

University of Mumbai



No. AAMS_UGS/ICC/2024-25/151

CIRCULAR:-

Attention of all the Principals of the Affiliated Colleges, Directors of the Recognized Institutions and the Head, University Departments is invited to this office Circular No. AAMS_UGS/ICC/2023-24/23 dated 08th September, 2023 relating to the NEP UG & PG Syllabus.

They are hereby informed that the recommendations made by the Board of Deans at its meeting held on 3rd September, 2024 vide item No. 6.9(N) have been accepted by the Hon'ble Vice Chancellor as per the power confirmed upon him under section 12(7) of the Maharashtra Public Universities Act, 2016 and that in accordance therewith syllabus for **M.Sc. (Industrial Polymer Chemistry) (Sem – III & IV) for University Department of Chemistry (Autonomous)** as per appendix (NEP 2020) with effect from the academic year 2024-25.

(The Circular is available on the University's website www.mu.ac.in).

MUMBAI – 400 032
21st September, 2024


(Dr. Prasad Karande)
REGISTRAR

To

All the Principals of the Affiliated Colleges, Directors of the Recognized Institutions and the Head, University Departments.

BOD 6.9(N) 03/09/2024

Copy forwarded with Compliments for information to:-

- 1) The Chairman, Board of Deans,
- 2) The Dean, Faculty of Science,
- 3) The Chairman, **Board of Studies in Chemistry**
- 4) The Director, Board of Examinations and Evaluation,
- 5) The Director, Department of Students Development,
- 6) The Director, Department of Information & Communication Technology,
- 7) The Director, Centre for Distance and Online Education (CDOE) Vidyanagari,
- 8) The Deputy Registrar, Admission, Enrolment, Eligibility & Migration Department (AEM),

Copy forwarded for information and necessary action to :-	
1	The Deputy Registrar, (Admissions, Enrolment, Eligibility and Migration Dept)(AEM), dr@eligi.mu.ac.in
2	The Deputy Registrar, Result unit, Vidyanagari drresults@exam.mu.ac.in
3	The Deputy Registrar, Marks and Certificate Unit,. Vidyanagari dr.verification@mu.ac.in
4	The Deputy Registrar, Appointment Unit, Vidyanagari dr.appointment@exam.mu.ac.in
5	The Deputy Registrar, CAP Unit, Vidyanagari cap.exam@mu.ac.in
6	The Deputy Registrar, College Affiliations & Development Department (CAD), deputyregistrar.uni@gmail.com
7	The Deputy Registrar, PRO, Fort, (Publication Section), Pro@mu.ac.in
8	The Deputy Registrar, Executive Authorities Section (EA) eau120@fort.mu.ac.in He is requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to the above circular.
9	The Deputy Registrar, Research Administration & Promotion Cell (RAPC), rapc@mu.ac.in
10	The Deputy Registrar, Academic Appointments & Quality Assurance (AAQA) dy.registrar.tau.fort.mu.ac.in ar.tau@fort.mu.ac.in
11	The Deputy Registrar, College Teachers Approval Unit (CTA), concolsection@gmail.com
12	The Deputy Registrars, Finance & Accounts Section, fort draccounts@fort.mu.ac.in
13	The Deputy Registrar, Election Section, Fort drelection@election.mu.ac.in
14	The Assistant Registrar, Administrative Sub-Campus Thane, thanesubcampus@mu.ac.in
15	The Assistant Registrar, School of Engg. & Applied Sciences, Kalyan, ar.seask@mu.ac.in
16	The Assistant Registrar, Ratnagiri Sub-centre, Ratnagiri, ratnagirisubcentar@gmail.com
17	The Director, Centre for Distance and Online Education (CDOE), Vidyanagari, director@idol.mu.ac.in
18	Director, Innovation, Incubation and Linkages, Dr. Sachin Laddha pinkumanno@gmail.com
19	Director, Department of Lifelong Learning and Extension (DLLE), dlleuniversityofmumbai@gmail.com

Copy for information :-	
1	P.A to Hon'ble Vice-Chancellor, vice-chancellor@mu.ac.in
2	P.A to Pro-Vice-Chancellor pvc@fort.mu.ac.in
3	P.A to Registrar, registrar@fort.mu.ac.in
4	P.A to all Deans of all Faculties
5	P.A to Finance & Account Officers, (F & A.O), camu@accounts.mu.ac.in

