BIO-INSPIRED MATERIALS
NATIONAL CENTER OF COMPETENCE IN RESEARCH

FNSNF
SWISS NATIONAL SCIENCE FOUNDATION

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

Research Projects Summer 2018

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; Either in Period I (May,15 - August,15) or 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, 2017 until January 15, 2018.

UNI FR UNIVERSITÉ DE FRIBOURG UNIVERSITÄT FREIBURG
adolphe merkle institute excellence in pure and applied nanoscience
UNIVERSITÉ DE GENÈVE
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ETH zürich

Project ID	Project title	Group	Field	Possible period
P18/01_Balog	A stochastic model of the endocytosis of nanoparticles	Fink	Biology, Mathematical Modelling & Computing	I & II
P18/02_Kilbinger	Unimolecular micelles based on amphiphilic hyperbranched ring opening metathesis polymers (ROMP)	Kilbinger	Chemistry	I & II
P18/03_Kilbinger	Ugi and Passerini reactions for biotin-labeled polymer end-functionalization using ring opening metathesis polymerization (ROMP)	Kilbinger	Chemistry	I & II
P18/04_Kilbinger	Heterotelechelic water soluble polymers for protein labeling synthesized by ring opening metathesis polymerization (ROMP)	Kilbinger	Chemistry	I & II
P18/05_Kilbinger	Degradable/biodegradable ring opening metathesis polymers (ROMP)	Kilbinger	Chemistry	I & II
P18/06_Lattuada	Preparation of bioinspired structured surfaces by magnetically-controlled dip coating	Lattuada	Nanoparticles, Materials Science & Engineering	I & II
P18/07_Mayer	Linking of proteins to supported lipid bilayers (SLBs)	Mayer	Biochemistry, Biophysics	I & II
P18/08_Mayer	DNA-modified pore-forming peptides for sensing applications	Mayer	Biochemistry, Biophysics	I & II
P18/09_Mayer	Development of peptide-based pore-forming DNA nanoconstructs	Mayer	Biochemistry, Biophysics	I & II
P18/10_Mayer	Fundamental and applied studies of self-assembled pore formation in lipid bilayer membranes	Mayer	Biochemistry, Biophysics	I & II
P18/11_Mayer	Effects of nanopore shape and particle position on the resistive-pulse protein sensing based on finite element simulation	Mayer	Biochemistry, Biophysics	I & II
P18/12_Radenovic	Nanodiamonds for cell imaging and sensing	Radenovic	Nanotechnology, Biology	II
P18/13_Rothen	Interaction of stimuli-responsive nanomaterials with single cells	Rothen	Biology, Biochemistry, Nanotechnology	I & II
P18/14_Steiner	Fabricating aligned nanostructures in block copolymer films	Steiner	Chemistry, Physics, Materials Science & Engineering	I & II
P18/15_Steiner	Helical block copolymers as templates for optical metamaterials	Steiner	Chemistry, Physics, Materials Science & Engineering	I & II
P18/16_Steiner	Investigation and preparation of microfluidic systems	Steiner	Chemistry, Physics, Materials Science & Engineering	II
P18/17_Vanni	Molecular dynamics simulations of cationic polymers	Vanni	Biology, Computer Simulation	I & II
P18/18_Weder	Supramolecular polymer adhesives inspired by Nature	Weder	Chemistry, Materials Science & Engineering	I & II
P18/19_Weder	Leaf cuticle-inspired membranes	Weder	Chemistry, Materials Science & Engineering	I
P18/20_Weder	Biocompatible, mechanically-adaptive polymers for intracortical implants	Weder	Chemistry, Materials Science & Engineering	I
P18/21_Bruns	Cuticle mimetic layered polymeric materials	Bruns	Chemistry, Materials Science & Engineering	I

