UNDERGRADUATE SUMMER RESEARCH INTERNSHIPS
National Center of Competence in Research for Bio-Inspired Materials

Research Projects Summer 2022

The National Center of Competence in Research (NCCR) Bio-Inspired Materials offers undergraduate students (from Switzerland and abroad) the opportunity to spend the summer break (8-12 weeks) participating in cutting-edge research within one of the Center's research groups. The undergraduate students have the opportunity to work on a research project and to interact with leading experts in their fields of interest and with fellow students from around the world. The students get a glimpse of advanced research work, gain desirable hands-on work experience, develop their transferable skills and have the unique opportunity to explore career options and network with professionals. Beyond conducting research in the hosting lab, undergraduates participate in scientific lectures, social and networking events. At the end of the summer, the students present the results of their research projects in a poster session followed by a summer party. The students have the opportunity to learn about Switzerland from an insider perspective, and to take the first steps toward learning or practicing French and/or German language skills.

Requirements

To apply to the program you need to fulfill the following conditions:

- Be a national of Switzerland, a member state of the European Union, or a country with a Visa exemption agreement with Switzerland for a maximum period of stay of 90 days;
- Be enrolled at a University as a full-time undergraduate student in a relevant field of natural sciences, such as medicine, biology, biochemistry, chemistry, physics or materials science;
- Be an undergraduate student having concluded a minimum of 2 years of a degree program by the start of the internship;
- Certify that you are and will be registered as an undergraduate at your University/College for the upcoming academic year;
- If you are studying in Switzerland, you cannot select a research project at the University where you are studying;
- Have very good (oral and written) English language skills (level B2/C1).

Terms of the research stay

Duration: 8-12 weeks; Only Period II (June 15 – September 15)

How to apply

Applicants must submit their applications online at www.bioinspired-materials.ch/

Applications are open from December 1, 2021 until January 20, 2022.

Project ID	Project title	Group	Field
P22-01_Acuna	Building up a displacement assay by using DNA nanotechnology	Acuna	Biology, Biochemistry, Chemistry, Physics, Material Science & Engineering
P22-02_Acuna	Plasmon - quantum emitters interactions using DNA self-assembly	Acuna	Chemistry, Physics, Material Science & Engineering
P22-03_Amstad	Bioinspired mineral hydrogel nanocomposites	Amstad	Material Science & Engineering
P22-04_Fromm	From rings to chains to chainmails	Fromm	Chemistry
P22-05_Kilbinger	Amphiphilic aromatic oligoamides inspired by human cathelicidin peptide LL-37	Kilbinger	Chemistry
P22-06_Lattuada	Structural colors from the self-assembly of non-spherical colloids	Lattuada	Chemistry, Material Science & Engineering
P22-07_Rüegg	DNA origami biosensor for the detection of cancer biomarkers	Rüegg	Biology, Physics, Medicine, Material Science & Engineering
P22-08_Salentinig	Nature inspired antimicrobial nanomaterials	Salentinig	Chemistry, Material Science & Engineering
P22-09_Salentinig	Nanoemulsions for functional food	Salentinig	Chemistry, Material Science & Engineering
P22-10_Scheffold	Microscopy study of the reentrant glass transition of emulsions	Scheffold	Chemistry, Physics
P22-11_Steiner	Bio-inspired hybrid photonic pigments	Steiner	Chemistry, Physics, Materials Science & Engineering
P22-12_Steiner	Surface engineering of nanostructured polymer electrolyte	Steiner	Chemistry, Physics, Materials Science & Engineering
P22-13_Steiner	Advanced methods in the creation of metallic microstructures	Steiner	Chemistry, Physics, Materials Science & Engineering
P22-14_Steiner	Bioinspired materials for hybrid photovoltaics	Steiner	Chemistry, Physics, Materials Science & Engineering
P22-15_Vanni	Dynamics of monolayer-protected gold nanoparticles	Vanni	Chemistry, Physics, Materials Science & Engineering
P22-16_Weder	Healable metallosupramolcular polymers	Weder	Chemistry, Materials Science & Engineering
P22-17_Weder	Light-responsive polymersomes for light-triggered release	Weder	Chemistry, Materials Science & Engineering
P22-18_Weder	Supramolecular interpenetrating polymer networks comprising metal-ligand and hydrogen bonding supramolecular interactions	Weder	Chemistry, Materials Science & Engineering
P22-18_Akrap	Optical spectroscopy of topological materials	Akrap	Physics
P22-20_Coskun	Synthesis and characterization of macrocyclic organic precursors and their polymers towards CO2 capture and conversion	Coskun	Chemistry, Materials Science & Engineering
P22-21_LeBoeuf	Collective control of development in ant colonies	LeBoeuf	Physics, Biochemistry