To,

1	The Chairman, Board of Deans pvc@fort.mu.ac.in
2	Faculty of Humanities, Dean 1. Prof.Anil Singh Dranilsingh129@gmail.com Associate Dean 2. Dr.Suchitra Naik Naiksuchitra27@gmail.com 3.Prof.Manisha Karne mkarne@economics.mu.ac.in
	Faculty of Commerce & Management, Dean 1. Dr.Kavita Laghate kavitalaghate@jbims.mu.ac.in Associate Dean 2. Dr.Ravikant Balkrishna Sangurde Ravikant.s.@somaiya.edu 3. Prin.Kishori Bhagat kishoribhagat@rediffmail.com

	Faculty of Science & Technology Dean 1. Prof. Shivram Garje ssgarje@chem.mu.ac.in Associate Dean 2. Dr. Madhav R. Rajwade Madhavr64@gmail.com 3. Prin. Deven Shah sir.deven@gmail.com
	Faculty of Inter-Disciplinary Studies, Dean 1. Dr. Anil K. Singh aksingh@trcl.org.in Associate Dean 2. Prin. Chadrashekhhar Ashok Chakradeo cachakradeo@gmail.com
3	Chairman, Board of Studies,
4	The Director, Board of Examinations and Evaluation, dboee@exam.mu.ac.in
5	The Director, Board of Students Development, dsd@mu.ac.in DSW directr@dsw.mu.ac.in
6	The Director, Department of Information & Communication Technology, director.dict@mu.ac.in

BOD – 3/9/2024

12(7) of M.P.U.A. 2016

Item No. 6.9 (N)

As Per NEP 2020

University of Mumbai



Title of the P.G. Program

M.Sc. (Industrial Polymer Chemistry)

Syllabus for

Semester – Sem.- III & IV

Department of Chemistry (Autonomous)

**Ref: GR dated 16th May, 2023 for Credit
Structure of PG**

(With effect from the academic year 2024-25)



(As per NEP 2020)

Sr. No.	Heading	Particulars
1	Title of program O: _____	M.Sc. (Industrial Polymer Chemistry)
2	Scheme of Examination R: _____	NEP 50% Internal 50% External, Semester End Examination Individual Passing in Internal and External Examination
3	Standards of Passing R: _____	40%
4	Credit Structure R: <u>SPA – 40 B</u>	Attached herewith
5	Semesters	Sem. III & IV
6	Program Academic Level	6.5
7	Pattern	Semester
8	Status	New
9	To be implemented from Academic Year	2024-25

Sign of the
Offg. Associate Dean
Dr. Madhav R. Rajwade
Faculty of Science &
Technology

Sign of the
Offg. Dean
Prof. Shivram S. Garje
Faculty of Science &
Technology

Preamble

1) Introduction

This program is designed to provide a comprehensive and in-depth understanding of the fascinating world of Industrial Polymer Chemistry. Through a rigorous academic curriculum and hands-on research experience, we aim to nurture the intellectual curiosity and scientific acumen of our students, preparing them for successful careers in various sectors of the chemical sciences. The M.Sc. (Industrial Polymer Chemistry) course is structured to equip students with a strong theoretical foundation, practical skills, and critical thinking abilities necessary to address the challenges and opportunities in the diverse fields of chemistry. Our esteemed faculty members are experts in their respective fields, with a passion for both teaching and research. They are committed to providing a nurturing learning environment, encouraging open discussions, and fostering collaborative research endeavors. Through their mentorship, students will have the opportunity to engage in cutting-edge research projects, pushing the boundaries of scientific knowledge and contributing to the advancement of the chemical sciences.

We envision our M.Sc. (Industrial Polymer Chemistry) postgraduates act as catalysts for positive change, equipped to drive innovation, shape industries, and address societal challenges through their expertise in chemistry. Whether your passion lies in research, industry, education, or beyond, our program aims to provide the knowledge and skills necessary to excel in your chosen path.

