Hierarchical & Functional Materials for health, environment & energy | HiFunMat

The Interdisciplinary thematic institutes of the University of Strasbourg & CNRS & Inserm funded under the Excellence Initiative program

ITI HiFunMat Master Internship Proposal

☒ M 1 ☐ M 2

Title: Design of plasmonic catalysts for CO_2 recycling into methane

Internship supervisor

Name, first name	CAPS Valérie
E-mail, Telephone	caps@unistra.fr 03 68 85 27 33
Laboratory	ICPEES
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Valérie KELLER

Student profile looked for

Master program (*more than one box can be ticked*)	☒ Material science and engineering ☒ Chemistry ☐ Physics
Other indications if necessary	

Internship description

Carbon dioxide is one of the major pollutants of our world. It is produced on a large scale, as an inevitable by-product of human activity. It is so far continuously released in the atmosphere, where it accumulates, with life-threatening consequences on climate change. On the other hand, useful energy resources, such as oil, are running out. What if CO_2 could be recycled and become the next generation, renewable and sustainable energy resource? This is what we are currently investigating in the CNRS-funded SelCO2PlasmonRed project. We have indeed found that CO_2 could be reduced into methane using light-activated catalysts. More precisely, we have found that the plasmon-induced transformation, i.e. the transformation driven by plasmonic metal nanoparticles, was particularly selective. It also allows to get continuous productions of methane over extended periods of time. However, turnovers remain very low and strategies to improve the catalytic materials remain to be found.

In particular, the composition of the metal nanoparticles (NPs) has been shown to affect the catalytic performances and some improvement has been achieved by using bi-metallic NPs supported on titania. This M1 internship of ITI HiFunMat will focus on the control of the alloy nanostructure in such supported bi-metallic systems, in order to allow determination of the optimal alloy nanostructure for the reaction. The internship will thus involve both the controlled chemical synthesis of supported mono- and bi-metallic metal NPs and their characterization with UV-visible spectroscopy, XPS and TEM.

Work will take place in the PhotoCatalysis and PhotoConversion (PCPC) team of ICPEES. It will benefit from the knowledge acquired within the SelCO2PlasmonRed project, the experience of the team in this field, and the support of technicians and PhD researchers of the PCPC team. The candidate is expected to be able to work both autonomously and in a team, with shared equipment and schedule.

This topic relates to both energy and environment.

To be returned by e-mail before **19 September 2022** to melodie.galerne@unistra.fr

ITI HiFunMat Master Internship Proposal

☒ M 1 ☐ M 2

Formulations prepared from oligoarginine-based polymers for the controlled release of drugs

Internship supervisor

Name, first name	CHAN-SENG Delphine
E-mail, Telephone	delphine.chan-seng@ics-cnrs.unistra.fr, +33 3 88 41 40 76
Laboratory	Institut Charles Sadron, UPR22
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes: Fouzia BOULMEDAIS (UPR 22)

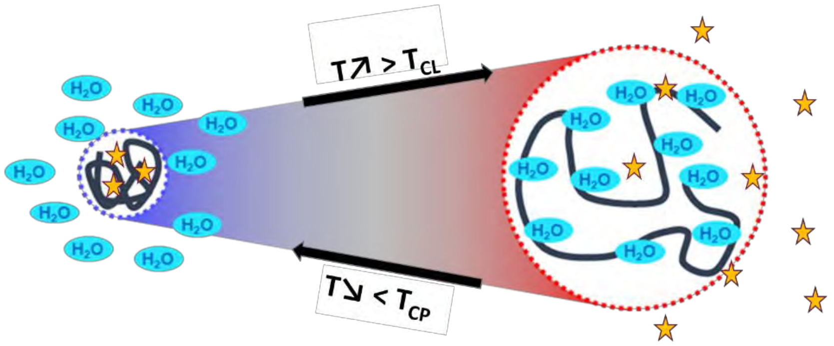
Student profile looked for

Master program (*more than one box can be ticked)*	☒ Material science and engineering ☒ Chemistry ☐ Physics
Other indications if necessary	

Internship description

Traditional chemotherapy is currently facing challenges. The low drug solubility and stability, its non-specificity, and its early elimination are resulting in undesirable and sometimes irreversible side effects. In order to overcome these problems, research groups are trying to develop new therapeutic strategies. Among them, vectorization consists in using nanoparticles as drug carriers able to release it in a spatially and temporally controlled manner. Smart materials are of increasing interest in this field. For example, thermosensitive polymers with an UCST (Upper Critical Solution Temperature) behavior could be candidates of choice. The drug release would be then based on the variation in polymer solubility triggered by the change in temperature. These polymers in solution are characterized by a phase transition temperature. Below this temperature (clearing point, T_{CL}), the polymer in solution is partially miscible and forms two phases (one rich in polymer and the other rich in solvent): in this state, the drug would be trapped in the polymer-rich phase. On the other hand, the polymer becomes fully miscible in the solution as the temperature increases above the phase transition temperature allowing the drug to be released.

Recently, our team has developed oligoarginine-based polymers whose UCST-like thermosensitivity relies on the nature and reversibility of the interactions between the guanidinium groups. These polymers are prepared in three main steps involving 1) the synthesis of the oligopeptide by solid-phase peptide synthesis, 2) its end-capping to introduce a (meth)acrylate function, and 3) the controlled radical polymerization of the macromonomer obtained in aqueous solution. During this last step, the control of the polymerization is essential to modulate the thermosensitive properties. A low molecular distribution of the polymer chains allows obtaining a marked transition, *i.e.* only over a range of 1 to 2 °C, while the degree of polymerization (DP) allows modulating the value of the phase transition temperature. However, due to their large number of charges, these polymers are sensitive to small changes in pH and/or ionic strength. For example, the addition of sodium chloride at the physiological concentration can induce a decrease of several tens of degrees, often leading to a phase transition temperature below room temperature. In order to exploit these properties of the polymers for biomedical applications, it is therefore necessary to reach a phase transition temperature above 35 °C in saline solution. To achieve this, two strategies can be considered i) considerable increase of the degree of polymerization and ii) formulation of the polymer with molecules capable of interacting specifically with its functions. Molecules of therapeutic interest (★)and capable of interacting with the polymer have been synthesized in the laboratory. Preliminary tests have shown an increase of the phase transition temperature of about 10 °C in aqueous solution for the formulation as compared to the polymer alone.



The aim of the internship will be to prepare formulations of polymers with these molecules in order to determine the conditions giving rise to a phase transition temperature higher than 35 °C in saline solution and allowing the controlled release of these molecules. The measurements of the phase transition temperature will be conducted by turbidimetry using a UV-Vis spectrophotometer equipped with a Peltier cell, while the controlled release study will be investigated by liquid chromatography coupled with a mass spectrometer. During the internship, other synthesis and characterization techniques could be implemented such as controlled radical polymerization (RAFT: Reversible Addition-Fragmentation chain-Transfer polymerization), UV-Visible, FTIR, and NMR spectroscopies, and steric exclusion chromatography.

ITI HiFunMat Master Internship Proposal

☒ M 1 ☐ M 2

Title : Optimization of the active sites measurements for activated carbons by mass spectrometry

Internship supervisor

Name, first name	RETY, Bénédicte
E-mail, Telephone	benedicte.rety@uha.fr 0389608742
Laboratory	Institut de Sciences des Matériaux de Mulhouse
Collaboration with a HiFunMat member (*please indicate their name*)	☒ No ☐ Yes :

Student profile looked for

Master program (*more than one box can be ticked*)	☒ Material science and engineering ☒ Chemistry ☐ Physics
Other indications if necessary	

Internship description

Activated carbons are widely used in water and gas treatment due to their high porosity. These materials have chemical surface groups and active sites, which are useful to adsorb molecules.

The quantification of active sites can be done using thermodesorption coupled with mass spectrometry (TPD-MS). The aim of this internship is to optimize the temperature and time parameters to ensure proper measurement of the active sites.

Under inappropriate experimental conditions, active sites measurements can lead to changes in surface area and weight loss of the activated carbon. Hence, it gives errors in the active sites quantification, therefore, the development of an accurate measurement protocol is required.

In this purpose, two activated carbons with different properties will be studied. The idea is to find measurement parameters that can be used for all kind of activated carbons.

During that internship the following techniques will be used for the materials characterization :

- **TPD-MS** : to quantify the active sites
- **Thermogravimetric Analysis** : to measure the weight loss
- **Gas adsorption** : to measure the specific surface area

The internship will be performed in the Carbon and Hybrid Materials group and specific experiments will be undertaken on the technical platforms of the institute.
https://www.is2m.uha.fr/fr/nos-axes-thematiques/carbone-et-materiaux-hybrides/

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ITI HiFunMat Master Internship Proposal

☒ M 1 ☐ M 2

Title : Development of ratiometric fluorescent chemosensors for ferric iron detection in disease diagnosis

Internship supervisor

Name, first name	ALBRECHT, Sébastien
E-mail, Telephone	sebastien.albrecht@uha.fr, 0389336714
Laboratory / Industry	LIMA
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Dr C. Ghimbeu IS2M
Address	3bis rue Alfred Werner, IRJBD-LIMA, Mulhouse

Student profile looked for

Master program	☐ Material science and engineering ☒ Chemistry ☐ Physics
Minimum duration of internship	☐ 2 months ☐ 4 months ☐ 6 months
Other indications if necessary	2.5-3 months (from april, 01st to June, 15th)

Internship description

Physiologically, Iron is the most abundant and versatile transition metal ion in human. Present in the cells to facilitate biological action, Iron metabolism disorders encompass a broad spectrum of common human diseases with diverse clinical manifestations, ranging from anemia to iron overload. Most pathological conditions are caused by extreme parameters e.g. too much or not enough iron. Multiple organs can be affected by excess iron and cause disease including Hereditary Hemochromatosis (HH) for the liver, ferritinopathy for the brain, macrophage overload, thalassemia syndromes or congenital- and acquired-sideroblastic anemias for the bone marrow compartment. Moreover, chronic oral administration or chronic blood transfusion may also induce iron overload.

The aim of this internship will be the development of novel ratiometric fluorescent chemosensors able to selectively detect intracellular endogeneous ferric iron.

In this position, you will design, plan and perform multi-step small molecule organic synthesis experimentation and evaluate the photophysical properties of the synthesized chemosensors. You will generate and evaluate data, interpret, report results, and draw conclusions.

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ITI HiFunMat Master Internship Proposal

☒ M 1 ☐ M 2

Title : Late-Stage Visible-light-assisted Functionalization of Uracil derivatives as potential antimalarial agents

Internship supervisor

Name, first name	ALBRECHT, Sébastien
E-mail, Telephone	sebastien.albrecht@uha.fr, 0389336714
Laboratory / Industry	LIMA
Collaboration with a HiFunMat member (*please indicate their name*)	☒ No ☐ Yes :
Address	3bis rue Alfred Werner, IRJBD-LIMA, Mulhouse

Student profile looked for

Master program	☐ Material science and engineering ☒ Chemistry ☐ Physics
Minimum duration of internship	☐ 2 months ☐ 4 months ☐ 6 months
Other indications if necessary	2,5 months (from March, 23rd to June, 10th)

Internship description

Despite significant progress in the control of malaria with a net reduction of morbidity and mortality over the past years, it remains as one of the deadliest infectious diseases in the world. New drugs with broad therapeutic potential and novel modes of action to overcome emerging drug resistances are urgently needed. We have recently identified a quinazolinedione-based scaffold exhibiting potent antimalarial activities against multiple life stages of Plasmodium, as well as fast acting and transmission blocking activities. The optimization of this "drug-candidate" is in progress and led us to direct our efforts towards the derivatization of uracil derivatives.

The aim of this internship will be the exploration of new methodologies for rapid construction of 5-aryl/heteroaryl/morpholino uracil derivatives under photoredox catalysis, and to transfer the previous batch method to continuous flow photochemistry.

In this position, you will design, plan and perform advanced discovery research projects by performing multi-step small molecule organic synthesis experimentation. You will generate and evaluate data, interpret, report results, and draw conclusions.

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ITI HiFunMat Master Internship Proposal

☒ M 1 ☒ M 2

Synthesis of organofluorine compounds for the design of fluorinated supramolecular systems having applications in the field of organic semiconductors.

Internship supervisor

Name, first name	Ruiz-Carretero, Amparo
E-mail, Telephone	Amparo.ruiz@ics-cnrs.unistra.fr
Laboratory	Institute Charles Sadron, UPR 22, Strasbourg
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Vincent Bizet

Student profile looked for

Master program (*more than one box can be ticked)*	☐ Material science and engineering ☒ Chemistry ☐ Physics
Other indications if necessary	

Internship description

This internship is a collaboration between the **BSM team of the LIMA laboratory in Mulhouse**, which possesses an expertise in the design of small fluorinated molecules, and the **SYCOMMOR team of the ICS laboratory in Strasbourg**, which focus his research on the study and design of semi-conducting polymers and self-assembled structures intended for the development of organic photovoltaic systems. Current solar panels mainly use silicon as a semiconductor material. However, this will no longer be sufficient to cover future solar energy needs. Systems using organic molecules as semiconductors are an advantageous alternative in view of their lower cost and their potential diversity via the control of their synthesis, which also allows a diversity in their properties. An option that has been little studied is the impact of non-covalent interactions on the performance of organic photovoltaic systems such as halogen and/or hydrogen bonds. The incorporation of fluorinated groups into organic molecules will impact the physicochemical properties (lipophilicity, biodisponibility, etc.) and mostly the pKa of nearby functional groups which could in turn enhance hydrogen and halogen bonding for self-assembling.

In this project, the SYCOMMOR and BSM teams want to share their know-how to build fluorinated supramolecular systems and study the formation of hydrogen bonds which can be enhanced by the presence of fluorinated groups and modulated according to the nature of the fluorinated groups (ex: F, CF_3, SF_5, etc).

The same project is proposed on the two sites: **in Mulhouse in the BSM team for the design of a library of fluorinated building blocks** (organic synthesis) and **in Strasbourg in the SYCOMMOR team for the incorporation of the fluorinated building blocks into supramolecular systems** (supramolecular chemistry). This project is part of an active collaboration between the BSM and SYCOMMOR teams and both aspects of the project are different but complementary, and can be driven by different students.

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ITI HiFunMat Master Internship Proposal

☒ M 1 ☒ M 2

Title: Grafting Poly(lactic acid) onto Zn-Mg Alloy for the Preparation of Bioresorvable Prostheses

Internship supervisor

Name, first name	MERY, Stephane
E-mail, Telephone	mery@ipcms.unistra.fr ; 0388107165
Laboratory	IPCMS, Strasbourg
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Lydie Ploux (U1121) & Karine MOUGIN (IS2M)

Student profile looked for

Master program (*more than one box can be ticked)*	☒ Material science and engineering ☒ Chemistry ☐ Physics
Other indications if necessary	

Internship description

Biocompatible and biodegradable prostheses whose resolvability can be controlled over time are of great interest in the medical field because they avoid additional costs and trauma, and the risk of potential infection associated with a second medical surgery.

