Savitribai Phule Pune University

(Formerly University of Pune)

Two Year Post-Graduate Program in Chemistry

(Faculty of Science & Technology)

Choice Based Credit System Syllabus (2019 Pattern)

of

M.Sc. Polymer Science Part-II

Colleges Affiliated to Savitribai Phule Pune University

Implemented from Academic Year

2020-2021

Title of the Course: M.Sc. (Polymer Science) (Part-II)

1. Structure of the Course:

Basic structure/pattern (Framework) of the proposed postgraduate syllabus for the two years integrated course leading to M.Sc. (Polymer Science) in Nowrosjee Wadia College affiliated to Savitribai Phule Pune University.The general structure for the M. Sc-II year (Polymer Science)is as follows:

Semester –III

Sr. No.	Paper No	Description	Credit
1	CCTP-7	Core Compulsory Theory Paper	4
2	CCTP-8	Core Compulsory Theory Paper	4
3	CCTP-9	Core Compulsory Theory Paper	4
4	CBOP-3	Choice Based Optional Paper –Theory	4
5	CCPP-3	Core Compulsory Practical Paper	4

Semester-IV

6	CCTP-10	Core Compulsory Theory Paper	4
7	CCTP-11	Core Compulsory Theory Paper	4
8	CBOP-4	Choice Based Optional Paper –Theory	4
9	CBOP-5	Choice Based Optional Paper –Practical/ Project	4
10	CCPP-4	Core Compulsory Practical Paper	4

Choice of the optional papers:

The college is encouraged to give the choice of optional papers to the students and conduct the separate classes if 40% or more students opt a different course than 60% or less students.

Teaching Hours

a) Theory –Each credit of theory is equivalent to 12 teaching hours +3 tutorial hours. For 1 credit of theory there will be 1 L of 1 hour per week. Thus, 1 theory course will have total 15 weeks of teaching and it will be distributed as of 48 h for teaching and 12 h for tutorials and internal evaluation. In case of theory paper consisting of sections, each section is of 2 credits and time allotted will be 24 h teaching and 6 h for tutorials and internal evaluation.

b) Practical –Each credit of practical is equivalent to 24 teaching hours + 6 tutorial hours. For 1 credit of practical there will 2 L of 1 h per week. Thus, 1 practical course will have total 15 weeks of teaching and it will be distributed as of 96 h for performing practical and 24 h for tutorials and internal evaluation.i) Each experiment will be allotted 4 h time(one practical session) and for 1 course two sessions of 4 h per week should be allotted or ii) In case practical course is extended for one year, then total 30 weeks (15 week per sem.) and 4 h. (one practical session) per week should be allotted to one practical course. There shall not be more than 10 students in one batch of practical.

3. Examination: Each theory and practical course carry 100 marks equivalent to4 credits. Each course will be evaluated with Continuous Assessment (CA) and Final assessment mechanism. Continuous assessment shall be of 30 marks (30%) while Final Evaluation shall be of 70 marks (70%). To pass the course, a student has to secure 40% mark in continuous assessment as well as final assessment. 12 marks in continuous assessment and 28 marks in final assessment. For Continuous assessment teacher must select variety of procedures for examination such as: i) Written test / Mid Semester test (not more than one for each course), ii) Term paper, iii) Viva-Voce, Project / survey / field visits iv) Tutorials v) Group discussion vi) Journal / Lecture / Library notes vii) Seminar presentation, viii) Short quiz ix) assignment x) research project by individual student or group of student xi) An open book test, etc. Each practical course will be extended over the year and practical examination will be conducted at the end of academic year.

