PhD student course

Microbial electrochemical technologies – fundamental aspects and methods of analysis

The purpose of this course is to give an introduction to microbial electrochemical technologies (METs). Focus is placed on fundamental concepts in electrochemistry and electrochemical methods that are useful in the study of METs.

Teaching method

The course is divided into seven weekly sessions. The first three sessions focus on basic electrochemistry. The last four sessions focus more specifically on microbial electrochemical technology and introduces different electrochemical methods of analysis for such systems. Each session consists of one weekly meeting and a set of exercises for the student to complete on their own. The weekly meetings start with a discussion of the previous week's exercises (if needed), which is then followed by a lecture on the upcoming week's topic.

Learning goals

Upon completion of this course the student should be able to:

- Use knowledge about the relationships between units of charge, current, voltage, power and energy to calculate the flow of charge and conversion of energy in electrical circuits.
- Account for some common uses of electrochemical systems in society.
- Calculate the electromotive force and electrode potential in different electrochemical systems given information about reactants and products.
- Use equations describing electrode reaction kinetics to describe relationships between current and overpotential in electrochemical systems.
- Account for different types of microbial electrochemical technologies (METs).
- Use polarization curves to analyze the performance on METs.
- Calculate the efficiency and turnover rates of reactants and products in METs.
- Use a potentiostat to control an electrochemical system.
- Use cyclic voltammetry to analyze electrode reactions.
- Use electrochemical impedance spectroscopy to analyze electrochemical systems.

Course plan

Week 1: Basic concepts

1. Units: Charge, current, voltage, energy
2. Basic electrical circuits: Ohm's law, resistors in series and parallel
3. Introduction to electrochemical systems: Terminology, common uses

Week 2: Thermodynamics of electrochemical systems

1. Gibb's free energy
2. Half-reactions
3. emf
4. Reduction potentials and the Nernst equation
5. Reference electrodes

6. Potential losses, overpotentials, internal resistance

Week 3: Kinetics of electrochemical reactions

1. Activation energy and catalysts
2. Electrode reaction kinetics
3. The Butler-Volmer equation
4. Tafel plots

Week 4: Types of microbial electrochemical reactors

1. Applications
2. Electrode materials
3. Reactor designs

Week 5: Methods and analysis 1

1. Polarization curves
2. How do we analyze a microbial electrochemical system?

Week 6: Methods and analysis 2

1. Instrumentation – the potentiostat
2. Voltammetry
3. Use of linear sweep and cyclic voltammetry in microbial electrochemical systems

Week 7: Methods and analysis 3

1. Electrochemical impedance spectroscopy