UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Valorisation Strategies for Sustainable Resources

2627-2-F7603Q007-F7603Q00701

Aims

The course provides the knowledge and methodological foundations for understanding the principles that define sustainable production and that follow the concepts of sustainable and/or "green" chemistry. The course presents the basic concepts, namely the 12 principles of Green Chemistry, and their real-world manifestations in the form of modern processes and practices in research and development, as well as in production within areas that rely on or include chemical transformations of sustainable resources, both natural and synthetic in the form of Novel Entities, including through a discussion of recycling/recovery processes.

Knowledge and Skills
Upon completion of the course, students should demonstrate a solid understanding of:
• The main parameters to evaluate to define a low environmental impact process.
• Green Chemistry.
• The connections between sustainable and/or green processes and the circular economy.
• The scientific challenges associated with the transition from a petroleum-based economy to a bioeconomy.
• The concept and implementation of the biorefinery and the generation of platform chemicals from renewable sources.

Applied knowledge and understanding
At the end of the course, students will demonstrate the ability to:
• apply the Green Chemistry concepts learned in the course, which form the basis of sustainable development.
• judge whether a process qualifies as 'green' and/or sustainable.
• describe sustainable processing methods.
• understand the concept of the biorefinery and the current opportunities and challenges in the field.

Making judgments
At the end of the course, students will demonstrate the ability to:
• apply the knowledge acquired in various contexts.
• transfer the concepts and approaches introduced in a given context to related fields.
• elaborate on the concepts of sustainable and green processing discussed in the course.

• analyze the life stages of a product or process.
• critically evaluate the results obtained from the application of models.
• identify possible interventions to reduce impacts.

Communication Skills
By the end of the course, students should demonstrate the ability to:
• analyze a chemistry problem clearly and concisely.
• explain orally, using appropriate language, the objectives, methods, and results of the calculations performed.

Learning Ability
By the end of the course, students should be able to apply the knowledge acquired to contexts other than those presented during the course and understand how sustainability topics are addressed in the scientific literature and in the manufacturing industry.

Contents

• The concepts of Green Chemistry and sustainable chemistry, their similarities and differences.
• The concept of biorefinery for the production of sustainable raw materials.
• Responsible and sustainable use of non-renewable resources such as metals, aspects of recycling within a circular economy.
• The reactivity of chemical compounds in the environment.
• Sustainable processes for the production of standard materials, platform chemicals, and high-performance materials.
• Sustainable processes in the field of chemistry for the production of chemical products.
• Sustainability in the field of nanomaterials.
• Recycling processes.

Detailed program

• Evolution of sustainability in industrial syntheses based on selected examples.
• Evolution of the concepts of Green Chemistry and sustainable chemistry.
• Similarities and differences between 'green' chemistry and sustainable chemistry.
• Description of the main renewable resources suitable for replacing petroleum as the main source of raw materials for the chemical industry, with particular reference to the structure of lignocellulosic materials.
• The concept of biorefinery with examples and applications, also in light of the circular economy.
• Synthesis of chemicals from renewable sources with sustainable processes.
• Sustainable and/or 'green' concepts for carrying out chemical reactions, such as flow chemistry.
• Sustainable processes in chemistry-related fields: point-of-care devices, organ-on-a-chip, model organisms.
• Synthesis and advantages of sustainable nanomaterials and associated regulatory aspects.
• Synthesis of new biodegradable and non-biodegradable materials from renewable sources with sustainable processes.
• Recycling, downcycling, and upcycling as tools for the circular economy.
• The integration of sustainable processes within the circular economy and their implementation.
• Description of the challenges associated with recycling and reuse processes for various materials, with examples of recycling processes for organic and inorganic materials; the concept of urban mining.
• Sustainable mining activities.
• Distribution of elements in various environments using (anthropo)biogeochemical cycles.
• Case studies.

Prerequisites

• Basic knowledge of organic and inorganic chemistry and biology.

Teaching form

• 3 CFUs of theoretical lessons in the classroom (48 hours):
-> 10 two-hour lectures, in person, Delivered Didactics;
-> 2 two-hour lectures, in person, reading and discsussing scientific articles in aula, Mixed / interactive Didattics / Seminar.
• Case studies, to be prepared during the lessons by the students in groups according to various schemes, with final discussions together.