M.Sc. (II) Polymer Science

To be Implemented from Academic Year 2020-21

Sr. No.	Paper No. & Code	Course Name	Credit
		Semester III	
1	CCTP-7 PSP-310	Polymer synthesis : Chain growth Polymerization.	**4**
2	CCTP-8 PSP-311	Polymer synthesis : Step growth polymerization	**4**
3	CCTP-9 PSP-312	Physical Chemistry of polymers	**4**
4	CBOP-3	A] Analytical Chemistry of polymers	**4**

	(Theory) PSP-313	B] Special Topics in Polymer Science I	**4**
5	CCPP-3 PSP-314 Practical	**Polymer Practicals Course I**	**4**
		Semester IV	
6	CCTP-10 PSP-410	Polymer processing	**4**
7	CCTP-11 PSP-411	Rheological and tribological study of polymers and composites.	**4**
8 **9**	CBOP-4 (Theory) PSP-412 CBOP-4 PSP-413 (Practical)	A] Advanced instrumental techniques in polymer Characterization B] Special topics in Polymer Science II **A] Polymer practicals III** **B] Project**	**4** **4** **4** **4**
10	CCPP-4 PSP-414	**Polymer Practicals II**	**4**

	Practical		

Equivalence to Previous Syllabus

Old Paper (2014 Pattern)	New Syllabus (2020)
Semester III	
PSP-310	CCTP-7: PSP-310
PSP-311	CCTP-8: PSP-311
PSP-312	CCTP-9 PSP-312 :
PSP-313 PSP-404	CBOP-3 , PSP- 313[:A] CBOP-3 , PSP- 313[B]
PSP-317	CCPP-3 , PSP-314 Practical I
Semester IV	
PSP-410	CCTP-10: ,PSP-410
PSP-411	CCTP-11: PSP-411
PSP-412	CBOP-4: PSP-412[A] CBOP-4 PSP-412[B]
PSP-417	CCPP-4 PSP-414 Practical II
PSP-418 PSP-419	CBOP-5 .PSP-413[A]: Practical III CBOP-5 PSP-413[B] Project

Detailed Syllabus: Semester and Paper Wise

Semester III

CCTP-7, PSP-310: Polymer Synthesis: Chain growth polymerization
[48L + 12T]

Section-I:
Kinetics and mechanism of Chain polymerization processes **[24 L +6 T]**

1. Chain reaction (Addition) polymerization **[8 L]**

Free radical addition polymerization mechanism of vinyl polymerization, generation of free radicals, initiation, propagation, termination, chain transfer inhibition of retardation, configuration of monomer units in vinyl polymer chains.

a. Kinetics of free radical addition polymerization – experimental determination of rate constants, derivations for rate expressions and expressions for kinetic chain length and hence degree of polymerization. Control of molecular weight by transfer, molecular weight and its distribution. Thermodynamics of free radical polymerization, effect of temp and pressure, enthalpies, entropies, free energies, activation energies o polymerization.

b. Ionic and coordination chain (addition) polymerization common features of two types of ionic polymerization, Mechanism of cationic polymerization, expressions for overall rate of polymerization and the number average degree of polymerization. Mechanism of anionic, polymerization, expressions for overall rate of polymerization and the average degree of polymerization, living polymers. Mechanism of coordination polymerization – Ziegler-Natta catalysts, expressions for overall rate of polymerization. Ring opening polymerization-mechanism of polymerization of cyclic ethers, cyclic amides and cyclosiloxanes.

2. Copolymerization **[8 L]**

Types of copolymerization- the copolymer composition equation, monomer reactivity rations, rate of copolymerization, composition of copolymers, variation of copolymer composition with conversion, mechanisms of copolymerization, block and graft copolymers.

3. Controlled polymerization methods **[8 L]**

Nitroxide mediated polymerization (NMD), Atom Transfer Radical Polymerization (ATRP), Group Transfer Polymerization (GTP), Reversible Addition Fragmentation Termination (RAFT).

