SYLLABUS MASTER

Mention Chimie

M2 chimie verte

http://www.fsi.univ-tlse3.fr/

2020 / 2021

6 AVRIL 2021
PRESENTATION OF DISCIPLINE AND SPECIALTY

DISCIPLINE CHIMIE

The master in chemistry offers four specialties: green chemistry, analytical chemistry, chemistry for health, theoretical chemistry and also offers training towards careers in teaching.

The objective is to train students into chemists executives for academic positions or positions in companies covering various business sectors such as the pharmaceutical, cosmetics, chemicals and food industry, materials and instrumentation.

The training also helps develop important transversal skills for employability such as: autonomy, communication, project management, ...

The master in chemistry proposes a progressive orientation in the chosen specialty.

The first year includes a significant share of core courses (60%), and 40% specific courses in the chosen specialty.

The second year is rather strongly focused on the specialty (85%) and comprises only 15% of core teachings.

Internships are included in the training (minimum 8 weeks in M1, 5 to 6 months in M2).

SPECIALITY

The aim of the Green Chemistry Master’s course is to provide students with the necessary skills to innovate towards more sustainable chemistry. Down the road they will be able to join academia or R&D teams in small or large industrial groups. The course will train high level graduates who will join the high ranks of the chemical industry, mainly in fine chemistry. They will be tomorrow’s innovators for cleaner and more efficient chemistry, and will be at the cornerstone of the debate between all actors of sustainable development. The proposed course is an undistinguished Master’s 2 (formerly “Research or Pro”) and can, depending on the student’s professional project, facilitate his hiring after graduation, or lead on to the preparation of a PhD. To this end, the course is associated with various research laboratories locally in accordance with the Sciences de la Matière graduate school (www.edsdm.ups-tlse.fr). The course also has a very valuable partnership with a local green chemistry industrial cluster (www.clusterchimieverte.fr).

PRESENTATION OF THE YEAR OF M2 CHIMIE VERTE

With this training, students will be able to devise and develop cleaner and safer processes, more respectful of the environment, particularly in the fields of alternative reaction media, catalysis, green processes, depollution, biodegradable materials design, alternative energy sources, biomass valorization. Aspects of regulation, legislation, toxicity, ecotoxicity, life cycles and project management will be dealt with.

The second year of the green chemistry Master’s is divided into 2 semesters:
- First semester (from September to December): theoretical teachings.
- Second semester (January to June): internship in academic or industrial lab.

Details of Semester 1 teaching units:
- Common core (TU common to all courses within the Chemistry Master’s):
  - Professionalization (6 ECTS). Management tools, project management, legislation, conferences by industrials and academics.
  - English (3 ECTS).

Teaching units specific to green chemistry (these units will be taught in English):
  - Further advances in organic synthesis (3 ECTS). Advanced strategies and synthetic tools towards greener chemistry.
— *Heterochemistry and stereoselective synthesis* (3 ECTS). The chemistry of heteroelements and transition metal complexes, and their vital role in synthesis and reactivity.

— *Tools in green chemistry and processes* (3 ECTS). This TU will introduce the currents stakes of the chemical industry and will demonstrate the advantages of cleaner chemistry.

— *Catalysis and alternative energies* (3 ECTS). This TU will describe the theoretical bases necessary to develop novel energy technologies.

— *Homogeneous, heterogeneous and nano-catalysis* (3 ECTS). This TU will describe catalysis in eco-friendly settings.

— *Project* (3 ECTS). Students will have the opportunity to exploit some of the knowledge and skills they acquired during the course by putting forward a green chemistry strategy in response to a particular challenge.

— *Toxicology/ecotoxicology* (3 ECTS). This TU will develop basic notions of toxicity that are necessary for debating with chemistry professionals.

### Semester 2: Internship

The 5-6 months internship will be most students’ first interaction with real world R&D. It can be done in an academic or industrial laboratory, in France or abroad. The internship will be finalised with a written report and an oral presentation.

**Jobs:** Engineers in industrial chemistry research and development - Engineers in technological innovation - Engineers in engineering and consulting firms - Life cycle analysts...

