MATERIALS ENGINEERING AND NANOTECHNOLOGY (LM76R)

(Lecce - Università degli Studi)

Teaching SCIENCE,TECHNOLOGY AND SUSTAINABILITY OF POLYMERS

GenCod A006097

Owner professor Mariaenrica FRIGIONE

Teaching in italian SCIENCE,TECHNOLOGY AND

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SSD code ING-IND/22

Reference course MATERIALS ENGINEERING AND

Course type Laurea Magistrale

Credits 12.0

Teaching hours Front activity hours: 108.0

For enrolled in 2025/2026

Taught in 2025/2026

Course year 1

Language ENGLISH

Curriculum Percorso comune

Location Lecce

Semester Second Semester

Exam type Oral

Assessment Final grade

Open **Course timetable**

BRIEF COURSE DESCRIPTION

The course aims at providing students a comprehensive knowledge of Science and Technology of (natural, bio-based or synthetic) polymers: from their synthesis, to their processing procedures and techniques, their macroscopic and microscopic properties and characteristics in both solid and fluid states, their durability, degradation/biodegradation in different environmental conditions, LCA (Lyfe Cycle Assessment) techniques applied to polymeric materials and their final disposal. Specific examples of natural (i.e. wood), bio-based polymers and technologically advanced polymers, or classes of polymers, will be illustrated. Issues related to sustainability of polymers and the impact of (waste) microplastics/nanoplastics on (marine/soil) environment and on human health will be discussed, presenting case studies of innovative researches aimed at studying, preventing/limiting the environmental impact due to plastic waste. Part of the course will be devoted to the characterization methods and techniques for polymers, with related laboratory experiences.

REQUIREMENTS

Knowledge of disciplines belonging to a Bachelor Degree in Industrial Engineering or Materials Science are required to the Students: Chemistry, Physics and Science and Technology of Materials.

COURSE AIMS

Knowledge and understanding. Students must have a solid background with a broad spectrum of basic knowledge related to science, technology and sustainability of (natural, bio-based or synthetic) polymers:

- the students must have the basic cognitive tools to think analytically, critically and to correlate information's needed to analyze, characterize, process, select a polymeric material, identify for it an appropriate recycling route;
- they must have solid knowledge of science, technology and sustainability of (natural, bio-based or synthetic) polymers;
- they must be able to find and manage any information required on a specific (natural, bio-based or synthetic) polymer, or a blend of polymers, on textbooks, handbooks, database.

Applying knowledge and understanding. After the course the student should be able to:
1) Recognize the main differences, characteristics and features of the different classes of polymers, i.e. (amorphous or semi-crystalline) thermoplastic polymers, crosslinked (i.e. thermosetting,elastomers) polymers.
2) Select the appropriate technique and processing conditions for a specific (bio-based or synthetic) polymer, or a blend of polymers.
3) Identify the relationship between chemical-physical, microstructural characteristics and macroscopic properties of different polymers (including bio-based ones) belonging to the different classes of polymers.
4) Select a proper polymeric material, or a blend of polymers, for a specific application.
5) Select the proper range of service temperature for a polymer, or a blend of polymers.
6) Identify the proper methods and techniques required to characterize a specific polymer, or a blend of polymers, in relation to the final use/application.
7) Analyze the results of an experimental test aimed at characterizing a specific property of a (natural, bio-based or synthetic) polymer/blend of polymers.
8) Distinguish between the degradation and biodegradation processes, the conditions and environments in which these processes occur.
9) Propose a method/technique for the recycle of polymer waste in order to prevent them to be landfilled, thus reducing the negative impact of microplastics on environment and human health.

Making judgments. Students are guided to learn critically everything that is explained to them in class, to select the more appropriate solution (in terms of a polymer/blend of polymers for a specific application), a method/technique to characterize or process a (natural, bio-based,or synthetic) polymer/blend of polymers, a recycling procedure. The students will be also able to justify any choice in comparison with available alternatives, taking into account also the eco-sustainability implications involved in the different choices, according to the principles of the "Circular Economy".

Communication. The students must be able to communicate with a varied and composite audience, not culturally homogeneous, in a clear, logical and effective way and with the appropriate terms, using the methodological tools acquired and their scientific knowledge. The course promotes the development of the following skills of the student: ability to expose with the appropriate specialist vocabulary any topic related to science, technology and sustainability of polymers; ability to describe and analyze the proper solution for any specific application/requisite; ability to illustrate the results of an experimental test performed on a polymeric material, ability to discuss on issues related to their disposal with environmental implications.

Learning skills. Students must acquire the critical ability to relate, with originality and autonomy, to the typical problems of science, technology and sustainability of polymers, and in general, cultural

knowledge and methods learnt with a view to possible continuation of studies at higher (doctoral) level or in the broader perspective of cultural and professional self-improvement of lifelong learning. Therefore, students should be able to switch to exhibition forms other than the source texts in order to memorize, summarize for themselves and for others, and disseminate scientific knowledge.