References:

1) Principles of polymerization, G.Odian, Wiley – Interscience (1981)
2) Organic polymer chemistry, K. J. Saunders, Chapman and Hall, London (1973).
3) High performance polymers, their origin and development, by Seymour R. B. and

Kirshenbaum G. S. Elservier.
4) Condensation polymers by interfacial and solution methods, Paul W. Morgen, Interscience publishers.
5) Industrial plastics: Theory applications by T. L. Richardson.
6) Organic chemistry of synthetic high polymers, Robert W. Lenz, Interscience publisher.

Section-II: Chemistry of hydrocarbon plastics and elastomers [24 L +6 T]

1. Properties and Application of Hydrocarbon plastics and elastomers **[8 L]**
Low density (branched) polyethylene, polypropylene, high density (linear) polyethylene, polypropylene, other olefin polymers, natural rubber and other isoprene polymers, rubbers derived from butadiene – acrylic acid copolymers, stereoregular polybutadienes, polychloroprene (neoprene), styrene- butadiene – acrylonitrile copolymers

2. Other carbon-carbon polymers **[16 L]**
Polystyrene and other related polymers, copolymers of polystyrene, acrylic polymers – acrylic fibers, acrylic adhesives, poly acrylates, polymethyl methacrylate(PMMA), poly acrylamide, polyvinyl acetate (PVA), polyvinyl alcohol, poly vinyl acetals, poly vinyl chloride, fluoro carbon polymers.

References:

1) Principles of polymerization, G.Odian, Wiley – Interscience (1981)
2) Organic polymer chemistry, K. J. Saunders, Chapman and Hall, London (1973).
3) High performance polymers, their origin and development, by Seymour R. B. and Kirshenbaum G. S. Elservier.
4) Condensation polymers by interfacial and solution methods, Paul W. Morgen, Interscience publishers.
5) Industrial plastics: Theory applications by T. L. Richardson.
6) Organic chemistry of synthetic high polymers, Robert W. Lenz, Interscience publisher.

Detailed Syllabus: Semester and Paper Wise

Semester III

CCTP-8, PSP-311: Polymer synthesis :Step Growth Polymerization
[48L + 12T]

Section-I:
Step reaction polymerization **[24 L +6 T]**

1. Step reaction (condensation) polymerization **[16 L]**

Step reaction (condensation) polymerization – Mechanism of step reaction polymerization, carbonyl addition elimination, carbonyl addition – substitution, nucleophilic substitution, and aromatic electrophilic substitution. Kinetics of step reaction polymerization, reactivity and molecular size. Kinetic expressions for polymerization in absence and in presence of a catalyst. Statistics of linear step reaction polymerization – number distribution and weight distribution functions, molecular weight control, Polyfunctional step reaction polymerization, prediction of gel point, its experimental observation, molecular wt. Distribution in – 3 D step reaction.

2. Hyperbranched polymers and dendrimers **[8 L]**

Hyperbranched polymers and dendrimers, methods of synthesis, characterization, properties and application.

References:

1. Principles of polymerization, G. Odian, Wiley – Interscience (1981)
2. Organic polymer chemistry, K. J. Saunders, Chapman and Hall, London (1973).
3. High performance polymers, their origin and development, by Seymour R. B. and Kirshenbaum G. S. Elservier.
4. Condensation polymers by interfacial and solution methods, Paul W. Morgen, Interscience publishers.
5. Industrial plastics: Theory applications by T. L. Richardson.
6. Organic chemistry of synthetic high polymers, Robert W. Lenz, Interscience publisher.

Section-II: Heterochain thermoplastics and thermosets [24 L +6 T]

1. Synthesis, properties and application of heterochain thermoplastics **[16 L]**

Historical development, preparative methods, properties and application of the following: polyamides , Nylon 6, Nylon 66, Nylon 610 etc.,polyesters , polyether and related polymers –

poly ethylene terephthalate (PET), polybut yllene, terphthalate (PBT), aromatic polyesters, polycarbonate, polyurethanes – Flexible and rigid polyurethane, polyurethane elastomers, coatings, adhesives, sulphur, containing polymers, polimdes, polybenimidazoles, polyethersulphones, polyetherketones.

