UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Processi a Basso Impatto Ambientale

2627-2-F7503Q019

Aims

The course aims to provide the conceptual and methodological foundations for the analysis and design of low environmental impact processes, with particular reference to the principles of green chemistry, bioeconomy, and circular economy. The course also examines selected chemical processes currently recognized as consistent with these sustainable approaches.

Knowledge and Understanding
At the end of the course, students will be able to:

- describe the main parameters required to assess the environmental sustainability of chemical and industrial processes;
- understand and correctly define the concepts of green chemistry, circular economy, and bioeconomy;
- recognize the main scientific and technological challenges associated with the transition from a fossil-fuel-based economy to a green economy and sustainable bioeconomy model.

Applying Knowledge and Understanding
At the end of the course, students will be able to:

- apply the principles of green chemistry to the analysis of existing industrial processes;
- assess the environmental sustainability of chemical processes in relation to circular economy and bioeconomy criteria;
- interpret the contribution of studied processes to the Sustainable Development Goals of the UN 2030 Agenda.

Making Judgements
At the end of the course, students will be able to:

- critically evaluate the environmental compatibility of chemical and industrial processes;
- distinguish between processes based on a linear economy model and those consistent with circular

economy principles;
- formulate independent judgments on the sustainability of alternative technological solutions within the context of the bioeconomy.

Communication Skills
At the end of the course, students will be able to:

- correctly use scientific terminology related to green chemistry, biorefineries, renewable resources, biodegradable materials, and life cycle assessment;
- communicate concepts and definitions clearly and appropriately, also through applied examples;
- describe sustainable chemical processes using coherent and structured technical language.

Learning Skills
At the end of the course, students will be able to:

- integrate knowledge of chemistry, sustainability, and industrial processes for the analysis of complex systems;
- independently deepen topics related to the bioeconomy and ecological transition through scientific and regulatory sources;
- develop a critical and interdisciplinary approach to the study of low environmental impact chemical processes.

Contents

The course covers some of the most significant examples of environmentally compatible processes for the production of materials, fine chemicals, fuels, and energy, aimed both at reducing the environmental impact of industrial processes and at promoting product recycling. In particular, the concept of green chemistry will be introduced. Since the late 1980s, green chemistry has significantly contributed to reducing the environmental impact of several industrial processes. Subsequently, the concept of biorefinery will be explored, which envisions the progressive replacement of petroleum as a primary source of chemicals with renewable raw materials. The course will also address the biotechnological and energy-related aspects associated with biorefinery processes.

Detailed program

Principles and review of organic chemistry.
Principles and review of major natural organic compounds: sugars and polysaccharides, amino acids and proteins, lipids.
Fundamentals of petrochemistry and polymer chemistry. Issues related to material recycling and reuse.
Evolution of low environmental impact industrial synthesis from the 1950s to the present day, with selected examples.
The twelve principles of green chemistry and the evolution of the green chemistry concept. Concepts of carbon economy and carbon efficiency. Green chemistry metrics and Life Cycle Assessment (LCA).
Major renewable resources, with particular reference to the structure of lignocellulosic materials.
The concept of biorefinery, bioeconomy, and circular economy, with an in-depth focus on the main pretreatment methods of lignocellulosic biomass and examples of applications in Italy and Europe.
Synthesis of chemicals and new biodegradable and non-biodegradable materials from renewable resources using low environmental impact processes.

Prerequisites

Basic knowledge of Chemistry and Biology.

Teaching form

24 lessons (2 h) of Delivered Didactics in class

Textbook and teaching resource

Chapters book from:

- Slides
- Green Chemistry Theory and Practice PT Anastas 1998 Oxfod University Press,
- Introduzione alla Chimica Ambientale Bruno Rindone Città Studi Edizioni, 1996.
- Scientific Articles

Semester

2nd semester

Assessment method

Single oral examination (without in-course assessments), graded on a scale from 18 to 30/30 with honors. The oral examination is designed to assess the learning of the concepts delivered during the course, with particular reference to the development of the concept of green chemistry through the study of industrial processes, with special emphasis on biorefineries.

