



HYDROGEN PRODUCTION AND STORAGE

<https://fitech.io/en/studies/hydrogen-production-and-storage/>

Hydrogen production and storage course is one of the four courses developed in Hydrogen Economy study module (<https://fitech.io/en/hydrogen-economy/>) and realized in FITech network. Course development was funded by JOTPA (<https://www.jotpa.fi/>).

COURSE DESCRIPTION

Hydrogen production and storage course provides understanding about hydrogen production technologies, hydrogen storage and safety issues. It also covers the hydrogen production technologies currently under research. After completing the course student has a comprehensive understanding on hydrogen production, knows why and how hydrogen is stored and what safety issues need to be considered.

Hydrogen production and storage course is realized in cooperation with the universities of Oulu (the course coordinator), Jyväskylä, Tampere, and Eastern Finland. The course consists of 11 lectures and lecture assignments in the fields of hydrogen chemistry, hydrogen production and safety, digitalization in hydrogen and P2X processes, and hydrogen storage – systematic approach and new material solutions.

COURSE LECTURES

Introduction to hydrogen chemistry

Lecturer: Prof. Karoliina Honkala and Dr. Minttu Kauppinen, University of Jyväskylä

- Basic properties of hydrogen
- Color coding of hydrogen cleanness levels
- Main industrial hydrogen production pathways
- Hydrogen production via steam methane reforming
- Introduction to heterogeneous catalysis
- Hydrogen production via electrolysis of water
- Current and future usage of hydrogen

Thermocatalytic methods for hydrogen production from methane

Lecturer: Prof. Ulla Lassi and Assoc. Prof. Varsha Srivastava, University of Oulu

- Thermocatalytic production of hydrogen from methane
 - Steam methane reforming
 - Partial oxidation of methane
 - Thermocatalytic decomposition of methane

Thermal decomposition of methane

Lecturer: Ass. Prof. Henrik Tolvanen, Tampere University

- Products of methane decomposition
- Kinetics of methane decomposition
- Catalysts in methane decomposition
- Industrial applications
- Environmental implications
- Challenges and limitations

Biological H₂ production

Lecturer: Prof. Marika Kokko, Tampere University

- Biological H₂ production routes
 - Light driven biological H₂ production
 - Dark fermentation
 - Bioelectrochemical H₂ production (microbial electrolysis cell)
- Details of dark fermentative H₂ production

Fossil free biohydrogen and clean energy from biogas

Lecturer: University Lecturer Satu Pitkäaho and University Teacher Esa Turpeinen, University of Oulu

- Biogas
- Syngas
- Biogas reforming to syngas
- Hydrogen production
- Hydrogen separation

Photocatalysis and photoelectrocatalysis in hydrogen production

This part consists of 3 lectures produced in collaboration by universities of Oulu, Eastern Finland and Tampere

1. Introduction & Fundamentals

Teachers: Coordinator Filipp Temerov, Dr. Javier Fernández-Catalá and University lecturer Jussi Malila, University of Oulu

2. Materials for Photo(electro)catalysis

Teachers: Prof. Anna Lähde and PhD Niko Kinnunen, University of Eastern Finland

3. Solar Hydrogen Reactors

Teacher: D.Sc.(Tech.) Harri Ali-Löytty, Tampere University

Hydrogen electrocatalysis

Lecturer: University Lecturer Marko Melander, University of Jyväskylä

- The role of hydrogen electrocatalysis in hydrogen economy
- The basics of electrochemistry: electrochemical cells, controlling the thermodynamics and kinetics using the electrode potential, and electrochemical interfaces
- Electrocatalysis: general features
- The hydrogen evolution reaction: Basics, electrocatalysis, and theory

Lightweight composite solutions for H₂ storage

Lecturers: Prof. Mikko Kanerva and Prof. Essi Sarlin, Tampere University

- Hydrogen storage parts, such as tanks and pipes, made of lightweight polymer composite materials
- The aspects of the manufacturing of lightweight and safe containers, pressurized vessels and piping for hydrogen
- The specific needs of composite materials are discussed for this particular application field including the barrier properties, thermal properties and mechanical properties of composites
- Typical design methodology and industry of modern composites are introduced

Why and how much hydrogen should be stored – systemic approach

Lecturer: Project manager Yrjö Majanne, Tampere University

- Introduction
 - Green hydrogen
 - Need for storages
- System Dynamics
 - Renewable energy production
 - Hydrogen production
 - End product production
- Role of storages
- Simulation examples

Digitalization in H2 and Power-to-X processes

Lecturer: Senior Research Fellow Markku Ohenoja, University of Oulu

- Digital tools for the H2 and P2X processes
- The role of modern automation solutions in design and operation of processes
- Case examples: 1) Flexibility of P2X processes; 2) Real-time optimization of H2 production
- Related challenges

Safety in hydrogen production and storage

Lecturer: Senior Research Fellow Arto Reiman, University of Oulu

- Lecture is divided into two parts
 - Basics of hydrogen safety in production and storage
 - Basics of accident analysis supplemented with a homework assignment (accident analysis to an imaginary incident in hydrogen production)

Basics of hydrogen safety and related legislation is discussed in the FITech course “Introduction to hydrogen economy” (Coordinator Aalto University). It is recommended to familiarize yourself to that material before joining this lecture.