ESE- 826 Industrial Catalysis for Energy Systems

Credit Hours: 3 **Pre-requisites: Nil**

Course Objectives:

a. To identify the type of catalysis operating in energy production.
b. To discuss the advantages and disadvantages of the use of different
c. types of catalysis in energy production.
d. To recognize the key factors of reactions occurring at interfaces.
e. To evaluate the sustainability of a catalytic process.
f. To discuss the stability and selectivity of the catalyst.
g. To describe and discuss the use of catalytic processes in the industry.

Course Contents: Energy production: (1) Primary energy sources, scales and the energy challenge. (2) Energy parameters, basic principles and chemical transformations (3) Energy Carriers (4) Fossil Fuels: Oil, Gas and Coal (5) H_2, H_2O_2, HCO_2H (6) MTO/MTG/MTH (7) Batteries. **Catalysis:** (1) Homogeneous and Heterogeneous Catalysis (2) Metal catalyst and support (3) Photo catalysis (4) Synthesis Techniques for catalyst (5) Characterization of catalyst (6) Enzyme catalysis. **Catalysis for Biofuel production:** (1) Feedstock (2) Transesterification (3) Base-catalyzed transesterification (4) Acid-catalyzed transesterification (5) Biofuels by Enzyme catalysis (6) Biomass hydrolytic enzymes. **Catalysis for biomass to liquid fuel (BTL):** (1) Coal to liquid fuel (2) Direct coal liquefaction (DCL) (3) Indirect coal liquefaction (ICL) (4) Fischer-Tropsch Synthesis (5) Flash Pyrolysis (6) Catalytic deploy merization **Catalysis for Hydrogen production:** (1) Steam reforming (2) Water gas shift reaction (3) Sorption enhanced processes (4) Partial Oxidation (5) Water Splitting. **Artificial photosynthesis and water splitting:** (1) Solar fuel (2) Photochemical hydrogen production. (3) Photochemical carbon dioxide reduction (4) Reduction of CO_2 to hydrocarbons. **Fuel Cell and Catalytic combustions** (1) The basic fuel cell components and types (2) H2 and H2O2 fuel cells (3) Hydrocarbon fuel cells (4) Catalytic hydrocarbon and NOx combustion **Environmental Catalysis:** (1) Purification of exhaust gases (2) Selective Catalytic Reduction **Lab work, workshops practice:** (1) Use of GTL (gas to liquid) facility in FT synthesis Lab (2) Visit to Industry (FFC)

Course Outcomes:

(a) The students will be able to comprehend the world energy challenge and the advantages and disadvantages of the basic energy carriers. (b) The students will be able to differentiate between different types of catalysis and next-generation energy production systems. (c) The students will be familiar with the catalyst requirements and advancement in biofuel production. (d) The course will provide knowledge about BTL, CTL technologies and catalysis. (e)The topic of artificial photosynthesis and photocatalysis will be important for advanced energy production technologies.

Recommended Reading (including Textbooks and Reference books)

- Bianchini, Claudio, and Pierluigi Barbaro, eds. Catalysis for sustainable energy production. Wiley-Vch, 2009.
- Chorkendorff, Ib, and Johannes W. Niemantsverdriet. Concepts of modern catalysis and kinetics. John Wiley & Sons, 2017.
- Triantafyllidis, Kostas, Angelos Lappas, and Michael Stöcker, eds. "The Role of Catalysis for the Sustainable Production of Bio-fuels and Bio-chemicals." (2013).
- Guczi, László, and András Erdôhelyi, eds. Catalysis for alternative energy generation. Springer Science & Business Media, 2012.
- Imhof, Pieter, and Jan Cornelis Van der Waal, eds. Catalytic process development for renewable materials. John Wiley & Sons, 2013.