The final grade will range from 18/30 to 30/30 with honors, based on the overall assessment and taking into account the following learning criteria:

- knowledge and understanding
- applying knowledge and understanding
- making judgments
- communication skills
- learning skills

Grade < 18
Knowledge and understanding:
The student is unable to adequately describe the main parameters used to assess the environmental sustainability of chemical and industrial processes. Understanding of the concepts of green chemistry, circular economy, and bioeconomy is fragmented or incorrect. The challenges of the transition towards sustainable models are not recognized.

Applying knowledge and understanding:
The student is not able to apply the principles of green chemistry to the analysis of production processes or to interpret process sustainability in relation to circular economy and bioeconomy criteria.
Making judgments:
The student is not able to distinguish between linear and circular economic models nor to formulate assessments of process sustainability.
Communication skills:
Scientific language is inadequate. The description of concepts and processes is confused and lacks logical structure.
Learning skills:
The student shows difficulty in integrating knowledge and does not demonstrate the ability to independently deepen their understanding.

Grade 18–22
Knowledge and understanding:
The student provides an essential description of the main environmental sustainability parameters and demonstrates only partial understanding of the concepts of green chemistry, circular economy, and bioeconomy. The challenges of ecological transition are recognized only superficially.
Applying knowledge and understanding:
The student partially applies the principles of green chemistry and is able to provide simple assessments of process sustainability.
Making judgments:
The student only makes basic distinctions between linear and circular economy models and formulates partially coherent judgments on process sustainability.
Communication skills:
Scientific terminology is used in a simple and not always accurate way. Process descriptions are basic and poorly structured.
Learning skills:
The student demonstrates a basic awareness of their learning pathway, with limited ability to connect concepts.

Grade 23–27
Knowledge and understanding:
The student correctly describes the main parameters for assessing environmental sustainability and demonstrates a good understanding of green chemistry, circular economy, and bioeconomy. The main challenges of the transition towards sustainable models are recognized.
Applying knowledge and understanding:
The student appropriately applies the principles of green chemistry to the analysis of production processes and evaluates process sustainability in relation to circular economy and bioeconomy criteria.
Making judgments:
The student is able to distinguish between linear and circular economy models and to formulate generally coherent judgments on process and technology sustainability.
Communication skills:
The student uses appropriate scientific terminology and describes processes clearly and in a structured way, also through relevant examples.
Learning skills:
The student integrates knowledge effectively and demonstrates the ability to independently deepen topics, showing a generally critical approach.

Grade 28–30 with honors
Knowledge and understanding:
The student demonstrates complete and in-depth knowledge of the parameters used to assess the environmental sustainability of chemical and industrial processes. They understand and rigorously define the concepts of green chemistry, circular economy, and bioeconomy, critically recognizing the challenges of the transition towards sustainable models.
Applying knowledge and understanding:

The student independently and rigorously applies green chemistry principles to the analysis of complex processes, comprehensively assessing environmental sustainability in relation to circular economy and bioeconomy criteria, including references to the UN 2030 Agenda goals.
Making judgments:
The student critically evaluates the environmental compatibility of processes, fully distinguishes between linear and circular economic models, and formulates autonomous, well-reasoned, and coherent judgments on the sustainability of alternative technological solutions.
Communication skills:
The student demonstrates full command of scientific terminology related to green chemistry, biorefineries, renewable resources, biodegradable materials, and Life Cycle Assessment (LCA). The oral presentation is clear, rigorous, structured, and supported by relevant examples.
Learning skills:
The student demonstrates a high level of autonomous and interdisciplinary learning, integrating chemical, environmental, and industrial knowledge and developing an advanced critical approach to sustainable process analysis.

Office hours

Every day. It is necessary to fix the meeting by E-mail

Sustainable Development Goals

DECENT WORK AND ECONOMIC GROWTH | INDUSTRY, INNOVATION AND INFRASTRUCTURE | RESPONSIBLE CONSUMPTION AND PRODUCTION | CLIMATE ACTION