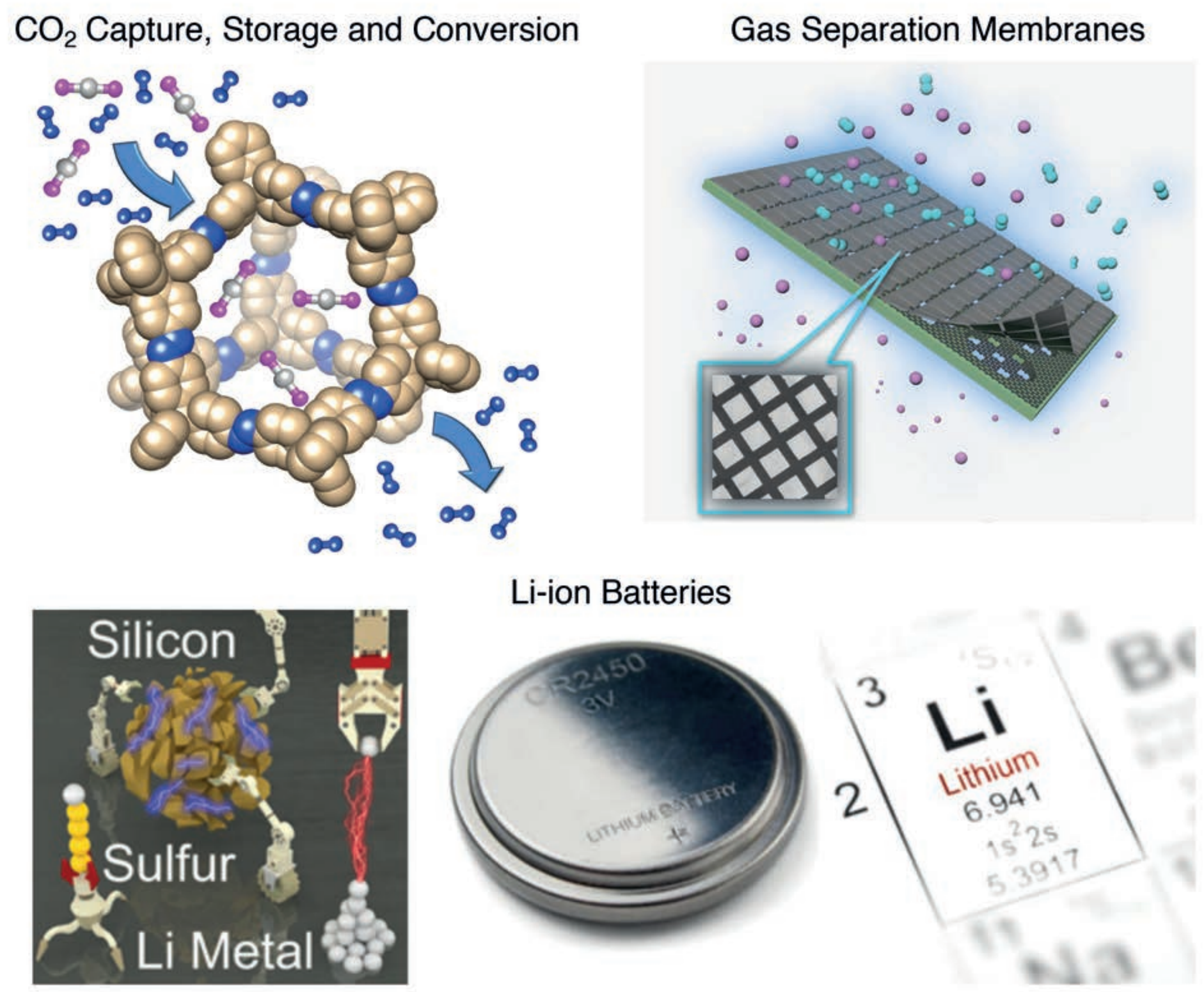
$CO_2$ emissions into the atmosphere account for the majority of environmental challenges and its global impact in the form of climate change is well-documented. Accordingly, the development of new, sustainable materials approaches to capture and convert $CO_2$ into value-added products is essential. Whereas the increased availability of renewable energy is curbing our reliance on fossil fuels and decreasing $CO_2$ emissions, the widespread adaptation of renewable energy still requires the development of high energy density batteries i.e., lithium ion batteries (LIBs). In this direction, our research program targets the development of functional materials by creating family of porous organic polymers, membranes, electrolytes and supramolecular polymers to solve critical energy and environmental problems with a particular emphasis on high energy density Li-ion batteries as well as gas capture and catalysis applications. The focus of our research is to identify fundamental design principles in these materials in order to correlate the functions at the molecular level to the resulting materials properties.

Our group has been developing porous organic polymers (POPs) with precise control over their porosity and surface chemistry for $CO_2$ capture, separation and conversion. To realize simultaneous $CO_2$ separation and conversion, we are also developing catalytically active two-dimensional membranes and POPs. More recently, we also expanded our research efforts to cover atmospheric water capture and recovery of precious metals from waste water conditions.
In the area of LIBs, we have recognized the potential of supramolecular chemistry as a general strategy for solving the capacity-fading problem associated with high energy density electrode materials such as Li-metal, silicon and sulfur, which offer extremely high battery capacity compared to conventional LIBs. Accordingly, we have demonstrated how molecular-level design of one- and two-dimensional supramolecular polymers can be directly translated into an improved electrochemical performance in high energy density LIBs.

These research directions provide an outstanding opportunity to my students to develop their skills in polymer, materials and electro- chemistry, enhanced by the experience of collaborating with scientists from other disciplines.



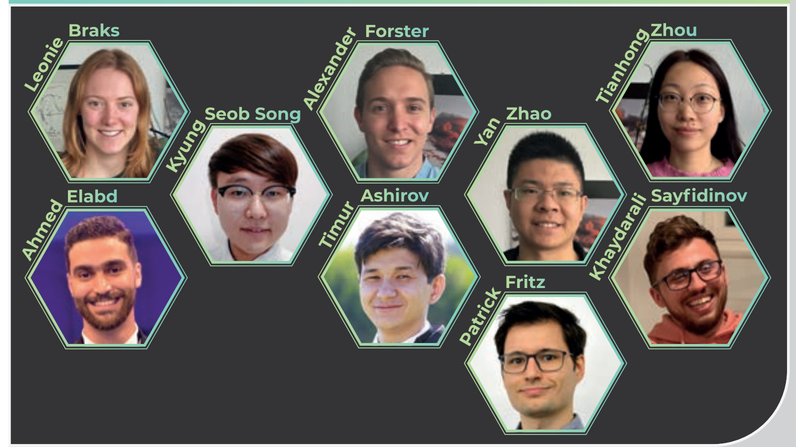





Overview of research activities in the Coskun Research Group ranging from $CO_2$ capture, storage, conversion to gas separation membranes to high energy density Li ion batteries.

# COSKUN

## Group




**Selected publications:**

**Ionic Liquid Functionalized Gel Polymer Electrolytes for Stable Lithium Metal Batteries**
Zhou, T.; Zhao, Y.; Choi, J.W.*; Coskun, A.*, Angew. Chem. Int. Ed., 2021, DOI:10.1002/anie.202106237.

**Ultrahigh Permeance Metal Coated Porous Graphene Membranes with Tunable Gas Selectivities**
Ashirov, T.; Coskun, A*, Chem, 2021, 7, 2385–2394.

**Three-dimensional Porous Organic Semiconductor Based on Fully sp2-Hybridized Graphitic Polymer**
Byun, Y.; Xie, L. S.; Fritz, P.; Ashirov, T.; Dincă, M.; Coskun, A.*, Angew. Chem. Int. Ed. 2020, 59, 15166–15170.

**Highly Elastic Binders Integrating Polyrotaxanes for Silicon Microparticle Anodes in Lithium Ion Batteries**
Choi, S.; Kwon, T.-w.; Coskun, A.*; Choi, J. W.*, Science, 2017, 357, 279.

**Direct Utilization of Elemental Sulfur in the Synthesis of Microporous Polymers for Natural Gas Sweetening**
Je, S. H.; Buyukcakir, O.; Kim, D.; Coskun, A. , Chem, 2016, 1, 482.

# Using nanoparticles to influence cells and cell mechanics

## Prof. Alke FINK

*There is a lot of stuff you can do with nanoparticles*

**Cellular behaviour is strongly dependent on the mechanical response of the substrate which has been shown to regulate important functions such as adhesion, migration and differentiation. The possibility to selectively control and direct cellular functions through materials selection, design and processing has huge value for e.g. improving patient health.**
**(Nano)particle surfaces offer a unique platform to study the interplay between cells and their physical environment.**

The adsorption of particles to surfaces introduces novel contextual cues which can potentially alter particle and surface biorecognition with consequences for cell mechanics.

In the last year and to understand how particle adsorption alters and defines nanobiointeractions, different bioactive particle surfaces were produced through electrostatically- mediated assembly. In general, we observe that under specific conditions, cells can remove these adsorbed particles in a manner akin to that of the famous robotic vacuum cleaner.

To highlight the contribution of mechanical properties to the capacity for cell-mediated clearance, poly(N-isopropylacrylamide) particles with differing stiffness were used to fabricate surface surfaces. Macrophages cultured on these particle surfaces showed a preference for stiffer particles. Particle recognition was noted to occur through reorganisation of adhesion complex proteins such as vinculin.
More complex particle bearing substrates are currently under investigation to examine the contribution of hierarchical topography to surface particle clearance. This work is funded through the NCCR for BioInspired Materials (51NF40-182881). All work is done in collaboration with my co-chair Prof. Barbara Rothen-Rutishauser and the Adolphe Merkle Institute (AMI) at the University of Fribourg.

Other main topics of the group evolve generally around engineered nanoparticles and include e.g. (1) the development of analytical methods to detect and quantify nanoparticles in complex media (such as consumer products, physiological fluids etc.), (2) nanoparticle dosimetry and (3) nanoplastics etc.





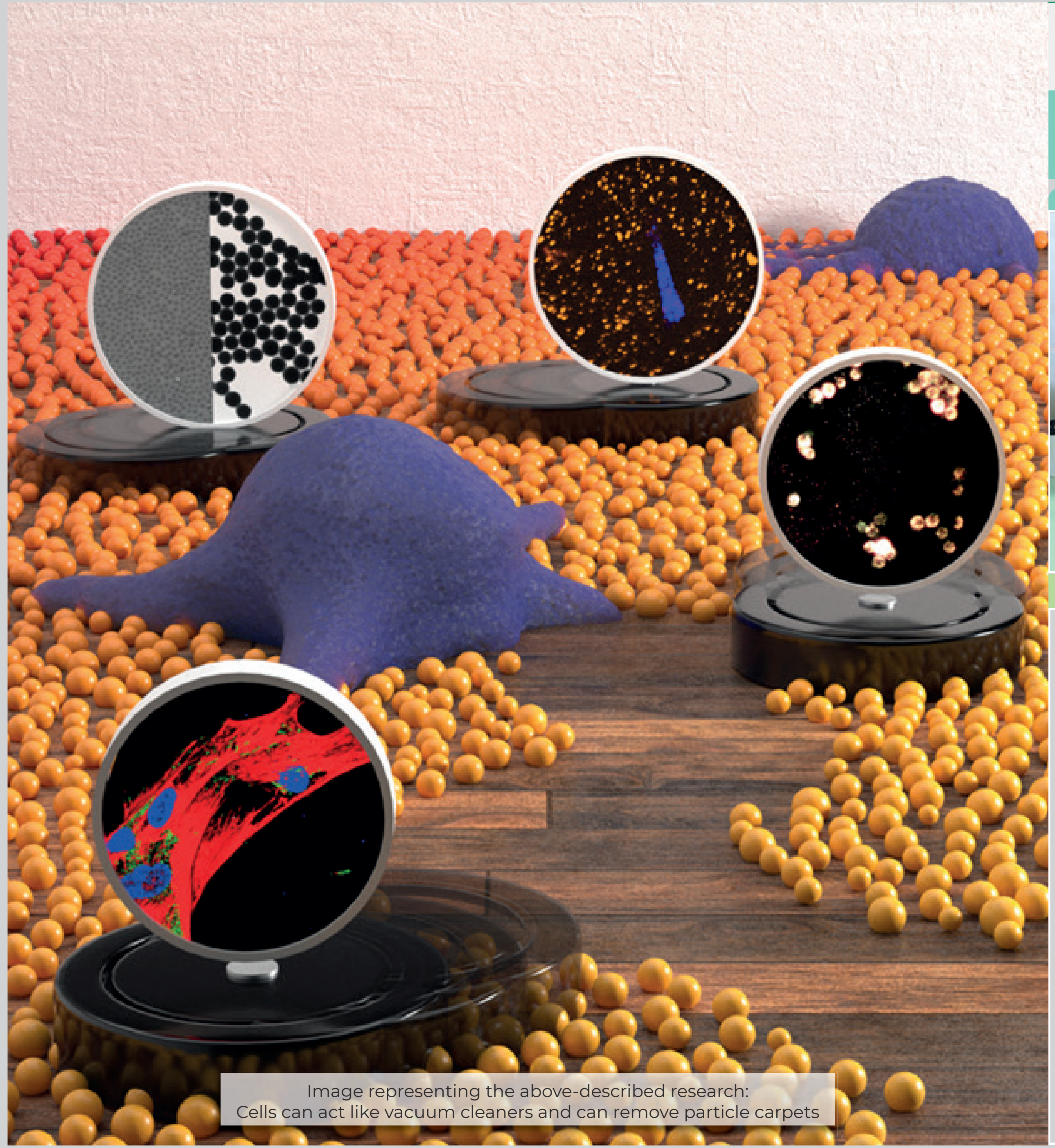



Image representing the above-described research:
Cells can act like vacuum cleaners and can remove particle carpets

# Fink

## Group


Prof. Fink currently has two affiliations, one in the Chemistry Department and the other one at the Adolphe Merkle Institute, where she co-chairs the BioNanomaterials group with Prof. Rothen-Rutishauser.

