Punyashlok Ahilyadevi Holkar Solapur University, Solapur

पुण्यश्लोक अहिल्यादेवी होळकर
सोलापूर विद्यापीठ
।। विद्यया संपन्नता ।।

NAAC Accredited-2022
'B^{++}'Grade (CGPA 2.96)

Name of the Faculty: Science &Technology

(As per New Education Policy 2020)

Syllabus: Polymer Chemistry

Name of the Course: M.Sc. II (Sem. III &IV)

(Syllabus to be implemented from June 2024)

पुण्यश्लोक अहिल्यादेवी होळकर सोलापूर विद्यापीठ ।। विद्यया संपन्नता ।। NAAC Accredited-2022 'B++' Grade (CGPA-2.96)	**Punyashlok Ahilyadevi Holkar Solapur University, Solapur** **Faculty of Science & Technology** **NEP 2020 Compliant Curriculum** **M.Sc. Polymer Chemistry** **Program Preamble**

The Master of Science (M.Sc.) in Polymer Chemistry is a comprehensive and dynamic program designed to provide students with a deep understanding of the fundamental principles and polymer reactions of Polymer Chemistry, along with the practical skills required to apply this knowledge in various scientific and technological contexts. Aligned with the vision of the National Education Policy (NEP) 2020, the program offers a flexible, multidisciplinary, and learner-centric curriculum that encourages critical thinking, innovation, and holistic development. The M.Sc. Polymer Chemistry program spans two years, with each year offering a progressively advanced curriculum designed to build a strong foundation in polymer Chemistry while allowing for specialization and interdisciplinary learning. The curriculum is structured around several key components:

1. **Discipline Specific Core Courses:** These core courses form the backbone of the program, providing in-depth knowledge and understanding of essential polymer chemistry concepts, theories, and methodologies. Students will engage with topics ranging from Importance of polymers, Classification of polymers, Chemical bonding in polymers and molecular interactions, molecular weight and nomenclatures of polymers ,Techniques of polymers , Petroleum based raw materials and intermediates for polymers , Renewable resources as feed stock ,Stereochemistry of polymers, Radical chain polymerization Free radical Co-Polymerization ,cationic anionic and ring opening polymerization, Controlled or living radical polymerization ,Metal mediated / Catalyzed Polymerization ,Macromolecular Architecture etc. Ensuring a robust and comprehensive education in the discipline.
2. **Discipline Specific Elective Courses:** The program encourages intellectual exploration beyond the core discipline by offering a wide range of elective courses. These electives enable students to pursue knowledge of their interests in diverse subjects, fostering creativity, critical thinking, and a well-rounded educational experience.
3. **Field Projects/Internships/Apprenticeships/Community Engagement Projects/On-Job Training:** To bridge the gap between theoretical knowledge and real-world applications, the program includes opportunities for field projects, internships, apprenticeships, and community engagement. These experiences provide students with practical insights, problem-solving abilities, and exposure to professional environments, enhancing their readiness for careers in Polymer Chemistry and related fields.
4. **Research Methodology and Research Projects:** Research is a critical component of the M.Sc. Polymer Chemistry program, with students acquiring skills in research methodology, data collection, analysis, and scientific inquiry. By engaging in independent research projects,

students are encouraged to develop innovative solutions to complex scientific problems, preparing them for advanced studies and research-oriented careers.

Multiple Entry and Multiple Exit Options

In accordance with the NEP 2020, the M.Sc. Polymer Chemistry program incorporates a Multiple Entry and Multiple Exit framework, offering students the flexibility to enter or exit the program at various stages. This approach ensures that students can tailor their educational journey according to their personal and professional goals, with options to earn certificates, diplomas, or degrees based on the duration of study completed.

- **Year 1:**
  Upon completion of the first year, students may exit with a **Certificate in Polymer Chemistry**.
- **Year 2:**
  After two years, students may choose to exit with a **M.Sc. Degree in Polymer Chemistry**

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Students graduating from the Master of Science in Polymer Chemistry program will be able to:

Discipline Specific Core Courses:

- **PO-1**: Demonstrate in-depth knowledge and understanding of core concepts, theories, and methodologies in the chosen major discipline.
- **PO-2**: To develop intellectual breadth and depth in polymer science. Impart knowledge about the types of polymers, polymerization techniques, and applications of polymers.
- PO-3: Learn about the structure of polymers, including homo-polymers, copolymers, morphology, molecular weight and its properties.
- **PO-4:** Understanding fundamental principles, laws and techniques of polymer chemistry
- **PO-5:** Development of abilities to study and understand properties of polymeric materials.

Discipline Specific Elective Courses:

- **PO-6**: Explore diverse subjects beyond the core discipline, fostering a broad-based education and cultivating analytical thinking and its application.

Research Methodology and Research Project:

- **PO-7**: Acquire research skills, including data collection, analysis, and interpretation, fostering a scientific approach to develop independent research projects handling capabilities.
- **PO-8:** Empowering the students to do independent research of high caliber.

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Faculty of Science & Technology

NEP 2020 Compliant Curriculum

M.Sc. (Polymer Chemistry)

Program Specific Outcomes (PSOs)

Students graduating from M.Sc. (Polymer Chemistry) will able to :

PSO-1: Mastery of Core Polymer Chemistry Concepts: demonstrate understanding of fundamental polymer Chemistry principles including polymer synthesis, theories, Chemical Kinetics, Electrochemistry, surface chemistry, molecular spectroscopy etc. allowing them to synthesis, modification and analysis of polymers.

PSO-2: Experimental and Analytical Skills: demonstrate proficiency in designing and conducting experiments, using modern laboratory equipment, and employing analytical techniques to interpret and present scientific data effectively.

PSO-3: Application of Polymer Chemistry knowledge in Technology and Research: apply their knowledge to develop innovative solutions in technology, engineering, and applied sciences, contributing to research and development in both academic and industrial settings.

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M.Sc.II Polymer Chemistry (w.e.f.2024-25)

Syllabus Structure and Credit Distribution

Sem.	Paper Code	Title of the Paper	Semester exam			L	T	P	Credits
		Mandatory	**Theory**	**IA**	**Total**				
III	**DSC-5**	Fundamentals of Polymer Science (**2324301**)	60	40	100	4	--	-	4
	DSC-6	Chain Polymerization Mechanism and Kinetics (**2324302**)	60	40	100	4		-	4
		Elective-3 (Anyone)							
	DSE-3A	Polymer Analysis and Characterization techniques (**2324306**)	60	40	100	4		-	4
	DSE-3B	Physical Chemistry of Polymers(**2324307**)	60	40	100	4		-	
		Field Project/RP/Internship/Apprenticeship							
	RP	Research Project –I (**2324303**)	60	40	100	4	-	0	4
		Practical							
	DSC-5P	Polymer Synthesis (**2324304**)	30	20	50	-	-	2	6
	DSC-6P	Polymer Analysis(**2324305**)	30	20	50	-	-	2	
		Elective-4(Anyone)							
	DSE-3AP	Polymer Characterization(**2324308**)	30	20	50			2	
	DSE-3B P	Polymer Modification(**2324309**)	30	20	50			2	
		Total for III semester	**330**	**220**	**550**	**16**	**550**	**6**	**22**
IV		**Mandatory**							
	DSC-7	Industrial Polymer Science(**2324401**)	60	40	100	4	--	-	4
	DSC-8	Paints and Coatings Technology(**2324402**)	60	40	100	4		-	4
		Elective(Anyone)							
	DSE-4A	Processing Technology and Polymer Properties (**2324405**)	60	40	100	4		-	4
	DSE-4B	Selected Topics in Polymers (**2324406**)	60	40	100	4		-	
		Field Project/RP/Internship/Apprenticeship/							
	RP	Research Project –II (**2324403**)	90	60	150	6	-	0	6
		Practical							
	DSC-7P	Polymer Synthesis (**2324404**)	30	20	50	-	-	2	4
		Elective(Anyone)							
	DSE-4AP	Polymer Modification(**2324407**)	30	20	50			2	
	DSE-4BP	Polymer Analysis(2324408)	30	20	50			2	
		Total for semester IV	**330**	**220**	**550**	**18**	**550**	**4**	**22**

