STAGE MASTER (6 mois) – 1er semestre 2024

Etude de la morphologie de nanofibres électrospinnées obtenues à partir de dispersion liquide-liquide contenant des polymères marqués par des fluorophores

Responsables : Carlotta Figliola et Émeline Lobry

Contexte et mission :

L'Institut de chimie et procédés pour l'énergie, l'environnement et la santé (ICPEES) est une unité mixte de recherche (UMR 7515) sous la cotutelle du CNRS et de l'Université de Strasbourg. Les travaux se feront au sein de l'équipe PolyFuN qui possède une expertise dans le domaine de l'electrospinning (https://icpees.unistra.fr/en/polymer-engineering/electrospinning/) et de l'équipe COMBO (https://icpees.unistra.fr/chimie-moleculaire-et-analytique/mari/themes-de-recherche/) qui travaille sur la conception et la synthèse des sondes fluorescentes.

L'électrospinning consiste à générer des nanofibres à partir de solutions de polymères. Les solvants organiques utilisés présentent souvent un risque toxique pour la santé et l'environnement. De plus, les polymères à mettre en œuvre sont parfois peu solubles et la production de nanofibres est limitée à cause des propriétés rhéologiques des solutions, ne permettant pas d'obtenir des diamètres moyens submicroniques. L'alternative proposée pour limiter l'usage de solvant et moduler les propriétés rhéologiques des solutions consiste à formuler des dispersions liquide-liquide.

Ce stage se focalise sur l'étude de dispersion huile dans eau. Deux types de dispersions seront étudiées : les émulsions et les miniémulsions. De plus, l'influence des paramètres de la formulation (taille de goutte, concentration en phase dispersée, nature des solvants et tensio-actif) sur la structuration interne des fibres (voir figure 1) sera étudiée.

Pour identifier la répartition des phases au sein des fibres, les phases huileuse et aqueuse seront marquées à l'aide de fluorophores. Deux systèmes seront étudiés :

1) Un système modèle huile-eau/polymère (les deux contenant un fluorophore à longueur d'onde d'émission différente) permettra à l'étudiant de prendre en main les différents outils du laboratoire pour générer les fibres et caractériser leurs propriétés morphologiques et photophysiques. Ce système permet de s'affranchir du phénomène d'évaporation de la phase huile qui peut modifier la structuration des fibres.
2) Un système basé sur des polymères biocompatibles sera testé pour développer un mat nanofibreux destiné à servir de système d'administration de médicaments. Pour améliorer l'intégration du fluorophore, une fonctionnalisation covalente entre le polymère et le fluorophore sera effectuée.

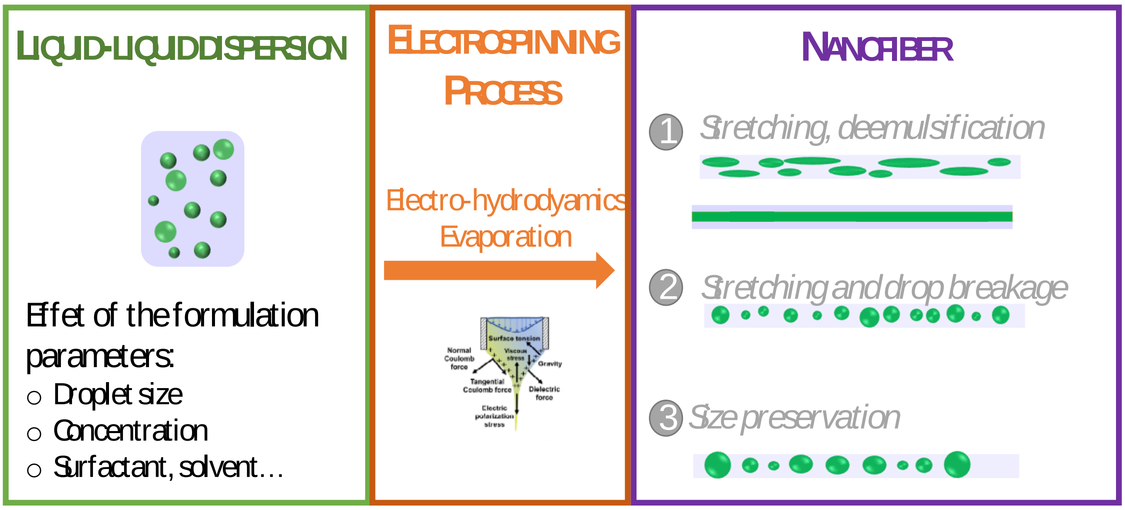


Figure 1 : Structuration des fibres en fonction des paramètres de formulation des dispersions liquide-liquide

Compétences Requises :

- Bonne formation en physico-chimie et science des polymères
- Goût pour la synthèse organique
- Travail expérimental rigoureux
- Curieux et force de proposition.
- Capacité à travailler en équipe et à communiquer sur ses résultats

Techniques et compétences qui seront développées :

- Formulation
- Electrospinning
- Synthesis of fluorophores
- Fonctionnalisation de polymère par greffage covalent de fluorophore
- Techniques de caractérisation (MEB, spectroscopie RMN, spectroscopie UV/Visible, microscope confocale à fluorescence)

Candidatures :

Le candidat devra transmettre une lettre de motivation, un CV détaillé et les relevés de notes de M1 à elobry@unistra.fr et figliola@unistra.fr .

MASTER 2 INTERNSHIP (6 months) – first semester 2024

Study of the electrospun nanofibers morphology obtained from liquid-liquid dispersions containing fluorophore-labelled polymers

Supervisors : Carlotta Figliola et Émeline Lobry

Contexts and missions:
The work will be carried out at the Institute of Chemistry and Processes for Energy, Environment and Health (ICPEES UMR7515) as part of a collaborative project between the COMBO (https://icpees.unistra.fr/chimie-moleculaire-et-analytique/mari/themes-de-recherche/) and the POLYFUN team (https://icpees.unistra.fr/en/polymer-engineering/electrospinning/.)

Electrospinning aims to generate nanofibers from polymer solutions. Organic solvents are often used with potential high toxicity and environmental damages. In some cases, the solubility of the polymer is limited and it affects drastically the rheological properties of the solution responsible for nanofibers generation. A possible solution to reduce use of organic solvent as well as to enhance the physico-chemical and rheological properties of the mixture is to formulate liquid-liquid dispersions. In this internship, oil in water dispersions will be preferentially studied and two types of systems will be studied: emulsion and miniemulsion. Furthermore, the effect of the formulation parameters (droplet size, concentrations, solvents, and surfactants type) on the internal structure of the nanofibers will be investigated (see Figure 1). To identify the distribution of phases within fibers, the oil and the water phases will be marked by fluorescent compounds. Two systems will be studied during the internship:

1) A model oil- /water-soluble polymer system, both containing a dye of different fluorescence wavelength, will enable the investigation of the effect of the formulation parameters without considering the evaporation phenomenon of the oil phase. This will help the student to become familiar with the different processes to generate the nanofiber and the characterization techniques for morphology and the photophysical properties.
2) A system based on biocompatible polymers will be tested to develop a nanofibrous mat aiming to serve as a drug delivery matrix for future medical applications. To improve the fluorophore integration and mimic the future applications, a covalent functionalization between the polymer and the fluorophore will be performed.

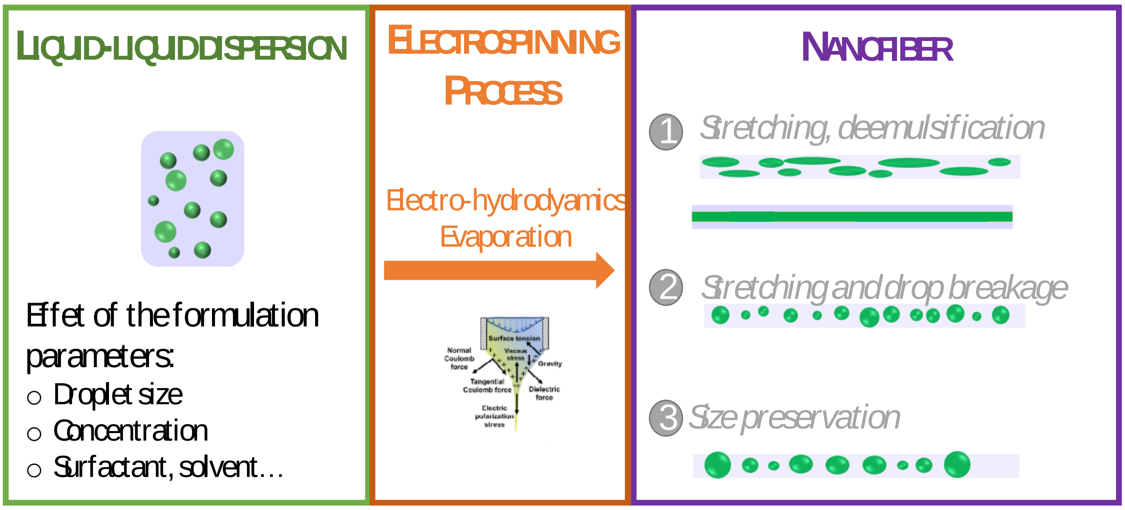


Figure 1 : Effect of the formulation parameters of the liquid-liquid dispersions on the fiber morphology

Required skills:

- Knowledge in physico-chemistry and polymer chemistry
- Interest in organic synthesis
- Rigorous experimental work
- Curious and proactive
- Ability to work as part of a team and to communicate results

Skills to develop during the M2 internship:

- Formulation
- Electrospinning
- Synthesis of fluorophores
- Functionalisation of polymers by covalent grafting of fluorophores
- Characterisation techniques (SEM, NMR spectroscopy, absorption and emission spectroscopy, confocal fluorescence microscopy)

Applications:

Cover letter, CV and final M1 grades to be sent elobry@unistra.fr and figliola@unistra.fr.

6-month internship topic

Liquid Embolic Agents for the Treatment of Malignant Tumors

Name of the advisors: Mehdi Vahdati, Fouzia Boulmedais
Laboratory: Institut Charles Sadron (ICS), 23 rue de Lœss, 67037 Strasbourg
Campus: Cronenbourg - ZRR structure
Team website: https://www.ics-cnrs.unistra.fr/equipe-pecmat.html
Approximate starting date: February 2023

Embolization is the process of occluding blood vessels as a treatment for malignant tumors. A wide range of embolic agents, such as coils, plugs, particulates, and liquid agents are currently used in clinical applications. Liquid embolic agents are particularly interesting for their fluidity and their capacity to load and deliver drugs.[1] Important factors in the design of liquid embolics are (i) their flow behavior for optimal delivery through microcatheters and (ii) their solidification kinetics for effective occlusion of the vessel. Merit Medical, one of the leading companies in this field, recently developed novel liquid embolics based on charged polymers, known as polyelectrolytes. These embolic agents are soft, water-based materials with widely adjustable mechanical properties.

