Course guides
240EM013 - 240EM013 - Structure and Properties of Polymers

Last modified: 19/06/2020

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

Degree: MASTER'S DEGREE IN MATERIALS SCIENCE AND ENGINEERING (Syllabus 2014). (Compulsory subject).
ERASMUS MUNDUS MASTER'S DEGREE IN ADVANCED MATERIALS SCIENCE AND ENGINEERING (Syllabus 2009). (Optional subject).
MASTER'S DEGREE IN MATERIALS SCIENCE AND ENGINEERING (Syllabus 2014). (Compulsory subject).
ERASMUS MUNDUS MASTER'S DEGREE IN ADVANCED MATERIALS SCIENCE AND ENGINEERING (Syllabus 2014). (Optional subject).
ERASMUS MUNDUS MASTER'S DEGREE IN ADVANCED MATERIALS SCIENCE AND ENGINEERING (Syllabus 2014). (Optional subject).

Academic year: 2020 **ECTS Credits:** 4.5 **Languages:** Spanish

LECTURER

Coordinating lecturer: Santana Perez, Orlando Onofre

Others: Maspoch Ruldua, Maria Lluïsa
Cailloux, Jonathan
García Masabet, Violeta Del Valle

PRIOR SKILLS

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

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, experiènciea 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 INFORMATI0N 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.

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

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

STUDY LOAD

Type	Hours	Percentage
Self study	72,0	64.00
Hours large group	27,0	24.00
Hours small group	13,5	12.00

Total learning time: 112.5 h

CONTENTS

Topic 1: Introduction, structure and clarification

Description:
Brief history of polymer science and technology.
Technological importance of polymeric materials.
Idealization of the polymer chain, preliminary definitions.
Configuration and conformation of the chains: isomerisms, molecular architecture, chain mobility.
Classification based on thermomechanical behavior: thermoplastics, thermosets and elastomers.
Classification based on consumption: "Comodities", Engineering and special applications.

Related activities:
Suggested reading and discussion-debate in class.

Full-or-part-time: 5h 42m
Theory classes: 3h
Self study : 2h 42m

Topic 2: Synthesis: Polymerization and copolymerization

Description:
Preliminary definitions: Monomers, Coppers, monomer functionality, Repetitive unit vs. Structural unit, Homopolymers vs. Copolymers
Main polymerization mechanisms:
- In chain: radicalar, anionic and cationic.
- By steps: Polycondensation vs. Polyaddition
Main polymerization processes:
- Mass
- In solution
- In suspension
- In emulsion

Full-or-part-time: 8h 24m
Theory classes: 3h
Self study : 5h 24m

Topic 3: Dimensions of the chains

Description:
Solubility in polymers: good, poor solvent. Condition "teta" of a solvent.
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.

Full-or-part-time: 12h 36m
Theory classes: 3h
Laboratory classes: 1h 30m
Self study : 8h 06m

Topic 4: Thermal transitions and aggregation states.

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

Full-or-part-time: 4h 42m
Theory classes: 1h 30m
Self study : 3h 12m

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.

Full-or-part-time: 29h 24m
Theory classes: 7h 30m
Laboratory classes: 3h
Self study : 18h 54m

Subject 6. Strcture-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
Enviromental Stress Cracking (ESC).
Ductile-brittle transition in polymers.

Related activities:
Lab. 4

Full-or-part-time: 21h
Theory classes: 6h
Laboratory classes: 1h 30m
Self study : 13h 30m

Subject 7. Polymer viscoelasticity

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, Bruger). Isochrone and isobaric curves.
Responses to cyclic loading: Storage modules, loss, dissipation factor. Micromodelos employees.
DMTA assays in polymers.

Full-or-part-time: 30h 24m
Theory classes: 7h 30m
Laboratory classes: 3h
Self study : 19h 54m

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:
- McCrum, N. G.; Buckley, C. P.; Bucknall, C. B. Principle of polymer engineering. 2nd ed. Oxford [etc.]: Oxford University Press, 1997. ISBN 0198565267.
- Ehrenstein, Gottfried W. Polymeric materials : structure, properties, applications. Hanser Publisher, 2001. ISBN 9781569903100.
- Young, Robert J.; Lovell, Peter A. Introduction to polymers [on line]. 3rd ed. Boca Raton [etc.]: CRC Press, cop. 2011 [Consultation: 13/05/2020]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=1460729. ISBN 9781439894156.

Complementary:
- Ward, I. M.; Sweeney, J. An Introduction to the mechanical properties of solid polymers. 2nd ed. Wiley, 2005. ISBN 047149626X.
- Gilbert, Marianne. Brydson's plastics materials. 8th ed. Butterworth-Heinemann, 2016. ISBN 9780323358248.
- Physical properties of polymers handbook. 2nd ed. New York: Springer-Verlag, cop. 2007. ISBN 9780387312354.

RESOURCES

Other 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.