

CIRCULAR:-

The Director, University of Mumbai Institute of Chemical Technology, the Directors/Heads, recognized Science Institutions concerned, the Principals of the affiliated colleges in Science, the Principals of affiliated colleges in Pharmacy and the Principals of affiliated colleges in Engineering are hereby informed that the recommendation made by the Dean Faculty of Technology has been accepted by the Academic Council at its meeting held on 7th June, 2006 vide Item No.4.10 and subsequently approved by the Management Council at its meeting held on 16th June, 2006 vide Item No.13 and that in accordance therewith the Master of Technology (Green Technology) degree course (Part-Time Course) M.Tech.(Green Tech.)(Part-Time course) under the Faculty of Technology is instituted by the University from the academic year 2006-2007.

Further that in exercise of the powers conferred upon the Management Council under Section 54(1) and Section 55(1) of the Maharashtra Universities Act 1994, it has made the Ordinances 5644, 5645, 5646, 5647, 5648 and 5649 and Regulations 5498, 5499, 5500, 5501, 5502, 5503, 5504, 5505, 5506, 5507, 5508, 5509, 5510, 5511, 5512, 5513, 5514, 5515, 5516, 5517, 5518, and 5519 including syllabus relating to the Master of Technology (Green Technology) degree course (Part-time course) M.Tech (Green Tech.) (Part-time course) is passed as per Appendix and that the same has been brought into force with effect from the academic year 2006-2007.

MUMBAI-400 032

10th August, 2006

A.C./4.10/07.06.2006

M.C./13/16.06.2006

To,

The Director, University of Mumbai Institute of Chemical Technology, the Director/Heads, recognized Institutions concerned, the Principals of the affiliated colleges in Science, the Principals of the affiliated colleges in Pharmacy and the Principals of affiliated colleges in Engineering

(Signature)
for REGISTRAR

No.UG/ 315 -A of 2006, MUMBAI-400 032 10th August, 2006

Copy forwarded with compliments for information to :-

1. The Dean, Faculty of Technology

(Signature)
for REGISTRAR

Copy to :-

The Director, Board of College and University Development, the Deputy Registrar (Eligibility and Migration Section), the Director of Students Welfare, the Personal Assistants to the Vice-Chancellor, the Pro-Vice-Chancellor, the Registrar and the Assistant Registrar, Administrative sub-center, Ratnagiri for Information.
The Offg. Controller of Examinations (10 copies), the Finance and Accounts Officer (2 copies), Record Section (5 copies), Publications Section (5 copies), the Deputy Registrar, Enrolment, Eligibility and Migration Section (3 copies), the Deputy Registrar, Statistical Unit (2 copies), the Deputy Registrar (Accounts Section), Vidyanaagari (2 copies), the Deputy Registrar, Affiliation Section (2 copies), the Director, Institute of Distance Education, (10 copies) the Director University Computer Center (IDE Building), Vidyanaagari, (2 copies) the Deputy Registrar (Special Cell), the Deputy Registrar, (PRO) and the Assistant Registrar, Academic Authorities Unit (2 copies) and the Assistant Registrar, Executive Authorities Unit (2 copies). They are requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to in the above Circular and that no separate Action Taken Report will be sent in this connection. the Assistant Registrar Constituent Colleges Unit (2 copies), BUCT (1 copy), the Deputy Account Unit V (1 copy), the In-charge Director, Centralize Computing Facility, M.J.A.S.A.

UNIVERSITY OF MUMBAI



**ORDINANCES, REGULATIONS
AND
SYLLABUS
FOR
MASTER OF TECHNOLOGY
(GREEN TECHNOLOGY)
(Part-time Course)**

(With effect from the academic year 2006-2007)

University of Mumbai
ORDINANCES, REGULATIONS AND SYLLABUS FOR
MASTER OF TECHNOLOGY (GREEN TECHNOLOGY)
M. Tech. (Green Tech.) (Part-time course)

