COURSE CODE: EKC 464

COURSE TITLE: BIOREFINERY ENGINEERING

COURSE SYNOPSIS:

This course covers fundamentals of biorefinery concept, resources, characteristic and energy content of biomass/feedstocks, pretreatment techniques for biomass, process reaction, synthesis and conversion technologies in biorefinery, separation and purification technologies in biorefinery and biorefinery system.

COURSE PREREQUISITES:

Nil

COURSE TEXT BOOKS:

- Jhuma Sadhukhan, Kok Siew Ng & Elias Martinez H. “Biorefineries and Chemical Processes: Design, Integration and Sustainability Analysis”, Wiley, 2014.
- Shri Rawaswamy, Hua-Jiang Huang & Bandaru V. Ramarao. “Separation and Purification Technologies in Biorefineries”, Wiley, 2013..
- Yebo Li & Samir Kumar Khanal. “Bioenergy: Principles and Application”, Wiley, 2017.
- James Clark & Fabien Deswarte. “Introduction to Chemicals from Biomass”, Wiley, 2nd. Edition. 2015.

PROGRAM OUTCOMES

1. Engineering Knowledge - Apply knowledge of mathematics, natural science, engineering fundamentals and an engineering specialization to the solution of complex chemical engineering problems.
2. Problem Analysis - Identify, formulate, research literature and analyses complex chemical engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.
3. Design/Development of Solutions - Design solutions for complex chemical engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.
4. Investigation - Conduct investigations of complex problems using research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions.
5. Modern Tool Usage - Create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex chemical engineering problems, with an understanding of the limitations.
6. The Engineer and Society - Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solutions to complex chemical engineering problems.
7. Environment and Sustainability - Understand and evaluate the sustainability and impact of professional engineering work in the solution of complex chemical engineering problems in societal and environmental contexts.
8. Ethics - Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.
9. Individual and Team Work - Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.
10. Communication - Communicate effectively on complex chemical engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. Project Management and Finance - Demonstrate knowledge and understanding of engineering management principles and economic decision-making and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. Life Long Learning - Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

COURSE TOPICS

Topics	Contents
1	**Fundamentals of biorefinery concept** • Biorefinery principles, type, platforms, product and development • Evaluating biorefinery performances: Performance indicator and Life Cycle Assessment (LCA) • Challenges and opportunities
2	**Resources, characteristic and energy content of biomass/feedstocks** • Renewable biomass resources and statistics • Chemical composition and energy content of biomass • Bioenergy feedstocks: Starch-based, oilseed-based, lignocellulose-based, and algae-based
3	**Pretreatment techniques for biomass** • Thermal, chemical, physicochemical and thermochemical pretreatments • Pretreatment of different types of biomass
4	**Process reaction, synthesis and conversion technologies in biorefinery** • Thermochemical processing of biomass: General features, fundamental of design calculation & process design • Thermal conversion technologies: Combustion for heat and power, gasification, and pyrolysis. • Chemical production from biomass • Biological conversion technologies: Enzymatic hydrolysis, ethanol & butanol fermentation, syngas fermentation, fundamental of anaerobic digestion, biogas production
5	**Separation and purification technologies in biorefinery** • Equilibrium-based separation techniques: Distillation, liquid-liquid extraction and supercritical extraction • Affinity-based separation techniques: Adsorption, ion exchange and simulated moving-bed technology for biorefinery applications • Membrane separation • Solid-liquid separation • Hybrid/integrated reaction-separation systems: Process intensification
6	**Biorefinery System** • Fischer–Tropsch liquid and methanol synthesis • Novel membrane reactors • Algae biorefineries

- Value-added chemicals

COURSE LEARNING OBJECTIVES [CO] Students will acquire the ability to:	[PO]	TEACHING PLAN			
		COURSE TOPICS	COURSE ACTIVITIES	COURSE ASSESSMENT (Must in line with BPK)	COMPLEX PROBLEM (Only for integrated design, FYP, Plant design)
1. Demonstrate the understanding of the fundamental of biorefineries concept, resources, characteristic and energy content of biomass.	PO1	Topic 1 Topic 2	Lecture Kahoot Video presentation Group discussion	Quiz Final Exam Test 1	
2. Outline the pretreatment techniques of biomass using thermal, chemical, physicochemical and thermochemical methods in biorefineries.	PO2	Topic 3	Lecture Group discussion Mentimeter	Quiz Final Exam Test 1	
3. Evaluate research data or information on the process reaction, synthesis, ~~and~~ conversion, separation and purification technologies in biorefineries.	PO4	Topic 4 Topic 5	Lecture Group discussion Quizlet	Quiz Final Exam Test 1 Test 2	
4. Make effective report and presentation on the biorefinery system on various fields and applications.	PO10	Topic 6	Lecture Group discussion	Assignment (Research presentation, Research report)	
5. Acquire the capacity to engage in lifelong learning by using self-directed approaches for gathering information and evaluating of various separation and purification technologies in biorefineries.	PO12	Topic 5	Lecture Group discussion	Assignment (Research report)	