**Beyond M2 Green Chemistry:** Graduates of the green chemistry Master’s course can carry on towards a PhD, particularly within the Science de la matière graduate school (www.edsdm.ups-tlse.fr).

**Admission:** Admission into M2 green chemistry is guaranteed for any student holding an M1 green chemistry from UPS. For students holding an M1 from another course or another university, admission will be reviewed based on the student’s credentials.

**LISTE OF COURSES GIVING ACCESS TO:**

**M1 CHIMIE VERTE (EMCHVE)**

Students who have not followed the previous year of the course, please contact the person in charge of the degree.
CONTACT INFORMATION CONCERNING THE SPECIALTY

PERSON IN CHARGE OF TEACHING AFFAIRS OF M2 CHIMIE VERTE

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### Table Summarizing the Modules That Make up the Training Program

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LIST OF THE MODULES
LEARNING GOALS
The objective is to prepare the student for his professional insertion by giving him a knowledge of the regional socio-economic environment in the field of chemistry and the expectations of companies.
Targeted skill:
— Understand how a company works: management tools, writing of a business plan...
— Interact with professionnals
— Apply for internship/job in companies or academic laboratories

SUMMARY OF THE CONTENT
This course is divided into four parts:
1) main management tools, marketing, business plan
2) legislation, patenting
3) conferences by industrials partners
4) courses given by invited professors from various countries

PREREQUISITES
Knowledge of your professionnal project and objectives.

KEYWORDS
management, marketing, business plan, patent
**LEARNING GOALS**

**Homogeneous, Heterogeneous and Nano-catalysis (H2nanocat)**
Increase and expand the knowledge of students in eco-friendly chemistry with integration of the catalysis concepts, homogeneous, heterogeneous and nano, for the development of cleaner and safer processes in the construction of compounds of industrial interest.

Skills:
- Master the fundamental concepts of organometallic chemistry
- Understand homogeneous catalysis and the basics of heterogeneous catalysis,
- Understand the structure-property relationship of surface-catalytic properties of nano-objects,
- Design nano-reactors for catalysis based on the concepts of self-assembly

**SUMMARY OF THE CONTENT**

**I. Introduction.** Class of catalysts, REACH regulation. Activity, selectivity, separation, recycling.

**II. Homogeneous organometallic catalysis.** Activation of small molecules (H2, CO, CO2, NH3, alkenes, alkynes), oligomerization, polymerization and metathesis. Mechanisms of catalytic reactions and significant processes.

**III. Phase-transfer catalysis and nanoreactors.** Emulsions, micro-emulsions. Phase-transfer catalysis and micellar catalysis.


**V. Supported catalysis and confinement.** Covalent and noncovalent catalyst immobilization on organic, inorganic and membrane supports. Catalyst confinement in mesoporous and MOF materials.

**VI. Heterogeneous Catalysis.** Molecule adsorption, reaction on solid surfaces, large-scale processes.

**PREREQUISITES**
Organic and organometallic chemistry of the Master 1’s level - Basic knowledge of kinetic and thermodynamic chemistry of the L3’s level.

**REFERENCES**

**KEYWORDS**
catalysis, catalytic cycle, mechanism, selectivity, atom-economy, saving steps, recycling.
LEARNING GOALS

**Heterochemistry and Stereoselective Catalysis (tHESIS)**

The aim of this course is the thorough study of main group and transition metal chemistry, with a particular interest dedicated to their role in synthesis and reactivity. The first part will be devoted to the non-classical main group elements (B, Si, P, S...), with particular attention to their use in synthesis and their contribution to transition metal chemistry and in catalysis. The second part will deal with stereoselective synthesis and enantioselective catalysis.

