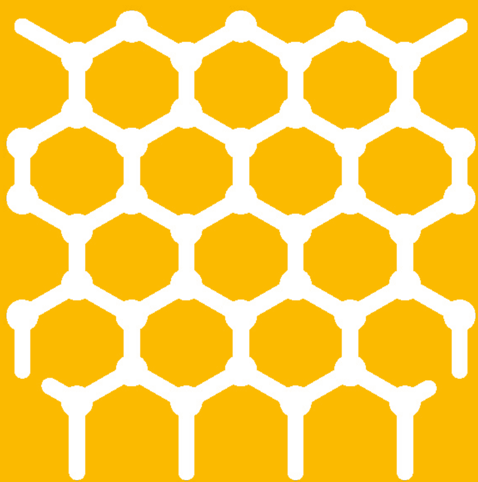
Master 2

Sciences, Technologies, Santé

2025-2026

Chimie

LUmière MOlécules MATière



M2 LUMOMAT

Recherche

Apprentissage

Contrat Pro.

Connaisciences université angers

Nantes Université

Université de Rennes

SOMMAIRE

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CONTACTS

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Student administration office

Hall A, Ground floor, Office A003
Opening hours
8.30 – 12.00
13.30 – 16.30
Monday to Friday
Closed on Wednesday afternoons

CALENDRIER

Troisième semestre

Rentrée et début des cours	Lundi 01 septembre 2025
Contrôles continus n°1	Jeudi 09 octobre 2025 et vendredi 10 octobre 2025
Contrôles continus n°2	Mardi 16 décembre 2025 et mercredi 17 décembre 2025
Vacances de fin d'année	*Samedi 20 décembre 2025 au dimanche 04 janvier 2026*
Contrôles continus n°3	Du Mercredi 12 février 2026 au vendredi 14 février 2026
Jury 1er semestre I Session 1	Jeudi 20 mars 2026

Quatrième semestre

Vacances d'hiver	*Samedi 21 février 2026 au dimanche 01 mars 2026*
Stage	Du lundi 23 février 2026 au vendredi 26 juin 2026
Soutenances de stage	Lundi 29 juin 2026 et mardi 30 juin 2026
Jury 2ème semestre I Session 1	Jeudi 02 juillet 2026
Examens 1er semestre I Session 2	Dates à définir (entre semaine 13 et 26)
Examens 2ème semestre I Session 2	
Jury 1er et 2ème semestre I Session 2	Jeudi 02 juillet 2026

ACADEMIC CALENDAR

Third semester

Programme opening and beginning of courses	Monday 01 september, 2025
Exam period No. 1	Thursday, October 09, 2025 and Friday, October 10, 2025
Exam period No. 2	Tuesday, December 16, 2025 and Wednesday, December 17, 2025
Christmas vacation	*Saturday, December 20, 2025 to Sunday, January 4, 2026*
Exam period No. 3	From Wednesday, February 12, 2026 to Friday, February 14, 2026
Exam board for 1st semester I session 1	Thursday March 20, 2026

Fourth semester

Winter vacation	*Saturday, February 21, 2026 to Sunday, March 01, 2026*
İnternship	From Monday, February 23, 2026 to Friday, June 26, 2026
İnternship presentation	Monday June 29, 2026 andTuesday June 30, 2026
Exam board for 2nd semester I Session 1	Thursday July 2, 2026
Exams 1st semester I Session 2	Dates to be defined (between week 13 and 26)
Exams 2nd semester I Session 2	
Exam board for 1st and 2nd semesters I Session 2	Thursday July 2, 2026

PRÉSENTATION DE LA FORMATION
PRESENTATION OF THE PROGRAM

OBJECTIFS DU MASTER
OBJECTIVES OF THE MASTER'S

Le Master LUMOMAT propose une solide formation en CHIMIE en forte interaction avec la Recherche scientifique et l'Innovation technologique. Il s'intègre dans la filière émergente et à très fort potentiel de l'électronique organique. Dans ce contexte, il propose une formation moderne, unique en France, visant à faire face à la demande croissante de cette filière industrielle et académique et à offrir aux étudiants une formation de haut niveau qui leur ouvre toutes les portes des secteurs des hautes technologies d'avenir telles que le photovoltaïque 3ème génération, les comburants solaires, OLED, les capteurs et sondes moléculaires pour la santé et l'environnement, les nano systèmes structurés pour le transport et le stockage de l'information.

The LUMOMAT Master's degree offers a strong training in CHEMISTRY in close interaction with scientific research and technological innovation. It is part of the emerging and very high potential sector of organic electronics. In this context, it provides students with an innovative and high-level curriculum which is unique in France, aiming to meet the growing demands of this in- dustrial and academic field and to give students access to high-tech sectors, such as third-generation photovoltaics, solar oxidants, OLEDs, molecular sensors and probes for health and environment, structured nanosystems for the transport and storage of information.

COMPÉTENCES VISÉES
EXPECTED SKILLS

Le Master 2 LUMOMAT a pour ambition de former des futurs professionnels dans le domaine des matériaux moléculaires pour la photonique et l'électronique organiques. Le Master LUMOMAT forme des chimistes de compétences pluridisciplinaires capables de concevoir, d'élaborer puis de caractériser physico-chimiquement des matériaux moléculaires, voire d'assurer leur intégration dans des dispositifs photoniques et/ou électroniques. A l'issue de la formation, les étudiants connaîtront l'industrie chimique et le milieu de l'entreprise, l'entrepreneuriat, la communication et le management de projets. Ils seront capables de :

— Utiliser les techniques de l'ingénierie moléculaire et supramoléculaire pour réaliser la synthèse de matériaux fonctionnels.

— Choisir les techniques de caractérisations adéquates et les modèles théoriques appropriés pour optimiser les propriétés des matériaux fonctionnels.

— Restituer des connaissances sur des matériaux organiques (photonique et électronique) et de leurs débouchés (actuels et à venir) et applications.

— Superviser et conduire des projets R&D dans les domaines des matériaux organiques (photonique moléculaire et électronique).

The 2nd-year LUMOMAT Master's degree aims to train future professionals in the field of molecular materials for organic photonics and electronics. The LUMOMAT Master's degree trains chemists with multidisciplinary skills to design, develop and then physico-chemically characterize molecular materials, or ensure their incorporation into photonic and/or electronic devices. At the end of the course, students will have

developed knowledge in the chemical industry and the business environment, as well as in entrepreneurship, communication and project management.
They will be able to:
— Use molecular and supramolecular engineering techniques to synthesize functional materials.
— Choose appropriate characterization techniques and theoretical models to optimize the properties of functional materials.
— Communicate their knowledge on organic materials (photonics and electronics), on their current and future outlets and on their applications.
— Supervise and lead R&D projects in the fields of organic materials (molecular photonics and electronics).

INSERTION PROFESSIONNELLE
CAREER OPPORTUNITIES

Le diplômé du Master LUMOMAT peut prétendre à des emplois aussi bien en recherche qu'en industrie. Les types d'emplois : Cadre supérieur en production ou recherche et développement / Thèse de doctorat / ingénieur d'étude dans les grands organismes de recherche (CNRS, INRA, INSERM,...).

LUMOMAT Master's degree graduates will qualify for jobs in both research and industry, e.g.: senior managers in production or research and development
/ PhD students / research engineers in large research organizations (CNRS, INRA, INSERM, etc.).

PUBLIC VISÉ
ENTRY QUALIFICATIONS

Le Master M2 est ouvert aux étudiants provenant du M1 LUMOMAT et d'autres masters 1 à dominante marquée en chimie ou en physique/chimie. L'inscription est de droit pour les étudiants du M1 LUMOMAT. Pour les étudiants provenant d'autres masters de chimie ou physique/chimie, l'admission est agréée après étude du dossier du candidat. Pour les étudiants provenant des autres parcours, l'admission est agréée par une commission de validation d'acquis.

The 2nd-year LUMOMAT Master's degree is open to students who have com- pleted the first year of the LUMOMAT Master's degree or other Master's pro- grams with a strong focus on chemistry or physics & chemistry. Registration is automatically possible to students who have completed the first year of the LUMOMAT Master's degree. For chemistry or physics & chemistry students, admission is subject to approval based on the candidates' files. For students from other courses, admission is subject to approval by a recognition of prior learning committee.

MODALİTÉS PRATİQUES EN ALTERNANCE
PRACTICAL ARRANGEMENTS FOR THE WORK/STUDY PROGRAM

Le Master LUMOMAT est co-habilité entre les universités d'Angers, de Nantes et de Rennes. Le Master 1 est localisé à Nantes et à Rennes et le Master 2 est localisé à Angers. Seul le Master 2 est aujourd'hui ouvert en alternance (Contrat de professionnalisation).
Sélection : sur dossier, d'avril à juin
Rythme d'alternance : voir calendrier (page 20).
Période de formation : M2 de septembre à septembre (1 an).
Durée de formation : voir calendrier de la formation.

