



POLITÉCNICA

INTERNATIONAL
CAMPUS OF
EXCELLENCE

COORDINATION PROCESS OF
LEARNING ACTIVITIES
PR/CL/001



E.T.S. de Ingenieros de
Caminos, Canales y Puertos

ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

43000614 - Polímeros

DEGREE PROGRAMME

04AN - Master Universitario En Ingenieria De Materiales

ACADEMIC YEAR & SEMESTER

2023/24 - Semester 2

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1. Description

1.1. Subject details

Name of the subject	43000614 - Polímeros
No of credits	4 ECTS
Type	Optional
Academic year of the programme	First year
Semester of tuition	Semester 2
Tuition period	February-June
Tuition languages	English
Degree programme	04AN - Master Universitario en Ingeniería de Materiales
Centre	04 - Escuela Técnica Superior De Ingenieros De Caminos, Canales Y Puertos
Academic year	2023-24

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Maria Victoria Alcazar Montero (Subject coordinator)	Chem. I ETSII	mariavictoria.alcazar@upm.es	Tu - 10:00 - 13:00 W - 10:00 - 13:00 Tutoring only by previous appointment (email) Tutoring is offered only during the period of lectures (not included exams)

			period and holidays)
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* The tutoring schedule is indicative and subject to possible changes. Please check tutoring times with the faculty member in charge.

2.3. External faculty

Name and surname	Email	Institution
De-yi Wang	deyi.wang@imdea.org	IMDEA Materiales

3. Prior knowledge recommended to take the subject

3.1. Recommended (passed) subjects

The subject - recommended (passed), are not defined.

3.2. Other recommended learning outcomes

- Previous knowledge acquired during the graduate studies (specially at engineering)

4. Skills and learning outcomes *

4.1. Skills to be learned

CE1 - Capacidad para aplicar los fundamentos científicos del comportamiento físico y químico de los materiales para relacionar causalmente sus propiedades fundamentales físicas y químicas con su comportamiento macroscópico y el de los productos con ellos realizados / Ability to apply the scientific foundations of the physical and chemical behavior of materials to correlate their fundamental physical and chemical properties with their macroscopic behavior and that of the products made with them.

CE5 - Capacidad para planificar, explotar y gestionar técnicamente la selección, fabricación, procesado, utilización, reciclado, reutilización y eliminación de materiales, de forma respetuosa con el medio ambiente, de conformidad con la legislación nacional e internacional, y promoviendo el desarrollo sostenible y el bienestar de la sociedad / Ability to technically plan, exploit and manage the selection, manufacturing, processing, use, recycling, reuse and disposal of materials, in an environmentally friendly manner, in accordance with national and international legislation, and promoting sustainable development and well-being of the society

CE6 - Capacidad para controlar y modificar los mecanismos físicos y químicos que determinan las fases del ciclo de vida de los materiales, su durabilidad y su incidencia en el medioambiente con el fin de poder evaluar, controlar y mejorar la seguridad, durabilidad e integridad estructural de los materiales y los componentes fabricados con ellos / Ability to control and modify the physical and chemical mechanisms that determine the phases of the life cycle of materials, their durability and their impact on the environment in order to be able to evaluate, control and improve the safety, durability and structural integrity of materials and components made from them

CG1 - Uso de la lengua inglesa: Los alumnos son capaces de transmitir conocimientos y expresar ideas y argumentos de manera clara, rigurosa y convincente, tanto de forma oral como escrita, adaptándose a las características de la situación y de la audiencia / Use of the English Language: Students are able to transmit knowledge and express ideas and arguments in a clear, rigorous and convincing manner, both orally and in writing, adapting to the characteristics of the situation and the audience .

CG6 - Respeto hacia el medio ambiente: Los alumnos desarrollan las mejores prácticas para interactuar con el entorno, de forma ética, responsable y sostenible, en orden a evitar o disminuir los efectos negativos que ocasiona la actividad humana, así como promover los beneficios que pueda generar la actividad profesional en el ámbito medioambiental, teniendo en cuenta sus implicaciones económicas y sociales / Respect for the environment: Students develop the best practices to interact with the environment, in an ethical, responsible and sustainable way, in order to avoid or reduce the negative effects caused by human activity, as well as promote the benefits that professional activity in the environmental field can generate, taking into account its economic and social implications.