UNDERGRADUATE SUMMER RESEARCH INTERNSHIPS

National Center of Competence in Research for Bio-Inspired Materials

Research Projects Summer 2018

Project ID	**URI P18/01_Balog**
Project title	**A stochastic model of the endocytosis of nanoparticles**
Research group	Prof. Alke Fink http://www.am-institute.ch/research/bionanomaterials
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	8-12 weeks
Possible period	**Both periods I (15 May - 15 August) & II (15 June - 15 September)**

Project summary

Nanoparticles (NPs) hold promise for medical applications, but also raise safety concerns. In this project we will explore the consequences of the fact that endocytosis of nanoparticles is intrinsically discrete. Depending on the uptake mechanism, NPs are either taken up as whole or in discrete packages by cells. Therefore, within any given time, only an integer number of particles is internalized by the cell. This simple postulate has far-reaching consequences that may explain several phenomena found in experimental cell biology addressing the cellular uptake of nanoparticles. For example, the considerable heterogeneity found in the number of nanoparticles taken by individual cells is explained without even the need of invoking cell-to-cell variability. In this work, we will use mathematical modelling and computation, and address selected physicochemical phenomena relevant for the endocytosis of nanoparticles. The primary goal is to 1) understand the consequences on the dose-vs-time course, and 2) design experiments to test the predictions of the model.

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

Research Projects Summer 2018

Project ID	**URI P18/02_Kilbinger**
Project title	**Unimolecular micelles based on amphiphilic hyperbranched ring opening metathesis polymers (ROMP)**
Research group	Prof. Andreas Kilbinger http://homeweb.unifr.ch/kilbinge/pub/kilbinger.html
Host Institution	Department of Chemistry, University of Fribourg
Duration	8-12 weeks
Possible period	**Both periods I (15 May - 15 August) & II (15 June - 15 September)**

Project summary

Micellar structures are important in biological systems. An important feature of such structures are the hydrophobic interior and hydrophilic exterior. This allows transport and solubility of non-polar molecules in aqueous media. One way to mimic such structures with polymers is via highly branched structures that exhibit different polarity on the inside and outside of the macromolecule. Such highly branched structures can be achieved via hyperbranched polymers. Many synthetic routes to hyperbranched polymers have already been described for most polymerization techniques. For the ring opening metathesis polymerization, one of the most functional group tolerant polymerization techniques known today, such methods are scarce. In this project we want to exploit the fact that cinnamyl alcohol groups with strained olefins will therefore lead to monomers that can undergo a hyperbranching reaction. This will lead to hyperbranched polymers potentially suitable as carriers for non-polar molecules such as for example drugs.

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

Research Projects Summer 2018

Project ID	**URI P18/03_Kilbinger**
Project title	**Ugi and Passerini reactions for biotin-labeled polymer end-functionalization using ring opening metathesis polymerization (ROMP)**
Research group	Prof. Andreas Kilbinger http://homeweb.unifr.ch/kilbinge/pub/kilbinger.html
Host Institution	Department of Chemistry, University of Fribourg
Duration	8-12 weeks
Possible period	**Both periods I (15 May - 15 August) & II (15 June - 15 September)**

Project summary

The Ugi and Passerini reactions are ideal reactions to be exploited to develop chemical libraries. Using the principles of combinatorial chemistry, the Ugi and Passerini reactions offer the possibility to synthetize a great number of different compounds in one reaction, by the reaction of various aldehydes, amines, isocyanides and carboxylic acids. These libraries can then be tested with enzymes or living organisms to find new active pharmaceutical substances. Chain-end functionalized polymers have attracted interest among scientists across all disciplines. Such materials combine macromolecular properties with defined reactive sites at the chain end. Our group developed a method to functionalize ring opening metathesis polymers (ROMP) with aldehyde end groups [4]. In this project we propose to use the polymeric aldehyde end-group in Ugi and/or Passerini reactions to introduce a variety of biologically functional or reactive moieties, in particular the biotin label. This method would allow a one pot functionalization of the aldehyde precursor polymer.

