BIOMASS CONVERSION AND BIOREFINERY

PROF. KAUSTUBHA MOHANTY

Department of Chemical Engineering

IIT Guwahati

INTENDED AUDIENCE : Final year BE/B.Tech., ME/M.Tech./MS/MSc and PhD students
INDUSTRIES APPLICABLE TO : All industries that process biomass to various products such as biofuels,platform chemicals and other value- added products

COURSE OUTLINE :

Since last two decades, researchers worldwide have drawn their attention to biomass based fuels as well as other value added products as biomass is not only renewable but also CO2 neutral. This course will provide an insight to the basics of biomass, various conversion technologies and the different types of products that can be obtained upon successful conversion. In first few lectures types biomass, their structure and composition has been discussed followed by details on various pre-treatment technologies currently adapted to produce cellulose. Later on conversion technologies basics along with reactor design for physical, chemical, thermal and microbial conversion techniques has been covered in detail. The next part of the course deals with various products such as biofuels, platform chemicals, polymers etc. Finally, integrated biorefinery concepts, types of biorefinery along with LCA and TEA has been added. The course will enable students to develop necessary skills to design appropriate biomass based fractionation technique as per the need

ABOUT INSTRUCTOR :

Prof. Kaustubha Mohanty has obtained his PhD degree in Chemical Engineering from Indian Institute Technology Kharagpur and is currently working as a Professor of Chemical Engineering at Indian Institute Technology Guwahati. He has more than 12 years of teaching and research experience at IIT Guwahati. His key research areas are biofuels, bioseparation, biological wastewater treatment, membrane technology, ionic liquids, and microalgae biorefinery and biomass pyrolysis. He has published more than 120 research papers in peer-reviewed journals and co-edited one book on Membrane Technology & Applications (Taylor & Francis, USA). He has an h-index of 27 and i10 index of 57 along with more than 2950 citations. He has supervised twelve PhD students and fifteen more are currently pursuing their PhD research under his supervision. He is involved in various sponsored and consultancy projects, four of which are currently running. He is an Editor of Journal of Chemistry; Associate Editor of The Journal of Institution of Engineers (India) Series: E; Associate Editor of Research Journal of Environmental Sciences; Review Editor of Frontiers in Bioenergy and Biofuel and Editorial board member of various journals. He is a Fellow of Royal Society of Chemistry, UK and fellow of Institution of Engineers, India. He is also Member of Society of Chemical Industry, London; Member of Canadian Society for Chemical Engineers and Life Member of Indian Institute of Chemical Engineers. He has served IITG in various capacities as Chairman of Cultural board and Head of Career Development Centre.

COURSE PLAN :

Week 1: Introduction: World energy scenario, consumption pattern, fossil fuel depletion and environmental issues

Week 2: Biomass: Availability and abundance, photosynthesis, composition and energy potential, virgin biomass production and selection, waste biomass (municipal, industrial, agricultural and forestry) availability, abundance and potential, biomass as energy resources: dedicated energy crops, annual crops (maize, sorghum sugar beet, hemp), perennial herbaceous crops (sugarcane, switchgrass, miscanthus), short rotation woody crops (poplar, willow), oil crops and their biorefinery potential, microalgae as feedstock for biofuels and biochemical, enhancing biomass properties for biofuels, challenges in conversion

Week 3: Biorefinery: Basic concept, types of biorefineries, biorefinery feedstocks and properties, economics

Week 4: Biomass Pretreatment: Barriers in lignocellulosic biomass conversion, pretreatment technologies such as acid, alkali, autohydrolysis, hybrid methods, role of pretreatment in the biorefinery concept

Week 5: Physical and Thermal Conversion Processes: Types, fundamentals, equipments and applications; thermal conversion products, commercial success stories

Week 6: Microbial Conversion Process: Types, fundamentals, equipments and applications, products, commercial success stories

Week 7: Biodiesel: Diesel from vegetable oils, microalgae and syngas; transesterification; FT process, catalysts; biodiesel purification, fuel properties

Week 8: Biooil and Biochar: Factors affecting biooil, biochar production, fuel properties, biooil upgradation

Week 9: Bioethanol and Biobutanol: Corn ethanol, lignocellulosic ethanol, microorganisms for fermentation, current industrial ethanol production technology, cellulases and their role in hydrolysis, concepts of SSF and CBP, advanced fermentation technologies, ABE fermentation pathway and kinetics, product recovery technologies

Week 10: Hydrogen, Methane and Methanol: Biohydrogen generation, metabolic basics, feedstocks, dark fermentation by strict anaerobes, facultative anaerobes, thermophilic microorganisms, integration of biohydrogen with fuel cell; fundamentals of biogas technology, fermenter designs, biogas purification, methanol production and utilization

Week 11: Organic Commodity Chemicals from Biomass: Biomass as feedstock for synthetic organic chemicals, lactic acid, polylactic acid, succinic acid, propionic acid, acetic acid, butyric acid, 1,3-propanediol, 2,3-butanedioil, PHA

Week 12: Integrated Biorefinery: Concept, corn/soybean/sugarcane biorefinery, lignocellulosic biorefinery, aquaculture and algal biorefinery, waste biorefinery, hybrid chemical and biological conversion processes, techno- economic evaluation, life-cycle assessment