UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Strategies for Materials Synthesis

2627-1-FSM02Q030

Aims

Course Overview
This course provides an integrated, interdisciplinary approach to the design and synthesis of functional materials. By bridging organic, inorganic, and macromolecular chemistry, the course equips students with a comprehensive "synthetic toolkit" necessary for modern materials science.

Common Vision
The three modules of this course share a foundational premise: that modern materials science requires a strategic design approach. Rather than viewing organic, inorganic, and macromolecular chemistries in isolation, this course emphasizes the common synthetic logic that connects them. Students are trained to analyze structure-property relationships to select the optimal precursors, reactions, and process conditions required to synthesize materials with tailored electronic, optical, thermal, and mechanical properties. The course fosters a problem-solving mindset, focusing on sustainability and performance optimization across all material classes.

Aims and Objectives

The objective of this course is to provide detailed knowledge of synthetic methodologies for preparing functional materials. It emphasizes green chemistry compliance, the ability to control structural hierarchy, and the selection of precursors to achieve desired physico-chemical characteristics in organic conjugated systems, inorganic/hybrid solids, and advanced polymeric architectures. The ultimate goal of the course's multidisciplinary approach is to enable students to synergistically combine tools and knowledge from the three modules in the development of new materials.

Learning Outcomes

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

- *Knowledge and Understanding:* Master the synthetic concepts governing conjugation, inorganic solid-state reactivity, and macromolecular architecture. Correlate synthetic pathways with material properties (thermal, optical, electrical, mechanical, magnetic).

- *Applying Knowledge and Understanding:* Select the most appropriate synthetic strategy (organic functionalization, inorganic processing, or polymer synthesis) to optimize material performance for specific applications.
- *Making Judgments:* Devise efficient synthetic strategies for complex materials. Propose functionalization or modification strategies to optimize specific features based on an analysis of structure-property relationships.
- *Communication Skills:* Communicate complex synthetic concepts clearly using the specific terminology of chemistry and materials science. Summarize and critique scientific/patent literature with authority.
- *Learning Skills:* Independently extend learned concepts to novel case studies, managing technical literature and research tools to address problems outside the direct scope of the classroom.

Contents

The program is organized into integrated thematic blocks that span the three modules:

- Foundations of Synthetic Strategy:
    - Structure-Property-Performance relationships.
    - Principles of conjugation, aromaticity, and bonding in materials.
    - Coordination and chemical equilibria in inorganic systems.
- Advanced Synthetic Methodologies:
    - Organic: Arylation, olefination, and functionalization reactions (Pd/Ni/Cu mediated).
    - Inorganic: Solid-state reactions, synthesis of solids from the gas phase, melts and solutions, sol-gel processes, hybrid and porous materials, and nanocomposites.
    - Macromolecular: Precision control of chain composition, topology, and molecular weight distribution.
- Materials Processing and Performance:
    - Synthesis of films, fibers, porous materials, and nanocomposites.
    - Thermoplastic, thermosetting, and liquid crystalline polymers.
    - Characterization techniques (solution vs. solid state).
- Sustainability and Innovation:
    - Green chemistry compliant approaches.
    - Renewable sources and biodegradable materials.
    - Advanced functional hybrids.

Detailed program

Detailed programs are outlined in the syllabi of the single modules

Prerequisites

Chemistry of materials requires an interdisciplinary approach exploiting general and inorganic, organic, macromolecular and physical chemistry (thermodynamics and chemical equilibria).

An interdisciplinary foundation is thus required, including:

- General and Inorganic Chemistry.
- Organic Chemistry.

- Physical Chemistry (Thermodynamics and Chemical Equilibria).

Teaching form

The lessons will be delivered in English.
12 two-hour lectures for each module (24+24+24), in person, Delivered Didactics.

Textbook and teaching resource

Textbooks and teaching resources are outlined in the syllabi of the single modules

Semester

Whole accademic year. The three teaching modules are scheduled as detailed below:

- Organic Strategies for Materials Synthesis (1st semester)
- Macromolecular Strategies for Materials Synthesis (1st semester)
- Inorganic Strategies for Materials Synthesis (2nd semester)

Assessment method

The final mark for "Strategies for Materials Synthesis" is a composite score derived from the three modules (Organic, Inorganic, and Macromolecular).

- Overall Evaluation Criteria:
  The assessment is conducted via oral examinations for each module. The final grade of Strategies for Materials Synthesis course is calculated as the average of the marks obtained in its three constituent modules: Inorganic Strategies for Materials Synthesis, Organic Strategies for Materials Synthesis and Macromolecular Strategies for Materials Synthesis

During the exam, the student will be required to answer 3–4 questions over a duration of approximately 20 minutes. One of these questions will be on a topic of the student's choice. The remaining questions will focus on the topics covered during the lectures with the aim to assess the ability to rearrange the concepts. Students will be encouraged to think about the possible use of their notions in practical examples/applications (problem solving).

The evaluation criteria for the overall course are as follows:

18-21 (Sufficient): Basic understanding of concepts; can identify common synthetic methods but struggles with selection/application; limited ability to link synthesis to specific material properties.
22-24 (Good): Clear understanding of synthetic methods and their features; can select appropriate approaches for standard materials; improved use of scientific terminology.
25-27 (Very Good): Strong, autonomous grasp of synthetic strategies; effective at justifying methodology choices; confident communication of complex ideas and literature findings.

28-30 Honors (Excellent): Exceptional mastery; can devise efficient strategies for complex/novel materials; demonstrates sophisticated critical thinking and the ability to integrate knowledge into a coherent synthetic design.

Partial exams are not scheduled.

Office hours

On appoitment by email with the professor of single modules:

Organic: mauro.sassi@unimib.it
Macromolecular: silvia.bracco@unimib.it
Inorganic: barbara.dicredico@unimib.it

Joint appointments can also be scheduled upon request for issue related to the whole course.

Sustainable Development Goals

AFFORDABLE AND CLEAN ENERGY | INDUSTRY, INNOVATION AND INFRASTRUCTURE | RESPONSIBLE CONSUMPTION AND PRODUCTION