SOLAPUR UNIVERSITY, SOLAPUR
M. Sc. POLYMER CHEMISTRY COURSE SYLLABUS
SEMESTER SYSTEM

A two-year duration **M. Sc. Polymer Chemistry** course syllabus has been prepared as per the semester system. Syllabus for M. Sc. Part I was implemented with effect from June 2014. M. Sc. II syllabus will be implemented from June 2015. The syllabus has been prepared taking into consideration the syllabi of other Universities, SET, NET, UGC guidelines, and the specific inputs of the Expert Committee Members from S.K. University and CSIR-NCL.

General Structure of the Course:

The course will be of four semesters spread over two academic years. Each semester will have four theory papers of 100 marks each. **There will be "Semester End Practical" Examinations.** Each "semester-end practical" examination will be of 200 marks. The distribution of marks is mentioned below

Theory Paper (Semester exam), 16 X 100 marks	1600 marks
Practical (Semester end exam.), 8 X 100 marks	800 marks
Seminar (Each Semester) (4 X 25 marks)	100 marks
	Total: 2500 marks

Ratio of marks (Theory: Practical): (67:33)

M. Sc. Part I* Chemistry

*This course is common for Polymer, Industrial, Organic, Physical, Analytical and Inorganic Chemistry courses.

Semester I

Theory Courses:

Paper No.	**Title**	
CH 101	Inorganic Chemistry-I	(70 marks Univ. Exam + 30 Marks Internal Exam)
CH 102	Organic Chemistry-I	(70 marks Univ. Exam + 30 Marks Internal Exam)
CH 103	Physical Chemistry-I	(70 marks Univ. Exam + 30 Marks Internal Exam)
CH 104	Analytical Chemistry-I	(70 marks Univ. Exam + 30 Marks Internal Exam)

Semester II

Paper No.	**Title**	
CH 201	Inorganic Chemistry-II	(70 marks Univ. Exam + 30 Marks Internal Exam)
CH 202	Organic Chemistry-II	(70 marks Univ. Exam + 30 Marks Internal Exam)
CH 203	Physical Chemistry-II	(70 marks Univ. Exam + 30 Marks Internal Exam)
CH 204	Analytical Chemistry-II	(70 marks Univ. Exam + 30 Marks Internal Exam)

Practical Course: (Semester end examination)
Practical Examination will be of 4 days for each semester

P I Chemistry Practicals:	Sem-I	(70 marks Univ. Exam + 30 Marks Internal Exam)
P II Chemistry Practicals:	Sem-I	(70 marks Univ. Exam + 30 Marks Internal Exam)
P III Chemistry Practicals:	Sem-II	(70 marks Univ. Exam + 30 Marks Internal Exam)
P IV Chemistry Practicals:	Sem-II	(70 marks Univ. Exam + 30 Marks Internal Exam)

M. Sc. Part II Polymer Chemistry

Semester III
(Compulsory Papers)

Theory Courses:

Paper No.	**Title**	
POLY CH 301	Fundamentals of Feedstocks and Polymers	(70 marks Univ. Exam + 30 Marks Internal Exam)
POLY CH 302	Morphology and Physical Chemistry of Polymers	(70 marks Univ. Exam + 30 Marks Internal Exam)
POLY CH 303	Basic Concept of Polymerization	(70 marks Univ. Exam + 30 Marks Internal Exam)
(Elective Papers)		
POLY CH 304	Spectral and Instrumental Analysis of Polymers	(70 marks Univ. Exam + 30 Marks Internal Exam)
POLY CH 304A	Natural and Synthetic Textile fibers and Resins	(70 marks Univ. Exam + 30 Marks Internal Exam)

Stereo regular Polymers and Modern Polymerization Methods

Semester IV
(Compulsory Papers)

Paper No.	**Title**	
POLY CH 401	Step-growth Polymers	(70 marks Univ. Exam + 30 Marks Internal Exam)
POLY CH 402	Stereoregular Polymers and Modern Polymerisation Methods	(70 marks Univ. Exam + 30 Marks Internal Exam)
POLY CH 403	Selected Topics in Polymers	(70 marks Univ. Exam + 30 Marks Internal Exam)
	(Elective Papers)	
POLY CH 404	Processing Technology and polymer Properties	(70 marks Univ. Exam + 30 Marks Internal Exam)
POLY CH 404A	Inorganic and Biopolymers	(70 marks Univ. Exam + 30 Marks Internal Exam)