DSC-Discipline Specific Course
DSE-Discipline Elective course
RM-Research Methodology
OJT-On Job Training
RP–Research Project
L–Lecture–Tutorial, **P**– Practical
Credits of Theory=4Hoursofteachingperweek 2
Credits of Theory = 4 Hours per week

Important Note:

1. Student should choose any one subject from Elective-III.
2. The Research Project can be initiated at the end of Semester II and the midterm examination will be conducted at the end of Semester- III, for 4 credits.
3. Student should choose any one subject from Elective-IV.
2. Each theory course prescribed for M. Sc. should be covered in 4 lectures per course per week each of 60 minutes duration including lectures, tutorials, seminars, classroom discussions, etc. (Total 60 h / theory course)
3. Eachpracticalcoursewillrequire12hoflaboratoryworkperweekpersemester.
4. Theresearchprojectmaybeextendedovertwosemestersviz.SemesterIIIandIVof06h/week/group and can be initiated at the end of Semester II. The examination will be conducted at the end of Semester IV for 6 credits.
5. For theory course, the question paper (Internal/External) may include numerical, short answer, long answer, MCQ questions to test understanding of the subject.
6. The marks for each paper are distributed as - external examination 60 marks and internal examination 40 marks. For internal assessment of each theory and practical course, 2 written tests will be taken.
7. Organizing educational tour aim in giving practical exposure to student expected (at their own cost).
8. To train the students for the SET/NET/GATE and other competitive examinations, University/College assessment 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

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***Teaching Scheme** **Lectures:04 Hours/week, 04 Credits**	***Examination Scheme** **UA:60 Marks** **CA: 40 Marks**

COURSE PREAMBLE:

The course provides an introduction to polymer science with respect to synthesis, polymerization kinetics and network formation/gelatin of macromolecules. The first part of the course will describe the shapes and sizes of polymer molecules, molecular weight and different polymerization techniques mentioned in the basic course are discussed in details, it also includes Renewable Resources and Stereochemistry of Polymers.

COURSE OBJECTIVES:

- Students learn about the structure of polymers, including homopolymers, Co-polymers, morphology, molecular weight and its properties.
- Importance of polymers and evaluation of concepts of macromolecules.
- Molecular weights, Nomenclature of Polymers.
- Use Petroleum Based Raw Materials, Renewable Resources, Stereochemistry Of Polymers.
- Students learn about different polymerization techniques.

COURSE OUTCOMES:

- At the successful completion of this course you (the student) should be able to:
- 1. Understand Characterization of molecular weight.
- 2. Gain knowledge about different molecular weight determination techniques and Material Characterization
- 3. Use fundamental polymer chemistry to explain and predict the synthesis of polymers as well as the resultant structure and properties.
- 4. Identify suitable characterization techniques based on polymer solubility and chemical structure.
- 5. Predict/interpret the behavior and properties of polymers as a function of their morphology and composition.
- 6. Evaluate technological developments in commodity and advanced polymers.

SYLLABUS:

Unit 1: (15 Hrs, 19 Marks)

(A) Importance of polymers and evaluation of concepts of macromolecules.

(B) Classification of Polymers: Addition- condensation, chain/step growth polymerization, organic-inorganic, natural synthetic, thermoplastic – thermosetting, polar- non polar polymers with suitable examples, based on applications - fibers, foams, adhesives and elastomers, based on performance – commodity and engineering polymers. Homopolymers, co-polymers, linear polymers, branched polymers, cross linked or three-dimensional polymers block and graft co-polymers, linear, branched, cross linked types of polymers, Vitrimers. Hyperbranched, star branched dendrimers, semiladder, ladder and layer lattices-polymers.

(C) Chemical Bonding in Polymers and Molecular Interactions: Molecular forces and chemical bonding in polymers, primary bonds (ionic, bond, covalent bond, coordinate bond, metallic bond), Secondary-bond forces (dipole forces, induction forces, dispersion forces, hydrogen bond) intermolecular forces and physical properties. Thermal transitions (TG and TM). Relaxation nature of glass transition, mechanism of glass transition, effect of molecular mass of polymers on its glass transition temperature and on flow temperature, relationship between Tg and Tm of polymers, chemical constituents of polymers and glass transition temperature.

(D) Molecular weights and Nomenclature of Polymers: Degree of polymerisation, various average molecular weights (Mn, Mw, Mv and Mz) and polydispersity. Nomenclature based on source, nomenclature based on structure (nonIUPAC), nomenclature based on structure IUPAC, trade names.

Unit 2: (15 Hrs, 19 Marks)

Techniques of Polymerization: Bulk, solution, precipitation, suspension, emulsion, inverse emulsion, melt polycondensation, solution polycondensation, interfacial polymerization, phase transfer catalyzed interfacial polymerization, solid state polymerization and gas phase polymerization. Batch, semibatch and continuous process, 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). Sonochemical, flow synthesis.

Unit 3: (15 Hrs, 19 Marks)

(A) Petroleum Based Raw Materials and Intermediates for Polymers: Crude oil, source of crude oil, origin of Petroleum, refining of crude oil, cracking thermal and catalytic), gaseous fuel (LPG), petrochemical as building blocks for monomers and polymers, carbon dioxide, acetylene and derivatives, ethylene and derivatives, propylene and derivatives, butane/butene, butadiene fractions, BTX and their derivatives: Polymer feed stocks (monomers, solvents), EHS registration.

(B) Renewable Resources as Feedstock: Non petroleum based renewable agricultural resources for monomers and polymers from wood (cellulose. lignin), carbohydrates (polysaccharides, starch, glucose,

sugar), CNSL, plant oils, agricultural- industrial-(molasses) green route to synthesis of monomers such as ethylene, adipic acid, caprolactone, MMA, acrylic acid, glycerol, furonics, Algae based chemicals, chitin and chitosan-based chemicals.

Unit 4: (15 Hrs, 19 Marks)

Stereochemistry of Polymers: Basic configuration, relative and absolute configuration, optical isomerism, methods of determination of configuration, constitutional isomerism in polymers. Types of stereoisomerism in polymers, tactic and atactic polymers, positional and geometrical isomers, stereoregular polymers from mono-and disubstituted ethylenes, carbonyl and ring opening polymerization of monomers, 1,3-Butadiene and 2-Substituted 1,3-Butadienes, 1-Substituted and 1,4-Disubstituted 1,3-Butadienes. Properties of stereoregular polymers, Analysis of Stereoregularity.

Reference Books:

1. Polymer Chemistry – M. P. Stevens, 2nd Ed., Oxford University Press, 1990.

2. Polymer Synthesis Theory and Practice, D. Braun, H. Cherdrown and H. RitterSpringer, 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, WileyEastern Limited (1995).

8. Polymeric Materials and Processing, Jean-Michail Charrier.

9. Polymer Technology, D. C. Miles.

10. Plastics Technology, Robert Milby.

11. Polymer Science and Engineering, D. J. Williams.

12. Mechanical Properties of Solid Polymers, I. M. Ward.

13. Mechanical Properties of Polymers and Composites, L.E. Nielsen.

14. Mechanical Properties of Polymers and Composites, Murayama.

पुण्यश्लोक अहिल्यादेवी होळकर सोलापूर विद्यापीठ ।। विद्यया संपन्नता ।। NAAC Accredited-2022 'B++' Grade (CGPA-2.96)	**PunyashlokAhilyadeviHolkar Solapur University, Solapur** **M.Sc.(Polymer Chemistry) Semester-III (Year- 2024-25)** **Vertical: DSC-6** **Course Code: 2324302** **Course Name: Chain Polymerization Mechanism and Kinetics**
***Teaching Scheme** **Lectures:04 Hours/week, 04 Credits**	***Examination Scheme** **UA:60 Marks** **CA: 40 Marks**

Course Preamble: Chain Polymerization Mechanism and Kinetics Course is designed for understanding the basic concepts of chain polymerization reactions the first two units includes detailed mechanisms of Polymer Chemistry. And remaining units includes catalyst or metal mediated polymerization; It also provides knowledge about macromolecular architecture of polymers.