In this context, we aim at developing innovating bioresorvable materials made of porous Zn-Mg alloy scaffold that are chemically functionalized by poly(lactic acid) (PLA). The degradation of PLA being much slower than that of the metallic scaffold, the role of the PLA coverage is therefore to provide a protective envelope for the implant for a given period of time, to allow the necessary time for a complete bone regeneration.

The aim of the internship consists in developing, optimizing and characterizing the grafting of a PLA layer of controlled thickness onto a model Zn-Mg alloy scaffold by using one or the two following procedures:

- **A grafting-from procedure, i.e. a surface-induced polymerization of lactate onto the Zn-Mg alloy**
- **A grafting-to procedure, i.e. the preliminary preparation of a PLA with end-reactive group and its subsequent reaction onto the Zn-Mg alloy.**

The internship essentially consists in polymer chemistry. It also includes the extensive characterization of every synthetic step by means of infrared (FTIR) and NMR spectroscopy, Size exclusion Chromatography (SEC) and by scanning Electron Microscopy (SEM) image analysis.

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ITI HiFunMat Master Internship Proposal

X M 1 X M 2

Syntheses of biosourced monomers and applications for radical photopolymerisations

Internship supervisor

Name, first name	BECHT, JEAN-MICHEL
E-mail, Telephone	jean-michel.becht@uha.fr ; 03.89.60.87.22
Laboratory	Institut de Science des Matériaux de Mulhouse (IS2M)
Collaboration with a HiFunMat member (*please indicate their name*)	X No ☐ Yes :

Student profile looked for

Master program (*more than one box can be ticked)*	X Material science and engineering X Chemistry ☐ Physics
Other indications if necessary	

Internship description

Polymers are important materials in the daily life of our modern societies. Their syntheses are mainly based on the use of starting materials derived from petroleum resources. The cost of synthesising polymers is therefore likely to rise sharply over the years as a result of the current increasing in oil prices. To overcome this drawback, the replacement of petroleum resources by biosourced resources is a topical issue. In this way, non-renewable fossil resources would be replaced by 'green', renewable compounds obtained from nature. This approach should also greatly limit the toxicity of the monomers and polymers synthesised.

The aim of this proposition will be to synthesise biosourced monomers by carrying out acrylation or methacrylation reactions of natural products present, for example, in plant seeds or in tree barks. Their reactivity will then be tested in formulations for radical photopolymerisations (polymerisations under light irradiation of a formulation containing the monomer and a photoinitiator system and sometimes additives). The mechanical properties of the polymers formed will also be studied in detail to obtain all the necessary informations on the final performances of the new biosourced polymers. Finally, the recyclability of the polymers will be studied (regeneration of the monomer by thermal decomposition, hydrolysis of the polymer into smaller molecules of interest or solubilisation of the polymer in a solvent). It should be noted that this internship will allow the candidate to acquire a solid experience in both organic synthesis and in the elaborations and characterizations of polymeric materials.

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ITI HiFunMat Master Internship Proposal

☒ M 1 ☒ M 2

Synthesis of organofluorine compounds for the design of fluorinated supramolecular systems having applications in the field of organic semiconductors.

Internship supervisor

Name, first name	Bizet, Vincent
E-mail, Telephone	vbizet@unistra.fr
Laboratory	LIMA UMR 7042, Mulhouse
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Amparo Ruiz Carretero

Student profile looked for

Master program (*more than one box can be ticked)*	☐ Material science and engineering ☒ Chemistry ☐ Physics
Other indications if necessary	

Internship description

This internship is a collaboration between the **BSM team of the LIMA laboratory in Mulhouse**, which possesses an expertise in the design of small fluorinated molecules, and the **SYCOMMOR team of the ICS laboratory in Strasbourg**, which focus his research on the study and design of semi-conducting polymers and self-assembled structures intended for the development of organic photovoltaic systems. Current solar panels mainly use silicon as a semiconductor material. However, this will no longer be sufficient to cover future solar energy needs. Systems using organic molecules as semiconductors are an advantageous alternative in view of their lower cost and their potential diversity via the control of their synthesis, which also allows a diversity in their properties. An option that has been little studied is the impact of non-covalent interactions on the performance of organic photovoltaic systems such as halogen and/or hydrogen bonds. The incorporation of fluorinated groups into organic molecules will impact the physicochemical properties (lipophilicity, biodisponibility, etc.) and mostly the pKa of nearby functional groups which could in turn enhance hydrogen and halogen bonding for self-assembling.

In this project, the SYCOMMOR and BSM teams want to share their know-how to build fluorinated supramolecular systems and study the formation of hydrogen bonds which can be enhanced by the presence of fluorinated groups and modulated according to the nature of the fluorinated groups (ex: F, CF_3, SF_5, etc).

The same project is proposed on the two sites: **in Mulhouse in the BSM team for the design of a library of fluorinated building blocks** (organic synthesis) and **in Strasbourg in the SYCOMMOR team for the incorporation of the fluorinated building blocks into supramolecular systems** (supramolecular chemistry). This project is part of an active collaboration between the BSM and SYCOMMOR teams and both aspects of the project are different but complementary, and can be driven by different students.

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ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Assessing the Local Reaction Environment during Electrocatalysis through the Use of ESIPT Fluorescent Probes

Internship supervisor

Name, first name	Asset, Tristan; Massue, Julien
E-mail, Telephone	t.asset@unistra.fr; massue@unistra.fr;
Laboratory	ICPEES
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Massue, Julien; Savinova, Elena; Ulrich, Gilles

Student profile looked for

Master program (*more than one box can be ticked)*	☒ Material science and engineering ☒ Chemistry ☐ Physics
Other indications if necessary	Knowledge in both electrochemistry and synthetic organic chemistry is required for this project

Internship description

Achieving a detailed understanding of the local reaction environment (LRE, *i.e.* the electrolyte and electrode properties near the electrocatalytic sites) during electrocatalysis is paramount and, throughout the past years, became one of the most important challenge brought fourth to the electrochemist' community, encompassing many applications such as fuel cells, electrolyzers, batteries, *etc.* For example, differences are often observed between the pH far from the electrode (*e.g.* the bulk) and the pH in the LRE [1,2]. Those pH differences can strongly impact the thermodynamics (as pH plays an integral role in the Nernst equation), surface states (*cf.* Pourbaix diagrams) or the kinetics of a given electrochemical reactions. As, nowadays, the characterization tools mainly focus onto the bulk, either of the electrode or of the electrolyte, new tools have to be developed to be able to assess, *operando*, the properties of the interface. Among them, organic fluorophores based on small molecules are attractive candidates, owing to the sensitivity of molecular fluorescence to probe their micro-environment., Indeed, organic chemistry allows the design of specific fluorescent probes, whose photophysical properties can be finely tuned by a specific set of electrolyte properties. Moreover, fluorescence spectroscopy is a highly sensitive analytical technique requiring probe concentration in the sub-10^{-6} M range, thus greatly limiting the impact of the probe on the electrochemical system (*e.g.* modification of the reactive interface by specific absorption).

Earlier this year, we investigated the possibility to use an organic fluorophore derived from the hydroxybenzazole (HBX) family, showing an 'excited state intramolecular proton transfer' (ESIPT) process. ESIPT fluorescence has been intensively studied as it confers, to the dyes displaying it, enhanced photostability and environment-sensitive optical profiles. Moreover, ESIPT process can compete with other excited-state dynamics, such as deprotonation, enabling the possibility to engineer ratiometric molecular switches. We studied the possibility to use a ratiometric signal, based on the ESIPT/deprotonation dual emission to assess the near-electrode change in pH for the water reduction, in the 11 – 13 pH range. The preliminary results were encouraging (see **Figure 1**). By using 10^{-6} M ethynyl-extended HBX fluorophores encapsulated in a selected amphiphilic polymer, in 0.1 M $NaClO_4$ + 0.1 mM NaOH we were able to follow *operando* the ratiometric changes in the molecule emission profile, *i.e.* the modulation of the intensity ratio between the two emission bands. We were able to translate these results to the determination of local pH, as a function of the potential applied at the working electrode and of time. The current project thus acts as an extension of this work, aiming to:

#1: Develop a library of novel ESIPT, encapsulated, ratiometric probes based on the HBX scaffold but also on other structures, capable to ratiometrically monitor the 1 – 13 pH range, including a detailed calibration of the ratiometric signal *vs.* pH.

#2: Design a spectro-electrochemical cell compatible with confocal scanning laser microscopy (CSLM) and electrochemical characterization.

#3: Assess the ESIPT probes capacity to provide high resolution mapping (< 500 nm) of the pH at the electrochemical interface through the use of CSLM in collaboration with ICPEES's partners.

The M2 intern, required for of this project is expected to have a basic understanding of both (i) organic synthesis; (ii) fluorescence spectroscopy and (iii) electrochemistry, as all of those aspects are pivotal for the completion of this project. The project will take place between the COMBO and ECE teams of the ICPEES, under the supervision of Drs Julien Massue and Tristan Asset.

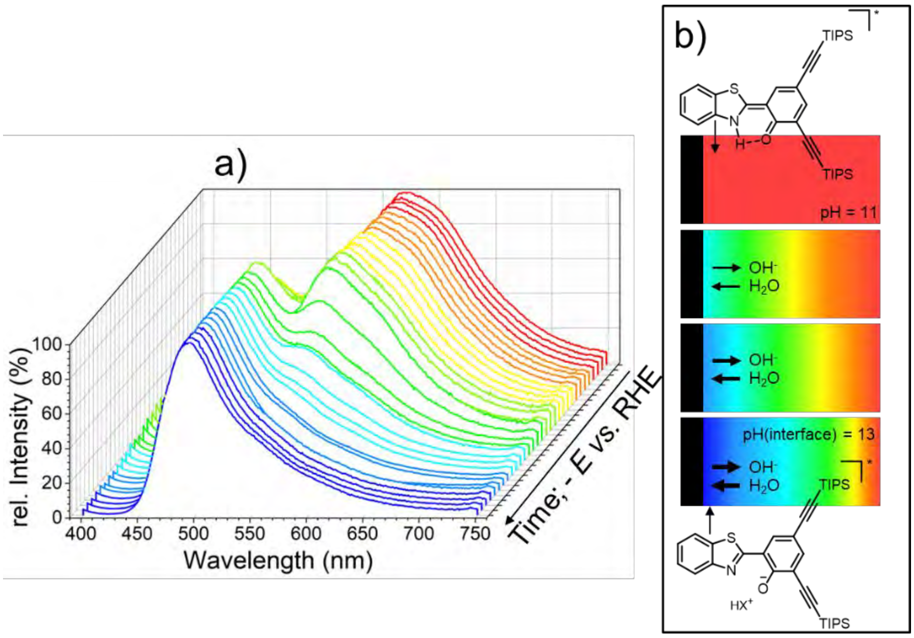

Figure 1. Illustration of the preliminary results (see. M. Walter *et al*, in preparation) **obtained on the use of encapsulated ESIPT fluorescent probes to assess the pH variation near the catalyst interface.** The measurements were performed in a UV-vis adapted electrochemical cell, using a platinum grid as the working electrode with N_2-saturated NaOH 0.1 mM + $NaClO_4$ 0.1M as the electrolyte. The potential was varied from – 0.05 to – 0.45 V *vs.* RHE by steps of – 100 mV every 5 min, thus allowing various reaction rates for the water reduction (leading to OH^- generation and, thus, pH increase); (a) fluorescent signal for the ESIPT probes illustrated in (b) measured near the electrode surface. The water reduction lead to a shift in the wavelength of the fluorescent probes, thus indicating a pH increase, as illustrated in (b).

1. Monteiro, M. C. O. & Koper, M. T. M. Measuring local pH in electrochemistry. *Curr Opin Electrochem* **25**, 100649 (2021).
2. Pande, N. *et al.* Electrochemically Induced pH Change: Time-Resolved Confocal Fluorescence Microscopy Measurements and Comparison with Numerical Model. *Journal of Physical Chemistry Letters* **11**, 7042–7048 (2020).

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ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Title: Plasmon-induced CO_2 recycling into methane over supported metal nanoparticles

Internship supervisor

Name, first name	CAPS Valérie
E-mail, Telephone	caps@unistra.fr 03 68 85 27 33
Laboratory	ICPEES
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Valérie KELLER

Student profile looked for

Master program (*more than one box can be ticked*)	☒ Material science and engineering ☒ Chemistry ☐ Physics
Other indications if necessary	

Internship description

Carbon dioxide is one of the major pollutants of our world. It is produced on a large scale, as an inevitable by-product of human activity. It is so far continuously released in the atmosphere, where it accumulates, with life-threatening consequences on climate change. On the other hand, useful energy resources, such as oil, are running out. What if CO_2 could be recycled and become the next generation, renewable and sustainable energy resource? This is what we are currently investigating in the CNRS-funded SelCO2PlasmonRed project. We have indeed found that CO_2 could be reduced into methane using light-activated catalysts. More precisely, we have found that the plasmon-induced transformation, i.e. the transformation driven by plasmonic metal nanoparticles, was particularly selective. It also allows to get continuous productions of methane over extended periods of time. However, turnovers remain very low and strategies to improve the catalytic materials remain to be found.

What we intend to study during the course of this M2 internship of ITI HiFunMat is the role of the inorganic support carrying the nanoparticles. The internship will thus involve supported metal nanoparticles synthesis and characterization, with techniques such as UV-visible spectroscopy, XPS, TEM. It will also involve catalytic evaluation of the materials in a state-of-the-art photocatalytic platform, dedicated to CO_2 photoreduction, to determine their performance.

Work will take place in the PhotoCatalysis and PhotoConversion (PCPC) team of ICPEES. It will benefit from the knowledge acquired within the SelCO2PlasmonRed project, the experience of the team in this field, and the support of technicians and PhD researchers of the PCPC team. The candidate is expected to be able to work both autonomously and in a team, with shared equipment and schedule.

This topic relates to both energy and environment.

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ITI HiFunMat Master Internship Proposal

☐ M 1 X M 2

Title : Localized Photo-ElectroChemical: Rapid optimization of photoelectrode material for Hydrogen production

Internship supervisor

Name, first name	Cottineau Thomas
E-mail, Telephone	cottineau@unistra.fr / 03 68 85 27 33
Laboratory	ICPEES UMR7515
Collaboration with a HiFunMat member (*please indicate their name*)	X No ☐ Yes :

Student profile looked for

Master program (*more than one box can be ticked)*	X Material science and engineering ☐ Chemistry ☐ Physics
Other indications if necessary	

Internship description

Solar energy has a great potential to meet the challenges that our societies face thanks to the large amount of energy brought annually to Earth by sunlight and its availability in almost all regions of the planet. Besides, the conversion of photon into electricity in photovoltaic panels, new applications using semiconductor (SC) material to convert light energy into chemical energy are emerging. These so photoelectrochemical (PEC) approaches uses thin-film electrodes and can convert solar energy into storable chemical energy (solar fuel, e.g.: H_2) or be used for degradation of pollutant in air or in water. If promising results were obtained by different teams around the world, it appears that a single material cannot gather all the required properties in terms of light collection, charge carriers mobility (e^-/h^+ pairs), stability in water and catalysis of the redox reactions. It is then required to create and optimize composite electrodes which will associate different materials that will ensure different functions. Furthermore, some of the mechanisms leading to high efficiency photo-electrochemical conversion still must be understood.