The LUMOMAT Master's program is co-accredited by the universities of An- gers, Nantes and Rennes. The first year of the Master's degree takes place in Nantes and Rennes and the second year is held in Angers. Only the second year of the Master is currently available on a work/study basis (professional training contract).
Selection: based on application file, from April to June Work/study periods: see calendar (page 20).
Training period: 2nd-year Master's degree from September to September (one year).
Duration of training: see academic calendar.

STAGE
INTERNSHIP

Le stage de M2 dure de 4 à 6 mois. Il donne lieu à un rapport de stage qui est évalué ainsi qu'à une soutenance qui donne également lieu à un échange avec le jury. Le semestre 4 est totalement dédié au stage (30 ECTS) et apporte autonomie et esprit d'initiative. Les étudiants peuvent bénéficier du réseau LUMOMAT : *http://www.lumomat.fr/* pour les aider dans leur recherche de stage en France et à l'étranger. La durée obligatoire du stage est de 4 mois 1/2 (mi-février-fin juin) extensible à 6 mois jusqu'à fin août. Le stage peut se dérouler en laboratoire de recherche ou en entreprise.

The internship for the 2nd-year Master's degree lasts 4 to 6 months. Students have to write an internship report which will be assessed, as well as make an oral presentation before an examination board. Semester 4 is dedicated to the internship (30 ECTS), allowing students to act more independently and show initiative. Students can benefit from the LUMOMAT network: http:// www.lumomat.fr/ to help them in their search for internships in France and abroad. The minimum compulsory duration of the internship is 4 months and a half (Mid-February till end of June) extendable to 6 months until the end of August. The internship may be completed in a research laboratory or in a company.

FONCTIONNEMENT
COURSE STRUCTURE

La plus grande part des enseignements du M2 est assurée sur le site d'Angers conjointement par des équipes pédagogiques mixtes des trois Universités. Quelques cours et TP spécifiques (environ 1 semaine) sont dispensés à la faculté des Sciences de Nantes.
Au sein d'un semestre :
— Un élément constitutif (EC) est acquis dès lors que sa moyenne est supérieure ou égale à 10 (hors séminaire non noté).
— Une unité d'enseignement est acquise dès lors que sa moyenne est supérieure ou égale à 10. Un EC non acquis dans cette UE est obtenu par compensation et ne peut donner lieu à seconde session.
Pour obtenir la seconde année de master son diplôme, l'étudiant doit atteindre une note terminale avant stage d'au moins 10/20 (moyenne du S1) et une note de stage d'au moins 10/20. Sont validés, les étudiants qui ont validé chaque Unité d'Enseignement (UE) ou qui compensent entre UE (moyenne >=10).
Sont diplômés du master LUMOMAT, les étudiants ayant validé 120 ECTS dans le master (M1+M2) ou admis sur dossier en M2 et ayant validé les 60 ECTS correspondants.
Les étudiants n'ayant pas validé leur année peuvent redoubler et conserver les UE validées et, lorsqu'une UE est constituée d'éléments constitutifs (EC) validant des ECTS, conserver les EC dans lesquels ils ont obtenu la moyenne.

Most of the 2nd-year Master's degree program is taught in Angers by professors from the universities of Angers and Nantes. Some specific courses and practical works (around 1 week) take place at the Nantes Faculty of Sciences.
Within a semester:
— To pass a course component ("élément constitutif" or "EC"), students are required to achieve an average grade greater than or equal to 10 out of 20 (excluding seminars which are not marked).
— To pass a course unit ("unité d'enseignement" or "UE"), they should achieve an average grade greater than or equal to 10 out of 20. A failed "EC" in this "EU" is passed by compensation and cannot lead to a second exam session. To successfully complete the second year of the Master's degree, students must achieve a final grade (not including the internship grade) of at least 10 out of 20 (average of Semester 1) and an internship grade of at least 10/20. Students must pass each course unit (UE) or compensate some of their UES (average mark > = 10).
Graduates of the LUMOMAT Master must have achieved 120 ECTS as part of the Master's degree (1st and 2nd year) or must have been admitted to the 2nd year of the Master's based on their application file and have achieved 60 ECTS during the 2nd year of the Master's degree.
Students who have not successfully completed their academic year can re- peat it and keep the passed UEs. If a UE is made up of course components (EC) awarding ECTS, students can keep the ECS in which they achieved a pass grade.

VOLUMES HORAIRES - ÉVALUATIONS

CONTACT HOURS AND COURSE ASSESSMENT

SEMESTRE 3 — 30 ECTS

UE	Matières	Volumes horaires				ECTS	Coeff.	Contrôle des connaissances			
								1ere session		2ème session	
		CM	TD	TP	Tot.			Examen	Durée	Examen	Durée
1	Anglais	0	0	10	10	1	1	Oral	30mn	Oral	30mn
	Formation professionnelle	0	0	15	15	0	0	P	-	-	-
	Projet Expérimental Étudiant	0	0	30	30	3	3	TP-0,67 Oral-0,33		TP-0,67 1 Oral-0,33	
2	Introduction à la planification d'expériences	11	0	4	15	1	1	CC-0,8 TP-0,2	1h30	CT-0,8 TP-0,2 1	1h30
	Modélisation Moléculaire	15	0	10	25	2	2	CC-0,5 TP-0,5	2h	CT-0,5 TP-0,5 1	2h
	Formulation	18	4	8	30	2	2	CC-0,8 TP-02	2h	CT-0,5 TP-0,5 1	2h
3	Ingénierie moléculaire des systèmes pi-conjugués	24	16	0	40	3	3	CC	3h	CT	3h
	Chimie supramoléculaire	25	0	10	35	3	3	CC-0,8 TP-0,2	3h	CT-0,8 TP-0,2 1	3h
4	Photophysique et photochimie	17	5	8	30	2	2	CC-0,8 TP-0,2	3h	CT-0,8 TP-0,2 1	3h
	Techniques de spectroscopies et Microscopies	12	0	0	12	1	1	CC	1h30	CT	1h30
	Interaction lumière-matière pour la biologie	13	0	0	13	1	1	CC	1h30	CT	1h30
	Électrochimie des surfaces modifiées	16	11	8	35	3	3	CC-0,8 TP-0,2	3h	CT-0,8 TP-0,2 1	3h
5	Matériaux moléculaires et hybrides, nanomatériaux	30	4	16	50	4	4	CC-0,8 TP-0,2	3h	CT-0,8 TP-0,2 1	3h
	Électronique organique	35	5	20	60	4	4	CC-0,8 TP-0,2	3h	CT-0,8 TP-0,2 1	3h
	Total	216	45	139	400	30					

1 En session 2, report note TP si note >ou= 10/20

! Pas de DA

Conditions de validation du semestre 3: Admis·e si moyenne > ou = à 10/20 et si Formation professionnelle validée

CT = Contrôle Terminal — *P = Validation en Présentiel*

CC = Contrôle Continu — *DA = Dispensé d'Assiduité*

SEMESTRE 4								30 ECTS			
UE	Matières	Volumes horaires				ECTS	Coeff.	Contrôle des connaissances			
								1ere session		2ème session	
		CM	TD	TP	Tot.			Examen	Durée	Examen	Durée
1	Stage Alternance	0	0	0	0	30	1	Oral **2**	-	Oral **2**	-
	Total	0	0	0	0	30					

Total année	216	45	139	400	60

2 1 seule note attendue : Écrit + oral + note de suivi

! Pas de DA

Conditions de validation du semestre 4 — Admis·e si moyenne > ou = à 10/20

Conditions de validation De l'année — Conditions de validation de l'année :
((S3 + S4) / 2) > ou = 10/20
pas de compensation entre S3 et S4

CT = Contrôle Terminal — *P = Validation en Présentiel*
CC = Contrôle Continu — *DA = Dispensé d'Assiduité*

SEMESTER 3									30 ECTS			
UE	Subjects	Contact hours				ECTS	weight	Course assessments				
		Lectures	Tutorials	Practical work	Tot.			1ere session		2e session		
								Mandatory attendance	Duration	Exam	Duration	
1	English	0	0	10	10	1	1	Oral	30 mn	Oral	30mn	
	Professionnal Training	0	0	15	15	0	0	On-site	-	-	-	
	Student Experimental Project	0	0	30	30	3	3	PW -0,67 Oral-0,33		PW-0,67* Oral-0,33		
2	Design of experiments	11	0	4	15	1	1	CA-0,8 PW-0,2	1h30	FA-0,8 PW-0,2*	1h30	
	Molecular Modelling	15	0	10	25	2	2	CA-0,5 PW-0,5	2h	FA-0,5 PW-0,5*	2h	
	Formulation	18	4	8	30	2	2	CA-0,8 PW-0,2	2h	FA-0,5 PW-0,5*	2h	
3	Molecular Engineering of π -conjugated Systems	24	16	0	40	3	3	CA	3h	FA	3h	
	Supramolecular Chemistry	25	0	10	35	3	3	CA-0,8 PW-0,2	3h	FA-0,8 PW-0,2*	3h	
4	Photophysics and Photochemistry	17	5	8	30	2	2	CA-0,8 PW-0,2	3h	FA-0,8 PW-0,2*	3h	
	Techniques of Spectroscopies and Microscopies	12	0	0	12	1	1	CA	1h30	FA	1h30	
	Light Matter Interaction for Biology	13	0	0	13	1	1	CA	1h30	FA	1h30	
	Electrochemistry of Modified Surfaces	16	11	8	35	3	3	CA-0,8 PW-0,2	3h	FA-0,8 PW-0,2*	3h	
5	Molecular Materials, Hybrids and Nanomaterials	30	4	16	50	4	4	CA-0,8 PW-0,2	3h	FA-0,8 PW-0,2*	3h	
	Organic Electronics	35	5	20	60	4	4	CA-0,8 PW-0,2	3h	FA-0,8 PW-0,2*	3h	

* Insession 2, report grade TP if grade > or= 10/20

✓ Successful completion of semester 3: minimum average grade of 10/20.

