240EM013 - Structure and Properties of Polymers

Coordinating unit: 295 - EEBE - Barcelona East School of Engineering
Teaching unit: 702 - CMEM - Department of Materials Science and Metallurgy
Academic year: 2018
Degree: MASTER'S DEGREE IN MATERIALS SCIENCE AND ENGINEERING (Syllabus 2014). (Teaching unit Compulsory)
MASTER'S DEGREE IN MATERIALS SCIENCE AND ENGINEERING (Syllabus 2014). (Teaching unit Compulsory)
ERASMUS MUNDUS MASTER'S DEGREE IN ADVANCED MATERIALS SCIENCE AND ENGINEERING (Syllabus 2009). (Teaching unit Optional)
ERASMUS MUNDUS MASTER'S DEGREE IN ADVANCED MATERIALS SCIENCE AND ENGINEERING (Syllabus 2014). (Teaching unit Optional)
ERASMUS MUNDUS MASTER'S DEGREE IN ADVANCED MATERIALS SCIENCE AND ENGINEERING (Syllabus 2014). (Teaching unit Optional)
ECTS credits: 4,5
Teaching languages: Spanish

Teaching staff
Coordinator: Santana Perez, Orlando Onofre
Others: Maspoch Ruldua, Maria Lluïsa
Cailloux, Jonathan
García Masabet, Violeta Del Valle

Opening hours
Timetable: Teachers will establish and communicate at the beginning of the semester.

Prior skills
Knowledge of materials structure, organic chemistry, physics, mathematics.

Requirements
There are no pre-requisites.

Degree competences to which the subject contributes
Specific:
CEMCEM-01. (ENG) Aplicar coneixements de matemàtiques, física, química, biologia i altres ciències naturals, obtinguts mitjançant estudi, experiència i, pràctica, amb raonament crític per a establir solucions viables a problemes tècnics.
CEMCEM-02. (ENG) Dissenyar i desenvolupar productes, processos, sistemes i serveis, així com l'optimització d'altres ja desenvolupats, atenent a la selecció de materials per a aplicacions específiques

Transversal:
02 SCS N1. SUSTAINABILITY AND SOCIAL COMMITMENT - Level 1. Analyzing the world¿s situation critically and systemically, while taking an interdisciplinary approach to sustainability and adhering to the principles of sustainable human development. Recognizing the social and environmental implications of a particular professional activity.
06 URI N1. EFFECTIVE USE OF INFORMATION RESOURCES - Level 1. Identifying information needs. Using collections, premises and services that are available for designing and executing simple searches that are suited to the topic.
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Teaching methodology

Depending on the number of students:

- Expositive and participative classes, with guided discussions.
- Theoretical-practical work, with oral presentation
- Practice laboratory
- Evaluation activities (examinations and reports).

Learning objectives of the subject

Acquire knowledge about structure, obtaining, physical and mechanical properties of polymeric materials.

Study load

<table>
<thead>
<tr>
<th>Total learning time: 112h 30m</th>
<th>Hours large group: 27h 24.00%</th>
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<tbody>
<tr>
<td></td>
<td>Hours medium group: 0h 0.00%</td>
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<tr>
<td></td>
<td>Hours small group: 13h 30m 12.00%</td>
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<td></td>
<td>Guided activities: 0h 0.00%</td>
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<tr>
<td></td>
<td>Self study: 72h 64.00%</td>
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</table>
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## Content

<table>
<thead>
<tr>
<th>Topic 1: Introduction, structure and clarification</th>
<th>Learning time: 5h 42m</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Theory classes: 3h</td>
</tr>
<tr>
<td>Brief history of polymer science and technology.</td>
<td>Self study: 2h 42m</td>
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<tr>
<td>Technological importance of polymeric materials.</td>
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<tr>
<td>Idealization of the polymer chain, preliminary definitions.</td>
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<tr>
<td>Configuration and conformation of the chains: isomerisms, molecular architecture, chain mobility.</td>
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<tr>
<td>Classification based on thermomechanical behavior: thermoplastics, thermosets and elastomers.</td>
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<tr>
<td>Classification based on consumption: &quot;Comodities&quot;, Engineering and special applications.</td>
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<tr>
<td><strong>Related activities:</strong></td>
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<tr>
<td>Suggested reading and discussion-debate in class.</td>
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<thead>
<tr>
<th>Topic 2: Synthesis: Polymerization and copolymerization</th>
<th>Learning time: 8h 24m</th>
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<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Theory classes: 3h</td>
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<tr>
<td>Preliminary definitions: Monomers, Coppers, monomer functionality, Repetitive unit vs. Structural unit, Homopolymers vs. Copolymers</td>
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<tr>
<td>Main polymerization mechanisms:</td>
<td>Self study: 5h 24m</td>
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<tr>
<td>- In chain: radicalar, anionic and cationic.</td>
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<tr>
<td>- By steps: Polycondensation vs. Polyaddition</td>
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<tr>
<td>Main polymerization processes:</td>
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<tr>
<td>- Mass</td>
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<tr>
<td>- In solution</td>
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<tr>
<td>- In suspension</td>
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<tr>
<td>- In emulsion</td>
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## Topic 3: Dimensions of the chains