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

Research Projects Summer 2018

Project ID	**URI P18/04_Kilbinger**
Project title	**Heterotelechelic water soluble polymers for protein labeling synthesized by ring opening metathesis polymerization (ROMP)**
Research group	Prof. Andreas Kilbinger http://homeweb.unifr.ch/kilbinge/pub/kilbinger.html
Host Institution	Department of Chemistry, University of Fribourg
Duration	8-12 weeks
Possible period	**Both periods I (15 May - 15 August) & II (15 June - 15 September)**

Project summary

Natural polymers carrying orthogonally functionalizable groups are commonplace. For synthetic polymers true monomer sequence control cannot be achieved with today's synthetic methods. However, synthetic polymers that carry two different end-groups with different reactivity at either chain end, so-called hetero-telechelic polymers, can by synthesized via a number of different ways. Water soluble polymers of this type are particularly useful for example for the attachment to bio-polymers such as proteins via one end and to a fluorescent label via the other. Most polymers used for this purpose today are based on poly(ethylene glycol); they are difficult to synthesize and therefore expensive.

We have recently developed a method to prepare heterotelechelic polymers based on the ring opening metathesis polymerization. Using a new water soluble strained olefin as the monomer we propose to prepare chromophore/fluorophore initiated olefin metathesis polymers that can carry a variety of functional groups capable of binding to proteins at the other chain end.

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

Research Projects Summer 2018

Project ID	**URI P18/05_Kilbinger**
Project title	**Degradable/biodegradable ring opening metathesis polymers (ROMP)**
Research group	Prof. Andreas Kilbinger http://homeweb.unifr.ch/kilbinge/pub/kilbinger.html
Host Institution	Department of Chemistry, University of Fribourg
Duration	8-12 weeks
Possible period	**Both periods I (15 May - 15 August) & II (15 June - 15 September)**

Project summary

Most natural macromolecules are biodegradable due to the presence of polar and hetero-atom containing functional groups in the backbone of the polymer chain such as esters or amides. Many synthetic polymers produced by chain growth polymerization are not easily degraded due to the lack of such functionality. The ring opening metathesis polymerization (ROMP) is a highly functional group tolerant polymerization technique and therefore ideally suited for the polymerization of cyclic olefins containing esters, amides, acetals or other highly polar reactive groups.

In this research project we will explore the synthesis of new high molecular weight polymers based on the above functional groups in the main chain of the polymer. The polymers will be prepared by ring opening metathesis polymerization using Grubbs' catalysts. Monomers and polymers will be synthesized and characterized and degradation studies will be performed on the final polymers.

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

Research Projects Summer 2018

Project ID	**URI P18/06_Lattuada**
Project title	**Preparation of bioinspired structured surfaces by magnetically-controlled dip coating**
Research group	Prof. Marco Lattuada http://www-chem.unifr.ch/en/home
Host Institution	Department of Chemistry, University of Fribourg
Duration	12 weeks
Possible period	**Both periods I (15 May - 15 August) & II (15 June - 15 September)**

Project summary

The preparation of surfaces with well-controlled patterns has attracted the attention of researchers from many different fields. Structured surfaces possess many exciting properties, such as unique wettability and structural colorations. Many techniques have been developed to create structural features on surfaces over multiple length scales, with lithography being the most advanced. More recently, self-assembly of nanoparticles has emerged as a promising alternative to prepare surfaces with nano- and micron-sized structural features. In particular, dip coating has proved to be a versatile method to create ordered assemblies of particles on the surface. In dip coating, the surface is immersed in a solution of colloidal particles, and their deposition on the surface is controlled by tuning the particles concentration and surface chemistry, as well as the rate at which the surface is withdrawn from the solution. The objective of this project is to prepare structured surfaces by using dip coating of magnetic particles, and combine it with magnetic fields to further control the particles deposition and ordering on the surface.