2) Aims and Objectives

The aims and objectives of M.Sc. (Industrial Polymer Chemistry) course are designed to provide students with a well-rounded and advanced education in the field of Analytical chemistry. These goals focus on equipping students with a deep understanding of chemical principles, fostering research and analytical skills, and preparing them for successful careers in various sectors of the chemical sciences.

The M.Sc. (Industrial Polymer Chemistry) course aims to produce skilled and knowledgeable professionals who can contribute to scientific research, industrial innovation, and the betterment of society through their expertise in Industrial polymer chemistry.

3) Learning Outcomes

The learning outcomes of an M.Sc. (Industrial Polymer Chemistry) course are designed to equip students with a comprehensive and advanced understanding of the field of chemistry. These learning outcomes reflect the knowledge, skills, and competencies that students are expected to gain upon successful completion of the program.

- 4) **Any other point (if any) :** The skills and knowledge acquired during this master's program will make the students well-equipped for diverse roles.

- 5) **Credit Structure of the M.Sc. (Industrial Polymer Chemistry) (Sem I, II, III & IV) (Table as per परीक्षा-1 with sign of HOD and Dean)**

R _____

Post Graduate Program: M.Sc. (Industrial Polymer Chemistry)

परिशि

फि षट-1

1)

Year	Level	Sem	Major					RM	OJT/ FP	RP	Cum. Cr.	Degree
			Mandatory			Electives						
1	6.0	Sem I	3*4+ 2=14			4		4		-	22	PG Diploma (after 3 Years Degree)
			Physical Chemistry-I (112016150111)	TH	4	Analytical Chemistry-I (112016150511) (OR) Applied Industrial Chemistry-I (112016150512)	Research Methodology (112016150611)					
			Inorganic Chemistry-I (112016150211)	TH	4							
			Organic Chemistry-I (112016150311)	TH	4							
			Chemistry Practical-I (112016150411)	PR	2							
		3*4+ 2=14			4			-	4	-	22	
		Sem II	Physical Chemistry-II (11201625071 1)	T H	4	Analytical Chemistry-II (11201625111 1) (OR) Applied Industrial Chemistry-II (11201625111 2)	(1120 16251 211)					
			Inorganic Chemistry-II (11201625081 1)	T H	4							
			Organic Chemistry-II (11201625091 1)	T H	4							
			Chemistry Practical-II (CHEM 510)/ 112016251011	P R	2							
Cum. Cr. For PG Diploma			28			8		4	4		44	
Exit Option: PG Diploma (44 credits) after Three Year UG Degree												

R: SPA – 40 B

Year	Level	Sem (2yr)	Major				RM	OJT/FP	RP	Cum. Cr.	Degree
2	6.5	Sem III	3*4+ 2=14			4	-	-	(CHEM 686) 4	22	PG Degree after 3- yr UG or PG Degree after 4- yr UG
			Basics of Polymer, Rubber and Additives (CHEM 681)	TH	4	Biopolymers and Biocomposites (CHEM 68511) OR Advanced Topics in Rubber Chemistry-I (CHEM 68512)					
			Rheology and Processing Rubbers (CHEM 682)	TH	4						
			Testing of Rubber, allied materials and composites (CHEM 683)	TH	4						
			Industrial Polymer Chemistry Practical (CHEM 684)	PR	2						
		Sem IV	3*4=12			4	-	-	(CHEM 691) 6	22	
			Design and Development of Rubber Products (CHEM 687)	TH	4	Polymer Nano Composites (CHEM 69011) (OR) Advanced Topics in Rubber Chemistry-II (CHEM 69012)					
			Latex Science and Adhesives (CHEM 688)	TH	4						
			Tyre Science and Technology (CHEM 689)	TH	4						
		Cum. Cr. For 1 Yr PG Degree			26			8			
Cum. Cr. For 2 Yr PG Degree			54			16	4	4	10	88	

Sign of HOD**Sign of Dean,**

Prof. Shivram S. Garje
Head of Department,
Department of Chemistry,
University of Mumbai

Prof. Shivram S. Garje
Dean, Science and Technology
University of Mumbai

**Syllabus for
M.Sc. (Industrial Polymer Chemistry)
(Sem. III & IV)**

PROGRAMME SPECIFIC OUTCOME (PSOs)