In this project we aim to develop a unique photoelectrochemical tool that can be used to determine some properties of the SC electrode *operando* in PEC conditions and that could turn into a powerful tool to rapidly optimize the structure of photoelectrodes. This method uses a small light spot as a probe to analyze the PEC efficiency of electrodes that present variable properties along their surface. In this way during the mapping of the electrode, the PEC reaction is only triggered under the illuminated area. First promising results were already obtained in our group on TiO_2 nanotubes film with variable thickness to optimize light absorption and charge transport in the photoelectrode for water splitting reaction (F. Gelb et al. *Sustain. Energy & Fuels*, 4, **2020**, 1099). Here the main objectives will be: (1) use this approach for composite electrode by studying the influence of the loading in Pt or Au nanoparticles deposited as co-catalyst on the surface of TiO_2 to accelerate the H_2 evolution reaction. (2) To use Photoelectrochemical impedance spectroscopy method (IMPS) combined with local illumination to determine photogenerated charge carrier transport properties locally on the surface of the electrode with variable properties.

This project is for a master 2 student in the field of Chemistry, Physico-Chemistry or Material Science. It requires a strong motivation for experimental work and an ability to understand the multidisciplinary aspects of the project such as electrochemistry, optic, materials synthesis *etc*. For more information and to apply please send a **CV and a motivation letter to Thomas Cottineau (cottineau@unistra.fr ; 03 68 85 27 33 ; ICPEES)**

To be returned by e-mail before **19 September 2022** to melodie.galerne@unistra.fr

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Quasi-homogeneous and physiological photo-Fenton catalysts for water treatment

Internship supervisor

Name, first name	KELLER Nicolas
E-mail, Telephone	nkeller@unistra.fr – 03 68 85 28 11 – 06 74 87 52 95
Laboratory	ICPEES UMR 7515 CNRS-Université de Strasbourg
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Olivier FELIX (ICS) and Lydie PLOUX (BIOMAT)

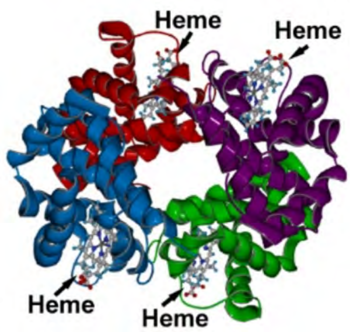
Student profile looked for

Master program (*more than one box can be ticked)*	☒ Material science and engineering ☒ Chemistry ☐ Physics
Other indications if necessary	

Internship description

Water treatment is an urgent issue that scientists must address. Classic treatments in place to date fail to flush a wide span of hazardous and biorecalcitrant organic pollutants from industrial or domestic sources (e.g. the high-impact contaminants of emerging concern). It is an all-in-one problem where we have to manage stringent environmental regulations, reduce the gap of water demand *vs.* resources, with the aim to develop sustainable cost-effective and efficient water treatment technology.
Solar light driven Advanced Oxidation Processes (AOPs) can meet this need: they generate highly active HO_x° radicals at ambient temperature, that react with the pollutants and further with the reaction intermediates to yield full mineralization of pollutants. Along this line, Fenton-type catalysis – based on the catalytic decomposition of H_2O_2, a green oxidant that forms H_2O and O_2 as byproducts, by Fe metallic ions under solar light –, is highly promising and shows by far higher reaction rates and photonic efficiencies than conventional photocatalysis. The internship will aim:

1. first at demonstrating to what extent Fe-rich blood-derived substances can be directly used as solar light driven photo-Fenton catalysts for water treatment. Hemoglobin and transferrin that can be extracted from blood (mostly from red cells and blood plasma, respectively) will be used as catalysts.
2. Second at showing that the physiological photoFenton systems can operate as quasi-homogeneous catalysts inside reactors, thanks to a suited immobilization as robust, nanoporous thin films using the versatile layer-by-layer (LbL) solution-processed assembly method for building films with controlled thickness and nanostructure.



The internship will involve the elaboration and characterization of LbL Fe-based physiological films with a wide span of physico-chemical techniques, and the evaluation of the catalytic efficiency in water treatment under solar light at the lab scale using a model substrate of refractory industrial pollutants.
The internship will be conducted in a collaborative way with Olivier Felix (ICS, PECMAT team) and Lydie Ploux (Biomaterials Bioengineering/BIOMAT unit), and will be mainly located at ICPEES and at ICS. The intern will benefit from the scientific, human and technical environment provided by the different teams expert in their respective fields, and fully equipped with the necessary tools to conduct the research.

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Solar light driven synthesis of H_2O_2 from H_2O and O_2 on 2D-layered g-C_3N_4 based catalysts

Internship supervisor

Name, first name	KELLER Nicolas
E-mail, Telephone	nkeller@unistra.fr – 03 68 85 28 11 – 06 74 87 52 95
Laboratory	ICPEES UMR 7515 CNRS-Université de Strasbourg
Collaboration with a HiFunMat member (*please indicate their name*)	☒ No ☐ Yes :

Student profile looked for

Master program (*more than one box can be ticked)*	☒ Material science and engineering ☒ Chemistry ☐ Physics
Other indications if necessary	

Internship description

Water treatment is an urgent issue that scientists must address. Classic treatments in place to date fail to flush a wide span of hazardous and biorecalcitrant organic pollutants from industrial or domestic sources (e.g. the high-impact contaminants of emerging concern). It is an all-in-one problem where we have to manage stringent environmental regulations, reduce the gap of water demand *vs.* resources, with the aim to develop sustainable cost-effective and efficient water treatment technology.

Solar light driven Advanced Oxidation Processes (AOPs) can meet this need: they generate highly active HO_x° radicals at ambient temperature, that react with the pollutants and further with the reaction intermediates to yield full mineralization of pollutants. Along this line, Fenton-type catalysis – based on the catalytic decomposition of hydrogen peroxide (H_2O_2), a green oxidant that forms H_2O and O_2 as byproducts, by Fe cations under solar light –, is highly promising and shows by far higher reaction rates and photonic efficiencies than classical photocatalysis. However, using H_2O_2 as reactant remains more expensive that using O_2 as oxidant, and thus still limits the viability of H_2O_2-mediated Fe-based catalysis.

Attention has thus been recently given to the solar light driven catalytic synthesis of H_2O_2 from H_2O and O_2 at ambient temperature via artificial photosynthesis as a high-prospect sustainable way for H_2O_2 production. The internship will aim:

1. first at demonstrating the potential of using 2D graphitic carbon nitride (g-C_3N_4) as solar-light active catalyst able at room temperature to synthesize H_2O_2 from H_2O and O_2.
2. second at studying to what extent the activity of g-C_3N_4 catalyst under as solar light can be enhanced through structural (electronic) doping with cationic heteroatoms within the 2D layers.

The internship will be conducted in collaboration with the Institut de Chimie Physique in Paris-Saclay deeper and the Politecnica Universidad in Madrid. It will involve the synthesis, characterization and testing of solar light driven C_3N_4 based catalysts with a focus on their doping with cationic heteroatoms as a key-factor to drive higher photonic efficiency towards the synthesis of H_2O_2 from H_2O and O_2.

The internship will be located at ICPEES. It will benefit from the scientific, technical and human resource environment provided by the 'Photocatalysis and Photoconversion' team, and fully equipped with the necessary tools to conduct the research.

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Conducting nanofibers from organic semiconductor polymers for thermoelectricity and electrochemical transistor applications

Internship supervisor

Name, first name	Leclerc, Nicolas
E-mail, Telephone	leclercn@unistra.fr
Laboratory	ICPEES
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Laure Biniek

Student profile looked for

Master program (*more than one box can be ticked*)	☒ Material science and engineering ☒ Chemistry ☐ Physics
Other indications if necessary	

Internship description

Context: In the past 20 years, organic semiconductors have emerged as promising candidates for numerous optoelectronic applications. They find applications in the fields of display and lighting technologies (organic light emitting diode (OLED)), energy (organic photovoltaics (OPV), thermoelectrics (TE), hydrogen photocatalysis, etc…) and health (organic electrochemical transistor (OECT)-based sensors).

In addition to a strong experience in nanofiber polymer processing by electrospinning (Figure 1 left and middle),[1,2] the host team is highly skilled in organic conjugated polymer (CP) synthesis and characterization for TE application.[2] Recently, in collaboration with the institute Charles Sadron (ICS), it has been shown that combining controlled polar side chains and polymer alignment is an efficient route towards highly conducting polymer materials for TE application and OECT as well (Figure 1 right).[3]

In this context, this master project aims to develop and study conducting nanofibers from organic semiconductor materials, for applications in TE and OECT.

Reflecting the field, this thesis project is particularly multidisciplinary and collaborative. Accordingly, the scientific methodology will be divided in four main tasks: **1)** Synthesis of conjugated polymers and modification of support polymers for fiber production (ex. PSU). **2)** Elaboration of aligned nanofibers following two strategies, either by co-axial electrospinning of PSU/CP or by solution-based CP coating of support electrospun aligned nanofibers. **3)** Study of the effect of a thermomechanical post-treatment of the nanofibers on the CP crystalline structure and alignment. **4)** Doping followed by structural and electrical characterizations.

References :

[1] D. Mailley, A. Hébraud, G. Schlatter, Macromol. Mater. Eng., 2021, 306(7), 2100115.

[2] V. Vijayakumar, Y. Zhong, V. Untilova, M. Bahri, L. Herrmann, L. Biniek, N. Leclerc, M. Brinkmann, Adv. Energy Mater., **2019**, 1900266.

[3] P. Durand, H. Zeng, T. Biskup, V. Vijayakumar, V. Untilova, C. Kiefer, B. Heinrich, L. Herrmann, M. Brinkmann, N. Leclerc, Adv. Energy Mater, **2022**, 12, 2103049.

Requirements & Application

Accordingly, the candidate should hence have excellent skills in organic synthesis and an open mind on polymer process and material characterizations. The candidate will be supervised by a strong interdisciplinary team and will benefit from a very high quality and internationally recognized collaborative network. A strong motivation for academic research is mandatory. The candidates are invited to contact N. Leclerc (DR, CNRS), A. Hébraud (Ass. prof, Univ Strasbourg) and G. Schlatter (Prof, Univ Strasbourg).

To be returned by e-mail before **19 September 2022** to melodie.galerne@unistra.fr

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Title : Exploration of biochars as innovative catalytic materials

Internship supervisor

Name, first name	Ksenia PARKHOMENKO
E-mail, Telephone	parkhomenko@unistra.fr 0368852766
Laboratory	ICPEES, research group "Energy and Fuels for a Sustainable Environment", Strasbourg 25 Rue Becquerel 67087 Strasbourg (campus Cronenbourg)
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : IS2M, Mulhouse (collaboration with Prof. Roger GADIOU)

Student profile looked for

Master program (*more than one box can be ticked)*	☒ Material science and engineering ☒ Chemistry ☐ Physics
Other indications if necessary	

Internship description

The Master 2 project titled « Exploration of biochars as innovative catalytic materials" deals with the complete transformation of the biomass with respect for the rules of the circular economy. Following biomasses: wood, grape pomace, sewage sludge, will be considered for this project. The main focus will be done on the preparation of biochars from those biomasses. All the biochars will be further activated, so a screening of gentle conditions will be necessary: activation with water vapor or CO_2. After activation the biochars are ready for application in catalysis as they are or after a deposition of an active metal. The properties of activated biochars will be studied, as well as a possible scale-up for their synthesis and activation (collaboration with local industrial partner). Finally, the prepared biochars will be tested in the reforming of toluene and phenols – a model reaction for the production of green hydrogen from renewable resources.

Thus, the desired candidate should have knowledge of biomass composition, laboratory synthetic methods for inorganic materials preparation, of materials science and heterogeneous catalysis. He/she will be required during his/her training to use many solid analysis techniques (XRD, IR, TGA, TPR, TPD, SEM, TEM, XPS, etc.). Catalytic reactions in the gas phase will be carried in a constant flow mode, the products formed will be analyzed by online and offline gas chromatography. The work on materials preparation and activation will be done in IS2M, biochars characterization and catalytic activity tests will be done at ICPEES.

The student will acquire knowledge in innovative technologies and will participate in a wide exploration of different biomass sources for renewable catalysts preparation.

To be returned by e-mail before **19 September 2022** to melodie.galerne@unistra.fr

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Title: Porous and conducting MOF/polymer hybride materials for thermoelectric applications

Internship supervisor

Name, first name	Biniek, Laure
E-mail, Telephone	Laure.biniek@ics-cnrs.unsitra.fr
Laboratory	Institut Charles Sadron
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Nicolas Leclerc (ICPEES), Gérald Chaplais (IS2M), Laurent Simon (IS2M)

Student profile looked for

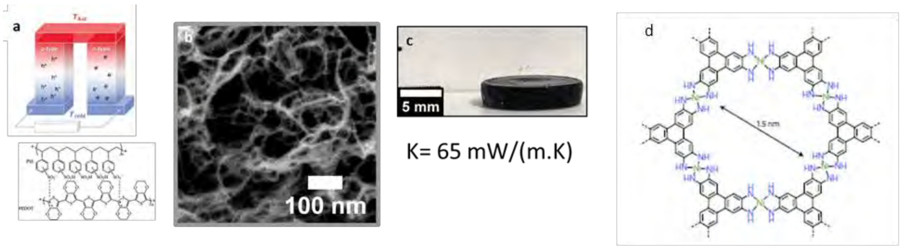
Master program (*more than one box can be ticked)*	☒ Material science and engineering ☒ Chemistry ☐ Physics
Other indications if necessary	

Internship description

Porous bulk conducting materials are of growing interest for different applications such as sensors, supercapacitors or the hot topic of thermoelectricity (TE) in which a temperature differences across a conducting material can be converted into voltage bias via the Seebeck effect. Thermoelectric efficiency is evaluated by its figure of merit expressed by $ZT= S^2\sigma T/\kappa$ (T: absolute temperature, S: Seebeck coefficient, σ: electrical conductivity, κ thermal conductivity). Most of the research in literature focusses on increasing σ, although it is equally important to minimize κ. We have recently demonstrated that introducing porosity into conducting polymeric materials can minimize κ. A mesoporous PEDOT:PSS aerogel exhibits thermal conductivity four times lower than the dense film counterpart while maintaining sufficient electrical conductivity (see figure).[1] Alternatively, conducting Metal Organic Framework (MOF) are promising materials because of their microporosity. Consequently, they are gaining attention in the field of TE, despite the lack of experimental work.[2]

Our objectives are to explore the possibilities of synthesizing hierarchical structures combining MOFs (Metal-Organic-Framework) and porous conducting polymers for thermoelectrics.