CA: Continuous Assessment
FA: Final Assessment
PW: Practical Work

SEMESTER 4 — 30 ECTS

UE	Subjects	Contact hours				ECTS	weight	Course assessments			
		Lectures	Tutorials	Practical work	Tot.			Lectures		Tutorials	
								Examen	Durée	Examen	Durée
1	Internship Work/Study	0	0	0	0	30	1	Oral **	-	Oral **	-

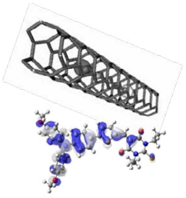
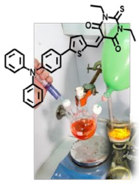
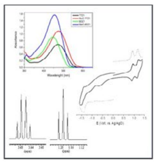
** Only 1 grade expected: Written + oral + follow-up grade

✓ Successful completion of semester 4: minimum average grade of 10/20.

No compensation between semesters 3 and 4.
The grade and ECTS assigned for the internship (semester 4) do not compensate for the average mark achieved in semester 3.

CA: Continuous Assessment
FA: Final Assessment
PW: Practical Work

CONTENUS DES ENSEIGNEMENTS - COURSE CONTENT


Design ➡ **Synthesis** ➡ **Characterizations** ➡ **Materials/Devices**

UE 1 Transverse Training	UE 2 Design	UE 3 Synthesis	UE 4 Characterizations and Organic Photonics	UE 5 Materials and Organic Electronics
English 10h *1 ECTS*	Design of experiments 15h *1 ECTS*	Molecular engineering of Π-conjugated systems 40h. *3 ECTS*	Photophysics and photochemistry 30h. *2 ECTS*	Molecular Materials, Hybrids and Nanomaterials 50h *4 ECTS*
Professional Training 15h *0 ECTS*	Molecular modelling 25h *2 ECTS*	Supramolecular chemistry 35h. *3 ECTS*	Techniques of spectroscopies and microscopies 12h *1 ECTS*	Organic Electronics 60h *4 ECTS*
Student experimental project 30h *3 ECTS*	Formulation 30h *2 ECTS*		Light-Matter interaction for Biology 13h *1 ECTS*	
			Electrochemistry of modified surfaces 35h *3 ECTS*	
55h, *4 ECTS*	70h, *5 ECTS*	75h, *6 ECTS*	90h, 7 ECTS	110h, 8 ECTS

400h students

› **Period 1**: Total: 113h, *8 ECTS*
— Organic electronics: 60h, 4 ECTS
— Molecular engineering of Π-conjugated systems: 40h, 3 ECTS
— Light-matter interaction for biology: 13h, 1 ECTS

› **Period 2**: Total: 122h, *10 ECTS*
— Molecular materials, hybrids and nanomaterials: 50h, 4 ECTS
— Electrochemistry of modified surfaces: 35h, 3 ECTS
— Molecular Modelling: 25h, 2 ECTS
— Techniques of spectroscopies and microscopies: 12h, 1 ECTS

› **Period 3**: Total: 93h, *8 ECTS*
— Supramolecular chemistry: 35h, 3 ECTS
— Photophysics and photochemistry: 30h, 2 ECTS
— Light-matter interaction for biology: 13h, 1 ECTS
— Formulation: 30h, 2 ECTS

— Student experimental project and English: 40h, 4 ECTS

SEMESTRE 3

UE OBLIGATOIRES - MANDATORY EDUCATION UNITS

Transverse training

UE1

ENGLİSH
Responsible: Sabrina Sebti

OBJECTİVES
The audiences of Master 2, fully taught in English, are diverse. Some students will have obtained the certification at the end of Master 1 and will continue to deepen the 4 language skills (written and oral comprehension, written and oral expression). The first objective is therefore the consolidation and deepening by the practice of these four linguistic skills in order to reach (or consolidate) a level of certification (type B2 level) defined by the European Framework of Languages.

CONTENT
After a diagnosis carried out to establish the level of oral English, the student will receive work leads. The evaluation will be carried out during the defense in English of the student experimental project.
Students will have the opportunity during the year to prepare and sit for the English certification implemented at the University.

KNOWLEDGE AND EXPECTED SKİLLS
Level B2 of the European framework.

UE1

PROFESSİONAL TRAİNİNG
Responsible: Thomas Cauchy

OBJECTİVES
The objectives of this module are to know the fundamental tools for a future professional integration either in research or in industry, to know and understand the main principles of a quality management approach and to know the main normative definitions (REACH) of quality, applied in industry.

CONTENT
The teaching will focus on scientific communication with training on writing an internship report, a scientific article, the acquisition of educational communication tools (designing a poster, etc.) and research training, bibliography and popular science. Students will participate in workshops dedicated to the concepts of meeting management, management, project management, and preparation for a recruitment interview.
Students will have the opportunity to attend the conferences offered within the Laboratory by internationally renowned researchers and teacher-researchers or industrials in the field of organic electronics. İn particular, an intervention by AFELİM (French Association of Printed Electronics) will be offered to enable students to open up to the various trades in printed electronics. İn this context, company visits to this area of application will also be organized.

The main normative definitions of Quality, the main regulatory requirements applicable to chemicals and their applications will be described so that students are aware of the different normative standards applied in industry (REACH regulations, İSO 9001 standards, İSO 14001, OHSAS 18001, İSO 26000).

1 Les règlementations « mères » sur les produits : REACH & CLP (2h), principales réglementations sur les produits pour avoir une vision globale des différentes obligations et de l'impact sur les entreprises.
2 La Fiche de Données de Sécurité et les mesures de gestion des risques chimiques (1h) Sensibilisation à la FDS et aux EPİ, EPC, évaluation du risque chimique. L'impact sur les sites industriels : SEVESO İİİ, İED et nomenclature İCPE.

3 Les règlementations sectorielles existantes (1h). Tour d'horizon des différentes réglementations existantes selon les types de produit et les marchés.
L'idée est que les étudiants sachent que des réglementations spécifiques vont s'appliquer selon les secteurs, ajoutant des obligations supplémentaires à REACH et CLP.
Mots clés : Biocides, Phytosanitaires, Dispositifs médicaux, Fertilisants, Jouets, Alimentaire, Cosmétiques, Carburants, Aérosols, Détergents, Médicaments, Peintures et vernis, Explosifs et précurseurs.

4 Les règlementations transverses (1h). Montrer aux étudiants que les réglementations transverses sont nombreuses et qu'il est indispensable de les prendre en compte avant de développer un nouveau projet/une nouvelle substance. PIC, RoHS / DEEE / Piles, Slatique, Précurseurs de Stupéfiants, POP, CIAC, R Nano Biens à double usage

5 Les référentiels normatifs appliqués en industrie (1h). Description d'un système de management, principe de l'amélioration continue et champ d'application des normes. ISO 9001, ISO 14001, OHSAS 18001/ISO 45001, ISO 26000, ISO 50001 SMI et Responsible care.

KNOWLEDGE AND EXPECTED SKILLS

— Know how to write a CV and cover letter in French and English.
— Being able to conduct an interview for recruitment in French and English.
— Know the basics of popular science to simplify a research topic.
— Understand the different fields of printed electronics thanks to the opening offered with the conference cycle.
— Be aware of quality in business through knowledge of the standards and regulations applied on an industrial scale.

UE1

STUDENT EXPERIMENTAL PROJECT

Responsible: Thomas Cauchy

OBJECTIVES

During the student experimental project, students will be immersed alone (or in pairs) in the host research laboratory under the responsibility of a supervisor. Over a period of 4 weeks, after a bibliographic research work, the students will set up the realization of the corresponding manipulations / calculations / analyzes. This project should take place as independently as possible.

At the end of the project, each student will submit an individual report written in English describing their investigations, analyzes and conclusions. The assessment will also be supplemented by an oral defense in English which will provide the mark for English evaluation.
The student experimental project or tutored project must be the subject of an internship agreement.

KNOWLEDGE AND EXPECTED SKILLS

— Conduct an innovative approach that takes into account the complexity of a situation by using information that may be incomplete or contradictory.
— Lead a project (design, piloting, implementation and management, evaluation, dissemination) that can mobilize multidisciplinary skills in a collaborative framework and assume responsibility.
— Work as a team as much as in autonomy and responsibility in the service of a project.
— Communicate orally and in writing, in a clear and unambiguous manner, and in a register adapted to the target audience.
— Use digital tools to acquire, process, produce and disseminate information as well as to collaborate internally and externally.
— Operate software for data acquisition and analysis with a critical mind.
— Use the methods of data collection and qualitative and quantitative data processing.
— Analyze and synthesize data with a view

to their exploitation.
— Adapt to new or multidisciplinary situations to provide solutions.
— Report on their work orally and in writing.
— Speak in public to defend a project.