- 1.** Gain knowledge of the advanced concepts in the branch of chemistry, identify and accomplish a solution to problems encountered in the field of research and analysis.
- 2.** Apply the basic knowledge of chemistry to perform various tasks assigned to them at the workplace in industry and academia to meet the global standards.
- 3.** Deduce qualitative and quantitative information of chemical compounds using advanced spectroscopic methods which can further be analysed using practical skills inculcated in them during the course.
- 4.** Imbibe the attitude as well as aptitude of a scientific approach along with analytical reasoning with respect to the novel techniques actually implemented in the Industry.
- 5.** Use the subject knowledge, communication and ICT skills to become an effective team leader/team member in the interdisciplinary fields.
- 6.** Understand, Manage and contribute to solve basic societal issues and environmental concerns ethically based on principles of scientific knowledge gained.
- 7.** Exhibit professional work ethics and norms of scientific development.

Semester – III

PROGRAM(s): M.Sc.-II		SEMESTER: III		
Course: Paper-I		Course Code: CHEM 681 Course Title:- Basics of Polymer, Rubber and Additives		
Teaching Scheme				Evaluation Scheme
Lectures (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks- 50)	Semester End Examination (Marks- 50)
04	–	04	50	50
Learning Objectives: 1. To enable learners to have comprehensive knowledge and understanding of basic structure and properties of polymers. 2. To apply the basic knowledge of polymer chemistry to perform various tasks assigned to them at the workplace in industry and academia to meet the job requirements as per global standards. 3. Accomplish a solution to problems encountered in the field of research.				
Course Outcomes: - The learners will be able to articulate the fundamental concepts of polymer and rubber chemistry. - The learners will be able to identify and select appropriate materials and additives for specific applications. - The learners will demonstrate the ability to apply knowledge of polymers, rubbers, and additives in practical scenarios. - The learners will critically analyze the role of additives in the functionality and efficiency of polymer and rubber products. - The learners will evaluate the suitability of different polymers and rubbers for various industrial applications. The learners will present case studies and research findings related to polymer and rubber technologies.				

Semester – III

Paper -I

Course Code: CHEM 681

Course Title:- Basics of Polymer, Rubber and Additives

Unit I POLYMERS & POLYMERIZATION TECHNIQUES [15L]

Polymers: monomer, oligomer and polymer, Average Molecular Weight, Molecular weight, Distribution & Poly dispersity Index, classification of polymers, structure of polymer. Types of polymerization.

Polymerization Techniques: Mass Polymerization, Bulk Polymerization, Solution Polymerization, Emulsion Polymerization, Suspension Polymerization, Mechanisms with explanation. Characteristics, Relative advantages and disadvantages.

Classification of Polymers: Natural and synthetic polymers, Biopolymers, thermoplastic, thermosets, Elastomers, Fibers etc.

Structure Property Relationship in Polymers: Structure of polymers, amorphous, semi-crystalline and crystalline states in polymers, glass transition, melting and crystallization temperature. Effect of structure on the chemical, mechanical, electrical and optical properties of polymers.

Unit II GENERAL PURPOSE RUBBER [15L]

Natural Rubber (NR): Origin – Natural Rubber Latex, tapping, processing, properties and applications – Conversion of Latex into dry rubber – Properties of dry rubber – Classification based on technical specifications – Modifications of Natural Rubber

Styrene-Butadiene Rubber (SBR): Introduction, polymerization, types of SBR, structure & property variation in Emulsion SBRs and Solution SBRs. Compounding, Processing, Applications.

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

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

Unit III SPECIAL PURPOSE RUBBER [15L]

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

Rubber blends: miscible and immiscible blends,

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

Unit IV NON-RUBBER ADDITIVES [15L]

Part A: Vulcanizing ingredients & other additives: Vulcanizing ingredients & their sequence of mixing: Activators and Accelerators: mechanisms of action. Other cure systems based on metal oxides, peroxides, etc. retarders, inhibitors anti-reversion agents.

