

M.Sc. (II) Polymer Science [Part II Autonomous]

To be implemented from Academic Year 2024-25

Course Structure

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:

Sr. No	Paper No.& Course Code	Course Name	Major core/ Elective	Credits
Semester – III				
1.	PSP 310	Polymer Synthesis: Chain Growth Polymerisation	Major Core	4T
2.	PSP 311	Polymer Synthesis: Chain Growth Polymerisation	Major Core	4T
3.	PSP 312	Instrumental Techniques in Polymer Analysis	Major Core	2T
4.	PSP 313-[A]	I] Morphology and order in crystalline polymers; Polymer Structure and physical properties OR II] Radiation chemistry of polymers	Major Elective	2T
5.	PSP 313-[B]	Polymer degradation and stabilization OR Specialty polymers	Major Elective	2T
6.	PSP 314	Polymer Practical Course I	Major Core	2P
7.	PSP 315	Polymer Practical Course II	Major Core	2P
8.	PSP 316	Research Project	RP	4
Semester – IV				
1.	PSP 410	Polymer processing	Major Core	4T
2.	PSP 411	Rheological and tribological study of polymers and composites.	Major Core	4T
3.	PSP 412	Rubber Technology	Major Core	2T
4.	PSP 413-[A]	I] Advanced instrumental techniques in polymer characterization OR II] Special topics in polymer science	Major Elective	2T
5.	PSP 413-[B]	I] Recent advances in Polymer Research and Polymer waste management OR II] Biopolymers and Biocomposites	Major Elective	2T
6.	PSP 414	Polymer Practical Course III	Major Core	2P
7.	PSP 415	Polymer Practical Course IV	Major Core	2P
8.	PSP 416	Research Project (RP)	RP	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 to 4 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 must 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 students 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.

Detailed Syllabus: Semester and Paper-wise

Semester III

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 of 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 ratios, 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) Polymer science by Govarikar V.R. Wiley Eastern (1986).
- 3) Introduction to Polymer Science & Technology, by Dr. Shrikant D. Dawande, Denett & co.
- 4) Organic polymer chemistry, K.J. Saunders, Chapman and Hall, London (1973).
- 5) High performance polymers, their origin and development, by Seymour R.B. and Kirshenbaum G. S. Elsevier.
- 6) Condensation polymers by interfacial and solution methods, Paul W. Morgen, InterScience publishers.
- 7) Industrial plastics: Theory applications by T. L. Richardson.
- 8) 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	[8L]
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, polyacrylates, polymethylmethacrylate (PMMA), polyacrylamide, polyvinylacetate (PVA), polyvinylalcohol, polyvinylacetals, polyvinyl chloride, fluoro carbon polymers.	
References:	
1. Principles of polymerization, G. Odian, Wiley–InterScience (1981). 2. Textbook of Polymer Science – Billmeyer	
Semester III	
PSP-311: Polymer synthesis: Step Growth Polymerization [48L + 12T]	
Section-I	
Step reaction polymerization [24 L +6 T]	
1. Step reaction (condensation) polymerization	[16L]
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. Hyper branched polymers and dendrimers	[8L]
Hyper branched polymers and dendrimers, methods of synthesis, characterization, properties and application. New developments in the chemistry of dendritic molecules.	
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. Elsevier. 4.Condensation polymers by interfacial and solution methods, Paul W. Morgen, InterScience publishers. 5.Organic chemistry of synthetic high polymers, Robert W. Lenz, InterScience publisher. 6.Synthesis of Polymers by Prof. A. Dieter Schluter.	

Section-II

Heterochain Thermoplastics and Thermosets [24L +6T]

1. Synthesis, properties and application of heterochain thermoplastics [12L]

Historical development, preparative methods, properties and application of the following: polyamides: Nylon 6, Nylon 66, Nylon 610, polyesters, polyether and related polymers – polyethylene terephthalate (PET), polybutylene terephthalate (PBT), aromatic polyesters, polycarbonate, polyurethanes, Flexible and rigid polyurethane, polyurethane elastomers, coatings, adhesives, sulphur, containing polymers, polyimides, polybenzimidazoles, polyether sulphones, polyether ketones.

2. Thermosetting resins: [12L]

Types of thermoset resins. Thermosetting resins—phenolic resins, amino resins epoxy resins, silicone polymers, and cyanate ester resins.