The main objective of this internship is to formulate and characterize the mechanical properties of novel liquid embolic agents in aqueous and physiological media. The intern will first formulate different liquid embolics based on the components provided by Merit Medical. They will then study the flow and viscoelastic behavior of the liquid embolics using underwater rheology. They will also characterize the solidification kinetics of the most promising embolic agents in a physiological buffer. This will be done using micro-indentation tests on thin films. The intern is required to hand in regular progress reports and to participate in group meetings as well as progress meetings with the R&D department of the company.

Candidate's profile and selection criteria: An open-minded, curious, and motivated master's or last year engineering school student in the field of materials science or polymers. Interest or experience in polymers, hydrogels, and or mechanical characterization is a plus. Applications are assessed based on relevance, motivations, and DE&I (Diversity, Equity, and Inclusion). Fluent communication in English (oral and writing) is a requirement.

Note: The internship is a collaboration between PECMAT team from ICS and the R&D team of Merit Medical. The intern will work at ICS (Cronenbourg campus).

How to apply: Please send a CV and a motivation letter (*both in English*) to mehdi.vahdati@ics-cnrs.unistra.fr and fouzia.boulmedais@ics-cnrs.unistra.fr.

References:

[1] Jiang, et. al., *ChemPhysMater*, 1, **2022**, 39-50.

ITI HiFunMat Master Internship Proposal

☒ M 1 ☐ M 2

Title: Design of Ag-Pt supported catalysts for plasmon-induced 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 TOGETHER-FOR-CO2 ANR project. It is known that CO_2 can in principle be reduced into methane using light-activated catalysts and water as the reducing agent. What we found is that this could be achieved in a highly selective, continuous gas phase process, over extended period of times, using plasmonic metal nanoparticles (NPs). This true artificial photosynthesis process based on plasmon-induced chemical activity however critically depends on the composition of the plasmonic nanoparticle and the nature of the underlying inorganic support.

This Master M1 internship will aim at enhancing reaction turnovers by material design. It will focus on Ag-Pt bi-metallic NPs supported on titania with various Ag/Pt ratios. It will include the inorganic chemical synthesis of supported mono- and bi-metallic NPs, their characterization with UV-visible spectroscopy, X-ray photoelectron spectroscopy, scanning/transmission electron microscopy, temperature programmed reduction, and their photocatalytic evaluation. Based on these data, this M1 internship is expected to allow to identify the effect of the alloy composition on the plasmon-induced performances of the catalyst and identify an optimal alloy nanostructure for the reaction.

Work will take place in the PhotoCatalysis and PhotoConversion (PCPC) team of ICPEES. It will benefit from the knowledge acquired within the CNRS-funded SelCO2PlasmonRed project (2021-2023) and the current ANR project (2023-2026), 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 the environment.

ITI HiFunMat Master Internship Proposal

☒ M 1 ☒ M 2

Title : Molecular Dynamics of electrochemical systems

Internship supervisor

Name, first name	Asset, Tristan; Wolff, Jules
E-mail, Telephone	t.asset@unistra.fr ; juleswolff@unistra.fr
Laboratory	ICPEES, CNRS
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : SAVINOVA Elena

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

Whereas chemical reactions frequently occur in homogeneous environments, electrochemical reactions take place exclusively at the interface between an electrode and an electrolyte. Due to the localized nature of this reaction, understanding this interface is critical, as even the slightest of its properties (*e.g.,* local pH, arrangement of cations in the electrolyte, etc.) can drastically affect the kinetics and thermodynamics of the said reaction. The properties in question are primarily influenced by (i) local variations of reactants and products inherent to the reaction itself and (ii) the reorganization of the interface induced by the application of a potential. Understanding this interface is, in fact, crucial in order to better design future electrochemical systems.

Currently, the Guy-Chapman-Stern model is widely used to predict the distribution of charges as a function of distance from the electrode, within the first nanometers between the electrode and the core of the solution (defined as the "electrochemical double layer"). However, this model has limitations. Firstly, it treats ions as point charges, i.e., completely neglecting their volume and mass. Secondly, it does not account for neutral molecules that can nevertheless affect interactions near the electrode. In this context, the use of molecular dynamics allows for simulating a realistic representation of the reorganization of molecules in the solution and also accounts for uncharged molecules.

Recently, a simulation tool called MetalWalls has been developed, offering the possibility to rigorously simulate electrodes and the applied potential (an illustration of an interface constructed through MetalWalls is presented in **Figure 2**). In classical models, the electrode is approximated to a charged wall, but with MetalWalls, it is possible to dynamically represent the charge distribution in the electrode according to associated physical models. The initial simulations conducted with MetalWalls have highlighted divergences from the Guy-Chapman-Stern model. Indeed, the electrochemical double layer is influenced by a much broader set of variables than those used in the latter (with an example of profile provided in **Figure 1**). Furthermore, the electrode material plays a crucial role in the distribution and orientation of molecules, including those of the solvent, which is also affected by the nature and concentration of charges near the electrode. This information is essential and contributes to explaining phenomena observed experimentally, in terms of reactivity for various electrochemical systems.

During this internship, the objective is to undertake an in-depth study of the different parameters that influence the concentration distribution near the electrode-electrolyte interface. The selected candidate will have three main tasks: firstly, to study the impact of temperature and concentration on the structure of the electrochemical double layer; secondly, to identify solvent orientation trends based on simulation parameters (*e.g.,* potential, temperature, types of ions in solution); finally, to develop an analysis method for the conducted simulations. In this perspective, a solid knowledge of electrochemistry as well as a basic understanding of molecular dynamics and cheminformatics are necessary.

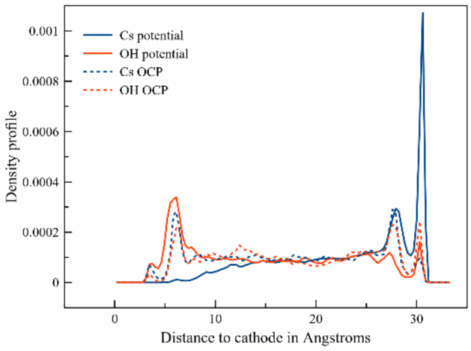


Figure 1 : Concentration distribution of Cs and OH ions in water with graphene electrode as a function of potential (OCP = open circuit potential, potential = 1V difference between the electrodes).

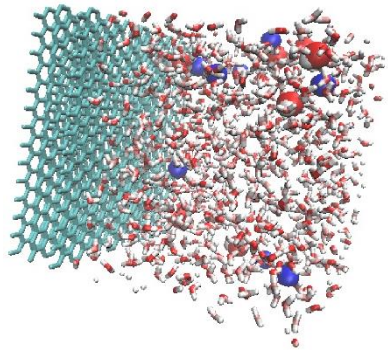


Figure 2 : NaOH 1M in water with graphene electrode (green = graphene, red/white = H_2O, red/white (big) = OH^-, blue = Na^+).

ITI HiFunMat Master Internship Proposal

☒ M 1 ☒ M 2

Design of Electrochemical Interfaces to Facilitate the Electrochemical Reduction of N_2 in NH_3 as an Alternative to the Haber-Bosch Process

Internship supervisor

Name, first name	Tristan Asset
E-mail, Telephone	t.asset@unistra.fr, 0659324521
Laboratory	ICPEES
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Elena Savinova

Student profile looked for

Master program (*more than one box can be ticked)*	☒ Material science and engineering ☒ Chemistry ☒ Physics
Other indications if necessary	The core topic of the internship shall be 'electrochemistry'

Internship description

The key role played by ammonia in our modern society requires the development of alternatives for the Haber-Bosch process (*i.e.,* the N_2 hydrogenation at high temperature/high pressure in presence of an iron catalyst to produce NH_3), to reduce its energy and CO_2 generation costs. Indeed, the H_2 used in the Haber-Bosch process mainly comes from fossil sources, and the aforementioned process is responsible for ***ca.* 2%** of the world yearly energetic consumption. An alternative lies in the electrochemical reduction of N_2 in NH_3 in near-ambient conditions. However, to make the latter possible, several objectives must be tackled. The nitrogen reduction reaction (NRR, $N_2 + 6H^+ + 6e^- \rightarrow 2NH_3$) occurs in the same potential range as the hydrogen evolution reaction (HER, $2H^+ + 2e^- \rightarrow H_2$). The latter, being far simpler and faster, dominates the catalytic activity. This domination is further increased owing to the fact that the N_2 solubility in aqueous media is extremely low, which also impact the NRR relative activity *vs.* the HER. Hence, the electrode interface at which the NRR happens must be tuned accordingly: (i) the local concentration of protons should be decreased to limit the HER, while still being sufficient to insure the NRR; (ii) the local concentration of N_2 should be drastically increased.

This internship aims to explore these approaches, by designing innovative interfaces on electrodeposited metallic ruthenium and metallic nickel, hence moving away from 'classical' interface as illustrated in **Fig. 1A**: (i) through the use of ionic liquids, *i.e.,* electrolytes only composed of liquid salts at room temperature, that shall be either used as encapsulating agents for the nanoparticles or as bulk electrolyte with various concentration of water or other protons carriers (see **Fig. 1B**); (ii) through the development of gas/liquid interfaces to ease the access of the N_2 under gaseous form at the reactive interface, thus greatly diminishing the limitations induced by its low solubility (see **Fig. 1C**).

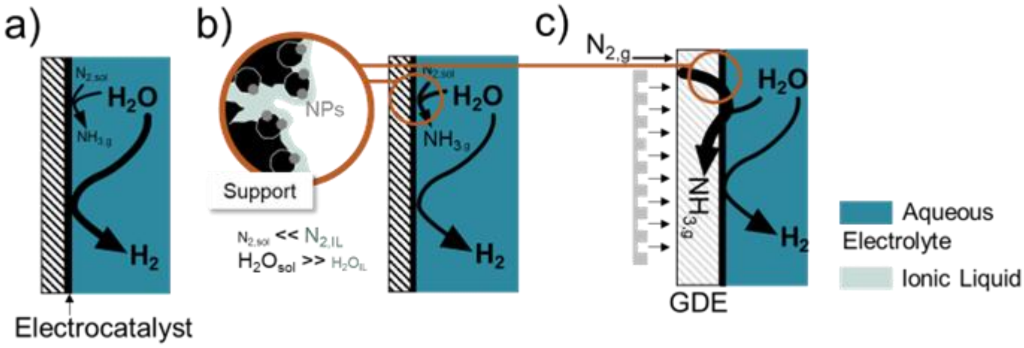


Figure 1. Schematic representation of the different types of interfaces to be envisioned for the nitrogen reduction reaction (NRR): (a) the 'conventional' interface, with aqueous environment and N_2 dissolved in H_2O, leading to a hydrogen evolution reaction (HER) dominated interface; (b) an aqueous interface with the active material encapsulated in ionic liquid (IL), thus tuning the solubility of the reactants at the interface; (c) a 'gas diffusion electrode' design, in which the N_2 is provided under gaseous form directly at the interface. Adapted from [1].