4. Thermosetting resins **[8 L]**

Thermosetting resins – phenolic resins, amino resins epoxy resins, silicone polymers, and cyanate ester resins.

References:

1) Principles of polymerization, G.Odian, Wiley – Interscience (1981)
2) Organic polymer chemistry, K. J. Saunders, Chapman and Hall, London (1973).
3) High performance polymers, their origin and development, by Seymour R. B. and Kirshenbaum G. S. Elservier.
4) Condensation polymers by interfacial and solution methods, Paul W. Morgen, Interscience publishers.
5) Industrial plastics: Theory applications by T. L. Richardson.
6) Organic chemistry of synthetic high polymers, Robert W. Lenz, Interscience publisher.

Detailed Syllabus: Semester and Paper Wise

Semester III

CCTP-9, PSP-312: Physical Chemistry of Polymers [48L + 12T]

Section-I: [24L + 6T]

Morphology and order in crystalline polymers and Polymer structure and physical properties

1. Morphology and order in crystalline polymers: Configurations of polymer chains, crystal structures of polymers, Morphology of polymer single crystals, structure of polymers crystallized from melt and solution, crystallization processes and kinetics, orientation and drawing. **(16 L)**

2. Polymer structure and physical properties: The crystalline melting point, the glass transition, Factors affecting Tm and Tg. Determination of Tg by (a.) Dilatometer, (b.) TMA and (c.) DSC,Properties involving large deformations, properties involving small deformations, property requirements and polymer utilization. **(8 L)**

References:

1. Principles of polymer chemistry by P.J. Flory
2. Molecular weight distribution in polymer by L.H. Peebles, Wiley- Interscience, N.Y. (1971).
3. Macromolecules in solution by H.Morawetz, Wiley Interscience, N.Y. (1975).
4. Polymer science by Govarikar V.R. and others, Wiley Eastern (1986).

Section-II: Polymer chains and their characterization and Radiation chemistry of polymers [24L +6T]

1. Polymer chains and their characterization.
Polymer solutions – Criteria of polymer solubility, conformations of dissolved polymer chain, stages and thermodynamics of polymer solutions nature (size and shape) of polymer in solutions, theta temperature, viscosity of dilute solution, phase separation in polymer solutions, moderately highly concentrated solutions. **(16 L)**
2. Radiation chemistry of polymers: Effect of radiation on polymer, structure and properties. Application in curing, coating purification, polymer
composites etc. radiation induced polymerization. **(8 L)**

References:

1. Principles of polymer chemistry by P.J. Flory
2. Molecular weight distribution in polymer by L.H. Peebles, Wiley- Interscience, N.Y. (1971).
3. Macromolecules in solution by H.Morawetz, Wiley Interscience, N.Y. (1975).
4. Polymer science by Govarikar V.R. and others, Wiley Eastern (1986).

CBOP-3 , PSP-313[A]: Analytical Chemistry of Polymers [48L + 12T]

Section-I:

[24 L +6 T]

1. Chemical analysis: Introduction, preparation of the sample, Determination of purity.
Physical tests. Preliminary examination, burning characteristics. Transition points. Density, refractive index, pyrolytic behaviour, chemical tests. Qualitative and quantitative elementary analysis. Solubility and acid numbers, acetyl number, iodine number end group analysis, colour tests. (4)
2. Infra red UV and Raman spectroscopy. Introduction theoretical background, Number and position of absorption bands, Instruments and specimen reparation. Elucidation of structure. Qualitative and quantities analysis. Studies in the physical and chemical nature of polymers. Orientation and crystallinity. (10)
3. N.M.R-H and C NMR phenomenon. Line broadening by local fields, broad line spectra. Experimental techniques, measurement of crystallinity. Spectra of vinyl polymers in solution poly methyl methacrylate, poly vinyl chloride, polystyrene, poly propylene, Head to head and head to tail measurement. Isomerism in dine polymers, dynamic Flexibility of chain (10)