**Recent publications:**

**Nanoparticle colloidal stability in cell culture media and impact on cellular interactions.**
Moore TL, Rodriguez-Lorenzo L, Hirsch V, Balog S, Urban D, Jud C, Rothen-Rutishauser B, Lattuada M, Petri-Fink A. Chem Soc Rev. 44: 6287-305, 2015.

**Form follows function: nanoparticle shape and its implications for nanomedicine.** Kinnear C, Moore TL, Rodriguez-Lorenzo L, Rothen-Rutishauser B, Petri-Fink A. Chem Rev. 117: 11476-521, 2017.

**Impurities in polyvinylpyrrolidone: the key factor in the synthesis of gold nanostars**
Patricia Taladriz-Blanco, Miguel Spuch-Calvar, Anselmo del Prado, Christoph Weder, Barbara Rother-Rutishauser, Alke Petri-Fink, Laura Rodriguez-Lorenzo, Nanoscale Advances (2022)

**High-Throughput Manufacturing of Antibacterial Nanofibers by Melt Coextrusion and Post-Processing Surface-Initiated Atom Transfer Radical Polymerization**
Justin D. Hochberg, David M. Wirth, Giovanni Spiaggia, Pooja Shah, Barbara Rothen-Rutishauser, Alke Petri-Fink, Jonathan K. Pokorski
ACS Applied Polymer Materials (2021)

**The Choice of Nanoparticle Surface-Coupled Fluorescent Dyes Impacts Cellular Interaction**
Ana M. Milosevic, Laetitia Haeni, Liliane Ackermann Hirschi, Stefano Vanni, Pablo Campomanes-Ramos, Barbara Rothen-Rutishauser, Laura Rodriguez-Lorenzo, Alke Petri-Fink, ChemNanoMat (2021)

CHEMISTRY SPANNING FROM MEDICINE TO PHYSICS VIA BIOLOGY
FROM BASIC SCIENCE TO APPLICATIONS AND BACK

# Coordination chemistry and nanoparticles as tools for new materials

Prof. Katharina M FROMM

*Playing the keyboard of the periodic table*

**Cellular behaviour is strongly dependent on the mechanical response of the substrate which has been shown to regulate important functions such as adhesion, migration and differentiation. The possibility to selectively control and direct cellular functions through materials selection, design and processing has huge value for e.g. improving patient health.**
**(Nano)particle surfaces offer a unique platform to study the interplay between cells and their physical environment.**

For example, we designed nanoscale coatings based on silver coordination polymers (and silver nanoparticles) to protect implantable prostheses from bacterial adhesion and thus infection. Such compounds need to fulfil the requirements of being antimicrobial on one hand and biocompatible on the other. This can be achieved by tuning the ligands that act as "glue" between the silver ions. Using silver compounds as antimicrobials, fundamental questions pop up, such as how the silver acts as an antimicrobial, how it can be biocompatible for humans at the same time, and if bacteria can become resistant to it. In this respect, we study also the coordination of the silver to peptides and proteins. Our current research involves thus the binding of efflux pump proteins to silver ions and their interplay, as well as studies how certain bacteria, e.g. Geobacter sulfurreducens, are able to cope with silver ions by reducing them outside of the cell. Silver is not the only antimicrobial metal, and we therefore also study zinc, copper, bismuth or gallium compounds and nanoparticles in this very same context.

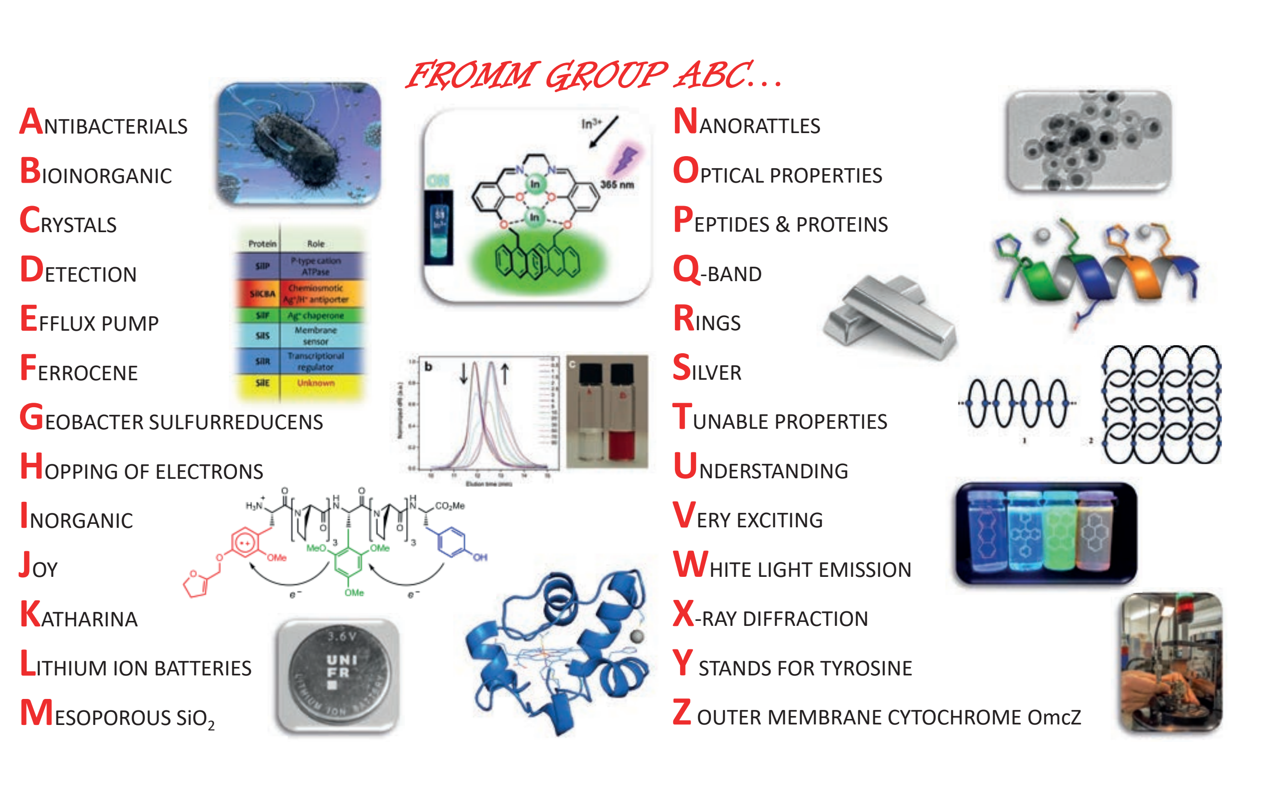
Another area of research concerns alkali and alkaline earth metal compounds in the context of batteries. We are particularly interested in superionic conductivity properties of their coordination compounds in order to use them e.g. as solid electrolytes, and in the possibility to use them as low-temperature precursors for the generation of nanoscale oxide materials for electrodes. The structural diversity of these coordination compounds is highly fascinating.

Structure-property relationships are at the heart of our interest when designing new coordination compounds and nanoparticles for sensing purposes – be it the optical sensing of the cork taste in wine or of toxic or explosive molecules in the environment. We use single crystal and powder x-ray diffraction, NMR, IR, UV-Vis, CD spectroscopy, mass spectrometry and electron microscopy to characterize all our materials.



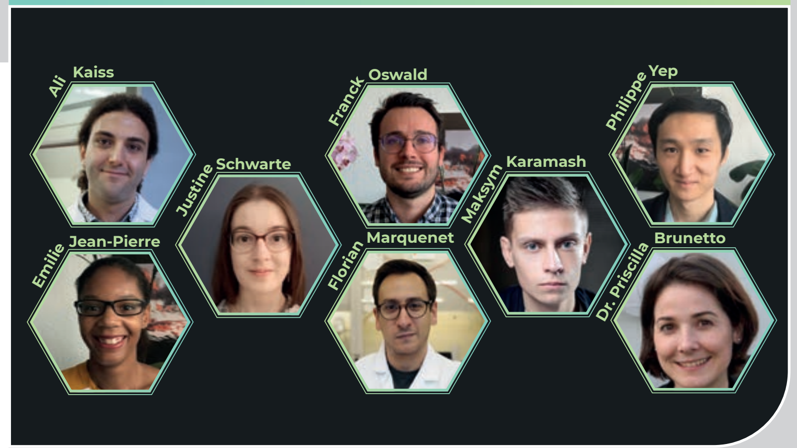
There is no limit for new compositions and applications on the keyboard of nature, and we are always open for new discoveries and ideas that take us beyond the known.








# Fromm Group




**Recent publications:**

**Kinetics and mechanism of mineral respiration: how iron hemes synchronize electron transfer rates**
V Chabert, L Babel, MP Füeg, M Karamash, ES Madivoli, N Herault, ...
Angewandte Chemie International Edition, 2020, 59 (30), 12331-12336

**Chemistry of alkaline earth metals: It is not all ionic and definitely not boring!**
KM Fromm
Coordination Chemistry Reviews, 2020, 408, 213193

**Silver-containing titanium dioxide nanocapsules for combating multidrug-resistant bacteria**
N Hérault, J Wagner, SL Abram, J Widmer, L Horvath, D Vanhecke, ...
International journal of nanomedicine 2020, 15, 1267

**Sequential Multiple-Target Sensor: In3+, Fe2+, and Fe3+ Discrimination by an Anthracene-Based Probe**
A Finelli, V Chabert, N Hérault, A Crochet, C Kim, KM Fromm
Inorganic chemistry, 2019, 58 (20), 13796-13806

**Alpha-helical folding of SilE models upon Ag (His)(Met) motif formation**
V Chabert, M Hologne, O Sénèque, O Walker, KM Fromm
Chemical Communications, 2018, 54 (74), 10419-10422

THE LABORATORY OF CATALYSIS AND ORGANIC SYNTHESIS

# Catalysis driven by visible-light and electricity

## Prof. Dmitry KATAYEV

*Sustainable molecular design*

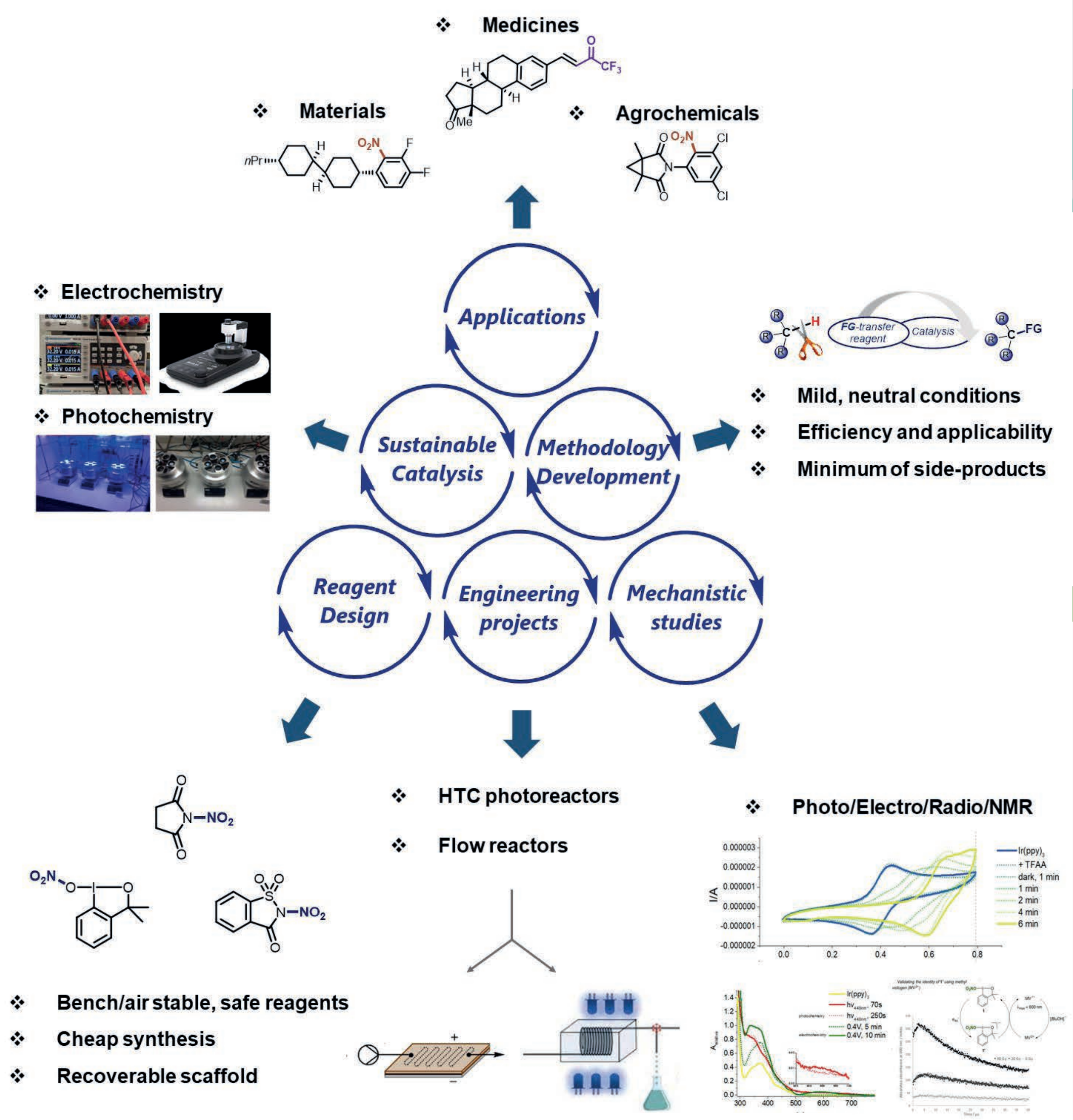
**Sustainable catalysis:** Katayev research group has a fundamental interest in developing innovative catalytic strategies, exemplified by photocatalysis, electrochemistry, synergistic, transition metal and organocatalysis, in order to overcome the major challenges of modern organic synthesis. A particularly focus is given on the development of light and electricity driven carbon-hydrogen (C–H) functionalization methodologies of substances, ranging from common feedstocks to complex molecules and materials. These span but are not limited to the formation of carbon-carbon (C–C), carbon-nitrogen (C–N), and carbon-oxygen (C–O) bonds, including asymmetric transformations.