Design

UE2

DESİGN OF EXPERİMENTS

Responsible: Dominique Wolbert
Teachers: Dominique Wolbert (ENSCR Rennes), Olivier Alévêque (Univ. Angers)

OBJECTİVES

The goal of the design of experiments is to conceive, execute and analyze a set of experiments resulting if the best possible compromise between quality of the requested information (precision, independence, ...) and the experimental effort deployed, considering the formulated hypotheses on the studied system's behavior. Frequently used by the industrial sector for R&D and quality control, the method appears also more and more for research purposes.

CONTENT

The following courses will be dedicated to the presentation and use of several types of designs, developed to answer different types of problems.

> *Introduction*

Objectives, technical and economical interest, investigation methodology.

> *Constitutive elements*

— The factors: discrete, continuous, ... ; main factors, noise factors,...
— Treatments, experimental units, ...
— Observations, special case: quality (reduction of the signal to noise ratio).
— The expected model, additivity hypotheses of the contributions, state vector, free or constrained effects.

> *Searching for an optimal design of experiments*

— The sampling variance/co-variance matrix of the effects.
— The a priori analysis of an experimentation, optimality criteria.
— Execution of a designed experimental set (randomisation, error estimation, ...).
— Reminder on the significance of statistical tests, risks, comparison of variance estimations (Fisher-Snedecor test), of mean estimations (Student test, Tuckey test) ...

> *Presentation/use of some types of designs*

— Discrete factor designs: complete blocking, incomplete, latin squares, ...
— Full factorial designs, 2p designs with interactions.
— Fractional designs, Taguchi designs, Box designs ..., notion of aliases, resolution ...
— Response surface designs, quadratic designs : Doehlert, composite, Box-Behnken.
— Mixture designs.
— Simplex design for optimum search.

KNOWLEDGE AND EXPECTED SKİLLS

— İsolate / detect the influencing factors of a system or process;
— Build an optimized experience plan;
— Conduct an experience plan during the experiments;
— Use the results of an experiment plan;
— İnterpret the results of an experiment plan;
— Optimize a system or process from an experience plan.
Other concepts discussed and not deepened (not required): Evaluate the validity and the precision of the experiment plan used; Use Taguchi plans to optimize a system or process.

UE2

MOLECULAR MODELLİNG

Responsible: Thomas Cauchy
Teachers: Thomas Cauchy (Univ. Angers), Denis Jacquemin (Univ. Nantes)

OBJECTİVES

The theoretical calculation of the absorption and emission properties of UV-visible light, as well as the modelling of organic reactivity, are now widely available with *ab initio* methods. The objective of this course is to train informed users capable of choosing, independently and with a critical eye, a calculation method to model the ground state and excited states of complex molecules. The first part of this teaching covers and deepens the problems related to the calculation methodology while the second part is dedicated to the practice of modelling optical spectra (absorption, emission) and is mainly carried out in the form of project work.

CONTENT

> *Choice of the theoretical model to answer a molecular problem – 7.5h CM*

— Available theoretical methods and their limitations.
— The problem of electronic correlation.
— Choosing calculations parameters.
— The potential energy surface of the excited states and the spectral modeling.
— The importance of vibronic coupling.
— Simple and advanced approaches to model reactivity.

> *Setting up a strategy adapted to a problem – 7.5h CM and 10h TP*

— Study of an experimental problem (article).
— Choice of a calculation strategy and its limits.
— Choice of a problem to study and practice.
— Simulation of the absorption and emission properties of complex molecules.

KNOWLEDGE AND EXPECTED SKİLLS

— Choosing the right theoretical model to answer a problem related to the reactivity or the UV-visible spectroscopic properties of a complex molecule.
— Exploit judiciously and rigorously the results of molecular calculations.
— Analyze and summarize data for exploitation.
— Conduct an innovative approach that takes into account the complexity of a situation by using information that may be incomplete or contradictory.
— Give an oral account of his/her work.

UE2

FORMULATİON

Responsible: Mohammed Boujtita
Teachers: Anne Blayo (İNP Pagora, Grenoble), Pascal Thobie (CETİM Nantes), Mohammed Boujtita (Univ. Nantes)

OBJECTİVES

Formulation is a multidisciplinary science which consists in associating active materials or active principles and formulation auxiliaries (excipients, additives…) leading to a mixture answering a precise specification. After studying the physico-chemistry of dispersed media (colloidal suspensions, solutions, emulsions, etc.) and related analytical methods (spectroscopy, rheology, etc.), a focus will be devoted to mixtures for organic electronics.
The objective is to understand how to make a functional material printable (conductive, semiconductor or dielectric material, for example). This involves understanding the general principles of the formulation of a liquid, knowing the physico-chemical and rheological properties of liquids, in order to meet the specifications of the implementation processes on the one hand, and the requirements of the intended application, on the other hand.

CONTENT

1 The main principles of the formulation:
— Generalities
— The classic components of mixtures (binders, solvents and diluents, pigments, fillers, additives, etc.)
— Formulation processes (solubilization, grinding, dispersion, …)
— Physico-chemical parameters of the formulation (solubility, interfaces, wettability, CPV / CPVC, compatibility of mixtures, stabilization, particle size, etc.)
Case study: paint formulation - physicochemical formulation techniques and parameters; Methods of transfer from laboratory to industry. P. Thobie (CETİM Nantes)

2 Rheology: L. Benyahia (İMMM Le Mans)
— İntroduction to rheology.
— Fundamental principle and determining factors (stress, deformation, …).
— Viscosity definition and energetical considerations.
— Effect of pressure and temperature on the viscosity.
— Time and shear dependence of the viscosity.
— Suspension rheology.
— Rheology of polymer solutions.

3 Printing and coating processes (used in printed electronics): A. Blayo (İNP Pagora, Grenoble)
— Printing techniques (screen printing, inkjet, rotogravure, flexography, other processes).
- Main features.
- Properties of associated functional inks.
- Advantages and limits for electronic applications, examples.
- Coating techniques (spin coating, slot-die, blade coating).
— Drying / Annealing techniques (thermal / photonic).

4 Functional inks (inks for printed electronics, in particular): A. Blayo (İNP Pagora, Grenoble)
— Specific constraints (graphic inks vs. functional inks).
— Functional materials used for inks:
- Conductive materials (metallic and carbon particles and nanoparticles, conductive polymers, etc.).
- Dielectric materials.
- Semiconductor materials (for PV and OLED applications, for example).
- X-chrome materials.
— Specific measurements of the properties of the printed film (conductivity, for example).

Practical work: Screen printing techniques (M. Boujtita, Nantes)

Visits of companies will allow students to have concrete applications of the content of this course: ARMOR La Chevrolière, world specialist in ink chemistry and printing processes, and SERİBASE Château-Gontier, a company specializing in screen printing techniques

KNOWLEDGE AND EXPECTED SKİLLS

— Know the main principles of formulation and formatting.
— Know the main operating principles of characterization techniques.
— Use the methods of data collection and qualitative and quantitative data processing.
— Analyze and synthesize data with a view to their exploitation.
— Define the methods, the means of study and their implementation (adequacy of the characterization technique to the parameter studied).

Synthesis

UE3

MOLECULAR ENGİNEERİNG OF π-CONJUGATED SYSTEMS

Responsible: David Canevet
Teachers: David Canevet (Univ. Angers), Philippe Leriche (Univ. Angers), François-Xavier Felpin (Univ. Nantes), Christophe Darcel (Univ. Rennes)

OBJECTİVES

This teaching unit is dedicated to the main families of π-conjugated systems used in organic electronics and photonics. The synthesis and functionalization of photo- and electroactive organic architectures will be discussed. A particular attention will be paid to the impact of functionalization over physico-chemical properties. İn a pluridisciplinar manner, this unit will also raise awareness to the basic concepts of green chemistry and the interest of non-noble metals in synthesis.

CONTENT

— Classic organometallic coupling reactions (Pd, Ni or Cu catalysts): Stille, Heck, Kumada, Sonogashira, Suzuki, Negishi.

— Direct arylations (directed or not), applications to aromatic heterocycles.
— Click chemistry (Cu, Ru) and C-H activation.
— Metathesis reactions, principles, (diastereo)selectivies.
— Amination and sulfuration reactions to design new syntheses of pi-conjugated systems.
— İnterest of non noble metals in synthesis.
— Main electro- and photoactive organic derivatives.
- Nanocarbons: fullerenes, nanotubes and graphene.
- Perylene, naphthalene, porphyrin, phthalocyanin, tetrathiafulvalene.
- Pigments (diketopyrrolopyrrole, isoindigo, Bodipy etc ...).
- Thiophene, furane, pyrrole, dithienopyrrole, fluorene, carbazole, phenylenevinylene, phenyleneethynylene ...
- Organometallic complexes displaying optoelectronic properties.
— Design, synthesis, reactivity and functionalisation of these monomers.
— Design and synthesis of extended pi-conjugated systems (oligomers and polymers displaying a weak band gap).
— Analysis of structure/properties relationships and importance of these derivatives.
— Green chemistry applied to pi-conjugated molecules (12 principles of green chemistry, atom economy, calculations of E factor).