COURSE OBJECTIVES:

- To study different mechanisms of polymerization like chain-growth polymerization and Sep growth polymerization.
- Kinetics can also be used to establish a theoretical polymer chain length.

COURSE OUTCOMES:

At the successful completion of this course you (the student) should be able to:

1. Understand different chain polymerization mechanisms like,
   - Radical Chain Polymerization,
   - Free Radical Co-Polymerization Cationic,
   - Anionic and Ring Opening Polymerization,
   - Metal Mediated / catalyzed Polymerization etc.
   -
2. Get knowledge about Macromolecular Architecture which plays a pivotal role in determining the properties of polymers.
3. Use different catalysts, initiators required for chain polymerization reaction.
4. Understand kinetics i.e. rate of reaction during polymerization.

SYLLABUS:

Unit 1: **(15 Hrs, 19 Marks)**

(A) Radical Chain Polymerization: Nature of radical chain polymerization, Structural arrangement of monomer units, rate of radical chain polymerization, propagation modes, H-T and H-H polymerization, mechanism and kinetics: energetic, chain transfer, experimental determination of rate of polymerization. Initiation by free radical, Redox, photochemical, ionizing radiation and thermal methods, efficiency of initiator transfer reactions, retardation, auto acceleration.

(B) Free Radical Co-Polymerization: Introduction, Copolymer composition, Copolymerization equations, Methods of determination of reactivity ratios, Reactivity ratio and copolymerization behavior, experimental determination of r1 and r2; Q-e scheme. Microstructure of copolymers, important examples of copolymers.

Unit 2 : **(15 Hrs, 19 Marks)**

Cationic, Anionic and Ring Opening Polymerization: Basic concepts of cationic and anionic methods of polymerization, comparison between radical and ionic polymerization. Kinetics of cationic and anionic polymerization. Group transfer polymerization. Ring opening polymerization, mechanism of ROP of cyclic ethers, cyclic amides and cyclosiloxanes; Ring opening metathesis polymerization. Commercial importance of cationic and anionic polymerization.

Unit 3 : **(15 Hrs, 19 Marks)**

(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 conventional 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) Metal Mediated / catalysed Polymerization: Historical Development of Ziegler–Natta Initiators, Chemical Nature of Propagating Species, Primary versus Secondary Insertion; Regioselectivity, Propagation at Carbon–Transition Metal Bond, Mechanism of Isoselective Propagation, Mechanism of Syndioselective Propagation, Direction of Double-Bond Opening, Effects of Components of Ziegler – Natta Initiator, Kinetics, Transition Metal Oxide Initiators. Stereospecific polymerization of polar vinyl monomers such as MMA, vinyl ethers, styrene and 1-3 dienes. Statistical models of 8 propagation, Bernoulli model, First order Markov model. Mechanism of stereospecific placement in ionic and co-ordination polymerization.

Unit 4 : **(15 Hrs, 19 Marks)**

Macromolecular Architecture: Functional Polymers, hyperbranched polymers, Dendrimers, Polymer blends, Block copolymers and properties of block copolymers. A-B diblocks (styrenebutadiene, styreneMMA), ABA-triblocks (PS-PB-PS), thermoplastic elastomers, -(AB)n multiblock copolymers based on addition and/or condensation type (ether-ester, siloxane polysulfone, spandex fibers etc).

References Book:

1. Contemporary Polymer Chemistry, H.R. Allcock and F.W.Lampe.

2. Introduction to Polymer Science and Technology An SPE Textbook, H. S. Kaufman and J. J. Falcetta, John- Wiley and Sons, New York.

3. Introduction to Synthetic Polymers, I. M. Campbell, 1st Ed., Oxford Press (1994).

4. Polymer Chemistry : An Introduction, G. Challa, 1st Ed., Ellis Harwood (1993).

5. Advanced Polymer Chemistry : A Problem Solving Guide, Manas Chanda, MarcelDekker (2000), ISBN 0-8247- 0257-3. 13. An Introduction to Plastics, H. G. Elias, 1st Ed., John-Wiley (1993).

6. An Introduction to Polymer Science, H. G. Elias, 1st Ed. John Wiley (1997).

7. Polymers: Chemistry and Physics of Modern Materials, J. M. G. Cowie, 2nd Ed., Staaley Thornes Publ (1991).

8. Polymer Degradation and Stabilization, N. Grassie & G. Scott; Cambridge University Press.

9. Polymer Degradation, T. Kellen.

10. Synthesis of Polymers a Comprehensive Treatments, A. D. Schultzer; Wiley VCH (1999).

11. The Chemistry of Polymers, 2nd Ed., J. W. Nicholson, The Royal Society of Chemistry(1997), ISBN 0-85404-558-9.

12. Comprehensive Polymer Science Vol.4, 5, 6.

13. Handbook of Polymer Synthesis Marcel Dekker, INC. New York (1992).

14. Anionic Polymerization: Principles & Practical Applications, Marcel Dekker, INC. NewYork (1996).

15. Cationic Polymerization: Mechanism, Syntheses & Applications Ed. K. Matyjarzerski; Marcel Dekkar, Inc. New York (1996).

16. Macromolecular Design: Concept and Practice, Ed. M.K. MishraPolymers Frontiers International, Inc Hopewell Jet New York (1994).

17. Designed Polymers by Carbocationic Macromolecular Engineering Theory & PracticeJ.P.Kennedy & B.Ivan; Hanser(1991).

18. Metalogranic Catalysts for synthesis and PolymerizationEd. W. Kaminsky; Springer (1999).

19. Ring Opening Polymerization Vol. 1, 2 & 3Ivin K.J., & Saegusa T., Elsevier Applied Science Publisher.

	PunyashlokAhilyadeviHolkar Solapur University, Solapur **M.Sc.(Polymer Chemistry) Semester-III (Year- 2024-25)** **Vertical: DSE-3A** **Course Code: 2324306** **Course Name: Polymer Analysis and Characterization techniques**
***Teaching Scheme** **Lectures:04 Hours/week, 04 Credits**	***Examination Scheme** **UA:60 Marks** **CA: 40 Marks**

Course Preamble: This course consists of four units. Unit I contain the structure determination of polymer molecules by different analytical techniques like NMR,IR, UV-Visible, Mass, Raman Spectroscopy etc. Second unit consist of different surface analysis techniques like SEM, TEM, XRD etc. The third unit contains different thermal analysis technique of polymers like TGA, DTA, and DSC etc. and the last unit contains polymer product testing techniques.

COURSE OBJECTIVES:

- To know the specific properties of polymers by analyzing their crystalline/amorphous ratio.
- Microscopy and spectroscopy are used for the characterization.

COURSE OUTCOMES:

All the successful completion of this course you (the student) should be able to:

1. Characterize the functionalized polymers include molecular weight distribution, molecular structure, morphology, thermal properties, and mechanical properties.
2. Identify Polymers qualitatively and their Intermediates.
3. Evaluate the biological qualities of polymers which are important for biomedical use
4. Do Polymer Product Testing.
5. Analysis different polymers by different spectroscopic methods like
   - Ultraviolet visible spectroscopy
   - X-ray diffraction method
   - Infra red spectroscopy
   - Mass spectroscopy
   - Raman spectroscopy etc.
6. Characterize polymer by Thermal analysis methods like :
   - Thermo gravimetric analysis
   - Differential Thermal analysis
   - Differential Scanning Calorimetric method etc.

SYLLABUS:.

Unit 1: (15 Hrs, 19 Marks)

Polymer Structure Determination using Spectroscopic Techniques :UV-Visible spectroscopy, IR and Raman spectroscopy, 1H NMR and 13C NMR spectroscopy, mass spectrometry, MALDI-TOF – case study. In situ monitoring of polymerization reaction.