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Project ID	**URI P22-01_Acuna**
Project title	**Building up a displacement assay by using DNA nanotechnology**
Research group	Prof. Guillermo Acuna https://www.unifr.ch/phys/en/research/groups/acuna/
Host Institution	Department of Physics, University of Fribourg
Duration	12 weeks
Possible period	**Only Period II (15 June - 15 September)**

Project summary

Aim of the project is to develop a displacement assay to detect cancer RNA. Based on silver or gold nanoparticle dimer structures (optical antennas), the change of the fluorescent signal by binding and unbinding of a target RNA strand should be studied by fluorescent microscopy. To build up these structures the method of DNA origami is used, which is well established in our lab.

In general, the following intermediate goals can be reached:

- Assembly of DNA origami structures
- Functionalization of AgNP with DNA
- Assembly and characterization of optical antenna structures, e.g. Ag/AuNP@DNA origami structures
- Single fluorescence measurements by optical microscopy
- Study of the fluorescence signal by binding and unbinding of the RNA target strand to the antenna structure.

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Research Projects Summer 2022

Project ID	**URI P22-02_Acuna**
Project title	**Plasmon - quantum emitters interactions using DNA self-assembly**
Research group	Prof. Guillermo Acuna https://www.unifr.ch/phys/en/research/groups/acuna/
Host Institution	Department of Physics, University of Fribourg
Duration	12 weeks
Possible period	**Only Period II (15 June - 15 September)**

Project summary

Interactions between plasmons (e.g. of ~60nm gold nanoparticles) and quantum emitters positioned nearby (e.g. fluorophores) display rich physical phenomena ranging from modification of fluorescence emission to plasmon-quantum emitter energy hybridization. Using DNA self-assembly, one can fabricate structures containing a pre-determined number of components (e.g. 2 nanoparticles and one single fluorophore) as well as control their inter-spacing and geometrical arrangement. This in turn tunes the degree of interaction.

During this project, the student will:

- Fabricate the structures using DNA self-assembly technique.

- Perform optical measurements including confocal and widefield fluorescence microscopies, and scattering and fluorescence spectroscopies of single structures.

- Characterize the structures using transmission and scattering electron microscopes.

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Research Projects Summer 2022

Project ID	**URI P22-03_Amstad**
Project title	**Bioinspired mineral hydrogel nanocomposites**
Research group	Prof. Esther Amstad https://smal.epfl.ch/
Host Institution	Soft Materials Laboratory, EPF Lausanne
Duration	12 weeks
Possible period	**Only period II (15 June - 15 September)**

Project summary

Hydrogels are polymeric networks encompassing large amounts of water. Thanks to their high biocompatibility, hydrogels were among the first biomaterials expressly designed for their use in biomedicine. However, state-of-the-art applications of hydrogels are severely limited due to their poor mechanical properties. To increase the versatility of hydrogels for load-bearing applications, new strategies that combine covalent and physical interactions have been developed. However, these hydrogels are either stiff but brittle or strong but weak. To fabricate hydrogels that are stiff and strong at the same time, new fabrication approaches are required. Inspired by nature, we are developing granular hydrogels that can optionally be mineralized to increase their stiffness.

This project aims at developing a bioinspired hydrogel nanocomposite composed of a hydrogel scaffold that is infiltrated with inorganic nanoparticles, which displays mechanical properties that are more similar to those of cartilage than the currently known composites. Within this project, you will fabricate single network hydrogels and investigate the effect of ion infiltration on their mechanical properties using rheology and tensile testing.