**Reagent design:** Functional groups play a key role in the molecules of life, and their selective installation into the organic and inorganic frameworks at the late-stage of the synthesis represent a formidable challenge for scientists. On this line, our group works on the development of new classes of functional group transfer reagents (FGTRs) capable to enforce direct translation of the functionality to a molecule of diverse complexities. Often, these reagents are meant to be easy-accessible, shelf-stable, recyclable, and can be activated under various catalytic pathways.

**Applications:** The subsequent implementation of such methodologies in the synthesis of natural products, pharmaceutical agents and functional materials is one of the key goals of applied research in our laboratory. We are also engaged in detailed mechanistic investigations via physical organic chemistry tools and computational studies, as the understanding of novel catalytic methodologies will lay a foundation for further applications of these concepts, both in academia and industry.

**Engineering projects:** In addition to our synthetic work to develop new reagents and finding sustainable transformations, we are interested in lab-based engineering projects. We have designed and are constantly working on improving our reactors, as well as focused on developing high-throughput screening photo-and electro-chemical equipment. Furthermore, the design of photo and electro flow systems for the scalable synthesis of fine chemicals has also been undertaken by our research group.






From reaction development to applications:
key research directions which are implemented in the Katayev group



# Katayev Group


**Recent publications:**


**Radical Trifluoroacetylation of Alkenes Triggered by a Visible-Light-Promoted C–O Bond Fragmentation of Trifluoroacetic Anhydride**
K. Zhang, D. Rombach, N. Y. Nötel, G. Jeschke. D. Katayev, Angew. Chem. Int. Ed. 2021, 60, 22487–22495.

**Synthesis, Characterization, and Diverse Reactivity of a Hypervalent Iodine-Based Nitrooxylating Reagent**
R. Calvo, A. Teillier, T. Nauser, D. Rombach, D. Nater, D. Katayev, Angew. Chem. Int. Ed. 2020, 21, 17162–17168; Angew. Chem. 2020, 132, 17312–17319.

**Taming Radical Intermediates for the Construction of Enantioenriched Trifluoromethylated Quaternary Carbon Centers**
R. Calvo, A. Comas-Vivas, A. Togni, D. Katayev Angew. Chem. Int. Ed. 2019, 58, 1447–1452.

**Facile Access to Nitro(hetero)arenes Using N-Nitrosacchrain: An Electrophilic and Shelf-Stable Nitrating Reagent**
R. Calvo, K. Zhang, A. Passera, D. Katayev Nat. Commun., 2019, 10 : 3410.

**Synthetic Diversity form a Versatile and Radical Nitrating Reagent**
K. Zhang, B. Jelier, A. Passera, G. Jeschke, D. Katayev, Chem. Eur. J. 2019, 25, 12929-12939.

POLYMER CHEMISTRY

# New mechanisms for the synthesis of highly defined polymers

## Prof. Andreas KILBINGER

*So long, and thanks for all the fish*

**The Kilbinger Group is mainly involved in the preparation of polymers. Polymers are long, typically linear, molecules consisting mostly of one but sometimes also of several different repeating units. Polymers have become an indispensable part of our everyday life. They perform a multitude of very different tasks, whereby most polymers have a rather banal function, namely that of filling space with mass. However, some polymers also have very demanding tasks to perform, e.g. by protecting drugs from breaking down too quickly in the body or from undesired immune responses. Others can change their properties depending on external influences such as temperature or light. In such highly specialised polymers, it is often important to have a large degree of control over the length, the sequence of repeating units or the chemical structure of the chain ends during synthesis. This requires a very detailed understanding of the polymerisation mechanisms. Only with such knowledge can new polymerisation methods be found or even better defined polymers be produced.**

The Kilbinger group is working on the development of such polymerisation mechanisms in relation to two very different groups of polymers. On the one hand, we are developing new polymerisation methods in the field of ruthenium carbene complex catalysed olefin metathesis polymerisation. On the other hand, new processes are being investigated that make it possible to incorporate step-growth polymers such as Kevlar in a defined way into other polymers or to produce tube-like polymers with antimicrobial properties.Other main topics of the group evolve generally around engineered nanoparticles and include e.g. (1) the development of analytical methods to detect and quantify nanoparticles in complex media (such as consumer products, physiological fluids etc.), (2) nanoparticle dosimetry and (3) nanoplastics etc.

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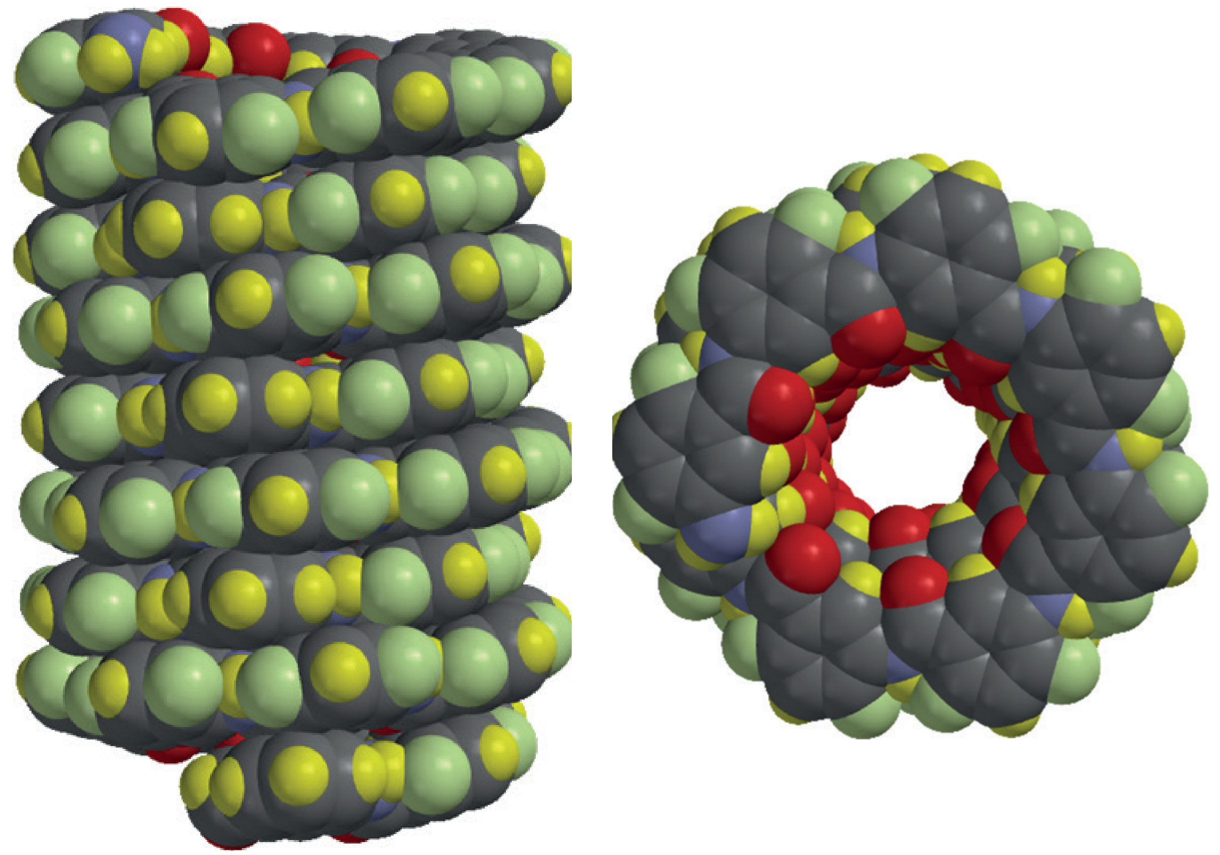
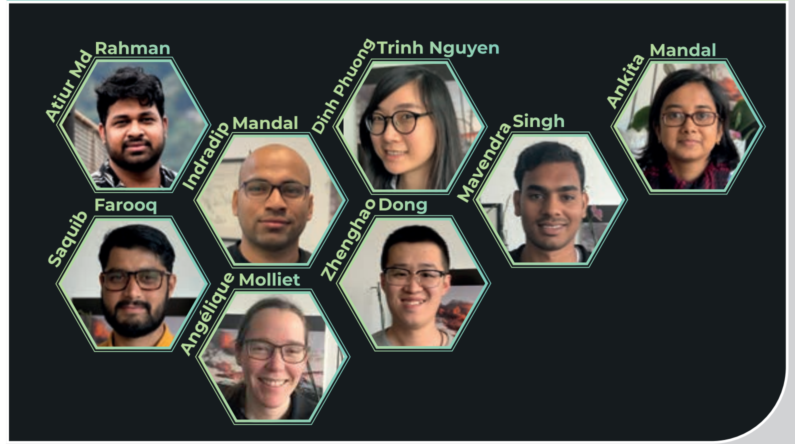
# Kilbinger Group



Model of a tube-like polymer as described above




**Recent publications:**

**A versatile living polymerization method for aromatic amides.**
Pal,S.; Nguyen,D.P.T.; Molliet, A.; Alizadeh, M.; Crochet, A.; Ortuso, R.D:; Petri-Fink, A.; Kilbinger, A.F.M. Nat. Chem. 2021, 13, 705

**One-Step Living Ring Opening Metathesis Block Copolymers.**
Yasir, M.; Liu, P.; Markwart, K.; Wurm, F.; Smart, J.; Lattuada, M.; Kilbinger, A.F.M. Angew. Chem. 2020, 59, 13597

**Catalytic living ring-opening metathesis polymerization with Grubbs' second- and third-generation catalysts.**
Yasir, M.; Liu, P.; Tennie, I.; Kilbinger, A.F.M. Nat. Chem. 2019, 11, 488

**Functional Metathesis Catalyst Through Ring Closing Enyne Metathesis: One Pot Protocol for Living Hetero-telechelic Polymers.**
Pal, S.; Lucarini, F.; Ruggi, A.; Kilbinger A.F.M. J. Am. Chem. Soc. 2018, 140, 3181

**Heterotelechelic Polymers by Ring-Opening Metathesis and Regioselective Chain Transfer.**
Liu, P.; Yasir, M.; Ruggi, A.; Kilbinger, A.F.M. Angew. Chem. 2018, 57, 914

COLLOIDAL PHYSICAL CHEMISTRY

# Exploiting nanoparticles self-assembly to create new materials

## Prof. Marco LATTUADA

*We design nanoparticles and use them as "Lego bricks" to create complex materials*