To this end, this internship will include different tasks: i) conjugated ligand and MOF synthesis and their chemical and structural characterization, ii) porous conducting polymer preparation (gelation and supercritical drying), iii) Polymer/MOF hybride material preparation by direct mixing method or in- situ synthesis method. The porosity of the materials will be characterized by electron microscopy (SEM, CRYO-SEM), and physisorption methods. The work will be made in collaboration with another master student involved in the physical and thermoelectric characterization of the materials.



Mesoporous PEDOT:PSS aerogel

Microporous $Ni_3(HITP)_2$ MOF

a) Schematic of a thermoelectric generator; Chemical structure of conducting PEDOT :PSS polymer. b) SEM image of the inner porous structure of the PEDOT :PSS aerogel. c) Aerogel , d) MOF structure.

References:

[1] Q. Weinbach, L. Biniek et al, *Front. Electron. Mater.* (2022)2:875856. doi:10.3389/femat.2022.875856.

[2] E. Redel, H. Baumgart, APL Mater. 8, 060902 (2020); https://doi.org/10.1063/5.0004699

Requirements & Application

We are looking for motivated and team-worker master Student willing to learn about conjugated ligands and MOF synthesis, characterization and thermoelectric properties. The candidate is expected to be not afraid of multidisciplinary field. Collaboration with G. Chaplais (MOFs synthesis) and L. Simon (physical characterization) at IS2M, Mulhouse, including short stays there, are envisioned.

Please send your application including a CV, a motivation letter and Master transcript of records to Laure Biniek [laure.biniek@ics-cnrs.unistra.fr], SYCOMMOR Team, Institut Charles Sadron and Nicolas Leclerc [leclercn@unistra.fr], POLYFUN team, ICPEES, Campus Cronenbourg. (please note that ZRR specific security protocols are taking place at ICS and ICPEES).

To be returned by e-mail before **19 September 2022** to melodie.galerne@unistra.fr

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Antibacterial and thermosensitive macromolecules as alternatives of antibiotics

Internship supervisor

Name, first name	Boulmedais, Fouzia and Chan-Seng, Delphine
E-mail, Telephone	fouzia.boulmedais@ics-cnrs.unistra.fr; delphine.chan-seng@ics-cnrs.unistra.fr
Laboratory	Institut Charles Sadron **Laboratory with ZRR** : the candidate has to contact us at least 2 month before the beginning of their internship
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes: Florent Meyer and Lydie Ploux (INSERM UMR 1121, Strasbourg)

Student profile looked for

Master program	☐ Material science and engineering ☒ Chemistry ☐ Physics
Other indications if necessary	**Profile:** molecular chemist with a strong interest in studies at the interface of chemistry and biology who wants to continue as PhD student on this subject (the funding of the PhD is available).

Internship description

The World Health Organization continues to alert the health sector to the emergence and proliferation of multi-resistant microbial strains to antibiotics. In Europe, one in twenty patients will contract a nosocomial infection during their hospitalization, representing the sixth leading cause of death in hospitals. As an alternative to antibiotics, strategies to control nosocomial infections must be implemented involving the discovery of new antimicrobial agents. We recently synthesized poly(methacrylate-*g*-oligoarginine)s which exhibit an unexpected upper critical solution temperature (UCST) behavior, i.e. transition from insoluble to soluble upon increasing the temperature (**Figure 1**).[1] This phenomenon is totally reversible allowing the formation of 200 nm aggregates at room temperature, able to encapsulate bioactive molecules, and their dissolution at 37°C or above. Moreover, the macromolecules showed antibacterial properties against *Staphyloccocus aureus* (*S. aureus*), one of the most virulent bacteria.[2]

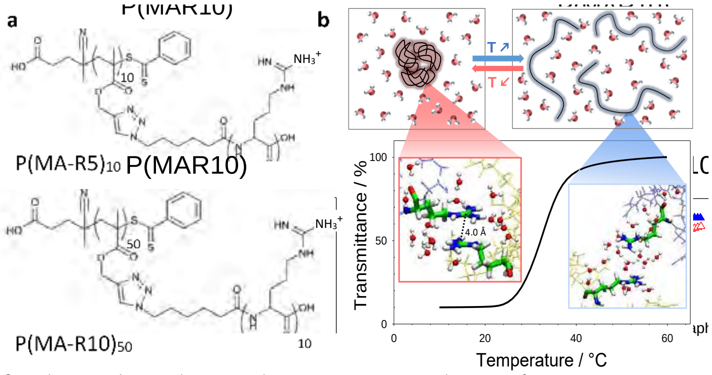
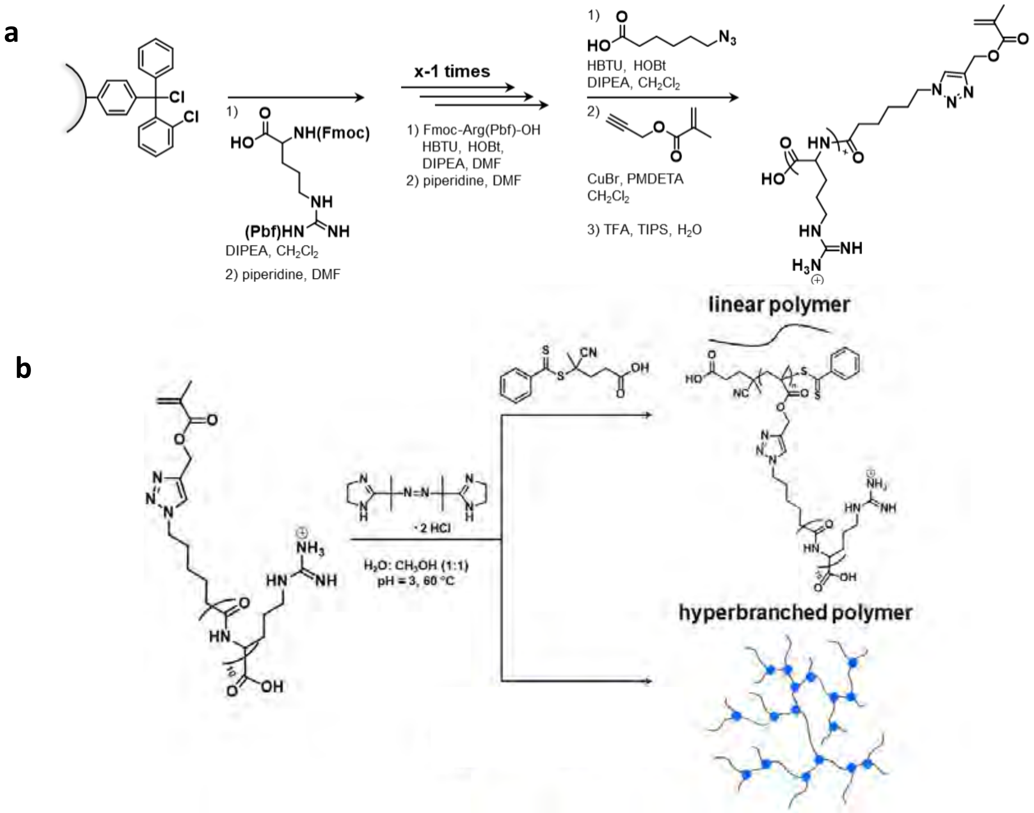


Figure 1: (a) Structures of poly(methacrylate-*g*-oligoarginine) with 5 and 10 arginine residues, (b) UCST property of the polymer in water due to the stacking of guanidinium groups from the arginine at room temperature, simulated by molecular dynamics.

The objective of the internship is to (i) synthesize antibacterial and thermoresponsive decaarginine-based polymers of different topologies and (ii) to evaluate their biocompatibility in contact with human cells and their antibacterial properties in collaboration with INSERM UMR 1121 (Strasbourg).

For this purpose, methacrylate-*graft*-decaarginine macromonomers (MA-R10) will be first prepared by combining solid-phase peptide synthesis and copper-assisted alkyne-azide cycloaddition (Scheme 1a). Then, linear UCST decaarginine-based polymers will be synthesized in a water/methanol mixture using 2,2'-azobis[2-(2-imidazolin-2-yl)propane] dihydrochloride (VA-044) as initiator and 4-(cyanopentanoic acid)-4-dithiobenzoate (CPABD) as a chain transfer agent (Scheme 1b). The hyperbranched polymers will be prepared by self-condensing vinyl polymerization (SCVP) (Scheme 1b).



Scheme 1: (a) solid-phase synthesis of the decaarginine-based macromonomer and (**b**) the approaches to prepare polymers with two different topologies by RAFT polymerization.

The cytotoxicity of the different macromolecules, selected from their temperature of transition near 37°C, will be tested in solution on human gingival keratinocyte. The antibacterial properties will be assessed against *S. aureus* and *Escherichia Coli* (*E. coli*) by the determination of the minimal inhibitory concentration of the macromolecules. To this aim, the pathogens will be grown in the absence and the presence of a large range of polymer concentrations for 24 h at a temperature below and above the phase transition temperature of the polymer.

References

1. Zydziak, N.; Iqbal, M. H.; Chaumont, A.; Combes, A.; Wasielewski, E.; Legros, M.; Jierry, L.; Lavalle, P.; Boulmedais, F.; Chan-Seng, D., Unexpected aqueous UCST behavior of a cationic comb polymer with pentaarginine side chains. *Eur Polym J* **2020,** *125*, 109528.
2. Boulmedais, F.; Chan-Seng, D.; Zydziak, N.; Lavalle, P. Arginine-based antibacterial polymers with UCST property WO2020225322A1, 12/11/2020, 2021.

5 to 6-month master's internship at ICS, Strasbourg

Novel Polymer Based Materials in Green Solvents

Overview

Using novel **green** solvents in polymer science has untapped potentials for various applications from energy storage and CO2 capture to bioelectronics and biomedical applications.[1] A new generation of green solvents, called **Natural** Deep Eutectic Solvents (**NaDES**), is based on mixtures of certain natural sugars, salts, and acids which, at certain mixing ratios, have a eutectic point below room temperature.[2]

Designing **novel** polymer-based materials in NaDES requires understanding the behavior of polymers in these solvents. Many physico-chemical and mechanical properties of polymer solutions and gels (e.g. viscoelastic properties) are closely linked to the conformation of the chains in the given solvent depending on its quality. An additional advantage of NaDES - as opposed to organic solvents and water - is that the physico-chemical properties of the solvent (polarity, viscosity, conductivity, etc.) are tunable based on its components. Few studies have addressed these questions so far.

Goals

The main goal of the internship is to study the viscoelastic and physico-chemical properties of model polymers in NaDES for potential **applications** in the construction sector. Polymer solutions and gels will be prepared in NaDES and compared to their classic counterparts in water (aqueous solutions and hydrogels). The intern will perform gel **synthesis**, **swelling** studies, **rheology** measurements and **compression** testing, as well as thermal **degradation** studies.

Profile

Master II and/or **3rd year engineering school** student (or equivalent). Physical chemists, polymers and / or materials scientists and engineers are encouraged to apply. Experience in materials science, polymer physics, and or mechanical characterization is a plus.

Selection criteria

Applications are assessed based on **motivations**, **relevance**, previous **experience**, and **DE&I** (Diversity, Equity, and Inclusion).

Location

The intern will be hosted at the CNRS **Institut Charles Sadron** in **Strasbourg** for a period of 5-6 months.

Contacts

Candidates are invited to send their **CV** and **motivation letter** to Dr. **Mehdi Vahdati** and Dr. **Fouzia Boulmedais** at mehdi.vahdati@ics-cnrs.unistra.fr and fouzia.boulmedais@ics-cnrs.unistra.fr. Given that the lab is within a ZRR (Zone à Régime Restrictive), applications must be sent at least 3 months prior to the starting date of the internship.

References

1. Tomé, Mecerreyes, *J Phys Chem B, 2020*, **124**, 8465-8478.

2. Liu, et. al., *J Nat Products*, 2018, **81**, 679-690.

Anisotropic n-type Thermoelectric Polymers

Supervisor: Martin Brinkmann , directeur de recherche

Laboratory : Institute Charles Sadron, 23 rue du loess, 67034 Strasbourg (ZRR)

Description. Plastic electronics has become a major field of both fundamental research and innovative applications in industry. Organic Light Emitting Diodes (OLEDs) are now integrated in a routine way in new electronic items such as smartphones and TVs. New applications are now currently attracting researchers in plastic electronics, in particular in the field of thermoelectricity. Thermoelectric materials have the capability to convert a temperature gradient in electric current or vice versa. They can be used in numerous places such as industry, cars or intelligent textiles where lost heat could be recovered and converted to electricity. Efficient TE materials are usually semi-conductors or conductors and must show high electric conductivity, high Seebeck coefficients ($S=\Delta V/\Delta T$) and low thermal conductivity. So far, inorganic materials were dominating the field of TE, but, in the last decade, it has been demonstrated that polymeric systems such as PEDOT-Tos show remarkable TE properties.[1]
In this internship, we propose to investigate a simple method to enhance TE properties of polymers, namely orientation of polymer chains in thin films using the method of high temperature rubbing developed at ICS.[2,3] We want to determine what are the processing parameters during orientation and doping stages that help improve TE properties of new n-type polymers (doping method, doping concentration, type of dopant, orientation of host polymer matrix). Recently, the group has demonstrated the high potential of this approach, reaching record values of charge conductivity beyond 10^5 S/cm and power factors of more than 1 mW/(m·K^2).[4]

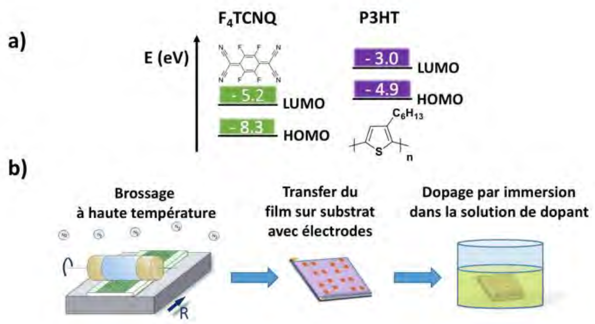


Figure 1. Schematic illustration of the molecular structure of the polymer and dopant (a) and of the preparation method of aligned and doped polymer films (b).

The student will have the opportunity to work in a dedicated environment for plastic electronics i.e. perform all processing under controlled atmosphere. The student will perform the characterization of the devices from a structural point of view (transmission electron microscopy) and from the electronic point of view (conductivity and Seebeck coefficient) so as to draw structure-property correlations. Polarized UV-vis-NIR and FTIR spectroscopies will also be used to follow the doping processes. The student will be integrated in an international team working on two collaborative projects on n-type TE materials (ITN Horates and ANR Thermopolys).