KNOWLEDGE AND EXPECTED SKİLLS

— Understand the reactivity of organometallic catalysts an their interest in molecular and macromolecular synthesis (C-C, C-heteroatom bond formation, direct arylations, metathesis).
— Handle the main synthetic methods to prepare π-conjugated systems (heterocyclic chemistry, organometallic coupling reactions, polymerization strategies, cycloadditions).
— Design the retrosynthesis of a given pi-conjugated system by taking into account the concepts of green chemistry.
— Understand the main principles of molecular engineering (polarity vs polarizability, extension and functionalisation of conjugated systems, dyes, pigments,...).
— Comprehend the methods developed to fine-tune the levels of frontier orbitals and the band gap of molecular materials for organic electronics and photonics.
— Use spectroscopic or electrochemical measurements to study a conjugated system and evaluate its potential in organic electronics.
— Know the main classes of molecular and macromolecular systems reported in the literature and their respective synthesis.
— Differente nanocarbons and proposing well-suited functionalization strategies.

UE3

SUPRAMOLECULAR CHEMİSTRY

Responsible: David Canevet
Teachers: David Canevet (Univ. Angers), Abdel El-Ghayoury (Univ. Angers), Sébastien Goeb (Univ. Angers), Stéphane Rigaut (Univ. Rennes)

OBJECTİVES

This teaching unit provides the conceptual bases of supramolecular chemistry, a mo- dern axis of chemistry centered on non-covalent interactions that is playing a key role in materials science and in particular in designing organized structures for complex functions, including at the macroscopic scale (molecular receptors, sensors, molecular machines, ...). The aim is to show students how this transverse new field of chemistry, often inspired by biological processes, can allow through a well-balanced use of va- rious tools of chemistry (organic synthesis, coordination chemistry, spectroscopies, physical chemistry, analytical chemistry), to control the structuring and the properties of different classes of materials, on scales ranging from nano- to micrometric sizes. İn particular, mastering these tools allow to design sophisticated supramolecular objects whose complexity could not be reached through traditional covalent synthesis.
The first part of this teaching unit is related

to the foundations on which is built this transverse field of chemistry (nature and characterization of non-covalent interactions, self-assembly and molecular recognition processes towards discrete structures, desi- gning molecular receptors). The module continues with an extension of these concepts to the case of supramolecular polymerization (gels), and then to the rational use of coordination bonds for the construction of various supramolecular architectures
and beyond, till the design of dynamic structures (molecular machines).
The complexity of the resulting systems is illustrated with the help of various recent examples from the literature. Also, practical work sessions (10h) allow to tackle several of these aspects. Finally, this course aims at stimulating the creativity of students in order to integrate the corresponding concepts into the different application areas which are considered in the other modules of the Master LUMOMAT.

CONTENT

Supramolecular Chemistry: basics (9h)
— From molecular to supramolecular chemistry.
— Supramolecular interactions.
— Characterization of supramolecular structures.
— Host molecules for the recognition of cations, anions and neutral molecules.
— Chemosensors.
— Molecular flasks.
— Supramolecular catalysis.

Supramolecular polymerization (4h)
— Physical and chemical gels.
— Application fields (conducting materials, mesophases, self-healing systems,...).
— Description of supramolecular polymerization processes (isodesmic, cooperative, chain-growth).
— Chirality and supramolecular polymers ("sergeant and soldiers" and "majority rules" experiments).
— H and J aggregates.
Supramolecular Chemistry based on metal (12h)
— Basics and tools
— Self-assembling: helicates.
— Self-assembling: grids, ladders and racks.
— Self-assembling: molecular polygons and polyhedra.
— Catenanes, rotaxanes and molecular knots.
— Molecular machines.
— Supramolecular polymers.

KNOWLEDGE AND EXPECTED SKİLLS

— Know and identify non-covalent interactions.
— Know the main families of natural and synthetic receptors (including their synthetic access).
— Apply various analytical methods for addressing the thermodynamics of host-guest complexes.
— Know new concepts associated to the reactivity in confined spaces.
— Understand the supramolecular polymerization mechanisms (isodesmic, cooperative, ...).
— Know the metal-directed strategies towards discrete and polymeric supramolecular structures based on metals.
— Know interlocked, stimuli-responsive and dynamic systems.

Characterisations and organic photonics

UE4

PHOTOPHYSİCS AND PHOTOCHEMİSTRY

Responsible: Matthieu Loumaigne
Teachers: Matthieu Loumaigne (Univ. Angers), Frédéric Paul (Univ. Rennes), Fabrice Odobel (Univ. Nantes)

OBJECTİVES

This course aims at developing further the concepts seen in M1 on the fundamentals and application of photophysics. The main objective is to give to chemist students a training base for tackling theoretical models from scientific literature and understan- ding the link between the chemical and electronic structure of a molecule and its optical and photophysical properties. The main notions of photochemistry, photophysics (in- cluding basics of nonlinear optics, of electron and energy transfer) and their application to biological photosynthesis, and artificial photosynthesis will be taught.

CONTENT

— Basic characteristics of light sources (intensity, spectrum, polarization, coherence, ...) and basic physics principle of light emission (black body, spectral lamp, LED, laser, ...).
— Basic understanding of the physics principles of light-matter interaction (light scattering and absorption).
— Reminders on the concepts seen in M1 of Jablonski diagram, quantum efficiency and fluorescence lifetime.
— Measure and analysis of fluorescence decays (TCSPC method).
— Dynamic and static quenching of fluorescence (Stern-Volmer model).
— İntroduction to solvatochromic effects and fluorescence anisotropy.
— Nonlinear polarisation of light: effects and applications.
— Engineering of Molecules for Second-Order Nonlinear Optics.
— Light-absorption and Electron-transfer: Marcus theory and «optical» electron-transfer vs. photoinduced-electron transfer (PET).
— İntroduction to mixed-valence complexes and molecular wires.
— Other applications of PET.
— Photoinduced energy transfer, theories of Förster and Dexter. Molecular examples with systems applied to amplify light harvesting.
— Artificial photosynthesis, basic concepts, molecular and hybrid systems for the conversion of sunlight into chemical potential.

KNOWLEDGE AND EXPECTED SKİLLS

This course, mainly intended to synthetic chemists, aims to teach the principles of the formation of excited states under UV-visible radiation. İt should enable them to assess the reactivity of excited states and their monomolecular (photophysical) evolution as well as their transformations by bimolecular interactions. The students should be able, in fine, to use the basic principles pertaining to interactions between light and molecules, taught in this course, to usefully design molecular systems adapted to a given task. This means:
— Mastering the representation and properties of photo-excited states, relaxation processes and physico-chemical properties of excited states.
— Use of fluorescence and Stern-Volmer processing as well as notions of quantum fluorescence yield to help decipher the mechanisms of electron or energy transfer. The latter are related to the conservation theory of orbital symmetry.
— Mastering basic notions to design NLO-active (hyperpolarisable) molecules.
— Mastering the photoinduced electron-transfer and energy transfer phenomena, inclu to electron-transfer with a special emphasis to donor-acceptor systems.
— Knowledge on the different approaches to realize artificial photosynthesis and associated processes.

> Experimental lab – 8h
— Basic optical experiments in order to illustrate the notion of polarization of light. Application to polarized microscopy.
— Basic optical experiments on diffraction in order to illustrate the working principle of spectrophotometer and monochromator.
— Measurement of the spectra of several light sources.
— Halide (Cl-) quenching of quinine sulfate fluorescence.
— Fluorescence lifetime measurement and analysis.
— Brève introduction à la microfluidique pour la manipulation des fluides in situ avant leur caractérisation.

UE4

TECHNIQUES OF SPECTROSCOPIES AND MICROSCOPIES

Responsible: Régis Barillé
Teachers: Régis Barillé (Univ. Angers), Bernard Humbert (Univ. Nantes)

OBJECTIVES

The objective of this module is first to complete the knowledge of the student on the microscopy techniques already approached in M1. Advanced microscopy techniques such as X microscopy (STXM, tomography), and near field microscopy (AFM, STM, SNOM) in the aim to acquire informations (dimensions, shape, composition, structuring) at the nanometric scale will be discussed without going deeply into the physics of these techniques, but simply as characterization tools for a student chemist. The goal is to answer the question: What is the useful technique to get important informations to know? With the same objective, Raman spectroscopy will be described as a tool for characterizations and applications.