Practical Course:

P V Polymer Practical	Sem-III	(70 marks) Univ. Exam + 30 Marks Internal Exam
P VI Polymer Practical	Sem-III	(70 marks) Univ. Exam + 30 Marks Internal Exam
P VII Polymer Practical	Sem-IV	(70 marks) Univ. Exam + 30 Marks Internal Exam
P VIII Polymer Practical (Including Project work / In-plant Training / Review Report)	Sem-IV	(70 marks) Univ. Exam + 30 Marks Internal Exam

Total: 400 marks

(Seminar should be conducted during Semester III and IV; And the Project work / In-plant training / Review Report in Semester IV)

Nature of Examination:

Each semester will have university theory examination of four papers of 70 marks each (3 hrs. duration). The practical examination of Semesters III & IV will be conducted at the end of the respective Semester. (Semester end practical examination). Duly certified copy of laboratory record must be produced at the time of examination.

Practical Examination of M. Sc. II
The practical examination will be of 3 days for each semester. The distribution of marks for each P V, VI, VII and VIII is as under,
70 marks Univ. Exam + 30 Marks Internal Exam for each practical which includes marks for Practical experiments, Oral examination and Journal.
** The valuation to be done by both external and internal examiners at the time of P V-VIII practical examination. Valuation of Seminars is to be done in Semester III and Semester IV by Departmental Committee of the teaching Faculty with Polymer Specialization.

Nature of university examination question paper (for M. Sc. II):

Time: 03 hours Maxi Marks: 70
Instructions
1. Attempt in all 05 questions.
2. Section I (question 1) is compulsory
3. Attempt any two questions from section II and any two questions from section III.
4. Answers to all 05 questions (from section I, II, III) should be written in the one and the same answer book.
5. All questions carry equal marks.
6. Figures to the right indicate full marks.
7. Use of log tables and calculators is allowed.

Section I

Q 1. Answer the following (7 sub-questions) Multiple choice / fill in the blanks / define the term / True-False etc.
(There can be 7 sub-questions 2 marks each / 14 sub-questions with 1 mark each if so required)
Sub-questions (i) To (vii)

Section II

Q 2. a) - --- -- - - - - - - - Marks 7
b) - - - - - - - - - - - - Marks 7
Q 3. a) - --- -- - - - - - - - Marks 7
b) - - - - - - - - - - - - Marks 7
Q 4. a) - --- -- - - - - - - - Marks 7
b) - - - - - - - - - - - - Marks 7

Section III

Q 5. a) - --- -- - - - - - - - Marks 05
b) - - - - - - - - - - - - Marks 05
c) - - - - - - - - - - - - Marks 04
Q 6. a) - --- -- - - - - - - - Marks 05
b) - - - - - - - - - - - - Marks 05
c) - - - - - - - - - - - - Marks 04
Q 7. Write short notes on (any three) Marks 14
a) - - - - - - - - - - -
b) - - - - - - - - - - -
c) - - - - - - - - - - -
d) - - - - - - - - - - -

N.B. In sections II and III, the sub-questions (a, b, and c) in a given question should be from different topics of the syllabus.

At least 25 % questions should be problem oriented, where-ever possible, in view to train students for the SET/NET/GATE and other competitive examinations. These questions should test the understanding of candidate rather than the memory. The question paper should cover all the Units included in the syllabus of the respective paper and the weightage of the questions should correspond to the number of lectures allotted to the respective Units / Topics.

Semester - III

POLY CH. 301: Fundamentals of Feedstocks and Polymers

Unit 1 : (15)

(A) RAW MATERIALS AND INTERMEDIATES FOR POLYMERS:

Petroleum based raw materials:

Crude oil, types and source of crude oil, refining various petroleum fractions, cracking (thermal and catalytic), knock and octane rating, petrochemical as building blocks, Acetylene and derivatives, propylene and derivatives, butane/butene, butadiene fractions, BTX and their derivatives: Polymer feed stocks (monomers, solvents), petroleum industry Carbon monoxide, Carbon dioxide as building block for monomers and polymers.