Skills: Achieve a chemical transformation involving a heteroelement and/or to carry out a chemical transformation in a stereoselective way according to the rules of the green chemistry Design and implement syntheses in a context of sustainable development

SUMMARY OF THE CONTENT


2) Stereoselective synthesis and catalysis. **Modern stereochemistry**: Complements on stereochemical analysis. Concepts and general strategies in enantioselective synthesis and catalysis. Chiral ligands. **Chiral transition metal complexes**: Synthesis and stoichiometric reactivity. Central and planar chirality (Ti, Fe, Cr ...). **Enantioselective catalysis**: Enzymatic, organic and organometallic catalysis. Oxidation (Ti, Mn, Os ...). Reduction (Rh, Ru, Ir ...). Formation of C-C bonds (Ni, Cu, Pd ...).

PREREQUISITES

Fundamental organic chemistry, elemental steps in organometallic chemistry, catalytic cycle, stereochemistry.

REFERENCES


KEYWORDS

Main-group elements, Complexes, Transition metals, Hydrofunctionalization, Catalysis, Stereochemistry, Stereoselective synthesis, Chiral ligands
LEARNING GOALS

Further advances in Organic Synthesis (OrgaSyn)

Improve & broaden the knowledge of students in organic synthesis, with particular emphasis on the selective construction of molecular architectures within the Green Chemistry context. Noteworthy is that this teaching unit is in logic continuation of the notions & concepts developed in two teaching units of the M1 CHIMIE, ie."Outils et Stratégies de Synthèse" / "Milieux Réactionnels et Modes d’Activation Alternatifs". Targeted skills :Master the concepts / principles of green chemistry and implement them rationally in organic synthesis

SUMMARY OF THE CONTENT

(1) Tools & strategies for organic synthesis I - alternative methods for functional group interconversion (focus on oxidation/reduction reactions) and for the formation of a single C-C bond (aldol-type reactions) - principles of asymmetric synthesis will be dealt with in this part.

(2) Tools & strategies for organic synthesis II - methods for the one-pot formation of multiple bonds (multicomponent reactions, domino/tandem reactions).

(3) Technological tools - miniaturization of processes, microfluidics, flow chemistry, automated synthesis.

(4) Recent applications - applications in the construction of complex molecular architectures and in total synthesis (cases studies with a further focus on protecting group-free chemistry, biomimetic chemistry, biomass, and chiral pool).

PREREQUISITES

Organic Chemistry & Organometallic Chemistry at the Master 1’s level - Knowledge of Green Chemistry principles & familiarity with the related metrics.

REFERENCES


KEYWORDS

alternative oxidation/reduction methods - asymmetric synthesis - multicomponent reactions - domino/tandem reactions - flow chemistry
TEACHER IN CHARGE OF THE MODULE

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LEARNING GOALS

The aim is to make students aware of the problematics of toxicity and ecotoxicity and to introduce them to the basics in these areas (scientific and regulatory), a key education to participate in active discussions with industrial partners. The student should then be able to play a major role in the sustainable development of chemical processes.

Targeted skills : Identify the main categories of environmental contaminants Understand the transfers and distribution of pollutants in the different compartments Analyze the biological effects of chemical substances at different scales of life organization Interpret the societal and regulatory consequences in a situation of contamination

SUMMARY OF THE CONTENT

— Toxicity : The different forms of toxicity will be presented as well as their expression at the level of the molecule, the individual and the ecosystem.
— Ecotoxicity : the structure and functioning of the environment will be presented in order to better understand the issues related to the dysfunction of the environment directly related to chemistry. The consequences of chemical productions will be examined in terms of impacts on living systems at different levels of perception of our environment.
— Environmental law : basic notions of law, presentation of the Environmental Risk Assessment process (ERA), on which multiple levels of national and international regulations are built, such as the European REACH regulation on the control of chemicals.
— Life cycle of a product and its optimization.

PREREQUISITES

Knowledge of the problematics of green / sustainable chemistry

REFERENCES

Chimie et environnement, P. Behra, Sciences Sup, Dunod, 2013.

KEYWORDS

Toxicity ; Ecotoxicity ; Environmental law ; Life cycle.
<table>
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**TEACHER IN CHARGE OF THE MODULE**

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**LEARNING GOALS**

The objectives are to mobilize the knowledge acquired through this formation in order to reach given objectives. For this, based on a problematic proposed by the course team, the students will have to propose an action plan to achieve the societal, economical, scientific and technical aspects in relation with this project.

