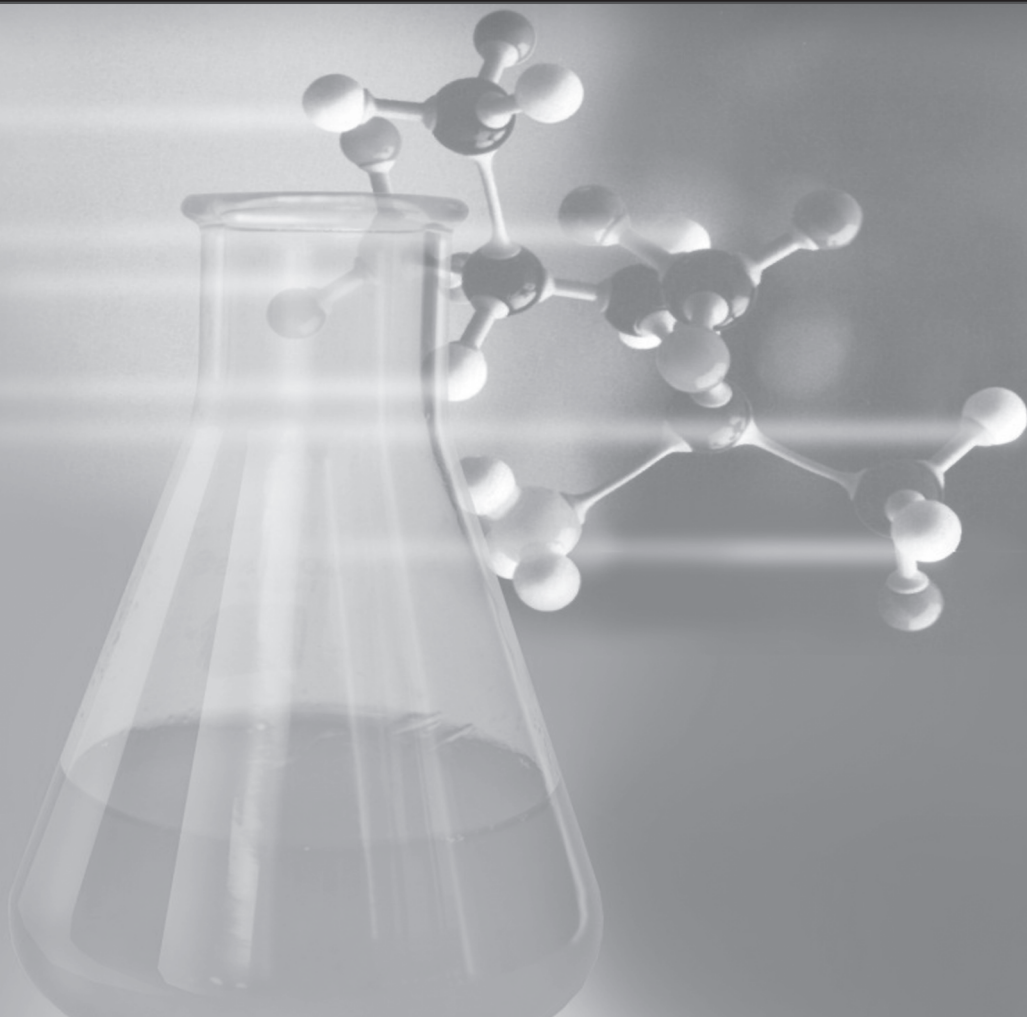


Pharmaceutical Technology (Process Chemistry)



I Semester

PT-510 Industrial Process and Scale up Techniques

(1 Credit)

1. Status of pharmaceutical industry: Status of bulk drugs, natural products and formulations in India vis-a-vis industrialized nations.
2. Scale-up Techniques: Scale-up techniques for process optimization, maximization of productivity, in-process control techniques.
3. Chemical technology of selected drugs: Case studies with emphasis on rationale for selection of routes, raw materials, process control methods, pollution control procedures etc.
4. Chemical technology of selected drugs: Data collection during pilot plant trails, preparations of flow diagrams, material balance sheets and technical data sheets.
5. Process technologies for some selected natural products of commercial interest, e.g. 4-hydroxyisoleucine.
6. Scale-up techniques for industrial pharmacy, typical standard operating procedures for different dosage forms; In-process control procedures.
7. Pharmaceutical manufacturing equipment: Equipment used to manufacture bulk drugs.
8. Pharmaceutical manufacturing equipment: Equipment used in formulations.

