Course guide
295586 - 295PB016 - Advanced Materials

Last modified: 04/06/2026

Unit in charge: Barcelona East School of Engineering
Teaching unit: 713 - EQ - Department of Chemical Engineering.
702 - CEM - Department of Materials Science and Engineering.

Degree: MASTER'S DEGREE IN POLYMERS AND BIOPLASTICS (Syllabus 2024). (Compulsory subject).

Academic year: 2026 **ECTS Credits:** 3.0 **Languages:** English

LECTURER

Coordinating lecturer: DAVID ZANUY GOMARA - TOBIAS MARTIN ABT

Others: Primer quadrimestre:
TOBIAS MARTIN ABT - Grup: T1
JAVIER GÓMEZ MONTERDE - Grup: T1
JORDI SANS MILÀ - Grup: T1
DAVID ZANUY GOMARA - Grup: T1

PRIOR SKILLS

Previous knowledge about organic, inorganic chemistry and the origin of physical properties of materials
Previous knowledge about plastic materials at the level of the subjects Fundamentals of Polymers and Plastic Materials and Composites.

LEARNING RESULTS

Knowledges:
K3. Identify the fundamentals of the processes of synthesis, manufacture, modification, use, recycling and degradation of polymers and biopolymers.
K1. Identify the molecular chemical structure of polymers and biopolymers.
K5. Relate the structure and properties of polymers and biopolymers in order to predict their behaviour and to obtain materials with new functionalities.
K2. Identify the physical principles that govern the behaviour of polymers and underlie many of the techniques used in polymer analysis.

Skills:
S5. Select polymers and biopolymers according to their properties and intended use.
S6. Design and optimise polymeric materials for specific applications.

Competences:
C3. Apply acquired knowledge and problem-solving skills both in discipline-specific environments and in new or unfamiliar environments in broader (or multidisciplinary) contexts related to the field of study.
C2. Apply appropriate methods of analysis, production and management in the field of polymers and biopolymers.
C4. Make effective use of information resources, managing the acquisition, structuring, analysis and visualisation of data and information within the field of specialisation and critically evaluating the results of this process.

TEACHING METHODOLOGY

MD.1.- Theoretical lectures
MD 2.- Participative lecture;
MD.3 - Project-based learning;
MD.4 - Case studies;
MD.5 - Laboratory practicals;
MD.6 - Cooperative group work.

LEARNING OBJECTIVES OF THE SUBJECT

Understanding the concept of advanced materials
Understanding the properties, their physicochemical origin, that confer a material the state of "advanced".
Acquiring the main concepts related with advanced applications of materials within the framework of polymer science, surfaces, and composite materials.
Theoretical comprehension of the main features that allow a polymeric material to conduct electricity.
Understanding of the physical basis and main structural features of the colloidal state.
Uses and applications of the colloidal state in materials sciences, pharmacology, and cosmetics industry.
Understanding mechanical properties and their determination in plastic materials.
Knowing the main types of organic matrices and reinforcements of composite materials.
Knowing the properties of the interface and how it can be modified.
Learning how to design a laminated composite material and estimating their elastic properties.

STUDY LOAD

Type	Hours	Percentage
Self study	54,0	72.00
Hours large group	21,0	28.00

Total learning time: 75 h

CONTENTS

Theme 1: Introduction to the concept of Advanced Materials

Description:
In this chapter the main features that define an advanced material will be discussed. The basic physical, chemical, and structural features will be described and the size and scale in which all the questions are defined. The boundaries between material bulk and surfaces will be set and the methodologies to describe and understand their main features demonstrated.

Specific objectives:
What is an Advanced Material?
General concepts and applications
Importance of Surface/Bulk. Nanotechnology

Full-or-part-time: 4h 40m
Theory classes: 2h
Self study : 2h 40m

Theme 2: Energy of surfaces (I)

Description:
In this chapter the fundamentals of surface energy will be exposed. The basic formulations will be discussed from a thermodynamic point of view. The concept of wettability by means of the water contact angle technique will be presented. Finally, the concepts and applications of superhydrophobic and superhydrophilic materials will be explained.