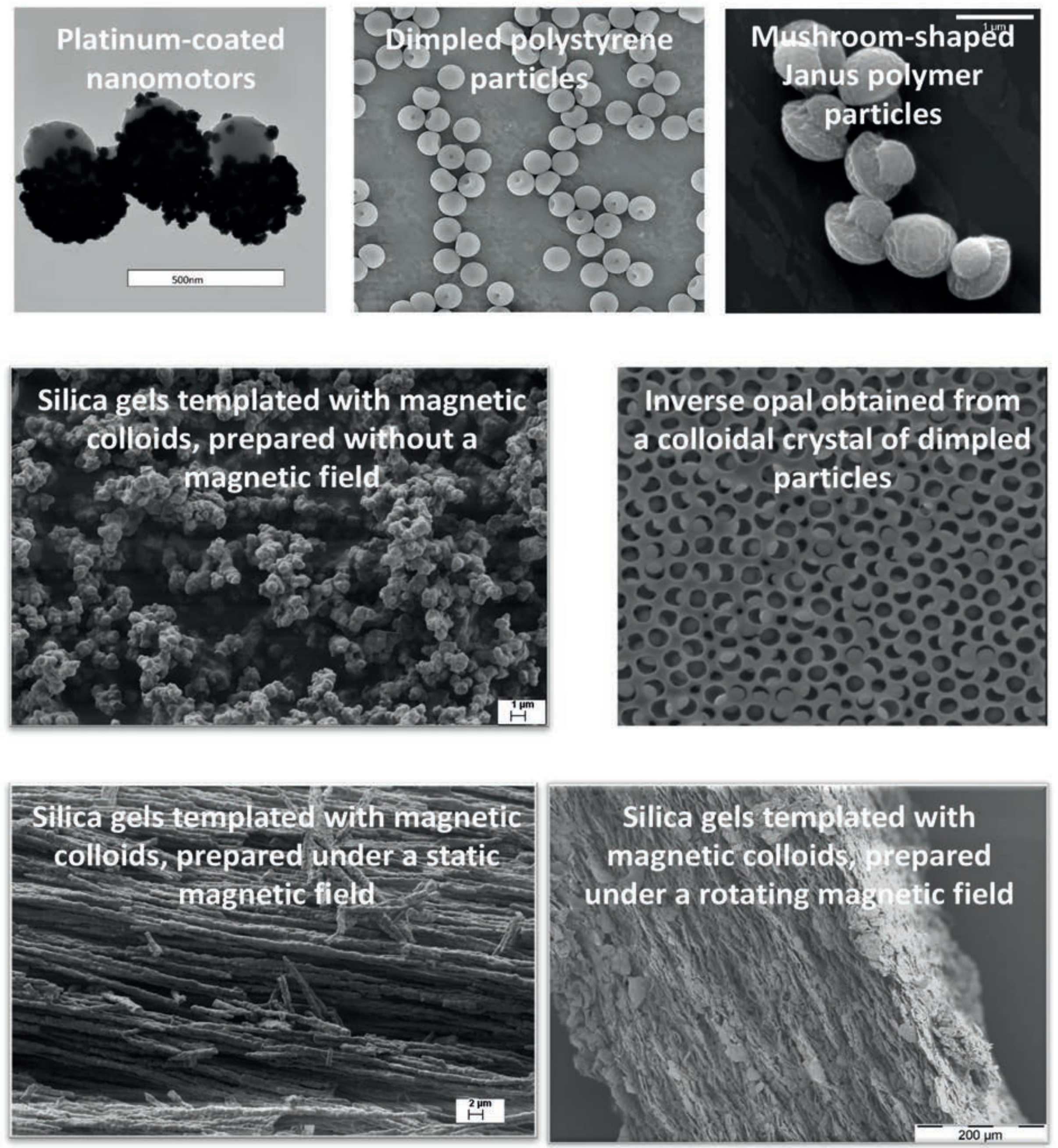
**Many futuristic science fiction novels and movies have fantasized about nanomachines capable of extraordinary feats. Over a few billion years, nature has instead developed real nanomachines with highly advanced capabilities: proteins. Proteins can perform incredible feats, such as self-organize into highly complex structures. Some material scientists try to imitate protein self-assembly using nanoparticles, in order to extend what nature does with a few chemical elements of the periodic table to a much wider variety of substances. The main objective of our work is to design new (nano)particles and understand how their interactions can be tuned to control their self-organization.**

One flexible method to control the organization of nanoparticles is to use magnetic fields. Magnetic nanoparticles can respond to external magnetic fields, and form complex structures. For example, they organize into chains in the presence of a static field, but can self-assemble into layered structures when exposed to a rotating field. We have taken advantage of magnetic particles to template both organic and inorganic materials, and have manipulated the materials structure with magnetic field, without altering their chemical composition to control their mechanical properties and porosity.

A second research direction of our group is the design of complex particles. Most common nano- and submicron-particles have a spherical shape, to minimize their interfacial energy. However, non-spherical and asymmetric particles are far more interesting for self-assembly purposes, because they mimic proteins, which are usually far from been spherical and isotropic. We developed various methods to prepare particles with multiple faces and multiple lobes, with controlled cavities, and with asymmetric functionalization patterns. Self-propelling particles, particle-based surfactants and multifunctional particles are among the target of our work. A third research direction aims at creating materials with structural coloration. Structural colors are ubiquitous in natural systems, and have many advantages over systems relying on dyes, such as non-fading colors and the possibility to tune the color by simply controlling the size of the basic structural elements. Arranging spherical particles into colloidal crystals is one manner to achieve this goal. However, nature shows that some degree of disordering is always present. We therefore use our ability to manipulate particle shape to create crystals with a controlled degree of disorder.

Finally, we use simulations techniques to achieve a better understanding of the behavior of particles. Computational methods are useful to explore in-silico the behavior or particles, to unravel the effect of interactions and access information difficult to retrieve experimentally. Our final objective is to bring theory and experiments together, in order to fully exploit the power of self-assembly as a rational strategy to design new materials.




Model of a tube-like polymer as described above

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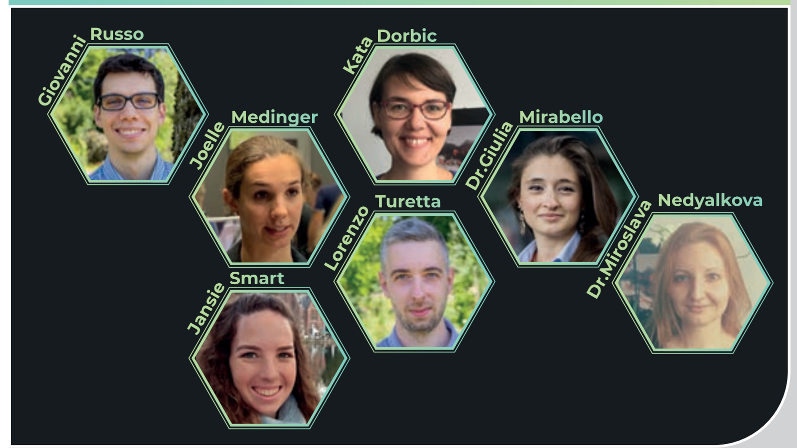
# Lattuada Group




**Recent publications:**


**Preparation and Machine-Learning Methods of Nacre-like Composites from the Self-Assembly of Magnetic Colloids Exposed to Rotating Magnetic Fields**
Joelle Medinger, Miroslava Nedyalkova, Marco Furlan, Thomas Lüthi, Jürgen Hofmann, Antonia Neels, Marco Lattuada, ACS Applied Materials & Interfaces, 2021

**Multiresponsive Photonic Microspheres Formed by Hierarchical Assembly of Colloidal Nanogels for Colorimetric Sensors**
Golnaz Isapour, Marco Lattuada, ACS Applied Nano Materials, 4, 3389-3396 (2021)

**Solvothermal Synthesis Combined with Design of Experiments—Optimization Approach for Magnetite Nanocrystal Clusters**
Joelle Medinger, Miroslava Nedyalkova, Marco Lattuada, Nanomaterials, 11, 360 (2021)

**Protein Amyloid Fibrils as Template for the Synthesis of Silica Nanofibers, and Their Use to Prepare Superhydrophobic, Lotus-Like Surfaces**
Simonetta Rima, Marco Lattuada, Small 14 (46), 1802854 (2018)

**Bioinspired stimuli-responsive color-changing systems**
Golnaz Isapour, Marco Lattuada, Advanced Materials 30 (19), 1707069 (2018)

BIOCOLLOIDS

# Physical Chemistry for Food and Health Applications

## Prof. Stefan SALENTINIG

*Food goes nano: the future of health materials*

**The research in our group focuses on the development of nature-inspired nanomaterials for food- and health applications. We are highly active in student training and teaching to transfer our knowledge to the next generation of scientists. Our approach is highly multidisciplinary and at the interface of fundamental and applied science. The team combines knowledge in fields including (bio)physical chemistry, colloid and interface chemistry, polymer chemistry, and biochemistry to design bioinspired materials for interactions on a molecular, structural and cellular level.**

We study nature's own functional materials such as milk and its interactions with the digestive tract to get inspired and guided by design strategies that have been optimized by evolution over millions of years. Ultimately, we envision the rational design of novel multi-functional materials with broad impact in the food and health sectors. These rational approaches provide a competitive advantage over current, mostly empirical methods.

The growing global demand for antimicrobial (antiviral, antibacterial, antifungal) materials triggered a plethora of research activities to develop functional, self-disinfecting surfaces and antimicrobial nanomaterials in our team. Among the most promising strategies are antimicrobial polymer-brush and nanopatterned liquid crystalline surfaces as well as antimicrobial peptide-based nanomaterials as alternative to current antibiotics.

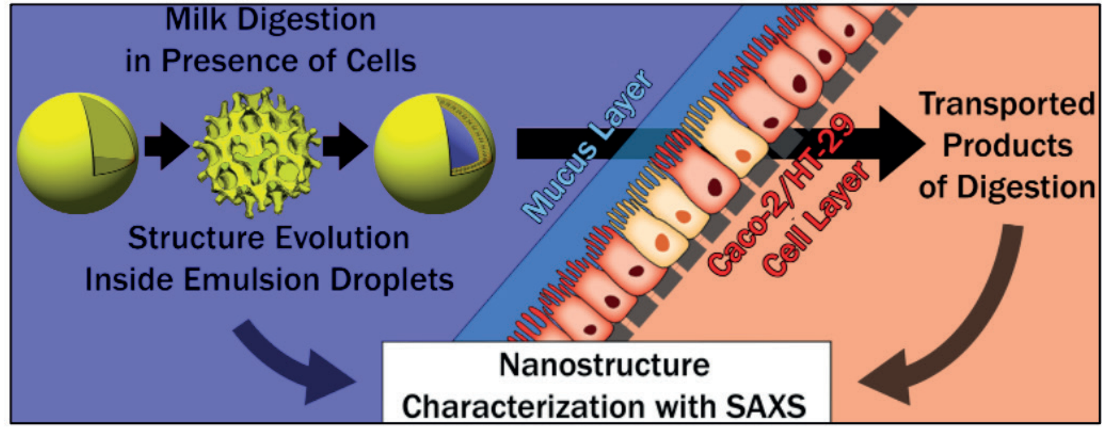
The group pursues research interests that include (directed) self-assembly and disassembly processes for the bottom-up creation of new supramolecular food and drug delivery materials, and adaptive, programmable bio-nanointerfaces. We are highly active in surface design through chemical functionalization, emulsion and dispersion design. We apply approaches from colloid and interface science to the design of biomimetic materials and focus on unravelling their composition – nanostructure - activity relationship with a combination of biophysical and in vitro biological investigations.

Our key experimental methods for the material design and the characterization of structures, composition and interactions on multiple levels include state-of-the-art in-situ and in-operando techniques in the laboratory and at synchrotrons. We are also active in adapting and optimizing experimental techniques and numerical analysis methods to answer our research questions. Examples include in-situ small angle scattering of X-rays and neutrons coupled with an in-vitro digestion model and multi-angle light scattering to study size, shape and dynamics in nanomaterials.

In addition to our strong research output in 2021, we successfully started a range of new collaborative projects, some with industry partners that are key players in the field of food and antimicrobials. We generated outreach by contributing to media panels and conferences, and several of our studies were highlighted in the media and flagged-up by other institutions for a broad audience.