Section II
[24 L +6 T]
1. X-ray diffraction analysis – methods of production of X-ray, properties of X-ray. Diffraction of X-rays. Braggs law, lattice and powder diffraction methods. Small angle scattering of X-ray by polymers. Analysis of molecular structure of simple polymers. (6) 2. Differential thermal analysis – physical transitions, melting thermo grams. Heat of fusion and degree of crystallinity or isotacticity, Random copolymer structure, Block copolymer structure, polymer mixture, melting point depression by diluents, crystallization, Melt crystallization, cold crystallization, Glass transition, crystal crystal transition . Chemical reaction (6) 3. Thermo gravimetric analysis: Introduction, instrumentation Determination of kinetic parameters. Method of freeman and Carroll, Methods of involving maximization of rate, method of multiple heating rates. Method of variable heating rate for a single thermo gram, Estimation of thermal stability from TGA curves, qualitative methods, semi quantitative and quantitative methods, Thermal degradation, behaviour of some polymer by TGA methods, styrenated polyester, polytetrafluioroethylene . (8) 4. Microscopy, optical diffraction, diachronic. Birefringence dielectric properties.(2) 5. Studies of optical properties: RI, Abbe No., Transparency, Mechanical, electrical properties, moisture and solvent resistance.(02)
Books Recommended 1. Analysis of polymers- an introduction, by Crompton T.R., pergaman press 1989. 2. Thermal characterization of polymeric materials, by Turi E.A., Academic press Inc. 3. Polymer science, a material science H.B. Vol I & Ii by Jenkins, A.D., North Holland publishing Co., Amsterdam London. 4. Carbon-13 Nuclear Magnetic Resonance for organic chemists by Levy G.C. and Nelson G.L., Wiley Interscience.

CBOP -3: PSP 313 [B] Special Topics in Polymers II

Section I Polymer degradation and stabilization [24L + 6T]

Radiation chemistry of polymers: Effect of radiation on polymer, structure and properties. Application in curing, coating purification, polymer composites etc. radiation induced polymerization.[08]

Chemical degradation, physical degradation, ageing, crazing, degradation by micro organisms, Biodegradable polymers, Mechanism of degradation, secondary chain reaction, Self reaction, depolymerisation, metal catalysed degradation .[08]

Thermal oxidation, Photooxidation, Mechanical degradation, Degradation by ionizing radiation, ozone attack. Degradation of special polymers: Polyolefins, PVC, PS, PMMA. Stabilization: Chain breaking antioxidants, bound antioxidants, Radiation protection, Stabilization against biodegradation.[08]

Section II **Biopolymers and speciality polymers.**
[24L+6T]

Biopolymers and biomedical applications 18 h Nucleic acids-nucleosides, nucleotides, RNA, DNA- structural aspects, Biological significance-coding of amino acids, Heredity, NA-Finger printing, gene technology, Application of genetic engineering techniques in agriculture, biology and medicine, Biomedical application of polymers: polymers as drug ca polymersrriers, polymers for surgery and plasma substitution. Polymeric drugs, polymers as artificial enzymes, synzymes, Biometric chemistry. [12]

Speciality Polymers 18 h Conduction polymers, conduction mechanism applications, Polyacytelene, polyparaphenylenes, polyanilines, polypyrrole, Photoconductive polymers, polymers in nonlinear optics, polymers with piezoelectric, pyroelectric and ferroelectric properties, Polyvinylidine fluoride. Photoresists for semiconductor applications, Negative Photoresists, Positive photoresists, Plasma reversible photoresistors, Electron beam lithography, Liquid crystalline polymers: preparation, properties, and applications, Chiral thermometric liquid crystal polymers, Nematic, liquid crystal polymers, Ionic Polymers: ionic crosslinking, Bound polymers and counter ion.[10]

Chiral polymers, tacticity, Property requirements and polymer utilization-Elastomers, fibers and plastics.[02]

1). F. Rodriguez, Principles of polymer systems, MacGraw Hill.