Unit 2: (15 Hrs, 19 Marks)

Surface Analysis : SEM, TEM, FESEM, contact angle and XPS for polymer analysis, Polarized Optical Microscopy (POM) for Spherulitic Studies. X-Ray Diffraction Analysis: 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.

Unit 3: (15 Hrs, 19 Marks)

Thermal Analysis of Polymers : Thermogravimetric analysis (TGA), applications- purity, thermal stability, thermal degradation, kinetics of thermal degradation, integral procedural decomposition temperature (IPDT). Method of variable heating rate for a single thermogram, Estimation of thermal stability from TGA curves, qualitative methods, semi quantitative and quantitative methods, etc. Differential thermal analysis (DTA) 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 crystaltransition. (Detailed instrumentation not expected).

Unit 4: (15 Hrs, 19 Marks)

(A) Qualitative Identification 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, bulkdensity, hardness, water absorption, moisture content, ash content.

(B) Polymer Product Testing: Testing procedures for different products like elastomers, films, pipes, tubes, laminates, adhesives, tyres and containers. Tensile strength, modulus, % elongation at brake, stressstrain 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, test for biodegradation and fibre testing

References Book :-

1. NMR of Polymers, F-Bovey and P. Miran, 1st Edn.; Academic Press (1996).

2. Polymer Spectroscopy, A. H. Faweett, 1st Edn.; John Wiley (1996).

3. NMR of Macromolecules; A Practical Approach, G. C. K. Roberts; 1st Edn. Oxford University Press (1993).

4. Introduction to Macromolecular Science,P.Munk, 1st Ed., John Wiley (1989).

5. Elements of Polymer Science and Engineering's: An Introductory Text and Reference for Engineers and Chemists, Rudin, 2nd Ed., Academic Press, (1998).

6. Textbook of Polymer Science, F. W. Billmeyer, Jr.
7. Principles of Polymer Chemistry, P. J. Flory.
8. Principles of Polymerization, G. Odian, John Wiley and Sons (1981).
9. Polymer Chemistry, B.Vollmert, Springer Verlag (1973).
10. Structure Property Relationship in Polymers, R. B. Seymour and C. E. Carraher Jr.
11. Fundamental Principles of Polymeric Materials, S. L. Rosen.
12. Principles of Polymer Engineering, N. G. Mecrum, C. P. Buckley, C. B. Bucknall.
13. Thermal Characterization of Polymeric Materials; E.A. Turi, Academic Press.
14. Thermal Methods in Polymer Analysis; Shallaby S.W. (Ed.), he Franklin Inst. Press Philadalphia.

पुण्यश्लोक अहिल्यादेवी होळकर सोलापूर विद्यापीठ ॥ विद्यया संपन्नता ॥ NAAC Accredited-2022 'B++' Grade (CGPA-2.96)	**PunyashlokAhilyadeviHolkar Solapur University, Solapur** **M.Sc.(Polymer Chemistry) Semester-III (Year- 2024-25)** **Vertical: DSE – 3B** **Course Code: 2324307** **Course Name: Physical Chemistry of Polymers**
***Teaching Scheme** **Lectures:04 Hours/week, 04 Credits**	***Examination Scheme** **UA:60 Marks** **CA: 40 Marks**

COURSE PREAMBLE: this course gives information about calculation of molecular weight of different polymers, as well as identification of polymers morphologically by XRD, DSC, TGA,TEM Techniques etc. The coarse also provide different theories of polymer Solution apart from this , Polymer Degradation and Stabilization can also be studied.

COURSE OBJECTIVES:

- Establishing knowledge and competence for understanding fundamental structure, property relations of polymers.
- Study morphology of polymers, including cross linking and crystalinity.
- Polymer Degradation and Stability.
- Study different theories of polymer solution.

COURSE OUTCOMES:

At the successful completion of this course you (the student) should be able to :

- 1. enhance and develop fundamental understanding of degradation reactions, their control
- or utilization for sustainability purposes including recycling.
- 2. determine Molecular weight and MWD (or molecular weight distribution) of the polymers .
- 3. describe the arrangement of molecules on a large scale.
- 4. determine crystalinity, branching, molecular weight and cross-linking of the polymers .

SYLLABUS:

Unit 1: (15 Hrs, 19 Marks)

Polymer Molecular Weight: Molecular mass of Polymers: polydispersity /, Distribution curve, Polydispersity, Molecular mass average determination, Absolute and relative methods. Colligative properties: ebullioscopy, cryoscopy, end group analysis, Membrane Osmometry, Vapour phase osmometry, Light scattering, Ultracentrifugation. Solution viscosity - Intrinsic viscosity, Determination of viscosity average molecular weight, Mark-Howink equation, determination of k and a, Fractionation of polymers- Gel permeation chromatography (GPC), Relation of chromatogram shape and MWD. Polymer conformation and chain dimensions, freely jointed chains, real chains, characteristic ratio.

Unit 2: (15 Hrs, 19 Marks)

Morphology of Polymers: 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 of polymers, determination of Tg, TMA and DSC, interpretations of DSC thermogram, applications - Tg, Tm, heat of fusion and degree of crystallinity etc. (Principles of TMA and DSC expected).

Unit 3 : (15 Hrs, 19 Marks)

Theory of Polymer Solution: Thermodynamics of polymer solution- Entropy, enthalpy, and free energy of mixing. Lattice model-solubility parameter, Free volume theory, Excluded volume, Flory-Huggins Theory, Flory-Krigbaum theory, Huggins and Kraemer equation, Phase equilibrium in polymeric systems. Viscosity of dilute solution. Critical solution temperature, LCST and UCST behavior, Experimental results in binary systems involving polymer blends.

Unit 4: (15 Hrs, 19 Marks)

Polymer Degradation and Stabilization : Chemical degradation, physical degradation, ageing, crazing, degradation by micro organisms, Biodegradable polymers, Mechanism of degradation, secondary chain reaction, Self reaction, depolymerisation, metal catalyzed degradation, Thermal oxidation, Photo oxidation, Mechanical degradation, Degradation by ionizing radiation, ozone attack. Degradation of special polymers: Polyolefin's, PVC, PS, PMMA. Stabilization: Chain breaking antioxidants, bound antioxidants, Radiation protection, Stabilization against biodegradation.

References Book :

1. Introduction to Physical Polymer Science, L. H. Sperling.

2. Polymer Processing Fundamentals, T. A. Ostwald.

3. Commercial Polymer Blends, L. A. Utracki.

4. Polymer Chemistry, M. G. Arora and M. Singh, (Amol Publ Pvt. Ltd. New Delhi110002).

5. Polymer Science, P. L. Nayak, Kalyani Publ.(2005), ISBN 81-272-1989-4.

6. Introductory Polymer Chemistry, G. S. Mishra, Wiley Eastern Ltd (1993).

7. Advanced Practical Organic Chemistry, 2nd Ed. J. Leonard, B. Lygo & G. Procter (2004), ISBN 0748740716.

8. Physical Chemistry of Macromolecules, D. D. Deshpande, Vishal Publ., Jalandhar (1985).

9. Physical Chemistry of Polymers, A. Tager, Mir Publ.

10. Polymer Characterization, E. Schroder, G. Muller and K. F. Arndt, Hanser Publishers, Munich.

11. Polymer Characterization: Physical Techniques, D. Campbell and J. R. White; Chapman &Hall, London (1989).

12. Polymer Melt Rheology, F. N. Cogswell.

13. Principles of Polymer Processing, R. T. Fenner.

14. Flow Properties of Polymer Melts, J. A. Brydson.

15. Plastics Recycling, J. L. Ehrig; Hanser Publ.(1989).

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **MSc (Polymer Chemistry) Semester-III** **Vertical : RP** **Course Code:2324303** **Course Name: Research Project**
***Teaching Scheme** **Practicals:08 Hours/week, 04 Credits**	***Examination Scheme** **UA:60 Marks** **CA: 40 Marks**

Course Preamble:

- The research project for M. Sc. Polymer Chemistry is introduced to get familiarize with literature survey of the work done in the field of interest
- It is expected that project should provide hands on training to the students on various instruments.
- They should learn independent working on a short research project.
- In Semester III, there is a Research Project of 4 credits. Students have to carry out project either at college laboratory or university laboratory or in any recognized R & D laboratory (Public/Private/Government) or Industry or Institute of national repute across the country under the guidance of scientist or a post-graduate faculty member.