Uses and applications of thermosets. Advantages and disadvantages, characterization of thermosets, thermoset resins curing processes, high performance thermosets.

References:

1. Textbook of Polymer Science – by Billmeyer.
2. Introduction to Polymer Science & Technology, by Dr. Shrikant D. Dawande, Denett & co.
3. A Textbook of Polymers (Condensation Polymers) Volume III, by Dr M.S. Bhatnagar.
4. Principles of Polymerization, G. Odian, Wiley InterScience (1981).
5. Organic polymer chemistry, K.J. Saunders, Chapman and Hall, London (1973).
6. High performance polymers, their origin and development, by Seymour R.B. and Kirshenbaum G. S. Elsevier.
7. Condensation polymers by interfacial and solution methods, Paul W. Morgen, InterScience publishers.
8. Industrial plastics: Theory applications by T. L. Richardson.
9. Organic chemistry of synthetic high polymers, Robert W. Lenz, InterScience publisher.

Semester III

PSP-312-Instrumental Techniques in Polymer Analysis [24 L +6 T]

1. X-ray diffraction analysis—methods of production of X-ray, properties of X-ray. Diffraction of X-rays, Bragg's law, lattice and powder diffraction methods, small angle scattering of X-ray by polymers, analysis of molecular structure of simple polymers. [06]

2. Differential thermal analysis – physical transitions, melting thermograms. 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 transition. [06]

3. Thermogravimetric analysis: Introduction, instrumentation Determination of kinetic parameters. Method of freeman and Carroll, Methods of involving maximization of rate, method of multiple heating rates of variable heating rate for a single thermogram method, Estimation of thermal stability from TGA curves, qualitative methods, semi quantitative and quantitative methods, Thermal degradation, behavior of some polymer by TGA methods, styrenated polyester, polytetrafluoroethylene. [06]

4. Infrared UV and Raman spectroscopy. Introduction theoretical background, Number and position of absorption bands, Instruments and specimen separation. Elucidation of structure. Qualitative and quantities analysis. Studies in the physical and chemical nature of polymers. Orientation and crystallinity. [03]

5. ^1H -NMR-and ^{13}C -NMR phenomenon. Line-broadening by local fields, broadline 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 diene polymers, dynamic Flexibility of chain [03]

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. Instrumental Analysis Willard, Meritt and Dean.
4. Analysis of polymers-an introduction, by Crompton T.R., Pergamon press 1989.
5. Thermal characterization of polymeric materials, by Turi E.A., Academic press Inc.
6. Polymer science, a material science H.B. Vol I&II by Jenkins, A.D., North Holland publishing Co., Amsterdam London.

Semester III

**PSP-313 [A]: Morphology and Radiation Chemistry of Polymers
[24L+6T]**

[I] Morphology and order in crystalline polymers and Polymer structure and physical properties [24L+6T]

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

OR

[II] Radiation chemistry of polymers [24L +6T]

Effect of radiation on polymer, structure and properties. Application in curing, coating purification, polymer composites etc. radiation induced polymerization.

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. Wiley Eastern (1986).

Semester III

PSP-313 [B] Polymer Degradation & Special Topics in Polymers I

[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]**

Types of Degradation: Chemical degradation, physical degradation, ageing, crazing, degradation by micro-organisms, Biodegradable polymers, Mechanism of degradation, secondary chain reaction, Self-reaction, depolymerization, metal catalyzed degradation, Thermal oxidation, Photo oxidation, Mechanical degradation, Degradation by ionizing radiation, ozone attack. Degradation of special polymers: Polyolefin, PVC, PS, PMMA. **[12]**

Stabilization: Chain breaking antioxidants, bound antioxidants, Radiation protection, Stabilization against biodegradation. **[04]**

OR

[II] Speciality polymers [24L+6T]

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

Speciality Polymers: Conduction polymers, conduction mechanism applications, Polyacetylene, polyparaphenylenes, polyanilines, polypyrrole, Photoconductive polymers, polymers in nonlinear optics, polymers with piezoelectric, pyroelectric and ferroelectric properties, Polyvinylidene fluoride. Photoresists for semiconductor applications, Negative Photoresists, Positive photo resists, 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 L]**

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

References:

1. F. Rodriguez, Principles of polymer systems, MacGraw Hill.
2. H. G. Elias, Macromolecules, Plenum.
3. P. J. Flory, Principles of polymer chemistry, Cornell University.
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. Billmeyer, Textbook of polymer science, Wiley.