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Research Projects Summer 2022

Project ID	**URI P22-04_Fromm**
Project title	**From rings to chains to chainmails**
Research group	Prof. Katharina Fromm http://www3.unifr.ch/chem/en/research/groups/fromm/
Host Institution	Department of Chemistry, University of Fribourg
Duration	12 weeks
Possible period	**Only period II = 15 June - 15 September**

Project summary

Catenation is a phenomenon observed in nature, e.g. in proteins and DNA plasmids. Such entangled structures also won the Nobel Prize in Chemistry in 2016. We will synthesize super-large rings and entangle them into chains and chainmail structures and also analyze these ring molecules by AFM/STM, electron microscopy, NMR, IR and UV-Vis. The work includes organic synthesis, separation techniques and analytical methods.

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Research Projects Summer 2022

Project ID	**URI P22-05_Kilbinger**
Project title	**Amphiphilic aromatic oligoamides inspired by human cathelicidin peptide LL-37**
Research group	Prof. Andreas Kilbinger https://www.unifr.ch/chem/en/research/groups/kilbinger/
Host Institution	Department of Chemistry, University of Fribourg
Duration	8 to 12 weeks
Possible period	**Only Period II (15 June - 15 September)**

Project summary

In this project, we will synthesize a mono and a di-substituted aromatic amino acid with either only a hydrophilic or both, a hydrophilic and a hydrophobic side chain. These two amino acid will then be coupled to a dimer. This dimer can then be polymerised in a living polycondensation or sequentially oligomerised on a peptide synthesizer. Subsequently, antimicrobial activity of the polymer/oligomer will be investigated in collaboration with the group of Prof. Salentinig (UniFR, see corresponding internship project there).

LL-37 is a 37 residue, alpha-helical, amphipathic, cathelicidin derived antimicrobial peptide. Important for the antimicrobial activity of LL-37 is its spacial distribution of hydrophilic and hydrophobic residues on either side of the alpha-helix. It is believed that the binding of LL-37 to the bacterial cell membrane results in cell rupture/lysis. This physical mode of action is believed not to induce bacterial resistance.

Here, we are trying to mimic the function of this naturally occurring peptide using amphiphilic shape-persistent aromatic amide oligomers. Suitable candidates for this project must have a strong interest in synthetic organic/polymer chemistry.

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Research Projects Summer 2022

Project ID	**URI P22-06_Lattuada**
Project title	**Structural colors from the self-assembly of non-spherical colloids**
Research group	Prof. Marco Lattuada https://www.unifr.ch/chem/en/research/groups/lattuada/
Host Institution	Department of Chemistry, University of Fribourg
Duration	12 weeks
Possible period	**Only Period II (15 June - 15 September)**

Project summary

Structural color is the result of interference of light of specific wavelength with matter having ordered structural features at a length scale compatible with that of light. One of the most difficult aspect of structural coloration, is that the outcome depends on the degree of ordering of the substrate. Both top-down and bottom up approaches can be used to prepared substrates displaying structural coloration. Our group is specialized in controlling self-assembly of particles, and one of our objectives is to guide self-organization of a variety of particles to obtain structural colors. This is achieved by preparing particles with various shapes, and functionalities (especially magnetic) and to control their organization into ordered structures with just the right degree of disordered. While it is known that monodisperse spherical particles can be arranged into face-centered cubic colloidal crystals, our objective is to introduce some disorder into their structural organization, by introducing defects in the particle shape, or by controlling orientation of non-spherical particles. The candidate will work on both the synthesis of a variety of particles, and on their deposition on substrates in order to control their optical properties.

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Research Projects Summer 2022

Project ID	**URI P22-07_Rüegg**
Project title	**DNA origami biosensor for the detection of cancer biomarkers**
Research group	Prof. Curzio Rüegg https://www.unifr.ch/med/de/research/groups/ruegg/
Host Institution	Department of Medicine, University of Fribourg
Duration	8 weeks
Possible period	**Only Period II (15 June - 15 September)**

Project summary

In many of the cellular processes, the signal transduction is initiated by the oligomerization of the ligand engaged cell surface receptors, which is crucial for the normal biological processes and development of pathologies, including cancer. Human epidermal growth factor receptor 2 (HER2) is overexpressed in 20-30 % of the early-stage breast cancer and can be targeted by the antibody trastuzumab with high specificity and efficiency. Overexpressed HER2 become active upon homodimerization or heterodimerization with HER1 and HER3, thereby initiating the downstream signaling pathways and affect the therapeutic efficiency of drugs. However, in case of heterodimerization such as HER2/HER3 cells become resistant to trastuzumab. Therefore, identifying the status of dimerization is highly critical for molecular subtyping and in-depth understanding of the signaling pathway and for guiding personalized HER2 breast cancer therapy. In this project, we will develop a bio-inspired DNA self-assembly approach based on proximity induced DNA hybridization chain reaction (HCR) to map the formed dimers on cell membrane by targeting receptors using aptamers or antibodies. DNA hairpins will be designed accordingly and decorated with fluorescent dyes for optical detection.

