BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, Pilani
Pilani Campus
AUGS/ AGSR Division

SECOND SEMESTER 2020-21
COURSE HANDOUT

Date: 15.01.2021

In addition to part I (General Handout for all courses appended to the Time table) this portion gives further specific details regarding the course.

Course No : **CHEM F 431**
Course Title : **Sustainable Chemistry using Renewables**
Instructor-in-Charge : **Bibhas R. Sarkar**
Instructor(s) : **--**
Tutorial/Practical Instructors: **--**

1. Course Description: The course will provide an overview of the chemistry involved with the utilization of renewable resources as alternative feedstock for the chemicals and fuels industry, to the currently used ones. Major emphasis is focused on the chemistry of the renewable bio-based alternative resources and understanding of their potential as feedstock of future, within the mainstream process structure, to visualize viable switch-over as necessary. The course will encompass around the bio-refinery concept and will describe the chemistry in all the essential branches of renewable resources (biomass, oils/ fats, H_2, CO_2 etc.) and will proliferate the practicality aspect of applied chemistry using catalysis approach for sustainable technology development.

2. Scope and Objective of the Course:
The course will be broadly divided into broad topics as in the course plan. Learning objectives for each of these broad topics as discussed in the course plan has been described in terms of the projected outcomes – what the learner should be able to do by studying these.

3. Text Books: **Catalysis for Renewables** by G. Centi and R. A. van Santen (Eds), Wiley-VCH, 2007

4. Reference Books: Green Carbon Dioxide: Advances in CO_2 Utilization by G. Centi and S. Perathoner (Eds.) Wiley, 2014

5. Course Plan:

Module No.	Lecture Session	Reference	Learning outcomes
1	**1.1: *Renewables chemistry and catalysis,*** (L01-L02) **Topics:** Introduction, Economic and societal concerns of conventional petro-based technology , Alternative technology options, Process options using biomass	T1: 1.1-1.5	*(i) Describe the advantages and disadvantages of the current technological scenario with respect to the economic and societal concerns, (ii) Discuss the alternative technology options using renewable resources as feedstock for chemical industry*
	1.2: *Chemicals from renewable resources*, (L03-L07) **Topics:** Bio-refinery concept, Strategies for biomass utilization, Platform molecules, Degraded molecules, Biomass conversions by new catalytic synthesis routes, Catalytic cascade reactions, One-pot multi-product synthesis	T1: 3.1-3.6	*(i) Specify the basic facets of the bio-refinery concept, (ii) State the different strategies for the effective utilization of biomass as renewable resource, (iii) Define and describe different platform and degraded molecules, (iv) Cite catalytic routes, cascade reactions, one-pot reaction strategies for the use of renewable resources*
2	**2.1: *Chemistry in lignocellulose conversions***, (L08-L12) **Topics:** Need for biomass resources, composition, Chemistry	T1: 2.1-2.6	*(i) Describe the various biomass resources with respect to composition etc., (ii) State and discuss chemistry for the different conversion processes as, using carbohydrates, pyrolysis,*