(B) **NON PETROLEUM BASED RAW MATERIALS:**

Non petroleum based renewable agricultural resources for monomers and polymers CNSL, lignocelluloses, plant oils, castor oil, vegetable oil, terpenes, and phenolics, carbohydrates- lactic acid, green route to synthesis of monomers such as adipic acid, caprolactone, MMA, acrylic acid, 1,3-propanediol.

Unit 2: CLASSIFICATION OF POLYMERS: (15)

Addition- condensation, (Chain/step growth polymers) organic-inorganic, natural- synthetic, polar non-polar with suitable examples, types of polymers. linear, branched, thermoplastic – thermosetting, block and graft copolymers, hyperbranched, star branched dendrimers, semiladder, ladder, crosslinked, and layer-latties- polymers. Nomenclature of polymers, names based on source, based on structure (IUPAC and Non IUPAC) Trade names.

Unit 3 : POLYMERISATION METHODS: (15)

Bulk, solution, suspension, precipitation, emulsion, inverse emulsion, dispersion, melt, interfacial (phase transfer catalyzed interfacial polymerization) and solid state polymerization. (examples-PET, PC) Batch and continuous, merits and limitations of each process and comparison of various polymerization processes with suitable commercial examples. (Polymerization in ionic liquids, in super critical media and MW induced. Approach to combinatorial polymer synthesis).

Unit 4: COMMERCIAL POLYMERS: (15)

Manufacture, properties and applications of Polyethylene Polypropylene, polystyrene, polymethylmethacrylate, Polyvinylchloride, polybutadiene and polyacetals, PET, Nylon-6,6.

POLY CH. 302: Morphology and Physical Chemistry of Polymers

Unit 1 : MOLECULAR WEIGHT : (15)

Concept of molecular mass, polydisperse nature and degree of polymerization, number average, weight average, viscosity average molecular weights and their statistical equations, molecular weight distribution. Determination of molecular weights of polymers by vapour phase osmometers, end group analysis, light scattering, viscometry and G P C. Polymer conformation and chain dimensions, freely jointed chains, real chains, characteristic ratio.

Unit 2: MORPHOLOGY OF POLYMERS : (15)

Crystalline and amorphous phase, factors affecting polymer crystallinity, XRD analysis for polymer crystallinity, crystallites, amorphous regions, spherulites, single crystal, fibrils,

Orientation, transitions, glass transition temperature (Tg), factors affecting Tg, determination of Tg, TMA and DSC (Principles of TMA and DSC expected).

Unit 3 : POLYMER SOLUTIONS : (15)

Stages and thermodynamics of polymers dissolution, heat of dissolution and solubility parameter, Flory- Huggins theory of polymer solutions, Krigbaun- Flory theory, mean field theory of Flory, viscosity of dilute solution.

Unit 4 : DEGRADATION AND STABILIZATION : (15)

Processes involved in degradation of natural and synthetic polymers, mechanism of degradation by mechanical, chemical, thermal and radiation (high energy, photo, ultrasonic) agencies, ceiling temperature, polymer stabilization, antioxidant, photo stabilizers.

POLY CH. 303: Basic Concept of Polymerization

Unit 1: RADICAL CHAIN POLYMERIZATION: (15)

Structural arrangement of monomer units, propagation modes, H-T and H-H polymerization, mechanism and kinetics: energetics, experimental determination of rate of polymerization. Initiation by free radical, redox, photochemical, ionizing radiation and thermal methods, efficiency of initiator transfer reactions, retardation, autoacceleration.

Unit 2: FREE RADICAL CO-POLYMERIZATION : (15)

Copolymerisation quotations, monomer reactivity ratios (r1 and r2) types of copolymerization, determination of r1 and r2; Q-e scheme. Important examples of copolymers.