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Research Projects Summer 2022

Project ID	**URI P22-08_Salentinig**
Project title	**Nature inspired antimicrobial nanomaterials**
Research group	Prof. Stefan Salentinig http://www3.unifr.ch/chem/en/research/groups/salentinig/
Host Institution	Department of Chemistry, University of Fribourg
Duration	12 weeks
Possible period	**Only Period II (15 June - 15 September)**

Project summary

The COVID-19 pandemic caused apprehension and concern around the thematic of microbial propagation. Antimicrobial nanomaterials may represent an "invisible" yet effective strategy among the available solutions. The goal of this project is the design and characterization of antimicrobial biopolymer materials that mimic the action of natural antimicrobial peptides in killing microbials. We recently discovered that certain biopolymer-lipid self-assemblies efficiently kill bacteria, including superbugs that are resistant to conventional antibiotics; and can inactivate enveloped viruses. The student will characterize the self-assembly of synthetic polymer amphiphiles in water and their interaction with bacteria and virus systems using i.e. light scattering, small angle X-ray scattering and cryo-TEM. Biological assays will provide the nanostructure - activity relationship in these materials. The project will be performed in collaboration with a second student focusing on polymer synthesis in the group of Prof. Kilbinger (see corresponding internship project). The student should have a strong background in physical chemistry related to polymers / materials.

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Research Projects Summer 2022

Project ID	**URI P22-09_Salentinig**
Project title	**Nanoemulsions for functional food**
Research group	Prof. Stefan Salentinig http://www3.unifr.ch/chem/en/research/groups/salentinig/
Host Institution	Department of Chemistry, University of Fribourg
Duration	12 weeks
Possible period	**Only Period II (15 June - 15 September)**

Project summary

Colloidal structures are crucial components in biological systems and provide a vivid and seemingly infinite source of inspiration for the design of functional bio-inspired materials. Our team recently discovered the in-situ formation of colloidal nanocarriers during the digestion of food emulsions, including milk, and pioneered novel methods for nanoemulsion design. Based on this, the global aim of this project is the design of functional nutrient loaded nanoemulsions and the study and optimization of their interactions with digestive tract components (e.g., lipases, bile salts). Towards this goal, colloid and interface chemistry will be combined with nanomaterial characterization and biochemical assays. Major characterization methods will include small angle X-ray scattering, static light scattering, confocal Raman microscopy and enzymatic assays. The student should have a strong background in physical chemistry, materials chemistry, nanomaterials characterization.

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Research Projects Summer 2022

Project ID	**URI P22-10_Scheffold**
Project title	**Microscopy study of the reentrant glass transition of emulsions**
Research group	Prof. Frank Scheffold https://www.unifr.ch/phys/en/research/groups/scheffold/
Host Institution	Department of Physics, University of Fribourg
Duration	12 weeks
Possible period	**Only Period II (15 June - 15 September)**

Project summary

A unique reentrant glass transition of emulsions controlled by temperature is observed recently in our previous studies. The sample contains micron sized oil droplets and pluronic (a triblock copolymer). The critical micelle concentration of pluronic is very sensitive to temperature. When a proper fraction of oil droplets and pluronic present in the solution, a reentrant glass transition can be observed just by changing the temperature of the sample. The aim of this project is to study the structure and dynamics of emulsions in different phases of the system.

The student will achieve the following intermediate goals:

- Fabrication of emulsions with homemade shear cell.

- Learn how to use a confocal microscope.

- perform 3D particle tracking analysis on fluorescent images.

- Measure dynamics and structure of colloidal glasses.

- Study how the dynamics and the structure change in a reentrant glass transition.