A. List of Recommended Books.

1. Polymer Chemistry – M. P. Stevens, 2nd Ed., Oxford University Press, 1990.

2. Polymer Synthesis Theory and Practice, D. Braun, H. Cherdrown and H.

RitterSpringer, 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 Ed., 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 Ed., John-Wiley (1993).

14. An Introduction to Polymer Science, H. G. Elias, 1st Ed. John Wiley (1997).

15. Polymers: Chemistry and Physics of Modern Materials, J. M. G. Cowie, 2nd Ed., Staaley Thornes Publ (1991).

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **MSc (Polymer Chemistry) Semester-III** **Vertical : DSC - 5P,6P** **Course Code: 2324304, 2324305** **Course Name: Polymer Synthesis, Polymer Anylasis** **Vertical : DSE – 3A P, 3B P** **Course Code: 2324308, 2324309** **Course Name: Polymer Characterization, Polymer Modification**
***Teaching Scheme** **Practicals:04 Hours/week, 02 Credits**	***Examination Scheme** **UA:30 Marks** **CA: 20 Marks**

Course Preamble:

The practical course is designed in such a way that students will get an experiential learning. The practicals are set on the core papers as well as elective courses. The Practicals are on the basis of Synthesis, analysis, Characterization and modification polymers. These practicals are further divided into short and long experiments. A Polymer chemistry practical course aims to provide students with hands-on experience in the laboratory, reinforcing theoretical concepts and developing essential laboratory skills.

Course Objectives

- **Experimental Techniques:**
  - Master fundamental laboratory techniques such as weighing, measuring, titration, filtration, and crystallization, Polymerization. Develop proficiency in using laboratory equipment, including balances, glassware, burners, and heating devices.
- **Observation and Data Collection:**
  - Synthesis and Analysis of polymers and record accurate observations, measurements and data.
  - Develop skills in data analysis, including graphing, calculations, and interpretation of results.
- **Problem-Solving and Critical Thinking:**
  - Apply theoretical knowledge to solve practical problems and design experiments.
  - Develop critical thinking skills to analyze experimental results and draw conclusions.
- **Laboratory Safety:**
  - Understand and adhere to laboratory safety procedures and regulations.
  - Handle chemicals and equipment safely and responsibly.

Course Outcomes:

- In-depth training on laboratory solution preparations on all concentration scales
- Training on laboratory safety and lab ethics in scientific work
- Training on planning, design and execution of experiments.
- Training on scientific literature search, defining the objective of the work, research skills, data representation in tabular and graphical form etc.
- Training on experimental verification of fundamental theories, comparison of data with literature and scientific discussion on any deviation of data from expected theoretical values or reported literature.
- Training on different techniques needed to characterize the polymers.
- Application of theoretical and practical knowledge for research training through mandatory research/industrial projects.

Practicals:-

A. Polymer Synthesis:

1. Free radicals (Redox) solution polymerization of acryl amide.
2. Solution polymerization of Methyl Methacrylate (MMA).
3. Suspension Polymerization of Vinyl Acetate.
4. Solution Polymerization of Vinyl acetate in Benzene.
5. Hydrolysis of Poly (vinyl acetate) to Poly (vinyl alcohol).
6. Precipitation Polymerization of Acrylonitrile.

B. Polymer Analysis:

1. Analyse the given Plasticizer and determine its Purity.
2. Estimation of Molecular Weight of Polyethylene glycol by end group analysis.
3. Estimation of Vinyl monomer Concentration by the Bromination method.

C. Polymer Characterization:

1. Determine acid value of given compound
2. Determine the molecular weight of the given polymer by viscometrically.

OR

D. Polymer Modification:

1. Preparation of Cellulose acetate
2. Preparation of Cellophanes
3. Preparation of Hexamethylene melamide
4. Preparation of Sodium Carboxyl methyl cellulose (CMC).

* **Any other relevant experiment may be added.**

Reference Book:

Polymer Chemistry-Practical Approach in Chemistry, F. J. Davis, Oxford University Press, Oxford, 2004.

2. Experiments in Polymer Science, D. G. Hundiwale, V. D. Athawale, U. R. Kapadi, V. V. Gite, New Age International Pvt. Ltd., New Delhi, 2009.

3. Polymer Science – V. R. Gowarikar, N. V. Viswanathan, Jayadev Shreedhar, New Age International Pvt. Ltd., New Delhi, 1997.

4. Principles of Polymerisation, P. Bahadur, N. V. Sastry, Narosa Publishing House, New Delhi, 2002.

M. Sc. II, Semester-IV (Polymer Chemistry)

पुण्यश्लोक अहिल्यादेवी होळकर सोलापूर विद्यापीठ ।। विद्यया संपन्नता ।। NAAC Accredited-2022 'B++' Grade (CGPA-2.96)	**Punyashlok Ahilyadevi Holkar Solapur University, Solapur** **M.Sc.(Polymer Chemistry) Semester-IV (Year- 2024-25)** **Vertical: DSC-7** **Course Code:2324401** **Course Name: Industrial Polymer Science**
***Teaching Scheme** **Lectures:04 Hours/week, 04 Credits**	***Examination Scheme** **UA:60 Marks** **CA: 40 Marks**

COURSE PREAMBLE:

The course provides an introduction to polymer science with respect to synthesis, basic polymer characteristics. The first part of the course describes the different type's polymers and polymerization reactions like Step-growth Polymers, Industrial manufacturing and recycling of commodity polymers, Polyamides etc. The Second part of the course describes the Polyamides, Polybenzimidazoles, Polyarene Ethers, Polyurethanes, Formaldehyde based Polymersand Epoxy resinsetc. basic courses are discussed in details.

COURSE OBJECTIVES:

- Chemical structure of polymers, how to measure the molecular weight, and how polymers are processed is studied.
- Importance of polymers and evaluation of concepts of Industrial polymer sciences is done.
- structure-property relationships, polymer processing techniques, testing and characterization, and their diverse applications

COURSE OUTCOMES:

- At the successful completion of this course you (the student) should be able to:
- 1. Understand Step-growth Polymers.
- 2. Gain knowledge about different Industrial manufacturing and recycling of commodity polymers
- 3. Synthesis, mechanism, properties and applications of different types of polymers like Phenol-formaldehyde (PF) resin, novolac and resol etc. can be studied.
- 4. Understand Factors affecting the prepolymer structure, mechanism of prepolymer formation, cross linking of novolacs and resoles.

SYLLABUS:

Unit 1: (15 Hrs, 19 Marks)

Step-growth Polymers: Reactivity of functional groups, basis for analysis of step growth polymerization kinetics. Kinetic equation for poly esterification, Carothers equation for DP, control of molecular weights in linear step-growth polymers, multi-chain polymerization.

(A) Industrial manufacturing and recycling of commodity polymers: Polyethylene, polystyrene, poly (vinyl chloride), PMMA, life cycle assessment, techno economic analysis of manufacturing.

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

(**C) Polyamides:** Developments of Nylons, Nomenclature, synthetic methods, applications and recycling of Nylon-6, Nylon-7, Nylon-11, Aromatic polyamides (Kevlar, Nomex).

Unit 2: (15 Hrs, 19 Marks)

(A) Polyamides:

Synthesis, properties and applications recycling of Polyimides, addition type polyimides.

(B) Polybenzimidazoles.

(C) Polyarylene Ethers: Synthesis, properties and applications recycling of polysulfones, polyketones, polyethers. Polyetherketones, Polyether-ether-ketones, polyphenylenes.

