Course name: Electrochemical systems (Undergraduate-level)

This course aims to provide a basic overview of principles in electrochemistry for undergraduate students. Students will be introduced with basic concepts in electrochemistry, including thermodynamics, kinetics, diffusion and migration. We will also discuss classic characterization techniques including cyclic voltammetry, bulk electrolysis, and electrochemical impedance spectroscopy. Applications such as catalysis and energy storages will be discussed during the instruction.

Part I: Introduction

Week 1 Theory and principles. Concepts of electrochemical potentials. Butler-Volmer equations

Week 2 Mass transport equation of species in solution. Diffusion-layer model.

Week 3 Experimental setups. Potentiostats; three-electrode setup; supporting electrolyte; series resistance.

Exercises 1

Part II: Homogeneous electrochemistry

Week 4 Basics of cyclic voltammetry.

Week 5 Coupling electron transfer and chemical reaction. Proton-couple electron transfer (PCET) reactions.

Week 6 Molecular electrocatalysis. How to understand kinetics from cyclic voltammetry.

Exercises 2

Part III: Heterogeneous electrochemistry

Week 7 Electrochemical double layers. Batteries, super-capacitors, and pseudo-capacitors.

Week 8 Qualitative understanding of Tafel equations. Rotating disk/ring electrode.

Week 9 Electrochemical impedance measurement. What it can do and cannot do.

Exercises 3

Part IV: Engineering electrochemical systems

Week 10 Topics about scale-up (if we have time). How to use numerical simulations to optimize an electrochemical system.

Grading: 3 Exercises (20% each) + Final exam (40%)

References:

1. Electrochemical Methods: Fundamentals and Applications, A. J. Bard, L. R. Faulkner, Wiley, 2nd Ed., 2000. (Required)
2. Electrochemical Systems, J. Newman, K. E. Thomas-Alyea, Wiley, 3rd Ed., 2004.
3. Elements of Molecular and Biomolecular Electrochemistry: An Electrochemical Approach to Electron Transfer Chemistry, J.-M. Savéant, Wiley, 2006.
4. Electrochemistry for Chemists, D. T. Sawyer, A. Sobkowiak, J. L. Roberts, Wiley, 2nd Ed., 1995.

Course name: Electrochemical systems (Graduate-level)

This course aims to provide a detailed description of the principles in the electrochemical systems. The topics of discussion will be directly relevant to the research of inorganic chemistry, materials sciences, and nanotechnology in the univeristy. With examples in recent literature and discussions of experimental practice, this course focuses on the qualitative and quantitative evaluation of the information obtained from electrochemical characterization methods.

Part I: Introduction

Week 1 Theory and principles. Concepts of electrochemical potentials; Marcus theory for electrochemical charge transfer. Butler-Volmer equation.

Week 2 Mass transport equation of species in solution. Diffusion-layer model. Geometrical effect

Week 3 Experimental setups. Potentiostats; three-electrode setup; choice of electrodes; supporting electrolyte; series resistance; separators and ion-conductive membranes.

Exercises 1

Part II: Homogeneous electrochemistry

Week 4 Basics of cyclic voltammetry. Experimental caveats. Numerical simulation.

Week 5 Coupling electron transfer and chemical reaction. Proton-couple electron transfer (PCET) reactions.

Week 6 Molecular electrocatalysis. Foot-of-wave analysis. How to extract kinetic information from cyclic voltammetry.

Exercises 2

Part III: Heterogeneous electrochemistry

Week 7 Electrochemical double layers. Nanoionic and nanofluidic systems. Batteries, super-capacitors, and pseudo-capacitors.

Week 8 Tafel analysis for mechanistic understanding. Rotating disk/ring electrode.

Week 9 Electrochemical impedance measurement. What it can do and cannot do.

Exercises 3

Part IV: Engineering electrochemical systems

Week 10 Topics about scale-up (if we have time). How to use numerical simulations to optimize an electrochemical system.

Grading: 3 Exercises (20% each) + Final exam (40%)

References:

1. Electrochemical Methods: Fundamentals and Applications, A. J. Bard, L. R. Faulkner, Wiley, 2nd Ed., 2000. (Required)
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