Specifically, the intern will:

- Using the preliminary results obtained by our team, optimize the design of electrodeposited Ru and Ni nanoparticles adapted to the study of innovative interfaces.
- Characterize their reactivity for the NRR (and the nitrate reduction reaction) in (a) aqueous media, in (b) presence of a fluor-rich ionic liquid (EMPA-$C_4F_9SO_3$) as encapsulating agent or electrolyte and in (c) a so-called GDE cell (similar to the design in **Fig. 1C**) by electrochemistry and spectroscopy.

The internship might eventually extend to the design of disruptive electrocatalysts and to the use of anion exchange membranes, instead of aqueous electrolyte, in the GDE cell.

[1] T. Asset, "The runt of ammonia production by N_2 reduction: Electrocatalysis in aqueous media", Curr. Opinion. Electro. 39 (2023) 101301, DOI: 10.1016/j.coelec.2023.101301

ITI HiFunMat Master Internship Proposal

☒ M 1 ☒ M 2

Self-decontaminating protective clothing: Photocatalytic textiles based on metal oxides

Internship supervisor

Name, first name	Keller Valérie, Robert Didier, Morguen Maël
E-mail, Telephone	vkeller@unistra.fr, didier.robert@univ-lorraine.fr, mael.morguen@etu.unistra.fr
Laboratory	Institut de Chimie et Procédés pour l'Energie, l'Environnement et la Santé (ICPEES), Equipe Photocatalyse, UMR- CNRS 7515, Université de Strasbourg, 25 rue Becquerel 67087 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

The different challenges of the next decades may bring an increase in geopolitical tensions and thus a risk of conflicts accompanied by an eventual use of Chemical Warfare Agents (CWA). As a result, protections against CWA need to be improved and the addition of self-decontaminating properties to military clothes is a promising tool to avoid (cross-)contamination issues.

The aim of the project is to develop photocatalytic textiles, i.e. textiles capable of degrading these toxic substances under the effect of sunlight. For this purpose, two materials will be used together to obtain enhanced photocatalytic properties. Titanium dioxide (TiO_2) [1], the most effective material and the most studied in photocatalysis, is only active under UV light, which represents only 5% of the solar spectrum. It will therefore be combined with a tungsten oxide (WO_3) [2], which is capable of absorbing visible light, but has a lower intrinsic activity due to the higher recombination of charges. The synthesis of TiO_2/WO_3 [3] composites will improve photocatalytic activity under visible light and charge separation via a heterojunction phenomenon. The synthesized composites will then be deposited on textiles using a "Layer-by-Layer" method [4] (Figures 1 and 2). This method enables both a control of the thickness of the photocatalytic layer and a strong adhesion on fibers.

The aim of this internship will be to explore several ways of synthesizing these composites to obtain the best possible interface, enabling efficient charge transfer between the two materials. The WO_3/TiO_2 ratio will also have to be optimized to obtain interesting photocatalytic properties under solar illumination. These materials will then be characterized (UV-Vis, XRD, SEM, Zeta, BET, IR…) and deposited on textiles so that they can be tested for the degradation of organophosphorus compounds.

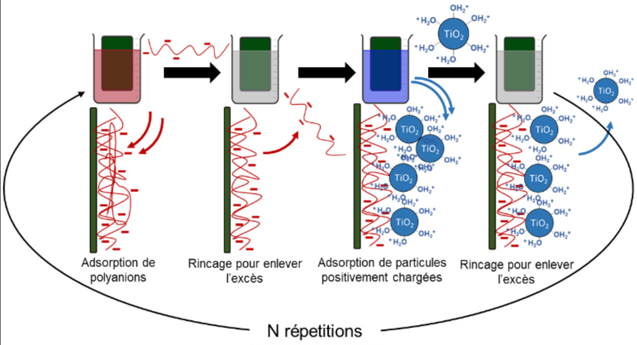


Figure 1. Layer-by-layer deposition principle

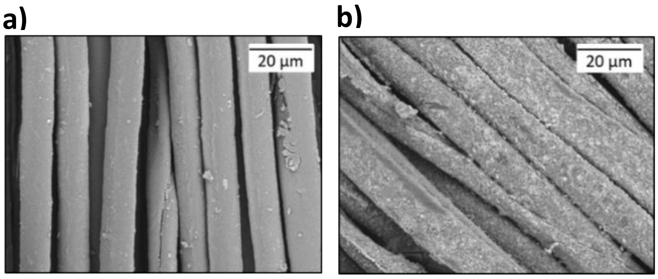


Figure 2. Textile a) not functionalized b) with TiO_2

[1] A. Komano *et al.*, « Titanium dioxide photocatalytic decomposition of ethyl-S-dimethylaminoethyl methylphosphonothiolate (VX) in aqueous phase », *Appl. Catal. B Environ.*, vol. 134-135, p. 19-25, mai 2013, doi: 10.1016/j.apcatb.2012.12.036.

[2] I. M. Szilágyi *et al.*, « WO3 photocatalysts: Influence of structure and composition », *J. Catal.*, vol. 294, p. 119-127, oct. 2012, doi: 10.1016/j.jcat.2012.07.013.

[3] C. Shifu, C. Lei, G. Shen, et C. Gengyu, « The preparation of coupled WO3/TiO2 photocatalyst by ball milling », *Powder Technol.*, vol. 160, nº 3, p. 198-202, déc. 2005, doi: 10.1016/j.powtec.2005.08.012.

[4] L. Truong-Phuoc *et al.*, « Layer-by-Layer Photocatalytic Assembly for Solar Light-Activated Self-Decontaminating Textiles », *ACS Appl. Mater. Interfaces*, vol. 8, nº 50, p. 34438-34445, déc. 2016, doi: 10.1021/acsami.6b12585.

ITI HiFunMat Master Internship Proposal

☒ M 1 ☒ M 2

Title

Internship supervisor

Name, first name	Biniek, Laure
E-mail, Telephone	Laure.biniek@ics-cnrs.unistra.fr, 03.88.41.41.78
Laboratory	Institut Charles Sadron
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Laurent Simon, Gérald Chaplais, Nicolas Leclerc

Student profile looked for

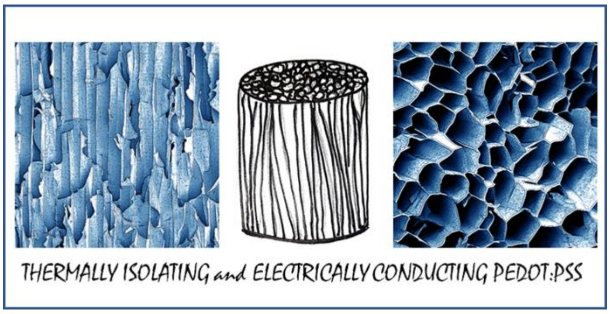
Master program (*more than one box can be ticked*)	☒ Material science and engineering ☒ Chemistry ☐ Physics
Other indications if necessary	

Internship description

Porous conducting polymer materials are of growing interest for various applications such as sensors, energy storage or power generation. These conducting polymer materials can be prepared by gelation of the polymer in a solvent followed by solvent extraction (freeze drying or supercritical drying method). The porous structure (pore size/geometry/directionality,...) plays an important role in the properties of the polymer. In particular, the thermal conductivity of the materials can be strongly influenced. Recently, we have developed honeycomb-like structures and 3D fibrillar networks. [1, 2] Open cells and double porous structures are our next challenge!

This internship aims firstly to develop new processing methods to control the porous structure of the polymer. Second, composite porous materials (polymer blends; or blends of polymer & conducting covalent organic frameworks or particles) will be considered to enhance the charge transport properties. A literature review on this topic will be carried out first. Experiments will be carried out to determine the important parameters that can influence the porous structure (solvent mixture, effect of pressure and temperature...).

All polymeric materials will be characterized by electron microscopy (SEM, cryo-SEM, cryo-TEM,...), thermal and electrical conductivities and spectroscopic techniques. The final aim is to produce porous polymer samples with different structures, low thermal and high electrical conductivities. The effect of the structure on the properties will be evaluated in collaboration with an engineer and a PhD student.



References:

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

[2] Q. Weinbach, L. Biniek et al, J. Mater. Chem.C (2023). https://pubs.rsc.org/en/content/articlelanding/2023/tc/d3tc01110k

Requirements & Application

We are looking for motivated and creative team-worker master student willing to learn with fun about polymers processing, scanning electron microscopy, and thermal conductivity. The candidate is expected to be at ease with physical-chemistry of polymers and not afraid of multidisciplinary field.

Please address your application including a CV, a motivation letter and Master transcript of records to Laure Biniek, SYCOMMOR Team, Institut Charles Sadron.

ITI HiFunMat Master Internship Proposal

☒ M 1 ☒ M 2

Development of electrodeposited coatings of catechol-based polyelectrolytes as adhesive interface and their enzymatic degradation

Internship supervisor

Name, first name	Boulmedais Fouzia
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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	IMPORTANT for M 2 students: The candidacy has to be sent at least 3 months before the beginning of the internship to apply the online CNRS procedure to allow hosting the candidate in the lab.

Internship description

The needs of society in terms of environmental protection, energy, resource-saving, and waste reduction represent new challenges for all fields of industrial production. Many devices are based on combinations of materials assembled via an adhesive interface. Their production often requires energy-intensive processes or the use of hazardous substances. New perspectives for the design of bioinspired and biodegradable adhesives are offered by compounds derived from mussel proteins (dopamine, polydopamine) or plants (polyphenols such as tannic acid). These compounds adhere to virtually all types of surfaces thanks to the chemistry of catechols.

The M ERA-NET InsBioration project aims to transfer scientific knowledge on these natural adhesive compounds to industrial production. Within the framework of the project, the master student will develop nanofilms based on polymers modified by catechols by electro-crosslinking by applying an electric potential on an electrode (Langmuir 2015, 31, 13385; Mater. Adv. 2022, 3, 2222). The optimization of the nanofilm deposition, their physicochemical characterization as well as their enzymatic degradation will be studied during the internship.

Activities:

- Preparation of aqueous solutions of water-soluble polymers
- Monitoring of the deposition of the nanofilms by quartz crystal microbalance and ellipsometry.
- Characterization of the enzymatic degradation of the films.

Profile: A motivated experimentalist with polymer, analytical chemistry, or material science background who is interested in studying the physical chemistry of polymeric films on a conductive surface using electrochemistry. No knowledge of electrochemistry is needed.

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
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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

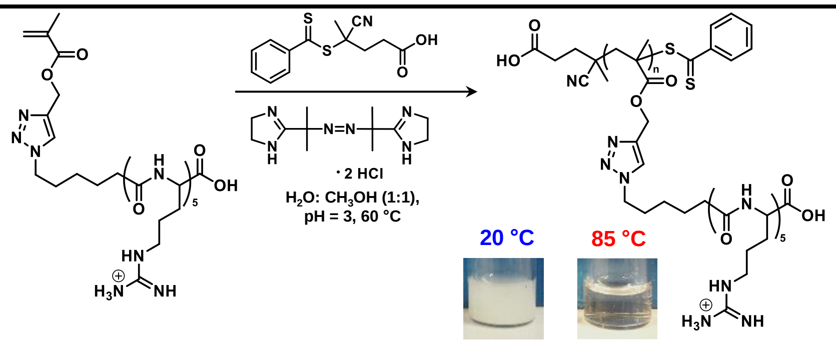
Master program (*more than one box can be ticked*)	☐ Material science and engineering ☒ Chemistry ☐ Physics
Other indications if necessary	Molecular chemist with interest in gaining experience in polymer syntheses.

