

Electrochemistry in Energy Applications, 4.0 credits

Electrochemistry in Energy Applications, 4.0 hp

Third-cycle education course

6FITN32

Department of Science and Technology

Valid from: First half-year 2024

Approved by
The Board of PhD Studies

Approved
2024-10-17

Registration number

Entry requirements

Entry requirement for studies on third-cycle education courses

- second-cycle degree,
- 240 credits in required courses, including at least 60 second-cycle credits,
or
- acquisition of equivalent knowledge in some other manner

The ground knowledge of chemistry and/or solid state physics is required to enter the course.

Learning outcomes

By the end of the course the students will be able to navigate in a variety of the phenomena happening on electrodes.

Knowledge and understanding

The students will get the basic knowledge on:

the principles of direct interconversion of electrical energy to chemical energy;

the basics of the thermodynamic and kinetics of electrode reactions;

the basic operational principles of electrochemical energy devices (e.g. batteries, fuel cells and electrolyzers).

Competence and skills

The students will acquire the basic competence in electrochemical methods

Judgement and approach

The students will be able to predict the energetics of electrochemical reactions

Contents

The course provides simplified insights of all ground-level electrode phenomena including electrode kinetics, ion transport, diffusion as well as electrode materials with emphasis of electrical energy storage.

The course comprises 8 lectures of different formats + 2 discussion sessions + 2 practical sessions.

Session 1: Basics. Thermodynamics and electrochemistry

Session 2: Experimental techniques. Electrochemical experiments; electrodes; pulsed techniques; voltammetry;

Session 3: Electrode kinetics. Double layer; faradaic reactions; Tafel slopes; exchange current; standard heterogeneous rate constant; overpotentials; electrocatalysis in energy conversion; mass transport limitation; hydrodynamic electrodes.

Session 4: Ionic transport and membranes. Transport of ions – general; diffusion and migration; conductivity and mobility; osmosis and electroosmosis in membranes; size and ion selectivity in membranes; nanochannel conduction phenomena; diffusion polarization; characterization and types of membranes; membrane applications.

Session 5: Discussion.

Session 6: Electrochemical devices: batteries and supercapacitors.

Batteries, supercapacitor and pseudocapacitors; Ragone plot, specific capacity, specific energy, specific power, ESW; charge storage mechanism in batteries and supercapacitors; advanced rechargeable batteries: An overview.

Session 7: Electrochemical devices: fuel cells and electrolyzers. Fuel cell principles and types; fuel cell performance; principles, types and performance of hydrogen electrolyzers; redox flow batteries.

Session 8: Electrochemical impedance spectroscopy. Basics.

Session 9: Electrode materials. Carbon materials; conducting polymers; redox charge storage.

Session 10: Discussion on papers

Session 11: Experimental session: 'half-cell'. Cyclic voltammetry; electrochemical impedance.

Session 12: Experimental session: 'device'. Supercapacitor cell; fuel cell operation

Educational methods

Educational methods applied in this course are based on combination of classical lectures, lectures with real-time drawings, discussions and practical sessions. The four lecturers involved in the course deliver sessions with four different formats of presentation. The sessions are performed on hybrid mode (physical in parallel to on-line). The materials are provided after each session.

Examination

The examination is oral in a form of real-time oral interview (physical or on-line) of each individual student carried out by two lecturers. The questions of the interview are related to the general phenomena on the electrodes. The interviews are carried out without preparation. Re-examination is possible as a repeat of the interview.

Change of examiner

Students who have failed the course or part of the course twice are entitled to request another examiner for the following examination occasion.

Course certificate

On the student's request, course certificate is issued by the course examiner.

Grading

Two-grade scale

Course literature

1. A. Bard, L. Faulkner. Electrochemical Methods: Fundamental and Applications. 2000, 2nd Edition, Wiley
2. Application notes of the companies-providers of electrochemical equipment (BioLogic, Gamry, Pine, Metrohm-Autolab).

General information

The course is planned and carried out according to what is stated in this syllabus. Course evaluation, analysis and suggestions for improvement should be fed back to the Research and PhD studies Committee (FUN) by the course coordinator.