(1) O. Bubnova et al., *Nat. Mat.* **2011**, 10, 429.

(2) A. Hamidi-Sakr, *Adv. Funct. Mat.* **2016**,26, 408

(3) A. Hamidi-Sakr, *Adv. Funct. Mat.* **2017**, 27, 1700173

(4) V. Vijayakumar et al., *Adv. Energy Mat*. **2019**, 9, 1900266.

(5) P. Durand et al. *Adv. Energy Mat.* **2022**, 12, 210349

Contact: Martin Brinkmann; e-mail: martin.brinkmann@ics-cnrs.unistra.fr

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Synthesis of thermoresponsive polymers for light-triggered drug release

Internship supervisor

Name, first name	CHAN-SENG Delphine
E-mail, Telephone	delphine.chan-seng@ics-cnrs.unistra.fr, +33 3 88 41 40 76
Laboratory	Institut Charles Sadron, UPR22
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Jacques Lalevée (IS2M UMR7361, Mulhouse)

Student profile looked for

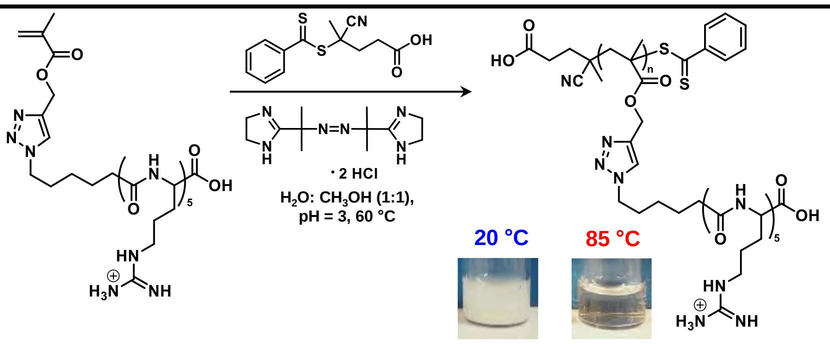
Master program (*more than one box can be ticked*)	☐ Material science and engineering ☒ Chemistry ☐ Physics
Other indications if necessary	Molecular chemist with an interest in gaining experience in peptide and polymer syntheses.

Internship description

Cancers, first leading cause of death worldwide, are usually treated by combining local and general treatments for better efficiency. For example, a surgery can be performed first to remove the tumor and some nearby tissues followed by a chemotherapy to eliminate the remaining cancer cells and prevent from a cancer recurrency. The main limitations of chemotherapy are the potential low therapeutic efficiency due to some resistance mechanism to the drug used and the appearance of side effects that could be due to the non-specificity of the anticancer drug. The development of strategies to deliver the anticancer drug at the tumor sites only remains a key challenge to lower the potential side effects of the drug while eliminating efficiently and definitely the cancer cells.

One strategy is to use polymers as carriers of the anticancer drug promoting its prolonged circulation in the blood stream and thus accumulation at the tumor site. To prevent the leakage of the drug during its circulation, different approaches have been considered like drug conjugation on the polymer or use of stimuli-responsive polymers. In the latter case, endogenic (*e.g.* redox, pH, enzymes) and exogenic (*e.g.* light, temperature, ultrasounds) stimuli have been considered for the development of drug delivery systems.

We recently demonstrated the synthesis of poly(methacrylate-*g*-oligoarginine)s by RAFT polymerization of methacrylate-*g*-oligoarginine under reversible addition-fragmentation chain transfer (RAFT) polymerization. These polymers exhibited a thermoresponsive behavior induced by the stacking of the guanidinium groups present on the side chain of the polymer.



The objective of this internship relies on the development of a photosensitive RAFT chain transfer agent that will be used to polymerize methacrylate-*g*-oligoarginine. The introduction of a near-infrared (NIR) dye on the polymer will offer the ability upon NIR irradiations to induce locally the increase of the temperature and thus the disassembly of the polymer. As proof-of-concept, a model molecule will be encapsulated in the nanoobjects formed by the polymer and its release upon NIR irradiations will be monitored.

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

PVC/Organogels Hybrid materials

Internship supervisor

Name, first name	GUENET Jean-Michel
E-mail, Telephone	guenet@unistra.fr; +33388414145
Laboratory	Institut Charles Sadron
Collaboration with a HiFunMat member (*please indicate their name*)	☒ No ☐ Yes :

Student profile looked for

Master program (*more than one box can be ticked*)	☒ Material science and engineering ☐ Chemistry ☒ Physics
Other indications if necessary	Collaboration with Nicolas Giuseppone

Internship description

In this project functional hybrid materials from PVC (polyvinyl chloride) and organogels will be prepared, and studied. Polyvinyl chloride (PVC) is the third-most widely produced synthetic plastic polymer. The continuous interest toward this polymer arises from two essential and ***unique properties***, ***triboelectricity*** and ***flame-retardant.*** Another interesting and unique property of this polymer lies in its propensity to produce ***thermoreversible gels*** in a ***large variety of solvents,*** which allows solvent-processing.

These past few years a wealth of molecules forming fibrillar gels in organic solvent have been synthesized (organogelators). In many cases these systems bear a functional property (opto-electronic, magnetic,..). In this project, we will use ***an approach based on the gel state of both systems for making functional materials with PVC by incorporation of function-bearing organogelators.*** The study will aim at establishing the best conditions as a function of the ***solvent type, concentration, ratio PVC/organogelator***, ***and the like*** for preparing adequate materials with appropriate properties. Emphasis will be put on a series of **conducting tri-aryl amines gelators**. Different characterization techniques will be used: DSC for mapping out the T-C phase diagram, determining formation and melting temperature; X-rays and neutron diffraction (at ILL, Grenoble), electron microscopy (SEM and TEM) for determining the molecular structure, the morphology and the degree of dispersion of one gel into the other, and rheology for observing the evolution of the gel mechanical properties.

Some references:

D. Dasgupta, S. Srinivasan, C. Rochas, A. Ajayaghosh, J. M. Guenet *Hybrid thermoreversible gels from covalent polymers and organogels* *Langmuir* **2009** 25 8593

J.M. Guenet a) *Thermoreversible Gelation of Polymers and Biopolymers*, 267 pages, Academic Press London **1992**; b) *Organogels: thermodynamics, structure and solvent role* Springer Verlag, **2016**

Z. Zoukal; S. Elhasri.; A. Carvalho; M. Schmutz; D. Collin; P. Vakayil; A. Ajayaghosh; J.M. Guenet.
Hybrid Materials from Poly[Vinyl Chloride] and Organogels ACS Applied Polymer Materials, **2019**, *1,* 1203

B. Kiflemariam; D. Collin, O. Gavat; A. Carvalho; E. Moulin; N. Giuseppone; J.M. Guenet
Hybrid materials from tri-aryl amine organogelators and poly[vinyl chloride] networks Polymer, **2020**, *207*, 122814

Talebpour, P.; Heinrich, B. ; Gavat, O. ; Carvalho, A. ; Moulin, E. ; Giuseppone, N. ; Guenet, J.M.
Modulation of the Molecular Structure of Tri-aryl Amine Fibrils in Hybrid Poly[vinyl chloride] Gel/Organogel Systems
Macromolecules **2021**, *54*, 8104

Guenet, J.M., Deme, B.; Gavat, O.; Moulin, E.; Giuseppone, N.
Evidence by neutron diffraction of molecular compounds in tris-amide triarylamine organogels and in their hybrid thermoreversible gels with PVC. Soft Matter, **2022**, *18*, 2851

To be returned by e-mail before **19 September 2022** to melodie.galerne@unistra.fr

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Optimisation of silicone formulations for architected silicone materials

Internship supervisor

Name, first name	JACOMINE, Leandro
E-mail, Telephone	jacomine@unistra.fr, 03.88.41.41.36
Laboratory	Equipe MIM, Institut Charles Sadron,
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : M. Legros

Student profile looked for

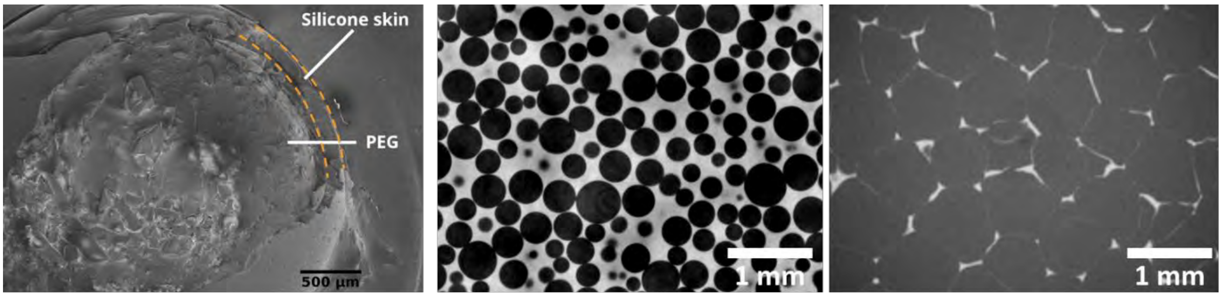
Master program (*more than one box can be ticked)*	☒ Material science and engineering ☒ Chemistry ☐ Physics
Other indications if necessary	

Internship description

Silicones are characterised by a wide range of excellent physical and chemical properties. They are chemically inert, transparent, have an excellent resistance to high and low temperatures, a very low glass transition temperature, excellent electrical properties, are bio-compatible, non-toxic, can be activated easily by plasma, have a very low surface energy and are fairly transparent to gases. This long list of useful properties can be extended by integrating gas or liquid pores into the silicone, turning it into a "multiphase silicone" including capsules (Figure I), foams (Figure II) or polyHIPEs (poly-High Internal Phase emulsions). The resulting three-dimensional architecture leads to large surface-to-volume rations, versatile mechanical, thermal and acoustic properties or allows gasses, fluids or tissue to penetrate. The marriage of the excellent silicone features with those of a multiphase architecture leads to materials with a particularly wide range of applications. Examples include energy, transport and storage applications, photocatalysis, wearable electronics, life science applications or water purification.

In the MIM team ("Mechanics of Interfaces and Multiphase Systems", https://www.ics-cnrs.unistra.fr/equipe-mim.html) we develop different kinds of silicone-based multi-phase materials via a "liquid templating approach": reactive silicone-systems in the liquid state are turned into the desired multi-phase systems (drops, foams, emulsions) before solidification of the silicone phase through hydrosilysation. Goal of our work is to establish relationships between the chemical, structural and mechanical properties of the obtained materials.

In the framework of this internship, we wish to establish a quantitative link between (1) the initial silicone formulation (molecular architecture of the reactive molecules, their relative concentrations, role of catalyst & inhibitors, etc.), (2) the reaction kinetics in bulk and at interfaces, and (3) the final mechanical properties of the obtained silicone material. The student will learn to use techniques such as bulk and interfacial rheology and he/she will interact with the characterization platform of the ICS on Size Exclusion Chromatography of the silicones. He/she will be full member of a dynamic, international team and contribute to a European project on metamaterials in collaboration with several international companies.



I. Silicone capsule **II. Silicone foam** **III.PEG-in-Silicone polyHIPE**

Requirements & Application

We are looking for motivated master Student with a background in physical chemistry or chemistry. He/she will be supervised by **Leandro Jacomine**, in close collaboration with Wiebke Drenckhan, Aurélie Hourlier-Fargette, Friedrich Walzel, François Schosseler, Mélanie Legros and Catherine Foussat from ICS and François Ganachaud, expert in silicone chemistry in Lyon.
Please address your applications (CV + motivation letter) to jacomine@unistra.fr and drenckhan@unistra.fr

To be returned by e-mail before **19 September 2022** to melodie.galerne@unistra.fr

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Synthesis and Study of Natural Polymers Hydrophobically Modified to Texture Edible Oils

Internship supervisor

Name, first name	MESINI, Philippe
E-mail, Telephone	mesini@ics-cnrs.unistra.fr
Laboratory	Institut Charles Sadron
Collaboration with a HiFunMat member (*please indicate their name*)	☒ No ☐ Yes :

Student profile looked for

Master program (*more than one box can be ticked*)	☒ Material science and engineering ☒ Chemistry ☐ Physics
Other indications if necessary	

Internship description

In many food products solid fats are necessary as texturing agents: they give their toughness and mechanical properties to many food products: ice cream, chocolates, butter... However, these solid fats, mainly of animal origin, increase the risks of coronary diseases, because they contain *trans* fat acids. Under the pressure of the regulations from public health authorities, food industry tries to replace these solid fats by healthier products. One of the most used substitution products is palm oil, but because of its deleterious effect on environment, it will be banned from EU. One envisioned solution of replacement is oleogels. These are liquid vegetable oils gelled by an additive in order to give them the sought mechanical toughness. The gel is thermoreversible and turns to a sol when heated. The gelling agent has to be food grade. Ethylcellulose, a food grade polymer, can gel edible oil, but its dissolution in oil requires temperature inducing the degradation of the oil.

We propose to modify cellulose nanofibrils with natural compounds to graft hydrophobic side chains. Then the student will test their ability to form gels in oil and, in case of success, will study the rheological and thermal properties of the formed gels.

The main part of the research work will be devoted to the synthesis of the modified polymers. In a first step, the student will synthesize the target polymers with various derivatization rates, with standard methods in order to test them. In a second step, the syntheses will be performed with food grade compounds only. The synthesized polymers will be tested in rapeseed oil to determine whether they can gel it and at which concentrations. The student will be initiated to rheology to measure the mechanical properties. With these experiments, along with microDSC and turbidimetry, we will study the gel-sol transitions.

We are looking for motivated master student with a background in polymer chemistry or organic chemistry, but curious to learn techniques beyond this background. Since we belong in a restricted access laboratory (ZRR), the application must be filed by mid-October.