(D) Polyurethanes: Synthesis, properties, applications and recycling of polyurethane elastomers, foams and spandex fibers.

Unit 3: (15 Hrs, 19 Marks)

(A) Formaldehyde based Polymers: 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, modification 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.

(B) Epoxy resins: General chemistry of bisphenol-A based expoxy resins, cycloaliphatic epoxy resins, novolac, flexible epoxy and flame retardant epoxy resins, commercial epoxy resin curing agents. Cyanate esters, bismaleimides, polybenzoxazines. Recyclable epoxy resins.

Unit 4: (15 Hrs, 19 Marks)

Speciality Polymers: 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. XV. Polymers based on Boron / Nitrogen. XVI. Additive manufacturing of polymers (3D panting). XVII. Lithium-ionbatteries.

Reference Books:

1. Polymer Chemistry – M. P. Stevens, 2nd Ed., Oxford University Press, 1990.

2. Polymer Synthesis Theory and Practice, D. Braun, H. Cherdrown and H. RitterSpringer, 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, WileyEastern Limited (1995).

8. Polymeric Materials and Processing, Jean-Michail Charrier.

9. Polymer Technology, D. C. Miles.

10. Plastics Technology, Robert Milby.

11. Polymer Science and Engineering, D. J. Williams.

12. Mechanical Properties of Solid Polymers, I. M. Ward.

13. Mechanical Properties of Polymers and Composites, L.E. Nielsen.

14. Mechanical Properties of Polymers and Composites, Murayama

पुण्यश्लोक अहिल्यादेवी होळकर सोलापूर विद्यापीठ ।। विद्यया संपन्नता ।। NAAC Accredited-2022 'B++' Grade (CGPA-2.96)	**PunyashlokAhilyadeviHolkar Solapur University, Solapur** **M.Sc.(Polymer Chemistry) Semester-IV(Year- 2024-25)** **Vertical: DSC-8** **Course Code: 2324402** **Course Name: Paints and coatings Technology**
***Teaching Scheme** **Lectures:04 Hours/week, 04 Credits**	***Examination Scheme** **UA:60 Marks** **CA: 40 Marks**

Course Preamble: Paints and coatings Technology Course is designed for understanding the basic concepts of paints & coatings development & its analysis. The first two units includes detailed Introduction about paints and Pigments and remaining two units includes manufacture of paints, resins and Coating as well as manufacture of powder Coatings, dry distempers, cement paints, oil-based distempers .

COURSE OBJECTIVES:

- Understand the fundamentals of paint and coating chemistry .
- Learn about their types, properties and characteristics.
- Design and develop coating formulations for specific applications
- Understand science and technology behind it.

COURSE OUTCOMES:

At the successful completion of this course you (the student) should be able to:

- Understand different Paints and coatings Technology
- get introduction about various Classification of coatings, Mechanisms of film formation in surface coatings, Technology of solvent based architecture etc.
- Manufacture of paints, pigments resin and their modifications.
- Get knowledge about Industrial coatings which reduce maintenance and downtime and extended product life .
- Understand many benefits, including: Resistance to rust and corrosion, improving product functionality and aesthetics, electrical insulation etc.

SYLLABUS:

Unit 1: **(15 Hrs, 19 Marks)**

Paint: Introduction to paints and enamels. Constituents of paints. Chemistry of drying, semidrying and non-drying oils. Classification of varnishes and coatings, Lacquer formulation, thinners, extenders/fillers. Principles of paint formulation, examples of flat, semi gloss and gloss paints, flow diagram of paint manufacture. Introduction of paint-Wet paint, constituents of paints, classification of paints, applications of paints, dry film properties of paints-adhesion,

Hardness, toughness and durability, flexibility, loss of decorative properties due to Weathering, ease of repair and surface renovation-solvent resistance, Paint's dry-drying Without chemical reaction and drying by chemical reaction.

Unit 2: **(15 Hrs, 19 Marks)**

Pigments: Paint additives (wetting and dispersing agents, rheology modifiers, etc.) and solvents. Pigment properties - tinting strength, light fastness, bleeding characteristics, hiding power, refractive index, particle size, particle shape, specific gravity, chemical resistivity, and thermal stability, Classification of pigments, chemistry, properties and application of white pigments, examples yellow, red, metallic, black, blue, green, fluorescent, pearl pigments.

Unit 3: **(15 Hrs, 19 Marks)**

Manufacture of Paints, resins and Coating:

(A) Manufacture of Paints: Basics of Paint formulations, Principles, source of added value, production strategies, manufacturing process for varnishes/paints/coating powers, equipment for pigment dispersion– high speed disperser, and or bead mill, triple roll mill, ball mill, titrator. Methods of application of paints, failure of paint film – Mar Test, Anti-condensation test, Fire Resistance test disperser.

(B) Important Resins or Modifications of Resins for Paints and Coatings:

Epoxy Resins (BPA based resin, curing agents & flame-retardant epoxy resins). Manufacturing of alkyds, Introduction of alkyds, different components of it, emulsions and

Hard resins, filtration of resins, paints; Modification with rosin, maleic anhydride, acrylics,

Vinyls, imides etc, forming of hard resins, marking and labeling of packaged products.

Polyester resins - Unsaturated polyester resins. Modification of phenolics such as novolac-

Epoxy oil soluble and oil reactive Modification of amino resins (UF & MF) with alcohols and phenols.

Unit 4: **(15 Hrs, 19 Marks)**

(A) Manufacture of Powder Coatings, dry distempers, cement paints, oil-based distempers

And paints, other stiff paints, putties, etc

(B) Anti-fouling coatings, Paints for marine environments, vinyl paints.

(C) Automotive protection products, paints, finishing and refinishing, Electrodeposition

coatings, UV curable coatings.

(D) Metallic paints, Powder coatings, Coil coatings, Wood finishing, Strippable coatings,

lacquers.

(E) Solvent emission, recovery and disposal, environmental, health and safety issues

References Book:

1. Contemporary Polymer Chemistry, H.R. Allcock and F.W.Lampe.

2. Introduction to Polymer Science and Technology An SPE Textbook, H. S. Kaufman and J. J. Falcetta, John- Wiley and Sons, New York.

3. Introduction to Synthetic Polymers, I. M. Campbell, 1st Ed., Oxford Press (1994).

4. Polymer Chemistry : An Introduction, G. Challa, 1st Ed., Ellis Harwood (1993).

5. Advanced Polymer Chemistry : A Problem Solving Guide, Manas Chanda, MarcelDekker (2000), ISBN 0-8247- 0257-3. 13. An Introduction to Plastics, H. G. Elias, 1st Ed., John-Wiley (1993).

6. An Introduction to Polymer Science, H. G. Elias, 1st Ed. John Wiley (1997).

7. Polymers: Chemistry and Physics of Modern Materials, J. M. G. Cowie, 2nd Ed., Staaley Thornes Publ (1991).

8. Polymer Degradation and Stabilization, N. Grassie & G. Scott; Cambridge University Press.

9. Polymer Degradation, T. Kellen.

10. Synthesis of Polymers a Comprehensive Treatments, A. D. Schultzer; Wiley VCH (1999).

11. The Chemistry of Polymers, 2nd Ed., J. W. Nicholson, The Royal Society of Chemistry(1997), ISBN 0-85404-558-9.

12. Comprehensive Polymer Science Vol.4, 5, 6.

13. Handbook of Polymer Synthesis Marcel Dekker, INC. New York (1992).

14. Anionic Polymerization: Principles & Practical Applications, Marcel Dekker, INC. NewYork (1996).

15. Cationic Polymerization: Mechanism, Syntheses & Applications Ed. K. Matyjarzerski; Marcel Dekkar, Inc. New York (1996).

16. Macromolecular Design: Concept and Practice, Ed. M.K. MishraPolymers Frontiers International, Inc Hopewell Jet New York (1994).