BIO-INSPIRED MATERIALS
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UNDERGRADUATE SUMMER RESEARCH INTERNSHIPS
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Research Projects Summer 2022

Project ID	**URI P22-11_Steiner**
Project title	**Bio-inspired hybrid photonic pigments**
Research group	Prof. Ullrich Steiner https://www.ami.swiss/physics/en/
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	12 weeks
Possible period	**Only Period II (15 June - 15 September)**

Project summary

A fascination for color is intrinsically rooted in all-time human civilizations and the quest for more stunning coloration effects has led to taking inspiration for coloration from the natural world. Here, evolution has produced remarkable optical effects, from the most brilliant iridescence and lustre of bird feathers and butterfly wings to adaptive coloration in camouflaging chameleons and octopuses. These typically arise from nontrivial combinations of multiple light-matter interaction phenomena, i.e., reflection, diffraction, absorption and scattering, which evolved to yield the most striking results.

Inspired by this, we will prepare full-spectrum, monochromatic, non-iridescent and highly reflecting bio-inspired hybrid photonic pigments able to combine structural color and light absorption. Such a hybrid system will be developed by exploiting the 3D confined self-assembly of block-copolymers in emulsion droplets along with the addition of high refractive index additives and broad-band absorbers.

The summer student will be involved in the preparation and characterization of the materials, spamming from chemistry, polymer science and physics.

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Research Projects Summer 2022

Project ID	**URI P22-12_Steiner**
Project title	**Surface engineering of nanostructured polymer electrolyte**
Research group	Prof. Ullrich Steiner https://www.ami.swiss/physics/en/
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	8-12 weeks
Possible period	**Only Period II (15 June - 15 September)**

Project summary

Batteries are nowadays expanding to an astonishing number of application fields. However, the safety of these devices remains an issue. One approach to improve safety is using non-flammable solid polymer electrolytes to replace flammable liquid electrolytes that are used in conventional cells. While ensuring safety, these electrolytes currently still suffer from low ionic conductivity, which prevents their commercialization and therefore drives the scientific research

In this project, we use a poly(styrene-b-ethylene oxide) diblock copolymer with a lamellar nanostructure as solid electrolyte. The main goal is to improve its ionic conductivity by controlling the copolymer orientation via engineering of the electrode-electrolyte interface. The structure and conductivity of the polymer electrolyte will be quantified by electrochemical impedance spectroscopy and scanning electron microscopy, respectively, as well as cyclic voltammetry, and differential scanning calorimetry, while dynamic mechanical analysis will be used to quantify the material's stiffness.

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Research Projects Summer 2022

Project ID	**URI P22-13_Steiner**
Project title	**Advanced methods in the creation of metallic microstructures**
Research group	Prof. Ullrich Steiner https://www.ami.swiss/physics/en/
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	12 weeks
Possible period	**Only Period II (15 June - 15 September)**

Project summary

Metallic nanostructures exhibit intriguing properties, some of which are not completely understood. Within our research group we are interested in such metallic nanostructures. More specifically, we are interested in expanding our method for their fabrication.

The traditional bottom-up route for fabricating nanoscopic metallic structures is the use of block-copolymer self-assembly. Each individual polymer can be selectively etched, allowing to back-fill the voided template with a metal through electrodeposition effectively yielding a nanostructured metallic array.

Here, we want to investigate a top-down approach. With the advance of additive manufacturing techniques, it is now possible to write microstructures directly using tools like nanoscribe.

As an intern in our group you will help developing a robust method for metallizing such written structures. Your work will involve experimenting with different additives for resins used in additive manufacturing and also test these resins with different electroless plating recipes after printing.

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Research Projects Summer 2022

Project ID	**URI P22-14_Steiner**
Project title	**Bioinspired materials for hybrid photovoltaics**
Research group	Prof. Ullrich Steiner https://www.ami.swiss/physics/en/
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	8 to 12 weeks
Possible period	**Only Period II (15 June - 15 September)**

Project summary

Hybrid perovskites have emerged as one of the leading materials for photovoltaics with extraordinary performances in solar-to-electric energy conversion. However, they feature instabilities that severely hinder their practical applications. Some of the underlying reasons for this are associated with detrimental ion migrations under operational conditions of voltage bias and light. While some of the ion migrations are reversible in the dark, others lead to irreversible degradation of the material as well as the resulting solar cells.