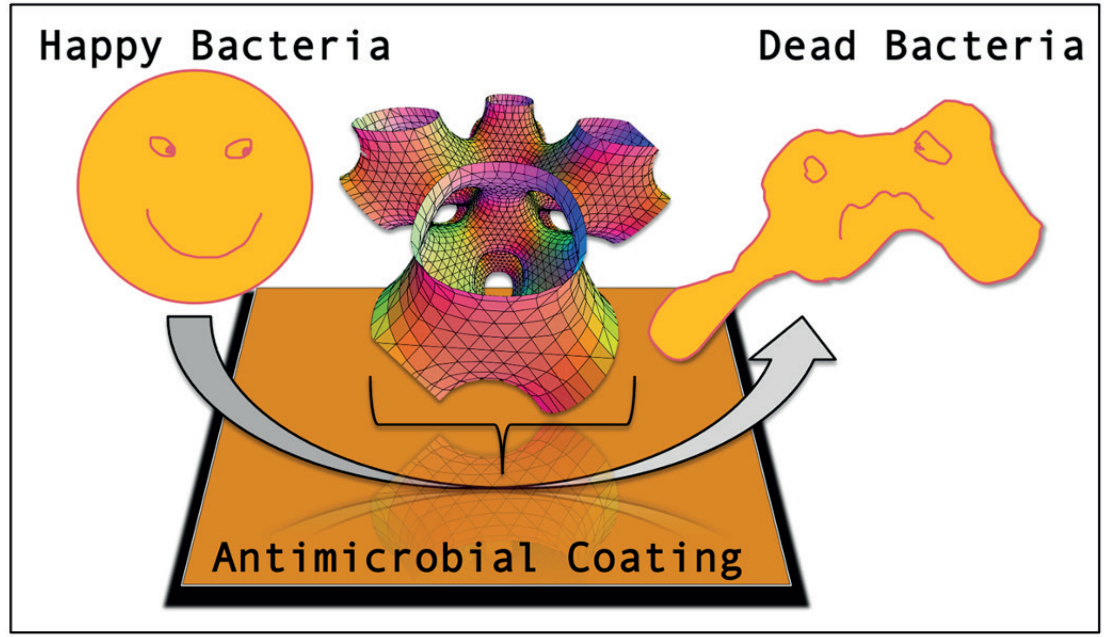



### 1. Watching Food Digestion In Situ




*Journal of Colloid and Interface Science*, **2020**, 574, 430-440

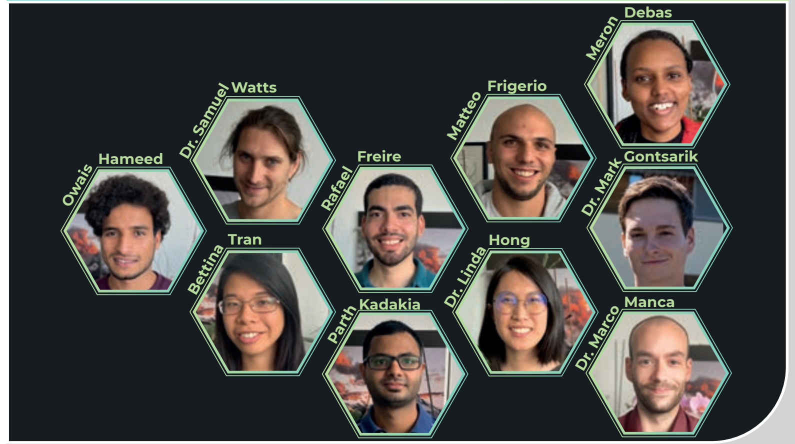
### 2. Nano-Engineering Antimicrobial Surfaces




*ACS Applied Biomaterials*, **2021**, *6*, 5295–5303

UNIVERSITY OF FRIBOURG | DEPARTMENT OF CHEMISTRY | 2020-2021

## Salentinig Group




**Recent publications:**


**Human Antimicrobial Peptide Triggered Colloidal Transformations in Bacteria Membrane Lipopolysaccharides.**
Hong L., Gontsarik M., Amenitsch H., Salentinig S.. Small, 2021, in press, https://doi.org/10.1002/smll.202104211

**Ethanol Inactivation of Enveloped Viruses: Structural and Surface Chemistry Insights into Phi6.**
Watts S., Ramstedt M., Salentinig S. Journal of Physical Chemistry Letters, 2021, 12, 39, 9557–9563

**Bio-Inspired Antimicrobial Coatings from Peptide-Functionalised Liquid Crystalline Nanostructures.**
Zabara M., Qun R., Amenitsch H., Salentinig S. ACS Applied Biomaterials, 2021, 6, 5295–5303.

**Protein Nanocage-Stabilized Pickering Emulsions.**
Lim S., Salentinig S. Current Opinion in Colloid & Interface Science, 2021, 101485.

**PH-Responsive Aminolipid Nanocarriers for Antimicrobial Peptide Delivery.**
Gontsarik M., Mansour A.; Hong L., Sicairos M.G., Salentinig S. , Journal of Colloid and Interface Science 2021, 603, 398-407

INORGANIC MEDICINAL CHEMISTRY

# Rare metal chemistry to the discovery of new pharmaceutical agents

## Prof. Fabio ZOBI

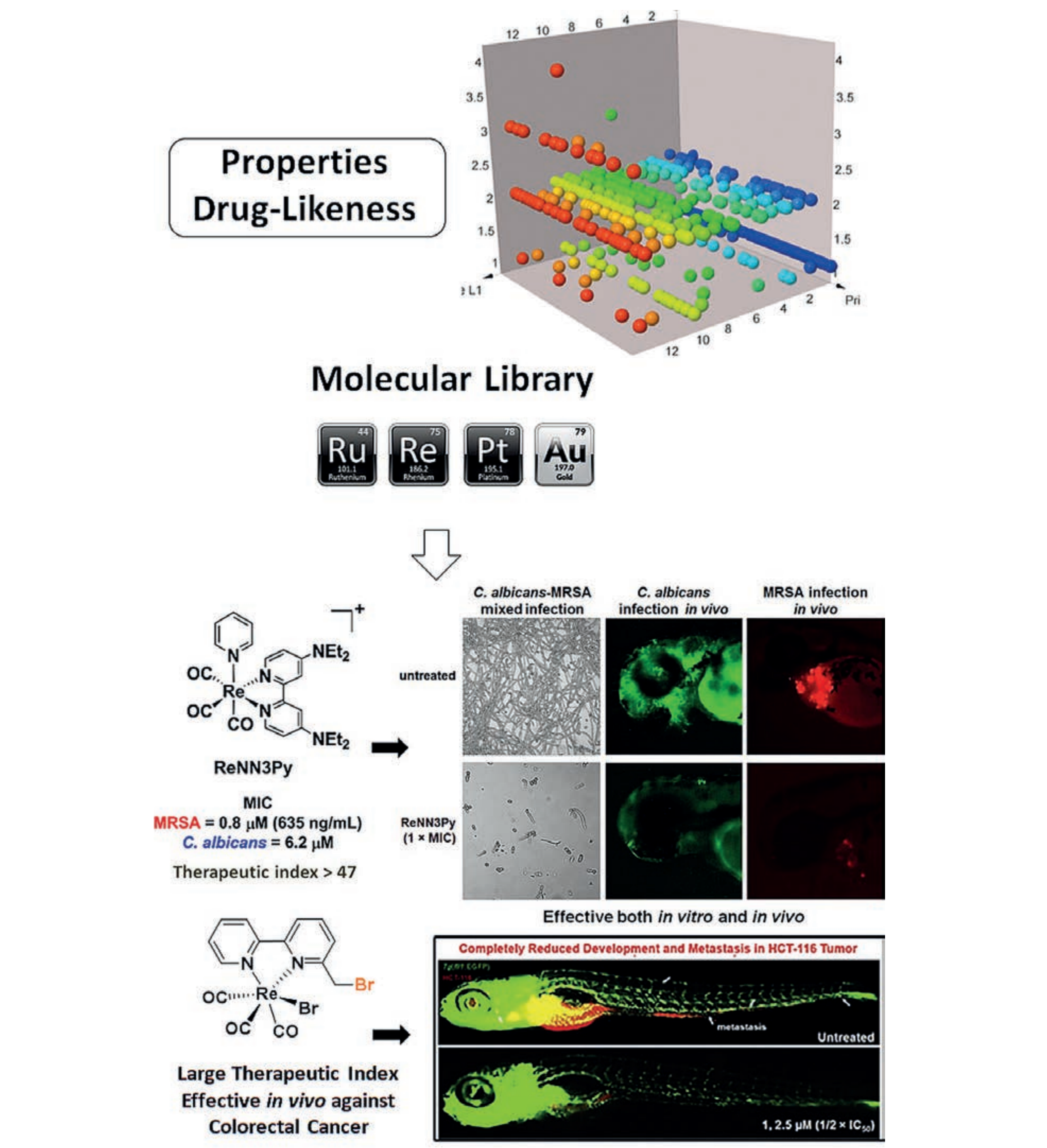
*In metallis raris solutiones unicae ad medicinam*

Medicinal chemistry is discipline at the intersection of chemistry and pharmacology and other biological specialties, aiming at the design, chemical synthesis and development of pharmaceutical agents, or bio-active molecules. Inorganic chemistry is the science dedicated to the preparation of metal-based substances in the laboratory. Thus, inorganic medicinal chemistry is a discipline dedicated to the preparation and study of metal-based molecules of pharmacological interest. Our group's interest and aim is to develop new chemistry of rare metal ions and consequently discover new molecules and reactivity of the same for medicinal applications. We focus in particular on the preparation of anticancer and antimicrobial agents and carbon monoxide releasing molecules as both cytotoxic and cytoprotective molecules. We devote particular attention to colorectal carcinoma (CRC) and methicillin-resistant Staphylococcus aureus and Candida infections. In parallel to these studies, we are also interested in the design and preparation of natural bio-carriers as delivery agents of our metal-based drugs. In particular, we use environmentally friendly, abundant and safe microalgae in their diatom form as delivery capsules for inorganic and organometallic antitumor agents. Tumour specificity of these materials is realised via functionalization of their surface with vitamin B12.
(Nano)particle surfaces offer a unique platform to study the interplay between cells and their physical environment.

In light of the cancer burden worldwide (18.1 million new cases and 9.6 million cancer deaths in 2018) and the concurrent emerging threats of antimicrobial resistance and invasive fungal infection, our line of research falls within the WHO recommendations of new solutions outside the traditional development pathway, with emphasis on new active compounds with non-classical mechanisms of action. To be able to reach our long-term goals of finding viable solutions for the above-mentioned pathologies, we approach the problem from both an academic and practical side: a) academically we develop new reactions to access unusual structures and properties of the metal complexes. b) from a more practical side, our group has established a long-term collaboration with the Institute of Molecular Genetics and Genetic Engineering of the University of Belgrade where the new substances we prepare are tested in vivo on clinical isolates derived from patients currently under hospital care.

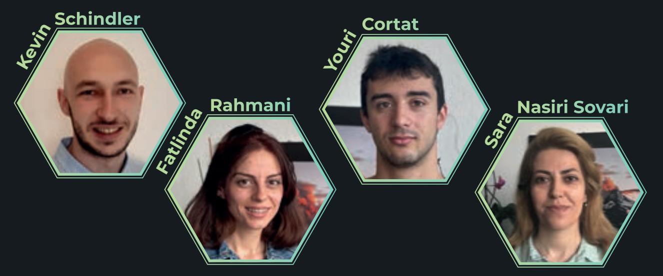







# Zobi

## Group




**Recent publications:**


**Combatting AMR: A molecular approach to the discovery of potent and non-toxic rhenium complexes active against C. albicans-MRSA co-infection.**
1.S. Nasiri Sovari, N. Radakovic, P. Roch, A. Crochet, A. Pavic, F. Zobi; Eur. J. Med. Chem., 2021, 226,113858.

**Identification of novel potent and non-toxic anticancer, anti-angiogenic and antimetastatic rhenium complexes against colorectal carcinoma.**
J. Delasoie, A. Pavic, N. Voutier, S. Vojnovic, A. Crochet, J. Nikodinovic-Runic, F. Zobi; Eur. J. Med. Chem., 2020, 204,112583.

**Design, synthesis and in vivo evaluation of 3-arylcoumarin derivatives of rhenium(I) tricarbonyl complexes as potent antibacterial agents against methicillin-resistant Staphylococcus aureus (MRSA).**
S. Nasiri Sovari, S. Vojnovic, S. S. Bogojevic, A. Crochet, A. Pavic, J. Nikodinovic-Runic, F. Zobi. Eur. J. Med. Chem., 2020, 205,112533.

**Photoactivatable Surface-Functionalized Diatom Microalgae for Colorectal Cancer Targeted Delivery and Enhanced Cytotoxicity of Anticancer Complexes.**
J. Delasoie, P. Schiel, S. Vojnovic, J. Nikodinovic-Runic, F. Zobi. Pharmaceutics, 2020, 12, 480.

**Natural Diatom Biosilica as Microshuttles in Drug Delivery Systems.**
J. Delasoie, F. Zobi. Pharmaceutics, 2019, 11, 537.

