PÉRIODE D'ACCRÉDITATION : 2016 / 2021

UNIVERSITÉ PAUL SABATIER

SYLLABUS MASTER

Mention Chimie

M2 chimie verte

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

2016 / 2017

7 AVRIL 2017

Syllabus mention chimie :

La formation offerte par le master chimie propose cinq grandes orientations en chimie verte, chimie analytique, chimie santé, chimie théorique et préparation aux métiers de l'enseignement.
L'objectif principal de la mention est de former des cadres supérieurs chimistes autonomes pour occuper des postes à responsabilité en milieu académique ou dans les secteurs d'activité comme ceux de l'industrie pharmaceutique, l'agroalimentaire, l'environnement, les cosmétiques, la parachimie, les détergents, les matériaux et l'instrumentation.
La formation permet également d'acquérir des compétences transverses importantes pour l'insertion professionnelle telles que : autonomie, communication en français et en anglais, gestion de projet, réalisation d'études...
Le master chimie propose une orientation progressive dans le parcours choisi.
La première année comporte une part importante de tronc commun (60%), et 40% d'enseignements spécifiques à la spécialité choisie.
La deuxième année au contraire est fortement axée sur l'enseignement de spécialité (85%) et ne comporte que 15% d'enseignements de tronc commun.
Des stages sont inclus à la formation (minimum 8 semaines en M1, 5 à 6 mois en M2).

M2 chimie CV :

Description :

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).
Description parcours :

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:

Responsable : Jean-Daniel Marty

Semestre 9		Semestre 10
Common core (to TU common all courses within the Chemistry Master's)	T.U. specific to green chemistry	internship 5-6 months 30 ECTS
o Professionnalization (6ECST) o English (3 ECTS)	oHomogeneous, heterogeneuous and nanocatalysis (3 ECTS) o Further advances in organic synthesis (3 ECTS) o Heterochemistry and stereoselective synthesis (3 ECTS) o Tools in green chemistry and processes (3 ECTS) o Catalysis and alternative energies (3 ECTS) o Toxicology/ecotoxicology(3 ECTS) o Project	
9 ECTS	3x7=21 ECTS	
Total 9 TU (30 ECTS)		

Common core (to TU common 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, heterogeneuous and nano-catalysis* (3 ECTS). This TU will describe 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 garanteed 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.

Description of Teaching Units

FURTHER ADVANCES IN ORGANIC SYNTHESIS

Stéphan Chassaing

Aims – 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'.

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).

Prerequisite – Organic Chemistry & Organometallic Chemistry at the Master 1's level – Knowledge of Green Chemistry principles & familiarity with the related metrics.

Books of reference -

JE Bäckvall - *Modern Oxidation Methods*, **2010** (WILEY-VCH)
L Tietze, G Brasche & KM Gericke - *Domino Reactions in Organic Synthesis*, **2006** (WILEY-VCH)
J Zhu, Q Wang & M Wang - *Multicomponent Reactions in Organic Synthesis*, **2014** (WILEY-VCH)

Keywords – alternative oxidation/reduction methods – asymmetric synthesis – multicomponent reactions – domino/tandem reactions – flow chemistry

HETEROCHEMISTRY AND STEREOSELECTIVE CATALYSIS

Blanca Matin-Vaca

Pre-requisites: Fundamental organic chemistry, elemental steps in organometallic chemistry, catalytic cycle, stereochemistry.

Objectives:
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. Different sources of chirality and recent advances in asymmetric induction by chiral ligands will be detailed.

Content
1) Application of non-classical main group elements (B, Si, P, S). **Physico-chemical properties:** Influence on structure and reactivity. **Functionalization:** Organoboron and organosilane compounds, phosphines and sulfoxides in organic synthesis, organocatalysis. **Chiral auxiliaries and formation of C-C bonds:** Sulfoxides and sulfones as chiral auxiliaries. Enolate chemistry (B, Si). Dithioacetals. Radical chemistry (S). **Formation of C=C bonds:** Stabilization of α-carbanions. Wittig reaction and related transformations. Peterson and Corey-Chaykovsky reactions. **Interface Main group elements/Transition metals**: Ligands. Hydrofunctionalization. C-C (Suzuki, Hyama) and C-X coupling.

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 …).

Keywords: Main-group elements, Complexes, Transition metals, Hydrofunctionalization, Catalysis, Stereochemistry, Stereoselective synthesis, Chiral ligands

Text books: Catalytic asymmetric synthesis, 2nd Ed, Ed. I. Ojima, Wiley-VCH, 2000
Organic chemistry, J. Clayden, N. Greeves, S. Warren ; Oxford University Press, USA, 2012

Tools in Green Chemistry and Processes

Responsable : Pascale de Caro

Objectives:

This TU aims to introduce current issues in the chemical industry and show the contribution of clean chemistry to control costs and impacts. Through the presentation of the chain that connects the researcher, industrial, and the final product, it is to show how concern ahead of health and environmental effects to generate safer and innovative products. 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.