5644
O **Title : Master of Technology (Green Technology) : M. Tech. (Green Tech.)**

5645
O **Eligibility :** The following candidates are eligible for admission

B.Chem. Eng./B. Sc.(Tech.)/B..Tech. (Chem. Tech.) (in all branches of chemical technology)/B. Pharm. degrees of the University of Mumbai in first class or equivalent degree of other university or IIT or NIT, with industrial experience of two years in production in production of chemicals, materials, drugs, intermediates, energy, etc. or R and D of the said industries

Or

M.Sc. (Chemistry, Biology, Microbiology, Biotechnology, Biochemistry) with first class with two years industrial experience in production of chemicals, materials, drugs, intermediates, energy, etc. or R and D of the said industries

The examination for the degree of M. Tech. (Green Tech.) will be held in two phases: (i) a theory examination (as detailed below) and (ii) a thesis to be submitted as mentioned hereunder.

5498
R. ... **Duration :** The duration of the course is three years. First and second years, consisting of two semesters each, will be devoted to course work whereas during the third year, research will be done by the candidate leading to a dissertation. However, candidates can do preliminary background work such experimental set-up, literature search, and preliminary experiments, etc. since beginning. The research will be done by the candidate in the institute or in his/her industry which is recognized by Central Agencies such as DSIR or DST or DBT, etc. or by the University.

5499
R..... Intake capacity : 30

5500
R Structure of course

3.3. Course Content

3.3.1 Six-semester course (part-time)

Semester	Core subjects	Elective subjects	Contact hours per subject	Credits per subject	Total contact hours	Total Credits
I	1	1	30	2	60	4
II	1	1	30	2	60	4
III	1	1	30	2	60	4
IV	1	1 seminar	30	2	60	4
V and VI	Research			16	One Year Thesis	16

5501
R..... A minimum of 16 credits of course work and thesis are required for consideration of the award of the degree with GPA. The students may take more electives to increase their knowledge and the additional credits will be mentioned in their certificates.

5502
RGrade Point Average

The University has introduced a 4-point grade scale for M.Tech. (Green Tech.) The overall GPA includes both institutional and transfer work. The students performance will be monitored continuously through quiz/assignment/participation in class discussions/attendance and the end-term semester examination for all theory and practicals. The weightage will be 50 % for continuous evaluation and 50 % for the end-term examination.

For each of the grades below, the grade carries quality point weights.

Grade	Marks out of 100	Quality Points
A+ -Outstanding	90-100	4
A - Excellent	80-89	3.75
B+-Very good	70-79	3.5
B-Good	60-69	3
C-Satisfactory	51-59	2
D-Passing	50	1
F-Failure	49 or less	0
WF-Withdrew Failing		0

Grade Point Averages are calculated at the end of each term after grades have been processed and after any grade has been updated or changed. Individual assignment quiz/surprise tests are all based on the same criterion as given above. The instructor should convert his marking into the quality points.

R.....⁵⁵⁰³ **How to Calculate a GPA**

The Grade Point Average (GPA) is calculated by dividing the number of hours scheduled in all subjects attempted in which a grade of A, B, C, D, F or WF has been received into the number of quality points earned on those hours scheduled. For example, a student had the following schedule. The tutor determines the total number of quality points and the GPA as given below:

Subject-Hours-Grade	Quality Points for the subject
Subject I-3-A	3*4=12
Subject II-4-C	4*2=8
Subject III-3-B	3*3=9
Subject IV-1-A	1*4=4
Subject V-3-B	3*3=9
Total Hours = 14	Total Quality Points = 42

Sum of Quality Points /

Total Number of Hours =

The student gets B grade.

GPA = 42 / 14 = 3.0 .

⁵⁵⁰⁴
RRepeated Subject work

If a student repeats a subject, only the grade of the most recent attempt of the subject will be used for the purpose of calculating the GPA. This is true even if the second attempt is lower than previous attempts. On the student's transcript previous attempts are marked with an 'E' to indicate the "Earlier" grades are included in the from GPA calculations.

⁵⁵⁰⁵
R..... Transfer students

For students whose previous attempts at a subject were from another institution/university/department, the carry-forward grades will be marked with a grade that includes a "©" symbol. The name of the earlier institute will be mentioned in the transcript as a foot note against this symbol.