2). H. G. Elias, Macromolecules, Plenum.

3). P. J. Flory, Principles of polymer chemistry, Cornell Univ.

4). F. A. Bovey, Polymer configuration and conformations, Academic.

5). R. J. Young, Introduction to polymer science, Wiley

6). G. Odian, Principles of polymerization, Wiley.

7). F. W. Billmayer, Text book of polymer science, Wiley.

8). K. K. Chawla, Composite materials, Springer 24. D. R. Paul and Newman, Polymer blends, Vol 1 and 2, Academic.

9). O. Olabisi, Polymer-polymer miscibility, Academic. 66 26. F. R. Jones.

Detailed Syllabus: Semester and Paper Wise

Semester III

CCPP-3, PSP-314: Polymer Practicals Course-I [48L + 12T]

Polymer modifications

i. Film casting from solutions.

a. PI

b. Cellophane

c. Cellulose acetate

ii. Casting and characterization of membranes.

iii. Preparation of cellulose acetate.

iv. Preparation of cellulose sodium carboxy methylcellulose.

v. Modification of PS to chloromethylated PS.

vi. Hydrolysis of PVAC, preparation of PVA.

vii. Preparation of poly (vinyl acetate) from PVA.

viii. Chlorination / chlorosulphonation of polyethylene.

ix. Dispersion of nano particle in polymers and characterization.

Polymer characterization

1. Determination of molecular weight by end group analysis (COOH group)
2. Acetyl contends of cellulose acetate

Polymer Analysis

1. To determine acid value of a given polymer
2. To determine sap value and %purity of plasticizer
3. To determine epoxy content of given polymer by pyridiumchloride/pyrinine method
4. Identification of plastics by heating/burning tests.

Instrumental techniques

1. Izod impact strength
2. Quantitative determination of impurities in given polymer by spectral techniques (UV-VIS).
3. NMR studies of polymer samples.
4. Determination of MFI.
5. Determination of moisture content and moisture regain of fibers.
6. Spinning and characterization of Fibers and hollow fibers.

*at least 12 experiment to be carried out.

Semester IV

[Detailed Syllabus]

CCTP -10

[PSP-410] Polymer processing

Section I **[24L+ 6T]**

1. Plastics technology -

Plastics technology Raw materials: types of forms, products, applications consumption pattern, Tailoring of material, quantitative aspects of polymer processing additives and compounding – fillers, plasticizers, antioxidants, colorants, flame retardants, stabilizers compounding. Molding – compression molding, transfer molding, injection molding, RIM, bow molding, rotational molding, thermoset molding, Extrusion – coextrusion, film extrusion, pultrusion, calendaring, casting, coating, foaming, forming laminates. Multipolymer systems and composites. (24)

Section II **[24L+6T]**

2. Fiber Technology –

Textile and fabric properties – Definition. Of textile terms, properties of textile fibers – electric, mechanical and fabric properties. Spinning – melt spinning, dry spinning, and wet spinning. Fiber after treatments scouring, lubrication, sizing, dyeing, finishing (12)

3. Elastomers technology –

Compounding and elastomers properties, Vulcanization – chemistry of vulcanization, sulfur vulcanization, physical aspects of vulcanization. Reinforcement, types of fillers, carbon black. (12)

Books Recommended:

1. Plastic technology by patten, W. J., D. Bavaporwala, Bombay.
2. Polymer plastics technology and Engineering Vol. II Naturaman, L.M. Dekkar (1979)
3. Polymer science and material science H.B. Vol. I & II by Jenkins, A.D. North Holland publishing co., Amsterdam London.
4. Principles of polymer processing by Fenner R.T., Chemical publishing N.Y. (1979)
5. Synthetic Rubber, G.S. Whitby, John Wiley & Sons.
6. Essential fabric chemistry, Mary E. Carter, Marcel Dakker.
7. Principles of polymer chemistry by P.J. Flory