17. Designed Polymers by Carbocationic Macromolecular Engineering Theory & PracticeJ.P.Kennedy & B.Ivan; Hanser(1991).

18. Ring Opening Polymerization Vol. 1, 2 & 3Ivin K.J., & Saegusa T., Elsevier Applied Science Publisher

	PunyashlokAhilyadeviHolkar Solapur University, Solapur **M.Sc.(Polymer Chemistry) Semester-III (Year- 2024-25)** **Vertical: DSE – 4A** **Course Code:2324406** **Course Name: Processing Technology and Polymer Properties**
***Teaching Scheme** **Lectures:04 Hours/week, 04 Credits**	***Examination Scheme** **UA:60 Marks** **CA: 40 Marks**

Course Preamble: Course gives information about differentProcessing Technologies of polymers and their Properties. The course also provide preview on designing polymer based materials. It will discuss polymers at various fronts.

COURSE OBJECTIVES:

- Establishing knowledge of Processing Technology and Polymer Properties
- Course deal with the study of basic nature of different polymers, polymer composites, and different manufacturing processes.
- It also provides rheological as well as mechanical properties of polymers.

COURSE OUTCOMES:

At the successful completion of this course you (the student) should be able to :

- Apply fundamental knowledge of polymer processing likeExtrusion, Injection Molding, Compression Molding etc. and study Effects of Processing.
- Get knowledge about different polymer molding technologies like Thermoforming, Calendaring, Rotational Molding, Transfer Molding, Transfer Molding, Processing of Reinforced Thermoplastics & Thermosets are studied.
- Understands the Rheology and the Mechanical Properties of Polymers.

SYLLABUS:

Unit 1: **(15 Hrs, 19 Marks)**

(A) Extrusion: General features of single screw extruder: Mechanism of flow, analysis of flow in extruder, general features of twin screw extruders and other techniques based on extruder – (Blow molding & Sheet making).

(B) Injection Molding: Introduction, details of the process, moulds, structural foam injection molding, sandwich molding, reaction injection molding (RIM), injection blow molding, injection molding of thermosets.

(C) Compression Molding: Introduction, principle, downstroke and upstroke compression presses, compression mold platens, molding materials, types of molds, advantages and disadvantages, troubleshooting.

(D) Effects of Processing: Microstructural changes, shrinkage & distortion, and residual stresses.

Unit 2: **(15 Hrs, 19 Marks)**

(A) Thermoforming: Introduction, description of process, applications, and analysis of thermoforming.

(B) Calendaring: Introduction, types of calendars and configurations, material used in calendaring and analysis of calendaring.

(C) Rotational Molding: Introduction, principle and description of process, material used, and applications.

(D) Transfer Molding: Introduction, description of process, advantages and disadvantages, comparison with compression moulding.

(E) Processing of Reinforced Thermoplastics & Thermosets: Manual Processing Methods, Semi-Automatic Processing Methods.

Unit 3: **(15 Hrs, 19 Marks)**

A. Processing of Fibers: Wet processing, dry processing, melt processing.

B. Methods for Polymer Coatings: Introduction, types of coatings, coating methods- roll coating, powder coating, spray coating, vacuum coating, Electrodeposition.

C**. Preparation of Polymer Composites (Conventional and Nanocomposites) :** General approaches of making nanocomposite

Unit 4: **(15 Hrs, 19 Marks)**

Rheology and the Mechanical Properties of Polymers: Introduction, rheological equation for state, fluids-ideal and Non-Newtonian, viscous flow, viscoelastic behavior, stress-relaxation, dynamic mechanical behavior, generalized Maxwell model, Kelvin-Vigot models, Mechanical spectra, effect of different factors on mechanical spectra. General behaviours of polymer melts, measurement of flow properties.

References Book :

1. Introduction to Physical Polymer Science, L. H. Sperling.

2. Polymer Processing Fundamentals, T. A. Ostwald.

3. Commercial Polymer Blends, L. A. Utracki.

4. Polymer Chemistry, M. G. Arora and M. Singh, (Amol Publ Pvt. Ltd. New Delhi110002).

5. Polymer Science, P. L. Nayak, Kalyani Publ.(2005), ISBN 81-272-1989-4.

6. Introductory Polymer Chemistry, G. S. Mishra, Wiley Eastern Ltd (1993).

7. Advanced Practical Organic Chemistry, 2nd Ed. J. Leonard, B. Lygo & G. Procter (2004), ISBN 0748740716.

8. Physical Chemistry of Macromolecules, D. D. Deshpande, Vishal Publ., Jalandhar (1985).

9. Physical Chemistry of Polymers, A. Tager, Mir Publ.

10. Polymer Characterization, E. Schroder, G. Muller and K. F. Arndt, Hanser Publishers, Munich.

11. Polymer Characterization: Physical Techniques, D. Campbell and J. R. White; Chapman &Hall, London (1989).

12. Polymer Melt Rheology, F. N. Cogswell.

13. Principles of Polymer Processing, R. T. Fenner.

14. Flow Properties of Polymer Melts, J. A. Brydson.

15. Plastics Recycling, J. L. Ehrig; Hanser Publ.(1989).

	PunyashlokAhilyadeviHolkar Solapur University, Solapur **M.Sc.(Polymer Chemistry) Semester-IV(Year- 2024-25)** **Vertical: DSE-4B** **Course Code: 2324406** **Course Name: Polymer Selected Topics in Polymers**
***Teaching Scheme** **Lectures:04 Hours/week, 04 Credits**	***Examination Scheme** **UA:60 Marks** **CA: 40 Marks**

Course Preamble: This course consists of four units. Unit I contain the Chemical Modification of Polymers, Polymer Nanotechnology, Cellulose modification, modification by hydrogenation, sulfochlorination and cross linking. The second unit consists of Polymer Supports for Organic Synthesis, Polymer Waste Management and Polymer for Sustainable Environment. The third unit contains different Natural and Synthetic rubber, Additives for rubber and final unit contain Electrical and Optical Properties of polymers.

COURSE OBJECTIVES:

1. To familiarize with the usage and importance of modification of wide variety of polymers. d
2. To learn about the different electrical and optical properties of polymers.
3. To understand environmental issues and waste management system.

COURSE OUTCOMES:

All the successful completion of this course you (the student) should be able to:

1. Isolate the key design features of a product which relate directly to the materials.
2. Improve mechanical properties, chemical resistance, surface modification, cross-linking, functional group introduction, grafting, hydrolysis and developing polymers etc.
3. Understand organic based polymers well as additives.
4. Apply knowledge for environmental problems through waste management system.
5. Study the nanotechnology related to polymers.
6. Get knowledge about electrical and optical properties of polymers.

SYLLABUS:.

Unit 1: **(15 Hrs, 19 Marks)**

(A) Chemical Modification of Polymers: Principles of polymer reaction. Cellulose modification, etherification and etherification of cellulose. PE modification: halogenations; sulfochlorination, grafting and radiation cross linking. Polystyrene modification: hydrogenation, suffocation and cross linking. Click chemistry approach.

(B) Polymer Nanotechnology: Nanotechnology: Importance of polymer nanoparticles, processing, characterization of polymer nanostructure, metal polymer nanocomposite synthesis, Polymer coated core shell nanopartcles, Importance of sub nanometer and micrometer sized organic and inorganic particles coated with polymer. Polystyrene capped gold nanoparticles -synthesis, gold nanoshells in blood immunoassay.

Unit 2: **(15 Hrs, 19 Marks)**

(A) Polymer Supports for Organic Synthesis: Polymer supported reagent and catalysts, Functionalization of Polymer, Functionalization of Monomer, and Comparison of the Two Approaches, Advantages of Polymer Reagents, Catalysts, and Substrates. Polymer Reagents, Polymer Catalysts and Polymer Substrates. Solid-Phase Synthesis of Polypeptides.

(B) Polymer Waste Management and Polymer 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 3: **(15 Hrs, 19 Marks)**

Rubber Chemistry and Technology

(A) Natural and Synthetic Rubber: Historical review, physical properties and chemistry of natural rubber, Natural Rubbermodification: chlorination, epoxidation, hydrogenation, cyclization and ebonite. Manufactureand physical properties of synthetic rubbers such as SBR, Nitrile, Butyl, EPDM andneoprene. Determination of crosslink density of vulcanization by swelling method.