ARTIFICIAL PHOTOSYNTHESIS

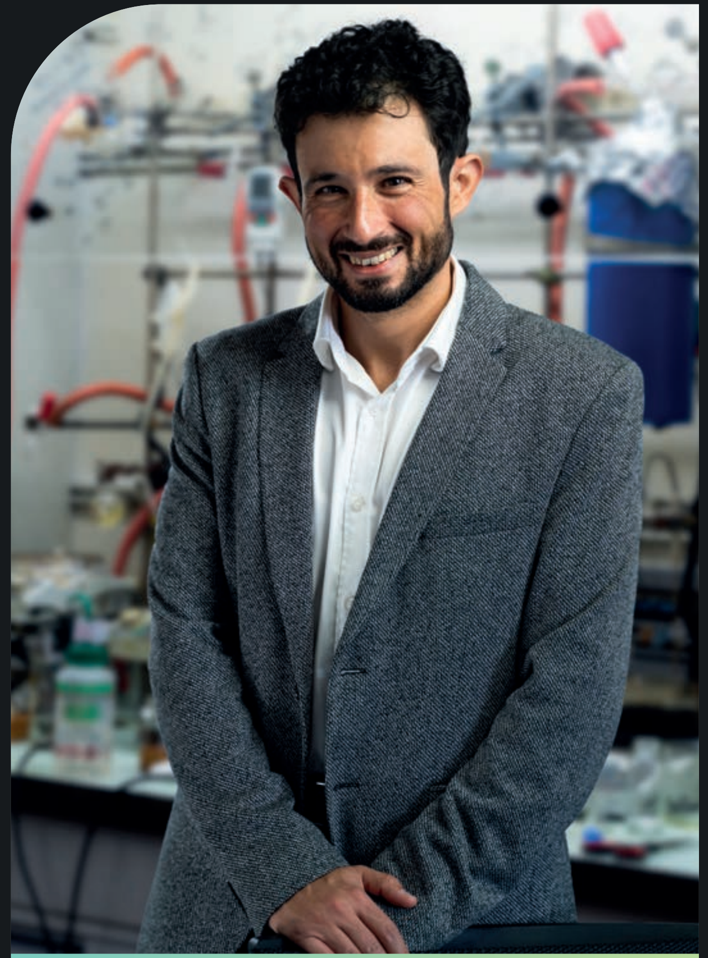
# Making solar fuels: water splitting and beyond

## Dr. Albert RUGGI

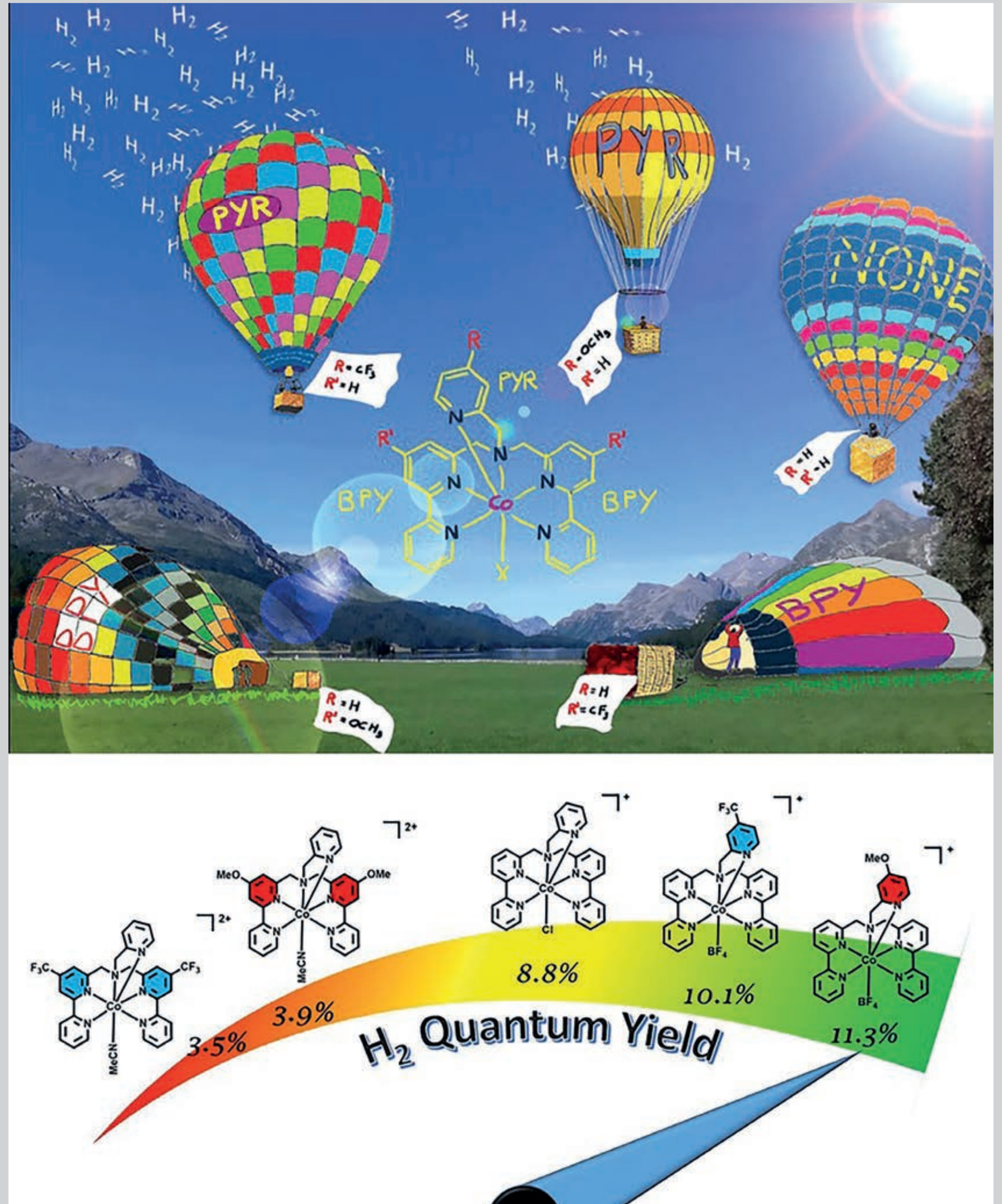
*Clean energy from a glass of water!*

**Hydrogen is one of the best candidates to replace traditional fuels: it has a high energy density and its combustion product (water) is environmentally friendly. Although molecular hydrogen is very scarce on the Earth, hydrogen is widely present in several compounds, like water Unfortunately, making hydrogen from water is a very challenging task, which requires a big amount of energy. Luckily, there is a form of energy that is virtually infinite, widely available and we can get it for free: sunlight! In Nature, plants use sunlight as a source of energy to make their own "fuels" (carbohydrates and other highly energetic molecules) in the well-known process of photosynthesis. The field of "artificial photosynthesis" aims at mimicking this process obtaining molecular hydrogen starting from water and sunlight. Three components are needed to realize artificial photosynthesis: a molecule capable of harvesting sunlight (sensitizer) and two molecules capable of producing hydrogen and oxygen (reduction and oxidation catalysts, respectively).**

Our current work is focused on the development of efficient catalysts for hydrogen production. In our research, we decided to avoid the use of rare and expensive elements like platinum or palladium, and we adopted a strategy based on earth-abundant metals like cobalt. We have recently developed a series of new catalysts with an exotic structure, which is associated with remarkably high activity towards light-triggered hydrogen production. We are not only synthesizing these catalysts but also investigating in detail their mechanism together with our collaborators. In this way, we learn how to design new species with optimized performances.
The investigation of the mechanism is a crucial step of our research: for example, we found out that, during the catalysis, one of the ligands is partly detached from the metal and it is protonated. In a second step, this proton is transferred back to the metal to form molecular hydrogen. The nature of the detached unit is of paramount importance: according to the ligand detached, the efficiency in hydrogen evolution can increase or decrease up to a factor of four. Remarkably, we can induce a specific detachment by introducing some groups in specific positions. Contrarily to what is commonly observed in other chemical systems, we have recently proved that the position where the group is located plays a major role, whilst the chemical nature of the group is of secondary importance. These findings will enable us and the other researchers working in this field to develop more active catalysts. We are now working also on the optimization of the other components: oxidation catalysts and sensitizers. Stay tuned!








A series of Co(II) catalysts capable of making hydrogen under the action of light.
The efficiency of the catalysts can be tuned by introducing substituents on suitable positions.



# Ruggi Group


**Recent publications:**

**Ratinalizing Photo-triggered hydrogen evolution using polypyridine cobalt complexes: substituent effects on hexadentate chelating ligands**
F. Lucarini, D. Bongni, P. Schiel, G. Bevini, E. Benazzi, E. Solari, F. Fadaei-Tirani, R. Scopelliti, M. Marazzi, M. Natali, M. Pastore, A. Ruggi, ChemSusChem, 2021, 14, 1874-1885.

**Insights into the mechanism of photosynthetic H2 evolution catalysed by a heptacoordinate cobalt complex,** F. Lucarini, J. Fize, A. Morozan, M. Marazzi, M. Natali, M. Pastore, V. Artero, A. Ruggi, Sustainable Energy and Fuels 2020, 4, 589-599.

**Synthesis of tetraarylethene luminogens by C-H vinylation of aromatic compounds with triazenes**
A. A. Suleymanov, M. Doll, A. Ruggi, R. Scopelliti, F. Fadaei-Tirani, K. Severin, Angewandte Chemie International Edition 2020, 132 (25), 10043-10047.

**Fluorescent label-free aptasensor integrated in a lab-on-chip system for the detection of ochratoxin a in beer and wheat**
F. Costantini, N. Lovecchio, A. Ruggi, C. Manetti, A. Nascetti, M. Reverberi, G. de Cesare, D.Caputo, ACS Applied Bio Materials, 2019, 2 (12), 5880-5887.

**Heptacoordinate Co(II) complex:**
**a new architecture for photochemical hydrogen production**
F. Lucarini, M. Pastore, S. Vasylevskyi, M. Varisco, E. Solari, A. Crochet, K. M. Fromm, F. Zobi, A. Rugg, Chemistry-A European Journal, 2017, 23, 6768-6771.






# Our Team

## Here are our competent and strong team members making our "chemistry" real.

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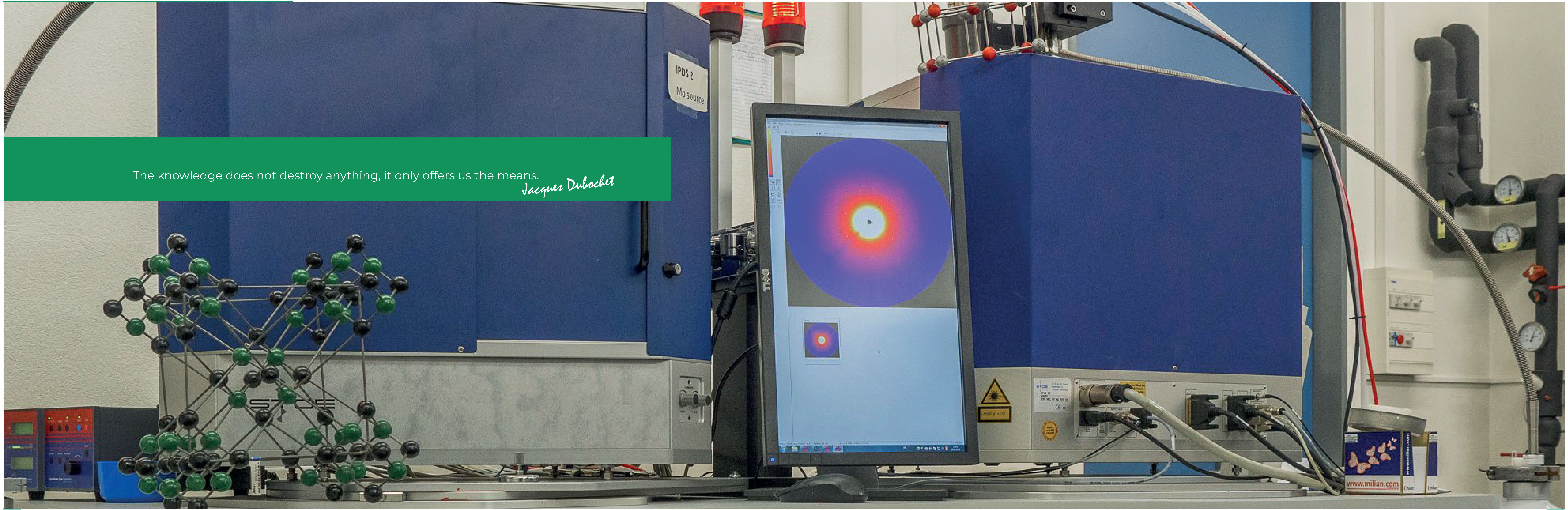
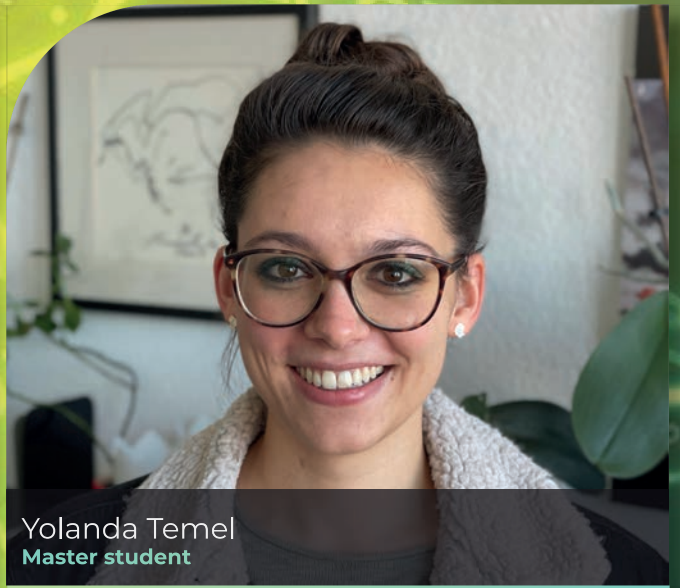
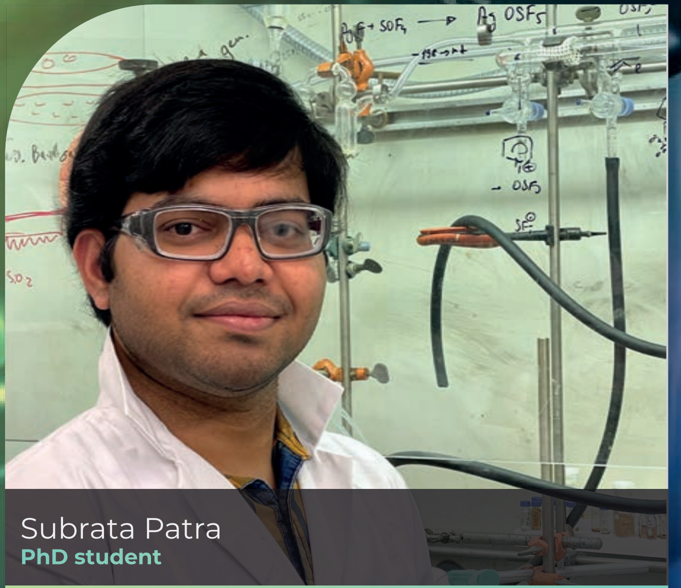



The knowledge does not destroy anything, it only offers us the means.
*Jacques Dubochet*

Luca Condrau
**Bachelor student**



Yolanda Temel
**Master student**



Subrata Patra
**PhD student**

Fasciné depuis petit par le monde et les phénomènes qui m'entouraient, ces intérêts n'ont fait qu'augmenter au fur et à mesure des années. C'est pourquoi, les matières scientifiques m'ont toujours attiré, elles m'aidaient à en apprendre un peu plus sur les lois qui régissent le monde.