CG8 - Resolución de problemas: Los estudiantes son capaces de reconocer, describir, organizar y analizar los elementos constitutivos de un problema para idear estrategias que permitan obtener, de forma razonada, una solución contrastada y acorde a ciertos criterios preestablecidos / Problem solving: Students are able to recognize, describe, organize and analyze the constitutive elements of a problem to devise strategies that allow obtaining, in a reasoned way, a contrasting solution and according to certain pre-established criteria.

CG9 - Que los estudiantes sepan comunicar sus conclusiones y los conocimientos y razones últimas que las sustentan a públicos especializados y no especializados de un modo claro y sin ambigüedades

CG9 - Análisis y Síntesis: Los alumnos son capaces de reconocer y describir los elementos constitutivos de una realidad, y de proceder a organizar la información significativa según criterios preestablecidos adecuados a un propósito / Analysis and Synthesis: Students are able to recognize and describe the constituent elements of a reality, and to proceed to organize significant information according to pre-established criteria suitable for a purpose.

4.2. Learning outcomes

RA16 - Knowledge and understanding of the electrical, optical, thermal and mechanical properties of materials

RA1 - Saber comunicar conocimientos, procedimientos, resultados o técnicas relacionadas con el comportamiento y el uso de materiales

RA25 - Conocer, comprender y saber aplicar los fundamentos científicos del comportamiento de los materiales y la interrelación entre su estructura, propiedades, procesado y aplicaciones

RA29 - C1 - Knowledge of the scientific method applied to structural and functional materials

RA3 - Conocer, comprender y saber aplicar las bases de la ciencia y del método científico

RA8 - RA32 - Conocer, comprender y saber aplicar los fundamentos científicos del comportamiento de los materiales

RA2 - Ser capaz de aprender y actualizar autónomamente nuevos conocimientos y técnicas

RA23 - Saber comunicarse con soltura en lengua inglesa de manera oral y escrita

RA41 - HRP1 - Ability to solve problems that require the design of novel structural or functional materials or devices based on them

* The Learning Guides should reflect the Skills and Learning Outcomes in the same way as indicated in the Degree Verification Memory. For this reason, they have not been translated into English and appear in Spanish.

5. Brief description of the subject and syllabus

5.1. Brief description of the subject

In this subject the students will learn some of the new trends in the field of polymers, exploring the applications of these versatile materials: power generation, fire-retardant materials, membranes, adsorbents and their recyclability. At the end of the course the students will have widened their knowledge about polymers, discovering new possibilities and applications of these versatile materials.

Subject contents and time distribution

LM: Lesson at room, RP: Problems Resolution, LB: Laboratory,, TI: Individual Work, TG: Group Work, DB: Debate at Room, VI: Visits, EV: Exams, OT: Other procedures

Item	Contents	Code
1	Introduction to the course Polymers.	LM, RP, TI, TG, D
2	Conductive polymers.	LM, TI, TG, DB RP
3	Molecularly imprinted polymers.	LM, TI, TG, DB RP
4	Fire retardant polymers.	LM, TI, TG, DB RP

5	Smart polymers	LM, TI, TG, DB RP
6	Polymers: recycling and sustainability	LM, TI, TG, DB RP

5.2. Syllabus

1. Introduction to the course

1.1. Polymers.

2. Conductive polymers

2.1. Conjugated polymers

2.1.1. HOMO and LUMO

2.1.2. Organic versus inorganic semiconductors

2.2. Optoelectronic processes.

2.2.1. Electroluminescence.

2.2.2. Materials for organic light emission diodes (OLEDs).

2.3. Organic photovoltaic cells (OPV).

2.3.1. Photovoltaic effect. Efficiency limit.

2.3.2. Polymer photovoltaic devices.

3. Molecularly imprinted polymers (MIPs).

3.1. Molecular recognition.

3.2. Preparation of MIPs.

3.3. Applications of MIPs.

4. Fire retardant polymers.

- 4.1. Fire and polymers.
- 4.2. Theories of fire retardancy: free radical trap, barrier, thermal and dilution by non-combustible gases.
- 4.3. High Performance Polymer Nanocomposites: Processing and Functionalization.
- 4.4. High Performance Polymer Nanocomposites: Properties.
5. Smart polymers
 - 5.1. Types of stimuli: chemical, physical or biochemical. Selected examples.
 - 5.2. Temperature-responsive polymers.
 - 5.3. pH-responsive polymers
 - 5.4. Photoresponsive polymers
6. Polymers: recycling and sustainability

