Approved in 44th BoA Meeting (24-11-2021)

Course number : EN 510
Course Name : Electrochemical Systems for Energy Engineering
Credit Distribution : 3-0-2-4
Intended for : UG/PG (Compulsory for MTech. in Materials and Energy Engineering, and Elective for others)
Prerequisite : None
Mutual Exclusion : None

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1. Preamble:

The course introduces the principles and applications of electrochemical systems, like batteries, fuel cells, supercapacitors etc. in the broader context of a renewable energy schemes. Students will understand the importance of electrochemical energy conversion and storage in energy systems of today and the future, especially in the framework of renewable energy scenarios with the help of theories and their realizations in laboratory experiments. Basics and key features of electrochemical devices will be discussed, and applications in the context of the overall energy system will be highlighted with focus on future mobility technologies.

2. Course Modules with quantitative lecture hours:

- **Module 1:** Electrochemical Engineering Fundamentals: Electrical Current/Voltage, Faraday's Laws; Electric Efficiency, and Mass Balance; Electrode Potentials and Electrode–Electrolyte Interfaces; Potential Difference; Electrochemical Cells- Galvanic, Electrolytic and concentration. [5 Hours]
- **Module 2:** Thermodynamics and Kinetics of an Electrochemical Cell: Electrochemical Cell Phases; The Nernst Equation; Mass Transfer Modes; Electrode Kinetics (Charger Transfer (Butler–Volmer Equation) and Mass Transfer (Diffusion Laws)); Limitations of Butler–Volmer Equation; Limiting Current Density; Galvanostatic Polarization; Polarization Methods- Linear Polarization, Tafel Extrapolation. [9 Hours]
- **Module 3:** Batteries: Introduction; Basic Li battery; Lead acid battery; Nickel-Metal Hydride (Ni-MH) Rechargeable Batteries; Metal–Air batteries; Self-discharge of batteries; Jump starting a car; Battery safety and toxicity. [6 Hours]
- **Module 4:** Fuel Cells: Introduction; Variety of fuel cells- proton exchange membrane fuel cell, Solid oxide fuel cell, Direct methanol fuel cell, Alkaline fuel cells; Hybrid fuel cell-battery system; Hydrogen Storage [6 Hours]
- **Module 5:** Supercapacitor: Introduction; Electric double-layer capacitors (EDLCs); Pseudocapacitor; Asymmetric hybrid capacitors; Concerns with cell assembly; Energy density and power density. [5 Hours]
- **Module 6:** Electroanalytical methods: Cyclic voltammetry and linear sweep voltammetry;

The need for a reference electrode; Impedance Spectroscopy; Chronoamperometry; Theopen circuit potential; Galvanometric charge-discharge; Ring disc electrode [8 Hours]

- **Module 7:** Electrochemical manufacturing: Electroplating; Electroless plating; Electrochemical machining and polishing. [3 Hours]

Laboratory/practical/tutorial Modules: [28 Hours]

- **Experiment 1:** Sample preparation
- **Experiment 2:** Cyclic voltammetry and linear sweep voltammetry
- **Experiment 3:** Impedance Spectroscopy
- **Experiment 4:** Chronoamperometry
- **Experiment 5:** Galvanometric charge-discharge
- **Experiment 6:** Ring disc electrode

3. Text books:

- Zhang, J., Zhang, L., Liu, H., Sun, A., & Liu, R. S. (Eds.). (2011). Electrochemical Technologies for Energy Storage and Conversion, 2 Volume Set (Vol. 1). John Wiley & Sons.
- Braun, A. (2018). Electrochemical Energy Systems. de Gruyter.

4. References:

- Dicks, A. L., & Rand, D. A. (2018). Fuel cell systems explained. John Wiley & Sons.

5. Similarity with the existing courses:
(Similarity content is declared as per the number of lecture hours on similar topics)

S. No.		Course Code	Similarity Content	Approx. % of Content
1.	Energy Storage Technologies	EN503	Li-ion battery& Metal hydride battery vs lead-acid battery, Working principle of supercapacitor, Operational principleof a fuel cell	<10%
2.	Chemical Thermodynamics and Electrochemistry	CY514	Basic electrochemical thermodynamics, kinetics (Buttler Volmer), electrode potential	<5%

6. **Justification of new course proposal if cumulative similarity content is >30%:**