Je pense que l'étude de la chimie nous offre la possibilité de répondre à la plupart de ces questions fondamentales et joue un rôle dans la vie de chacun en touchant d'une manière ou d'une autre presque tous les aspects de notre existence.

Mon choix pour l'université de Fribourg s'est porté sur la proximité et la possibilité d'effectuer un Bachelor en Chimie tout en ayant ce réel contact avec certain.e.s professeur.e.s, doctorant.e.s et membres de l'université.

Mon parcours au sein de la faculté m'a donné l'opportunité de créer mon propre cursus d'études en combinant des branches à choix, comme le suivi de la branche complémentaire « chimie industrielle » à l'école d'ingénieur située sur le même campus. De plus, le département de chimie possède un large éventail de groupe de recherches dans les différents domaines de la chimie, ce qui permet à chacun de trouver sa voie et ouvre plusieurs portes pour de bonnes perspectives académiques ou industrielles.

Chemistry can be found everywhere in our daily lives, whether in medicines, food or cosmetics for example, but unfortunately also in pollution. It is for this last reason that I personally chose to study chemistry.

In my opinion, studying at the Department of Chemistry at the University of Fribourg has many advantages. Indeed, as the Department is quite small, we have the chance to have a good relationship with the other students as well as with the Professors, which is very important, as we can turn to them in any situation.

Furthermore, throughout the studies, but especially in the Master's program, practical work in the laboratory has an important place in the curriculum beside the lectures. After completing the experiments based on learning different methodologies, we end up having our own projects to work on.

In general, the different research groups of the Department focus on multiple aspects of materials chemistry. So, even within this small Department here in Fribourg, a wide range of chemistry topics can be studied in a familiar environment.

Chemistry is everywhere and known as central science as it connects physical sciences with applied sciences. Organic chemistry studies structure and properties of organic molecules, which are present in foods, pesticides, fungicides, dyes, drugs, fuels, plastics and many more. While we use chemicals in our day to day life, cooking these molecules in lab is the most interesting part for me.

I decided to learn more about photo-electrochemistry and apply this powerful tool to functionalize organic molecules in a more sustainable way. The University of Fribourg gave me the opportunity to work on selective functionalization of (un)activated hydrocarbons using photo-electrochemical strategies in Fribourg.

So far, this doctoral journey at this department has benefited me to learn and develop multi-disciplinary research systems as well as improve communication skills. Despite the small size of the chemistry department, it includes a diversified field of research with cutting edge research facilities. The friendly environment in this department is great advantage for students to interact with fellow researchers and professors to discuss ideas and to collaborate with them.

Moreover, synthetic organic chemistry helps to improve cooking skills.

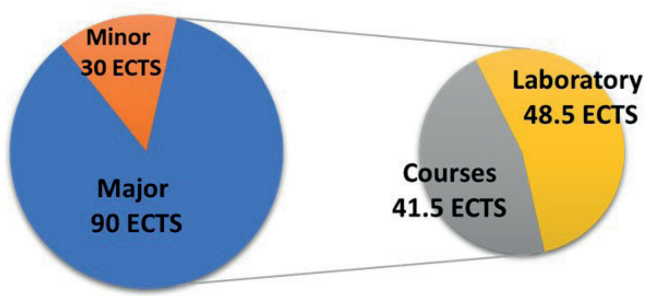




# Study Programs

**Everything around us, including ourselves, is made up of atoms and molecules. The ability to create new materials and compounds, to analyse their behaviour and to modify them according to our needs, is the basis of research in chemistry. However, in order to meet the challenges of the future, it is necessary to have a sound background: for this reason, the Department of Chemistry has a strong focus on teaching at all levels, from Bachelor to Master to Doctorate. thanks to an extremely favourable student/teacher ratio, we can take care of our students at an individualised level.**

## B.Sc. Programme (150 ECTS)

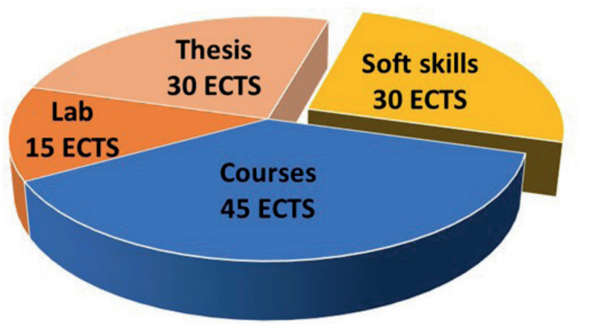



At the Bachelor level, we offer a 150 ECTS program over 6 semesters, with a Major (Branche Principale, Hauptfach) of 90 ECTS in chemistry, complemented by a Minor (Branche complémentaire, Zusatzfach) of 30 ECTS of the student's choice. This division enables students to explore different fields and to keep a high level of flexibility. Just to mention some examples, popular Minors are Industrial Chemistry (proposed by the HES-SO Fribourg) and Minors offered by the Faculty of Science (Biology, Biochemistry, Physics, ...). Minors offered by other Faculties within the University of Fribourg are also possible. The Major in chemistry nicely complements theoretical and practical courses: didactic laboratories constitute more than 50% of the total ECTS. The students will gain first hand practical experience in all fields of chemistry, including Analytical Chemistry, Organic Synthesis, Physical chemistry,... A project (Bachelor Projects) conducted in one of the research groups will also provide the students with a first experience of scientific research.

Bilingualism constitutes a strong asset of our teaching: Bachelor classes are taught in French or German (according to the choice of the teacher), whilst the exams can be done in French or German, according to the student's choice. The written exams of the first year and some exams of the second and third year can be done also in Italian. Bilingualism is mentioned on our B.Sc. diplomas.

At a Master level, we offer a 90 ECTS program over 3 semesters. The study plan is divided between a core block of compulsory courses (42 ECTS) complemented by a series if elective courses (18 ECTS). This combination allows students to follow their own inclinations and interests, providing at the same time a strong common background on advanced topics. To make students capable of interacting in international environments, the courses and exams take place in English. The Master is also strongly focused on the practical courses: a module of 15 ECTS consisting of an advanced multidisciplinary didactic laboratory

## M.Sc. Programme (90 + 30 ECTS)




and two research projects (100 hours each) will enable students to get familiar with advanced research topics. The Master thesis (30 ECTS) is the culmination of undergraduate studies: the students will spend an entire semester in a research laboratory of their choice, interacting with the researchers, applying their theoretical knowledge to real-life cases and strengthening their practical skills. An extra Soft Skill module (30 ECTS) has been recently introduced, providing in depth formation on transversal competencies, including scientific writing, entrepreneurship and experimental design.

The Department of chemistry is actively involved in the training and formation of Doctoral (Ph.D.) students, both in their research activity and in their theoretical formation. Seminars, summer schools and lectures given by invited speakers are regularly organized during the year.





# Public Outreach

The MINT program (Mathematics, Computer Science, Science and Technology) has set itself the goal of providing all pupils with a first access to science regardless of their professional future. It should enable everyone to deal with scientific topics and gain new insights. For this reason, we are already working with children from the primary school age, but also with high school students, sometimes with their teachers directly. The program is being implemented by employees of the Chemistry Institute of the University of Fribourg and the Adolphe Merkle Institute. It is co-financed by the Swiss Academy of Arts and Sciences.

## MINT consists of several branches:

**KidsUni** is an association founded in early 2014 by two professors from the Department of Chemistry of the University of Fribourg and the Adolph Merkle Institute. The idea is to bring chemistry and the scientific method to dren from 9-11 years old through interesting and quality workshops. Over the time, more professors in different scientific fields have joined to the association. Today we can offer the following workshops once a year:

1. **Chemistry:** Light and Color with Prof. Alke Fink and Prof. Marco Lattuada.
2. **Material Science:** Polymers with Dr. Stephen Schrettl from the Adolphe Merkle Institute.
3. **Industrial Chemistry:** Batteries and Energy with Prof. Jean-Pascal Bourgeois, Prof. Olivier Nicolet and Prof. Véronique Breguet Mercier from the Engineering School of Fribourg.
4. **Informatics:** The Robot Thymio with Prof. Jacques Supcik from the Engineering School of Fribourg.
5. **Geoscience:** Climate Change with Dr. Martina Barandun and Mountains Formation with Dr. Jon Mosar, both from the Department of Geosciences.
6. **Biologie:** The Best Vermifuge for your Cat with Dr. Chantal Wicky, The Genomics of Cheese with Dr. Laurent Falquet and The Lipids with Prof. Stefano Vanni, all from the Department of Biology.
7. **Mathematics:** Mathematics & Play with Prof. Christoph Leuenberger and Polyhedra with Prof. Emanuele Delucchi, both from the Department of Mathematics.
8. **Physics:** The Properties of Gas with Dr. Baptiste Hildebrand from the Department of Physics.
9. **Microscopy:** Analysis of Pollen with Dr. Dimitri Vanhecke from the Adolphe Merkle Institute.

**WINS** (Women in Science and Technology) is a program that gives girls between the ages of 15 and 16 the opportunity to get into the department to slip into the skin of a scientist. This internship is organized by the Faculty of Science and Medicine and the Department of Egality of the University of Fribourg. The internship consists of two full days of experiments at two different departments of the Faculty of Science and Medicine (one per day).

**Swiss Young Researcher** (Schweizer Jugend Forscht) is a foundation that is intended to arouse interest among young Swiss in the fields of innovation, science and technology. Their goal is to provide a platform for young people of secondary level I and II (high school, vocational training), where they can get an initial insight into the scientific work.

The foundation offers study weeks in various scientific fields, especially in our department every two years. The young people will have the opportunity to develop their project in our laboratories in a research group.

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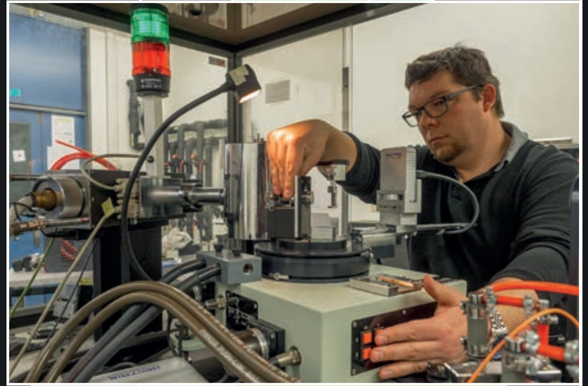
Chemistry: that most excellent child of intellect and art. *Cyril Norman Hinshelwood*

# X-Ray Service

The X-ray diffraction service of the Chemistry department of the University of Fribourg, built up by Prof. K. M. Fromm since 2006, is equipped with different single-crystal diffractometers (Mo, Cu and Ag radiation) and two powder diffractometers (Cu-Kα1 and Cu-Kα radiation). Dr. Aurélien Crochet is in charge of the service, provides single crystal structure determination service and assistance and formation for the use of the powder diffractometer.

The application field of the service is directly related with the research field of the customers. Among them are for example the investigation of the photolysis mechanism of nitroaromatic esters, the structure of polyaramide hollow helices, structure-property relationships of molecular sensors and antimicrobial, silver-based compounds, the study of precursors for oxide-materials and the investigation of metal-organic frameworks for sensing purposes or solid-state electrolytes for (high-voltage) batteries. Covalent organic frameworks, porous polymers and rhenium dicarbonyl complexes are further examples of research conducted in the department, using X-ray crystallography. Apart from these internal collaborations, the Crystallography lab offers its services also to research groups and industries at national and international level.



**Powder diffractometer:**

- **Stoe STADIP, transmission diffractometer with a Cu Kα1 incident beam from a germanium monochromator with Mythen1K detector (CCD) and exchangeable sample holders.**
- **Bruker D8 advance, reflection diffractometer with Cu Kα incident beam with a LynxEye XE-T detector. This diffractometer is also equipped with a battery cell and potentiostat.**

**Single Crystal Diffractometers:**

- **StadiVari (Stoe) with microfocus Ag and Cu radiation, and Pilatus3 R 300K**
- **IPDS2 (Stoe) equipped with Mo radiation, and image plate**
- **IPDS2T (Stoe) equipped with microfocus Cu radiation, and image plate**


All single crystal diffractometers are equipped with cryostats (150-500 K). The application field is very large from organic molecules to inorganic and organometallic compounds. The single crystal service carries out measurement and full crystal structure determination. Ready to publish CIF-files are provided and deposition to the CCDC is done on demand.