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 (photo)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

Title: Artificial active biomimetic cell compartments

Internship supervisor

Name, first name	Stocco Antonio
E-mail, Telephone	stocco@unistra.fr
Laboratory	Institut Charles Sadron UPR22, 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

Internship description

Recently, we have experimentally investigated the interaction between active microparticles and empty cells made of lipid membranes. Several physical and chemical aspects of this interaction are important in processes such as viral infections, drug delivery and toxicity from nanomaterials. Lipid membranes can deform and wrap solid particles as a result of a delicate balance between adhesion, particle activity and membrane properties (tension, bending and charge).[1,2,3]

Now, we aim at studying giant unilamellar vesicles (GUV), which are not empty but filled with self-propelled particles. This internship is dedicated to the fabrication of such biomimetic cell systems able to show active motion and dynamics such as giant fluctuations, cell division and tube formations.

Phospholipids and microparticles (made of silica, copper and gold) will be investigated to fabricate giant vesicles containing microparticles, which are able to self-propel and impart forces on lipid membranes. Bright-field and fluorescence microscopy will be used. Particle tracking and image treatment will be used for analysis.

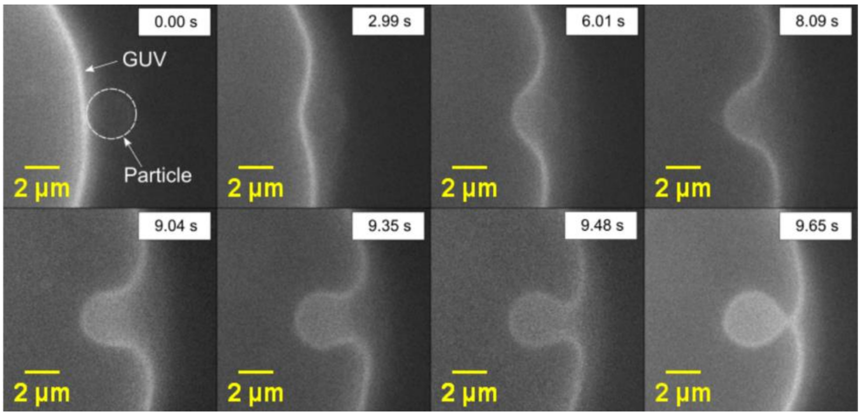


Figure. Giant unilamellar vesicle (GUV)-Particle interaction by fluorescence microscopy and optical trapping.

REFERENCES:

1 Active colloids orbiting giant vesicles, V. Sharma et al. Soft Matter 2021.

2 Entry of microparticles into giant lipid vesicles by optical tweezers, F Fessler et al. PRE 2023

3 Driven engulfment of Janus Particles by Giant Vesicles in and out of thermal equilibrium, V. Sharma et al. Nanomaterials 2022

ITI HiFunMat Master Internship Proposal

☒ M 1 ☒ M 2

Title: Synthesis of conjugated polymers for doped electronic applications

Internship supervisor

Name, first name	MERY, Stéphane
E-mail, Telephone	mery@ipcms.unistra.fr, 03 88 10 7165
Laboratory	IPCMS, Strasbourg
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : N. Leclerc, O. Bardagot (ICPEES) and M. Brinkmann (ICS)

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 Nobel Prize in Chemistry awarded to Heeger, MacDiarmid and Shirakawa on conducting polymers in 2000, conjugated polymers are today the focus of intense research for their application in organic electronics, and in particular the realization of lightweight, flexible and low-cost devices.

Good conduction properties arise from the self-assembly of π-conjugated polymers, achieved by microsegregation between conjugated polymer backbones and the presence of flexible side chains [1]. The addition of doping molecules to these polymers considerably amplifies the electrical conductivity of these systems [2]. However, the doping process and its mechanisms are still poorly understood. In particular, it is difficult to control the localization of dopants and avoid the destruction of self-assemblies.

The aim of the internship project is multidisciplinary and consists of synthesizing new high-performance π-conjugated polymers for doping. The molecular engineering work involves tailoring the side chains to (i) control the position of the dopant and (ii) stabilize the organization of the polymers in the solid state as thin films. Two applications in particular are targeted: electrochemical organic transistors [2] and thermoelectric devices [3,4].

In practice, the candidate will work essentially on the synthesis of organic conjugated systems and on polymerization. If interested, the candidate could also participate in the characterization of the physicochemical, electrical and charge transport properties in collaboration with other teams at the Cronenbourg Campus. The host team already has a thesis grant on this subject for the start of the 2024 academic year.

Selected publications by the host teams in the field: [1] N. Kamatham et al. *Adv. Funct. Mater.* **2021**, *31*, 2007734. Link; [2] O. Bardagot et al., in Review in *Nature Materials*, **2023**. Link; [3] P. Durand et al. *Adv. Energy Mater.* **2022**, *12*, 2103049. Link; **[4]** V. Vijayakumar et al. *J. Mater. Chem. C* **2020**, *8*, 16470. Link.

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.

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.

To be returned by e-mail before **19 September 2023** to melodie.galerne@unistra.fr

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Title: Synthesis and characterization of anisotropic semiconducting polymer thin films for organic electrochemical transistors

Internship supervisor

Name, first name	Bardagot, Olivier
E-mail, Telephone	olivier.bardagot@cnrs.fr
Laboratory	ICPEES
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Martin Brinkmann, Nicolas Leclerc

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 main task of this M2 internship, for student registered to the Graduate School, is to manufacture and characterize polymer thin films with increasing molecular order (porosity and alignment). The goal is to find the optimal compromise between high electrical conductivity and fast doping kinetics to enhance the performance of organic electrochemical transistors (OECTs). OECTs are a fast-growing technology used mainly for heath applications (e.g.: biosensors, electrophysiologic devices). The student will work on this hot topic in a pluri-disciplinar team including another M2 student and be supervised by a young researcher eager to share its scientific interests. High quality results are expected, as demonstrated by our manuscript reporting record OECT performance for highly aligned polymers (10x higher than state-of-the-art), currently under review for publication in Nature Materials (https://www.researchsquare.com/article/rs-3221543/v1).

Daily work will include:

- Bibliographic study of the impact of porosity/polymer alignment in the electrochemical doping kinetics of semiconducting polymer thin films
- Processing of semiconducting polymers in solution
- Casting of these solutions in air under a controlled atmosphere (humidity, temperature) and potentially in a glove box
- Scanning electron microscopy (SEM) to visualize the resulting thin films
- OECT manufacture
- Electrical characterization of electrochemical transistors (transfer, output)
- Time-resolved Vis/NIR absorbance spectroscopy during electrochemical doping
- Data analysis using Python (computing)

Hard skills which will be learnt:

- Bibliographic search
- Database management
- Semiconducting polymer design
- Polymer processing
- Vis-NIR absorbance spectroscopy
- Electrochemistry
- Computing (Python for heavy data analysis and graph plotting, LabVIEW if interested)

Soft, transferable, skills which will be learnt:

- Collaboration, teamwork
- Effective communication
- Scientific data presentation (oral and written in English)
- Project management (time management, supply management, etc)
- Progress reporting
- Creativity/independency (depending on the will of the student)

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Title: Design of supported bimetallic catalysts for plasmon-induced 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 TOGETHER-FOR-CO2 ANR project. It is known that CO_2 can in principle be reduced into methane using light-activated catalysts and water as the reducing agent. What we found is that this could be achieved in a highly selective, continuous gas phase process, over extended period of times, using plasmonic metal nanoparticles (NPs). This true artificial photosynthesis process based on plasmon-induced chemical activity however critically depends on the composition of the plasmonic nanoparticle and the nature of the underlying inorganic support.

The general aim of this Master M2 internship is to improve reaction rates by material design. It will focus on various bi-metallic NPs (Ag, Au, Pt, Pd) supported on titania at a given M1/M2 ratio. It will include the inorganic chemical synthesis of titania-supported mono- and bi-metallic NPs, their characterization with UV-visible spectroscopy, X-ray photoelectron spectroscopy, scanning/transmission electron microscopy, temperature programmed reduction, and their photocatalytic evaluation. These data are expected to allow to identify the effect of the nature of the metals on the plasmon-induced performances of the bimetallic catalyst and identify the working mechanism of the functional couples of supported metal NPs.

Work will take place in the PhotoCatalysis and PhotoConversion (PCPC) team of ICPEES. It will benefit from the knowledge acquired within the CNRS-funded SelCO2PlasmonRed project (2021-2023) and the current ANR project (2023-2026), 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 the environment.

ITI HiFunMat Master Internship Proposal

☐ M 1 X M 2

Title : Localized Photo-ElectroChemical: Rapid optimization of photoelectrode materials 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 X Chemistry X 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 complex 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 CoO nanoparticles deposited as co-catalyst on the surface of TiO_2 to accelerate the water splitting reaction. (T. Favet et al. *Mater. Today Energy*, 37, **2023**, 101376) (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. (T. Cottineau et al. *Phys. Chem. Chem. Phys.*, 19, **2017**, 31469)

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, materials synthesis etc. The work will be done at the ICPEES on the campus of Cronenbourg (ZRR) and a PhD on the same topics can potentially follow this master internship.

The daily work, will include electrochemical synthesis and characterization, design of opto-electrochemical measurements, material characterizations (XRD, XPS SEM…) and the associated data analysis.

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)**

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Title : Green electrospinning of bio-based nanofiber mats for air filtration application

Internship supervisor

Name, first name	Lobry, Emeline
E-mail, Telephone	elobry @unistra.fr
Laboratory	ICPEES
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Anne Hébraud, Guy Schlatter

Student profile looked for

Master program (*more than one box can be ticked)*	☒ Material science and engineering ☐ Chemistry ☐ Physics
Other indications if necessary	additional characterizations will be performed in collaboration with IMTAtl Nantes – Dr Félicie Théron

Internship description

The main task of this M2 internship, for student registered to the Graduate School, is to develop new nanofibrous layers based on bio renewable resources and green electrospinning. Cellulose derivatives will be selected during this internship. Different fibers morphologies are considered depending on the formulation. In a first way, green solvents will be tested to produce the nanofibers. In a second way, emulsion electrospinning will be considered by combining the use of poly(lactic acid) PLA and cellulose nanocrystals CNC. Water in oil emulsion consisting in aqueous suspension of CNC in a continuous PLA solution will be electrospun. The droplets size will vary to tune the fiber morphology. Indeed, it is expected that depending on the droplet size, the droplets will either coalesce, deform, or keep their size. The solvent evaporation between core or shell will be also crucial to control the final fiber morphology. The different morphologies of nanofibers will be characterized by SEM or TEM.