This project aims to address this instability by developing hybrid perovskite solar cells that adapt to the operating conditions through the use of bioinspired strategies employing stimuli-responsive materials. This will be achieved by relying on an interdisciplinary approach involving material synthesis and characterization, as well as solar cell device fabrication and analysis towards more resilient photovoltaics.

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Research Projects Summer 2022

Project ID	**URI P22-15_Vanni**
Project title	**Dynamics of monolayer-protected gold nanoparticles**
Research group	Prof. Stefano Vanni https://www3.unifr.ch/bio/en/research/bioinformatics/vanni.html
Host Institution	Department of Biology, University of Fribourg
Duration	12 weeks
Possible period	**Only Period II (15 June - 15 September)**

Project summary

Self-assembled monolayer-protected gold nanoparticles (AuNPs) are nanoscale materials composed by a rigid metal core coated by a flexible ligand shell. Notably, functionalized AuNPs present high potential in biomedical applications (e.g., as ideal scaffolds for drug delivery) since their gold core is non-toxic, inert, and biocompatible. Because surface coating defines the boundaries between the NPs and their surroundings, it plays a key role on the aggregation propensity of these nanomaterials and controls many of their physicochemical properties. Both NPs behavior in solution as well as their interaction with cellular membranes are also modulated by the environmental conditions to which they are exposed, such as solvent, ionic strength, or membrane composition.

In this project, we aim at using computational methods, mainly molecular dynamics simulations, to investigate, at the molecular level, the driving forces that trigger NPs behavior in different environments. This knowledge would be instrumental to assist the rational design of novel AuNPs with ad hoc properties.

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Research Projects Summer 2022

Project ID	**URI P22-16_Weder**
Project title	**Healable metallosupramolcular polymers**
Research group	Prof. Christoph Weder https://www.ami.swiss/en/groups/polymer-chemistry-and-materials/
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	10 to 12 weeks
Possible period	**Only Period II (15 June - 15 September)**

Project summary

The possibility to heal defects in polymeric materials is of great technological relevance as it allows considerable improvements in terms of lifetime and reliability. All thermoplastic polymers can, in principle, be healed by heating above their glass transition or melting temperature, but due to their high molecular weight, this process is unpractically slow. In contrast to that, healing by external stimuli like heat or light is readily possible if metallosupramolecular polymers (MSPs) are used. MSPs form through the self-assembly of ligand-functionalized monomers with suitable transition metal ions via the formation of dynamic metal ligand complexes. However, all healable MSPs reported so far exhibit limited mechanical properties and therefore are not useful for real life applications. To combine the benefits of both worlds, we are introducing a few supramolecular binding motifs into commercially available polymers via post-synthesis modification and test the mechanical properties and healability of these materials. The student intern will be involved in the fabrication and characterization of new materials based on this design.

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Research Projects Summer 2022

Project ID	**URI P22-17_Weder**
Project title	**Light-responsive polymersomes for light-triggered release**
Research group	Prof. Christoph Weder https://www.ami.swiss/en/groups/polymer-chemistry-and-materials/
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	12 weeks
Possible period	**Only Period II (15 June - 15 September)**

Project summary

Polymersomes are hollow, spherical structures formed through the self-assembly of diblock copolymers comprising a hydrophilic and a hydrophobic block. They are very promising for a variety of applications such as nanoreactors, cell mimics, and drug carriers. Especially for the latter, the release of cargo in a spatially and temporarily controlled manner is of great interest: light-responsive polymersomes that would encapsulate and protect their cargo until they reached the area of release are ideal candidates for drug delivery systems. In this project, a new self-assembly methodology will be used along with light-responsive moieties to develop stimulus-responsive polymersomes. The summer student will be involved in (i) the synthesis of light-responsive moieties and block copolymers, (ii) the self-assembly of such functional diblock copolymers into polymersomes, (iii) their characterisation by means of NMR, microscopy, light scattering, etc., and (iv) measuring the light-triggered release of drug model compounds from the polymersomes.