⁵⁵⁰⁶
R... Calculation of GPA for subjects transferred from other institutes where GPA system does not exist

The table given above with absolute marks and grades will be used to determine the equivalence in such cases.

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R... Cumulative Grade Point Average

Each Semester Grade Point Average is calculated by dividing the total of product of grade point and subject credit by sum of all subject credits as given above. This gives the aggregate performance of student in each semester. A similar measure calculated cumulatively gives Cumulative Grade Point Average (CGPA) giving the aggregate performance of student up to that semester.

$$CGPA = \frac{\sum_i^N C_i \cdot GP_i}{\sum_i^N C_i}$$

- N is the number of subjects,
- C_i is credits for the i^{th} subject,
- GP_i is grade points for the i^{th} subject, and,
- $CGPA$ is the cumulative grade point average.

In all cases where selection is to be done -award of prizes/placement etc., selection is based on CGPA unless some other measure is advocated under the conditions of the award. A student gets rigorous academic input here over the curriculum. The University expects absolute academic honesty from all the students. In the exams/assignments/ tutorials/project a students must report his/her own work/ analysis and conclusions. Whenever he/she uses other's work he/she must give proper citation references. An honest mediocre work with your best efforts is tolerated rather than reporting stolen work of someone that is plain academic plagiarism. Academic dishonesty /adoption of unfair means in examinations/ assignments/ class tests etc. will attract severe punishment including expulsion from the course.

5508

R. Every candidate registered for the degree of M. Tech. (Green Tech.) (part time) shall be required to pass a theory examination which will be held in four parts: Part I – to be hereinafter referred to as Semester I, Semester II and Semester III and Semester IV examinations. The Semesters I, II, III and IV will be normally of 60 hours of classroom teaching/lectures duration, scheduled in such a way, either on week ends or evenings, so that the candidates are able to attend these lectures and the examination for each semester will be held during/after 16th week after the commencement of Semester I.

5509

R. ... Every Candidate Registered for the degree of M. Tech. (Green Tech.) (part-time) shall be required to carry out research work in all the six semesters. During Semesters I- IV, the research supervisor/guide will decide the quantum of research work to be done by the student.

5510

R..... No candidate will be admitted to the Semester I examination unless he produces a satisfactory testimonial of having passed the qualifying examination referred to in **O.....** , having kept one term, to the satisfaction of the Head of the Institute/Department and production of essential experience certificate from the concerned industry.

O.....⁵⁶⁴⁶..Undertaking by the Sponsor

No individual can sponsor a candidate for the part-time course. The sponsoring industry must take an undertaking on a stamped paper of Rs. 100/- that the candidate is their permanent employee and is being sponsored by them for M. Tech. (Green Tech.) (part time); they will pay all fees in advance and that they have adequate research facilities including modern instrumentation required to do research for which the candidate is going to be registered. A recognition of R and D Centre of sponsoring industry by DSIR, DST, DBT or any central agency or by the University of Mumbai is necessary if the candidate desires to do his/her research during the third year in the that industry. Industries which do not have recognised R and D must give an undertaking that they will give leave to the candidate during the third year for research. The University has a separate mechanism to grant recognition to R and D Centres, upon payment of prescribed fees and recommendation by a team of experts. This process can start simultaneously when the candidate is offered admission subject to satisfaction of the condition that the R and D of the sponsoring industry gets the due recognition.

O⁵⁶⁴⁷..Change of employment and continuation of registration

The University is not responsible if the candidate wishes to change his/her job and the liabilities of the candidate towards the original sponsor. In the case, if the candidate changes his job during the period of registration for the M. Tech.(Green Tech.) (part-time), he should produce no objection certificate from the previous as well as current employer, for continuation as a student.

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R.... At the beginning of the each semester, every year, the Head will notify to the candidates a subject or subjects of Electives, in the first week of commencement of the semester, and if the number of subjects so notified is more than one, then every candidate registered for the degree will have to notify to the Head in writing the subject which the candidate desires to offer for the semester examination under the subject head "Elective", from among the subjects notified by the Head . A comprehensive list of elective subjects is provided. If the candidate fails to pass in the subject of Elective, the candidate will have to select a fresh Elective subject from amongst the subjects notified by the Head in that year for subsequent examination.

