UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Fundamentals of Electrochemistry for Energy Storage

2627-1-FSM02Q017

Aims

The course aims to provide students with the principles and bases to understand the behavior of electrochemical technologies for energy conversion and storage, and to place them in the broader context of the current energy scenario.

Knowledge and understanding
At the end of the course, the student knows:

- Basic concepts of electrochemical systems (electrolytes, electrodes, transport phenomena, electrified interface theory).
- Main technologies for electrochemical energy storage (supercapacitors, batteries), their nature and composition.
- Electrochemical analysis techniques of the aforementioned devices (constant current analysis, voltammetry, impedance spectroscopy).

Applying knowledge and understanding
At the end of the course, the student is able to:

- Understand the main electrochemical phenomena and the nature of electrochemical devices.
- Apply the acquired knowledge to critically evaluate the choice of materials in different electrochemical energy storage devices, considering their structural, electronic and functional properties.
- Assemble an electrochemical device, preparing electrolytes and electrodes.
- Understand and perform analyses on the various components of a storage system (electrolyte, anode and cathode)

Making judgments
At the end of this course, the student must demonstrate the ability to:

- Demonstrate mastery of the topics covered in the course

- Understand the operating principle of an electrochemical energy storage device
- Demonstrate the ability to critically analyze electrochemical data collected in the laboratory. This also includes the ability to organize the data in a scientific paper.

Communication skills
At the end of this activity, the student will be able to orally and with proper language skills present the scientific topics related to energy storage systems. The student will also be able to produce a written paper related to the laboratory experiments.

Learning skills
Upon completion of the course, the student is able to:

- Independently deepen their knowledge of electrochemical energy storage materials and devices through scientific literature and specialist resources.
- Constantly update themselves on research developments and technological evolution in the field of electrochemical storage systems.
- Critically evaluate new information and data in the sector, to support decision-making and problem solving.
- Develop a multidisciplinary approach to the study and understanding of electrochemical energy storage systems, integrating principles of materials science, chemistry and engineering.
- Effectively continue their learning path both in academic and professional settings, particularly in the field of energy storage technologies.

Contents

Thermodynamic and kinetic principles of the ionic conductors and electrochemical interfaces will be presented and the method for their electrochemical characterization discussed. The electrochemical technologies for energy conversion (fuel cells, electrolyzers, primary batteries) and storage (secondary batteries, supercapacitors) will be classified and the basic reaction mechanisms discussed.

Detailed program

Introduction to the basic ideas of electrochemical cells and elements (electrodes, electrolytes). Fundamentals of electrochemical thermodynamic and the electrochemical equilibrium at the electrode interface. Type of electrodes and IUPAC definitions in electrochemistry. Kinetic treatment of simple electrochemical reactions at the electrode. Charge transfer control and the mass transport problem. Electrolytes classification, conductivity, and mobility. The solid crystalline electrolyte.
Problems and solutions in experimental electrochemistry. Electrochemical methods, DC chrono methods and potential sweeps methods. Fundamentals of electrochemical impedance spectroscopy.
Galvanic cells and electrolyzers. Energy and power of electrochemical power sources. The Ragone plot, open and closed systems. Fuel cell classification and fundamentals of fuel cell thermodynamic. The current potential characteristic of an ideal fuel cell. Primary and secondary batteries, the general battery scheme, and the role of the electrolyte. Discharge curves in batteries. Efficiencies in secondary batteries. Electrochemical double layer capacitors, current potential curves. The concepts of super- and pseudo-capacitors.

Prerequisites

Standard physic and mathematic knowledge , thermodynamic and kinetic of chemical systems

Teaching form

The teaching method is divided into lectures (5 CFU) and laboratory experiences (1 CFU). The lectures will be supported by multimedia teaching material. The laboratory consists of shared experiences (groups of 3 - 5 students) on the topics covered during the course.

Textbook and teaching resource

Teacher's slides and slected chapters from the following books:
Bockris Reddy, Modern Electrochemistry 1 – Ionics (second edition) chapter 4
Bockris Reddy Gamboa-Aldeco, Modern Electrochemistry 2A – Fundamental of Electrodics (second edition), chapters 6,7
Bard Faulkner: Electrochemical Methods, Fundamental and Applications (2° Edition), chapters 3,4
Selected scientific papers

Semester

I semester

Assessment method

The main exam will be held in oral mode and will be related to the topics covered during the course. A paper produced at the end of the laboratory experiences (constructed along the lines of a scientific article) will also be evaluated to contribute to the judgment.

Office hours

on appointment

Sustainable Development Goals

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