PhD course "*An Introduction to Green Chemistry: Bridging Organic Chemistry with Sustainable Practices*"

SYLLABUS

1 Lecturer information

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2 Title of the course

"*An Introduction to Green Chemistry: Bridging Organic Chemistry with Sustainable Practices*"

3 Course program

Class 1: Introduction to Organic Chemistry and Green Chemistry

- **Organic Chemistry**: Definition, functional groups, applications in industry and medicine.
- **Problems of Conventional Chemistry**: Use of toxic solvents, hazardous waste, high energy demand.
- **Green Chemistry**: Definition, benefits, and the 12 fundamental principles.
- **Examples**: Green synthesis of ibuprofen, bioplastics as a sustainable alternative.

Class 2: Organic Reactions and Green Optimization

- **Main Reactions**: SN1, SN2, elimination, addition, oxidation-reduction, catalytic couplings.
- **Green Optimization**: Green solvents, catalysis, atomic economy, waste reduction.
- **Examples**: Nucleophilic substitution in water, Suzuki couplings with green catalysts.

Class 3: Catalysis and Sustainable Materials

- **Types of Catalysis**: Homogeneous (transition metals), heterogeneous (zeolites, metal oxides), enzymatic.
- **Sustainable Materials**: Biopolymers, nanomaterials, recyclables.

- **Examples**: Biodiesel production with lipases, biodegradable polymers vs. conventional ones.

Class 4: Industrial Applications and the Future of Green Chemistry

- **Applications**: Pharmaceutical industry, sustainable plastics, biofuels, green hydrogen.
- **Innovations**: Enhanced catalytic processes, continuous flow chemistry, circular economy.
- **Trends**: Sustainable nanomaterials, artificial intelligence in chemical processes, environmental regulations.

4 Course content detailed per lesson of two hours (possibly with dates and room real and virtual)

Lesson 1: Introduction to Organic Chemistry and Green Chemistry

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Lesson 2: Organic Reactions and Their Green Optimization

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- **Innovations**: Improved catalytic processes, continuous flow chemistry, circular economy.
- **Trends**: Sustainable nanomaterials, artificial intelligence in chemical processes, environmental regulations.
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5 Suggested reading

- Klein, D. R. (2017). *Organic chemistry* (3rd ed.). Wiley.
- Clayden, J., Greeves, N., Warren, S. "Organic Chemistry". Oxford University Press.
- Tundo, V. (2005). Methods and reagents for green chemistry. Wiley.

- Lancaster, M. (2002). Green chemistry: An introductory text. RSC Publishing.
- Ahluwalia, V. K., & Kidwai, M. M. (2016). Green organic chemistry and its interdisciplinary applications. Wiley.
- Tiwari, V. K., Kumar, A., Rajkhowa, S., Tripathi, G., & Singh, A. K. (2022). Green chemistry: Introduction, application, and scope. Wiley.

6 Learning Objectives

Lesson 1: Introduction to Organic and Green Chemistry

- Understand the basics of organic chemistry, functional groups, and their applications.
- Recognize the environmental issues of conventional chemistry.
- Learn the principles and benefits of green chemistry.
- Explore examples of green chemistry, like ibuprofen synthesis and bioplastics.

Lesson 2: Organic Reactions and Green Optimization

- Learn key organic reactions (SN1, SN2, etc.).
- Understand green optimization methods, including eco-friendly solvents and catalysis.
- Study examples such as nucleophilic substitution in water and Suzuki couplings with green catalysts.

Lesson 3: Catalysis and Sustainable Materials

- Understand different types of catalysis (homogeneous, heterogeneous, enzymatic).
- Learn about sustainable materials like biopolymers and nanomaterials.
- Explore examples such as biodiesel production and biodegradable polymers.

Lesson 4: Industrial Applications and Future of Green Chemistry

- Discover the applications of green chemistry in industries like pharmaceuticals, plastics, and biofuels.
- Learn about innovations like continuous flow chemistry and circular economy.
- Explore future trends such as sustainable nanomaterials and AI in chemical processes.

7 Knowledge and Skills to be acquired

- Understand organic chemistry basics and green chemistry principles.
- Recognize environmental issues in conventional chemistry.
- Learn how to optimize organic reactions using green chemistry.
- Understand different types of catalysis and sustainable materials.
- Explore green chemistry applications in industry (pharmaceuticals, biofuels, etc.).
- Stay updated on trends like sustainable nanomaterials and AI in chemical processes.
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8 Prerequisites

- Basic knowledge of **general chemistry**, including concepts like atomic structure, bonding, and chemical reactions.
- **Introduction to Organic Chemistry** or familiarity with fundamental organic chemistry concepts (functional groups, reaction mechanisms, etc.).
- Understanding of **stoichiometry** and basic **chemical calculations**.
- Familiarity with basic **laboratory techniques** (e.g., use of laboratory glassware, handling chemicals safely).
- Basic understanding of **environmental issues** related to chemistry (optional but beneficial).

9 Teaching Methods

Lessons delivered in-person and in remote with simultaneous recording by the GMEET platform

(The lessons must be recorded and available to all the students that cannot take part to the lessons in streaming. The Webex platform must be used. All course content should be uploaded to the Moodle platform on the Chemical Sciences PhD page "Courses and Seminars of the PhD in Chemical Sciences 2021-2022")

10 Further information

There is no further information to provide.

11 Type of Assessment

The final evaluations will have to be validated maximum 1 month after the end of the course

The final exam will consist of 5 multiple-choice questions, subject to the schedule set by the instructor in charge.

12 Period

From June 3rd to June 6th, 2025.

- **AULA D4 plesso CALABRESI – Tuesday, 3.06.2025, 2.30 – 5.30 pm**
- **PhD Course M I Mangione - Lesson 1**

Link alla videochiamata: https://meet.google.com/dbs-qfum-mon

- **AULA D4 plesso CALABRESI – Wednesday, 4.06.2025, 9.00-12.00 am**
- **PhD Course - MI Mangione Lesson 2**

Link alla videochiamata: https://meet.google.com/nkb-vsyc-qqb

- **AULA D4 plesso CALABRESI – Thursday, 5.06.2025, 2.30 – 5.30 pm**
- **PhD Course - MI Mangione Lesson 3**

Link alla videochiamata: https://meet.google.com/qje-vruz-pdq

- **AULA01 TENDOSTRUTTURA – Friday, 06.06.2025, 9.00-11.00 am**
- **PhD Course M I Mangione - Lesson 4**

Link alla videochiamata: https://meet.google.com/xje-penw-tqy