UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Catalysis for Energy and The Environment

2627-1-FSM02Q019

Aims

The student will acquire the theoretical, conceptual, and methodological fundamentals on the key aspects and applications of catalysis, in particular for the fields of environment and energy transition.

Key knowledge and understanding

At the end of the course the student knows:

- the fundamentals of homogeneous and heterogeneous catalysis;

- the fundamentals of photocatalysis and electrocatalysis;

- preparation methods of homogeneous and heterogenous catalysts;

- characterization methods of catalytic activity and selectivity;

- methods to identify the reaction mechanisms, including kinetic and spectroscopic techniques;

- the main applications of catalysis in the fields of energy, chemical industry, biochemistry, environment, etc.

- the main research areas in the field of catalysis for environment and energy applications and their challenges.

Applying knowledge and understanding

At the end of the course the student is able to:

- Recognize the added value of catalysis and its importance in accelerating chemical reactions, choose the most suitable characterization techniques, identify the rate limiting step of a chemical reaction and how to design a catalyst to speed them up;

- Evaluate the most suitable kind of catalyst of a given chemical reaction and identify the most suited design tools.

The final goal of the course is to make the student able to apply the acquired knowledge to contexts different from those presented during the course, and to understand the topics covered in the scientific literature concerning the chemical aspects of catalysis.

Independent thinking

At the end of the course the student is able to:

- Recognize the potential of catalysis for immediate practical applications in the chemical, energy and environmental industries;

- Recognize the innovative potential of research potential long-term effects of research in the field of catalysis.

Communication skills

At the end of the course the student has learned how to describe in a technical report the main advances in a given catalytic process and to clearly and synthetically explain the objectives, procedures and results of the analysis carried out with adequate scientific language.

Contents

- Fundamentals of catalysis: kinetics of reaction, reaction mechanisms, role of catalysis

- Catalysis classification: homogeneous catalysis, heterogeneous catalysis, photocatalysis, electrocatalysis: differences and analogies, representative examples

- Synthesis and characterization of catalysts, catalytic activity and selectivity, measurement of catalytic properties

- Applications of catalysis with particular emphasis to energy and environmental applications.

Detailed program

1. Fundamentals: what is catalysis?

Chemical kinetics, catalysis and reaction mechanisms: reaction rate limiting steps

2. Catalysis classification

Homogeneous catalysis

Heterogeneous catalysis

Photocatalysis

Electrocatalysis

3. Catalyst preparation and characterization

Preparation of catalytic materials

Catalytic activity and selectivity

Measurement of catalytic properties

4. Applications of catalysis

Catalysis for chemical, automotive, food and pharmaceutical industries

Catalysis for the environment and to reverse climate change

Catalysis for energy conversion and storage

Prerequisites

Basic knowledge of general chemistry, molecular chemistry, solid state chemistry, and spectroscopy.

Teaching form

18 two-hour lectures in person, Delivered Didactics.
6 two-hour lectures with presentation and discussion of students' scientific projects on the topic of catalysis, in person, Interactive Teaching.

Textbook and teaching resource

Slides presented and suggested reading therein.

Semester

First semester.

Assessment method

The assessment method consists in an evaluation of the fundamental concepts presented in the lectures and in the preparation of a final project on a topic selected among the ones proposed related to catalysis in the field of sustainable energy, environmental chemistry, new innovative materials, etc.

The assessment of the fundamental concepts presented in the lectures will take place through short tests.

The final project will be evaluated with respect to the following aspects:

1. The process of project selection, bibliographical search, outlining, preparing a draft and incorporating feedback, to assess the student autonomy and organizational skills.

2. The oral presentation, in class or during the exam session, to evaluate the student's presentation skills and the ability to identify particularly promising advances in a given catalysis sector.

3. The in-class presentation will be followed by an open discussion, with questions and argumentation, to evaluate the level of acquired knowledge and the autonomy of analysis and judgment.

The presentation and discussion can take place in Italian or English at the choice of the student.

The final grade, expressed in thirtieths with possible “laude”, is the weighted average of the grades of the different evaulations (tests 25%, final project 75%).

Office hours

Any working day by appointment and availability of the teacher.

Sustainable Development Goals

AFFORDABLE AND CLEAN ENERGY | RESPONSIBLE CONSUMPTION AND PRODUCTION | CLIMATE ACTION