Part B: Fillers

Carbon black-Its preparation, structure, properties and their effect on rubber properties
Silica fillers & coupling agents, Other fillers: Clay, Calcium carbonate, titania etc. Nano-fillers:

Reinforcement by filler: Reinforcement, Factors influencing elastomers reinforcement, fillers characteristics, main effects of fillers on vulcanizate properties, Influence of fillers characteristics on the cross linking process, Filler incorporation, the role of bound rubber, reinforcement and crosslink density.

Part C: Processing aids & other additives: Processing aids, plasticizers, process additives, release agents, Other additives like colourants, blowing agents, factice, Fire Retardants, Antistatic Agents, Deodorants and Reodorants, Biocides and Fungicides etc.

Antidegradants: Introduction, Autoxidation of Hydrocarbon Polymers, Amine & Phenolic Antioxidants & other types, Antizonants, Prevention of Ozone Attack with the use of waxes & saturated polymer for Ozone Protection.

References:

1. F. W. Billmeyer Jr., Text Book of Polymer Science, Ed. Wiley-Interscience, 1984.
2. V. T. Gowariker, N. V. Viswanathan, and J. Sreedar, Polymer Science, 1988.
3. M. Morton, Rubber Technology, Chapman Hall, 1995.
4. J. Brydson, Rubber Chemistry, Butterworths, 1978
5. B. Kothandaraman, Rubber Materials, Ane Books, 2008.
6. I. Franta, Elastomers and Rubber Compounding materials, Elsevier, 1989.
7. B. Kothandaraman, Rubber Materials, Ane Books, 2008.

PROGRAM(s): M.Sc.-II	SEMESTER: III			
Course: Paper-II	Course Code: CHEM 682 Course Title:- Rheology and Processing Rubbers			
Teaching Scheme				Evaluation Scheme
Lectures (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks- 50)	Semester End Examination (Marks- 50)
04	–	04	50	50
Learning Objectives: - To develop the ability to explain the fundamental concepts of rheology and its significance in the processing of rubbers. - To understand the influence of processing parameters on the properties and quality of rubber products. - To understand the principles behind common rheological tests (e.g., viscosity, elasticity, creep, and stress relaxation).				
Course outcomes: - The learners will be able to describe the fundamental principles of rheology and their application to rubber materials. - The learners will be able to perform and interpret rheological tests on rubber materials. - The learners will be able to formulate rubber compounds to achieve desired rheological properties and product performance. - The learners will be able to critically analyze the relationship between processing parameters and the rheological behavior of rubber. - The learners will effectively communicate technical information related to the rheology and processing of rubbers.				

Semester – III

Paper -II

Course Code: CHEM 682

Course Title:- Rheology and Processing Rubbers

Unit I RHEOLOGY OF RUBBERS

[12L]

Definition of Rheology, Rheological Perspective, The importance of nonlinearity, Solids and liquids, Components of rheological research: Rheometer, Constitutive equations, Complex flows of elastic liquids.

Unit II COMPOUNDING & MIXING TECHNIQUES

[12L]

Rubber mixing mechanism, mixing machinery - Open mill mixing – Internal mixers – Continuous mixers – Factors affecting mixing – Flow behaviour of rubber compound, processibility test, Latex compounding and mixing. Troubleshooting.

Unit III POSTCOMPOUNDING PROCESSING

[12L]

Calendaring: Sheetting –Skim coating – Fractioning – Topping – Doubling – Profiling – Spreading – Roll configurations – Control of thickness. Extrusion; Ram type – Screw type – L/D ratio and its influence – Hot & cold feed extruders – Pin barrel extruder – Twin screw extruder – Criteria for machine selection. Troubleshooting.

Unit IV MOLDING & VULCANIZING TECHNIQUES

[12L]

Molding: Mold design, Compression, transfer and injection moulding – Blanks & pre-heating techniques, preparation of surfaces for bonding. **Curing:** Autoclaves, Hot air chambers, curing of built up articles, continuous vulcanization, L.C.M. (Liquid Curing Media), Fluidized Bed, microwave curing. Hand building and forming equipment for tank, pipe lining, roller covering. Troubleshooting.

Unit IV FINISHING OF RUBBER PRODUCTS

[12L]

Equipment's for flash and spew removal – Cryogenic techniques – Hand trimming – roller trim, buffing, tumbling, punching, grinding, shot blasting, painting, lacquering – Guards, Trip devices, Photoelectric and pressure sensitive devices – Maintenance of guards.