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

Research Projects Summer 2018

Project ID	**URI P18/07_Mayer**
Project title	**Linking of proteins to supported lipid bilayers (SLBs)**
Research group	Prof. Michael Mayer http://www.am-institute.ch/research/biophysics
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	12 weeks
Possible period	**Both periods I (15 May - 15 August) & II (15 June - 15 September)**

Project summary

In our lab, we developed a solid-state nanopore based resistive pulse sensing method for single protein characterization, capable of measuring several parameters of a protein at the same time. This was achieved by coating a solid-state pore with a supported lipid bilayer and anchoring the protein in the membrane to slow translocation. Our current protocol for attaching proteins to the membrane is not very efficient and requires high protein concentrations. We are looking for a more efficient anchoring method.

We want to use copper-free click chemistry to attach the proteins to the membrane and test this process on a model system (a supported lipid bilayer on a glass slide). Therefore, we will functionalize the native protein with a cross-linker containing an azide group. It is important that only one cross-linker binds to each protein, otherwise additional charges will influence the later analysis. This will require fine-tuning of the protocol. We add these mono-functionalized proteins to a supported lipid bilayer containing modified lipids. The modified lipids can now react with the cross linker by a click reaction and form a covalent bond.

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

Research Projects Summer 2018

Project ID	**URI P18/08_Mayer**
Project title	**DNA-modified pore-forming peptides for sensing applications**
Research group	Prof. Michael Mayer http://www.am-institute.ch/research/biophysics
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	12 weeks
Possible period	**Both periods I (15 May - 15 August) & II (15 June - 15 September)**

Project summary

This project will explore the use of pore-forming peptides and lipid membranes for sensing applications. To this end we will take inspiration from living cells, which employ receptor and ion channel proteins to amplify signals and trigger often a cascade of intracellular reactions that further amplify the signal. Detection modalities may be electrochemical or fluorescence changes. Selectivity for various analytes of interest will be studied with tailor-made pore-forming molecules that act upon interactions with the analyte.

One of the goals will be to characterize further the behavior of these pores. Delivery experiments of (macro-) molecules through the formed pores will be conducted and monitored by ion current recordings and fluorescence measurements.

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

Research Projects Summer 2018

Project ID	**URI P18/09_Mayer**
Project title	**Development of peptide-based pore-forming DNA nanoconstructs**
Research group	Prof. Michael Mayer http://www.am-institute.ch/research/biophysics
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	12 weeks
Possible period	**Both periods I (15 May - 15 August) & II (15 June - 15 September)**

Project summary

We aim to construct lipid bilayer spanning nanopores for sensing application. Typically natural pore formers like alpha-hemolysin, aerolysin, cytolysin A, etc. are used in this context. Sensing application will strongly benefit from tuning of pore properties and geometry, which is currently only possible in a very limited range. We try to employ DNA nanotechnology methods like single stranded tile assemblies or the origami technique to guide the assembly of protein or peptide pores and study their properties.

This project involves DNA nanostructure design, production and characterization with TEM, AFM and gel electrophoresis. The constructs will be used in planar lipid bilayer experiments with ion current recordings.

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

Research Projects Summer 2018

Project ID	**URI P18/10_Mayer**
Project title	**Fundamental and applied studies of self-assembled pore formation in lipid bilayer membranes**
Research group	Prof. Michael Mayer http://www.am-institute.ch/research/biophysics
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	12 weeks
Possible period	**Both periods I (15 May - 15 August) & II (15 June - 15 September)**

Project summary

Pore-forming peptides are part of the innate immune response across all forms of life. These molecules display selective antimicrobial activity, which is interesting in the context of developing new therapies that combat the growing problem of antibiotic resistance. Our group is interested both in studying the self-assembly behavior of pore-forming peptides and in engineering peptide assemblies with certain desired characteristics, such as large pore diameter, long-term pore stability, and triggerable pore formation in the presence of specific chemical markers.

In this summer project, an intern will assist in studying and/or developing applications for the assembly of pores using electrical or colorimetric monitoring of planar or droplet-interface lipid bilayers.