8. Molecular weight distribution in polymer by L.H. Peebles, Wiley- Interscience, N.Y. (1971).
9. Macromolecules in solution by H.Morawetz, Wiley Interscience, N.Y. (1975).
10. Polymer science by Govarikar V.R. and others, Wiley Eastern (1986).
11. Order in polymer solutions by Sok K.
12. Polymer science, a material science H.B. Vol I & II by Jenkins, A.D., Norh Holland publishing co., Amsterdam London.

CCTP-11 [PSP-411]
Rheological and tribological study of Polymers.

Section I :Rheology and mechanical properties of polymers [24L +6T]

1) Rheology and mechanical properties of polymers: - Introduction to Rheology, Definition, Newton's and Hooks laws, rheological response of materials, the ideal fluid, non Newtonian Fluids, time dependent fluids, power law models. Viscous flow, Relationship between stresses and stain, viscoelastisity, Mechanical models – Maxwell and voigt Boltzmann's superposition principles. Kinetic theory of rubber elasticity. The glassy state and the glass transaction, dynamic mechanical testing, relaxation spectrum, frequency dependent visco-elastic behavior stress – strain behavior of elastomers, the mechanical properties of crystalline polymers. (14)

1) Properties of polymers relevant to surface coatings, printing/painting of plastics, colorants, dyes pigments used in polymers (04)
2) Properties of polymers relevant to the adhesive applications (04)
3) Polymeric properties in packaging applications. (02)

Section II
Tribology of polymers and composites [24L+6T]

1) Tribological study in bulk polymers and reinforced polymers. [12]
2) Study of weathering effects in polymeric coatings and surface modifications.[04]

3) Biopolymer tribology: wear and tear in biopolymers,wear testing of biopolymers and implant wear testing. Influence of lubricant on wear. Future developments in biopolymers.[08]

Books Recommended:

1) Plastic technology by Patten, W. J., D. Bavaporwala, Bombay.
2) Polymer plastics technology and Engineering Vol. II Naturaman, L.M. Dekkar (1979)
3) Polymer science and material science H.B. Vol. I & II by Jenkins, A.D. North Holland publishing co., Amsterdam London.
4) Principles of polymer processing by Fenner R.T., Chemical publishing N.Y. (1979)
5) Synthetic Rubber, G.S. Whitby, John Wiley & Sons.
6) Essential fabric chemistry, Mary E. Carter, Marcel Dakker.
7) Principles of polymer chemistry by P.J. Flory
8) Molecular weight distribution in polymer by L.H. Peebles, Wiley- Interscience, N.Y. (1971).
9) Macromolecules in solution by H.Morawetz, Wiley Interscience, N.Y. (1975).
10) Polymer science by Govarikar V.R. and others, Wiley Eastern (1986).
11)Outline of paint Technology, W M Morgsn.
12) Paints, Coatings and solvents –Dieter Stoye
13) Handbook of Polymer Tribology.Edited by Sujeet Kumar Sinha ,IIT, Delhi,India.

CBOP-4 [PSP-412] [A]

Polymer Characterization

Section I **[24L+6T]**

Principle, working and applications of the following advanced instrumental techniques in polymer characterization:

Chromatographic techniques (GC, HPLC, UPLC, GPC-Triple detector, etc;) [20]

Hyphenated analytical systems [04]

Section II **[24L+6T]**

Surface characterization techniques: Raman Spectroscopy, Atomic force microscope (AFM); X-ray photoelectron spectroscopy (XPS); [6]

Elemental / chemical depth profiling techniques (FTIR-Attenuated total reflectance (FTIR-ATR) [6]