People who want to have access to one of the instruments have to contact Dr. Aurélien Crochet in order to discuss about their needs.

**Recent publications and highlights:**

K. Schindler, A. Crochet, F. Zobi; RSC Adv., 2021, 11, 7511-7520.
S. Pal, D. P. T. Nguyen, A. Molliet, M. Alizadeh, A. Crochet, A. Petri-Fink & A. F. M. Kilbinger; Nat. Chem. 2021 13, 705–713.
A. B. Solea, S. Wang, X.-S. Xue, A. Crochet, K. M. Fromm, K. N. Houk, O. Mamula, C. Allemann; Org. Biomol. Chem., 2021, 19, 8025-8029.
A. Finelli, S.-L. Abram, N. Hérault, A. Crochet, and K M. Fromm; Cryst. Growth Des., 2020 20 (8), 4945-4958.
D. Yordanov, V. Deneva, A. Georgiev, A. Crochet, K. M. Fromm, L. Antonov; Spectroch. Act. Part A, 2020, 237, 118416.





# Repair & Development

With a long experience, the Electronics Workshop at the Department of Chemistry provides services to assist in the development, maintenance and safety of its research and teaching facilities.

It has a diverse range of equipment and facilities relevant to modern chemical science.
Services provided are Consultancy & Advice / Design & Construction of Laboratory Equipment, Equipment Maintenance & Repair, Machine Shop Facilities, stock of Electronic Components & Consumables.
The skills in electronic and mechanical development are very high - from development to programming electronic cards and from drilling to machining parts.
We are also proud that, over the years, we have accumulated experience in repair and maintenance of the majority apparatus used in chemistry.

For details, please contact Mr. Olivier Graber.

# Synthesis Lab Service

The Synthesis Laboratory was created in 2001, when the Institutes of Inorganic Chemistry, Organic Chemistry and Physical Chemistry merged to form the present Department of Chemistry.

The main task of the collaborators of the synthesis laboratory is to support the professors and researchers of the department, providing them with help for the practical part of their research work.

This support is provided through the realization of syntheses as well as all the preparations necessary for the progress of the projects of the doctoral students and the scientific collaborators of the different research groups. The laboratory is equipped with a wide range of apparatus and glassware, which are available to the researchers. The synthesis laboratory also includes a hydrogenation laboratory, which currently allows the realization of reactions up to 50 bars.

Starting with two collaborators alternately supervising between two and four trainees in chemistry, the synthesis lab staff rapidly progressed to stabilize three collaborators and six trainees since 2006.
Through supervision and support, the employees of the synthesis laboratory contributed to the training and success of 34 apprentices, who obtained their federal certificate of competence, accompanied by more than 90% of them with an integrated professional maturity.

For details, please contact Mrs Anne Schuwey, Laboratory Manager.

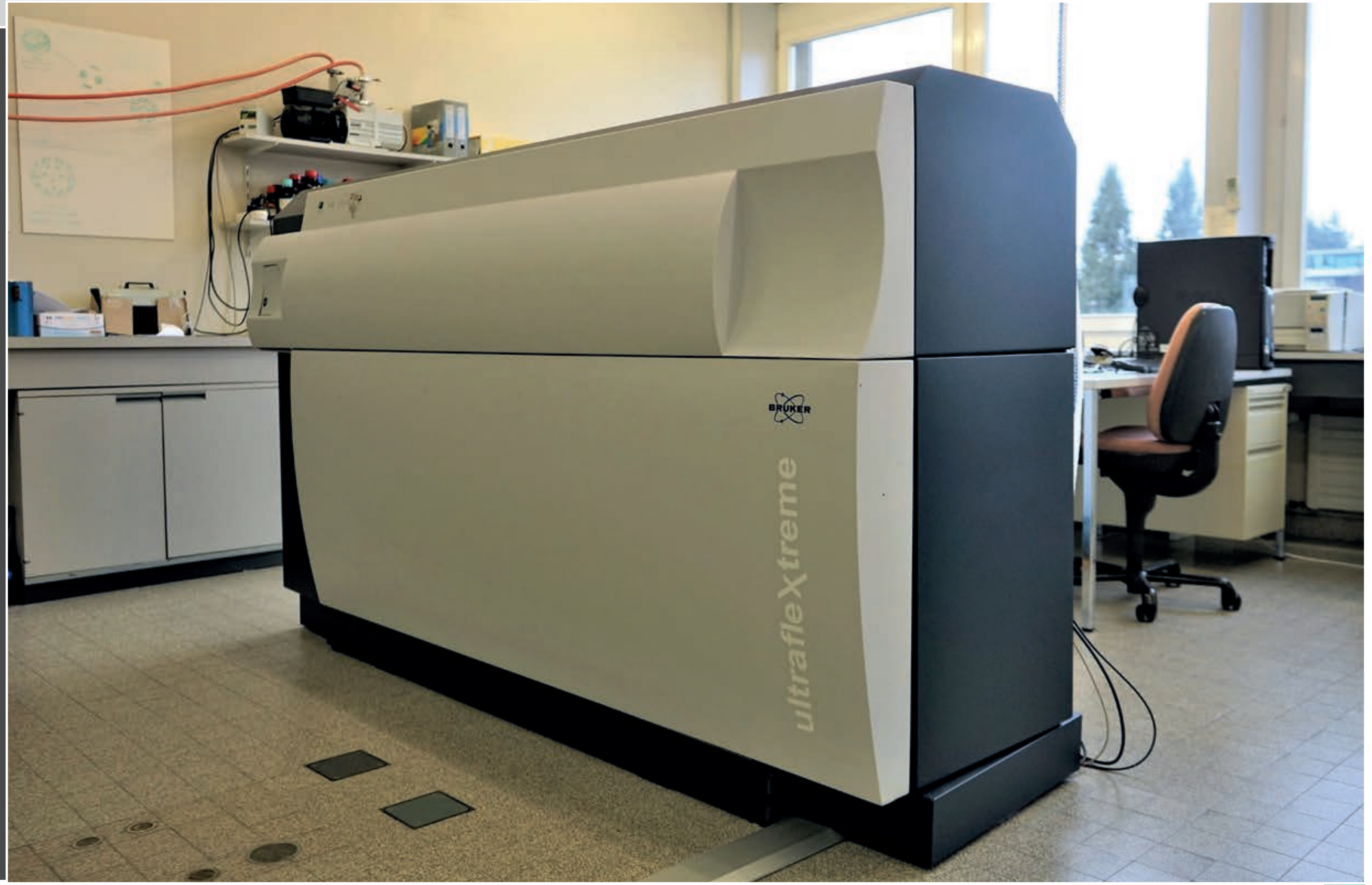





# MALDI

## (Bruker UltrafleXtreme MALDI-TOF)

This instrument is capable of measuring molecules of high molecular weight (1000-500000 m/z) and it is the standard instrument for polymer analysis. The access to this instrument is restricted.
For details, please contact Dr. Albert Ruggi.



# HIGH FIELD NMR INSTRUMENTS

## 600 MHz

High field 600 MHz Bruker Ascend magnet controlled with Avance NEO console, equipped with Prodigy BBO and 1.3 mm CP-MAS has been recently installed.

## 500 MHz

Our 500 MHz Bruker magnet is controlled with Avance III HD console and equipped with - 24 position - SampeCase autosampler. Currently, 5mm BBO probe with Z-gradient is installed in the system. It is tunable over a frequency range that enables observation of nuclei between $^{31}P$ and $^{15}N$, as well as $^{19}F$. $^{1}H\{^{19}F\}$ decoupled measurements are also possible. The probe can measure in wide temperature range, from -150°C up to 150°C.

In principle, this is restricted access instrument available for the NMR Service only. On special request, qualified individuals, may gain the access to the 500 MHz instrument. After prior training instrument may be reserved via https://iris.science-it.ch/






# OPEN ACCESS NMR INSTRUMENTS

## 400 MHz

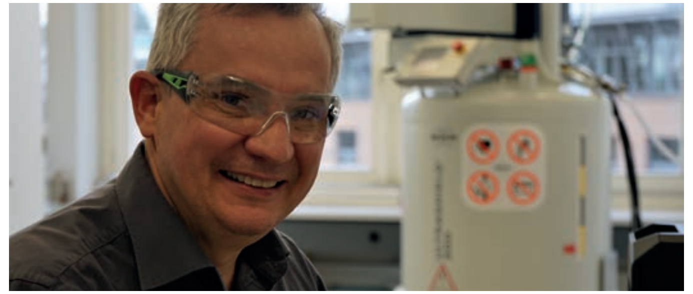
Our 400 MHz Bruker Ascend magnet is controlled with Avance Nanobay (Avance III HD) console and equipped with high throughput - 60 position - SampeCasePlus autosampler. Currently, dual channel 5mm BBO probe with Z-gradient is installed in the system. It is tunable over a frequency range that enables observation of nuclei between $^{31}P$ and $^{15}N$, as well as $^{19}F$. $^{1}H\{^{19}F\}$ decoupled measurements are also possible. The probe is equipped with BCU I temperature control unit that allows NMR measurements at temperatures other than RT.

## 300 MHz

Our 300 MHz Bruker Ultrashild magnet is controlled with Avance Nanobay (Avance III) console and equipped with high throughput - 60 position - SampeXpress autosampler. Currently, dual channel 5mm BBO probe with Z-gradient is installed in the system. It is tunable over a frequency range that enables observation of nuclei between $^{31}P$ and $^{15}N$, as well as $^{19}F$. $^{1}H\{^{19}F\}$ decoupled measurements are also possible.

In principle, the above instruments, with currently installed probes, are more sensitive for heteronuclear ($^{13}C$, $^{31}P$, ...) detected methods (APT, DEPT, etc.) but they will also provide decent spectra for $^{1}H$ proton detected NMR methods such as 1d, DOSY, homonuclear $^{2}d$ (COSY, NOESY, ROESY, TOCSY...) and all inverse detected methods (HSQC, HMBC, etc.).

Right after the experiment, collected spectra can be downloaded by the authenticated users for further processing and archiving.

At present we operate two solid-sate NMR instruments:

## 400 MHz

Our 400 MHz Bruker UltraShield magnet is controlled with Avance Neo console and equipped with dual channel BB probe. Spectra of samples filled in 4 mm diameter rotor can then be acquired in single/double resonance.

If the compound of interest is insoluble or unstable in solution and when information about the solid-state structure is desired this is the system to go for. Samples can be spun from 1 kHz up to 15 kHz. Variety of different nuclei including, $^{1,2}H$, $^{6,7}Li$, $^{13}C$, $^{23}Na$, $^{27}Al$, $^{29}Si$, $^{31}P$, can be measured by our solid-state NMR.

After prior training instrument access may be reserved via https://iris.science-it.ch/.

## 600 MHz

High field 600 MHz Bruker Ascend magnet controlled with Avance NEO console, equipped with 1.3mm CP-MAS probe to be installed soon. As for the liquid samples, the system is equipped with prodigy $N_2$-cooled cryoprobe to provide the researchers with very high-resolution NMR data. Moreover, as a solid probe, the system is also equipped with a "very fast" 1.3 mm solid-probe capable of spinning up to 67 KHz, which will provide extremely high resolution for the analysis of solid samples.

# NMR FOR INDUSTRY

We encourage external users to measure their samples with our systems. Once trained, you can prepare, measure, and interpret your own samples yourself! If your time is too precious, we will do all that for you. Isn't that great?

**Try us out!**

For details and pricing, please contact Dr. Krzysztof Piech.

UNIVERSITY OF FRIBOURG | DEPARTMENT OF CHEMISTRY | 2021-2022


If you want to have good ideas you must have many ideas. Most of them will be wrong, and what you have to learn is which ones to throw away. *Linus Pauling*

# DEPARTMENT OF CHEMISTRY
## IN FIGURES FOR 2020-2021






## IMPRESSUM & CONTACTS
## CHEMISTRY DEPARTMENT UNIVERSITY OF FRIBOURG

## Impressum

**Content:** Department of Chemistry Professors, Services Staff
**Redaction:** Esra Coskun, Maja Ivanovic
**Layout:** Sebastien Gobet
**Photos:** Maja Ivanovic, Fabien Debrot (www.torbedfilms.com), Kyung Seob Song (amorfatisks@gmail.com)
**Illustration:** Flaticon.com, Pixabay.com, Sebastien Gobet
**Printer:** Miscreants.ch@gmail.com


## Our contacts

FOLLOW US
SUIVEZ-NOUS
FOLGE UNS

@unifrchemistry

@unifrchemistry

@unifrchemistry

University of Fribourg, Department of Chemistry

https://www.unifr.ch/chem

University of Fribourg
Department of Chemistry
Chemin du Musée 9
CH-1700 Fribourg