The main application for these membranes is air filtration. The porosity and pore size distribution will be evaluated by capillary flow porometer. The most promising mats will be sent to IMTAtl to evaluate their filtration performance (efficiency and pressure drop).

Missions

- Bibliographic study on cellulose electrospinning and green strategies
- Formulation of different mix for electrospinning (solution, emulsion…)
- Electrospinning
- Characterization of the morphology of the nanofibers (SEM)
- Characterization of porosity and filtration performance
- Link between process, nanofiber morphology and filtration performance

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Title Aligned blends of polymer semiconductors for the design of new efficient thermoelectric materials

Internship supervisor

Name, first name	Brinkmann Martin
E-mail, Telephone	Martin.brinkmann@ics-cnrs.unistra.fr
Laboratory	ICS
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	Preliminary experience in polymer and/or material design/analysis is requested.

Internship description

Polymer semiconductors are ubiquitous in materials science. Recent progress has been made in the use of doped polymer semiconductors for the design of thermoelectric (TE) generators that have the capability to transform a temperature gradient to an electrical current. Given the large amount of wasted heat in the environment, it is essential to find effective means to recover waste heat and transform it to electricity in cars and buildings for example. Polymers are particularly attractive since they are facile to process in strong contrast to inorganic materials.

Still, the performances of doped polymers need to be improved. In this perspective, our group uses the crystalline structure and the chain alignment as handles to improve transport properties in doped polymer films. In this internship, we want to investigate how the orientation of a polymer blend can help enhance TE properties. Our strategy is to design a highly organized heterojunction of two polymer semiconductors using new alignment and growth methods. In particular, we will use the method of high temperature rubbing. Transmission Electron Microscopy (diffraction and high resolution) will be used to probe both the crystallization of the two polymers and the structural evolution upon doping. The student will perform an experimental work with the typical equipment used in organic electronics (glove box) as well as electron microscopy. The student will participate to a funded ANR project (Tripode) with the possibility to pursue for a PhD. A CV shall be sent to the supervisor.

References:

(1) Zhong, Y.; Untilova, V.; Muller, D.; Guchait, S.; Kiefer, C.; Herrmann, L.; Zimmermann, N.; Brosset, M.; Heiser, T.; Brinkmann, M. *Advanced Functional Materials* **2022**, *32* (30), 2202075. https://doi.org/10.1002/adfm.202202075.

(2) Durand, P.; Zeng, H.; Biskup, T.; Vijayakumar, V.; Untilova, V.; Kiefer, C.; Heinrich, B.; Herrmann, L.; Brinkmann, M.; Leclerc, N. *Advanced Energy Materials* **2022**, *12* (2), 2103049. https://doi.org/10.1002/aenm.202103049.

INTERNSHIP OFFER

Understanding foam stability in plasterboard formulations

Context

Foam is a key element in the composition of plasterboards, allowing for the reduction of the board weight. Lightweight boards have a lower CO2 footprint and are easier to handle on jobsite. Therefore, Saint-Gobain and its Gypsum business strive towards lightweight boards. However, a lower density often comes at the expense of the mechanical properties. It is therefore crucial to control the bubble size within the plasterboard to limit detrimental effects on the mechanics. The incorporation of novel additives can negatively affect foam stability, inducing a loss of control over the bubble size distribution.

Objectives

Goal of this internship is to provide an understanding of how different additives entering in the composition of plasterboards affect foam stability. The student will characterise plaster-free model foams and formulate hypotheses describing the mechanisms responsible for the stabilisation/destabilisation of foams. The student will resort to the following experimental techniques (amongst others):
- Surface tension measurements
- Interfacial rheology
- Automated foam stability analysis (Foamscan)
- Thin film stability analysis (Thin Film Pressure Balance)

A visit to SGR Paris allowing for the student to work on systems more closely related to the plasterboards will be planned.

Profile

M2/Last year of engineering school - Physical chemist or physicist of soft matter

Duration: 6 months

Site

The internship is conducted in close collaboration with Saint-Gobain Research Paris but will take place at the Institut Charles Sadron (UPR 22 CNRS, 23 rue du Loess, 67000, STRASBOURG). The internship convention will be signed by the CNRS.

Contacts

Applicants should send resume and covering letter (in English or in French) to:

Wiebke Drenckhan-Andreatta, Research Director: wiebke.drenckhan@ics-cnrs.unistra.fr
Leandro Jacomine, Research Engineer: jacomine@unistra.fr
Sébastien Andrieux, Research Engineer: sebastien.andrieux@saint-gobain.com

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Title: Constructing complex multilayer stacks from sustainable materials with anisotropic properties

Internship supervisor

Name, first name	FELIX Olivier
E-mail, Telephone	olivier.felix@ics-cnrs.unistra.fr, 03.88.41.40.67
Laboratory	Institut Charles Sadron
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : PAULY Matthias, ROLAND Thierry

Student profile looked for

Master program (*more than one box can be ticked)*	☒ Material science and engineering ☒ Chemistry ☒ Physics
Other indications if necessary	Student having skills and/or interests in the following areas: materials, physical chemistry, thin layers, polymers and surfaces

Internship description

Nature has developed composite materials (e.g. plant cell walls and Arthropod exoskeleton) with complex and hierarchical organization from the nano- to the macro-scale via molecular assembly. Such materials often possess remarkable optical and/or mechanical properties by simply assembling hard and soft elements. The outstanding properties of these materials have prompted the fabrication of bio-inspired composites.

Among all methods available for the preparation of multifunctional nanostructured composite materials, layer-by-layer (LbL) assembly,[1] is currently one of the most simple and versatile nanofabrication method.[2] Recently, we have assembled isotropic and anisotropic transparent wood-inspired nano-composite materials with mechanical properties challenging even medium quality steel.[2][3] The combination of LbL assembly with grazing incidence spraying (GIS)[4-5] has permitted us to extend our approach toward the preparation of complex (e.g. helical) multilayer films in which the composition and orientation of anisotropic nano-objects like nanocelluloses can be controlled independently in each layer.

The goal of this internship is to study the preparation of nanocellulose-based composite materials using different deposition methods (dipping, spray-assisted, GIS, ...) and various surface analysis techniques (ellipsometry, UV-vis spectroscopy, …) and their optical and mechanical properties. The performance of these materials will be determined by advanced mechanical and optical characterization tools as a function of their composition and structure, the orientation of reinforcing agents, and the experimental conditions.

[1] G. Decher *Science* **1997**, *277,* 1232.
[2] R. Merindol, S. Diabang, O. Felix, T. Roland, C. Gauthier, G. Decher *ACS Nano* **2015**, *9*, 1127.
[3] R. Merindol, S. Diabang, R. Mujica, V. Le Houerou, T. Roland, C. Gauthier, G. Decher, Felix. O. *ACS Nano* **2020**, *14*, 16525.
[4] R. Blell, X. Lin, T. Lindström, M. Ankerfors, M. Pauly, O. Felix, G. Decher, *ACS Nano* **2017**, 11, 84.
[5] R. Mujica, A. Augustine, M. Pauly, V. Le Houerou, G. Decher, Y. Battie, O. Felix. *Compos. Sci. Technol.* **2023**, *233*, 109889.

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 Foam-fibre systems: towards new mechanically auto-assembled architected materials

Internship supervisor

Name, first name	Hourlier-Fargette Aurélie
E-mail, Telephone	hourlierfargette@unistra.fr
Laboratory	Institut Charles Sadron UPR22
Collaboration with a HiFunMat member (*please indicate their name*)	☒ No ☐ Yes :

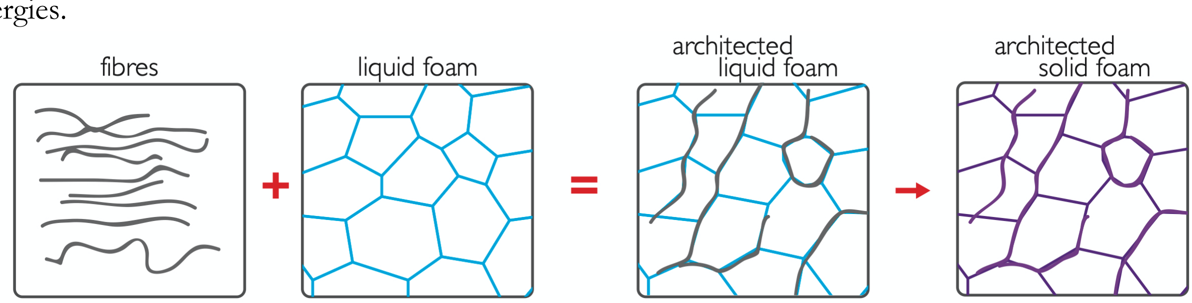
Student profile looked for

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

Internship description

Architected materials are attracting a growing interest: structural design results in intriguing features that drastically differ from that of the bulk materials, with a combination of light weight and interesting mechanical, acoustic, electrical or thermal properties. Beyond rapid prototyping and 3D printing of architected materials, polymer foams are mechanically self-assembled cellular materials for which reaching an unprecedented structural control would be highly beneficial: using bottom-up self-assembly is a key advantage in terms of production upscaling. However, the structure of foams is strictly constrained by capillary forces, and more specifically by Plateau's laws.

Our research activities aim to obtain new types of architectures of solid polymer foams through mechanical self-assembly of bubbles mixed with fibres, taking advantage of a competition between elasticity and capillarity in the liquid precursors of solid foams. These structures will be imposed not only by a minimization of interfacial energies (as for usual foams resulting from a liquid precursor for which an equilibrium state is reached before solidification), but by the combination of interfacial and elastic energies.



To produce foam-fiber systems, we will work on formulations and microfluidics (millifluidics) processes allowing the production of the different building blocks (polyurethane foams and elastic intruders). The intern will be co-supervised by Aurélie Hourlier-Fargette and Guillaume Cotte-Carluer, PhD student on this topic.

The internship will include preparation of solutions and samples, optimization of experimental setups, data analysis, and use of a cutting-edge equipment park available at ICS (rheometer, tensiometer to measure surface tensions, microscope, X-ray tomograph, mechanical characterization) when needed throughout the project. The intern will be encouraged to take personal initiatives to carry out his/her research and will be fully associated to the scientific activities of the team (seminar, scientific discussion, weekly meetings with people working around foams at ICS …) and discussions with partner groups.

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Title: Nanotubes with controlled diameters: toward a new model of tubular self-assemblies

Internship supervisor

Name, first name	MESINI, Philippe
E-mail, Telephone	mesini@ics-cnrs.unistra.fr, 03 88 41 40 70
Laboratory	Institut Charles Sadron
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : COMBET

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

There are a few organic compounds able to self-assemble in nanotubes.[1] Some theoretical models have been developed for tubes formed by lipids, but concern only large tubes often microtubules. But so far one cannot explain at the molecular level why such self-assembly leads to a nanotubular shape. As a matter of fact, only a few examples of structures of the tubes have been elucidated at the molecular level.[2–4] In our group we have developed simple amide-based molecules, BHPBn (Fig. 1) able to form nanotubes with diameters of a few tens of nm, as shown by freeze fracture TEM and small angle X-ray scattering (SAXS) experiments.[5,6] The diameter depends on the length ***n*** of the ester chain. Recently we have shown that related monoamide compounds also form nanotobes and that in these tubes the compounds form in inner and an outer sheet, with their ester parts turned toward the inner and outer wall, and the amide chains form an interdigitated middle layer like in Fig. 3.[7]

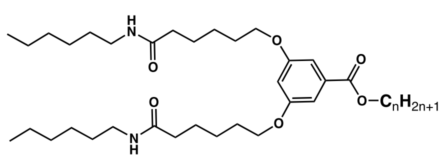


Fig. 1. Chemical structure of BHPBn. n is the number of C atoms in the ester.