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

Research Projects Summer 2018

Project ID	**URI P18/11_Mayer**
Project title	**Effects of nanopore shape and particle position on the resistive-pulse protein sensing based on finite element simulation**
Research group	Prof. Michael Mayer http://www.am-institute.ch/research/biophysics
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	12 weeks
Possible period	**Both periods I (15 May - 15 August) & II (15 June - 15 September)**

Project summary

When a protein diffuses into a nanopore, it causes an ionic current blockade due to the increased resistance of the pore. The resulting current signal, corresponding to the volume and residence time of the proteins passing through the pore, is significantly dependent on the pore shape and the position of the protein within it.

This project investigates proteins translocation through differently-shaped nanopores using finite element simulations by COMSOL Multiphysics. Nanopore sensing experiments may also be run for comparison with the simulation results. The simulation process is conducted by calculating the electric field and the resulting current trace of a protein located in different positions within the pore. Effect of nanopore shape (i.e. cylindrical, conical and hour-glass) is also characterized. These simulations will provide a fundamental insight about how nanopore shape and protein position affect the current trace. The results will also allow a better determination of the shape and volume of the analyzed proteins, helpful for further experimental protein characterization.

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

Research Projects Summer 2018

Project ID	**URI P18/12_Radenovic**
Project title	**Nanodiamonds for cell imaging and sensing**
Research group	Prof. Aleksandra Radenovic https://lben.epfl.ch/page-47156.html
Host Institution	Laboratory of Nanoscale Biology, EPF Lausanne
Duration	10 weeks
Possible period	**Only period II = 15 June - 15 September**

Project summary

Nanodiamonds are carbon-based nanoscale particles, which are currently receiving an increasing attention from the scientific community due to their unique properties and biocompatibility. The goal, suggested by this research project, is to develop functionalized diamond nanosensors for nanoscale metrology, introduce them into living cells, and explore their interactions with the intra-cellular environment.

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

Research Projects Summer 2018

Project ID	**URI P18/13_Rothen**
Project title	**Interaction of stimuli-responsive nanomaterials with single cells**
Research group	Prof. Barbara Rothen-Rutishauser http://www.am-institute.ch/research/bionanomaterials
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	8-12 weeks
Possible period	**Both periods I (15 May - 15 August) & II (15 June - 15 September)**

Project summary

Stimuli-responsive nanoparticles (NPs) have gained increased interest for biomedical applications. However, those NPs have first to be thoroughly tested for their possible impact on biological systems, i.e. single cells, at an early stage of the development phase. Aim of this summer project is to develop an understanding of the current standard in hazard assessment of such newly designed NPs. Different cell types will be exposed to an increasing concentration of NPs. Cell viability is then tested using different methods routinely performed in our laboratory. Possible observed effects will be correlated with the cellular uptake of the NPs, which can be assessed via laser scanning microscopy (LSM) for fluorescently labelled NPs. For selected NPs the interaction with cells and possible impact on cell viability will be visualized time-dependently by acquiring live cell movies at the LSM. These results will provide a better understanding of the interaction of stimuli-responsive NPs with cells and the possible consequences.

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

Research Projects Summer 2018

Project ID	**URI P18/14_Steiner**
Project title	**Fabricating aligned nanostructures in block copolymer films**
Research group	Prof. Ullrich Steiner http://www.am-institute.ch/research/soft-matter-physics
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	8-12 weeks
Possible period	**Both periods I (15 May - 15 August) & II (15 June - 15 September)**

Project summary

Block copolymers (BCPs) consist of two or more polymers linked together by covalent bonds. BCPs self-assemble into ordered structures with a wide range of periodic 3D nano-morphologies such as gyroids, cylinders and lamellae. These polymer nanomorphologies can be converted into optical meta-materials by electrodepositing or gold silver into the nanostructured polymer templates.

The main limitation of this approach is the present inability to control the long-range order of the BCP morphology. In this project electric fields will be used to align the nanostructures.

Preparation Methods: Thin film processing, spin coating, electric field alignment.