**Learning time:** 12h 36m  
Theory classes: 3h  
Laboratory classes: 1h 30m  
Self study: 8h 06m

**Description:**  
Characteristic ratio and radius of rotation.  
Distribution of molecular masses and average molecular masses: by weight, in number, viscosimetric, and third moment of distribution. Technological importance of its determination.  
Molecular mass determination techniques:  
- Viscosimetry  
- Chromatography by size exclusion  
- Light scattering  
- Osmometry  

**Related activities:**  
Lab. 1.

## Topic 4: Thermal transitions and aggregation states.

**Learning time:** 4h 42m  
Theory classes: 1h 30m  
Self study: 3h 12m

**Description:**  
Glass transition (Tg).  
Melting temperature (Tm).  
States of aggregation as a function of temperature.  
Techniques for determining transition temperatures:  
- Differential scanning calorimetry (DSC).  
- Thermomechanical analysis (TMA).  
- Softening temperatures: HDT and VICAT
### Topic 5: Organization in the Solid State

**Description:**
- Disorder:
  - Amorphous polymer as sub-cooled liquid.
  - Structural factors that affect the vitreous transition.
  - Vitrification as a kinetic process.
  - Volumetric relaxation vs. Entálpica relaxation: Physical aging.

- Order:
  - Crystal structures: Lamela, spherulite, Sheas Kebab, Row nucleated
  - Isothermal and non-isothermal crystallization process.
  - Factors that affect crystallization ability.
  - Melting process in polymers.

**Related activities:**
- Lab. 2.
- Lab. 3.

### Subject 6. Structure-mechanical properties relationship.

**Description:**
- Plane stress state and plane strain state: triaxiality.
- Stress-Strain curves in polymers: Engineering, true and intrinsic.
- Practical aspects of the determination of stress-strain curves in polymers. Consider construction.
- Phenomenology of the deformation process in polymers: Energy elasticity, entropic elasticity (elasticity of rubber), plastic deformation, hardening by deformation (natural draw ratio).
- Relationship between structure and intrinsic stress-strain curves in polymers: efect of Molecular Weight, aggregation state, orientation, cristalline texture.
- Mechanism of plastic deformation in polymers: Shear yielding vs. Crazing
- Environmetal Stress Cracking (ESC).
- Ductile-brittle transition in polymers.

**Related activities:**
- Lab. 4
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**Subject 7. Polymer viscoelasticity**

**Learning time:** 30h 24m
- Theory classes: 7h 30m
- Laboratory classes: 3h
- Self study: 19h 54m

**Description:**
Viscoelasticity as a consequence of the macromolecular nature.
The concept of time characteristic of the process.
Effect of the viscoelastic nature on quasi-static mechanical tests.
Linear viscoelasticity: Principle of stress / strain superposition (Boltzmann) and time-temperature correspondence.
Generation of master curves.
Responses in static loadings: Creep, Relaxation of tensions, Creep-recovery (quantification parameters).
Micromechanical models used (Maxwell, Kelvin Voight, 3 elements, Bruder). Isochrone and isobaric curves.
Responses to cyclic loading: Storage modules, loss, dissipation factor. Micromodelos employees.
DMTA assays in polymers.

**Qualification system**

2 partial exams (NPP-1 and NPP-2) + Continuous evaluation (NEC).
In both exams they must obtain a minimum grade of 4 points. Otherwise, the final exam will be presented and the Final grade (NF) will be calculated according to Option 2.

The final grade (NF) will be calculated from the following expression:

\[
NF = 0.7 \text{NTeoria} + 0.3 \text{NEC (Continuous evaluation)}
\]

NEC: average group activities: Tasks, reports of laboratory sessions. A minimum of 2 evaluable group activities is contemplated.

Option 1: Supposed to exceed the minimum grade in both partial tests (4/10 in each).

\[
\text{NTeory} = 0.5 \text{Npp-1} + 0.5 \text{NPP-2}
\]

Option 2: Assumption of NOT to exceed the minimum mark in any of the partial tests (4/10 in each).

\[
\text{NTeoria} = 0.25 \text{Npp-1} + 0.25 \text{NPP-2} + 0.5 \text{EF}
\]

There is no Re-evaluation test.
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**Regulations for carrying out activities**

2 partial exams (NPP-1 and NPP-2) + Continuous evaluation (NEC). All evaluation items will be evaluated in the scale of 10, and are mandatory to be able to approve the subject.

Partial examinations P1 and P2:
Two written tests, with a maximum duration of 1.5h. No use of support material. The topics to be evaluated in each of them will be communicated during the course. The minimum assessment in each of them must be 4/10. Otherwise a final exam (EF) must be done.

Final exam:
Maximum duration 2h. All the topics covered in the course will be evaluated. Students who have not obtained a minimum grade of 4/10 in any of the partial tests will be presented compulsory.

Reports of practical activities:
They will be presented according to a model that will be published in the digital campus of the subject. The groups or work teams will be established at the beginning of the quarter by the students themselves. The maximum number of participants in each group will be between 3 and 4 students.

**Bibliography**

**Basic:**


**Complementary:**


**Others resources:**

In the digital campus of the subject will be placed, prior to the theoretical sessions, the visual support material used in the class sessions, as well as the scripts of laboratory practices and the technical report template to be used in the presentation of the laboratory reports.