Course guide
240EQ231 - 240EQ231 - Polymer Technology I

Last modified: 27/05/2024

Unit in charge: Barcelona East School of Engineering
Teaching unit: 713 - EQ - Department of Chemical Engineering.

Degree: **Academic year:** 2024 **ECTS Credits:** 6.0
Languages: English

LECTURER

Coordinating lecturer: SEBASTIAN MUÑOZ GUERRA

Others: Sebastián Muñoz Guerra, Jordi Puiggalí Bellalta

PRIOR SKILLS

Basic knowledge in organic chemistry and polymers

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Transversal:
1. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

2. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

TEACHING METHODOLOGY

Subject in process of extinction. There is no teaching, the students that enroll it do so only with the right to an exam.

LEARNING OBJECTIVES OF THE SUBJECT

1) Know the chemical and physicochemical methods used for polymerization and copolymerization, the molecular mechanisms underlying these processes, their designing possibilities according to properties of the product, and the technologies used forits application on the manufacturing of polymers on both industrial and laboratory scales.
2) Know the available procedures for the chemical modification of polymers and biopolymers addressed to the modification of their properties, the chemical, thermal and environmental degradation processes, and to examine how these processes are followed and controlled by the appropriate chemical and physical analysis and tests.
3) Understand the theoretical principles governing the structure and performance of polymers both in solution and in the solid state and know the techniques used in the structural analysis of amorphous and crystalline polymers.
4) Understand the thermal and mechanical properties of polymers, their relation to the chemical and crystallographic structure, the techniques used for the calorimetric study and to monitor the crystallization phenomenon and the tests applied to evaluate the mechanical performance.
5) Know in a general way the specific properties of the polymers justifying its use as optical and electrical conducting materials or membranes, and introduce the study of multicomponent materials for its interest in improving the properties.

STUDY LOAD

Type	Hours	Percentage
Hours large group	54,0	36.00
Self study	96,0	64.00

Total learning time: 150 h

CONTENTS

POLYMERIZATION I

Description:
Chemical structure and properties. Monomer and polymer. Functionality, regiochemistry and reactivity. Linear polycondensation. Kinetics and thermodynamics. Molecular weights: stoichiometry and chain size. Three-dimensional polycondensation: jellification. Polyaddition. Radical and ionic mechanisms. Kinetics and thermodynamics. Transference reactions. Molecular weights: chain regulators and inhibitors. Living polymers.

Specific objectives:
Know the chemical and physicochemical methods of polymerization going through polycondensation and polyaddition mechanisms, and how they are applied to the preparation of polymers both in industry and laboratory.

Related activities:
Troubleshooting exercises of practical and theoretical nature to deepen in the application of the concepts introduced in this topic.

Full-or-part-time: 18h
Theory classes: 6h
Laboratory classes: 3h
Self study : 9h

POLYMERIZATION II

Description:
Stereochemistry of polymerization. Ziegler-Natta polymerization. Metallocenes. Stereospecific polymerization of olefines and dienes. Opening cycles of polymerization (ROP). Polymerizable ROP cycles and mechanisms. Special methods of polymerization. Dendrimers and hyperbranched polymers.

Specific objectives:
Determine the chemical and physicochemical methods of polymerization used in the polymers' synthesis of organometallic catalysts and by means of special mechanisms as these are applied to the preparation of polymers on an industrial scale or laboratory .

Related activities:
Troubleshooting of practical and theoretical exercises to deepen the implementation of the introduced concepts in this topic.

Full-or-part-time: 10h
Theory classes: 3h
Laboratory classes: 1h 30m
Guided activities: 5h 30m

COPOLYMERIZATION

Description:
Structure and properties of the copolymers. Addition copolymerization. Relative reactivities of the monomers. Composition and microstructure of the copolymers. Condensation copolymers. Telechelic polymers. Design structure and copolymers with specific properties. Graft copolymers.

Specific objectives:
Know the chemical and physicochemical methods used in the synthesis of copolymers through different possible mechanisms, and as they are applied to the preparation and design of copolymers on both industrial and laboratory scales according to the properties to be achieved for these materials.

Related activities:
Troubleshooting of practical and theoretical exercises to deepen the implementation of the introduced concepts in this topic.

Full-or-part-time: 10h
Theory classes: 3h
Laboratory classes: 1h 30m
Self study : 5h 30m

POLYMERIZATION TECHNOLOGY

Description:
Characteristics of the polymerization reactions. Bulk polymerization. Solution polymerization. Polymerization in suspension: stability of the systems. Emulsion polymerization: kinetics. Operational variables and polymer properties. Other methods of polymerization. Industrial examples.

Specific objectives:
Know the technologies used in industrial production of polymers according to the polymerization mechanism involved, the comparative advantages and disadvantages, and the systems and equipment needed. Acquire the basic criteria for the selection of the technology process that is suitable for the preparation of a given polymer.

Related activities:
Troubleshooting of practical and theoretical exercises to deepen the implementation of the concepts introduced in this issue. Elaboration of a report on illustrative processing cases.

Full-or-part-time: 12h
Theory classes: 3h
Laboratory classes: 1h 30m
Self study : 7h 30m

MODIFICATION AND DEGRADATION OF POLYMERS

Description:
Chemical reactions on polymers. Modification of properties. Crosslinking and formation of gels. Degradation of polymers: analysis and monitoring techniques. Thermal degradation: mechanisms of pyrolysis. Depolymerization. Chemical degradation: hydrolysis. Photo-oxidative degradation. Biodegradation.