Recommended books:

1. Process Chemistry in Pharmaceutical Industry by Kumar Gadamasetti, Vol I & II
2. Advanced Organic Chemistry by Jerry March
3. Pharmaceutical Process Chemistry for Synthesis: Rethinking the Routes to Scale-Up by Peter J. Harrington , Wiley
4. Practical Process Research and Development by Neal G. Anderson, Academic Press
5. Strategies for Organic Drug Synthesis and Design by Daniel Lednicer

PT-560 Synthetic Aspects of Process Chemistry

(2 credits)

1. Reaction progress kinetic analysis: Streamlining reaction steps, route selection, characteristics of expedient routes, characteristics of cost-effective routes, reagent selection, families of reagents useful for scale-up, solvent selection, selecting solvents based on physical characteristics, selected solvent impurities.
2. Green chemistry: 12 Principles of green chemistry, examples of greener route to chemical reactions, designing robust reaction conditions, reaction media for green chemistry, organic reactions in water, sustainable development of a process.
3. Transition-metal and Organo-catalysis in organic synthesis: Metal-catalyzed reactions, asymmetric organo-catalysis, phase transfer catalysis, benefits and challenges of applying phase transfer catalysis technology in pharmaceutical industry.
4. Emerging trends in process chemistry: Use of Domino, Cascade, and Tandem reactions, multi-component reactions, development of efficient one-pot process with examples, lithium-halogen exchange reactions in process chemistry.

5. Click chemistry: Beyond the paradigm of carbonyl chemistry, Click chemistry reaction types, Click chemistry in water, Click reactions in "solid phase synthesis", examples of Click Chemistry sequences-diversity with ease, its application in the synthesis of heterocycles and macromolecules.
6. Microwave reactions: Discovery and advantages of its use, increased reaction rates, mechanism, superheating effects of microwave, effects of solvents in microwave assisted synthesis, microwave technology in process optimization, its applications in various organic reactions and heterocycles synthesis.
7. Impurity consideration: Introduction, Steps to optimizing reactions, minimizing impurity formation by indentifying impurities first, method development for separation, synthesis and isolation of impurities and their characterization, Statistical design of experiments.
8. Troubleshooting: Physical and chemical causes of processing problems, steps for troubleshooting a process, debottlenecking a problem, Stereoselective enzymatic synthesis of APIs.

Books recommended:

1. Process Chemistry in the Pharmaceutical Industry by Kumar Gadasetti, Marcel Dekker Inc.
2. Practical Process Research &Development by Neil G. Anderson, Academic Press
3. Principles of Process Research and Chemical Development in the Pharmaceutical Industry by O. Repic, John Wiley &Sons, Inc
4. Pharmaceutical Process Chemistry for Synthesis by Peter J. Harrington

MC-511 Spectral Analysis **(2 credits)**
(Refer to Page No. 03)

MC-520 Logic in Organic Synthesis-I **(3 credits)**
(Refer to Page No. 04)

NP-510 Separation Techniques **(1credit)**
(Refer to Page No. 14)

GE-510 Biostatistics **(2 credits)**
(Refer to Page No. 15)

GE-520 Fundamentals of Intellectual Property (IP) and Technology Management **(1 credit)**
(Refer to Page No. 16)

GE-511 Seminar
(Refer to Page No. 17)

(1 credit)

LG-510 General Laboratory Experience - 15 hours / week **(3 credits)**

1. Analytical techniques: (75 hours)
 - a) Spectral analysis workshop (45 hours)
 - b) Separation Techniques (30 hours)
2. Computer and application in pharmaceutical sciences (100 hours): Introduction to computers, basic unit and functions, H/W and S/W, operating systems, word processing, spread sheet, graphic programs, dbase, windows, statistical S/W programs and packages. Steps involved in S/W development, computer languages with emphasis to FORTRAN language and programming, hands on experience in pharmaceutical software systems. Use of computers in information retrieval systems.
3. Specialization (95 hours):
 List of Experiments:
 Esterification; Etherification; Tosylation; Hydrogenation; Nitration; Grignard; Witting; Claisen-Schmidt; Friedel-Crafts alkylation and acylation; Halogenation; Cyloaddition; Sulphonation; Cannizzaro; Benzoin condensation; Aldol and cross-aldol condensation; Dehydration reaction of amides and aldoximes; Hydroxylation; Coupling and Hofmann reaction.