5648

O.... Failure to pass the semester I or semester II examination of the M. Tech. (Green Tech.) (part time) course will not disqualify the candidate from continuing his/her studies for the second year. He/She must take repeat examinations to get through the backlog. Failure to pass any semester examination will not disqualify the candidate for presenting himself on a subsequent occasion on a new application being forwarded and a fresh examination fee paid. Such a candidate is also allowed to keep terms and appear for the Semester II examination, notwithstanding the fact that he may not have cleared the Semester I examination. A candidate who has failed to pass the Semester II examination may present himself on a subsequent occasion on a new application being forwarded and fresh fee paid. However, the candidate must clear both semesters I and II before the commencement of the second year. Since the third year is devoted to research leading to a dissertation, the candidate must have cleared all semester examinations before submission of the thesis.

5512

R..... Every candidate is allowed to continue his research work and submit a thesis for the degree in accordance with the relevant Regulation, but the result of the thesis will not be declared until he has cleared the Semesters I-IV examinations.

R.....⁵⁵¹³

Every candidate registered for the degree of M. Tech. (Green Tech.) (part-time) shall be required to carry out research work for the thesis under the supervision and guidance of a recognized University Teacher. There can be a co-guide from the sponsoring industry. However, such a guide must have got recognition as a guide in relevant subject to Green Technology, such as Chemical Engineering, Chemical Technology, Chemistry, Biology, Biotechnology, Pharmacy, and Environmental Engineering. A separate procedure is adopted for recognition of guides and the concerned industry should take necessary steps if a co-guide is required. Whole or a part of the research work could also be carried out in an industrial establishment or a research institution approved by institute as given in the previous R.⁵⁵..... The research project shall be assigned not later than the end of the first semester. Three typewritten copies of the thesis embodying the result of the research project, together with a synopsis and a statement indicating to what extent the candidate's work is original and to what extent it is referred to other sources, shall be submitted by the candidate to the Controller of Examinations, through the candidate's guide or guide and co-guide for joint

supervision. The thesis shall be candidate's own work carried out under the guidance of his guide(s) and shall be submitted to the Controller of Examinations at the end of the Semester VI of attendance. The time limit for the submission of the thesis can be extended maximum up to the VIII semester, upon payment of fresh fees. Extension of time limit will be on the basis of recommendations from the Research Supervisor and approved by the Head.

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R..... At least two months before submitting his thesis a candidate shall forward to the Controller of Examinations through the University Teacher under whom he has worked or by whom he has been guided, a statement giving the title and the synopsis of the thesis along with his form of application for admission to the examination and a fee of Rs. 5000 (Five Thousand). In the synopsis the candidate shall indicate the broad outlines of the work carried out by him. Before submission of the thesis every candidate should present a Research colloquium at least two weeks prior to the submission of the thesis. Colloquium schedule should be formally announced at least ten days before the presentation and the colloquium shall be open to all.

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R..... Every candidate shall submit a certificate signed by the guiding teacher under whom he has worked stating that there is a *prima-facie* case for the consideration of the thesis. Such a certificate has to be submitted along with the synopsis of the thesis. Such a certificate shall be regarded as satisfying the Research and Recognition Committee for the Board of studies in Chemical Technology that the candidate has done sufficient work to enable him to appear for the examination.

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R..... The thesis shall be referred for examination and report to two referees, to be appointed by the Board of Examinations on the Recommendation of the Research and Recognition Committee for the Board of Studies in Chemical Technology; one of the referees being always the guiding teacher or the main guide. If both the referees recommend the thesis for the award of the degree, viva-voce examination shall be conducted jointly and at the time of viva-voce examination, copy of the thesis should be in their possession. The referees to whom the thesis is refereed for examination, shall after valuing the thesis and holding viva-voce examination, report to the Controller of Examinations whether the thesis should be accepted or rejected and their report shall be final.