Characterization techniques: Optical microscopy, atomic force and scanning electron microscopy, X-ray scattering.

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

Research Projects Summer 2018

Project ID	**URI P18/15_Steiner**
Project title	**Helical block copolymers as templates for optical metamaterials**
Research group	Prof. Ullrich Steiner http://www.am-institute.ch/research/soft-matter-physics
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	8-12 weeks
Possible period	**Both periods I (15 May - 15 August) & II (15 June - 15 September)**

Project summary

Block copolymers (BCPs) are polymer materials made of two or more distinct monomers or block units covalently bonded together in a variety of different architectures. Due to their strong incompatibility, the blocks tend to phase separate. BCPs can self-assemble into various nanoscale morphologies including spheres, cylinders, lamellae, or the bicontinuous gyroid. Interestingly, if one of the blocks is semicrystalline, BCPs can even self-assemble into a helical morphology, which can serve as a template for the fabrication nanostructured plasmonic metals, e.g. gold (Au). Helical nanostructured plasmonic materials are predicted to behave as optical metamaterials, i.e. they may exhibit optical properties otherwise unheard of in nature (e.g. a negative refractive index). However, for BCP self-assembly to be relevant for applications in nanotechnology the fabrication of nanostructures with controlled degrees of order is required. The aim of this project is the fabrication and characterization of helical block copolymer films and their replication into Au. Films will be made by means of drop casting or spin coating. Self-assembly into helical morphology will be realized by an annealing process. The resulting helical morphology will be replicated into Au by electroplating. The prepared structure will be characterized by means of SFM, SEM and SAXS.

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

Research Projects Summer 2018

Project ID	**URI P18/16_Steiner**
Project title	**Investigation and Preparation of Microfluidic Systems**
Research group	Prof. Ullrich Steiner http://www.am-institute.ch/research/soft-matter-physics
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	8-12 weeks
Possible period	**Only period II = 15 June - 15 September**

Project summary

Microfluidic Systems are a popular and straightforward tool, employed in various scientific areas due to their practical applications in automation and high-throughput screening. It is a multidisciplinary field combining engineering, physics, chemistry, biochemistry and nanotechnology. The dimension confinement forms the key element of such a device. The main part of this project will be the fabrication of such a device using mainly 3D-printing techniques followed by the investigation of its properties. The influence of different materials as well as toying with the confinement features is expected to give indication of the most relevant factors for specific device design.

We want to fabricate a series of different microfluidic devices, suitable for preparing multiple emulsions.

Requirements: Learning how to use a CAD - Software (free choice, preferably Blender)

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

Research Projects Summer 2018

Project ID	**URI P18/17_Vanni**
Project title	**Molecular dynamics simulations of cationic polymers**
Research group	Prof. Stefano Vanni http://www.unifr.ch/biology/research/vanni/
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	10-12 weeks
Possible period	**Both periods I (15 May - 15 August) & II (15 June - 15 September)**

Project summary

Cationic polymers are of great interest as both genetic carriers to be used in gene therapy or biotechnology, as well as antimicrobial agents. In particular, complexes of a cationic polymer (polylysine) with short single strands of NDA are known to form coacervate microdroplets that mimic membrane-free protocells. In this summer project, we plan to use coarse-grain molecular dynamics simulations to study the conformational flexibility of polylysine polymers and their self-assembly behavior both in the absence or presence of single strands DNA. In this summer project, the student will learn how to work in an UNIX-environment and to use high-performance computing software to investigate structural and dynamical properties of both synthetic and natural molecules

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

Research Projects Summer 2018

Project ID	**URI P18/18_Weder**
Project title	**Supramolecular polymer adhesives inspired by Nature**
Research group	Prof. Christoph Weder http://www.am-institute.ch/research/soft-matter-scattering
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	8-12 weeks
Possible period	**Both periods I (15 May - 15 August) & II (15 June - 15 September)**

Project summary

Many natural adhesives are based on non-covalent interactions, e.g. the gecko footpads (van der Waals forces) or the adhesion of mussels (hydrogen- bonding/metal-ligand complexation). The incorporation of such dynamic, supramolecular bonds into polymeric materials is exploited in stimuli-responsive materials whereby a change in the properties can be induced by external triggers, such as light or heat. This feature is particularly attractive when considering adhesives that can debond on demand.