Unit 3 : CATIONIC, ANIONIC AND RING OPENING POLYMERIZATION: (15)

Basic concepts of cationic and anionic methods of polymerization, distinguishing between radical and ionic polymerization. Group transfer polymerization. Ring opening polymerization, mechanism of ROP of cyclic ethers, cyclic amides and cyclosiloxanes; Ring opening metathesis polymerization.

Unit 4: STEP GROWTH POLYMERIZATION: (15)

Polymerization which proceed with formation of C-C, C-O and C-N bond formation Suzuki, Heck, ADMET, Chain-growth polycondensation [examples-polyamides, polyether-ketones], enzyme/metal catalyzed step growth polymerization; Reactivity of functional groups, basis for analysis of step growth polymerization kinetics. Kinetic equation for polyesterification, Carothers equation for DP, control of molecular weights in linear step-growth polymers,

POLY CH. 304: Spectral and Instrumental Analysis of Polymers

Unit 1: (15)

(A) INTRODUCTION:

The purpose of characterization, molecular architecture, crystallizing polymer, survey of characterization techniques.

(B) UV, IR AND RAMAN SPECTROSCOPY:

Electronic spectroscopy, characteristic absorption’s of organic monomers and polymers, UV spectral data for polymer characterization. Infrared spectroscopy, introduction to ATR technique.

IR spectra of organic monomers and polymers, structural characterization of polymers by IR (and Raman) spectroscopy.

Unit 2: NMR AND MASS SPECTROSCOPY: (15)
Interpretation of H-1 NMR of organic monomers, introduction to C-13 NMR, chemical shift, C-H spin coupling, FT-NMR, 2D NMR (COSY, HSQC, HMBS), Wide-Band proton decoupled CMR, solid state CMR, high resolution CMR of PET and PPO, copolymer composition. Analysis of stereoregularity by CMR in PP and polybutadienes. Polymer analysis by mass spectrometry, polymer pyrolysis GC-MS, FABMS technique, MALDI-TOF.

Unit 3: (15)
(A) : THERMAL ANALYSIS OF POLYMERS:
Thermogravimetric analysis (TGA), differential thermal analysis (DTA), thermo-mechanical analysis (TMA).
(Detailed instrumentation not expected).
(B) : OPTICAL AND ELECTRON MICROSCOPY:
SEM, TEM, AFM, and XPS for polymer analysis, Polarized Optical Microscopy (POM) for Spherulitic Studies

Unit 4 : X-RAY DIFFRACTION ANALYSIS: (15)
Methods of production of x-rays, properties of x-rays, 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 by XRD, determination of crystallinity, size and orientation of crystallites.

POLY CH 304A: Natural and Synthetic Textile fibers and Resins

Unit 1: General consideration of natural textile fibers, cotton fiber, wool fiber, silk fiber, Rayon:- Hydrocellulose and oxycellulose. **(15)**

Unit 2: General considerations of synthetic fibers, polyamide fibers, polyester fibers, Acrylic fibers, polyvinyl chloride fibres, polyvinyl alcohol fibers, polyolefin fibers, polyurethane fibers, (Spandex). Indetification of textile fibers. **(15)**

Unit 3: Water soluble resins:- Modified starches, methyl and hydroxypropyl methyl cellulose derivatives, hydroxyethyl cellulose, carboxymethyl cellulose, poyvinyl alcohol, polyvinyl pyrollidone, poly (acrylic acid) and its homologues, polyacrylamide, ethylene oxide polymers, polyethylenimine. **(15)**

Unit 4: Epoxy resins:- General chemistry of bisphenol-A based expoxy resins, chemistry, properties and applications of cycloaliphatic epoxy resins, chemistry, properties and applications of epoxy, novolac, flexible epoxy and flame retardant epoxy resins, commercial epoxy resin curing agents. **(15)**

Semester - IV

POLY CH. 401: Step-growth Polymers

Unit 1 : **(15)**

(A) POLYESTERS AND POLYCARBONATE:

History, synthetic methods, manufacture of PBT, PEN, Sarona (from 1, 3-propanediol and DMT) Unsaturated and Saturated Network polymers. Synthetic methods, properties and applications of Aromatic polycarbonates.