II Semester

PT-610 Topics Relevant to Drugs and Pharmaceutical Industry (1 credit)

1. Drug and pharmaceutical plants: Building layout, equipment layout, regulatory requirements for the same.
2. Safety aspects: Fire, explosion, toxicity, hazards of some selected organic/ inorganic chemicals and methods to handle them safely.
3. Disaster planning: Hazard appraisal and control, "on-sight" and "off-sight" disaster planning.
4. Corrosion and its prevention: Corrosion characteristics of selected organic/ inorganic chemicals and compatible materials of construction.
5. Documentation and regulatory record keeping: Record keeping as required by different statutory bodies.
6. Management information systems (MIS): Information management, need, users, systems.
7. Concept and type of pollution, ecology and ecological balance, pollution and health hazards, gaseous pollution and control, water pollution and control.
8. Waste Management: Waste minimization technology used in pharma plants.
9. Instrumentation and process control: Fundamentals of automatic control, process measurements -concept of accuracy, sensitivity and precision, measurement and control of temperature, pressure level, density, pH, dis-solved oxygen and carbon dioxide.
10. Use of computers in process control: Basics and recent computer developments in automation.

Recommended books:

1. Fire Safety Management by SatishTandon
2. Pollution Prevention of Chemical Processes by Allen DavidT.
3. TheTreatment and Handling ofWastes by Bradshaw,A.D.
4. Good Pharmaceutical Manufacturing Practice: Rationale and Compliance by Sharp John
5. Management Information Systems by Laudon Kenneth C.
6. Plant Design and Economics for Chemical Engineers by Peters, Max S.

PT-630 Synthetic Bulk Drug Technology**(2 credits)**

1. Unit Processes: Oxidation, Reduction, Sulfonation, Nitration, Halogenation and their applications to the manufacture of known drugs.
2. Bond formation and cleavage: Industrially feasible C-C bond formation and cleavage reactions, Epoxide and aziridine ring formation and opening.
3. Application of new synthetic methodologies in bulk drug synthesis: Click chemistry, Click reactions in "solid phase synthesis", Domino, Cascade, and Tandem reactions, Multicomponent reactions, development of efficient one-pot process with examples, lithiumhalogen exchange reactions in process chemistry.
4. Industrial synthesis of chiral drugs: Commercial synthesis of (S, S)-Reboxetine, Commercial route to Rizatriptan, their medicinal chemistry approaches and subsequent chemical development.
5. Impurity consideration: Introduction, Steps to optimizing reactions, minimizing impurity formation by indentifying impurities first, method development for separation, synthesis and isolation of impurities and their characterization, Statistical design of experiments.
6. Bulk organic chemicals as building blocks for drugs and drug intermediates: List of raw materials, their manufacturer in India and abroad and their uses.
7. Green chemistry: 12 Principles of Green chemistry, Designing robust reaction conditions for green chemistry, organic reactions in water, sustainable development of a process.
8. Transition-metal and Organo-catalysis in organic synthesis: Metal-catalyzed reactions, asymmetric organocatalysis, phase-transfer catalysis, benefits and challenges of applying phase-transfer catalysis technology in pharmaceutical industry.
9. Catalysis in industrial organic synthesis: Use of achiral and chiral heterogeneous and homogeneous catalysts
10. Biocatalysis: Use of enzymes in organic synthesis, immobilized enzymes/cells in organic reaction

Recommended books:

1. Organic Chemistry by J. Clayden, N. Greeves, S. Warren and P. Wothers
2. Advanced Organic Chemistry, Part A: Structure and Mechanisms by F.A. Carey and R.A. Sundberg