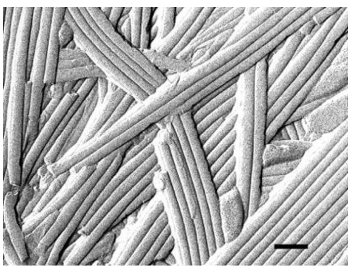


Fig. 2. Freeze fracture TEM of BHPB10 in cyclohexane; Bar is 50 nm

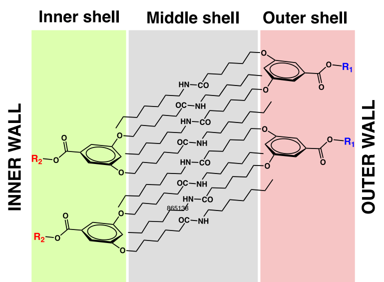


Fig. 3. Possible structure of the self-assembly of BHPBn in the nanotubes.

The project aims at studying the inner structure of the nanotubes of BHPBn, especially to prove and refine the structure proposed in Fig. 3, by small angle X-ray and neutron scattering (SAXS and SANS). The model will be also confirmed by synthesizing analogues of BHPBn with deuterated ester and aromatic parts and studying their self-assemblies by SANS, with the contrast variation method. A second objective is to study the behavior of binary mixtures BHPBn/BHPBm and to measure the variations of the structures with the mixture ratios. We will first verify that they form solid solutions by DSC and that also form tubes. Then, we will analyze with deuterated analogues how the BHPBn and BHPBm are distributed. Are they equally located on the inner and outer walls of the tubes or do they selectively occupy one face? The latter case would explain why the self-assembly induces a curvature.

The hired student will 1) synthesize a homologous series of BHPBn and the deuterated analogues of BHPB8 and BHPB10, 2) study the structure of the self-assemblies by freeze fracture TEM, in collaboration with M. Schmutz and by SAXS in collaboration with J. Combet. The binary mixtures will be studied by microDSC.

We are looking for a motivated student with a background in organic or polymer chemistry eager to learn physicochemical techniques; or with a background in physical chemistry able to conduct few chemical syntheses. A good proficiency in English is a plus. The applicant should send her/his resume and material to mesini@ics-cnrs.unistra. All acceptation, enrolment and paperwork has to be done by October 8th, because the Institut Charles Sadron is a ZRR lab (restricted access area).

1 Shimizu, T. *et al. Chem. Rev.* 105, 1401–1444 (2005)
2 Valéry, C. *et al. Proc. Natl. Acad. Sci.* 100, 10258–10262 (2003)
3 Tarabout, C. *et al. Proc. Natl. Acad. Sci. U. S. A.* 108, 7679–7684 (2011)
4 Oda, R. *et al. J Am Chem Soc* 130, 14705–14712 (2008)
5 Diaz, N. *et al. Angew Chem Int Ed* 44, 3260–3264 (2005)
6 Simon, F.-X. *et al. Soft Matter* 9, 8483–8493 (2013)
7 Zapién-Castillo, S. *et al. Int. J. Mol. Sci.* 21, 4960 (2020)

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Title: Synthesis and characterization of electrically conductive PEDOT coated particles for thermoplastic composite applications.

Internship supervisor

Name, first name	Parpaite, Thibault
E-mail, Telephone	parpaite.thibault@ics-cnrs.unistra.fr
Laboratory	ICS
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

Intrinsically conducting polymer materials (ICPs) are highly sought after for multiple emerging applications, particularly in the field of flexible electronics or plastronics due to their versatility and tunable electrical properties, which can be tailored for specific applications.

In the framework of the ANR ELABELEC project (ELABoration of thermoplastic composites with high ELECtrical conductivity), the main objective of this M2 internship is to develop a portfolio of new core/shell like structures with various form factors from sphere to sheet (1D/2D/3D). To do so, mineral core such as silica or clays will be used as support for the polymerization of conductive polymers coating like poly(3,4-ethylenedioxythiophene) PEDOT.

Internship work program will entail:

- **State of the art of supported polymerization of PEDOT**
- **Synthesis of core/shell structures using eco-friendly polymerization of EDOT in water**
- **Numerous characterizations (morphologies, internal structure, electrical conductivity)**
- **Evaluating the homogeneity and thickness of the coating (SEM/TEM/cryo-TEM)**
- **Measure the electrical conductivity of synthetized structures using four probes system**
- **Characterize the internal structure of PEDOT (XRD)**
- **Processing of thermoplastics composites using twin screw extrusion (depending on progress)**

The candidate must demonstrate good collaboration/teamwork (progress reporting) and communication skills (scientific data presentation oral and written in English) throughout the duration of the internship

The candidate will be able develop valuable skills in bibliographic search, structure/properties relationship of conductive polymer, oxidative polymerization process, synthesis and characterization of core/shell objects. The candidate will be integrated in the IP2 team of ICS and will be supervised by a multidisciplinary team.

A funding for a thesis on the same project has been approved with an aim to start the work in September 2024. Depending on the progress of the work, the candidature for the thesis could be secured after internship.

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Title: Chiral hybrid plasmonic nanostructures as enantioselective photocatalysts

Internship supervisor

Name, first name	Pauly, Matthias
E-mail, Telephone	03 68 85 17 49 matthias.pauly@ics-cnrs.unistra.fr
Laboratory	Institut Charles Sadron
Collaboration with a HiFunMat member (*please indicate their name*)	☒ No ☐ Yes :

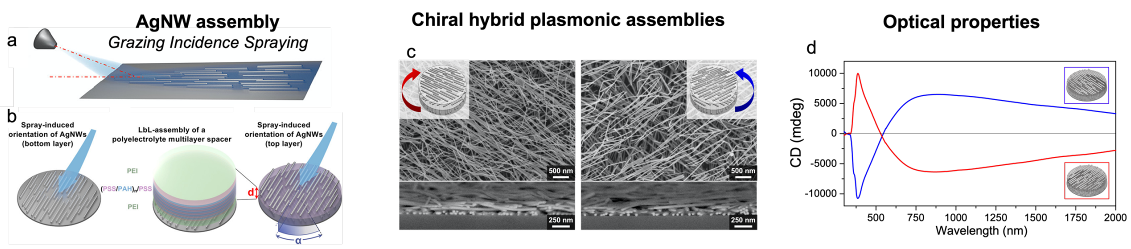
Student profile looked for

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

Internship description

With the increasing demand for chiral compounds in many industries such as pharmacology, the **synthesis of enantiopure chemicals** is of paramount importance. Chiral separation is nowadays the industrial strategy of choice, while asymmetric catalysis is the best approach leading to the formation of enantiopure molecules. Although the use of light as energy source is well established in photocatalysis, little is known about its implementation in heterogeneous asymmetric reactivity. Therefore, there is an urgent need to find new strategies to drive efficient asymmetric photochemical reactions with visible and near-infrared photons.

In this internship, which is part of an ambitious project recently funded by the ANR with partners in Paris and Bordeaux, we propose to combine the unique features of **plasmonic photocatalysis with asymmetric reactivity** in order to perform heterogeneous and asymmetric photocatalytic reactions driven by plasmons. To this end, **various molecular and nanoparticulate catalysts will be coupled to a chiral plasmonic metasurface prepared by self-assembly.** Grazing Incidence Spraying (GIS, Fig. 1a) will be used to assemble silver nanowires into oriented mono– and multilayer thin films with well-controlled orientation and spacing. GIS will be combined with the Layer-by-Layer (LbL) approach to build multilayer superstructures (Fig. 1b) embedding various catalysts. We have recently shown[1,2] that such chiral nanostructures (Fig. 1c) display a very high circular dichroism (Fig. 1d) over a broad wavelength range. The advantage of this approach is that multimaterial nanocomposites can be easily fabricated over large areas with a fine control over the nanoscale architecture. The polyelectrolyte multilayer matrix in which the nanowires are embedded will be used to host molecular catalysts that are chemically compatible with this hydrophilic environment, and inorganic nanoparticle catalysts.



The structure of the assembly will be systematically characterized using 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, FTIR and CD spectroscopy).

Requirements & Application

This multidisciplinary internship, at the frontier between materials science, nanoscience and physical chemistry will involve both sample fabrication and physicochemical characterization. We are looking for a highly motivated student with a background in **physical chemistry, nanoscience and/or materials science**. Depending on the student's interest and progress during the internship, **this work can be continued with a doctoral thesis**, for which funding has already been secured (ANR 2023-2027).

IMPORTANT: Due to the internal security rules for access to the laboratories (ZRR), the recruitment process must start at least 10 weeks before the internship.

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.
2. 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

Deciphering the R-body Extension-retraction Mechanism

Internship supervisor

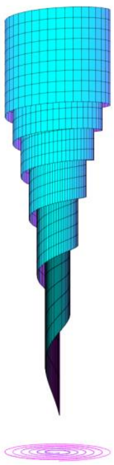
Name, first name	Schmatko Tatiana, Kulic Igor
E-mail, Telephone	schmatko@unistra.fr, kulic@unistra.fr
Laboratory	Institut Charles Sadron, Mcube team (soft matter and membranes)
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Laurent Pieuchot, Laurent.pieuchot@uha.fr

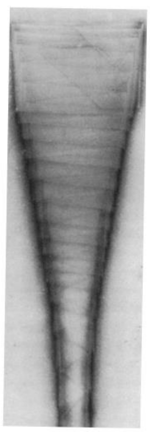
Student profile looked for

Master program (*more than one box can be ticked)*	☒ Material science and engineering ☒ Chemistry ☒ Physics
Other indications if necessary	The Institut Charles Sadron (ICS-Strasbourg. France) and the Institut de Sciences des Materiaux de Mulhouse (IS2M-Mulhouse France) are looking for a **motivated** master student in Experimental Physics, Material Physics or Biophysics with a **taste for interdisciplinarity**.

Internship description

R-bodies are unique molecular pistons produced by endosymbiotic bacteria that can switch in a fraction of second from 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 start deciphering R-bodies' extension-retraction cycle dynamics and mechanism by combining optical microscopy imaging, force spectroscopy methods and theoretical models.





The R-bodies will be produced in E.coli in Mulhouse by our ITI-HiFunMat partner. The student will immobilize R-bodies inside chambers allowing rapid buffer exchange. He will assess the influence of buffer viscosity on R-bodies dynamics and the force generated during extension using, micrometer beads, high speed optical microscopy imaging and optical tweezers.

