### M.Sc. POLYMER SCIENCE CREDIT SYSTEM SYLLABUS

#### M. Sc. Part II

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Semester III

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)
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:
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)


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 terephthalate (PBT), aromatic polyesters, polycarbonate, polyurethanes – Flexible and rigid polyurethane, polyurethane elastomers, coatings, adhesives, sulphur, containing polymers, polyimides, polybenimidazoles, polyethersulphones, polyetherketones. (15)

4. Thermosetting resins – phenolic resins, amino resins epoxy resins, silicone polymers, and cyanate ester resins. (8)

Books Recommended:
5. Industrial plastics: Theory applications by T. L. Richardson.

**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  

**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)  
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)
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)

Books Recommended
3. Polymer science, a material science H.B. Vol I & II by Jenkins, A.D., North Holland publishing Co., Amsterdam London.
Semester IV

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

1. Plastics technology -

2. Fiber Technology –

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:
7. Principles of polymer chemistry by P.J. Flory
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 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, viscoelasticity, 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)
4) Principles of polymer processing by Fenner R.T., Chemical publishing N.Y. (1979)
6) Essential fabric chemistry, Mary E. Carter, Marcel Dakker.
7) Principles of polymer chemistry by P.J. Flory
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)


**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 Nanocomposites (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.NaNO2 solution
   III) Poly (methyl acrylate) - toluene/benzene.
2. Determination of molecular weight by end group analysis PEG. (OH group).
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
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)