Targeted skills:  
- Analyzing the environmental impacts related to the use of a material / process  
- Being able to analyze the life cycle of a material and know how to implement the corresponding indicators  
- Implementing project management tools for group work  
- Using theoretical knowledge through a multidisciplinary project
LEARNING GOALS
This teaching unit aims to introduce current issues in the chemical industry and show the contribution of clean chemistry to control costs and impacts. The aim is to raise awareness of the different approaches available to the chemist to make an eco-friendly transformation (new environments, modes of activation, catalytic systems) and show that the use of raw materials of plant origin and the implementation of catalytic processes are the key elements in developing green chemistry.
Skills : Master the basic concepts of green chemistry and their implementation in chemical engineering
Be able to analyze a production scheme and identify improvement pathways to reduce impacts.

SUMMARY OF THE CONTENT
In introduction are presented the current challenges of chemistry and chemical engineering are faced in a context of scarcity of raw materials, energy saving and environmental pressure. This context favors the development of a sustainable chemistry based on a set of principles aimed specifically to reduce or eliminate the use or generation of hazardous or toxic substances in the design, manufacture and use of a product. We will show how the development of green chemistry, bioprocesses and other clean technologies can provide solutions to the chemical industry, meeting the requirements of sustainable development and innovation. Biomass is an inexhaustible reservoir of molecules whose properties make it interesting alternative raw materials. On heterogeneous catalysis, green chemistry tool, methods of preparation, characterization of catalysts (supported or not) are presented in relation to their application.

PREREQUISITES
Good level in organic chemistry concepts in chemical engineering or chemistry-industrial.

REFERENCES
Chimie verte, chimie durable, Sylvain Antoniotti, Ellipse, 2013.

KEYWORDS
green chemistry, sustainable industry, renewable resources, heterogeneous catalysis
LEARNING GOALS
After this training, students will be aware of the socio-economic, technical and environmental issues related to the current high energy demand. They will have acquired the theoretical foundations of new energy technologies. They will be able to offer sources / vectors of alternative energy sources to conventional fuels. The theoretical knowledge provided by the courses will be supplemented by concrete examples that will enable students to identify in particular the catalysts involved in specific processes (fuel cell, biomass conversion and CO2).
Skills : Master the basic concepts of new energy technologies, including the contributions of chemistry and catalysis.
Being able to analyze a chemical problem in the context of new energy technologies and to be a source of proposals.

SUMMARY OF THE CONTENT
The Teaching Unit illustrates the major role of chemistry in particular catalysis, which is the basis of efficient energy components.
In a national and international context that largely promotes low-carbon energy, the TU addresses the fields of new energy technologies that are key to a sustainable energy future. Among them should be mentioned: the production of electricity from solar energy, both for stationary applications as mobility; production, storage and use of hydrogen for various applications such as electric mobility or smoothing the production of intermittent renewable energy with fuel cells; or the energy uses of non-food biomass, and recovery of CO2. Examples of catalytic processes involved in the development of biomass or CO2 for the production of biofuels and high value-added industrial products will also be detailed.

PREREQUISITES
Good level in inorganic chemistry, basic level in material chemistry, concepts in heterogeneous catalysis (TU: Tools in Green Chemistry and Processes).

REFERENCES

KEYWORDS
energy, catalysis, fuel cells, photovoltaic, hydrogen, CO2, biomass
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LEARNING GOALS
Level C1 of the CEFRL (Common European Framework of Reference for Languages)
To develop the indispensable skills enabling students to integrate into professional life. To improve communication tools to enable students to express themselves in today's international environment and to acquire the linguistic autonomy required for this purpose.

SUMMARY OF THE CONTENT
Teaching is centred on oral expression.
Documents in the field of expertise can be used for collaborative activities between science and language teachers.
Training is tailored to the individual needs of each student. Oral Comprehension - Reading Comprehension - Oral Expression - Written Expression
Being able to communicate in scientific English
Being able to pick out key elements of oral or written statements in their field of expertise.
Being able to speak in public (conferences or meetings) at a symposium, for a research project or for a professional project.