3. Advanced Organic Chemistry, Part B: Reactions and Synthesis by F.A. Carey and R.A. Sundberg
4. Advanced Organic Chemistry- Reactions, Mechanisms and Structure by J. A. March, M. B. Smith
5. Modern Methods of Organic Synthesis, by W. Carruthers and I. Coldham
6. Strategic Applications of Named Reactions in Organic Synthesis by L. Kurti and B. Czako
7. Organic Syntheses Based on Name Reactions by A. Hassner and C. Stummer

PT-690 Downstream Processing of Biological Products (1 credit)

1. Pre-treatment: Importance of pre-treatment; Dealing with high viscosity fermentation broth; Coagulation; Flocculation; Pasteurization; Sterilization; Adsorption on filter aids; heating etc.
2. Filtration: Theories of filtration, Conventional and Non-conventional filtration Darcy's equation, Various forms of Darcy's equation, Batch filters, continuous rotary filters, Microfiltration, Ultrafiltration, Reverse Osmosis; Symmetric and asymmetric membranes.
3. Centrifugation: Gravity sedimentation, Centrifugal sedimentation; Stoke's equation; Batch and continuous centrifuges; Various types of centrifuges; Centrifugation theory; Determination of molecular weight and particle size from centrifugation data; Sedimentation coefficient; Various forms of Stoke's equation; Scale-up of centrifuge.
4. Cell disruption: Different methods of cell disruption, advantages, disadvantages, solid shear method and liquid shear method; Factors affecting the rate of cell disintegration and solving of numerical thereof.
5. Solvent-solvent extraction: Theories of solvent-solvent extraction; co-current and counter-current extraction; separation factor; solid yield; Aqueous two phase extraction; Supercritical fluid extraction; pervaporation and numerical thereof.
6. Adsorption: Langmuir adsorption isotherm; Equilibrium relationship for adsorption; Adsorbate; Adsorbate; Freundlich adsorption isotherm; Fixed bed adsorber, analysis thereof; Antibody recovery by adsorption; case studies.
7. Evaporation: Theories of evaporation; Evaporator cum crystallizer; Economics of evaporator design; Evaporative equilibrium; Factors influencing the rate of evaporation; Solving of numericals associated with evaporation.
8. Crystallization: Crystallization theory; Rate of nucleation and rate of crystal growth; Particle size distribution of crystals; Solving of numericals associated with crystallization; Batch and continuous crystallizers.
9. Distillation: Theories of distillation; Batch and continuous distillation; Azeotropic distillation; Distillation in food processing; Simple distillation; Fractional distillation; Steam distillation; Vacuum distillation etc.
10. Drying: Drying of bioproducts; Drying mechanism; Freeze drying; Supercritical drying; atural air drying; Spray drying; Equipment for drying; Equilibrium moisture content of bioproducts; Rate of drying curves.

Recommended books:

1. Process Biotechnology Fundamentals 2nd/ed by S. N. Mukhopadhyay
2. Bioprocess Engineering Principles by Pauline M. Doran
3. Principles of Fermentation Technology Biotol series by Peter F. Stanbury, Allan Whitaker, Stephen J. Hall
4. Biotol Series: Biotechnological Innovations in Chemical Synthesis by J.A. M. van Balken
5. Biotol Series, Product recovery in Bioprocess Technology by Butterworth Heinemann
6. Industrial sterilization by Richards

MC-620 Logic in Organic Synthesis-II (3 credits)
(Refer to Page No. 07)

MC-650 Stereochemistry and Drug Action (2 credits)
(Refer to Page No. 10)

PA-620 Modern Instrumental Techniques for Evaluation of APIs and Drug Products (2 credits)
(Refer to Page No. 19)

GE 611 Seminar (1 credit)
(Refer to Page No. 23)

LS-610 General Laboratory Experience (10 hours/week) (2 credits)

Synthesis of a complex molecule/ drug intermediate or a catalyst which may include 5 or more steps to isolate, purify (chemical methods and through chromatography) and characterize the product from each step. To be familiar with modern analytical methods like UV, IR, NMR, GCMS, LC-MS, & HPLC methods. To learn about unit processes (hydrogenation, oxidation etc.). Chiral resolution of racemic mixtures and their characterization using polarimeter and chiral HPLC methods.