UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Chimica Organica per l'Energetica Sostenibile

2526-1-F5402Q013

Aims

To provides an overview on organic and hybrid systems potentially exploitable in the production, conversion andstorage of energy using renewable energy sources.

O1 – knowledge and understanding

To the student is requested to show an adequate comprehension and skills of organic chemistry:

1) To recognize and to understand which are the organic systems or bonds where it is possible to store energy.

2) To recognize which type of energy is possible to store.

3) To recognize and to understand which organic chemical structure are able to interact with electromagnetic radiation (sun light) and useful in the production of renewable and environmental friendly fuels

4) To understand which organic systems are potentially exploitable in hydrogen or energy storage

5) To understand the principal photophysical and photochemical processes involved in the absorption of electromagnetic radiation (UV/Vis light) and useful in the energy storage and in the production of renewable fuels.

O2 – Applying knowledge and understanding

The student, during the assessment method has to demonstrate an adequate capability of applying the knowledge and understanding of the provided concepts:

1) To individuate organic systems or bonds where it is possible to store energy.

2) To individuate which type of energy is possible to store.

3) To individuate organic chemical structures are able to interact with electromagnetic radiation (sun light) and useful in the production of renewable and environmental friendly fuels

4) To individuate the chemical properties of organic systems useful for energy saving and competitive with convention inorganic ones (organic light emitting diodes).

5) To individuate which organic systems are potentially exploitable in hydrogen storage

6) To individuate the principal photophysical and photochemical processes involved in the absorption of electromagnetic radiation (UV/Vis light) useful to energy storage and to production of renewable fuels.

O3 – Making judgements

To be able to conduct a reasonable analysis on organic systems with potential utility in energy saving and environmental issues.

O4 –Communication skills

To be able to show and identify organic systems of interest for energy and environmental sustainability also illustrating the protocols for their preparation with an appropriated language.

O5 –Learning skills

To be able to apply the acquired knowledge to energy and environmental sustainability issues.

Contents

The course aims to provide an overview of molecules and polymers for the production, conversion and storage of energy with a relatively low environmental impact starting from renewable energy sources. The course describes: a) organic-polymer based systems for energy transport and storage; b) organic (molecular or polymeric) and organometallic based systems for photovoltaic applications; c) organic and organometallic based systems for the production of solar fuels by water photo-splitting processes or CO2 reduction for the production of E-Fuels; d) organic and organometallic based systems for energy storage.

Detailed program

Overview on systems used for energy production, conversion and storage. Concept of chemical energy and its application in planning organic systems for energy storage. Beckon of molecular design and main supramolecular interactions in organic materials for energy applications. Beckon of photochemistry (light-matter interaction and photoactivated processes). Conductive polymers and applications in the field of energy transport and storage. Systems for photovoltaic applications (dye-sensitized solar cells, organic photovoltaics, perovskite solar cells, tendem cells). Systems for hydrogen production via water photosplitting and photocatalytic reduction of water, systems for the production of hydrocarbons (methane or C2+) from carbodioxide and solar energy. Organic and/or organometallic systems mimic the photosynthesis in the production of fuels (solar fuels). Organic materials for energy storage and different possible redox systems for the production of organic batteries alternative to Li/Li+ ones. Redox flow batteries. Notes on organic systems for hydrogen storage.

Prerequisites

For an optimum understanding of the topic treated, a consolidated organic chemistry background is required together with basic knowledge on the interaction of electromagnetic radiation with the matter or molecules (excited states, relaxation mechanisms, absorption and emission properties)

Teaching form

22 two-hour lectures, in person, Delivered Didactics
2 two-hour practical classes in person in delivered mode in the initial part aimed at involving students interactively in the next part. Mixed teaching.

Textbook and teaching resource

H. Tian, G. Boschloo, A. Hagfeldt, Molecular Devices for Solar Energy Conversion and Storage, Springer, 2018 (https://doi.org/10.1007/978-981-10-5924-7)
Notes, slides and articles provided by the lecturers

Semester

I year and II semester

Assessment method

Oral examination is the assessment method employed to check the level of understanding of the concepts taught during the course. Questions will ask to the student regarding the entire topic treated during the course. A mark will be proposed to the student expressed in thirtieths. The exam is passed with a minimum mark of 18/30. From 2016/2017 academic year, the positive final examinations show an average mark of 27.9/30; minimum mark 24/30 and a maximum mark 30 with honors. On request, the assessment can be hold in English.

The following level of judgment is applied in relation to the following parameters:

1. Conceptual knowledge and understanding ability
2. Ability to apply knowledge and understanding
3. Communication and argumentation skills
4. 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 some relevant elements in a phenomenon, without being able to integrate them into an organic analysis.

Communication and argumentation skills

In the oral exam, the student develops an essential argument, lacking logical articulation and characterized by numerous expository inaccuracies.

Learning, self-assessment and self-regulation skills

The student is able to reconstruct only some aspects of his/her learning and professional development path.

Score 18-22

Knowledge and Understanding

The student recognizes and returns most of the conceptual characteristics and is able to provide a relatively coherent explanation, although 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, although 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 his/her learning path, managing to trace essential connections between the formative experiences, although with some inaccuracies.

Score 23-27

Knowledge and Understanding

The student demonstrates an in-depth understanding of the conceptual characteristics. In the oral exam, the explanations are well-structured and supported by an adequate 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 a methodological rigor that is not always solid.

Communication and argumentative skills

In the oral exam, the student develops a coherent and well-organised argument, demonstrating good command of the language and a solid logical-argumentative structure. Communication is clear and effective.

Learning, self-assessment and self-regulation skills

The student analyses his/her learning path in a clear and structured way, highlighting significant relationships between the different evolutionary stages and demonstrating a good capacity for critical reflection.

Score 28-30

Knowledge and Understanding

The student demonstrates a complete mastery of the concepts, articulating complex connections and providing exhaustive 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, identifying and interpreting all the salient elements in an exhaustive manner. The application of knowledge occurs with methodological rigor, supported by a solid and articulated argument.

Communication and argumentative skills

In the oral exam, the student develops a solid and articulated argument, with a rigorous logical structure and a high level of textual coherence. The speech is fluid and well-structured.

Learning, self-assessment and self-regulation skills

The student demonstrates an advanced ability to self-reflect, developing a detailed and in-depth analysis of his/her own learning and professional development path. The connections between training experiences and theoretical concepts are clear, coherent and rigorous.

Office hours

Prof. Manfredi receives students every day.
Prof. Abbotto receives students every day.
Students must fix an appointment in advance

Sustainable Development Goals

AFFORDABLE AND CLEAN ENERGY | SUSTAINABLE CITIES AND COMMUNITIES