Semester III

PSP-314 Polymer Practical Course I [24L + 6T]

Polymer analysis

1. To estimate the amount of HCHO in the given solution by sodium sulphite method.
2. To identify polymer by solubility test [by referring a chart].
3. Instrumental Techniques-
 - Quantitative determination of impurities in given polymer by spectral technique (UV-Vis).
 - IR studies of polymers
 - NMR studies of polymer samples.
 - DSC analysis of polymers
 - Izod impact strength
4. Preparation of polyacrylamide and its electrophoresis.
5. Identification and classification of natural rubber by using FTIR, Mooney, and other chemical methods.
6. Identification and classification of synthetic rubbers by using burning test, FTIR, Mooney, and other chemical methods.
7. Identification and classification of different types of carbon black.
 - a. DBP absorption
 - b. IAN
 - c. Surface area calculation
10. Identification and classification of rubber compounding materials namely, Zinc oxide /Stearic acid/Sulfur/Antioxidants/Accelerators/Processing oils. [any two]

Semester III

PSP-315: Polymer Practical Course-II [24L + 6T]

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 sodium carboxy methylcellulose.
- v. Modification of PS to chloromethylated PS.
- vi. Hydrolysis of PVAC, preparation of PVA.
- vii. Preparation of poly(vinylacetate) from PVA.
- viii. Chlorination / chlorosulphonation of polyethylene.
- ix. Dispersion of nanoparticles in polymers and characterization.

Polymer characterization

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

Polymer Analysis

3. To determine acid value of a given polymer.
4. To determine sap value and % purity of plasticizer.
5. To determine epoxy content of given polymer by pyridium chloride/pyrinine method.
6. Identification of plastics by heating/burning tests.
7. Determination of MFI.
8. Determination of moisture content and moisture regain of fibers.
9. Spinning and characterization of fibers and hollow fibers.

*at least 12 experiments to be carried out.

PSP 416 Project 2 [24L +6T]

Semester IV

[PSP-410] Polymer processing [48L+ 6T]

Section-I Plastics Technology [24L]

Raw materials (monomers), Chemicals that produce monomers, 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, blow molding, rotational molding, thermoset molding, calendaring; Casting- Extrusion, coextrusion, film extrusion, pultrusion.

Section-II Polymer Applications [24L]

1. Polymer Applications –

Lamination- preparation, techniques, forming laminates; Adhesives- surface treatment, physical nature of adhesives, types of adhesives, types of epoxy adhesives, Bio adhesives, test methods in determining the strength and properties of adhesives; Composites- matrix material, types of resins, composite wood materials, types of boards, molded products, composite fabrication process, standardization of test methods for polymer matrix composites; Surface coating- types of coating, surface preparation, coating methods, theory of powder coating, curving process, electroplating, safety measures in paint industry. [12L]

2. Fiber Technology—

Textile and fabric properties – Definition of textile, 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 3D printing with fiber reinforcement, fiber reinforced polymer, fiber matrix adhesion, fiber extraction and retting process. Recycling of fibers and their composites, colorants and dyeing. Applications of fibers: High performance fibers, smart fibers for sensing, fire retardant textiles, wearable fiber electronics, fibers in energy storage, healthcare, fibers in environmental remediation, analysis, testing and quality control of fibers and textiles. [12L]

References:

1. Textbook of polymers- processing and applications, Vol. I & II, by Bhatnagar.
2. Introduction to Polymer Science & Technology, by Dr. Shrikant D. Dawande, Denett & co.
3. Plastics Material Handbook (vol II), by A. S. Athalye.
4. Polymer plastics technology and Engineering Vol.-II, Natureman, L.M. Dekkar (1979).
5. Plastic technology by patten, W.J.D. Bavaporwala, Bombay.
6. Polymer science and material science H.B. Vol. I & II by Jenkins, A.D. North Holland publishing co., Amsterdam London.
7. Principles of polymer processing by Fenner R.T., Chemical publishing N. Y. (1979)
8. Essential fabric chemistry, Mary E. Carter, Marcel Dakker.
9. Principles of polymer chemistry by P.J. Flory.

10. Macromolecules in solution by H. Morawetz, Wiley InterScience, N.Y. (1975).
 11. Polymer science by Govarikar V.R. Wiley Eastern (1986).

