UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Chemistry of Macromolecular Materials With Laboratory

2526-2-ESM01Q011

Aims

The course will provide the basic knowledge on the structure and on the synthesis of high molecular weight polymers. The laboratory will allow to learn the main techniques for the preparation of polymers, the characterization of the molecular weights and the thermomechanical properties.
Knowledge and understanding
At the end of the course the student knows:

- the stereochemistry, the main methods of macromolecular synthesis and the principles of molecular mass distribution.
- the property-structure relationships in amorphous and semi-crystalline polymers.
- the main techniques for the characterization of polymeric materials (determination of molecular weights, calorimetry, dynamic mechanical analysis)
  Applying knowledge and understanding
  At the end of the course the student is able to:
- synthesize polymeric materials by chain, step and coordination polymerization.
- determine the average molecular weights and characterize the polymers with calorimetric and dynamic machanical techniques.
  Making judgments
  At the end of the course the student is able to:
- choose the most appropriate synthesis method for the realization of polymeric materials of interest.
- identify the most suitable characterization methods for the description of synthesized polymers.
  Communication skills
  To be able to present the topics of the course in a suitable language and describe the procedure and the results of
  the experiments carried out in the laboratory in a clear and concise scientific report.
  Learning skills To be able to apply the acquired knowledge to contexts different from those presented during the
  course, and to understand the topics covered in the scientific literature concerning polymeric materials.

Contents

The course describes the properties of polymer chains, the stereochemistry, the principles of molecular weight distribution and the synthesis of polymers by chain, step and coordination polymerization. During the course the main properties of some polymer families will be presented. Then it will follow the description of the properties of crystalline and amorphous polymers with regard to their viscosity, thermal properties and main transitions, such as glass transition, melting and crystallization, the separation of molecular weights with chromatographic methods. The laboratory activity includes synthesis exercises for step and chain polymerization, determination of the properties (dynamic-mechanics, viscosity, etc.) and of the distribution of the molecular weights of the obtained polymers.

Detailed program

STRUCTURE OF MACROMOLECULES
Constitution, stereochemistry and topology of macromolecules. Statistical analysis and distribution of monomeric units and molecular weights.
PREPARATION OF THE MAIN POLYMER CLASSES
Step polymerization
Degree of polymerization as a function of stoichiometry and the degree of progress of the reaction. Distribution of molecular weights according to the Flory theory. Linear, branched and crosslinked polymers.
Chain polymerizations
Radical Polymerization: Beginning of propagation, transfer and termination.
Degree of polymerization and Mayo Lewis relationship. Copolymerization equation.
Anionic polymerization: 'Living' polymerization and polymer with narrow distribution of molecular weights.
Coordination polymerization: Polymerization mechanism
Heterogeneous Ziegler-Natta and catalysts of successive generations.
Homogeneous polymerization promoted by metallocenes.
The course deals with the preparation, the characterization of the molecular weights, the study of the thermal and thermomechanical transitions of representative polymeric materials. The main experimental aspects concerning the purification of monomers and the execution of polymerizations in an inert environment will be addressed.
Polymeric materials will be prepared with the following processes:
Step polymerization: Nylon preparation by interfacial method and, in particular, Nylon-6,6 and Nylon-6,10.
Examples of chain polymerization with a radical process for obtaining polymers, such as polystyrene or polymethyl methacrylate with controlled molecular weights.
The materials thus obtained will be characterized by viscosimetric techniques for the determination of the molecular mass by means of the Mark Houwink relationship. The distribution of the molecular weights will be evidenced by steric exclusion chromatography.
The thermal properties and the main transitions, such as the glass transition and the melting, will be determined on the obtained materials, as a function of the molecular weights and the thermal history.
Furthermore, the materials will be characterized according to their dynamic-mechanical properties to establish the module, the dissipative phenomena and the plastic regime.

Prerequisites

A basic knowledge of general and organic chemistry is requested.

Teaching form

Lectures, exercises and laboratory activities in Italian.
14 lessons of 2 hours delivered didactis in presence.
6 2-hour exercise activities delivered in interactive mode in person.
9 4-hour laboratory activities carried out in interactive mode in person.

Textbook and teaching resource

Fondamenti di Scienza dei Polimeri, AIM, Pacini Editore, Pisa.
Textbook of Polymer Science (III edition) F.W.Billmeyer, Wiley
E.M. Mc Caffery, Laboratory Preparation for Macromolecular Chemistry, Mc Graw-Hill

Semester

Second year; first and second semester.

Assessment method

- Evaluation of an individual technical report regarding the experiences carried out by the student in the laboratory.
- Oral interview on the topics covered in classes and on the technical report, aimed at verifying the level of the
  acquired knowledge, the autonomy of analysis and judgment, the student's exhibition skills.
- In itinere partial tests are planned to evaluate the knowledge acquired by the student during the course to face the laboratory experiences.

Office hours

By appointment.

Sustainable Development Goals

RESPONSIBLE CONSUMPTION AND PRODUCTION