If at the time of viva-voce examination one of the referees rejects the thesis, while the other recommends it for the degree, the Board of Examination shall appoint a third referee and shall decide whether the thesis be accepted or not for the award of degree, after considering the reports of all the three referees. In addition, viva-voce examination of the candidate should be conducted once again by the new referee, guiding teacher and one of the members or nominee of the Research and Recognition Committee for the Board of Studies in Chemical Technology. Majority decision as to whether the thesis should be accepted or rejected shall be final. This decision shall be circulated to the members of the Research and Recognition Committee for the Board of Studies in Chemical Technology and placed before the Board of Examinations for information.

In case the two referees differ in their opinion on accepting the thesis prior to holding the viva-voce examination, the Board of Examination will appoint the third referee and shall decide whether viva-voce examination should be conducted or not depending upon two of the referees accepting or rejecting the thesis. If the thesis is accepted, two of the referees accepting the thesis for the degree will conduct viva-voce examination in accordance with the procedure outlined above.

If two of the referees reject the thesis, the viva-voce examination will not be conducted. The candidate may resubmit the thesis within one year from the date he is informed about the thesis being rejected. The candidate has to pay fresh tuition and examination fees. If candidate does not submit the thesis within this period or if his thesis is rejected again, he will not be granted re-admission for the M. Tech. (Green Tech.) Degree course.

Provided further that the thesis submitted and accepted for the degree shall be given a grade:

Grade	Quality Points
A+ -Outstanding	4
A - Excellent	3.75
B+-Very good	3.5
B-Good	3

The grade to be awarded shall be decided by the referees valuing the thesis depending on the quality and the presentation of the research work and performance at the viva-voce examination. If the research work included in the thesis is already published or accepted for publication in a peer reviewed international journal, the candidate shall provide a proof of the same. Only such a candidate should be considered for A+ grade. A mention of the grade so awarded shall be made in the results of the examination.

5517
R..... Successful candidate shall be awarded the combined GPA in the final degree certificate jointly on the basis of the results of All Semester examinations and the thesis submitted by him/her.

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O.... A thesis that has been rejected may be submitted again after due revision and payment of fresh tuition and examination fees. The revised thesis has to be submitted within two semesters after rejection.

5518
R..... The syllabus of the course for Semester I – IV examinations is laid down as follows:

3.4. Syllabus

3.4.1. Semester I

1. Fundamentals of Green Chemistry and Technology (2 credits, 30 hours)

Nature of chemicals and world chemical scenario, Prevention, Atom Economy, Less Hazardous Chemical Syntheses, Designing Safer Chemicals, Safer Solvent and Auxiliaries, Design for Energy Efficiency, Use of Renewable Feedstocks, Reduction of Derivatives, Catalysis, Design for Degradation, Real-time Analysis for Pollution Prevention, Inherently Safer Chemistry for Accident Prevention.

2. Elective -1 (2 credits, 30 hours)

3.4.2 Semester II

1. Fundamentals of Catalytic Science and Engineering (2 credits, 30 hours)

Relevance and examples, Homogenous and heterogeneous catalysis, Fundamentals of homogeneous catalysis and mechanisms and kinetics, Fundamentals of adsorption, isotherms, energetics, structural and dynamic considerations, Mechanisms, models and kinetics of surface reactions, Fractal models, Determination of surface structure through modern methods, Significance of Pore structure and models, Solid and surface chemistry of catalysis, Quantum mechanical, molecular mechanical and hybrid models, Acid--base catalysis, Transition metal catalysis. Metal and supported metal catalysis, metal-support interaction, Metal oxides and determination of acidity and basicity, Nature and type of supports, Solid acid catalysis, Solid base catalysis, Catalyst design through artificial intelligence and computer modelling, Poisoning, promotion, deactivation and selectivity,