Specific objectives:
Know the available procedures for the chemical modification of polymers and biopolymers, how these reactions modify the properties of materials and the limitations of their practical application. Interpret the parameters defining the occurrence of chemical, thermal and environmental degradation, to elucidate the chemical mechanisms involved in the degradation processes and how these processes are studied and are followed by chemical and physical analysis.

Related activities:
Troubleshooting to deepen the implementation of the concepts introduced in this issue and study illustrative cases.

Full-or-part-time: 10h
Theory classes: 3h
Laboratory classes: 1h 30m
Self study : 5h 30m

PHYSICAL CHEMISTRY OF POLYMERS

Description:
Thermodynamics of concentrated dissolutions. Phase separation. Flory temperature. Fractionation. Polymer blends. Phase diagram. Concept of random coil. Molecular interactions and excluded volume. Thermodynamics of dilute solutions. Measurements of molecular weights.

Specific objectives:
Determine the theoretical principles governing the performance of polymers in both dilute and concentrated solutions. Relate the theoretical concepts with practical application in both separation and fractionation processes, as in the characterization of blends or alloys, as well as in the basic characterization of polymeric materials.

Related activities:
Resolution of a collection of practical and theoretical exercises to deepen the implementation of the concepts introduced in this section.

Full-or-part-time: 16h
Theory classes: 4h 30m
Laboratory classes: 3h
Self study : 8h 30m

THE SOLID STATE. STRUCTURAL CHARACTERIZATION TECHNIQUES

Description:
The amorphous state: Interactions of short and long range. Macromolecular dynamics. The crystalline state: molecular requirements and levels of supramolecular organization. Conformation and molecular packing. Crystal morphologies: Lamellae, spherulites and fibers. Structural characterization methods: X-ray diffraction and electron microscopy.

Specific objectives:
Have a basic understanding of inter-and intramolecular interactions that determine the molecular organization in both the amorphous and crystalline states. Understand the crystallization process and learn to justify the morphologies derived therefrom. Introduce the main techniques used in structural analysis and be able to select the most suitable in order to solve a specific problem.

Related activities:
Resolution of exercises designed to facilitate the understanding of the molecular organization in the crystalline state and deduction of the most characteristic structural parameters.

Full-or-part-time: 13h
Theory classes: 4h 30m
Laboratory classes: 1h 30m
Guided activities: 7h

THERMAL PROPERTIES OF POLYMERS:ANALYTICAL TECHNIQUES

Description:
Thermal transitions of first and second order. Dilatometry. Compensated power differential calorimetry. Differential thermal analysis. Melting temperature, molecular structure and composition. Crystallization of polymers. The glass transition.

Specific objectives:
Relate the chemical and crystallographic structure of a polymer with the thermal properties of both the amorphous and the crystalline states. Introduce the main techniques used in the calorimetric analysis of a polymer.

Related activities:
Interpretation of a set of calorimetric data representative of different classes of polymers. Perform exercises that introduce the analysis of crystallization kinetics.

Full-or-part-time: 10h 30m
Theory classes: 3h
Laboratory classes: 1h 30m
Self study : 6h

MECHANICAL PROPERTIES OF POLYMERS:ANALYTICAL TECHNIQUES

Description:
Mechanical testing. Mechanical and rheological properties. Stress-strain performance of elastomers. Viscoelastic performance models. Time-temperature equivalence. Dynamic mechanical techniques. Relaxation mechanisms.

Specific objectives:
Gain knowledge of the different mechanical performance of materials and how they relate to their structure and the test temperature. Understand the effect of the variable time and relaxation mechanisms. Acquire knowledge about the diverse mechanical testing techniques.

Related activities:
Resolution of representative exercises paying special attention to the viscoelastic performance and rheological properties in general.

Full-or-part-time: 10h 30m
Theory classes: 3h
Laboratory classes: 1h 30m
Self study (distance learning): 6h

SPECIFIC PROPERTIES: MULTICOMPONENT SYSTEMS

Description:
Electrical and optical properties of polymers. Adhesive materials. Diffusion and permeability: membranes. Multicomponent composite materials. Young's modulus of multicomponent polymeric materials. Mechanisms of losses of mechanical properties.

Specific objectives:
Gain generic knowledge on the specific properties of the polymers justifying its use as optical materials, electrically conducting materials or membranes. Introduce the study of multicomponent materials and understand the interest in improving specific properties.

Related activities:
Individual work on the properties of a given material, correlating them with the acquired knowledge about its structure.

Full-or-part-time: 10h
Theory classes: 3h
Laboratory classes: 1h 30m
Self study (distance learning): 5h 30m

GRADING SYSTEM

Subject in process of extinction. There is only one final test that corresponds to 100% of the final grade of the subject.

BIBLIOGRAPHY

Basic:
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Complementary:
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- Odian, George G. Principles of polymerization [on line]. 4th ed. Hoboken, N.J: Wiley-Interscience, cop. 2004 [Consultation: 22/05/2020]. Available on: https://onlinelibrary.wiley.com/doi/book/10.1002/047147875X. ISBN 9780471478751.
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- Fried, Joel R. Polymer science and technology. 3rd ed. Upper Saddle River: Prentice Hall, cop. 2014. ISBN 9780137039555.
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- Wunderlich, Bernhard. Thermal analysis of polymeric materials : with 974 figures. New York: Springer Heidelberg, cop. 2005. ISBN 3540236295.
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