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 for future applications.

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Title: Atomic scale simulation of exciton dynamics in organic materials for photovoltaic applications

Internship supervisor

Name, first name	Martin, Evelyne
E-mail, Telephone	evelyne.martin@unistra.fr
Laboratory	ICube
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Steveler, Emilie and Heiser, Thomas

Student profile looked for

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

Internship description

In organic solar cells, light is absorbed and generates a bound electron-hole pair, i.e. an exciton, in a polymer or small molecule. The photogenerated exciton diffuses until it dissociates at the interface between electron-donor and electron-acceptor materials into two free particles, an electron and a hole, that are collected and create an electric current. The modeling of the exciton diffusion and dissociation enables the understanding of its atomic-scale origin, and will allow in fine to optimize the devices and increase their efficiency.

The purpose of the internship is to study the exciton diffusion by resorting to an atomic scale method that describes both the ionic and electronic motion, i.e. first-principles molecular dynamics (FPMD). Recently, we have proposed and published a FPMD-based methodology able to predict the measured diffusion coefficient in the P3HT polymer, a donor photovoltaic material widely characterized. The purpose of the internship is to learn the computational methodology and apply it to an acceptor molecule in order to achieve a deeper understanding of the exciton life and recombination.

The candidate will interact with the PhD student who did the calculation on the P3HT, and more globally with the students and researchers of the modeling consortium ADYNMAT . He will also interact with the members of the organic electronics consortium STELORG.

Daily work will be performed on the computer. Skills in materials physics/chemistry are expected (electronic structure, thermodynamics).

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Title: Liquid crystals in Small-molecule Organic Solar Cells: a new approach to higher efficiency

Internship supervisor

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

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

For sustainable global economic growth, an abundant supply of energy is essential. At the same time, our energy needs are increasing in order to improve our lives. In the long run, the supply of conventional energy is limited, and will not be able to meet future energy demand. To solve the global energy crisis, the development of solar energy is undoubtedly one of the best answers. Despite development in inorganic photovoltaic device, organic photovoltaics remain a promising low-cost renewable energy technology, due to the versatility of organic semiconductor materials and simple device structures that can be constructed by a variety of printing techniques. Recently, organic solar cells with polymer as donors have achieved excellent efficiencies over 18%. Compared with polymers, small molecules seem to be more promising because of their high purity, well-defined molecular structure and reproducibility in organic solar cells (OSCs). However, the power conversion efficiencies (PCEs) of small molecule donors currently still lag behind their polymer-based counterparts, which is usually limited by their relatively the phase separation morphology of the active layer. Typically, the ideal morphology implies reasonable molecular crystallinity and large correlation scales, which favour excitons, separation, and charge transport. To improve the morphology, a new concept has been recently investigated, by introducing of liquid crystals (LCs) in the organic materials. According to the literature, the good exciton diffusion length and the high charge-carrier mobility of discotic (disc-shaped) liquid crystals lead to a high efficiency organic photovoltaic solar cells.[1] Most recently, J. Wen reported ternary OSCs based on a broad-band donor polymer and a low-band acceptor system. The introduction of a calamitic (rod-like) liquid crystal donor results in an efficiency of up to 17.92%.[2]

This internship aims to explore this approach in small-molecule (SM) OSCs, understand the mechanisms underlying the interactions between LC molecules and small molecules donor/acceptor. We will investigate the influence of the molecular shape of LCs of physical, optical, and electrical proprieties of the new mixture of active layer. The final goal is to obtain a high efficiency SM OSC.

References:
[1] Zheng Q. et al., Efficiency improvement in organic solar cells by inserting a discotic liquid crystal. Sol. Energy Mater Sol. Cells, 95,2200-2205 (2011).
[2] Wen J. et al., Efficient and Stable Ternary Organic Solar Cells Using Liquid Crystal Small Molecules with Multiple Synergies. ACS Appl. Energy Mater. 5, 12809–12816 (2022)

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Title Understanding the Interactions between Bio-based Polyelectrolytes and Bacterial Functional Amyloids

Internship supervisor

Name, first name	Ploux Lydie
E-mail, Telephone	ploux@unistra.fr, 07 61 88 07 03
Laboratory	INSERM U1121
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

Amyloids have conventionally been associated with protein misfolding disorders in both humans and animals [1]. However, over two decades of research have unveiled the intriguing prevalence of amyloids in diverse bacterial and fungal species, serving multifaceted functions such as biofilm structural components, toxins, epigenetic material, and adhesins mediating interactions with host cells [2]. Recent research on bacterial functional amyloids has sparked interests in leveraging amyloid fibrils (AFs) as potential targets for developing antibacterial compounds and materials, with a particular focus on inhibiting biofilm formation. Biofilms play a pivotal role in bacterial infections by providing protection against host immune responses and antimicrobial agents. Consequently, targeting AFs as a means to inhibit biofilm formation becomes imperative. The primary objective of this study is to elucidate the intricate molecular interactions between AFs and bio-based polyelectrolytes, which are capable of inhibiting or interfering with amyloid fibrillation. Of particular interest in this study are functional amyloids from *Staphylococcus aureus* and *Pseudomonas aeruginosa,* two biofilm-forming organisms commonly implicated in healthcare associated infections. An array of microscopy and spectroscopy techniques will be employed to investigate the assembly and disassembly (by polyelectrolytes) dynamics of AFs derived from the target organisms. Furthermore, the physicochemical and mechanical properties of these AFs will be characterized. These characterizations will yield invaluable insights into the molecular mechanisms underlying the interactions between polyelectrolytes and AFs, encompassing critical aspects such as aggregation kinetics and the stability of aggregates. The overarching goal is to identify anti-amyloidogenic polyelectrolytes, paving the way for the development of anti-biofilm surface coatings.

1. Hawthorne, W., Rouse, S., Sewell, L. and Matthews, S.J., 2016. Structural insights into functional amyloid inhibition in Gram− ve bacteria. *Biochemical Society Transactions*, *44*(6), pp.1643-1649.
2. Van Gerven, N., Van der Verren, S. E., Reiter, D. M., & Remaut, H. (2018). The role of functional amyloids in bacterial virulence. *Journal of molecular biology*, *430*(20), 3657-3684.

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Design, synthèse et caractérisation de difluorures de bore de curcuminoïdes pour des applications en diode électroluminescente.

Internship supervisor

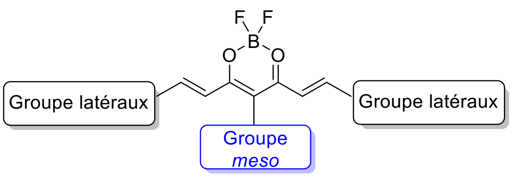
Name, first name	D'Aléo Anthony
E-mail, Telephone	Anthony.daleo@ipcms.unistra.fr
Laboratory	
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Nicolas Leclerc, Thomas Heiser

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

Les difluorures de bore de curcuminoïdes sont de plus en plus développées depuis une dizaine d'années pour des applications en biologie[1] ou en électronique organique[2,3]. Les propriétés de ces colorants sont très dépendantes des groupe en position *meso* et des groupes latéraux. Il est donc important des régler finement les propriétés donneurs/accepteurs de ces groupes afin de les utiliser dans des diodes électroluminescentes (OLEDs).



Au cours de ce stage, la synthèse de synthons sera tout d'abord réalisée en préparant des dérivés de type acétylacetonate mettant ainsi en jeu des couplages de type Ullman ou des réactions radicalaires. De plus, les synthèses de difluorures de bore de curcuminoïdes sont faites en couplant un acétylacetonate avec un aldéhyde (couplage de Claisen-Schmidt), ces derniers seront conçus par des réactions de Vilsmeyer-Haack. Ainsi, les réactions seront optimisées et les effets donneurs et accepteurs des molécules cibles seront déterminées afin de sélectionner les meilleures molécules pour utilisation en OLEDs.

Alors que les caractérisations structurales seront effectué par RMN (^{1}H, ^{13}C et ^{19}F), les propriétés photophysiques seront réalisées en mesurant les absorptions électroniques UV/visible et les spectres de fluorescences (ainsi que les rendements quantiques de fluorescence).

[1]: K. Kamada, T. Namikawa, S. Senatore, C. Matthews, P.-F. Lenne, O. Maury, C. Andraud, M. Ponce-Vargas, B. Le Guennic, D. Jacquemin, P. Agbo, D. D. An, S. S. Gauny, X. Liu, R. J. Abergel, F. Fages, A. D'Aléo *Chem. Eur. J.* **2016**, *22*, 5219–5232. Two-photon absorption and brightness optimization of curcuminoid borondifluoride complexes.

[2]: Kim, D.-H.; D'Aléo, A.; Chen, X.-K.; Sandanayaka, A. D. S.; Yao, D.; Zhao, L.; Komino, T.; Zaborova, E.; Canard, G.; Tsuchiya, Y.; Choi, E.; Wu, J. W.; Fages, F.; Brédas, J.-L.; Ribierre, J.-C.; Adachi, C.: High-efficiency electroluminescence and amplified spontaneous emission from a thermally activated delayed fluorescent near-infrared emitter. *Nat Photon* **2018**, *12*, 98-104.

[3]: Ye, H.; Kim, D. H.; Chen, X.; Sandanayaka, A. S. D.; Kim, J. U.; Zaborova, E.; Canard, G.; Tsuchiya, Y.; Choi, E. Y.; Wu, J. W.; Fages, F.; Bredas, J.-L.; D'Aléo, A.; Ribierre, J.-C.; Adachi, C.: Near-Infrared Electroluminescence and Low Threshold Amplified Spontaneous Emission above 800 nm from a Thermally Activated Delayed Fluorescent Emitter. *Chem. Mater.* **2018**, *30*, 6702-6710.

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Elaboration and studies of porous and conducting MOF/polymer composites for thermoelectric applications

Internship supervisor

Name, first name	CHAPLAIS Gérald / SIMON Laurent
E-mail, Telephone	gerald.chaplais@uha.fr / laurent.simon@uha.fr 03 89 33 68 87 / 03 89 33 66 03
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: October 2023 otherwise beginning at conventional date, February 2024

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 $zT= S2\ \sigma\ T/\varkappa$ [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).

In this project, we aim to synthesis a new class of composite and 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. As MOFs have also, in general, a higher Seebeck coefficient than conducting polymers, a high Seebeck coefficient is thus expected for the composites.

At IS2M, we will **synthesize MOF-type materials** which will be then used by ICS to elaborate MOF/polymer composites. MOFs result from combination of metal sources and organic ligands which lead to 1D, 2D and 3D scaffolds (Figure 1). They are commonly prepared by hydro/solvothermal, microwave or precipitation routes. Another part of the internship will be devoted to the **study of transport properties of the MOF/polymer composites** by using a nanoprobing station under a SEM (FEG-SEM XL30 equipped with a cryo-stage Kammrath®- 77K-600K and 4 nicro-nano-manipulator IMINA®).