Textbook and teaching resource

• M. Aresta, A. Dibenedetto, F. Dumeignil
Biorefineries – An introduction
De Gruyter
• P.T. Anastas
Green Chemistry - Theory and Practice
Oxfod University Press
• slides
• notes shown during lectures and additional material on selected topics, i.e., scientific articles, made available on the e-learning website of the course.

Semester

I semester (October - January)

Assessment method

The final exam consists of an oral exam at the end of the course, with a score between 18-30/30 *cum laude*, which consists of the discussion of various topics discussed during the lessons, linking the concepts to an industrial process or to a new biorefinery or green chemistry process presented in a scientific article, to arrive at a critical evaluation of the presented process from the point of view of overall sustainability.
The discussion of the exam is based on a short 10-minute powerpoint presentation that must be prepared by the student for the exam; the article and / or documentation of the process to be evaluated will be sent to the student one week before the exam.

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

conceptual knowledge and understanding
ability to apply knowledge and understanding
communication and argumentation skills
learning, self-assessment, and self-regulation skills

Grade < 18
Knowledge and Understanding: The student only partially identifies the characteristics of the concepts. The connections between the concepts are fragmented and poorly supported by theoretical knowledge.
Ability to apply knowledge and understanding: The student identifies only a few relevant elements in a phenomenon, unable to integrate them into a coherent analysis.
Communication and Argumentation Skills: In the oral exam, the student develops a basic argument, lacking logical structure and characterized by numerous expository inaccuracies.
Learning, self-assessment, and self-regulation skills: The student is able to reconstruct only some aspects of their learning and professional development journey.

Grade 18-22
Knowledge and Understanding: The student recognizes and explains most of the conceptual features and is able to provide a relatively coherent explanation, albeit with some inaccuracies. Theoretical references are present but not always rigorously.
Ability to apply knowledge and understanding: The student is able to recognize a significant number of elements and provide a partial explanation, while highlighting some gaps in the analysis.
Communication and argumentation skills: In the oral exam, the student constructs a basic argument, with a minimal structure but with some inaccuracies.
Learning, self-assessment, and self-regulation skills: The student demonstrates a basic awareness of their learning path, managing to draw essential connections between learning experiences, albeit with some inaccuracies.

Grade 23-27
Knowledge and Understanding: The student demonstrates a thorough understanding of conceptual characteristics. In the oral exam, explanations are well-articulated and supported by an appropriate use of theoretical references.
Ability to apply knowledge and understanding: The student accurately identifies the essential elements of a phenomenon. The application of knowledge occurs with methodological rigor that is not always solid.
Communication and argumentation skills: In the oral exam, the student develops a coherent and well-organized argument, demonstrating good command of language and a solid logical-argumentative structure. Communication is clear and effective.
Learning, self-assessment, and self-regulation skills: The student analyzes his or her learning journey in a clear and structured manner, highlighting significant relationships between the various developmental stages and demonstrating a good capacity for critical reflection.

Grade 28-30
Knowledge and Understanding: The student demonstrates a thorough mastery of concepts, articulating complex connections and providing comprehensive explanations. Theoretical references are used with relevance and rigor.
Ability to apply knowledge and understanding: The student demonstrates an advanced ability to analyze a phenomenon, comprehensively identifying and interpreting all salient elements. Knowledge is applied with methodological rigor, supported by solid and detailed argumentation.
Communication and argumentation skills: In the oral exam, the student develops a solid and detailed argument, with a rigorous logical structure and a high level of textual coherence. The presentation is fluent and well-structured.
Learning, self-assessment, and self-regulation skills: The student demonstrates an advanced capacity for self-reflection, developing a detailed and in-depth analysis of their learning and professional development journey. The connections between learning experiences and theoretical concepts are clear, coherent, and rigorous.

Office hours

Always, after scheduling an appointment *via* phone or e-mail.

Sustainable Development Goals

QUALITY EDUCATION | SUSTAINABLE CITIES AND COMMUNITIES | RESPONSIBLE CONSUMPTION AND PRODUCTION