CONTENT

> *X and electron microscopy sciences*

— Spectroscopies with electron microscopes: EELS et EDX
— Spectroscopy of X absorption in synchrotron: XANES et EXAFS
— Electron spectroscopy for surface characterization: XPS

> *Near-field Microscopies*

— AFM: contact mode (c-AFM), non-contact (nc-AFM), intermittent contact (t-AFM), lateral forces (lf-AFM), spécific interactions, force spectroscopy.
— SNOM: Optical near-field, operating principle, type of set-up, experimental set-up
— STM: topographic mode (i-V constant or constant tip-sample distance) and tunnel-effect spectroscopy (STS).

> *Raman Spectroscopy*

— Relation of molecular-structures - macroscopic phenomena (physical origin of the refractive index, absorption, diffusion).
— Application of Raman spectroscopy in microscopy.
— Main sources of light (white source, LED, Laser diode): materials and temporal and spectral characteristics.
— Principles of Raman and Resonance Raman spectroscopy.
— Extension on non-linear spectroscopy (second harmonic generation, emission with biphotonic absorption).

KNOWLEDGE AND EXPECTED SKILLS

— Be able to explain the fundamental differences between spectroscopic methods presented for the characterization of materials (XPS, XANES, EDX, EELS).
— Know how to choose the best characterization technique based on the sample concerned.
— Know how to choose which microscopies for the best characterization of materials and surfaces.
— Be able to use and interpret imaging results obtained with near-field microscopies.
— Be able to understand the relevance of scientific articles based on spectroscopic studies and near-field characterization of materials.

UE4

LIGHT-MATTER INTERACTION FOR BIOLOGY

Responsible: Elena Ishow
Teachers: Elena Ishow (Univ. Nantes), Olivier Mongin (Univ. Rennes)

OBJECTIVES

Light has become a key tool in biology to image and study living matter, probe specific locations in tissues and cells, and very recently trigger biological events. In a broader sense, biophotonics, coupling light and life, can be regarded as a strongly interdisciplinary topic at the interface of chemistry, biology and physics. Chemistry therefore plays a major role to provide specifically designed chemicals as a function of the biological issues to be addressed and the resorted detection optical setups, especially optical microscopes. In this course, two main aspects will be interrogated. The first part will be devoted to the stakes of optical bioimaging with respect to the current diagnostic technologies and tackle the in vitro-in vivo continuum through the presentation of appropriate luminescent molecules and nanomaterials. The challenge for deep light penetration and high sensitivity in tissues will be addressed through the introduction of more established (two-photon microscopy) or emerging (photoacoustics) techniques and the targeted labels or probes thereof. The second part will rely on the photoactivation of photophysical and chemical processes in a controlled and remote manner to either induce damaged cell apoptosis (photodynamic therapy), or photoswitch the activity of drugs, enzymes, cell attachment or ion transporters (photopharmacology).

CONTENT

A Optical bioimaging

1 Stakes

2 Design of luminescent labels and probes
— molecular agents,
— photoactive nanoparticles,
— probing the biological surroundings.

3 Two-photon microscopy for improved sensitivity
— fundamentals,
— optical setup,
— nonlinear optical labels.

4. Photoacoustic microscopy for improved depth detection
— principles,
— main endogenous and exogenous tracers.

B Photobiology

1 Photodynamic therapy
— principles,
— structural evolution of photosensitizers,
— in the clinics.

2 Photopharmacology
— structural requirements,
— drug photo-uncaging,
— photoswitches for structural and functional photoregulation.

KNOWLEDGE AND EXPECTED SKILLS

— The students can master the bases of optical bioimaging with regard to the main detection technologies in terms of sensitivity, spatial resolution, and detection rate.
— The students can delineate the complexity and constraints of biological media and propose the design of biocompatible emissive labels.
— The students can identify the main functional components of a photoactive label and anticipate the most adequate bioimaging technique and responses.
— The students can propose photochemical or photophysical explanations to support the observed phototriggered biological.

▪ PREVIOUS KNOWLEDGE

Thorough knowledge of the fundamental concepts of organic chemistry (main functions and reactivities, π-conjugated structures, inductive and mesomeric effects), physical chemistry (intermolecular forces, acido-basicity, photophysics) at the bachelor and master 1 chemistry level.

UE4

ELECTROCHEMISTRY OF MODIFIED SURFACES

Responsible: Tony Breton
Teachers: Tony Breton (Univ. Angers), Christelle Gautier (Univ. Angers), Charles Cougnon (Univ. Angers), Olivier Alévêque (Univ. Angers), Christine Lagrost (Univ. Rennes)

OBJECTIVES

The objective of this module is to train students in surface functionalization at the nanometric scale and bring skills in the electrochemical characterization of surface and divided nanomaterials.

CONTENT

The different conductive surface modification methods will be presented and their study will be detailed through practical work. The characterization of these nanomaterials will be studied via electrochemical and coupled techniques (electrochemical microbalance, spectro-electrochemistry, electrochemical microscopy). Finally, applications in catalysis, luminescence and energy storage will be the subject of case studies.

KNOWLEDGE AND EXPECTED SKİLLS

— Know the different surface functionalization processes for massive and divided materials (nanoparticles, carbon nanotubes, graphene).
— İdentify the variables allowing to play on the surface coverage, the interfacial activity and the electroactivity of the materials.
— Know how to reason about the different parameters of a cyclic voltammogram (Ep^{ic}, ip^{ic} ...) and distinguish the electrochemical rules usable for electroactive materials.
— Calculate surface coverages via the study of voltammetric and gravimetric results.
— Know which characterization technique to use to obtain structural information by exploiting simple spectra of advanced techniques.
— Understand the processes that govern electrocatalysis, luminescence or energy storage on nanoscale materials.

Materials and electronics

UE5

MOLECULAR MATERİALS, HYBRİDS, NANOMATERİALS

Responsible: Narcis Avarvari
Teachers: Narcis Avarvari (Univ. Angers), Rémi Dessapt (Univ. Nantes), Lenaïc Lartigue (Univ. Nantes), Dominique Lorcy (Univ. Rennes), Jeanne Crassous (Univ. Rennes), Fabrice Pointillart (Univ. Rennes), Nicolas Zigon (TP, Univ. Angers), Flavia Pop (TP, Univ. Angers), Hélène Brault (Univ. Nantes)

OBJECTİVES

This module aims at presenting the main families of functional hybrid organic-inorganic materials and nanomaterials, commonly encountered in applications of condensed matter physics (conducting and magnetic molecular materials), photonics (optical protection, surface plasmon resonance sensing) or in health, especially in nanomedicine (diagnosis, therapy). A particular focus will be dedicated to the fabrication of hybrid systems present in many areas thanks to the complementarity provided by the constituting organic and inorganic bricks. The main coupling methods of the complementary entities will be developed together with the experimental techniques to characterize the composition and structure of the hybrid architectures thus obtained.

CONTENT

1 Conducting molecular materials:
Synthesis of molecular materials precursors: electroactive π-conjugated organic and organometallic molecules (several examples of donor and acceptors: TTF; bis(-dithiolene) complexes of Ni, Pd, Pt, Au; TCNQ. Functionalization/introduction of non-covalent interactions: hydrogen, halogen, chalcogen. İntermolecular interactions in the solid – Open shell molecules: - neutral radicals, stabilization, delocalization – two-stage redox systems (Würster, Weitz) – overlap interactions in the solid – mixed valence dimers – 1D materials – band structures – Peierls transition.

2 Magnetic molecular materials:
İntroduction to fundamentals of magnetism of the transition metals. Magnetism of the essential lanthanide ions for our society. Single-Molecule Magnets as potential materials for high-density data storage applications.

3 Hybrid materials:
The concept hybrid, definitions and synthetic strategies (sol-gel, grafting, self-assembly, intercalation, coordination)
Classification of hybrid organic-inorganic materials (classes 1 and 2). The main families of amorphous and crystalline hybrid materials (organo-mineral polymers, functionalized silica, coordination polymers (CPs or MOFs), hybrid polyoxometallates, halometallates, phosphonates). Crystalline structure-properties relationship (luminescence, photo- and electrochromism, ferroelectricity, multiferroics, semi-conductors).

4 Nanomaterials:

Definition, history, classification.
Mechanism of formation and stabilization of nanoparticles (thermodynamic and kinetic aspects).
Synthesis of organic and inorganic nanoparticles. Properties (photophysics and plasmonics).
Functionalization and bio-conjugation.
Nanomedicine (delivery of the active principle and outcome in the body).