(B) POLYAMIDES

Developments of Nylons, Nomenclature, synthetic methods, Nylon-6, Nylon-7, Nylon-11, Aromatic polyamides (Kevlar, Nomex).

Unit 2 : **(15)**

(A) POLYIMIDES:

Polyimides, addition type polyimides, polybenzimidazoles.

(B) POLYARYLENE ETHERS :

Synthesis, properties and applications of polysulfones, polyketones, polyethers. Polyether-ketones, Polyether-ether-ketones, polyphenylenes.

Synthesis, properties and applications of polyurethane elastomers and foams.

Unit 3 : FORMALDEHYDE BASED POLYMERS: **(15)**

Phenol-formaldehyde (PF) resin, novolac and resol type, factors affecting the prepolymer structure, mechanism of prepolymer formation, crosslinking of novolacs and resols, properties and applications of PF resin. Melamine formaldehyde (MF) resin, basic reactions, modifaction of MF prepolymer, crosslinking reactions in MF, properties and applications of MF resin. Urea-formaldehyde (UF) resin, synthesis of UF prepolymer; crosslinking, mechanism, properties and applications of UF resin.

Unit 4 : THERMOSETTING EPOXY RESINS : **(15)**

General chemistry of bisphenol-A based expoxy resins, chemistry, properties and applications of cycloaliphatic epoxy resins, chemistry, properties and applications of epoxy, novolac, flexible epoxy and flame retardant epoxy resins, commercial epoxy resin curing agents. Cyanate esters, bismaleimides, polybenzoxazines.

POLY CH: 402 Stereo regular Polymers and Modern Polymerization Methods

Unit 1 : STEREOCHEMISTRY: **(15)**

Basic configuration, relative and absolute configuration, methods of determination of configuration, stereospecific and stereoselective process. Types of stereoisomerism in polymers, tactic and atactic polymers, positional and geometrical isomers, stereoregulated polymers from mono-and disubstituted vinyls, 1, 3- butadienes. Properties of stereoregular polymers.

Unit 2 : METAL MEDIATED AND CATALYZED POLYMERIZATIONS: **(15)**

Ziegler–Natta Polymerization : Components in Z-N initiator, mechanism of Z-N polymerization of non-polar vinyl monomers. Stereospecific polymerization of polar vinyl monomers such as MMA, vinyl ethers, styrene and 1-3 dienes. Statistical models of propagation, Bernoulli model, First order Markov model. Discovery of MAO (Methylaluminoxane), Metallocene catalyzed polymerization and current polymer grades produced using Metallocenes, Post-metallocences and their industrial applications. Functional olefin (co)polymerization, Brookhart catalyst, Drent (Phosphine-sulfonate) catalyst, Advantages over Z-N/Metallocence

polymerization. Metathesis Polymerization: Mechanism of olefin-metathesis, Ring Opening Metathesis Polymerization (ROMP).

Unit 3 : **(15)**

(A) CONTROLLED OR LIVING RADICAL POLYMERIZATION:

Atom Transfer Radical Polymerization: Different ATRP agents, Mechanism, radical reactivity taming and control, Kinetics versus Thermodynamics, Advantages of ATRP over free radical polymerization. Reverse ATRP: Difference and significance of Reverse ATRP over ATRP. NMP: Nitroxy-radicals stability and unreactivity under certain conditions and their use in NMP, RAFT: Advantage of RAFT over ATRP, reaction mechanism and preparation of different polymer architectures.

(B) STEREOSPECIFIC PLACEMENT:

Mechanism of stereospecific placement in ionic and co-ordination polymerization.

Unit 4 : BLOCK CO-POLYMERS: **(15)**

A-B diblocks, ABA-triblocks, thermoplastic elastomers, -$(AB)_n$- multiblock co-polymers based on addition and/or condensation type.