Semester IV

[PSP-411]

**Rheological and Tribological Study of Polymers and composites
 [48L+ 6T]**

Section I: Rheological properties of polymers [24L]

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 strain, viscoelasticity, Mechanical models–Maxwell and Voigt Boltzmann's superposition principles. Kinetic theory of rubber elasticity. The glassy state and the glass transition, dynamic mechanical testing, relaxation spectrum, frequency dependent viscoelastic behavior stress–strain behavior of elastomers, the mechanical properties of crystalline polymers.

Section II: Tribological and Mechanical Properties of Polymers and composites [24L]

Tribology of polymers and composites:

Tribological study in bulk polymers and reinforced polymers. Study of weathering effects in polymeric coatings and surface modifications. Biopolymer tribology: wear and tear in biopolymers, wear testing of biopolymers and implant wear testing. Influence of lubricant on wear. Future developments in biopolymers. **[12L]**

Properties of polymers relevant to surface coatings, printing /painting of plastics, colorants, dyes pigments used in polymers. Properties of polymers relevant to the adhesive applications, polymer properties in packaging applications. **[12L]**

References:

1. Polymer composites for tribological applications, by K. Friedrich; Advanced Industrial and Engineering Polymer Research Vol 1, Issue 1, (2018), 3-39.

Semester IV

[PSP-412]

Rubber Technology [24L+ 3T]

1. General purpose rubber: **[08L]**

Natural Rubber (NR):

Origin–Natural Rubber Latex, tapping, processing, properties and applications – Conversion of Latex into dry rubber – Properties of dry rubber – Classification based on technical specifications – Modifications of Natural Rubber Styrene-Butadiene Rubber (SBR): Introduction, polymerization, types of SBR, structure & property variation in Emulsion SBRs and Solution SBRs. Compounding, Processing, Applications.

Polybutadiene Rubber (PBR): Manufacture, Structure and Properties of Polybutadienes, Processing and Applications.

Synthetic Polyisoprene (IR) Rubbers: Preparation of Synthetic Polyisoprene (IR) Rubbers, Properties, IISRP Numbering System, Processing, Applications.

2.Special purpose rubber:

[08L]

Preparation, properties and Application of: Nitrile Rubber & modified NBR (HNBR & XNBR), Butyl Rubber & Halogenated butyl rubbers, Polychloroprene Rubbers, Ethylene Propylene Rubber and Ethylene Vinyl acetate copolymers – Elastomersbased on modified polyethylene (chlorinated polyethylene & chlorosulphonated polyethylene), Acrylate rubbers, Polysulphide rubbers, Hydrin rubbers, Silicones and Fluroelastomers etc. Rubber blends: miscible and immiscible blends,

Thermoplastic Elastomers – Preparation, properties and Application of: SBS and SIS Block copolymers, Thermoplastic Polyurethane elastomers, Thermoplastic-co-polyesters, Thermoplastic elastomers based on Plastics, Dynamic Vulcanization

3.Additives in rubber:

Vulcanizing ingredients & other additives: Vulcanizing ingredients & their sequence of mixing, Activators and Accelerators, mechanisms of action, fillers, retardants, anti-degradants.

[08L]

References:

Semester IV

PSP 413[A]

Advanced Instrumental Techniques in Polymer Characterization OR Special Topics in Polymer Science

[I] Advanced Instrumental Techniques in Polymer Characterization [24L+6T]

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

Chromatographic techniques (GC, HPLC, UPLC, GPC-Triple detector) Hyphenated analytical systems.

[06L]

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

[06L]

Elemental/chemical depth profiling techniques (FTIR-Attenuated total reflectance (FTIR-ATR) [Microscopy and related techniques (Scanning electron microscope (SEM),

Transmission electron microscope (TEM).

[06L]

Mass spectrometric techniques: Matrix Assisted Laser Desorption Ionization–Time of Flight Mass Spectroscopy (MALDI-TOF).