To be returned by e-mail before **19 September 2022** to melodie.galerne@unistra.fr

Master *Matière Condensée et Nanophysique*
Année universitaire 2022/2023

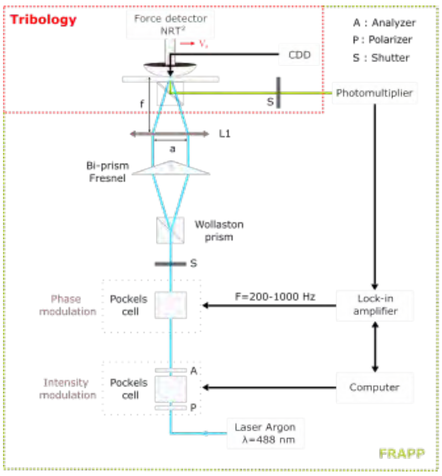
Nom du responsable et intitulé du laboratoire d'accueil : Christian Gauthier, Institut Charles Sadron UPR22

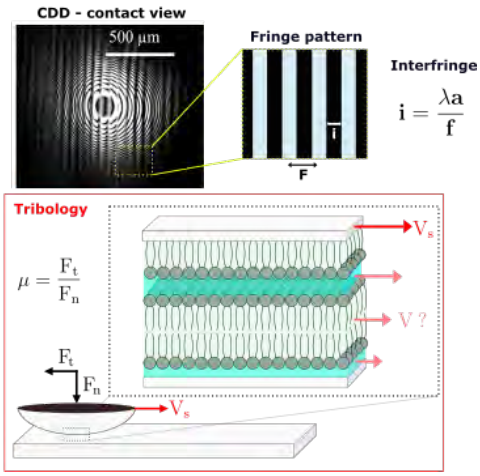
Adresse : 23, Rue du Loess BP 84047 67034 STRASBOURG CEDEX 2

Nom, prénom et grade des responsables de stage : Swen Helstroffer (Doctorant), Pierre Muller (Chargé de Recherche), Charitat Thierry (Professeur),
Téléphone : 03 88 41 40 07 / 03 88 41 40 28 / 03 88 41 40 05

e-mail : swen.helstroffer@etu.unistra.fr, thierry.charitat@ics-cnrs.unistra.fr

Title : Rheology of charged lipid layer: velocity profile characterization





Abstract: Nature has produced water-based lubricant systems that by far outclass the best man-made devices (Urbakh et al., 2004). Biological contacts such as the articulating cartilage surfaces in human hips or knees often operate under severe conditions (i.e., high load and low speed), which is related to a boundary lubrication regime. In this regime, actual contact between the surfaces can be prevented by boundary lubricant that attaches itself to the solid surfaces due to molecular forces, thereby modifying their tribological properties. This boundary regime is characterized by a very low friction coefficients (μ=0.005–0.02, for the human joint). Phospholipids, the main constituents of cell membranes are critical in these systems.

The present internship project aims to better understand the role of phospholipid layers in biolubrication by associating velocimetry and tribology experiments on well controlled model system. We have developed an original experimental setup, which couples the precise tribological characterization of the system, and the measurement of velocimetry by Fluorescence Recovery After Patterned Photobleaching. Using this setup, we want to address the question of the velocity profile and the localisation of sliding plane. We will focus on the case of charged phospholipids, involving complex electrostatic interactions, which are supposed to strongly modify the tribological properties.

The student will be first introduced to the preparation of supported layer methods available at the MCube group of the Charles Sadron Institute and to use the coupled experimental setup. The Master intern will be fully associated to the scientific activities of the team (seminar, scientific discussion, …) and discussion with partner groups.

Contacts: https://ics-mcube.cnrs.fr/

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Enhanced sensing of chiral (bio−)molecules with chiral plasmonic metasurfaces

Internship supervisor

Name, first name	Pauly, Matthias
E-mail, Telephone	matthias.pauly@unistra.fr, 03 88 41 40 41
Laboratory	Institut Charles Sadron
Collaboration with a HiFunMat member	☒ No ☐ Yes :

Student profile looked for

Master program (*more than one box can be ticked*)	☒ Material science and engineering ☒ Chemistry ☐ Physics
Other indications if necessary	

Internship description

Chirality is ubiquitous in nature's biomolecules and critically affects how molecules interact with their environment. There is a need for sensitive methods to quantify enantiomeric excess, for instance in drug synthesis, or to detect low quantities of chiral protein and DNA in diagnostics. Because chiral structures exhibit a polarization-dependent interaction with light, optical analytical techniques are well suited to sense and characterize chirality. Among those, Circular Dichroism (CD) spectroscopy is widely used in both fundamental scientific research and chirality sensing applications. Unfortunately, molecular CD is inherently weak, resulting in small signals and low sensitivity. Thus, large quantities of chiral molecules are required for adequate signal-to-noise ratios. In contrast, nanomaterials can be engineered on a larger size scale to generate stronger CD. Additionally, metallic NPs exhibit an especially strong CD due to their localized surface plasmon resonance (LSPR). It has been proposed[1] to use plasmonic chiral metasurfaces to strongly enhance the CD of molecules and increase the sensitivity of CD spectroscopy.

In this internship, we wish to investigate how chiral plasmonic metasurfaces prepared by self−assembly can be used for enhanced CD sensing of chiral molecules. Grazing Incidence Spraying (GIS) will be used to assemble silver nanowires into oriented mono− and multilayer thin films with well-controlled orientation and spacing. GIS will be combined to the Layer-by-Layer (LbL) approach in order to build multilayer superstructures. We have recently shown[2,3] that such chiral nanostructures display a very high circular dichroism over a broad wavelength range. Such chiral metasurfaces will be used as an enhanced sensing platform and their performance tested for various model proteins and peptides.

The structure of the assembly will be systematically characterized by various microscopy techniques (AFM, SEM, TEM). The optical properties will be measured by combining different spectroscopic and polarimetric approaches (including UV-Vis-NIR polarized spectroscopy, ellipsometry, and CD spectroscopy).

References

1. L. A. Warning; A. R. Miandashti; L. A. McCarthy; Q. Zhang; C. F. Landes; S. Link Nanophotonic Approaches for Chirality Sensing. *ACS Nano* **2021***, 15,* 15538-15566.
2. H. Hu; S. Sekar; W. Wu; Y. Battie; V. Lemaire; O. Arteaga; L. V. Poulikakos; D. J. Norris; H. Giessen; G. Decher; M. Pauly Nanoscale Bouligand Multilayers: Giant Circular Dichroism of Helical Assemblies of Plasmonic 1D Nano-Objects. *ACS Nano* **2021**, *15*, 13653-13661.
3. W. Wu; Y. Battie; V. Lemaire; G. Decher; M. Pauly Structure-Dependent Chiroptical Properties of Twisted Multilayered Silver Nanowire Assemblies. *Nano Lett.* **2021**, *21*, 8298-8303.

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Induced chiroptical properties of a non−chiral molecular dye coupled to a plasmonic chiral nanostructure

Internship supervisor

Name, first name	Pauly, Matthias
E-mail, Telephone	matthias.pauly@unistra.fr, 03 88 41 40 41
Laboratory	Institut Charles Sadron
Collaboration with a HiFunMat member (*please indicate their name*)	☒ No ☐ Yes :

Student profile looked for

Master program (*more than one box can be ticked*)	☒ Material science and engineering ☒ Chemistry ☒ Physics
Other indications if necessary	

Internship description

Circularly polarized light has many applications, including circular dichroism spectroscopy, three-dimensional displays, bio-sensing, optical recording and even quantum computation. Circularly polarized light, also referred to as chiral light, is usually created with optical filters, or with chiral organic emitters. However, there has been recently a growing interest in the design of metamaterials, which are are man-made structures composed of tailored building blocks that can control the flow of light in unprecedented ways. In particular, it has been shown that chiral plasmonic metasurfaces lead to huge optical activity in the visible range. On the other hand, the optical properties of molecular dyes (in particular the intensity and polarization state of the emitted light) is modified when coupled to a plasmonic particle. **The aim of this project is to explore a new way to produce chiral light by coupling a non-chiral molecular emitter to a chiral assembly of plasmonic nanowires.**

In this internship, Grazing Incidence Spraying (GIS) will be used to assemble silver nanowires into oriented mono− and multilayer thin films with well-controlled orientation and spacing. GIS will be combined to the Layer-by-Layer (LbL) approach in order to build multilayer superstructures that include various molecular emitters. We have recently shown that such chiral nanostructures display a very high circular dichroism. We will in particular focus on how the polarization state of the emitted light is influenced by the architecture and composition of the assembly.

The structure of the assembly will be systematically characterized by various microscopy techniques (AFM, SEM, TEM). The optical properties will be measured by combining different spectroscopic and polarimetric approaches (including UV-Vis-NIR polarized spectroscopy, ellipsometry, and fluorescence spectroscopy) and will be correlated to the structural characterization.

References

1. H. Hu; S. Sekar; W. Wu; Y. Battie; V. Lemaire; O. Arteaga; L. V. Poulikakos; D. J. Norris; H. Giessen; G. Decher; M. Pauly Nanoscale Bouligand Multilayers: Giant Circular Dichroism of Helical Assemblies of Plasmonic 1D Nano-Objects. *ACS Nano* **2021**, *15*, 13653-13661 ; W. Wu; Y. Battie; V. Lemaire; G. Decher; M. Pauly Structure-Dependent Chiroptical Properties of Twisted Multilayered Silver Nanowire Assemblies. *Nano Lett.* **2021**, *21*, 8298-8303.

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Title: Active particle-Membrane interaction and dynamics

Internship supervisor

Name, first name	STOCCO, ANtonio
E-mail, Telephone	stocco@unistra.fr, +33 (0)388414113
Laboratory	Institut Charles Sadron CNRS UPR22
Collaboration with a HiFunMat member (*please indicate their name*)	☒ No ☐ Yes :

Student profile looked for

Master program (*more than one box can be ticked*)	☒ Material science and engineering ☐ Chemistry ☒ Physics
Other indications if necessary	

Internship description

Interaction of microparticles to biological membranes plays a determinant role in many important processes such as viral infections, drug delivery and toxicity from nanomaterials. For particle sizes in the micron range, membrane wrapping of the particles depends on particle (surface charge, surface coating, particle shape and size) and membrane properties (tension, bending and charge).[1] Many theoretical models have been developed in the last decades, however, few experimental investigations have been reported on the different transitions that microparticles may undergo when they come into contact with biological or biomimetic membranes.[2,3] Microparticles may become completely (C) or partially (P) engulfed by the membrane if the adhesion energy overcomes the stretching and bending costs of the membrane, see Figure. This internship is dedicated to study the microparticle engulfment by lipid membranes (in giant vesicles) by tuning the Janus geometry of the microparticles and the particle activity leading to self-propulsion.[4]

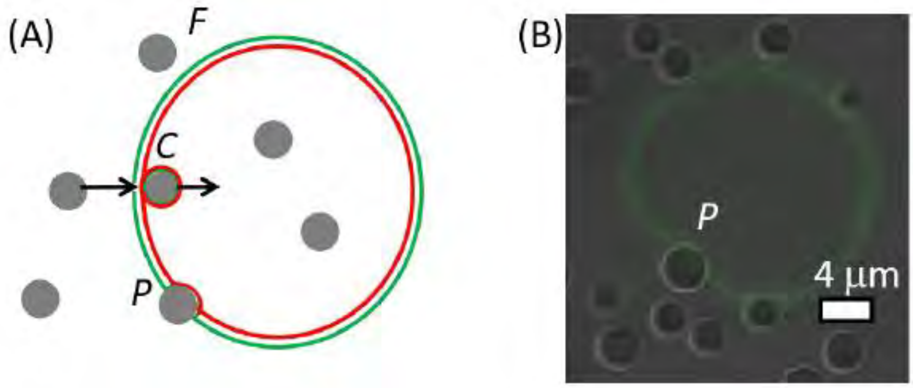


Figure. (A) Free (F), completely (C) or partially (P) engulfed states of microparticles by a membrane. (B) Preliminary experiments: Fluorescent/Bright field optical microscopy image of silica colloids interacting with a fluorescently labelled (DOPC) lipid membrane in a giant vesicle.

REFERENCES:
1 S. Zhang, H. Gao and G. Bao, ACS Nano, 2015, 9, 8655–8671.
2 K. Shigyou, K. H. Nagai and T. Hamada, Langmuir, 2016, 32, 13771–13777.
3 C. Dietrich, M. Angelova and B. Pouligny, J. Phys. II, 1997, 7, 1651–1682.
4 V. Sharma… and A. Stocco, Soft Matter, 2021, 17, 4275–4281.

To be returned by e-mail before **19 September 2022** to melodie.galerne@unistra.fr

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Control of the reversible behaviour of nanoparticles by external stimulus

Internship supervisor

Name, first name	VAUTHIER Madeline
E-mail, Telephone	madeline.vauthier@ics-cnrs.unistra.fr
Laboratory	Institut Charles Sadron
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Karine MOUGIN karine.mougin@uha.fr

Student profile looked for

Master program (*more than one box can be ticked)*	☒ Material science and engineering ☒ Chemistry ☐ Physics
Other indications if necessary	

Internship description

Since the 90s, the creation of advanced particles for various applications, such as electronics, textiles, cosmetics, pharmaceutical applications, food processing, aeronautics or automotive, is of high interest for researchers and engineers. Moreover, the advantages of polymeric particles are that they are stable, they can be prepared from **renewable materials** (biocompatibility and biodegradability) and their particle size and constituent can easily be controlled.

In this project, Institut Charles Sadron (UPR 22, Strasbourg)[1-3] and Institut de Science des Matériaux (UMR 7361, Mulhouse) [4,5] propose and study biocompatible core-shell systems composed of **polymeric particles**, **encapsulating gold nanoparticles**. After the development of the functionalized particles encapsulating gold nanoparticles, the sensitivity of the system to hyperthermia will be investigated.

1. M. Vauthier, C.A. Serra, *Coll. Surf. A*, **2021**, 626, 127059
2. M. Vauthier, L. Jierry, M. L. Martinez Mendez, Y-M. Durst, J.B. Kelber, V. Roucoules, F. Bally-Le Gall, The *J. Phys. Chem. C*, **2019**, 123 (7), 4125-4132
3. M. Vauthier, J. Oliveira, M-P Laborie, V. Roucoules, F. Bally-Le Gall, *Adv. Funct. Mat.*, **2018**, 19 (10), 1806765
4. S. Darwich, K. Mougin, H. Haidara, *Soft Matter*, **2012**, *8* (4), 1155-1162
5. P. Bauer, K. Mougin, D. Faye, A. Buch, P. Ponthiaux, V. Vignal, *Langmuir*, **2020**, 36 (37), 11015–11027

To be returned by e-mail before **19 September 2022** to melodie.galerne@unistra.fr

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Title: Deciphering the **R**-body **E**xtension-retr**A**ction **M**echanism

Internship supervisor

Name, first name	Schmatko Tatiana
E-mail, Telephone	tatiana.schmatko@ics-cnrs.unistra.fr
Laboratory	ICS & IS2M
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Laurent Pieuchot, Igor Kulic (co-direction)

Student profile looked for

Master program (*more than one box can be ticked)*	☒ Material science and engineering ☐ Chemistry ☒ Physics
Other indications if necessary	Mechanobiology, biochemistry

Internship description

R-bodies are unique molecular pistons produced by endosymbiotic bacteria that can switch in a fraction of second from self-enrolled 500nm ribbons to 20 microns membrane-perforating needles. Their extension is triggered by pH variation via a mechanism that remains unclear. Within this internship the student will decipher R-bodies' extension-retraction cycle dynamics and mechanism by combining microfluidics, high speed imaging, force spectroscopy methods and theoretical models.

The R-bodies will be produced in E.coli and immobilized inside microfluidic chambers allowing rapid buffer exchange. We will assess the influence of buffer viscosity on R-bodies dynamics and the force generated during retraction using high speed imaging and optical tweezers. R-bodies will be trapped into giant unilamellar vesicles together with photoacid molecules and oscillatory rapid actuation will be triggered by light.