References:

1. Dr. B. R. Gupta, Rheology of Elastomers.
2. H. A. Barnes, J. F. Hutton and K. Walters, An Introduction to Rheology, Elsevier, 1989.
3. Rubber Processing, James L. White, Hanser Publishers, 1995.
4. C. M. Blow and C. Hepburn, Rubber Technology and manufacture, Butterworths, 1982.
5. C. W. Evans, Practical Rubber Compounding and processing, Applied Science, Publishers, London, 1981.

6. J. L. White, Rubber Processing Technology Materials, Principles, Hanser Publication, New York, 1995.
7. Kleemann, Weber, Elastomer Processing, Hanser, 2005.

PROGRAM(s): M.Sc.-II			SEMESTER: III
			Course Code: 683 Course Title:- Testing of Rubber, allied materials and composites
Teaching Scheme			Evaluation Scheme
Lectures (Hours per week)	Credit	Continuous Assessment (CA) (Marks- 50)	Semester End Examination (Marks- 50)
04	04	50	50
Course Objectives: 1. To understand importance of testing in the development and application of rubber, allied materials, and composites. 2. To identify and describe the physical, chemical, and mechanical properties of rubber, allied materials, and composites. 3. To enable learners to understand various testing methods for rubber and composites (e.g., tensile, compression, hardness, fatigue, thermal analysis). 4. To understand the role of testing in product certification and compliance with industry standards.			
Course Learning Outcomes. After completing the course students will be able to: 1. articulate the importance and principles of testing rubber, allied materials, and composites. 2. demonstrate proficiency in various testing techniques for rubber and composites. 3. apply testing methods to evaluate material properties and ensure product quality. 4. evaluate the effectiveness of different testing methods in quality control and assurance. 5. present case studies and research findings related to the testing of rubber, allied materials, and composites.			

Semester – III

Paper -III

Course Code: CHEM 683

Course Title:- Testing of Rubber, allied materials and composites

Unit I PRINCIPLES OF TESTING & RAW MATERIAL TESTING [15L]

Principles of Testing, Standards and specification, Nomenclature- ISO and other standards, Laboratory Management System as per ISO/IEC 17025:2005 and Quality Management System as per ISO : 9001:2015.

Molecular weight distribution using GPC, Analysis of antioxidant, process oil and other additives by using GC GCMS, UV-Vis spectrophotometer, ICP-OES and DSC. Polymer identification by FTIR, Ash Content, Melting point, Moisture content and Specific gravity

Unit II TESTING OF RAW RUBBER & UN-VULCANIZED RUBBER COMPOUND

[15L]

Viscosity Characterization – Brookfield Viscosity, Mooney viscosity,

Mass, Density, Dimensions Compression plastimeter, plasticity retention index, rotation plastimeters, extrusion rheometer, Scorch and cure rate: oscillating disk rheometer, moving die rheometer, rubber process analyzer etc.

Unit III TESTING OF VULCANIZATE [15L]

Mechanical Properties –Different types of Hardness,(Shore A, Shore D, IRHD and micro hardness) tear, tensile, compression, application of test data, abrasion resistance, Shear, Creep & Stress relaxation, Resilience, Aging and uniaxial, biaxial compression test.

Thermal Analysis: Instrumentation, Polymer Identification, Compositional analysis, volatile matter, Rubber, Polymer blends, C-black & ash estimation using Thermal Analysis (TGA). Glass transition, Heat capacity, Thermal history of polymers, State of cure studies by using DSC and Thermal Mechanical Analysis (TMA)

Unit IV PROCESS & QUALITY CONTROL [15L]

Effect of environment – Oxygen, heat, ozone and swelling media

Fatigue – Flex cracking and cut growth – Heat buildup **Dynamic mechanical testing of rubbers**—Storage modulus, loss modulus, Tan delta, Natural frequency, transmittance and damping factor.

Testing of rubber products like hoses, gaskets, automotive tubes, bearings, Testing of conveyor belts, V-belts and Mounts.

