M.Sc. POLYMER SCIENCE CREDIT SYSTEM SYLLABUS

M. Sc. Part II

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Semester IIII

PSP-310 Chain polymerization (4 credits; 48 lectures)

Kinetics and mechanism of Chain polymerization processes:

1. Chain reaction (Addition) polymerization

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. (4)

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. (4)

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. (8)

2. Copolymerization – 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. (8)

3. Controlled polymerization methods, viz, Nitroxide mediated polymerization (NMD),Atom Transfer Radical Polymerization (ATRP), Group Transfer Polymerization (GTP), Reversible Addition Fragmentation Termination (RAFT).(8)

4. Synthesis, properties and Application of Hydrocarbon plastics and elastomers – 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. (8)

5. Other carbon – carbon polymers- polystyrene and other related polymers, copolymers of polystyrene, acrylic polymers – acrylic fibers, acrylic adhesives, poly acrylates, polymethyl methacrylate(PMMA), poly acrylamide (4)

6. polyvinyl acetate (PVA), polyvinyl alcohol, poly vinyl acetals, poly vinyl chloride, fluoro carbon polymers. (4)

Books recommended:

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.

PSP-311 Condensation polymerization (4 credits; 48 lectures)

1. 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. (15)
2. Hyperbranched polymers and dendrimers, methods of synthesis, characterization, properties and application. (10)
3. Synthesis, properties and application of heterochain thermoplastics – Historical development, preparative methods, properties and application of the following:
polyamides, Nylon 6, Nylon 66, Nylon 610 etc., polyesters , polyether and related polymers – polyethylene terephthalate (PET), polybutylene terphthalate (PBT), aromatic polyesters, polycarbonate, polyurethanes – Flexible and rigid polyurethane, polyurethane elastomers, coatings, adhesives, sulphur, containing polymers, polyimdes, polybenimidazoles, polyethersulphones, polyetherketones. (15)
4. Thermosetting resins – phenolic resins, amino resins epoxy resins, silicone polymers, and cyanate ester resins.(8)

Books Recommended:

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.

PSP-312 Physical Chemistry of polymers (4 credits; 48 lectures)

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)
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)
3. 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)
4. Radiation chemistry of polymers: Effect of radiation on polymer, structure and properties. Application in curing, coating purification, polymer
Composites, etc. radiation induced polymerization. (8)

Books Recommended:
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).

PSP-313 Analytical Chemistry of polymers (4 credits; 48 lectures)

1. Transition points. Density, refractive index, pyrolytic behaviour. 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 o 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 broadningby 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)

4. 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. (8)

5. 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. (8)

6. 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, polytetrafluoroethane. (8)

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.
5. Polymer sequence determination: carbon- 13 NMR method by James Crandall, Academic press.

Semester IV

PSP-410 Polymer processing (4 credits; 48 lectures)

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)
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.

PSP-411 Rheology and mechanical properties of polymers (4 credits; 48 lectures)

1) Rheology and mechanical properties of polymers: - Introduction to Reheology, 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. (24)
2) Properties of polymers relevant to surface coatings, printing/painting of plastics, colorants, dyes pigments used in polymers (8)
3) Properties of polymers relevant to the adhesive applications (8)
4) Polymeric properties in packaging applications. (8)

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)
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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 Technoogy, W M Morgsn.
12) Paints, Coatings and solvents –Dieter Stoye

PSP-412 Advanced instrumental techniques in polymer characterization **(4 credits; 48 lectures)**

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

Chromatographic techniques (GC, HPLC, UPLC, GPC-Triple detector. (12)

Hyphenated analytical systems (GC-MS; LC-MS) (4)

Surface characterization techniques: Raman Spectroscopy, Atomic force microscope (AFM); X-ray photoelectron spectroscopy (XPS) (8)

Elemental / chemical depth profiling techniques (FTIR-Attenuated total reflectance (FTIR-ATR) (8)

Microscopy and related techniques (Scanning electron microscope (SEM), Transmission electron microscope (TEM) (8)

Mass spectrometric techniques: Matrix Assisted Laser Desorption Ionization – Time of Flight Mass Spectroscopy (MALDI-TOF) MS (8)

PSP 404 Special topics in polymer science (4 credits; 48 lectures)

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)
7. Greening of polymer synthesis and Processing (4)
8. Self healing polymers (4)
9. Polymer Nanocomposits (4)
10. Biodegradable polymers (4)
11. Recycling of polymers (4)
12. Polymer blends and alloys (4)

PSP 317 Polymer Practicals Course-I (MSc II Sem III Practicals)
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 contents 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.

PSP 417 Polymer Practicals Course-II (MSc II Sem IV Practicals)

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.

PSP 418 M Sc II Sem- IV Practicals

Polymerization processes

1. Rate of polymerization by dilotemetry
2. Kinetics of condensation polymerization by dilotemetry.
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 dyeinteration/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.

PSP 419 Project Work (100 marks) (in lieu of PSP 419)