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Research Projects Summer 2022

Project ID	**URI P22-18_Weder**
Project title	**Supramolecular interpenetrating polymer networks comprising metal-ligand and hydrogen bonding supramolecular interactions**
Research group	Prof. Christoph Weder https://www.ami.swiss/en/groups/polymer-chemistry-and-materials/
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	12 weeks
Possible period	**Only Period II (15 June - 15 September)**

Project summary

Interpenetrating Polymer Networks (IPNs) are polymer networks interlaced at a molecular scale that do not share chemical connectivity. These materials have been extensively studied because of their remarkable mechanical properties. Examples of IPN systems featuring covalent crosslinks are numerous, but their supramolecular counterparts have been scarcely explored. Differently from covalent IPNs, the (dis)assembly of supramolecular IPNs should occur under mild conditions, which should enable agile recycling/reprocessing.

In this project, we will create supramolecular IPNs built on metal-ligand coordination and hydrogen-bonding interactions. The former would rely on 2,6-bis(1′-methylbenzimidazolyl)pyridine (MeBip) complexed to Zn2+ ions, whereas the latter on the quadrupole hydrogen-bonding interactions of the 2-ureido-4[1H]pyrimidinone (UPy) moiety. We will prepare and study supramolecular IPNs possessing different compositions of the two supramolecular motifs. Thus, the student will gain experience in organic and polymer synthesis, and materials processing and engineering.

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Research Projects Summer 2022

Project ID	**URI P22-19_Akrap**
Project title	**Optical spectroscopy of topological materials**
Research group	Prof. Ana Akrap https://www.unifr.ch/phys/en/research/groups/akrap/
Host Institution	Department of Physics, University of Fribourg
Duration	12 weeks
Possible period	**Only Period II (15 June - 15 September)**

Project summary

Topological materials—like graphene, topological insulators, or Weyl semimetals—are exciting because they can sometimes let us observe relativistic-like phenomena, in a piece of solid. These materials could in future be used as detectors, in opto-electronic devices, or in your future smartphones.

Their electronic properties are especially interesting at very low energies. Optical spectroscopy allows us to access this low-energy physics in topological materials. During this project, the student will learn how to do experiments in optical spectroscopy, how to analyze the data, and how to understand what we can learn from it about the electronic band structure.

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Research Projects Summer 2022

Project ID	**URI P22-20_Coskun**
Project title	**Synthesis and characterization of macrocyclic organic precursors and their polymers towards CO2 capture and conversion**
Research group	Prof. Ali Coskun https://www.unifr.ch/chem/en/research/groups/coskun/
Host Institution	Department of Chemistry, University of Fribourg
Duration	8 weeks
Possible period	**Only Period II (15 June - 15 September)**

Project summary

CO2 is considered the main driving force behind climate change. As a result, porous materials capable of sequestering CO2 from gas streams have been heavily investigated. Among porous materials, porous organic polymers (POPs) are considered ideal candidates due to their high chemical and physical stability while providing chemists with ample means of tuning the properties of the polymers.

This project consists of two main tasks. The first is focused on the preparation of novel macrocyclic precursors and their porous polymers, while the second focusses on the characterization (SS-NMR, BET N2/CO2, TGA, FTIR, XPS) of the obtained POPs and in assessing their capabilities as organo-catalysts.

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National Center of Competence in Research for Bio-Inspired Materials

Research Projects Summer 2022

Project ID	**URI P22-21_LeBoeuf**
Project title	**Collective control of development in ant colonies**
Research group	Prof. Adria LeBoeuf https://www.unifr.ch/bio/en/research/eco-evol/le-boeuf-group.html
Host Institution	Department of Biology, University of Fribourg
Duration	12 weeks
Possible period	**Only Period II (15 June - 15 September)**

Project summary

Ant workers frequently share fluids mouth-to-mouth in a behaviour called trophallaxis (LeBoeuf et al., 2016, 2018, Hakala et al. 2021). This behavior results in a social circulatory system that transmits both food and ant-produced signals and cues throughout the colony. Our research indicates that materials transmitted over the social circulatory system, including proteins, hormones and lipids, impact larval development and may allow the queen to live decades longer than the workers.

Depending on the student's competences, this student could pursue a project doing agent-based modeling of fluid and resource flow or could record and work with real data from our machine-learning based trophallaxis tracking system (maintains adult and larval identities and tracks fluorescence flow) to study the implications of the social circulatory system. The project would take place in the LeBoeuf Lab of Social Fluids at UniFr.