6. Schedule

6.1. Subject schedule*

Week	Classroom activities	Laboratory activities	Distant / On-line	Assessment activities
1	Introduction to the course Duration: 01:00 Lecture Scientific article Duration: 00:40 Problem-solving class			Debate en clase Group work Continuous assessment Presential Duration: 00:20
2	Polymers. Duration: 01:20 Lecture Polymers Duration: 00:40 Problem-solving class			Entrega problemas/cuestiones resueltos en clase Group work Continuous assessment Presential Duration: 00:20
3	Conductive polymers. Conjugated polymers: HOMO and LUMO. Organic versus inorganic semiconductors. Duration: 01:00 Lecture Conductive polymers Duration: 01:00 Problem-solving class			Entrega problemas/cuestiones resueltos en clase Individual work Continuous assessment Presential Duration: 00:20
4	Organic photovoltaic cells (OPV). Duration: 01:00 Lecture Organic photovoltaic cells Duration: 01:00 Problem-solving class			Trabajo /problema Actividad no presencial Individual work Continuous assessment Not Presential Duration: 01:00
5	Molecularly imprinted polymers (MIPs). Duration: 01:00 Lecture MIPs Duration: 00:40 Problem-solving class			Entrega problemas/cuestiones resueltos en clase Group work Continuous assessment Presential Duration: 00:20
6	Preparation of MIPs: covalent and non-covalent approach. Duration: 01:00 Lecture MIPs Duration: 00:40 Problem-solving class			Entrega problemas/cuestiones resueltos en clase Individual work Continuous assessment Presential Duration: 00:20

7	<p>Fire retardant polymers. Fire and polymers. Duration: 01:30 Lecture</p> <p>Fire retardant polymers Duration: 00:30 Problem-solving class</p>			<p>Trabajo /problema Actividad no presencial Individual work Continuous assessment Not Presential Duration: 01:00</p>
8	<p>High Performance Polymer Nanocomposites: Duration: 01:30 Lecture</p> <p>Polymer nanocomposites Duration: 00:30 Problem-solving class</p>			<p>Entrega problemas/cuestiones resueltos en clase Individual work Continuous assessment Presential Duration: 00:20</p>
9	<p>Smart polymers. Duration: 01:30 Lecture</p> <p>Smart polymers Duration: 01:00 Problem-solving class</p>			<p>Entrega problemas/cuestiones resueltos en clase Group work Continuous assessment Presential Duration: 00:20</p>
10	<p>Temperature and pH-responsive polymers Duration: 01:00 Lecture</p> <p>Temperature and pH responsive polymers Duration: 01:00 Problem-solving class</p>			<p>Trabajo /problema Actividad no presencial Individual work Continuous assessment Not Presential Duration: 01:00</p>
11	<p>Photo-responsive polymers Duration: 01:00 Lecture</p> <p>Photo-responsive polymers Duration: 00:40 Problem-solving class</p>			<p>Entrega problemas/cuestiones resueltos en clase Individual work Continuous assessment Presential Duration: 00:20</p>
12	<p>Polymers: recycling and sustainability Duration: 01:00 Lecture</p> <p>Scientific article Duration: 00:40 Problem-solving class</p>			<p>Entrega problemas/cuestiones resueltos en clase Individual work Continuous assessment Presential Duration: 00:20</p>
13	<p>Polymers: recycling and sustainability Duration: 01:00 Lecture</p> <p>Polymers recycling Duration: 00:40 Problem-solving class</p>			<p>Trabajo /problema Actividad no presencial Individual work Continuous assessment Not Presential Duration: 01:00</p>
14	<p>Polymers: recycling and sustainability Duration: 01:00 Lecture</p> <p>Polymers recycling Duration: 00:40 Problem-solving class</p>			<p>Entrega problemas/cuestiones resueltos en clase Individual work Continuous assessment Presential Duration: 00:20</p>

15				Examen de evaluación para los alumnos de evaluación progresiva Written test Continuous assessment Presential Duration: 02:00
16				
17				Examen final asignatura Written test Final examination Presential Duration: 02:00

Depending on the programme study plan, total values will be calculated according to the ECTS credit unit as 26/27 hours of student face-to-face contact and independent study time.

* The schedule is based on an a priori planning of the subject; it might be modified during the academic year, especially considering the COVID19 evolution.