Specific objectives:
• Surface Energy. Fundamentals
• Water Contact Angle
• Superhydrophilicity and Superhydrophobicity

Related activities:
Presentation of a real scientific work I (last 30 mi)

Full-or-part-time: 4h 40m
Theory classes: 1h 30m
Practical classes: 0h 30m
Self study : 2h 40m

Theme 3: Energy of Surfaces (II)

Description:
In the second part of the topic (Energy of surfaces) the strategies to design and control the wettability of materials will be discussed. On the other hand, the Biocompatibility and Adhesion properties of advanced materials will be related in terms of their surface energy properties

Specific objectives:
• Control of the Wettability Properties
• Biocompatibility
• Adhesives

Related activities:
Presentation of a real scientific work II (last 30 mi)

Full-or-part-time: 4h 40m
Theory classes: 1h 30m
Practical classes: 0h 30m
Self study : 2h 40m

Theme 4: Other advanced Applications and properties

Description:
This chapter is devoted to show the high versatility and wide range of possibilities when preparing and designing advanced materials. For this reason, several examples and strategies will be presented and discussed, such as catalysis, actuators or incorporation of nanoparticles, among others.

Specific objectives:
• Incorporation of Nanoparticles
• Actuators
• Biomedical Applications
• Catalysis

Related activities:
Presentation of a real scientific work III (last 30 mi)

Full-or-part-time: 4h 50m
Theory classes: 1h 30m
Practical classes: 0h 30m
Self study : 2h 50m

Theme 5: Conducting Polymers

Description:
In this chapter the physics-chemical framework from which electricity conduction in polymers stems from are presented. The structure and electronic organization of such materials will be shown and the different paths from which conduction in polymers can be archived discussed. Finally, the main applications and the rapidly increasing prospects for their use will be demonstrated. Some particular real cases presented.

Specific objectives:
Polymers and Electrical conduction
Types of conduction polymeric systems
The doping of a polyene moiety
Applications and prospects

Full-or-part-time: 3h 30m
Theory classes: 1h 30m
Self study : 2h

Theme 6: Colloidal state

Description:
In this chapter the theoretical basis, the physical origin and the organization of the colloidal state will be discussed. From the main physical property that allows the formation of such sort of state, the surface tension, passing through the phenomena of capillarity and wettability. The following section will dive into the properties of the chemical substance that allow the control and manipulation of the surface tension of liquid, the surfactant family. The different types of surfactants and their main properties will be covered. Finally, the main applications of the colloid state and their different uses in the industry will be discussed.

Specific objectives:
Introduction to colloids.
Surface tension.
Surface forces, capillarity and wettability.
Characterization of surface tension.
Surfactants.
Surfactants and superficial tension.
Micelle formation
Critical Micelle Concentration (CMC)
Langmuir - Blodgett Films.
Vesicles and liposomes.
Intermolecular Forces and colloid formation.
Types of Colloids and industrial applications

Full-or-part-time: 10h 30m
Theory classes: 3h 30m
Self study : 7h

Theme 7: Mechanical properties and their determination in polymers (prof. N. León)

Description:
General definitions and mechanical behavior in plastic materials' elastic and plastic range

Specific objectives:
Loading scenarios in service conditions
Main definitions: engineering stress, engineering strain, elastic modulus, Poisson's ratio
Engineering stress-strain curve
True stress-strain curve

Full-or-part-time: 10h 50m
Theory classes: 2h
Self study : 8h 50m

Theme 8: Uniaxial tensile test (Group activity) (N. León)

Description:
Experimental determination of the main tensile parameters on specimens manufactured of recycling bottle caps.

Specific objectives:
Experimental analysis of tensile curves
Relevance of the recycling process in polymers

Related activities:
Delivery of a report with the main results of the laboratory session

Full-or-part-time: 9h
Practical classes: 2h
Self study : 7h

Theme 9: Composite materials: Components and classification. Fibres, particles and nano-composites (T. Abt)

Description:
Definition and classification. Examples of applications. Natural compounds.
Types of fibres, types of polymeric matrices. Matrix fibre interfaces. Key factors that determine the properties of a compound.