POLY CH. 403: Selected Topics in Polymers

Unit 1 : SPECIALITY POLYMERS: **(15)**

I. Conducting polymers. II. Polymer liquid crystals. III. Polymers in lithography. IV. Composites and nanocomposites. V. Hydrogels and stimulli sensitive hydrogels, controlled release drug delivery polymer systems. VI. Polymer in optoelectronics. VII. Polymers in medicine – biomedical applications (UHMWPE, PU, Polysiloxanes). VIII. Polymer membranes for gas separation, per evaporation and fuel cell. IX. Silicone resins. X. Polymer blends and alloys. XI. Ionic polymers. XII. Polymers in tissue engineering. XIII. Self–assembling Polymers. XIV. Polymer adhesives.

Unit 2 : **(15)**

(A) CHEMICAL MODIFICATION OF POLYMERS:

Principles of polymer reaction. Cellulose modification, esterification and etherification of cellulose. PE modification: halogenation; sulfochlorination, grafting and radiation crosslinking. Polystyrene modification: hydrogenation,sulfonation and crosslinking.

(B) PAINTS VARNISHES AND COATINGS:

Introduction to paints and enamels. Principles of paint formulation, examples of flat, semi gloss and gloss paints, flow diagram of paint manufacture. Chemistry of drying, semidrying and non-drying oils, synthetic resins used in paints, classification of varnishes and coatings, Lacquer formulation, thinners, extenders/fillers. Colorant and pigments: Classification of pigments, chemistry, properties and application of white pigments, examples yellow, red, metallic, black, blue, green, fluorescent, pearl pigments. Natural and synthetic, organic / inorganic, nitroso, nitro, azo, vat and phthalocyanin dyes. Brief exposure to methods of analysis and testing of paints, methods of application of paints, failure of paint film – Mar Test, Anti-condensation test, Fire Resistance test

Unit 3 : **(15)**

(A) POLYMER SUPPORTS FOR ORGANIC SYNTHESIS:

Polymer supported reagent and catalysts, Solid phase peptide synthesis.

(B) POLYMER WASTE MANAGEMENT and POLYMERS FOR SUSTAINABLE ENVIRONMENT:

Polymer industry and environment. Waste management, polymer for Classification of polymer recycling processes. Waste polymer recovery, sortation, microsortation, polymer reprocessing. Polymer incineration.

Unit 4 : RUBBER CHEMISTRY AND TECHNOLOGY (15)

(A) NATURAL AND SYNTHETIC RUBBER:

Historical review, physical properties and chemistry of natural rubber, Natural Rubber modification: chlorination, epoxidation, hydrogenation, cyclization and ebonite. Manufacture and physical properties of synthetic rubbers such as SBR, Nitrile, Butyl, EPDM and neoprene. Determination of crosslink density of vulcanizate by swelling method.(Flory-Rehner equation).

(B) ADDITIVES FOR RUBBER:

Compounding and master batch preparation. Rubber additives including fillers, colorants and pigments, antioxidants and stabilizers, light UV stabilizers, flame-retardant additives, antistatic/ conductive additives, curing systems, accelerators, curing agents, catalysis, plasticizers, compatibilising agents, process modifiers and processing aids, blowing agents, lubricants, mould release agents, and miscellaneous additives. Examples, their functions and mode of action is expected.

POLY CH. 404: Processing Technology and Polymer properties

Unit 1: (15)

(A) QUALITATIVE INDENTIFICATION OF POLYMERS AND THEIR INTERMEDIATES:

Identification of polymers by heating and burning tests, identification of elements and functional groups, Acid value, Softening point, HDT, melting point, melt-flow index, bulk-density, hardness, water absorption, moisture content, ash content.

(B) ELECTRICAL AND OPTICAL PROPERTIES:

Electrical properties of polymers, sample preparation, procedures for dielectric constant; dielectric strength, dielectric loss factor, factors governing dielectric loss, volume restivity and breakdown voltage. Optical properties, refractive index, gloss haze, yellowness index, transmittance and photoelastic properties

Unit 2 : POLYMER PRODUCT TESTING: (15)

Testing procedures for different products like elastomers, films, pipes, tubes, laminates, adhesives, tyres and containers. Tensile strength, modulus, % elongation at brake, stress-strain curves, Maxwell and Voight model. Boltzmann's superposition principle. Compressive strength, tear strength flexural strength, impact strength, ultimate polymer properties and structure relationship, elastomers, fibre and plastics.