In this project well-established procedures will be followed for the synthesis and functionalization of polymers containing bio-inspired supramolecular motifs such as hydrogen-bonding units or metal-ligand complexes. A range of materials will be prepared and their mechanical properties will be studied using industrially relevant techniques. Furthermore, their potential application as light and/or temperature-responsive adhesives will be investigated.

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

Research Projects Summer 2018

Project ID	**URI P18/19_Weder**
Project title	**Leaf cuticle-inspired membranes**
Research group	Prof. Christoph Weder http://www.am-institute.ch/research/soft-matter-scattering
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	10 weeks
Possible period	**Only period I = 15 May - 15 August**

Project summary

The objective of this project is to prepare and investigate bio-inspired nanocomposite membranes consisting of a hydrophobic polymer matrix and polysaccharides that form a dispersed phase and enable the transport of water and other hydrophilic compounds. The targeted materials mimic the structure and transport function of leaf cuticles. These heterogeneous bio-membranes are primarily composed of a hydrophobic matrix in which polysaccharides create hydrophilic pathways that permit (controlled) transport of polar species. Artificial materials that adopt this structure and function are useful for the design of products where transportation of water or other hydrophilic compounds should be facilitated, e.g. sportswear and membranes for separation processes. The summer intern involved in the project will 1) prepare composite materials composed of commercially available polymers and polysaccharides and 2) evaluate the mechanical, thermal and transport properties of the materials.

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

Research Projects Summer 2018

Project ID	**URI P18/20_Weder**
Project title	**Biocompatible, mechanically-adaptive polymers for intracortical implants**
Research group	Prof. Christoph Weder http://www.am-institute.ch/research/soft-matter-scattering
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	8-12 weeks
Possible period	**Only period I = 15 May - 15 August**

Project summary

The aim of this project is to produce mechanically-adaptive intracortical implants based on known biocompatible polymers. While an extensive range of such polymers is commonly utilized in aqueous solutions for drug delivery applications, their use in macroscopic devices that interface with the body is limited. The materials obtained in this project will be mechanically tested both in their dry state and under conditions simulating the body. As a result of water uptake, these materials exhibit mechanically adaptive properties: stiff when dry and soft when in the body. Additionally, as a result of their biocompatibility, such mechanically adaptive polymers are immensely interesting for the coating of stiff cortical electrodes: they can penetrate into the brain and, upon softening, retain the properties of the electrode while preventing further tissue damage.

The summer intern will prepare a functional monomer exhibiting interesting properties, prepare polymers and evaluate the mechanical properties of these novel materials under physiological conditions (both dry and body-simulating).

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

Research Projects Summer 2018

Project ID	**URI P18/21_Bruns**
Project title	**Cuticle mimetic layered polymeric materials**
Research group	Prof. Nico Bruns http://www.am-institute.ch/research/macromolecular-chemistry
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	8-12 weeks
Possible period	**Only period I = 15 May - 15 August**

Project summary

The cuticle proper of plant leaves a stack of polymer and wax layers. It influences the diffusion of waxes from the cells beneath to the surface of the plant. The wax layer on plants determines the wetting properties a leaf and the adhesion properties of insects on the leaves. The aim of this project is to design and prepare cuticle-mimetic multilayer polymer-wax coatings. Techniques like spin-coating, analyzing thin films by ellipsometry and chemical synthesis will be taught and applied in this interdisciplinary project. The transport of waxes and other components across multilayered materials will be studied (e.g. by fluorescence microscopy) and the influence of mechanical deformation of the multi-layer coatings in the release of waxes will be investigated.