The longer term vision is to develop the first biophysical model integrating the experimental results on the thermodynamics and kinetics of the R-body phase transition and to ultimately tame this powerful and unique, nano-machine workhorse for future applications in the nano-realm.

<u>In detail, the master intern will:</u>

❶ Immobilize R-Bodies inside a microfluidic chamber through chemical crosslinking.

❷ Monitor the precise extension-retraction mechanism kinetics using a high-speed camera.

❸ Analyse step by step the movement of the needle using image analysis algorithms

❹ Modulate fluid viscosities in order to better decompose the steps of the movement.

❺Attach a colloidal probe particle on the R-body and by optical trapping, measure the particle displacement during extension-retraction transitions in order to measure the force.

❻ Encapsulate R bodies into Giant Unilamellar Vesicles (GUVs) or Small Unilamellar Vesicles (SUVs) to design smart nano-carriers which could deliver drugs upon pH trigger.

The experimental observations will be carried out with the intention to develop a theoretical model to explain the R-body extension-retraction mechanism.

Profile: background in physics, physical chemistry or biochemistry and a taste for interdisciplinarity.

To be returned by e-mail before **19 September 2022** to melodie.galerne@unistra.fr

Hierarchical & Functional Materials for health, environment & energy | HiFunMat
The Interdisciplinary thematic institutes of the University of Strasbourg & CNRS & Inserm funded under the Excellence Initiative program

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Title Adaptive glazing based on photovoltaic spatial light modulators to improve the energy efficiency of buildings.

Internship supervisor

Name, first name	LIN, Yaochen
E-mail, Telephone	yaochen.lin@unistra.fr, 0388106549
Laboratory	ICUBE laboratory
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Heiser Thomas Fall Sadiara

Student profile looked for

Master program (*more than one box can be ticked*)	☒ Material science and engineering ☐ Chemistry ☐ Physics
Other indications if necessary	

Internship description

According to the European Union (EU) Buildings Observatory, about 40% of energy consumption and 36% of CO_2 emissions in the EU are due to buildings. Improving the energy efficiency of buildings has therefore become one of the priorities in the fight against global warming. The development of so-called "adaptive glazing", whose transparency can adapt to the intensity of solar radiation, is one way of achieving this goal.[1,2] Limiting the heating of interior spaces in summer by reducing the transmission of infrared rays while maintaining a high level of luminosity during less sunny periods will reduce energy consumption for air conditioning and lighting. It is in this context that the MaCEPV research team has recently proposed a new concept of adaptive glass, called "PSLM" (for "photovoltaic spatial light modulator").[3] A PSLM glass is a hybrid thin-film device, composed of a nematic liquid crystal (LC) in direct contact with thin-film organic semiconductors. Its operating principle is based on the ability of the LC molecules to orient themselves in the direction of a low amplitude electric field and on the ability of the organic semiconductors to generate an electric field when exposed to light (photovoltaic effect).

To ensure a stable response under light, it is necessary to keep the ionic conductivity of the liquid crystal as low as possible. To achieve this objective, the project will include an in-depth study of the efficiency of trapping residual ions by bi-functional thin films. Recent work by the MaCEPV team demonstrated that such films can ensure both liquid crystal alignment and ion trapping. However, the underlying physical mechanism is not yet clearly established. This internship is dedicated to identify and study the physical properties of the polymers responsible for ion trapping and to deduce optimal conditions for their utilization.

References:

[1] S.D. Rezaei et al. A review of conventional, advanced, and smart glazing technologies and materials for improving indoor environment, Solar Energy Materials & Solar Cells 159 (2017) 26

[2] N.C. Davy et al., Pairing of near-ultraviolet solar cells with electrochromic windows for smart management of the solar spectrum, Nature Energy 2 (2017) 17104

[3] https://anr.fr/Projet-ANR-19-CE05-0036

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ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Title Designing hydrogels functionalized with Virus-Like Particles to control cell behavior

Internship supervisor

Name, first name	ARNOLD Carole
E-mail, Telephone	carole.arnold@uha.fr
Laboratory	IS2M (Mulhouse) https://biointerfaces.wordpress.com/
Collaboration with a HiFunMat member (*please indicate their name*)	☒ No ☐ Yes :
	https://www.is2m.uha.fr/fr/nos-axes-thematiques/biomateriaux-biointerfaces/

Student profile looked for

Master program (*more than one box can be ticked)*	☒ Material science and engineering ☐ Chemistry ☐ Physics
Other indications if necessary	Field : Biomaterials. Skills or interest on biomaterials or biology are expected.

Internship description

The living world encompasses a large range of proteins able to self-assemble and form **nanometric 3D dynamic objects** with specific shapes and functions (e.g. microfilaments and microtubules, viral capsids…). **Multimeric self-assemblies** can be synthesized in vitro and genetically modified to present surface peptides or ligands with the ability to induce various cell responses. We have already designed and produced self-assemblies based on **Virus-Like Particles** (**VLPs** [1]) adsorbed on polydimethylsiloxane (PDMS) and presenting surface peptides with **cell adhesion** properties. These functionalized surfaces have efficiently enhanced cell adhesion. We have also produced several types of VLPs decorated with various differentiation peptides with osteogenic and myogenic properties (Fig. 1C), as well as VLPs with a **Spytag/spycatcher polymerization system** (Fig. 1A to D). This system can be used to create **functionalized hydrogels**.

In this project, we will produce **bioactive hydrogels** [2] based on VLPs to create a **network of multifunctional particles** in which cells will be hosted and receive molecular signals that will influence their morphology and behavior (Fig. 1F).

<u>In detail, the master intern will :</u>

❶ **Produce** and **purify** monomeric VLPs by chromatography

❷ **Create** hydrogels based on multifunctional VLPs with the Spytag/spycatcher system

❸ **Culture** cells in these hydrogels

❹ **Perform** time-lapse confocal microscopy to image cell morphology and behavior in 3D and in real time within the hydrogels.

Material surface biofunctionalization has relevance for the improvement of **implant biointegration** but also for the fundamental understanding of the **interaction mechanisms between cells and materials**. It also enables to address fundamental questions concerning cell morphology, behavior and fate in response to **extracellular cues in a 3D microenvironment**.

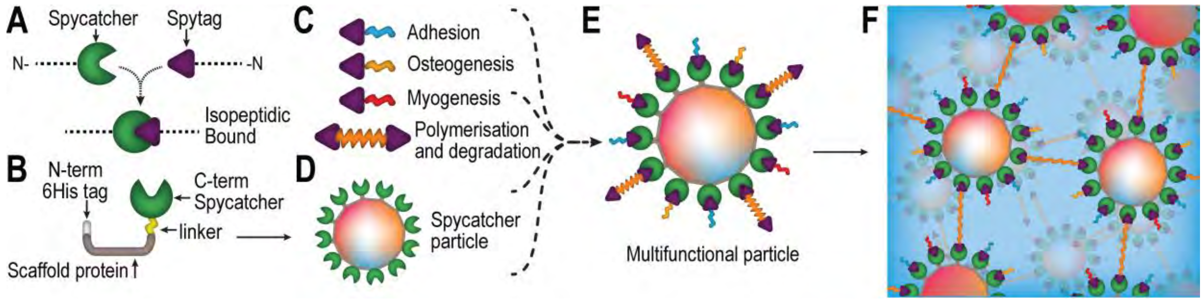

Figure 1 : The Spytag/spycatcher system is a technology for irreversible conjugation of recombinant proteins by the formation of an isopeptidic bound between the two moieties (A). The Spytag moiety has been fused to various bioactive peptides influencing cell adhesion, osteogenesis and myogenesis, as well as polymerization proteins (C). We have fused the Spycatcher moiety to the scaffold protein of the VLP (B) to self-assemble Spycatcher particles (D). These particles will be combined to the fusions described in (C) to obtain a multifunctional particle (E) enabling the formation of a hydrogel displaying functional peptides for the control of cell morphology, behavior and fate (F).

[1] X. Ding, D. Liu, G. Booth, W. Gao, and Y. Lu. Biotechnol J. 13(5):e1700324. Review. (2018).
[2] Yang L , Liu A , de Ruiter MV , et al. Nanoscale. 10(8):4123-4129. doi:10.1039/c7nr07718a (2018).

To be returned by e-mail before **19 September 2022** to melodie.galerne@unistra.fr

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Title Synthesis of polymer-clay nanocomposite in situ

Internship supervisor

Name, first name	DZENE Liva
E-mail, Telephone	liva.dzene@uha.fr , 03 89 33 67 38
Laboratory	Institut de Science des Matériaux de Mulhouse
Collaboration with a HiFunMat member (*please indicate their name*)	☒ No ☐ Yes :

Student profile looked for

Master program (*more than one box can be ticked*)	☒ Material science and engineering ☒ Chemistry ☐ Physics
Other indications if necessary	

Internship description

Research on clay mineral-polymer composites accelerated significantly after the 1990s, when researchers at Toyota Central Research & Development Laboratories demonstrated that a modified nylon-6 – clay composite had significantly superior mechanical properties compared to pristine nylon-6 [1]. As a result, numerous studies have revealed that in addition of improving the mechanical properties of a polymer, the presence of clay minerals in the formulation can also impact the fire resistance, gas barrier properties and thermal stability of the material. The research project proposes an original approach for the preparation of polymer–lamellar filler composites, using a silane-modified polymer as a source of silicon [2] and a sol-gel route for the synthesis of organic-inorganic hybrid material with a talc-like structure [3]. This approach can be considered as environment-friendly because it is carried out at room temperature, with non-harmful solvents and for short periods of time. It could lead to the formulation of a new family of composites. The study will consist of preparing a silane-modified polymer, followed by synthesis of an organic-inorganic hybrid using the modified polymer, and the incorporation of these compounds in polyurethane type coatings. The prepared material will be characterized by different techniques such as X-ray diffraction, Fourier transform infrared spectroscopy and ^{29}Si solid nuclear magnetic resonance spectroscopy.

Researchers participating in the project : Anne-Sophie Schuller (MCF, LPIM), Christelle Delaite (PR, LPIM) and Jocelyne Brendlé (PR, IS2M).

[1] Y. Kojima et al., J. Mater. Res., 1993, 8, 1185–1189.

[2] A. S. Schuller, C. Delaite and H. Farge, Polym. Bull., 2011, 66, 77–94.

[3] J. Brendlé, Dalt. Trans., 2018, 47, 2925–2932.

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ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Title: Synthesis of carbon quantum dots (CQDs) doped with nitrogen and sulphur

Internship supervisor

Name, first name	Ghimbeu, Camélia
E-mail, Telephone	Camelia.ghimbeu@uha.fr; 03 89 60 87 43
Laboratory	Institut de Sciences des Matériaux de Mulhouse, UMR 7361
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Sébastien Albrecht Laboratoire d'Innovation Moléculaire & Applications

Student profile looked for

Master program (*more than one box can be ticked)*	☒ Material science and engineering ☒ Chemistry ☐ Physics
Other indications if necessary	Experience in nanomaterial synthesis and/or characterization will be appreciated but not obligatory.

Internship description

The objective of this stage is to develop ratiometric fluorescent sensors based on carbon quantum dots (CQDs) for the detection of iron ions. Iron is present in the human body in different forms (Fe^{2+} and Fe^{3+}), and its detection is very important for the identification of various diseases. The today used technologies to detect iron are expensive, time-consuming, or lacking sensibility. For this reason, recent works explored the possibility of using CQDs for the detection of iron. CQDs attracted attention mainly due to their properties (biocompatibility, low toxicity, and good dispersion in water). They can be obtained by using a large variety of precursors which are eco-friendly and cost-effective via simple synthesis methods. The possibility of easy incorporation of nitrogen and sulphur in their structure, along with the particle size tuning, allow them to exhibit different fluorescent properties and selectivity toward iron detection.

The first part of the internship will focus on the synthesis of CQDs doped with nitrogen and sulphur, using hydrothermal carbonization and microwave routes. Several parameters will be investigated: the source of carbon, nitrogen, and sulphur, the concentration of precursors and solvent, and the operation conditions (temperature, time, and microwave power).

In the second part, the properties of the obtained materials will be characterised by several techniques: particle size by TEM (transmission electron microscopy), the surface chemistry by XPS (X-ray photoelectron spectroscopy) and Fourier transform infrared (FTIR) spectroscopy, and structure by Raman spectroscopy. The UV-VIS absorption and fluorescence spectra of the materials will be measured, and the obtained results will be linked with the properties of the materials.

Finally, the as-obtained materials will be used by LIMA partner to detect iron ions and to test the selectivity towards other ions present in human body (Na^{+}, Ca^{2+}, Mg^{2+} etc.).

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ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Title: Electrodes manufacturing optimization for improved performance in Na-ion batteries

Internship supervisor(s)

Name(s), first name(s)	GHIMBEU Camelia / BEDA Adrian
E-mail(s), Telephone(s)	camelia.ghimbeu@uha.fr / adrian.beda@uha.fr ; +33 (0)3 89 60 87 43 / +33 (0)3 89 60 88 59
Laboratory	Mulhouse Materials Science Institute (IS2M), France
Collaboration with a HiFunMat member (*please indicate their name*)	☒ No ☐ Yes :

Student profile looked for

Master program (*more than one box can be ticked)*	☒ Material science and engineering ☒ Chemistry ☐ Physics
Other indications if necessary	Experience on electrode fabrication, glove box manipulation and/or electrochemical cells assembly is highly appreciated.

Internship description

Na-ion based batteries (NIBs) have been widely studied as a promising alternative to the state-of-the-art, Li-ion batteries. Among the materials used as negative electrodes for NIBs, hard carbons (HC) have received great interest due to their low-cost and appropriate physico-chemical features. The electrochemical performance delivered by the HC electrodes are closely related to their properties but not only that. Electrode manufacturing process plays an important role on the battery performance, have a significant influence on the morphology and interface properties.

The electrode fabrication implies several steps such as: components mixing, coating on the current collector, solvent evaporation, and electrode punching. All these steps depend on numerous parameters, including mixing conditions (e.g., speed, time), solvent type, binder matrix, active material, casting conditions, drying process, etc. Establishing the optimal conditions for all these features is critical for improved electrochemical performance.

The aim of the internship is to conduct a systematic study to evaluate the parameters involved in the process of HC electrode fabrication (i.e., slurry preparation and coating, electrode drying and punching) and to identify the best conditions that lead to optimal electrodes and enhanced electrochemical performance in NIBs. Electrochemical cells assembly and the testing conditions will be carefully investigated, as well.

Techniques used: Thermal pyrolysis, Ball milling, X-Ray diffraction (XRD), Raman spectroscopy, Scanning electron microscopy (SEM), Energy-dispersive X-ray spectroscopy (EDX)and electrochemical techniques (e.g. galvanostatic charge discharge).