[06L]

OR

[II] Special Topics in Polymer Science [24L+6T]

1. Functional polymers-

2. Self-healing polymers
3. Recycling of polymers and biodegradable polymers
4. Liquid crystalline polymers
5. Electrically conducting polymers, optical and electrical Properties
6. Greening of polymer synthesis and processing.
7. Polymer blends and alloys
8. Polymer Nanocomposites

References:

Semester IV

PSP 413 [B] Recent advances in Polymer Research and Polymer waste management OR Biopolymers and Biocomposites

**I] Recent advances in Polymer Research and Polymer waste management
[24L+6T]**

Novel methods of synthesis of polymer and polymer composites. Bio-catalytical routes to polymers. Organic and inorganic reaction mechanisms useful in polymer technology. Anionic and cationic polymerization. Emulsion polymerization. Polymerisation in organized media. Cyclic macromolecule synthesis. **[12L]**

Polymer waste management: Biodegradation, incineration and recycling, reuse and future demand. Overview of rules on PWM and most recent updates about Government rules. **[12L]**

References:

1. Plastic Technology Handbook, Manas Chand.
2. Plastics Material Handbook (vol II), by A. S. Athalye.
3. Textbook of polymers-processing and applications, Vol II by Bhatnagar
4. Polymer plastics technology and Engineering Vol.II Naturaman, L.M. Dekkar (1979)
5. Polymer science and material science H.B. Vol. I&II by Jenkins, A.D. North Holland publishing co., Amsterdam London.
6. Principles of polymer processing by Fenner R.T., Chemical publishing N.Y. (1979)
7. Principles of polymer chemistry by P.J. Flory

OR

II] Biopolymers and Bio-composites [24L+6T]

1. Biopolymers and biodegradation.

Biopolymers: Classification, Biopolymers from natural origin and mineral origin, isolation, properties.

Biodegradation: mechanism of biodegradation (polyesters, polycarbonates, polyvinyl alcohol, polyurethanes and polyethers, factors influencing biodegradation, types of biodegradable polymers– properties and application. **[08L]**

2. Characterization & Testing for Biodegradability.

Test methods and standards for bio-degradable plastics, criteria used in evaluation of biodegradable plastics, description of current test methods – scanning test for ready biodegradability, Test for

inherent biodegradability, Test for simulation studies, other methods for assessing polymer biodegradability. **[08L]**

3. Bio-composites

Definition-classification-natural biofiber and nanofillers as reinforcement, biodegradable/bio-based resins as matrices. Properties of bio composites. Applications in automobile & buildings. **[04L]**

4. Applications of biopolymers biopolymer Films, biodegradable mulching, advantages and disadvantages, chemical sensors–biosensors, functionalized Biopolymer coatings and films, Applications of biopolymers in horticulture, food Packaging, functional Properties, safety and Environmental aspects, Shelf life, films and coatings in food applications, materials for edible films and coatings, biopolymer coatings for paper and paperboard, bio-nanocomposite films and coating **[04L]**

References:

1) R. Smith, Biodegradable polymers for industrial applications, Woodhead Publishing Ltd

Semester IV

PSP 414 Polymer Practical Course III [24L +6T]

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

- Purification of monomer

- Polymerization using BPO/AIBN

2. Synthesis of polyurethane foams.

3. Synthesis of Polyvinylester.

4. Preparation of nylon 66/6

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

- Preparation of IPC

- Purification of IPC

6. Redox polymerization of acrylamide.

7. precipitation polymerization of acrylonitrile.

8. Preparation of urea formaldehyde resin.

9. Preparations of Novalac resin/resold resin.

Polymer characterization

1. Determination of molecular weight by viscometry-

i. PS-toluene/benzene

ii. Polyacrylamide-aq. NaNO₂ 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.

*at least 10 experiments to be carried out

Semester IV

PSP 415 Polymer Practical Course IV [24L +6T]

Polymer Synthesis

1. Removal of inhibitor from monomer by washing with alkali
2. Synthesis of polystyrene
3. Synthesis of polyurethane foam
4. Synthesis of polyvinyl ester
5. Preparation of polyaniline by free radical polymerization.
6. Preparation of plasticizer from polymer waste.

Characterization of polymers

7. Thermal analysis of a polymer sample.
8. Identification of polymer components by chromatography.
9. Identification of fibers by solubility test and chemical method.

Physical properties of polymers

1. Rate of polymerization by Dilatometry (kinetics of condensation polymerization)
 2. Determination of purity of polymer by refractive index measurement.
 3. Photodegradation of PVC.
 4. Copolymerization of styrene and MMA and determination of reactivity ratio.
 5. Electrical conductivity of polymers.
 - a. Inherently conducting polymers.
 - b. Polymers with conducting fillers.
 4. Rheology of polymer solutions / melts.
- *at least 10 experiments to be carried out

PSP 416 Project 2 [24L +6T]