4. Elective -2(2 credits, 30 hours)

3.4.3. Semester III

1. Analysis and Development of Green Industrial Processes (2 credits, 30 hours)

Pollution statistics from various industries, Important example. Refinery Industry -FCC, reforming, platforming, hydroforming, polymerisation, alkylation, isomerisation; hydrodesulfurisation, hydronitrogenation, Pharmaceutical and fine chemical industry, Dyestuff and intermediate industries, Perfume and flavour industry, Polymer industry, Textile industry, Paint industry, Edible oil industry, Food industry, Waste water treatment, Catalysis for auto-exhaust pollution abatement, DeNox, DeSOx technologies

2. Elective-3 (2 credits, 30 hours)

3.4.4. Semester- IV

1. Elective-4 (2 credits, 30 hours)

2. Seminar (2 credits, 30 hours)

Presentation and discussion of reports covering current advances and research work appearing in scientific journals. The teachers associated with this course will supply a list of contemporary topics.

3.4.3. List of Electives (each of 2 credits, 30 hours)

1. Industrial Catalysts

Catalyst design, preparation and activation, Clay and modified clays, Ion exchange resins, Zeolites and zeotypes, Heteropoly acids, Inorganic-organic catalysts, Immobilised enzymes, zozymes, complexes, Electrochemical catalysis, Photocatalysis, Microwave catalysis, Ultrasound catalysis, Synergistic catalysis. Bio-catalysis : Microbes and enzymes, Phase transfer catalysis, Micellar catalysis, Microemulsion catalysis, Electron transfer catalysis, Homogeneous polymer catalysis, Heterogenisation of homogeneous catalysts, Catalysis by microwaves and ultrasound, Catalyst recovery and reuse,

2. Green Product Design

Green product design definition, Product strategy, Life cycle of product, ISO 14000, Environmental load of product, Material selection, resource use, production requirements and planning for the final disposition (recycling, reuse, or disposal) of a product. Integration with existing product design approaches such as quality, producibility, and functionality. Upgradability, Disassembly, "Greening" Supplier Inputs, Improving Whole Systems, International laws on take-back laws, extended responsibility, Eco-labeling, Examples from Pharmaceuticals, Foods, Cosmetics, Packaging, Computers, Polymers, Automobiles, Electronics Industry.

3. Environmental Engineering and Pollution Prevention

Air pollution: Definition of pollutants. Standards and limits of pollutants. Sources and sinks of pollutants. Meteorology. Problems associated with dispersion. Sampling techniques. Control techniques for removal of particulate and gaseous pollutants. Water pollution: Characterization of industrial wastewaters. Standards and limits of pollutants. Preliminary primary, secondary and tertiary treatment methods. Separation technique for removal and recovery of pollutants. Solid waste treatment. Socio-economic aspects recovery waste as abatement. End of pipe solutions, Life cycle analysis of plastics, papers, tins; Identification of wastestreams from processes, Waste minimization strategies, Prioritizing pollution prevention options, Selecting environmentally compatible materials, Design of unit operations for pollution prevention, Economics of pollution prevention, Process flow-sheeting for pollution prevention,

4. Industrial Safety and Hazard Analysis

Introduction ISO standards with reference to chemical industry, Safety aspects pertaining to the design of chemical plants. Industrial hygiene and safety aspects related to toxicity, noise, pressure, temperature, vibrations, radiations, etc. Explosions including dust, vapour cloud and mist explosions. Hazard identification, assessment and safety audit, HAZOP, HAZAN and consequence analysis. Safety aspects related to (i) transport handling and storage of flammable liquids and gases and toxic materials (ii) Process equipment including piping (fire, static electricity, pressure, temperature, etc.) Safety aspects at process development and design stage. Reliability engineering. Hazard mitigation systems Emergency planning. Case studies. Life cycle analysis of chemicals

5. Advances in Separation Processes

Selection of separation process. The chemistry of adsorption. Adsorbents. Equilibria. Yield and Purity. Batch adsorption. Kinetic analysis. Discrete stage analysis. Adsorption in fixed beds. Design and scale-up of adsorption and chromatography equipment. Reactive distillation, Principle of separations through membranes. Micro filtration. Ultrafiltration. Reverse Osmosis. Pervaporation. Selection of membranes. Mechanism of fouling. Design and scale-up of membrane equipment. Electrophoresis. Electro dialysis and isoelectric focusing. Chemical, physical and biochemical aspects of isolation and purification of biomolecules. Product release from a cell. Concentration and separation

methods: membrane, ion exchange. Precipitation and extraction. Chromatographic methods of purification. Design of downstream processing equipment. Downstream process economics.