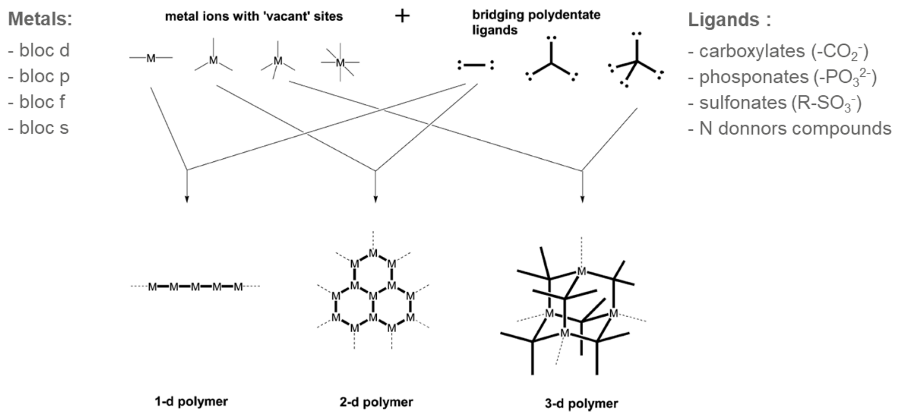


Figure 1. Assembly of inorganic and organic components to form MOFs

Requirements & Application

We are looking for motivated and team-worker master Student (chemist, chemo-physicist) willing to learn about conjugated ligands and MOF synthesis, characterization and thermoelectric properties. Remuneration will be provided for the internship. Collaboration with L. Biniek (ICS) and N. Leclerc (ICPEES) including short stays there (laboratories in Strasbourg), will be possible.

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

Preliminary discussions by phone are obviously possible and welcome.

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Title: Design of carbon quantum dots (CQDs) for Fe^{3+} detection

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, LIMA

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.). The promising materials will be tested for iron (III) detection at Institute of Research in Hematology and Transplantation (IRHT).

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Title: Surface Functionalization with Photoinitiators for Plasma Polymers Deposition

Internship supervisor

Name, first name	OLIVEIRA, Jamerson
E-mail, Telephone	jamerson.oliveira@uha.fr, 03 89 60 88 30
Laboratory	Institut de Science des Matériaux de Mulhouse (IS2M)
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

The goal of the internship is to elaborate functional surfaces, containing photoiniators, and test their influence on the final properties of polymers deposited via plasma enhanced chemical vapor deposition (PECVD).

The internship will offer the intern practical training in surface functionalization strategies through wet chemistry and PECVD. The intern is expected to work on the preparation of reactive self-assembled monolayers, the photo-assisted functionalization of those through wet chemistry and the evaluation of the surface influence on the formation kinetics and morphology of polymers deposited through PECVD. In addition, surface patterning will be generated through the use of a SmartPrint UV (Microlight3D) based on Digital Light Processing (DLP) or alternatively through Direct Laser Writing (DLW). The intern will carry out chemical, physico-chemical and morphological characterizations of the functional substrates and polymers using the available techniques at the IS2M (contact angle measurements, ellipsometry, infrared spectroscopy (FTIR), X-ray photoelectron spectroscopy (XPS), atomic force microscopy (AFM)...). The intern will develop disciplinary skills in materials chemistry, particularly in surface characterization as well as in PECVD. More generally, she/he will learn how to work within a research team, exploit data, use scientific databases, write a report and communicate on her/his results.

References:

Carneiro de Oliveira, J.; Meireles Brioude, M. de et al., Plasma polymerization in the design of new materials: looking through the lens of maleic anhydride plasma polymers. Materials Today Chemistry 2022, 23, 100646.

Zhang, Junning et al., Facile Surface Functionalization Strategy for Two-Photon Lithography Microstructures. Small 2021, vol. 17, n° 34, e2101048.

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Title

Internship supervisor

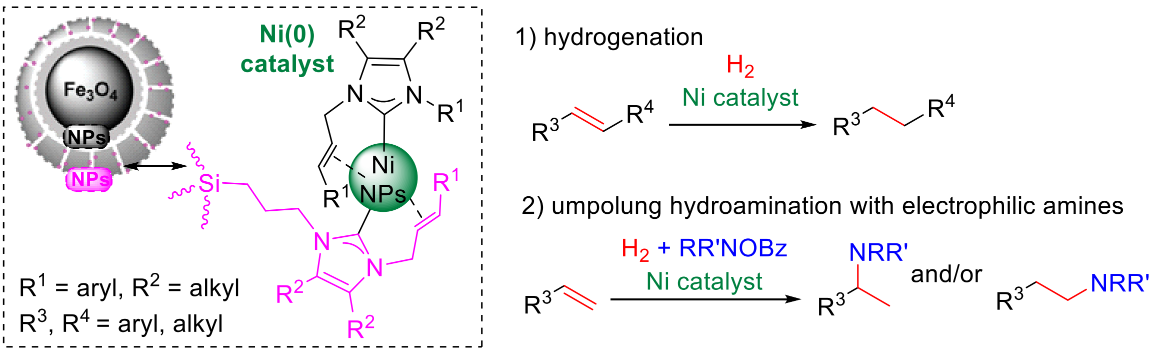
Name, first name	MICHON, Christophe
E-mail, Telephone	cmichon@unistra.fr, 03.68.85.28.08
Laboratory	LIMA UMR7042 CNRS-Unistra
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Dr Benoit LOUIS (ICPEES UMR7515 CNRS Unistra)

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 project aims to develop new sustainable nanomaterials for catalysis using yolk-shell-structured magnetic mesoporous silica nanoparticles (NPs) as support, comprising a magnetic iron oxide core and a specific mesoporous silica external layer. A functionalization of the NPs mesoporous silica surface by organic ligands composed of N-heterocyclic carbene (NHC) and olefin moieties will allow the coordination of nickel(0) NPs of defined sizes and with unique catalytic properties. After characterizations (by microscopy MEB and TEM, XRD, XPS, DLS, Raman, ^{29}Si CP-MAS NMR, ICP and elemental analyses), the prepared materials will be applied as catalysts for hydrogenation and hydroamination of alkenes through an umpolung strategy for the latter. The catalysts recovery and reuse will be investigated thanks to their magnetic properties. Finally, the application of a non-contact electromagnetic inductive heating shall be also investigated in order to overcome energy losses and transfer limitations during the catalytic reactions by heating exclusively the nickel catalysts through the use of iron oxide NPs acting as a heat-transfer agent.



References:
B. Louis et al. *Dalton Trans.* **2014**, *43*, 3722 & C. Michon et al. *Chem. Commun.* **2023**, *59*, 1537

ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Title: TIGERsens -TiO_2-Gated organic Electrochemical TRansistor (OECT) for light-activated sensing

Internship supervisor

Name, first name	Bardagot, Olivier
E-mail, Telephone	olivier.bardagot@cnrs.fr
Laboratory	ICPEES
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Cottineau, Thomas

Student profile looked for

Master program (*more than one box can be ticked*)	☒ Material science and engineering ☐ Chemistry ☐ Physics
Other indications if necessary	An interest in organic semiconducting polymers, electrochemistry and device manufacturing is preferred.

Internship description

The main task of this **6-month M2 internship** is to manufacture and characterize **original organic electrochemical transistors** (OECTs) for the **detection** of biomarkers. OECTs are a fast-growing technology used mainly for **heath applications** (e.g.: biosensors, electrophysiologic devices) whose detection limit are significantly lower than the current applied technologies. The main objective of the internship is to investigate the benefit of using a mesoporous **gate electrode made on TiO_2 nanotubes**. TiO_2 nanotubes present a **high capacitance** and can be **activated by light**, thereby offering unique features such as **spatial resolution** and **regeneration** of the sensor.

The student will work on this **hot topic** in a **pluri-disciplinary** environment including two teams of the ICPEES. He/she will be in charge of **fabricating OECTs** made of **PEDOT:PSS** channel and of **synthesizing mesoporous TiO_2 gate electrodes**. The student will then investigate the properties of these novel OECTs in different conditions of **irradiation** in 'test' aqueous electrolyte. Finally, the performances of the resulting biosensors will be tested in **'applicative' conditions** by replacing the test electrolyte by an **analyte containing bilirubin** for its detection. Bilirubin is a biomolecule generated during the breakdown of red blood cells. Its accurate and reversible detection would contribute to the early diagnosis of liver-related diseases in the hope of better treatment.

High quality results are expected, as demonstrated by our manuscript reporting record OECT performance for highly aligned polymers (10x higher than state-of-the-art), currently under review for publication in Nature Materials (https://www.researchsquare.com/article/rs-3221543/v1).

Daily work will include:

- Bibliographic study of the impact of the gate porosity on the OECT response
- Processing of (semi)conducting polymers in solution (mainly PEDOT:PSS)
- Synthesizing TiO_2-Nanotubes gate electrodes
- Scanning electron microscopy (SEM) to visualize the resulting thin films and electrodes
- OECT manufacture
- Electrical characterization of electrochemical transistors (transfer, output)
- Time-resolved Vis/NIR absorbance spectroscopy during electrochemical doping
- Data analysis using Python (computing)
- Calibration and use in 'test' and 'applicative' conditions of novel biosensors

Hard skills which will be learnt:

- Bibliographic search
- Database management
- Semiconducting polymer design
- Electrochemical synthesis
- Polymer processing
- Vis-NIR absorbance spectroscopy
- Electrochemistry
- Computing (Python for heavy data analysis and graph plotting, LabVIEW if interested)

Soft, transferable, skills which will be learnt:

- Collaboration, teamwork
- Effective communication
- Scientific data presentation (oral and written in English)
- Project management (time management, supply management, etc)
- Progress reporting
- Creativity/independency (depending on the will of the student)

References:

1. **High-performance OECT manufacture:** O. Bardagot*, P. Durand, S. Guchait, G. Rebetez, P. Cavassin, J. Réhault, M. Brinkmann, N. Leclerc, N. Banerji, *In Review - Nature Materials*, **2023**, 10.21203/rs.3.rs-3221543/v1
2. **OECT doping kinetics:** B. T. DiTullio, L. R. Savagian, O. Bardagot, M. De Keersmaecker, A. M. Österholm, N. Banerji, J. R. Reynolds, *J. Am. Chem. Soc.* **2023**, *145*, 122–134.
3. **TiO_2 Nanotube synthesis:** F. Gelb, Y.-C. Chueh, N. Sojic, V. Keller, D. Zigah, T. Cottineau*, *Sustainable Energy Fuels* **2020**, *4*, 1099–1104.
4. **TiO_2-based sensors:** D. Spitzer, T. Cottineau, N. Piazzon, S. Josset, F. Schnell, S. N. Pronkin, E. R. Savinova, V. Keller, *Angewandte Chemie International Edition* **2012**, *22*, 5334–5338.
5. **TiO_2-gated OECT:** M.-J. Lu, F.-Z. Chen, J. Hu, H. Zhou, G. Chen, X.-D. Yu, R. Ban, P. Lin, W.-W. Zhao, *Small Structures* **2021**, 2, 2100087.