UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

# COURSE SYLLABUS

# Advanced Functional Polymers

**2425-2-FSM01Q025**

## Aims

**General objectives**

To present the main classes of functional polymers used in the industrial, medical and environmental fields with particular attention to recent examples taken from the most advanced scientific and technological research.

**Knowledge and understanding**

At the end of the course the student:

1) Knows how to distinguish the type of polymers depending on the application

2) Knows how to clearly identify the correlation between the structural elements of the polymer and the possible applications

3) Knows the main descriptive tools of nanoparticles in polymers and functionalization methods

4) Knows the main characterization methods of colloidal dispersions

**Applying Knowledge and understanding:**

1) Can propose synthesis methods of a functional polymer

2) Knows how to propose further lines of development of existing polymers with particular attention to innovative applications

3) Knows the main areas of application of functional polymers

4) It is able to develop functional polymers for the "green transition"

**Making judgments.**

He knows how to contextualise classic problems of polymer chemistry such as the control of molecular weight, the distribution of comonomers along the polymer chain and the control of chain terminals. He knows how to propose functional polymers for water treatment, for use in the medical and biological fields, or as solid or semi-solid electrolytes in batteries and solar cells. He knows how to develop shape memory erasers or with reversible lattices.

**Communication skills.**

He knows the specific terminology of the chemistry of innovative functional polymers and is able to use it both in written and oral form, in order to summarize the characteristics and possible solutions to formulation problems in a complete and concise way.

**Learning skills.**

He knows the specific terminology of the chemistry of innovative functional polymers and is able to use it both in written and oral form, in order to summarize the characteristics and possible solutions to formulation problems in a complete and concise way

## Contents

This course aims to describe the development of polymeric materials with specific properties for cutting-edge topics in science and technology including nanomedicine, prosthetics, wearable electronics, photonics, and issues related to the green transition including the replacement of products of animal origin, smart mobility, purification of fluids and gases, recycling.
Through selected examples, the main methods of intervention on the properties of the material will be described. The peculiarities regarding the synthesis of these polymers will be illustrated. First, achieving specific functions often requires the synthesis of complex monomers through organic chemistry methods. The presence of these monomers in turn requires the development of specific syntheses, which allow for example good control of the distribution of comonomers, molecular weights, branching and cross-linking. In general, their functions do not depend only on the single chain. These advanced control methods also allow in some cases to expand the properties and use of traditional monomers, such as olefins.
Finally, an even wider range of properties is available by expanding the control concept from the single chain to the entire material, regulating its structure on different scales, obtaining nano- and mesostructured morphologies, or creating optimized nanocomposites through the management of surface grafting.

## Detailed program

Detail:

1. Review of prerequisite concepts:
   a. Polymers, from the molecule to the material. Cross-linked and branched polymers. Elastomers. Thermodynamics of the polymer chain, methods for the study of cross-linking.
   b. Synthesis of polymers
   c. “soft matter”, colloids, dispersions, hydrogels
   d. Review of the chemistry of conjugated compounds with particular reference to structure-property relationships and synthesis methods
2. Top down and bottom up
   a. Microfluidics, nanofabrication, electrospinning and applications

b. 3D printing, printing of soft structures, mild conditions
c. Self-assembly, block copolymers
d. Blending, phase diagrams, interface and interphase, methods for measuring the degree of intimacy
3. Semiconductor polymers: synthesis methods, optical, electrical and optoelectronic characteristics
4. Inks based on semiconductor polymers: printable electronics
5. Adhesion and intrinsic surface, antibacterial and antiviral treatments. Use of reactive plasma
6. Nanomedicine. Drug delivery, artificial blood, tissue regeneration, Molecular Imprinted Polymers.
7. Membranes, polymeric ionic liquids (PIL), insertion of “ionic liquid” monomers into the polymer chain. Polymers of intrinsic microporosity (pims).
8. Solid and gel polyelectrolytes and their use in batteries and "dye sensitized solar cells"
9. Green transition:
a. Case study: Diels-Alder reversible cross-linking
b. Case study 2: rubber in rubber
10. Nanoparticles in the polymer
a. Properties obtainable with NPs: barrier, refraction index, dielectric, magnetic, light diffusion
b. Surface functionalization for blending in polymer matrices (chemical and physical aspects, Kumar phase diagram).

## Prerequisites

Sound basic knowledge of organic and polymer. Capability to handle the topics of physical chemistry.

## Teaching form

Standard lessons supplemented by supporting multimedia tools functional to a better understanding of the practical aspects.

## Textbook and teaching resource

Textbooks

Slides

## Semester

first

## Assessment method

The exam consists of an oral exam in which the topics presented in the lessons are discussed. In addition to

learning the fundamentals presented in the course, the student's skills and aptitudes are also assessed to adapt the theoretical foundations of polymer sinthesys to particular operational and practical conditions; the exhibition capacity and adequacy of the student's language is evaluated.

## Office hours

upon request

## Sustainable Development Goals

SUSTAINABLE CITIES AND COMMUNITIES | RESPONSIBLE CONSUMPTION AND PRODUCTION