6. Chiral Engineering

Chirality and green chemistry, Preparation and Importance of Chiral Molecules, chirality in pharmaceuticals, agrochemicals and specialties, Weiland - Meischer Dione, Chiral Synthesis, , Crown Ether Technology, Nazarov's Reagent Production, Michael Addition, Chiral Analysis, Engineering of the ee, Computer Modeling

7. Chemical Reaction Engineering

Types, classification, application of industrial importance. Reactor design, Reactor safety, Hydrodynamic characteristics of different phases in particulate and aggregative fluidized beds, bubble columns, slurry reactors spray columns, loop reactors and mechanically agitated contactors. Estimation of design parameters such as pressure drop, fractional phase hold-up, mass and heat transfer coefficient, extent of mixing, etc. Experimental methods on multiphase reaction engineering. Mathematical modeling.

7. Modern Instrumental Methods

Fourier Transform Infrared Spectroscopy: Molecular Vibrations, Frequency shifts associated with structural changes; Basic theory of FTIR spectroscopy, interferogram, digitization of interferogram, data points collection; Instrumentation and advantages of FTIR spectrophotometry; Qualitative and quantitative analysis using infrared spectrophotometry. Ultraviolet and Visible Spectrophotometry: Electronic transition, spectrum, shift of bands with solvents, isolated double bonds, conjugated dienes, carbonyl compounds, aromatic and heteroaromatic compounds; Application in pollution control and chemical industry. Nuclear Magnetic Resonance: Basic principle of NMR phenomenon, relaxation processes, spin-spin interaction, chemical shifts, interpretation of NMR spectra, correlation-hydrogen bonds to carbon and other nuclei; Instrumentation-Continuous and pulsed NMR, carbon-13NMR. X-ray Diffraction: Crystal geometry and structural determination; Bragg law of X-ray diffraction, powder method ; X-ray spectrometers-wide and small angle diffractometers; Chemical analysis by X-ray diffraction. Particle Size Analysis: Particle size, sampling, conventional techniques of particle size measurement, light scattering, particle size

measurement by light scattering techniques; Dynamic light scattering (DLS), fiber optic dynamic light scattering (FDLS).

Chromatography: Basic theory of separation, efficiency, resolution; Liquid chromatography, high performances liquid chromatography; Gas chromatography-columns and detectors; Qualitative and quantitative analysis.

Mass Spectroscopy: Basic principle, ionization of a molecule on electron impact, fragmentation processes in organic compounds, interpretation of mass spectra, molecular weight, molecular formula; Instrumentation-different types of ionization sources and magnetic analyzer.

9. Green Biotechnology

Biotechnology, Applications of green concepts in biotechnology

Biochemistry and microbiology, Enzymatic reactions, Supported Enzyme Catalysis, Enzyme engineering, enzyme modifications, stability, reactivity and selectivity considerations,

Genetics and Genetic engineering, DNA recombinant technology, Hybridoma technology, single cell proteins, gene manufacturing,

Fermentation and design of fermenters with modified organisms

Bioprocess simulations, molecular modelling for protein synthesis and drug design, protein engineering,

Applications in fermentation industry, pharmaceutical industry, medical field such as gene therapy, Biomedical engineering,

Bioreactor design, Scale up of bioreactions/reactors, Downstream processing in biochemical industry,

Organic synthesis using supported microbes and enzymes.