Microscopy and related techniques (Scanning electron microscope (SEM), Transmission electron microscope (TEM) [6]

Mass spectrometric techniques: Matrix Assisted Laser Desorption Ionization – Time of Flight Mass Spectroscopy (MALDI-TOF) MS;[6]

CBOP 4 PSP-412[B]
Special topics in Polymer Science II

Section I **[24L+6T]**

1. Functional polymers (4)
2. Membranes separations processes and applications (4)
3. Biomedical polymers Drug-delivery systems (4)
4. Liquid crystalline polymers (4)
5. Electrically conducting polymers, optical and electrical Properties, (4)
6. Water soluble polymers and polymer gels (4)

Section II **[24L +6T]**

1. Greening of polymer synthesis and Processing (4)
2. Self healing polymers (4)
3. Polymer Nanocomposits (4)
4. Biodegradable polymers (4)
5. Recycling of polymers (4)
6. Polymer blends and alloys (4

Books recommended.

1) Introduction to Instrumental Analysis R.D.Braun Mcgraw Hill 91897)

2) Instrumental Methods of Analysis Willard.Merritt,Dean and Settle.

3) Polymer Chemistry An introduction Seymour,Carraher,Marcel Dekkar Inc. New York

5)Textbook of Polymer Science F.W.Billmeyer Jr. John Wiley and Sons Inc.(1971)

Detailed Syllabus: Semester and Paper Wise

Semester IV

CCPP-4, PSP-414: Polymer Practicals Course-I [48L + 12T]

Polymer synthesis

1. Free radical solution polymerization of ST/MMA/MA/AA.

A) Purification of monomer

B) Polymerization using BPO/AIBN

2. Preparation of nylon 66/6

3. Interfacial polymerization, preparation of poly ester from IPC and phenolphthalein

A) Preparation of IPC

B) Purification of IPC

C) Interfacial polymerization

4. Redox polymerization of acrylamide

5. precipitation polymerization of acrylonitrile

6. Preparation of urea formaldehyde resin

7. Preparations of Novalac resin/resold resin.

8. Microscale Emulsion Polymerization of Poly (methyl acrylate).

Polymer characterization

1. Determination of molecular weight by viscometry

I) PS-toluene/benzene

II) Polyacrylamide-aq.$NaNO_2$ solution

III) Poly (methyl acrylate) - toluene/benzene.

2. Determination of molecular weight by end group analysis PEG. (OH group).

3. Testing of mechanical properties of polymers.

4. Determination of hydroxyl No. of polymer using colorimetric method.

Polymer analysis

1. To estimate the amount of HCHO in the given solution by Sodium sulphite method

2. Instrumental Techniques

3. IR studies of polymers

4. DSC analysis of polymers

5. Preparation of polyacrylamid and its electrophoresis

*at least 10 experiment to be carried out.

Detailed Syllabus: Semester and Paper Wise

Semester IV

CBOP-5, PSP-413[A] : Polymer Practicals Course-III [48L + 12T]

Polymerization processes

1. Rate of polymerization by dilatometry
2. Kinetics of condensation polymerization by dilatometry.
3. Determination of reactivity ratios.
4. Radiation polymerization and modification of polymers by radiation

Characterization of polymers

1. Thermal analysis of a polymer sample
2. End group analysis by dye interation/dye partition technique.

Physical properties of polymers

1. Rubber elasticity
2. Orientation of amorphous polymers in polarized light
3. Dielectric properties of polymers
4. Electrical conductivity of polymers

a. Inherently conducting polymers

b. Polymers with conducting fillers

5. Rheology of polymer solutions / melts

Polymer technology /processing

1. Introduction to various processing techniques (Injection/Compression/blow molding)
2. Formulation and characterization of surface coating.
3. Experiment related to control release technology.

*at least 10 experiment to be carried out.

OR

CBOP-5

PSP_413[B]

Project