Prerequisite:

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

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. Finally, niche, dedicated to a case study for analyzing the implementation of a green chemistry approach through the design of a functional product (bioplastics, biofuels, bioplasticizers, biotensio-active ...), by through a multi-criteria analysis.

Books:

Chimie verte, chimie durable, Sylvain Antoniotti, Ellipse, 2013
Génie des procédés durables, M. Poux, P. Cognet, et Ch. Gourdon, Dunod, 2010.
Green Chemistry for Environmental Sustainability, S. K. Shama, A. Mudhoo, CRC Press 2010.
Sustainability through biobased Chemistry, R. Chapas, CRC Press, 2017.

Targeted skills:

• Master the basic concepts of green chemistry and their application in chemical engineering,• Know the contributions of clean technologies related to catalysis, biotechnology and green processes, • Know the properties of vegetable raw materials as alternative resources and associated characterization methods, • Know the basics of heterogeneous catalysis and its contribution in Green Chemistry, • Be able to analyze a production scheme and identify possible improvements to reduce impacts.

Keywords :

green chemistry, sustainable industry, renewable resources, heterogeneous catalysis

Catalysis and Alternative Energies

Responsable Philippe Serp

Objectives:

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 CO_2).

Prerequisite:

Good level in inorganic chemistry, basic level in material chemistry, concepts in heterogeneous catalysis (TU1)

Content:

The TU 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 CO_2. Examples of catalytic processes involved in the development of biomass or CO_2 for the production of biofuels and high value-added industrial products will also be detailed.

Books:

Green Chemistry and Catalysis, R. A Sheldon, I. Arends, U. Hanefeld, Wiley-VCH, 2007.
Introduction to Biomass Energy conversions, Sergio Capareda, CRC Press, 2013
Biofuels and Bioenergy, Processes and Technologies, Sunggyu Lee, T.Y Shah, CRC Press, 2012.

Targeted skills:

• Master the basic concepts of new energy technologies,

• Know the contributions of chemistry and catalysis for these new technologies,

• Be able to analyze chemical problems in the context of new energy technologies and be proactive.

Keywords :

energy, catalysis, fuel cells, photovoltaic, hydrogen, CO_2, biomass

Homogeneous, Heterogeneous and Nano-catalysis

Responsable : Maryse Gouygou

Objectives:

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.

Content:
I-Introduction. Class of catalysts, REACH regulation. Activity, selectivity, separation, recycling.
II-Homogeneous organometallic catalysis. Activation of small molecules (H_2, CO, CO_2, NH_3, 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.
IV-Nano-catalysis. Nanoparticles: synthesis, properties, characterization and catalysis.
Growth process, solid-liquid interface stabilization, surface-reactivity relationship.
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.

Prerequisite:

Organic and organometallic chemistry of the Master 1's level – Basic knowledge of kinetic and thermodynamic chemistry of the L3's level.

Books of reference :

Catalysis, From principles to Applications, M. Beller, A. Renken, R. A. van Santen, Wiley-VCH, 2012.
Concepts of Nanochemistry, L. Cademartiri, G.A. Ozin, Wiley-VCH, 2009.
Handbook of Green Chemistry, P. T. Anastas, Vol 1-2, Wiley-VCH, 2013.

Keywords : catalysis, catalytic cycle, mechanism, selectivity, atom-economy, saving steps, recycling.

Project

Responsable : Jean-Daniel Marty

Objectives:

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.

Tox/ecotox

Responsable : Nancy de Viguerie

Objective :

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.

Contenu :

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.

Pré-requis :

Knowledge of the problematics of green / sustainable chemistry

Ouvrage(s) de référence : 240 caractères au maximum

Essentials of Toxicology, Casarett & Doulls, Mc Graw Hill edt, 3e Edition, 2015 ; Chimie et environnement, Philippe Behra, Sciences Sup, Dunod edt, 2013; Introduction à l'écotoxicologie fondements et applications [ebook], François Ramade, Tec Et Doc, Lavoisier edt.

Mots clés :

Toxicity ; Ecotoxicity ; Environmental law ; Life cycle.

Internship

N. de Viguerie

Objectives:

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.

Contents:

Starting in January and until June, the students will carry out a full time, research-based internship, counting towards 30 ECTS. 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 (EDSM, 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…