KNOWLEDGE AND EXPECTED SKİLLS

— Know the characteristics and properties of PCPs (or MOFs).
— Apprehend the chemistry and optical and redox properties of polyoxometallates.
— Recognize the different interactions (weak or strong) in a hybrid organic-inorganic material.
— Synthesis of the main electroactive precursors.
— Analyze the band structures of molecular solids.
— Comprehend the basis of molecular magnetism of lanthanide complexes.
— Know how to define a synthetic strategy to prepare a nanoparticle system with specific propertie.s

UE5

ORGANİC ELECTRONİCS

Responsible: Philippe Blanchard
Teachers: Philippe Blanchard (Univ. Angers), Clément Cabanetos (Univ. Angers), Muriel Hissler (Univ. Rennes), Fabrice Odobel (Univ. Nantes), Emmanuel Jacques (Univ. Rennes), Laurent Fontaine (Univ. Le Mans), Sylvie Dabos (TP, Univ. Angers), Yann Pellegrin (TP, Univ. Nantes), Factory visit : ARMOR

OBJECTİVES

Organic conducting and semiconducting materials based on π-conjugated systems or organic/inorganic hybrid materials have become essential components in the field of low-cost flexible electronics. They are used in three key technological areas with very high industrial development potential: organic light-emitting diodes for lighting and displays, organic field-effect transistors and photovoltaic cells. The main objectives of this course are to: i) present these classes of organic and organic/inorganic hybrid materials, their properties and their characterization methods, ii) establish structure / property relationships and iii) describe the operating principle of electronic components incorporating such materials as well as the laws that govern their efficiencies. The physical methods used for the characterization of the performance of these devices will also be introduced in order to give a global vision of their design, manufacturing and evaluation. Although this course does not intend to dwell on synthesis of π-conjugated systems, a specific attention will be paid to the chemical and electrochemical synthesis of polymers for electronic organics as well as their application in the fields of electrochemical and optical sensors, transparent conducting or electrochromic materials.

CONTENT

> *Introduction to π-conjugated systems for Organic Electronics*

— İntroduction on Organic Electronics.
— Electronic structures and properties of conjugated systems: From the doped state (conducting) to the neutral state (semiconducting).
— İntroduction or reminders to various electrochemical and spectroscopic techniques.
— Determination of HOMO (IP) and LUMO (EA) energy levels of organic materials and construction of energy diagrams of electronic organic devices.
— Characterization of the molecular structure of thin-films.

> *Conducting polymers*

— Synthesis by electropolymerization and their characterization.
— Structure / property relationship analysis.
— Application to electrochemical and optical sensors, transparent conducting or electrochromic materials.

> *Organic light-emitting diodes (OLEDs)*
— Operating principle.
— Active materials and optimization (from fully organic materials to Perovskites and quantum dots).
— Fabrication methods and characterization of OLEDs.
— Applications.

> *Organic field-effect transistors (OFETs)*
— Operating principle.
— Active materials and optimization.
— Fabrication methods and characterization of OFETs.
— Applications.

> *Organic solar cells (OSCs)*
— İntroduction to the different photovoltaic technologies.
— Operating principle of OSCs.
— Active materials and optimization
— Fabrication methods and characterization of OSCs (theory and practical courses).
— Transfer on an industrial scale: visit of ARMOR©, world specialist in the chemistry of inks and printing processes (near Nantes).

> *Dye-sensitized solar cells (DSSCs)*
— Operating principle.
— The components of the DSSC and their optimization.
— Fabrication methods and characterization of DSSCs (theory and practical courses).
— Applications for Building İntegrated Photovoltaics (BİPV), Dye-Sensitized Photoelectrosynthetic Cells (DSPECs) and dye sensitized photocatalytic systems.

> *Perovskite solar cells (PSCs)*
— Operating principle.
— Active materials and optimization.
— Fabrication methods and characterization of PSCs.
— Applications.

> *Polymers for Organic Electronics*
— Reminders on polymers and polymer chemistry: main synthetic approaches.
— Methods of controlled/living polymerization leading to tailor-made polymers, random, block and graft copolymers, functionalized polymers, etc., with predetermined structure and architecture.
— Applications: polymers for organic electronics.

KNOWLEDGE AND EXPECTED SKİLLS

— Establish relationships between molecular structures and properties in solution, in the solid state and in the devices.
— Characterize organic compounds endowed with electronic properties.
— Work in a multidisciplinary team to produce and characterize electronic devices.
— İntegrate organic materials into lab scale electronic devices.
— Guide technological choices.
— Develop or improve tests and trials, manufacturing processes.
— Perform measurements and analyzes, collect data, analyze and transmit them.
— Know the principles of polymerization, the main families of polymers used for organic electronics and their properties.

UE1

İNTERNSHİP

Responsible: Thomas Cauchy

The internships of Master 1 then of **professional integration** of Master 2 do not have the same expectations. The first is intended as an internship to discover the professional environment while the second corresponds to a specialization and to a pre-professionalization (towards research or industry). They are all validated not only from an internship thesis accompanied by an oral defense in front of a jury but also by the evaluation of the supervisor.

İn Master 2, a professional integration internship of at least 20 weeks, a real springboard to employment or a thesis, is to be completed during semester 4. This internship is carried out either in a research laboratory or in a company. İn the first case, it preferably takes place in one of the specialty's reception laboratories. İt can also be carried out abroad, for example in an academic laboratory partner of a host laboratory, after mutual agreement. İn the case of internships in companies, the place and subject of the internship, which is sought by the student, are previously validated by the persons responsible for the Master. These internships are assessed on the basis of a written report, the oral defense of the work and a note from the internship director. The evaluation jury is made up of a university tutor, a university rapporteur and the person responsible for the day-to-day follow-up of the intern in the host structure (company or university).

Site 06

Campus Lombarderie

Sciences et techniques
Maison des services universitaires

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- Autobus - ligne 23
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1	Bât. administratif, scolarité Amphis A, B, C, D, E
2	Bât. enseignement Amphi Pasteur
3	Recherche Physique
4	Recherche Géologie Laboratoire de planétologie et géodynamique
5	TP Zoologie Botanique
6	TP Bio animale et taxo-écologie
7	Serres
8	Recherche Biologie
9	Recherche Biologie et physicochimie cellulaire Centre de développement pédagogique
10	Recherche Maths Laboratoire de mathématiques - Jean Leray
11	Laboratoire des sciences du numérique - LS2N
12	TP Chimie
13	TP Physique
14	Bât. Enseignement
15	Bât. Enseignement Informatique
16	Services techniques
18	BU Sciences
21	Base d'aviron
22	Chimie et interdisciplinarité : synthèse, analyse et modélisation (CEISAM)
23	Comité des personnels (CPUN)
25	Centre François Viète
26	Bât. Erdre (Enseignement)
27	ISOMER
28	Amphis F, G, H
29	Cafet'
30	Imprimerie centrale
31	Institut des matériaux - Jean Rouxel
32	Microcaractérisation
34	Laboratoire des sciences du numérique - LS2N
35	Maison des services universitaires Orientation - Parcours - Métiers (SUIO) Service de santé des étudiants (SUMPPS) Médecine du personnel (MPPU) Relais handicap
19, 20, 24, 33	Locaux techniques

Nantes Université

Université de Rennes

CAMPUS DE BEAULIEU

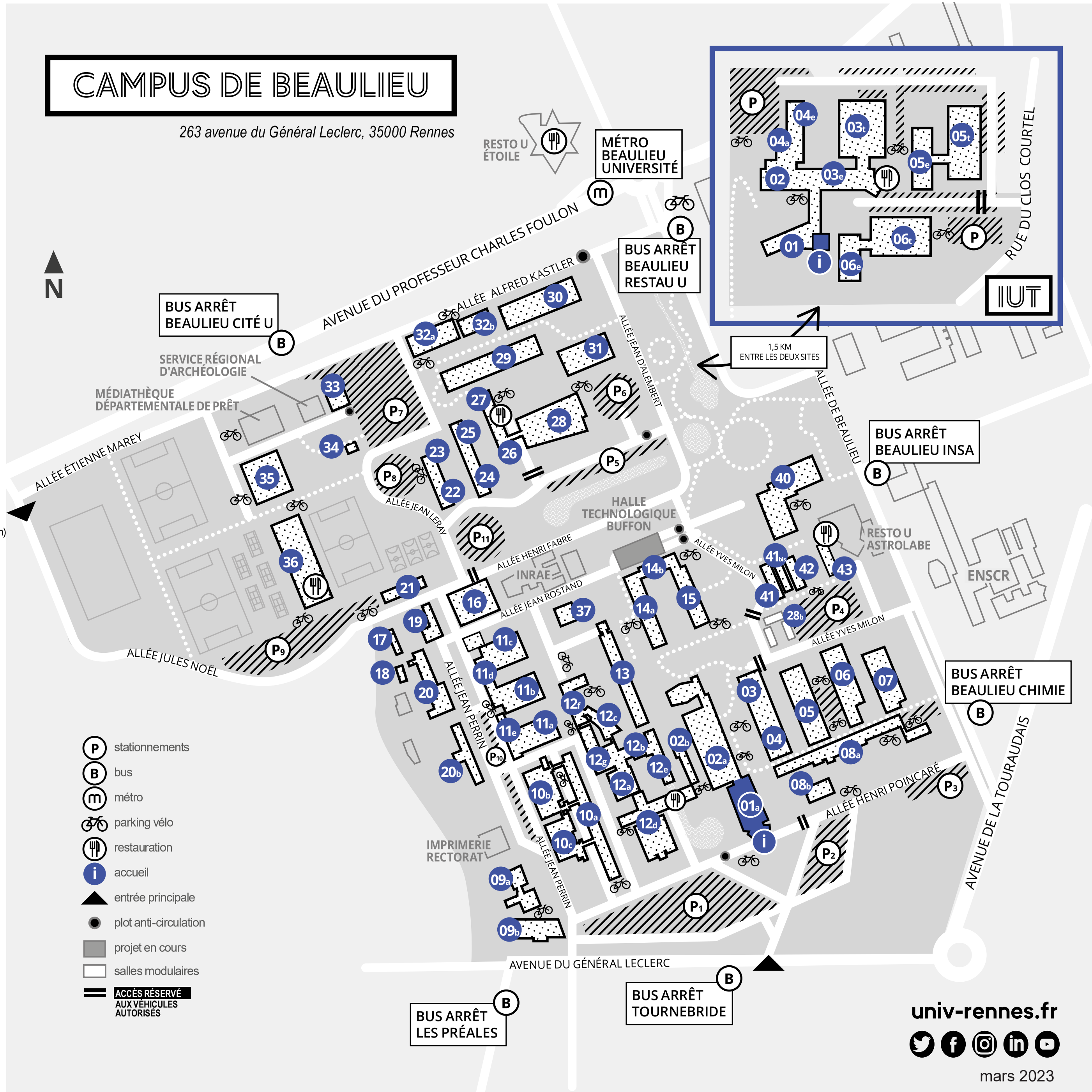
263 avenue du Général Leclerc, 35000 Rennes

