UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Chimica Organica II e Laboratorio

2627-2-E2703Q010

Aims

Knowledge and Understanding

By the end of the course, the student will know:

- The concept of aromaticity and the main scientific approaches.
- The primary classes of aromatic and heteroaromatic compounds, including their structural, chemical, and electronic properties.
- The main reactivity and synthetic methods of aromatic and heteroaromatic substances.
- The conceptual foundations of organic synthesis.
- The principal methods for purifying organic compounds (separation, extraction, crystallization, distillation, and chromatographic methods).
- The primary methods for characterizing organic compounds, including chromatographic methods and melting point determination.

Applying Knowledge and Understanding

By the end of the course, the student will be able to:

- Recognize and interpret the main properties of aromatic and heteroaromatic substances.
- Synthesize and apply the principal reactions of aromatic and heteroaromatic substances.
- Design and execute a simple synthesis of an organic compound starting from commercially available precursors.
- Purify and characterize the synthesized organic compounds in a laboratory setting.

Autonomy of Judgment

By the end of the course, the student will be able to:

- Select the main classes of aromatic and heteroaromatic substances based on their intended use and properties.
- Select the most appropriate reactions and syntheses based on the target products to be obtained.
- Choose the most suitable method of synthesis, purification, and characterization to realize an organic compound in the laboratory.

Communication Skills

By the end of the course, the student will know how to:

- Describe clearly and concisely in writing, and present orally with appropriate technical language, the main concepts of aromaticity, properties, and reactivity.
- Describe clearly and concisely in a technical report the objectives, procedures, and results of the experimental laboratory procedures performed.

Learning Skills

By the end of the course, the student will be able to:

- Apply the acquired knowledge to different classes and contexts from those presented during the course.
- Independently extend their knowledge through the study of advanced textbooks, scientific literature of the sector, patents, and technical-scientific reports.

Contents

Molecular orbitals, Hückel method, and the concept of aromaticity. Properties, synthesis, and reactivity of monocyclic, polycyclic aromatic, and heteroaromatic compounds. Introduction to the fundamental operations of synthesis, separation, purification, and characterization in the organic chemistry laboratory.

Detailed program

Theory Module (Organic Chemistry II)

Mononuclear Carbocyclic Aromatic Systems: In-depth analysis of the basic concepts. Molecular orbitals and Hückel Molecular Orbital (HMO) theory. Benzene: aromaticity, resonance, resonance energy, and delocalization. Hückel's rule. Side-chain reactions. Reductions and oxidations. Electrophilic aromatic substitution reactions on benzene and benzene derivatives. Substituent effects and orientation theory. Nitro derivatives. Aromatic amines: synthesis and reactivity. Diazonium salts: preparation, reactivity, and synthetic utility. Arylsulfonic acids: mechanism of sulfonation and synthetic utility. Aromatic halogen derivatives: synthesis. Nucleophilic aromatic substitution. Cross-coupling reactions catalyzed by transition metals. Phenols and phenolic ethers. Kolbe synthesis, reactions with formaldehyde, Reimer-Tiemann reaction, coupling reactions. Quinones: synthesis, reactivity, and redox equilibria.
Polynuclear Carbocyclic Aromatic Systems: Biaryls. Naphthalene: synthesis and electrophilic substitution reactions. Anthracene and phenanthrene.
Heteroaromatic Systems: Nomenclature and main properties. Klopman-Salem equation. Electrophilic substitution reactions through molecular orbital theory. Five-membered mono-heteroatom systems: nomenclature, properties, synthesis, and reactivity. Six-membered mono- and poly-heteroatom systems: nomenclature, properties, synthesis, and reactivity. Five-membered di- and poly-heteroatom systems: introduction to nomenclature. Natural derivatives and compounds of biological importance.

Laboratory Module (Organic Chemistry II Laboratory)

- Safety regulations in the organic laboratory.
- Separation and extraction techniques.
- Distillation techniques.
- Crystallization techniques.
- Chromatographic methods.
- Spectroscopic techniques and melting point determination.
- Problem-solving exercises and drafting of technical reports.

Prerequisites

Basic knowledge of General Chemistry, Organic Chemistry I, Inorganic Chemistry, and Physical Chemistry.

Teaching form

The course includes both in-person and remote lectures, exercises, and practical laboratory sessions:

Theoretical Lectures:
17 lectures (2 hours each) and 1 lecture (1 hour) held in person;
3 lectures (2 hours each) and 1 lecture (1 hour) delivered remotely.

Classroom Exercises:
12 sessions (2 hours each) conducted interactively in person;
6 sessions (2 hours each) conducted interactively online.

Laboratory Sessions:
9 hands-on laboratory sessions (4 hours each) conducted interactively in person.

Textbook and teaching resource

Recommended Textbooks

- P. Y. Bruice, Organic Chemistry, EdiSES.
- A. Abbotto, N. Manfredi, O. Bettucci, Chimica Organica, Scienza Express, 2025.
- A. Abbotto, G. Pagani, Chimica Eterociclica, Piccin.

Supplementary Materials

- Lecture notes provided by the instructor and the course E-learning platform. Second year, first semester.

Semester

Second year, first semester.

Assessment method

The final evaluation integrates both the theoretical and practical components of the course:

Laboratory Module Assessment:
Evaluation is based on performance and behavior in the laboratory (compliance with current safety regulations, ability to work independently, and mastery of fundamental techniques) as well as the evaluation of written technical reports (accuracy in handling experimental data, application of error theory, conciseness, and completeness).

Theory Module Assessment:
The final exam consists of an oral examination lasting approximately one hour, covering all course topics. Short written exercises (on the board or paper) may be required during the oral interview. Alternatively, students can take optional written partial exams (midterms) during the semester, featuring open-ended and multiple-choice questions. If passed successfully, the final oral exam becomes optional for the first exam session immediately following the course.

*The grading criteria *follow the University's qualitative framework (from A+ to E for the midterms; final score out of 30) across four main core parameters: conceptual knowledge, application of knowledge, communication/argumentation skills, and learning/self-regulation abilities.

Please refer to the specific module syllabuses for precise indications regarding the evaluation parameters

Office hours

By appointment, to be requested in advance via email.

Sustainable Development Goals

QUALITY EDUCATION