Biopharmaceuticals, biorefinery and biotechnology, bio-inorganics

8. Nanotechnology in Green Chemistry

Theory of Nanoparticle Catalysis And Electrocatalysis: Theory and modelling of catalytic and electrocatalytic reactions - some selected examples, Simulations of the reaction kinetics on nm supported catalyst particles, Electronic structure and chemisorption properties of supported metal clusters - model calculations

Model Systems - From Single Crystals To Nanoparticles: State-of-the-art characterization of single crystal surfaces; Single crystal surfaces as model platinum-based fuel cell electrocatalysts, Electrochemical nanostructuring of surfaces, Adsorption and reaction at supported model catalysts, Size-dependent

electronic, structural, and catalytic properties of metal clusters supported on ultra-thin oxide films, Physical and electrochemical characterization of bimetallic nanoparticle electrodes.

Synthetic Approaches In Nanoparticle Catalysis And Electrocatalysis:

Nanomaterials as precursors for electrocatalysts; preparation, characterization, and properties of bimetallic nanoparticles, Physicochemical aspects of preparation of carbon supported Nobel metal catalysis.

Particle Size, Support, And Promotional Effects: Electrochemical and chemical promotion on metal films and nanoparticles

Metal-supported interaction in low temperature fuel cell electrocatalysis

Effects of nanoparticle size, structure, and metal-support interactions; promotion, electrochemical promotion and metal-support interactions, Support effects on catalytic performance of nanoparticles; abnormal infrared effects of nanometer scale thin film material of platinum group metals and alloys at electrode/electrolyte interfaces, Design of electrocatalysts for fuel cells; effect of particle size and support on some catalytic properties of metallic and bimetallic catalysts.

Advanced Electrocatalytic Materials: Catalyst nanoparticles on synthetic diamond surfaces, Electrocatalysis with electron conduction polymers modified by platinum metal nanoparticles, Novel nanostructured material based on transition metal compounds for electrocatalysis.

Bulk Metal and Ceramics Nanocomposites: Ceramic/Metal Nanocomposites, Metal Matrix Nanocomposites Bulk Ceramic Nanocomposites for Desired Mechanical Properties, Thin-Film Nanocomposites: Multilayer and Granular Films, Nanocomposites for Hard Coatings, Carbon Nanotube-Based Nanocomposites, Functional Low-Dimensional Nanocomposites, Inorganic Nanocomposites for Optical Applications, Inorganic Nanocomposites for Electrical Applications, Nanoporous Structures and Membranes: Other Nanocomposites, Nanocomposites for Magnetic Applications Magnetic Multilayer Nanocomposites, Nanocomposite Structures having Miscellaneous Properties, Concluding Remarks on Metal/Ceramic Nanocomposites

Polymer-based and Polymer-filled Nanocomposites: Nanoscale Fillers, Nanofiber or Nanotube Fillers, Carbon Nanotubes, Nanotube Processing,

Other Nanotubes, Plate-like Nanofillers Inorganic Filler/Polymer Interfaces Processing of Polymer Nanocomposites, Nanoparticle/Polymer Composite Processing, Direct Mixing, Modification of Interfaces, Modification of Nanotubes, Properties of Composites,

Natural Nanobio-composites, Biomimetic Nanocomposites, and Biologically Inspired Nanocomposites: Natural Nanocomposite , Materials, Biologically Synthesized Nanoparticles, Biologically Synthesized Nanostructures, Biologically Derived Synthetic Nanocomposites, Protein-Based Nanostructure Formation, DNA-Templated Nanostructure Formation, Protein Assembly, Biologically Inspired Nanocomposites, Lyotropic Liquid-Crystal Templating, Liquid-Crystal Templating of Thin Films, Block-Copolymer Templating Colloidal Templating, Modeling of Nanocomposites: Introduction The Need For Modeling Current Conceptual Frameworks, Multiscale Modeling, Multiphysics Aspects.

9. Advances in Green Chemistry for Sustainable Development (Open elective)

This subject will be based on the lectures and seminars of visiting scientists, distinguished Chairs and persons from industry. A total of 15 such lectures will be organized during the semester. The idea behind such an elective is to expose the students to a variety of new topics on cutting edge. This also conforms to the 'open boundary' syllabus.

Bibliography and Journal Articles for all Subjects

Since the area is fast developing the following are given as bibliography. The students must read the current trends in the area from journal articles.

The Need for Green Chemistry

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