The internship will take place within the Carbons and Hybrid Materials (CMH) team.

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ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Physical properties studies at the meso-scale of porous and conducting MOF/polymer hybrid materials for thermoelectric applications

Internship supervisor

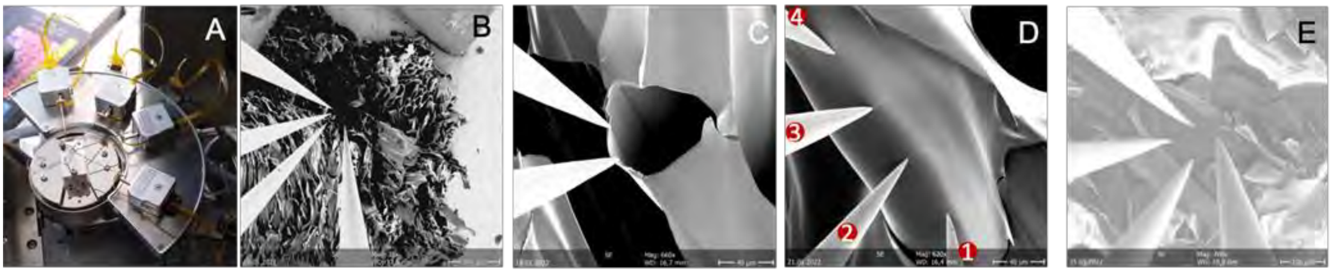
Name, first name	SIMON Laurent / CHAPLAIS Gérald
E-mail, Telephone	laurent.simon@uha.fr / gerald.chaplais@uha.fr 03 89 33 66 03/ 03 89 33 68 87
Laboratory	Institut de Science des Matériaux de Mulhouse (IS2M)
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : BINIEK Laure

Student profile looked for

Master program (*more than one box can be ticked)*	☒ Material science and engineering ☒ Chemistry ☒ Physics
Other indications if necessary	Possible starting date: September 2022

Internship description

This project is in the framework of the research of new sources of energy and transitioning towards green technologies. L. Biniek and co-workers (ICS-Strasbourg) have developed a new class of polymer materials (Cryogel) which are able to generate electricity by thermoelectric effect (TE). These materials overcome the drawback of the already existing TE inorganic nanomaterial (based out of semiconducting chalcogenides (Pb, Bi, Te)), such as their toxicity, high cost, scare resources of elements for their fabrication and poor mechanical properties. In general, a TE material is assessed by its dimensionless figure of merit zT; which is defined by the equation $zT= S^2 \sigma T/\varkappa$ [T: absolute temperature (K), S: Seebeck coefficient (V/K), σ: electrical conductivity (S/m), ϰ: thermal conductivity (W/(m.K)]. In that purpose, organic TE (OTE) materials appear as promising candidates as they fix disadvantages previously mentioned and they can harvest low grade heat (below 150°C). On a general basis, polymer TE has only developed since the pioneering work of Crispin and coworkers in 2011 and much is still to learn.



A) Photo of the nanoprobing station with the four Micro-Nano robot IMINA in the FEG-MEB on the cryo stage. B) General view of the PEDOT:PSS polymer with the four probe. C) Measurement of the conductivity on the edge of the tubular structure with wall thickness of 250 nm. D) E) two examples of four probe measurement in TLL D) and in van der Paw configuration E).

In this project, we aim to synthesis a new class of hierarchical structure which combines MOFs (Metal-Organic-Framework) and porous conducting polymers for TE. The combination of the two hierarchical materials should enable the coexistence of micro- (< 2 nm) and meso (< 50 nm) or macro (> 50 nm) porosity. This is expected to play a large role on the phonon scattering and thus limit the thermal conductivity. MOFs have also in general higher Seebeck than conducting polymers, a high Seebeck coefficient is thus expected for the composites. The synthesis and preliminary tests will be done by the team of L. Biniek (ICS) and N. Leclerc (ICPEES). At IS2M, with G. Chaplais and L. Simon, we will study the physical properties and more particularly the transport measurement at the meso-scale in order to explore the link between the structure and the physical properties of the material at the meso-scale. We will provide detailed studies of transport properties in function of the local order of the structure. In the framework of the NanoteraHertz project (Region Grand-Est, UE-FEDER), we have developed a nanoprobing station under a SEM (FEG-SEM XL30). This consists in four IMINA® micro-nano manipulators which can be equipped with tungsten tips, optical fiber or micro-nano-manipulator tools (precision down to 10 nm) on a cryo-stage (300°C/-190°C). The figures show the nanoprobing station and first conductive measurement realized on Cryogel PEDOT:PSS. During the master's internship, we aim to design and develop new tool into the SEM to measure also, to our knowledge for the first time, the Seebeck coefficient at the mesoscale

Requirements & Application

We are looking for motivated and team-worker master Student (physicist or chemi-physicist) willing to learn about conjugated ligands and MOF synthesis, characterization and thermoelectric properties. The candidate is expected to be not afraid of multidisciplinary field with chemists. Collaboration with L. Biniek (ICS) and N. Leclerc (ICPEES) including short stays there, will be possible.

Please send your application including a CV, a motivation letter and Master transcript of records to L. Simon [laurent.simon@uha.fr], and G. Chaplais [gerald.chaplais@uha.fr] from IS2M

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ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Development of a regenerative sensor for the detection of molecules in the space domain

Internship supervisor

Name, first name	KELLER Marc/MOUGIN Karine
E-mail, Telephone	marc.keller@uha.fr/karine.mougin@uha.fr
Laboratory	Institut de Science des Matériaux de Mulhouse (IS2M)
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Arnaud SPANGENBERG

Student profile looked for

Master program (*more than one box can be ticked)*	☒ Material science and engineering ☒ Chemistry ☒ Physics
Other indications if necessary	

Internship description

The proposed subject is part of an academic project in collaboration with CNES (Toulouse) **to develop a nanostructured sensor for the detection of trace of molecules**. The goal of the internship is to optimize the development process of the sensor and to verify the reproducibility of the measurements previously realized during a Ph-D.

Within the framework of this internship, the synthesis of metallic nanoparticles by electrochemical way will be privileged in order to obtain nanosensors with a controlled morphology according to the conditions of the synthesis. The limits of detection of the sensor will vary according to the physico-chemical properties (large specific surface, surface plasmon, etc....) of these nanoparticles.

Quantification of the adsorbed organic molecules on the sensor will be carried out by optical and electrochemical method.

The final objective of the project focuses on the miniaturization of this sensor in a context of weight reduction of the instruments embarked during space missions, versatility and gain in performance.

Based on the literature related to the study, the trainee student will be in charge of optimizing the manufacturing process of the sensor by synthesizing nanoparticles and studying the limits of adsorption and detection inherent to the sensor. To do so, different characterization techniques will be used such as Scanning Electron Microscopy/Transmission, Atomic Force Microscopy, UV-Visible Spectroscopy, Infrared Spectroscopy, Raman Spectroscopy but also a Quartz Microbalance.

<u>This internship will be followed by a one-year contract as a research engineer.</u>

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ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Title Formulation of pure albumin materials using salt-assisted compaction: loading of an antitumor active drug

Internship supervisor

Name, first name	FRISCH Benoît
E-mail, Telephone	frisch@unistra.fr 0368854168
Laboratory	LCAMB UMR 7199 3BIO TEAM, ILLKIRCH
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Dr. LAVALLE Philippe, Pr. SCHAAF Pierre

Student profile looked for

Master program (*more than one box can be ticked)*	☒ Material science and engineering ☒ Chemistry ☐ Physics
Other indications if necessary	

Internship description

In this project, we propose to take advantage of the mechanical properties of new albumin-based biomaterials (patented in 2019) to exploit them as a delivery system for an anti-tumor active principle. Indeed, unorganized albumin in the form of biomaterials is already used as a carrier for several anti-tumor molecules in drugs used in chemotherapy. Some albumin-based nanoparticles have already shown significant improvements. The abraxane used in the treatment of breast cancer, among others, uses albumin as a carrier and vector for paclitaxel[1]. Our main objective is therefore to develop an anti-tumor construct based on a 100% natural and highly effective biomaterial. This biomaterial will be composed of native proteins that have not been chemically or physically modified. Biomaterials loaded with the active ingredient, in the form of a cylinder (very large quantity of active ingredient), foam (very large contact surface with the surrounding environment) or micro(nano)particles (subcutaneous or blood injections), will be manufactured and optimized. Their slow degradation should allow a constant and durable release of the anti-tumor molecule. This project will be carried out in four phases: i) manufacture and optimization of biomaterials in the form of implants, membranes, foams or micro(nano)particles by ultracentrifugation, evaporation or other techniques to be developed, ii) physico-chemical analysis of the new biomaterials (mechanical properties, rheology, stability, solubility, ...), iii) optimization of the loading of the active principle into the various implants either by pre-loading (drug associated with the biomaterial during its formation) or by post-loading (loading of the drug after the formation of the biomaterial) and iv) evaluation and optimization of the release of the active principle from the various implants as a function of the environment (acid, basic, culture medium, serum, etc.). The evaluation phase on cell cultures will be considered depending on the evolution of the project and/or the *desirata* of the candidate. A collaboration with an industrial partner is possible.

[1] https://www.vidal.fr/Medicament/abraxane-84573-pharmacodynamie.htm

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ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Title : Development of ratiometric fluorescent chemosensors for ferric iron detection in disease diagnosis

Internship supervisor

Name, first name	ALBRECHT, Sébastien
E-mail, Telephone	sebastien.albrecht@uha.fr, 0389336714
Laboratory / Industry	LIMA
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Dr C. Ghimbeu IS2M
Address	3bis rue Alfred Werner, IRJBD-LIMA, Mulhouse

Student profile looked for

Master program	☐ Material science and engineering ☒ Chemistry ☐ Physics
Minimum duration of internship	☐ 2 months ☐ 4 months ☐ 6 months
Other indications if necessary	5 months (from February, 01st to June, 30th)

Internship description

Physiologically, Iron is the most abundant and versatile transition metal ion in human. Present in the cells to facilitate biological action, Iron metabolism disorders encompass a broad spectrum of common human diseases with diverse clinical manifestations, ranging from anemia to iron overload. Most pathological conditions are caused by extreme parameters e.g. too much or not enough iron. Multiple organs can be affected by excess iron and cause disease including Hereditary Hemochromatosis (HH) for the liver, ferritinopathy for the brain, macrophage overload, thalassemia syndromes or congenital- and acquired-sideroblastic anemias for the bone marrow compartment. Moreover, chronic oral administration or chronic blood transfusion may also induce iron overload.

The aim of this internship will be the development of novel ratiometric fluorescent chemosensors able to selectively detect intracellular endogeneous ferric iron.

In this position, you will design, plan and perform multi-step small molecule organic synthesis experimentation and evaluate the photophysical properties of the synthesized chemosensors. You will generate and evaluate data, interpret, report results, and draw conclusions.

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ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Axial chirality in circularly polarized photoluminescence (CPL) of organosilicon compounds: a new path to the OLEDs of tomorrow

Internship supervisor

Name, first name	Donnard Morgan
E-mail, Telephone	donnard@unistra.fr
Laboratory	LIMA UMR 7042
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Emilie Steveler (ICube)

Student profile looked for

Master program (*more than one box can be ticked)*	☐ Material science and engineering ☒ Chemistry ☐ Physics
Other indications if necessary	Organic synthesis

Internship description

Within the framework of a collaboration between the COHA team (UMR7042-LIMA) and ICube (UMR7357), we are offering a position for an M2 intern in synthetic organic chemistry. The objective of the trainee will be to develop new chiral organosilicon compounds in order to study their photophysical properties in polarized luminescence.

Due to their massive use in small screen devices, OLEDs (Organic Light Emitting Devices) are probably the most developed organic materials. In recent years, a new type of OLEDs called CP-OLEDs, whose specificity is to produce circularly polarized luminescence (CPL), has emerged and is very promising in fields as strategic as 3D displays, cyber security or medical imaging. In this project, we aim to develop for the first time silicon-based compounds carrying axial chirality for use as novel CPL promoters.

In the course of this work, we will rationalize and correlate the relationship "axial chirality/molecular structure/ luminescence properties" to make these new materials useful for optoelectronic devices.

We are looking for a person with a good theoretical and practical background in synthetic organic chemistry. Beyond technical skills, he/she should be curious, motivated, a good listener, sociable and have good adaptation skills.

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ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Stabilisation of nickel nanoparticles through coordination of NHC ligands for catalysis

Internship supervisor

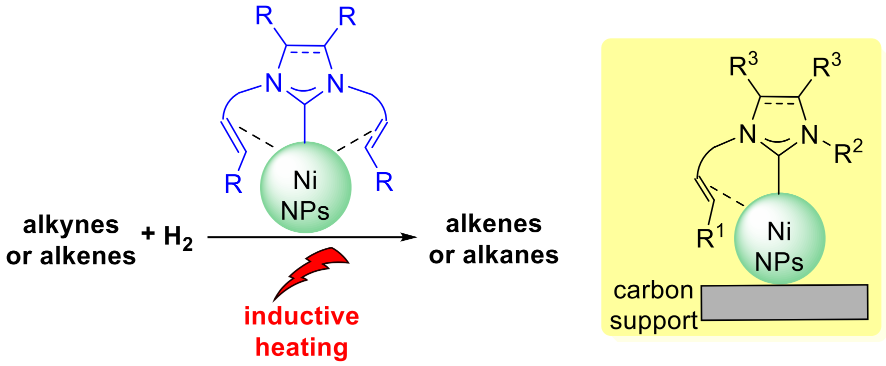
Name, first name	MICHON, Christophe
E-mail, Telephone	cmichon@unistra.fr , 0368852797
Laboratory	LIMA UMR7042 – team of Applied Organometallic Chemistry
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Dr. Cuong Pham-Huu (ICPEES) and Dr Christophe Michon (LIMA)

Student profile looked for

Master program (*more than one box can be ticked*)	☒ Material science and engineering ☒ Chemistry ☐ Physics
Other indications if necessary	Skills in synthetic molecular chemistry are required.

Internship description

This project implies the development of new sustainable nanocatalysts based on nickel nanoparticles (NPs) coordinated to bi- or tridentates ligands comprising a strong σ-donating N-heterocyclic carbene (NHC) fragment and one or two π-accepting appended olefins. With the use of a carbon support, this strategy will lead to stabilised nanoparticles, of defined sizes and with unique reactivity for organic reactions. The prepared species will be studied for the catalysis of the semi-hydrogenation of alkynes and of the hydrogenation of alkenes. Furthermore, a contact-free heating by electromagnetic induction will be applied in the nanoparticles synthesis, as well as in the catalytic reactions. This will allow to reduce the energy loss and the limitations during the reactions' heat transfer by heating exclusively the nickel species through the carbon support and a heat transfer agent. Finally, the spent catalysts will be recovered and reused thanks to their magnetic properties (magnetic recovery) or their supported structure (recovery by filtration).



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