7. Activities and assessment criteria

7.1. Assessment activities

7.1.1. Assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
1	Debate en clase	Group work	Face-to-face	00:20	%	/ 10	CG8 CG9 CE1 CG1
2	Entrega problemas/cuestiones resueltos en clase	Group work	Face-to-face	00:20	5%	/ 10	CG8 CG1
3	Entrega problemas/cuestiones resueltos en clase	Individual work	Face-to-face	00:20	0%	/ 10	
4	Trabajo /problema Actividad no presencial	Individual work	No Presential	01:00	5%	/ 10	CG9 CE1
5	Entrega problemas/cuestiones resueltos en clase	Group work	Face-to-face	00:20	5%	/ 10	CG9 CG1 CG9
6	Entrega problemas/cuestiones resueltos en clase	Individual work	Face-to-face	00:20	5%	/ 10	CE5 CG1
7	Trabajo /problema Actividad no presencial	Individual work	No Presential	01:00	5%	/ 10	CE5 CG8
8	Entrega problemas/cuestiones resueltos en clase	Individual work	Face-to-face	00:20	%	/ 10	
9	Entrega problemas/cuestiones resueltos en clase	Group work	Face-to-face	00:20	5%	/ 10	
10	Trabajo /problema Actividad no presencial	Individual work	No Presential	01:00	5%	/ 10	CG8 CE5
11	Entrega problemas/cuestiones resueltos en clase	Individual work	Face-to-face	00:20	%	/ 10	
12	Entrega problemas/cuestiones resueltos en clase	Individual work	Face-to-face	00:20	5%	/ 10	CE5 CG6 CE1

13	Trabajo /problema Actividad no presencial	Individual work	No Presential	01:00	5%	/ 10	CE5 CE6 CG6 CG9 CE1 CG1
14	Entrega problemas/cuestiones resueltos en clase	Individual work	Face-to-face	00:20	5%	/ 10	CE5 CE6 CG9 CG1
15	Examen de evaluación para los alumnos de evaluación progresiva	Written test	Face-to-face	02:00	50%	4 / 10	

7.1.2. Global examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
17	Examen final asignatura	Written test	Face-to-face	02:00	100%	5 / 10	CG8 CE5 CE6 CG9 CG6 CG9 CE1 CG1

7.1.3. Referred (re-sit) examination

Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
Examen de evaluación final extraordinaria	Written test	Face-to-face	02:30	100%	5 / 10	

7.2. Assessment criteria

Ordinary evaluation

According to the UPM regulations there is a preference for the distributed or progressive evaluation systems.

(NORMATIVA DE EVALUACIÓN DEL APRENDIZAJE EN LAS TITULACIONES OFICIALES DE GRADO Y MÁSTER UNIVERSITARIO DE LA UNIVERSIDAD POLITÉCNICA DE MADRID, aprobada por Consejo de

Gobierno en su sesión del 26 de mayo de 2022)

Distributed or progressive evaluation

The final mark is obtained through the following items:

- class activities and homework assignments CA (50%)
- exam EX 50% (last week)

Pass mark: $0.5 \cdot CA + 0.5 \cdot EX \geq 5$

Final exam

The final mark is obtained only by the contribution of the written exam EX (100%)

Pass mark: $EX \geq 5$

According to the scheduled exams for the subject

Extraordinary evaluation

Only final exam with a total weight of 100%.

Pass mark: $EX \geq 5$

For ordinary and extraordinary evaluation, a minimum score of 5 is required

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
Organic electronics	Bibliography	So, F., Organic Electronics. Materials, Processing, Devices and Applications. CRC Press 2010.
MIPs	Bibliography	Alvarez-Lorenzo, C. and Concheiro, A., Handbook of Molecularly Imprinted Polymers. Smithers Rapra Technology Ltd, 2013.
Polymer electrolytes	Bibliography	Sequeira, C. and Santos, D., Polymer electrolytes. Fundamentals and Applications. Woodhead Publishing 2010.
Smart polymers	Bibliography	Aguilar, M. R. and San Román, J., Smart Polymers and their Applications. Woodhead Publishing 2014.
Artículos científicos	Bibliography	Se proporcionarán a los alumnos artículos relevantes de revistas científicas

Moodle	Web resource	Diapositivas de teoría y problemas de clase Ejercicios complementarios
Enlaces web	Web resource	Se proporcionarán enlaces a páginas de interés

9. Other information

9.1. Other information about the subject

This subject is related to the following Sustainable Development Goals adopted by all United Nations Member States :

- Goal 7 Ensure access to affordable, reliable, sustainable and modern energy for all (topic organic photovoltaic cells, for example)
- Goal 3 Ensure healthy lives and promote well-being for all at all ages (topic smart polymers for example)