Unit 3 : POLYMER PROCESSING TECHNOLOGY: (15)

Processing thermoplastics material, polyolefins, injection moulding, thermo forming, extrusion, General Features of single screw extrusion, mechanism of flow, Analysis of flow in Extruder,

general features of twin-screw extruder, pultrusion, blow moulding and casting : introduction, details of process. Rotational moulding, calendering and it's analysis, structural foaming. Moudling : sandwitch moulding, RIM. Moulding of thermoset : preparation of material for moulding, compression moulding, transfer moulding. Effect of processing, microstructural changes, Shrinkage and distorsion, residual Stress. Processing of fibres and fabrics, spinning and post-spinning Processes. Gel Spining, Phase Separation Spinning, Reaction Spinning. Application of rheological aspects in polymer Processing.

Unit 4 : VISCOELASTIC PROPERTIES: (15)

Introduction, rheological equation for state, fluids-ideal and Non-Newtonian, viscous flow, viscoelastic behaviour, stress-relaxation, dynamic mechanical behaviour, generalised Maxwell model, Mechanical spectra, effect of different factors on mechanical spectra. General behaviours of polymer melts, measurement of flow properties.

POLY CH. 404A: Inorganic and Biopolymers

Unit 1. (15)

Phosphorous nitrogen polymers, introduction and structural chemistry, synthesis and reactions, polymer chemistry.

Boron polymers, boron –nitrogen, boron-phosphorous, boron-oxygen, boron-carbon, boronhydrogen polymers.

Silicon polymers, preparation and properties, coordination polymers, Natural and synthetic coordination polymers, reactions, polyanions and polymeric hydroxides.

Unit 2: (15)

Types of naturally occuring sugars deoxysugars, aminosugars, branched chain sugars, sugar methyl ethers and acid derivatives of sugars. General methods of structure and ring size determination with particular reference to maltose, lactose, starch and cellulose: photosynthesis of carbohydrates, metabolism of glucose, Glycoside-Anygdalin.

Classification, synthesis and properties of amino acids. Modern methods of peptide synthesis, sequence determination. Chemistry of insulin and oxytocin. Protein : structure, conformation and properties. Enzyme: Kinetics, inhibition mechanism, structure and regulations.

Unit 3: (15)

Classification and biological importance of Lipids. Chemical synthesis of simple phospholipids. Statistical mechanics of biopolymers: chain configuration of macromolecules, statistical distribution, end to end dimensions, calculation of average dimensions for various chain structures.

Forces involved in biopolymer interactions. Electrostatic charges and molecular expansion, hydrophilic forces, dispersion force interactions.

Thermodynamics of biopolymer solutions, osmotic pressure, membrane equilibrium.

Unit 4: (15)

Synthetic and Natural polymers, blends, composites in medical devices, Physical and Chemical properties of biomedical polymers and their characterization, processing techniques to prepare scaffolds, implants, micro / nanoparticles, cell and biomaterial interactions and applications and examples. Drug containing nanofibers for biomedical applications.

Following or similar Advanced Level experiments, illustrating the principle and techniques learnt in Theory are expected.

