UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Macromolecular Strategies for Materials Synthesis

2627-1-FSM02Q030-FSM02Q03003

Aims

The macroscopic properties of polymeric materials strongly depend on the chemical nature and on the physical and chemical treatments, starting from the synthetic approach, and on the presence in the material of suitable additives. The course aims to introduce the fundamental strategies for the realization of polymeric materials and how to modulate the macroscopic properties (thermal and mechanical) by varying the architecture of the polymer chains. Particular emphasis will be given to property-structure relationships in amorphous and semi-crystalline polymers.

Knowledge and understanding
At the end of the course the student will have acquired knowledge on:
• main conventional synthesis methods
• latest generation of synthetic strategies for the production of innovative polymers
• property-structure relationships in amorphous and semi-crystalline polymers.

Applying knowledge and understanding
At the end of the course the student will be able to describe the main synthetic approaches to modulate the properties of polymers for scientific and applicative uses.

Making judgments
The student will be able to orient himself in the field of polymers both in terms of chemical structure, conventional and innovative synthesis methods, and in terms of properties of polymeric materials.

Communication skills
The student will be able to express the topics covered during the course with language skills suitable for polymer science.

Learning skills
The student will be able to apply the knowledge acquired during the course to understand the topics dealt with in the scientific and patent literature in the field of innovative polymeric materials.

Contents

The course focuses on the relevant aspects of polymer science in terms of macromolecular architecture; main synthetic tools to control polymer structure and topology, molecular mass and distribution; and property-structure relationships.
The solution and bulk-phase properties of polymers will be described by means of some characterization methods, highlighting the impact of the polymer microstructure on the performance of the materials. Special topics on liquid crystal polymers, thermosetting resins and sustainable polymers will also be addressed.

Detailed program

- Various classes of polymers and their chemical structure, including cross-linked polymers, copolymers, blends and polymeric composites.
- Synthetic tools to precisely control macromolecular structure including chain composition, microstructure, functionality, and topology.
- Thermoplastic polymers, thermosetting polymers, elastomers, and termoplastic elastomers.
- Aggregation states in polymers.
- Main properties and transitions of amorphous and semicrystalline polymers and their dependence on the main parameters, such as molecular mass and distribution.
- Impact of stereochemistry and degree of order on thermal and mechanical properties of polymers.
- Fundamental structure-property-performance relationships in polymeric materials.
- Copolymers: synthesis methods, structures and interfaces.
- Synthesis of three-dimensional polymers and dendrimers.
- Polymers of intrinsic microporosity (PIMs) for membrane fabrication.
- Polyolefins and Spheripol process for polymer growth with morphology retention.
- Confined polymerization.
- Sustainable polymers: polymers from renewable sources, biodegradable and biocompatible (the case study of PLA).
- Polymers in the liquid crystalline state.
- Synthesis of polycarbonates from CO? (case study).
- Thermoset resins and polymeric composites.
- Macromolecular characterization methods in solution and in the solid state.

Prerequisites

Chemistry of materials requires an interdisciplinary approach that draws on general and inorganic, organic, macromolecular, and physical chemistry (thermodynamics and chemical equilibria).
A strong interdisciplinary background is required, including:
General and Inorganic Chemistry
Organic Chemistry
Physical Chemistry (Thermodynamics and Chemical Equilibria)

Teaching form

The lessons will be delivered in English.
24 two-hour lectures, in person, Delivered Didactics.

Textbook and teaching resource

- Notes provided by the professor (power point presentations to support teaching activities)
- Polymers, Walton, D. J., Lorimer, J. P. (2001). Oxford Chemistry Primers, Oxford University Press.
- Polymer Chemistry Koltzenburg, S.; Maskos, M.; Nuyken, O. ; Springer: Berlin, Germany, 2017.
- Principle of Polymerization, (4th edition) G. Odian, 2004 John Wiley & Sons, Inc.
- Polymer Chemistry" (Second Edition) P.C. Hiemenz, T.P. Lodge, CRC Press, 2017.
- Articles from the scientific literature.

Semester

1st year, 1st 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 is an average of the overall 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
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 oral exam consists of the evaluation of the knowledge acquired by the student in the field of polymer science, with particular attention to the synthesis, structure and properties of polymers. The autonomy of analysis and judgment, and the ability of exposure will be evaluated.

The evaluation criteria 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.

Office hours

By appointment. (silvia.bracco@unimib.it)

Sustainable Development Goals

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