TEACHING METHODOLOGY

The course consists of theory lessons, seminars, laboratory experiences, exercises, visits to industrial plants and/or research laboratories (when possible). The theory lessons, carried out by using slides of other didactic material made available to students a few days before the lesson, are aimed at improving their knowledge and understanding through the illustration of definitions, assumptions, models and methods; students are invited take part to the lesson with autonomy of judgment, by asking questions and presenting examples. The seminars are aimed at giving an insight on some selected (updated every year) topics on science and technology of polymers and on issues related to sustainability and environmental impact of plastic waste, to the use of polymeric materials in different industrial applications. The laboratory experiences are aimed at illustrating the main characterization techniques, testing machines and equipment employed to analyze and characterize polymeric materials. The exercises in classroom are aimed at illustrating how to analyze, report in a graph/table and critically discuss the results of an experimental test performed on a polymeric material. Visits to industrial plants and/or research laboratories (when possible) are aimed at illustrating the on field application of what the students learn during lessons.

ASSESSMENT TYPE

Final (oral) exam:

The student is asked to describe for a specific (natural, bio-based or synthetic) polymer, or a blend of polymers, one or more of the following: synthesis, appropriate processing techniques, main properties and characteristics, characterization measurements and techniques and discussion of relative results, applications, durability features, biodegradation paths, LCA and environmental impact, recycling alternative methodologies. The student is also asked to supply alternatives for a polymeric material, for a characterization technique or for a technological method taking into account a specific goal (application, characterization, recycling).

In the evaluation of the exam, the following elements will be taken into consideration: the logical route followed by the student in solving the proposed issue; the correctness of the procedure used to address the question and provide a solution; the adequacy of the proposed solution in relation to the competencies that the student is supposed to have acquired; the capacity to make connections among the different topics covered in the course; the use of an appropriate technical language.

OTHER USEFUL INFORMATION

Students can find information on the date and time of meeting with students on the website https://elearning.unisalento.it/.

Students can also contact Prof. Frigione by e-mail: mariaenrica.frigione@unisalento.it.

Students can apply for the exam on Web-VOL system.

FULL SYLLABUS

Theory Lessons:

1) Polymer's Chemistry. Molecular Structure of polymers. Polymeric solutions: rules for polymer solubility in solvents. Molecular weight and measurements. Gel Permeation Chromatography. Polymerization reactions. Step-growth polymerization. Chain polymerization.

2) Polymer's physics. Classification of polymers with examples. Glassy state of polymers. Characteristic temperatures for polymers. Glass transition temperature. Crystalline state of polymers.

3) Thermal characterization of polymers. Instruments and techniques for thermal analysis of polymers. Properties measured with thermal analysis.

4) Rheology and rheological analysis for polymer characterization. Classification of fluids on the basis of their rheological properties. Viscosity measurements and relative instruments. Rheological instruments employed for characterization of polymers.

5) Mechanical Properties of polymers. Standard tests and instruments for the characterization of the mechanical properties of polymers. Dynamic-mechanical properties.

6) Processing of polymers. Main industrial techniques and instruments for the processing of polymers. Characteristics of final products.

7) Durability and environmental aging of polymers. Chemical Aging. Physical Aging. Weathering. Natural and accelerated aging. Case studies.

8) Degradation and Biodegradation processes: conditions and environments, mechanisms. Biodegradable polymers.

9) Natural polymer (composite): Wood. Definitions, characteristics and properties of composite materials. Wood structure at different levels of magnitude. Influence of water/moisture content on wood properties. Mechanical properties of wood: standard tests, specimens, instruments and results. Durability of wood. Similarities and differences between synthetic polymer composites and wood.

10) Circular economy concepts applied to polymers. Bio-based polymers and bio-composites: production, properties, applications. Case studies.

11) LCA (Lyfe Cycle Assessment) techniques applied to polymeric materials. Issues related to sustainability of polymers, impact of polymer waste, macro/microplastics on the (ground/marine/air) environments and on human health. Issues related to nanoplastics. Case studies.

12) Recycling methodologies for polymers. Advantages and technological limits for each recycling method. Case studies for recycling of thermoplastic, thermosetting and elastomeric polymers. Innovative polymer recycling/reuse techniques.

Laboratory Experiences: Thermal, Mechanical characterizations of polymers.

Exercitations: analysis and discussion of the results from (thermal, mechanical) tests performed on different polymers.

Seminars held by experts.

Visits to industrial plants and/or research laboratories (when possible).

REFERENCE TEXT BOOKS

L.H. Sperling, 'Introduction to Physical Polymer Science', John Wiley, 2006.

F.W. Billmeyer, 'Textbook of Polymer Science', John Wiley & Sons Inc., 1984.

S. Bruckner, G. Allegra, M. Pegoraro, F. La Mantia, "Scienza e Tecnologia dei Materiali Polimerici", Edises, 2007.

U.W. Gedde, 'Polymer Physics', Chapman & Hall, 1996.

F. Rodriquez, 'Principles of Polymer Systems', McGraw Hill, 1989.

A.W. Birley, B. Haworth, J. Batchelor, 'Physics of Plastics', Hanser Publishers, 1992.

J. Mark, K. Ngai, W. Graessley, L. Mandelkern, E. Samulski, J. Koenig, G. Wignall, "Physical Properties of Polymers", Cambridge University Press.

Slides and other didactic material provided by the teacher.