Polymer synthesis in bulk.
PMMA synthesis by free radical.
Rate of polymerization by dilatometry.
Kinetics of condensation polymerization.
Kinetics of addition polymerization.
Rate studies decomposition of azobisisobutyronitrile
Determination of reactivity ratios.
End group analysis.
Number average molecular weight of polymer.
Dielectric constant of polystyrene.
Volume resistivity of nylon and polyester
Hardness and Impact strength of polystyrene and PVC.
IR and NMR H-1 and C-13 analysis.
Crystallinity of polymers.
Determination of Mol. Wt. by end group analysis (COOH Group)
Acetyl content of cellulose acetate.
To determine the acid value of a given compound/ oligomer/ polymer.
To determine sap value and percentage purity of plasticizer.
To determine epoxy content of given resin by pyridine hydrochloride/ pyridine method.
Izod impact strength.
Quantitative Determination of impurities in given polymer by spectral techniques (UV-VIS)
Free - radical solution Polymerization of St/MMA.
a) Purification of monomer. b) Polymerization Using BPO/AIBN.
Redox Polymerization of acrylamide.
Precipitation polymerization of acrylonitrile.
Determination of molecular weight by viscometry (i) PS- toluene / Benzene
(ii) polyacrylamide- aqueous $NaNO_3$ solution.
Determination of molecular weight by end group analysis- PEG.(-OH group).
To estimate the concentration of vinyl monomer by bromination method.
IR study of polymers PI, PS, PE, PP, CA, PET,PTFE etc.
To study effect of molecular weight of polymer on viscosity by Ostwald's viscometry using PEG-200, PEG-400 etc.
To determine the viscosity of PEG-100 by Brook field viscometer.
To study effect of solvent's nature on viscosity of polymer using Ubbelhode viscometer.
To determine Viscosity of polymer in dilute solution at various concentration on Ubelhode viscometer and determine molecular weight of polymer.
St- MMA copolymer.
Shore hardness Test/Impact strength test.
MFI experiment.
To identify common polymer plastic sample by heating burning test.
(PVC, HDPE, LDPE, PP, PF, PC, Nylon, PS, UF, PMMA, SBR etc.)
To study kinetic of uncatalysed polyesterification.
Determination of bulk density of polymer powder.
Thermal conductivity of polymers.
Stress-strain relaxation process in polymers.
Heat capacity of polymers.

Size of the molecule.
Polymer polarizability.
Polymer blends - ultrasonic studies.
Polymer blends - viscometric studies.
Polymer blends - Compatibility studies by R.I.
Environmentally Sensitive Hydrogel
Superabsorbent polymer
Poly(vinyl acetate) glue
Microscale emulsion polymerization(vinyl acetate)
Isotactic poly(methyl methacrylate)
Bulk step-growth polymerization(nylon-11)
Controlled Radical Polymerization (ATRP, RAFT)
Polyaniline

A List of Recommended Books.

1. P. Rempp and E.W. Merill
Polymer Synthesis
Huethig and Wepf Verlag, Basel
2. Polymer Synthesis Theory and Practice
D. Braun, H. Cherdrown and H. Ritter
Springer, Heidelberg (2001) ISBN 3-540 –41697-8
3. Principles of Polymer Chemistry, 2Nd Ed.
A Ravve
Kluwer Academic Publisher (2000) ISBN 0-306- 48368-7
4. Organic Chemistry of Synthetic High Polymers
R.W. Lenz
Interscience Publishers, New York (1967)
5. Polymer Science and Technology
J.R. Fried
Prentice Hall (1995)
6. Polymer Chemistry – An Introduction
R. B. Seymour and C. E. Carraher, Jr.
Marcel Dekker, Inc. New York
7. Polymer Science
V.R. Gowariker, V.N. Vishwanathan and J.Sreedhar
Wiley- Eastern Limited (1995)
8. Contemporary Polymer Chemistry
H.R. Allcock and F.W.Lampe
9. Introduction to Polymer Science and Technology An SPE Textbook
H. S. Kaufman and J. J. Falcetta
John- Wiley and Sons, New York.
10. Introduction to Synthetic Polymers
I. M. Campbell 1st Ed., Oxford Press (1994)
11.Polymer Chemistry : An Introduction
G. Challa, 1st edn, Ellis Harwood (1993)
12. Advanced Polymer Chemistry : A Problem Solving Guide
Manas Chanda, Marcel- Dekker (2000), ISBN 0-8247- 0257-3
13.An Introduction to Plastics

H. G. Elias, 1st Edn., John-Wiley (1993).
14. An Introduction to Polymer Science
H. G. Elias, 1st Edn. John Wiley (1997).
15. Polymers: Chemistry and Physics of Modern Materials
J. M. G. Cowie, 2nd ed., Staaley Thornes Publ (1991)
16. Introduction to Macromolecular Science,
P .Munk, 1st Ed., John Wiley (1989).
17. Elements of Polymer Science and Engineering's.: An Introductory Text and Reference for Engineers and Chemists, Rudin, 2nd Ed., Academic Press, (1998).
18. Textbook of Polymer Science
F. W. Billmeyer, Jr.
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