PREREQUISITES
N.A.

REFERENCES
N.A.

KEYWORDS
project - pick out - writing scientific English - style - register - review - professional - commenting
This 5-6 month internship is intended as a first experience in real world RnD situations. It is an opportunity to put in practice the theoretical understandings of chemistry in a professional environment and to further develop the skills that are necessary for professional integration. This internship is the perfect opportunity to explore various career choices. The internship in industry will help you familiarize with the chemical industry and better prepare your professional integration at the end of your Master’s. The internship in an academic research settings is geared towards a future PhD.

SUMMARY OF THE CONTENT
Starting in January and until June, the students will carry out a full time, research-based internship. The internship topic must match the preoccupations of green chemistry. It can be carried out in an academic or industrial laboratory, in France or abroad. Students are strongly incited to find an internship either in industry in order to facilitate their future professional integration, or in an academic lab abroad to broaden their horizons. In Toulouse, the Green Chemistry Master’s course is associated with a number of chemistry research laboratories that are affiliated with the graduate school Ecole Doctorale des Sciences de la Matière (EDSDM, www.edsdm.ups-tlse.fr), as well with a local cluster of companies with a focus on green chemistry (www.clusterchimieverte.fr). In either cases, you will be an integral member of a research team and will take asked to attend meetings and conferences, present your results...

KEYWORDS
Internship
GENERAL TERMS

DEPARTMENT
The departments are teaching structures within components (or faculties). They group together teachers lecturing in one or more disciplines.

MODULE
A semester is structured into modules that may be mandatory, elective (when there is a choice) or optional (extra). A module corresponds to a coherent teaching unit whose successful completion leads to the award of ECTS credits.

ECTS: EUROPEAN CREDITS TRANSFER SYSTEM
The ECTS is a common unit of measure of undergraduate and postgraduate university courses within Europe, created in 1989. Each validated module is thus assigned a certain number of ECTS (30 per teaching semester). The number of ECTS depends on the total workload (lectures, tutorials, practicals, etc.) including individual work. The ECTS system aims to facilitate student mobility as well as the recognition of degrees throughout Europe.

TERMS ASSOCIATED WITH DEGREES
Degrees have associated domains, disciplines and specialities.

DOMAIN
The domain corresponds to a set of degrees from the same scientific or professional field. Most of our degrees correspond to the domain Science, Technology and Health.

DISCIPLINE
The discipline corresponds to a branch of knowledge. Most of the time a discipline consists of several specialities.

SPECIALITY
The speciality constitutes a particular thematic orientation of a discipline chosen by a student and organised as a specific trajectory with specialised modules.

TERMS ASSOCIATED WITH TEACHING

LECTURES
Lectures given to a large group of students (for instance all students of the same year group) in lecture theatres. Apart from the presence of a large number of students, lectures are characterized by the fact they are given by a teacher who defines the structure and the teaching method. Although its content is the result of a collaboration between the teacher and the rest of the educational team, each lecture reflects the view of the teacher giving it.

TD : TUTORIALS
Tutorials are work sessions in smaller groups (from 25 to 40 students depending on the department) led by a teacher. They illustrate the lectures and allow students to explore the topics deeper.
TP : PRACTICALS
Teaching methods allowing the students to acquire hands-on experience concerning the knowledge learned during lectures and tutorials, achieved through experiments. Practical classes are composed of 16 to 20 students. Some practicals may be partially supervised or unsupervised. On the other hand, certain practicals, for safety reasons, need to be closely supervised (up to one teacher for four students).

PROJECT
A project involves putting into practice in an autonomous or semi-autonomous way knowledge acquired by the student at the university. It allows the verification of the acquisition of competences.

FIELD CLASS
Field classes are a supervised teaching method consisting of putting into practice knowledge acquired outside of the university.

INTERNSHIPS
Internships are opportunities enabling students to enrich their education with hands-on experience and to apply lessons learned in the classroom to professional settings, either in industry or in research laboratories. Internships are strongly regulated and the law requires, in particular, a formal internship convention established between the student, the hosting structure and the university.