PhD course "**The Industrial Applications of Electrochemistry**"

SYLLABUS

1 Lecturer information

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2 Title of the course

The Industrial Applications of Electrochemistry

3 Course program

Significant advances in fields as diverse as energy storage, medical devices and new materials have been made by combining electricity and chemical phenomena. The synergy between electricity and chemistry has played a significant role in inventing batteries, electrochemical sensors and electronic devices. These have revolutionised the use of energy in everyday life. This integration of electricity and chemistry also led to the discovery of new elements through electrolysis, which uses an electric current to separate substances into their constituent elements. This method was instrumental in isolating elements such as sodium, potassium, calcium and magnesium, expanding our understanding of the periodic table. Electrolysis also revolutionised industrial processes by producing metals such as aluminium, copper, zinc and others. It enabled the efficient extraction of metals from ores and the production of chlorine, hydrogen and oxygen. It opened up new avenues in manufacturing, water treatment and the synthesis of various chemicals.

Electrochemistry's influence extends further into surface engineering, where it facilitates the electrodeposition of coatings and the synthesis of conversion coatings, providing enhanced protection and performance characteristics for various materials in demanding environments.

Overall, the lecture aims to provide an in-depth understanding of the wide range of applications of electrochemistry in industrial processes, chemical analysis, materials science and corrosion control.

It is designed to highlight the transformative impact of electrochemistry in scientific research and industrial innovation and to provide an integrated view of its applications in modern technology.

4 Course content detailed per lesson (possibly with dates and room real and virtual)

Lecture 1: Introduction to Electrochemistry and Its Industrial Applications (25.06.2024) 3 h

- Overview of electrochemistry: fundamental concepts, history, and principles.
- Introduction to the role of electrochemistry in industrial applications.
- Case studies of electrochemical processes in energy storage (e.g., batteries) and production (e.g., hydrogen through electrolysis).

Lecture 2: Electrochemistry in Material Science and Corrosion Control (27.06.2024) 2 h

- Electrodeposition and electroplating for material enhancement.
- Corrosion science and electrochemical methods to prevent or control corrosion.
- Synthesis of conversion coatings for material protection.

Lecture 3: Electrochemical Production and Environmental Applications (02.07.2024) 2 h

- Electrolysis for the production of metals like aluminium, copper, zinc.
- Production of chlorine, hydrogen, and oxygen through electrochemical processes.
- Electrochemistry in water treatment and environmental remediation.

Lecture 4: Advanced Applications of Electrochemistry (04.07.2024) 2 h

- Electrochemical sensors and diagnostics in medical and environmental fields.
- Innovations in electrochemical energy devices (e.g., supercapacitors, fuel cells).
- Future directions of electrochemistry in industrial and research applications.

Lecture 5: Final exam (05.07.2024) 3 h

4.1 Suggested reading

"Electrochemical Methods: Fundamentals and Applications" by Allen J. Bard and Larry R. Faulkner.

"Industrial Electrochemistry" by Derek Pletcher and Frank C. Walsh.

5 Learning Objectives

- Understand the basic principles of electrochemistry.
- Recognize the importance of electrochemistry in industrial processes.
- Analyse case studies of energy storage and production through electrochemical means.
- Understand the principles of electrodeposition and electroplating.
- Comprehend the mechanisms of corrosion and its electrochemical control.
- Identify the processes for creating conversion coatings on metals.
- Understand the electrochemical processes involved in metal production.

- Recognize the importance of electrochemistry in producing industrial gases.
- Evaluate the role of electrochemistry in environmental applications.
- Identify the role of electrochemical sensors in various applications.
- Understand the principles behind advanced electrochemical energy storage and conversion devices.
- Future trends and potential research areas in electrochemistry.

6 Knowledge and Skills to be acquired

- Fundamental electrochemical concepts (e.g., electrolysis, redox reactions).
- Analytical skills to understand and discuss industrial applications.
- Ability to relate electrochemical principles to energy storage technologies.
- Knowledge of materials engineering and surface chemistry.
- Skills in designing and analyzing corrosion control strategies.
- Understanding of the applications of conversion coatings in industry.
- Knowledge of industrial electrolysis processes.
- Ability to analyze the environmental impact of electrochemical production.
- Skills in applying electrochemical solutions to environmental issues.
- Knowledge of electrochemical sensing technologies and their applications.
- Understanding of advanced energy storage and conversion technologies.
- Ability to forecast future directions in electrochemical research and industrial applications.

7 Prerequisites

Fundamental knowledge of basic chemistry principles, including electrochemical processes.

Understanding of general and physical chemistry, especially concepts directly related to electrochemistry.

Basic knowledge of materials science, focusing on the properties of metals and alloys.

8 Teaching Methods

□ MODE 1 - Pre-recorded lessons uploaded on the moodle platform (a meeting must be organized with PhD students in order to clarify eventual doubts)

X MODE 2 (preferred) - Lessons delivered in-person and in remote with simultaneous recording by the WEBEX platform

(The lessons must be recorded and available to all the students that cannot take part to the lessons in streaming. The Webex platform must be used. All course content should be uploaded to the Moodle platform on the Chemical Sciences PhD page "Courses and Seminars of the PhD in Chemical Sciences 2021-2022")

9 Further information

10 Type of Assessment

The final evaluations will have to be validated maximum 1 month after the end of the course

11 Period

June and July 2024 - 12 h including final exam