	and processes for (i) using carbohydrates, (ii) Pyrolysis, (iii) Gasification, (iv) Hydrolysis, (v) Sugar derivatives; Economics associated therewith		*gasification, hydrolysis etc. and many others*
3	**3.1: *Bio-based Oleochemicals,*** (L13-L17) **Topics:** Raw material scenario, Ecological compatibility, Products and applications (Polymers, dimer acids, polyols based on epoxides, fatty acids based lubes and surfactants, amino acids, carbohydrate-based surfactants, Esters, Guerbet alcohols etc.) **3.2 : *Fatty acid epoxidation,*** (L18-L21) **Topics:** Non-catalytic, Catalytic and Chemo-enzymatic epoxidation of fatty acids, Epoxidation of FAMEs (pure, mixtures, oil-derivatives etc.)	T1: 4.1-4.5 T1: 12.1-12.6	*(i) Describe the raw-material situation for use of natural fats/ oils as renewable feedstock for chemicals, (ii) State the products base and applications for the bio-based oleochemicals, (iii) Chemistry strategies for polymers, acids, polyols, surfactants, esters etc.* *(i) Study of scope of catalytic epoxidation chemistry as sustainable technology, (ii) Describe the chemistry of epoxidation reactions with respect to mechanism specific to the catalytic/ non-catalytic/ enzymatic processes, (iii) describe epoxidation of FAMEs as renewable feedstock based process and other application horizons*
4	**4.1*: Fine Chemicals from renewables***, (L22-L25) **Topics:** Catalytic process routes for fine chemicals from bio-based molecules, case studies and examples **4.2: *Thermochemical conversion to fuels and other chemicals***, (L26-L27) **Topics:** Thermal/ Thermochemical processes for fuels and other chemicals, Gasification (biomass and pyrolysis oils, fluid assisted gasification), Liquefaction process and chemistry, upgradation process and chemistry of pyrolysis oils, Catalyst design approaches, fuels from biomass	T1: 5.1-5.9 T1: 6.1-6.10, 7.1-7.6	*(i) Describe the chemistry involved in catalytic routes for fine chemicals arising from bio-based renewable resources, (ii) Cite case studies and discuss future directions* *(i) Describe the chemistry of thermal and thermochemical processes for fuels and chemicals from renewable platforms, (ii) State and discuss the chemistry involved in thermal processes such as gasification, liquefaction, upgradation etc., (iv) Describe the roles of catalyst and its design chemistry with respect to thermal/ thermo-chemical processes*
5	**5.1: *Analyticals in thermal biomass conversions***, (L28-L29) **Topics:** Tunable diode laser measurement of kinetics, Propagation of thermal fronts, influencing parameters	T1:8.1-8.5	*(i) Describe the important analytical tools and predictive techniques for the processes using renewable resources as feedstock for chemicals*

6	**6.1: *Bio-ethanol : production, upgradation and valorization,*** (L30-L32) **Topics:** Using bioethanol as fuel, fuel-additive, fuel blends, bio-ethanol and fuel cells, bio-ethanol upgradation, conversion to fuel components, conversion to other chemicals	T1: 9.1-9.5	*(i) Describe chemistry of utilization of bio-ethanol from perspective of current product diversity; (ii) Delineate the prospective/ emerging process routes to other chemicals/ intermediates staring from bio-based ethanol.*
	6.2: *Glycerol as feedstock*, (L33-L36) **Topics:** Properties, Glycerol to fuels and additives, Etherification reaction (catalysis and kinetics), Biodiesel process and improvements, glycerol reforming (APR, steam). Catalytic dehydration process, Oligomerization, reactions with alkenes, Catalytic oxidations, Catalytic hydrogenolysis and other miscellaneous chemistry involving glycerol	T1: 10.2-10.6; 11.2-11.7	*(i) State and discuss the properties and possibilities of glycerol as alternative feedstock for chemicals, (ii) Describe the modes of using glycerol and its derivatives as platforms to different chemicals/ intermediates, (iii) Cite glycerol-based catalytic processes such as dehydration, oligomerization, oxidations, hydrogenolysis, reforming etc. and discuss the chemistry associated in each*
7	**7.1: *Hydrogen and CO_2***, (L37-L41) **Topics:** Hydrogen energy chain, H_2 production for alternate feedstock, , Electro-catalysis, Solar photo-catalysis, Fuel cell technology and challenges, CO_2 capture and valorization	T1: 14.2-14.4; 16.2-16.4 R1: Ch 2-5	*(i) Describe the current scenario of using H_2 and CO_2 as renewable feedstock, (ii) State and discuss the existing technical knowhow on electrocatalysis, solar-photocatalysis, fuel cells etc. for production of H_2,and the challenges therein (iii) Describe different strategies and process routes for utilization of CO_2 and the chemistry associated.*

6. Evaluation Scheme:

Component	Duration	Weightage (%)	Date & Time	Nature of component (Close Book/ Open Book)
Mid-Semester Test	90 Min.	30	<TEST_1>	Online tests
Comprehensive Examination	2 h	40	<TEST_C>	Online tests
Continuous Evaluation	15 min each	30	To be announced	Online tests

7. Chamber Consultation Hour: To be announced

8. Notices: All notices regarding the course will be displayed in Nalanda and/ or Department of Chemistry Notice board.

9. Make-up Policy: Make up would be considered only for genuine reasons

10. Note (if any):

Instructor-in-charge
Course No. CHEM F431