- 01a ACCUEIL Présidence, Scolarité sciences, DAJI - Direction des affaires juridiques et institutionnelles
- 02a Amphithéâtres A, B, C, D, E, Louis-Antoine, Hall des examens
- 02b TP informatique
- 03 TP zoologie
- 04 TP botanique Collections et musée de zoologie
- 05 TP géologie, électronique Collections et musée de géologie
- 06 TP physique, électronique
- 07 TP chimie
- 08a IUT Carrières sociales, IUT GEA Salles d'examen, SMUT, DIL
- 08b Bibliothèque Paul Le Bohec Salle Condorcet
- 09a Pôle images et réseaux, Salle immersive Inria, Salle visioconférence, Écoles doctorales
- 09b PNRB - Pôle numérique Rennes Beaulieu, Suptice, SFCA (formation Continue et alternance), SOIE (orientation insertion entrepreneuriat)
- 10 abc ISCR - Institut des sciences chimiques de Rennes, organisations syndicales
- 10b Amphi Daniel Grandjean IPR - mécanique
- 11 abce IPR - Institut de physique de Rennes, UFR SPM
- 11a CRMPO - Centre régional de mesures physiques de l'Ouest
- 11 bcd IETR - Institut d'électronique et des technologies du numérique, Halle technologique
- 12i Accueil IRISA, Inria
- 12 abc efg IRISA, Inria (informatique) Amphithéâtre G (Inria)
- 12d ISTIC - UFR Informatique et électronique, amphithéâtre P, DSI - Direction du Système d'information
- 13 UFR SVE, IGDR - Institut génétique et développement de Rennes
- 14 ab OSUR, ECOBIO, Géosciences Rennes
- 15 Géosciences Rennes, OSUR
- 16 Pôle mécanique
- 19 Local courrier - colis
- 20 DIL - Direction de l'Immobilier et de la Logistique
- 20b DPSE - Direction Prévention, Sécurité, Environnement
- 21 DFVU - Pôle vie étudiante, SSE (santé des étudiants)
- 22 UFR Mathématiques, LTSI - Laboratoire du traitement et du signal
- 23 IRMAR - Institut de recherche mathématique de Rennes
- 24 Archéologie, Agence comptable, DRH
- 25 Recherche biologie environnement
- 26 SCELVA (langues vivantes)
- 27 Pôle pédagogique licences, salles d'examen
- 28 Amphithéâtres F, G, H, I, J, K (Victor Bach)
- 28b Salles de cours modulaires
- 29 TP biologie
- 30 TP physique
- 31 TP chimie
- 32a TP biochimie, salles d'enseignement
- 32b UFR Philosophie Amphithéâtre 12
- 33 DIL - Maison du projet
- 34 Permanence week-end sport (SIUAPS)
- 35 SIUAPS - Gymnase, salles de sports
- 36 Diapason, SCAC (service culturel)
- 37 Serres botaniques
- 40 BU Beaulieu, salles informatiques libre service, TP informatique
- 41 41bis 42 ESIR - École supérieure d'ingénieurs de Rennes, Amphithéâtres M, N, L
- 43 Locaux des associations étudiantes

IUT - INSTITUT UNIVERSITAIRE DE TECHNOLOGIE (CLOS COURTEL)

3 rue du Clos Courtel, 35000 Rennes

- 01 ACCUEIL Accueil, administration/scolarité
- 02 Amphithéâtres
- 03 et Service formation continue et alternance, CNAM Département génie civil
- 04 ae Administration chimie, Département chimie
- 05 et Département GMP
- 06 et Département GEII
- 08a Départements carrières sociales, GEA
- 08b Bibliothèque Paul Le Bohec Salle Condorcet



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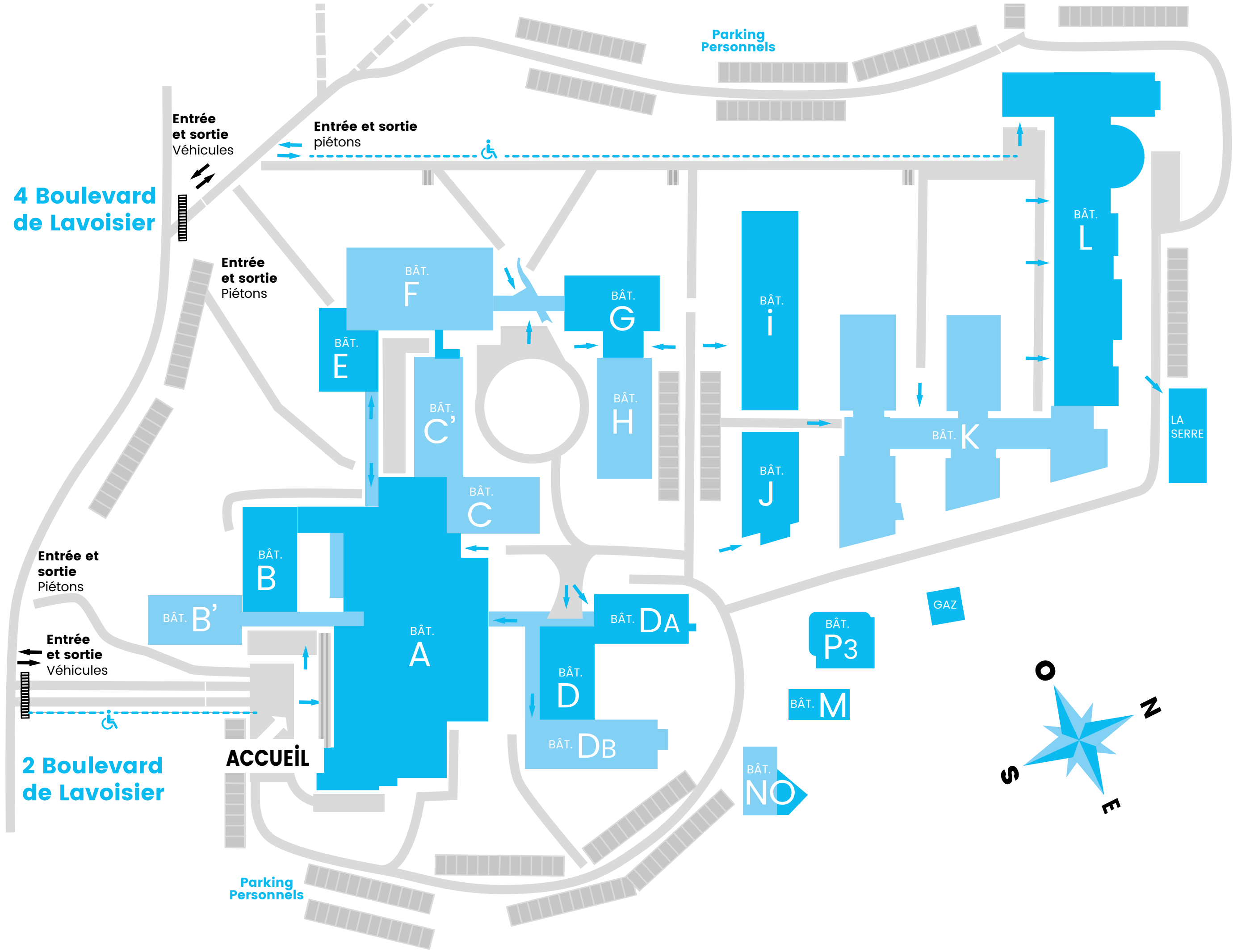

A Scolarité ı Accueil ı Enseignement (Amphi A à E) ı Administration
B Enseignement biologie
B' Enseignement biologie
C Enseignement chimie
C' Recherche
D Enseignement physique
Da Enseignement physique
Db Recherche
E Enseignement biologie
F Enseignement biologie ı Recherche
G Enseignement géologie ı informatique
H Enseignement informatique ı Recherche
i Enseignement mathématiques ı Recherche
J Enseignement chimie
K Recherche
L Enseignement transversaux ı Enseignement (Amphi L001 à L006)

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