Specific objectives:
Types of composites: MMC, CMC and PMC
Types of coupling agents, fillers and additives
Types of fibres, particles and nano-composites
Mechanical and specific properties of fibre-reinforced composites
Rule of mixtures

Full-or-part-time: 9h
Theory classes: 2h
Self study : 7h

Theme 10: Group Activity: Quality control of laminates

Description:
Determination of tensile properties of unidirectional continuous fibre reinforced composites from experimental data.
Determination of the volumetric fibre content. Estimation of the elastic constants using the rule of mixtures.

Related activities:
Example: To solve exercises related to the properties of general purpose plastics and plastic identification practice.

Full-or-part-time: 6h
Theory classes: 2h 30m
Self study : 3h 30m

Theme 11: Micromecanics of continuous fibre reinforced composites

Description:
Unidirectional mechanical properties of composite materials with long fibres from known properties of the fibre and matrix.
Mechanical properties in laminates: estimation of elastic constants in the mid plane.
Mechanical design of laminates.

Specific objectives:
Rule of mixtures of unidirectional long fibre reinforced composites.
Classical Laminate Theory

Full-or-part-time: 7h 20m
Theory classes: 2h
Self study : 5h 20m

GRADING SYSTEM

Any academic fraud, plagiarism or use or possession of unauthorised means in an assessment activity leads to a mark of zero (0) for the affected test or assignment. Furthermore, in accordance with the University's regulations, if disciplinary proceedings are initiated the subject is recorded as "Pending Assessment" until a decision is reached. These incidents are managed in accordance with the **Action Framework for Academic Integrity in Assessment at the UPC**.

There are several evaluation tasks, each representing a different milestone of the course.

FG=G_(Part I)*0.5+ G_(part II)*0.5

G_Part I: Grade corresponding to the first 7 sessions. Can be overcome either by taking a test or by presenting a small research paper.
G_Part II: Grade corresponding to the second 7 sessions. Grade is the average of the grades of two laboratory reports.

EXAMINATION RULES.

1. There will be a grade covering the first 7 sessions based either on one test or on a written work.

BIBLIOGRAPHY

Basic:
- Friedrich, Klaus; Fakirov, Stoyko; Zhang, Zhong. Polymer composites : from nano-to-macro-scale. New York: Springer, 2005. ISBN 0387241760.
- Mallick, P. K.; Newman, Seymour; Chapman, Gilbert B. Composite materials technology : processes and properties. Munich [etc.] : New York: Hanser, cop. 1990. ISBN 3446156844.
- Michaeli, Walter. Tecnología de los composites/plásticos reforzados. Barcelona: Hanser, DL 1992. ISBN 8487454046.
- Hull, Derek. Materiales compuestos. Barcelona [etc.]: Reverté, cop. 1987. ISBN 8429148396.
- Barsoum, Michel W. Fundamentals of ceramics. New York ; London: Taylor & Francis, cop. 2003. ISBN 9780750309028.
- Chawla, Nikhilesh; Chawla, Krishan K. Metal matrix composites [on line]. 1st ed. 2006. New York, NY: Springer, 2006 [Consultation: 18/09/2024]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=302651. ISBN 9786610459636.
- Wachtman, J. B.; Cannon, W. Roger; Matthewson, M. John. Mechanical properties of ceramics. 2nd ed. Hoboken, NJ: John Wiley & Sons, cop. 2009. ISBN 9780471735816.

Complementary:
- Vinod K. Sarin. Composites science and technology [on line]. New York: Elsevier Science Pub Co, 1999 [Consultation: 18/09/2024]. Available on: https://www-sciencedirect-com.recursos.biblioteca.upc.edu/journal/composites-science-and-technology. ISBN 1879-1050.

RESOURCES

Other resources:
Classroom material available at ATENEA