UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Synthesis and Special Organic Techniques in Material Chemistry

2526-2-F5401Q071

Aims

The course describes the synthesis of complex organic molecules and polymers, predominantly polyunsaturated, using a retrosynthetic approach, the use of protecting groups, and cross-coupling reactions mediated by both metal and non-metal catalysts.

O1 – Knowledge and Understanding
Students are expected to develop a knowledge of modern organic synthesis techniques and the structure–property relationships in polyunsaturated derivatives sufficient to:

1. Predict the optical and electronic properties of a polyunsaturated organic compound based on its structure.
2. Conduct a reasonable retrosynthetic analysis to identify a possible and effective synthetic strategy.
3. Demonstrate adequate mastery of the reactivity of the main functional groups in organic chemistry and their use in the preparation of polyunsaturated molecules and polymers.
4. Understand metal-catalyzed coupling reactions.
5. Prepare the main polymeric and oligomeric materials used in the field of polyunsaturated materials.
6. Describe the main photophysical and photochemical processes involved in the absorption of electromagnetic radiation and their effects on photoinduced reactivity.

O2 – Applying Knowledge and Understanding
Students are expected to demonstrate adequate ability to apply the knowledge and understanding acquired by:

1. Identifying structural and electronic parameters of polyunsaturated structures based on the nature and connectivity of their elementary building blocks.
2. Applying retrosynthetic concepts to simplify the synthetic strategy of organic semiconductors and multifunctional molecules by identifying the best disconnections, the synthons generated by the disconnection, and their corresponding synthetic equivalents.
3. Knowing the reactivity of the main organic functional groups and the relevant protection strategies.
4. Understanding the main coupling strategies of unsaturated units (aromatic and heteroaromatic systems) catalyzed by transition metals.

O3 – Making Judgments
Being able to independently plan the most appropriate synthetic strategy to access multifunctional and even polyunsaturated derivatives.

O4 – Communication Skills
Being able to describe and identify the most relevant organic semiconductors for optoelectronic applications, and clearly illustrate retrosynthetic and synthetic approaches useful for their preparation.

O5 – Learning Skills
Being able to apply acquired knowledge in retrosynthesis and synthesis to polyunsaturated derivatives with electrical, optical, and optoelectronic properties of interest for printable electronics, photonics, and (bio)sensing.
Being able to predict and exploit photoinduced reactivity in polyunsaturated materials from a synthetic perspective.

Contents

The course provides an overview of synthetic strategies for polyunsaturated organic materials suitable for use in optoelectronic devices. The synthetic approach includes familiarization with concepts of retrosynthetic analysis, the most common strategies for functional group protection, arylation reactions, metal-mediated cross-coupling reactions, and olefination reactions. An overview of aspects and concepts related to organic photochemistry will also be provided as a useful support for organic synthesis.

Detailed program

Retrosynthetic analysis. Synthons, retrons, and examples of complex molecules.
Protecting group chemistry. Protection of alcohols, carbonyl compounds, amines, and thiols.
Metal-mediated cross-coupling reactions. Basic concepts: oxidative addition and reductive elimination.
Overview of relevant organometallic compounds and their transmetallation reactions: organolithium, organozinc, cuprates, organotin compounds, and Grignard reagents.
Suzuki–Miyaura, Stille, Negishi, Kumada–Corriu, Yamamoto, Buchwald–Hartwig, Ullmann, Heck, Sonogashira reactions, direct arylation, and photoinduced direct arylation.
Main classes of polyunsaturated organic compounds of interest for optoelectronic applications and their synthesis.
Elements of photochemistry of organic compounds.

Prerequisites

For an optimum understanding of the topic treated, a consolidated organic chemistry background is required together with basic knowledge on the optical and electronic properties of polyconjugated organic molecules and polymers.

Teaching form

24 two-hour lectures, in person, Delivered Didactics

Textbook and teaching resource

Main reference text: Synthetic Methods in Organic Electronic and Photonic Materials by Timothy C. Parker and Seth R. Marder, RSC, 2015.
Full classroom lecture recordings.
Annotated slides.
Selected recent literature articles.

Semester

first semester

Assessment method

Oral examination is the assessment method employed to check the level of understanding of the concepts taught during the course. Questions will ask to the student regarding the entire topic treated during the course. The final mark proposed to the student is in thirtieths, and a final minimum mark of 18/30 is necessary to pass the examination.

Evaluation Scale:

18-19: Knowledge of a limited number of topics from the course syllabus, with restricted ability in discussion and analysis, which, in the case of an oral exam, emerge only with the help and questions from the instructor; expository skills and vocabulary are not always accurate, with limited critical thinking ability.
20-23: Knowledge of some topics from the course syllabus, independent analytical skills only on purely practical and procedural issues, use of correct but not entirely precise and clear vocabulary, and an occasionally uncertain expository ability.
24-27: Knowledge of a broad range of topics covered in the course syllabus, ability to conduct argumentation and critical analysis independently, ability to apply knowledge to different contexts and connect topics to real cases, use of correct vocabulary and proficiency in disciplinary language.
28-30/30L: Comprehensive and thorough knowledge of the exam topics, independent ability to discuss and critically analyze themes, capacity for reflection and self-reflection, as well as for connecting topics to real cases and various contexts, excellent critical and independent thinking skills, full command of disciplinary vocabulary, and a structured, rigorous expository ability, with strong argumentative, reflective, and interdisciplinary connections skills.

Office hours

upon request, on appointment

Sustainable Development Goals

GOOD HEALTH AND WELL-BEING | QUALITY EDUCATION | AFFORDABLE AND CLEAN ENERGY | SUSTAINABLE CITIES AND COMMUNITIES | CLIMATE ACTION