(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 andmode of action is expected. Bio based additives, water-based formulation.

Unit 4: **(15 Hrs, 19 Marks)**

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

References Book :-

1. NMR of Polymers, F-Bovey and P. Miran, 1st Edn.; Academic Press (1996).

2. Polymer Spectroscopy, A. H. Faweett, 1st Edn.; John Wiley (1996).

3. NMR of Macromolecules; A Practical Approach, G. C. K. Roberts; 1st Edn. Oxford University Press (1993).

4. Introduction to Macromolecular Science,P.Munk, 1st Ed., John Wiley (1989).

5. Elements of Polymer Science and Engineering's: An Introductory Text and Reference for Engineers and Chemists, Rudin, 2nd Ed., Academic Press, (1998).

6. Textbook of Polymer Science, F. W. Billmeyer, Jr.

7. Principles of Polymer Chemistry, P. J. Flory.

8. Principles of Polymerization, G. Odian, John Wiley and Sons (1981).

9. Polymer Chemistry, B.Vollmert, Springer Verlag (1973).

10. Structure Property Relationship in Polymers, R. B. Seymour and C. E. Carraher Jr.

11. Fundamental Principles of Polymeric Materials, S. L. Rosen.

12. Principles of Polymer Engineering, N. G. Mecrum, C. P. Buckley, C. B. Bucknall.

13. Thermal Characterization of Polymeric Materials; E.A. Turi, Academic Press.

14. Thermal Methods in Polymer Analysis; Shallaby S.W. (Ed.), he Franklin Inst. Press Philadalphia.

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **MSc (Polymer Chemistry) Semester-IV** **Vertical : RP** **Course Code:2324403** **Course Name: Research Project**
***Teaching Scheme** **Practicals:08 Hours/week, 04 Credits**	***Examination Scheme** **UA:60 Marks** **CA: 40 Marks**

Course Preamble:

- The research project for M. Sc. Polymer Chemistry is introduced to get familiarize with literature survey of the work done in the field of interest
- It is expected that project should provide hands on training to the students on various instruments.
- They should learn independent working on a short research project.
- In Semester III, there is a Research Project of 4 credits. Students have to carry out project either at college laboratory or university laboratory or in any recognized R & D laboratory (Public/Private/Government) or Industry or Institute of national repute across the country under the guidance of scientist or a post-graduate faculty member.

List of Recommended Books.

1. Polymer Chemistry – M. P. Stevens, 2nd Ed., Oxford University Press, 1990.

2. Polymer Synthesis Theory and Practice, D. Braun, H. Cherdrown and H. RitterSpringer, 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 Ed., 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 Ed., John-Wiley (1993).

14. An Introduction to Polymer Science, H. G. Elias, 1st Ed. John Wiley (1997).

15. Polymers: Chemistry and Physics of Modern Materials, J. M. G. Cowie, 2nd Ed., Staaley Thornes Publ (1991).

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **MSc (Polymer Chemistry) Semester-IV** **Vertical : DSC - 7P** **Course Code: 2324404** **Course Name: Polymer Synthesis** **Vertical : DSE – 4A P, 4B P** **Course Code: 2324307, 2324308** **Course Name: Polymer Modification,PolymerAnalysis**
***Teaching Scheme** **Practicals:04 Hours/week, 02 Credits**	***Examination Scheme** **UA:30 Marks** **CA: 20 Marks**

Course Preamble:

The practical course is designed in such a way that students will get an experiential learning. The practical's are set on the core papers as well as elective courses. The Practicals are on the basis of Synthesis, analysis and modification polymers. These practical's are further divided into short and long experiments. A Polymer chemistry practical course aims to provide students with hands-on experience in the laboratory, reinforcing theoretical concepts and developing essential laboratory skills.

Course Objectives

- **Experimental Techniques:**
  - Master fundamental laboratory techniques such as weighing, measuring, titration, filtration, and crystallization, Polymerization. Develop proficiency in using laboratory equipment, including balances, glassware, burners, and heating devices.
- **Observation and Data Collection:**
  - Synthesis and Analysis of polymers and record accurate observations, measurements and data.
  - Develop skills in data analysis, including graphing, calculations, and interpretation of results.
- **Problem-Solving and Critical Thinking:**
  - Apply theoretical knowledge to solve practical problems and design experiments.
  - Develop critical thinking skills to analyze experimental results and draw conclusions.
- **Laboratory Safety:**
  - Understand and adhere to laboratory safety procedures and regulations.
  - Handle chemicals and equipment safely and responsibly.

Course Outcomes:

- In-depth training on laboratory solution preparations on all concentration scales
- Training on laboratory safety and lab ethics in scientific work
- Training on planning, design and execution of experiments.
- Training on scientific literature search, defining the objective of the work, research skills, data representation in tabular and graphical form etc.
- Training on experimental verification of fundamental theories, comparison of data with literature and scientific discussion on any deviation of data from expected theoretical values or reported literature.
- Training on different techniques needed to characterize the polymers.
- Application of theoretical and practical knowledge for research training through mandatory research/industrial projects.

Practicals:-

A. Polymer Synthesis:

7. Free radicals (Redox) solution polymerization of acryl amide.
8. Solution polymerization of Methyl Methacrylate (MMA).
9. Suspension Polymerization of Vinyl Acetate.
10. Solution Polymerization of Vinyl acetate in Benzene.
11. Hydrolysis of Poly (vinyl acetate) to Poly (vinyl alcohol).
12. Precipitation Polymerization of Acrylonitrile.
13. Preparation of Nylon 6,6
14. Preparation of Urea Formaldehyde Resin
15. Preparation of Phenol Formaldehyde Resin
16. Preparation of Melamine Formaldehyde Resin
17. Synthesis of glyptal resin

B. Polymer Analysis:

4. Analyse the given Plasticizer and determine its Purity.
5. Estimation of Molecular Weight of Polyethylene glycol by end group analysis.
6. Estimation of Vinyl monomer Concentration by the Bromination method.

D. Polymer Modification:

5. Preparation of Cellulose acetate
6. Preparation of Cellophanes
7. Preparation of Hexamethylene melamide

8. Preparation of Sodium Carboxyl methyl cellulose (CMC).

* **Any other relevant experiment may be added.**

Reference Book:

Polymer Chemistry-Practical Approach in Chemistry, F. J. Davis, Oxford University Press, Oxford, 2004.

2. Experiments in Polymer Science, D. G. Hundiwale, V. D. Athawale, U. R. Kapadi, V. V. Gite, New Age International Pvt. Ltd., New Delhi, 2009.

3. Polymer Science – V. R. Gowarikar, N. V. Viswanathan, Jayadev Shreedhar, New Age International Pvt. Ltd., New Delhi, 1997.

4. Principles of Polymerisation, P. Bahadur, N. V. Sastry, Narosa Publishing House, New Delhi, 2002.

Nature of question paper (M. Sc. II)

Polymer Chemistry Semester- III,

Year- 20245-25

Time: 2 ½ hours Maximum Marks: 60

Instructions:

1. All questions are compulsory
2. All questions carry equal marks.
3. Figures to the right indicate full marks.
4. Use of log tables and calculators is allowed.

Q 1. A) Choose correct alternative **Marks 8 (1 x 8)**

Sub-questions (i) to (viii)

B) Fill in the blanks **Marks 4 (1 x 4)**

Sub questions (i) to (iv)

Q 2. Answer the following (any six) **Marks 12 (2 x 6)**

Sub-questions (a) to (h)

Q 3. Answer the following (any three) **Marks 12 (3 x 4)**

Sub-questions (a) to (d)

Q 4. Answer the following (any two) **Marks 12 (6 x 2)**

Sub-questions (a) to (c)

Q 5. Answer the following (any two) **Marks 12 (6 x 2)**

Sub-questions (a) to (c)

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.