Course Syllabus

Department/Faculty
School of Engineering

Graduate Program
Materials Engineering and Nanotechnology

Degree
☒ Academic Master's ☒ Doctorate (PhD) ☐ Professional Master's

Course Name
Advanced Electrochemistry

Professor
Prof. Dr. Cecília de Carvalho Castro e Silva

Office hours
48

Course Overview

The course addresses the definitions and fundamental concepts of electrochemistry, including models for the formation of the electrical double layer, charge transfer kinetics, empirical equations such as Butler–Volmer and Tafel, Marcus theory of electron transfer, and various overpotentials (activation, ohmic, and mass transport). It explores faradaic processes at electrode interfaces, experimental methods for studying solid/liquid interfaces and charge transfer kinetics, as well as electrochemical devices for charge storage. The course also covers sensors and biosensors with electrochemical detection.

Topics outline

1. Definitions and fundamental concepts;
2. Electrochemical interfaces: formation of the electrical double layer (models);
3. Charge transfer kinetics; empirical equations: Butler–Volmer and Tafel;
4. Marcus theory of electron transfer;
5. Overpotentials: activation, ohmic, and mass transport;
6. Faradaic processes at electrode interfaces;
7. Electrochemical instrumentation (potentiostatic, galvanostatic, and potentiometric techniques);
8. Experimental methods for studying the solid/liquid interface and charge transfer kinetics (linear and cyclic sweep voltammetry, pulse voltammetric techniques, and electrochemical impedance spectroscopy);
9. Determination of mechanisms in electrocatalytic reactions;
10. Electrochemical devices for charge storage and chemical sensing (basic principles of lithium-ion batteries, supercapacitors, and electrochemical sensors and biosensors).

Classes will include both lectures and laboratory sessions.

Letter Grade Assignment
Grade A (Excellent) - Grade points between 9 and 10
Grade B (Good) - Grade points between 8 and 8.9
Grade C (Satisfactory) - Grade points between 7 and 7.9
Grade D (Unsatisfactory) - Grade points between 0 and 6.9

Texts, Materials, and supplies

Basic bibliography

- COMPTON, R. G.; BANKS, C. E. *Understanding Voltammetry*. 3rd ed. World Scientific Publishing Europe, 2018.
- ELIAZ, N.; GILEADI, E. *Physical Electrochemistry: Fundamentals, Techniques, and Applications*. 2nd ed. John Wiley & Sons, 2019.
- BARD, A. J.; FAULKNER, L. R. *Electrochemical Methods: Fundamentals and Applications*. 2nd ed. New York: Wiley, 2001.
- BRETT, A. M. O.; BRETT, C. M. A. *Electroquímica: Princípios, Métodos e Aplicações*. Coimbra: Almedina, 1996.
- CIUCCI, F. *Modelling Electrochemical Impedance Spectroscopy*. *Current Opinion in Electrochemistry*, vol. 3, pp. 132–139, 2019.
- PAJKOSSY, T.; JURCZAKOWSKI, R. *Electrochemical Impedance Spectroscopy in Interfacial Studies*. *Current Opinion in Electrochemistry*, vol. 1, pp. 53–58, 2017.

Supplementary Bibliography:

- MEMMING, R. *Semiconductor Electrochemistry*. 2nd ed. Germany: John Wiley & Sons, 2015.
- Review articles from the current scientific literature.