References:

1. Standard - ISO / IEC 17025:2005
2. Standard – ISO 9001:2015

3. C. D. Craver and T. Provder, Polymer Characterization, ACS Advances in chemistry Series, Volume 227, 1990
4. J. S. Dick, Rubber Technology Compounding and testing for Performance, Hanser Publisher, 2001.

PROGRAM(s): M.Sc.-II		SEMESTER: III		
Course: Practical		Course Code: CHEM 684 Course Title:- Industrial Polymer Chemistry Practical		
Teaching Scheme				Evaluation Scheme
Practical (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks- 25)	Semester End Examination (Marks- 25)
16	NA	02	25	25
Learning Objectives: 1. To understand the basic principles of polymer chemistry, including polymerization mechanisms, kinetics, and thermodynamics. 2. To develop proficiency in laboratory techniques used in polymer synthesis and characterization. 3. To learn different methods of polymer synthesis (e.g., bulk, solution, emulsion, and suspension polymerization). 4. To understand various techniques to characterize polymers (e.g., spectroscopy, chromatography, thermal analysis, mechanical testing) 5. To understand the principles of polymer processing techniques (e.g., extrusion, molding, casting). 6. To apply knowledge of polymer chemistry to solve real-world industrial problems.				
Course Outcomes: 1. The learners will understand the fundamental principles and industrial applications of polymer chemistry. 2. The learners will demonstrate proficiency in synthesizing and characterizing polymers using standard laboratory techniques. 3. The learners will apply their knowledge to design and conduct experiments related to polymer synthesis and processing. 4. The learners will critically analyze experimental data to understand the properties and behavior of polymers. 5. The learners will effectively communicate their findings through written reports and oral presentations. 6. The learners will use characterization data to determine the suitability of polymers for specific industrial applications.				

Semester – III

Paper -IV

Course Code: CHEM 684

Course Title:- Industrial Polymer Chemistry Practical

INDUSTRIAL POLYMER CHEMISTRY PRACTICAL-I

1. Preparation of Phenol formaldehyde resin – novolak and resol / polysulfide rubber
2. Determination of: acid value / hydroxyl value of given polymer sample
3. Determination of saponification value of given oil
4. Estimation of total alkalinity of the latex
5. Viscosity measurement by Brookfield viscometer
6. Molecular weight determination of polymer by GPC
7. Determination of volatile matter, dirt, ash content in Rubber from Natural sources
8. Estimation of Cu, Fe and Mn in rubber by ICP
9. Rubber identification pyrolysis and spot test by specific reagents (ASTM solution)
10. TGA of different rubber
 11. DSC analysis of Rubber Compounds
 12. Mixing behaviour of NR on two roll mill / carbon black filled NR / carbon black filled SBR / carbon black filled SBR & NR blend / carbon black filled EPDM / carbon black filled NBR
13. Extrusion characteristics of a filled rubber mix- NR Ex / SBR / NBR / EPDM
 14. Calendaring of rubber mix

INDUSTRIAL POLYMER CHEMISTRY PRACTICAL-II

1. Identification and classification of natural rubber by using FTIR, Mooney, and other chemical methods.
2. Identification and classification of synthetic rubbers by using burning test, FTIR, Mooney, and other chemical methods.
3. Identification and classification of different type of carbon black
 - a. DBP absorption
 - b. IAN
 - c. Surface area Calculation
4. Identification and classification of rubber compounding materials, namely, **Zinc oxide / Stearic acid / Sulfur / Antioxidants / Accelerators / Processing oils**
5. Evaluation of tyre tread compound by using abrasion resistance index, heat build-up and DMA.
6. Evaluation of properties of seal & gasket rubber compound
7. Tyre testing by Endurance, rolling resistance, plunger energy, bead unseat etc.
8. Testing of: LPG Hose, Pressure cooker rubber gasket / Hose testing / Mount / Conveyor Belt / Condom / Tube

9. Design & development of : Tyre tread material / Hose cover / Conveyor belt cover / Gasket compound / footwear compound / latex dipped products / mounts / rubber mats / door profiles / tube compound
10. Curing Process of Rubber Compound- NR filled / SBR filled / NBR filled / EPDM filled / BR filled
11. Curing Process of Rubber Compound- by transfer molding technique
12. Curing Process of Rubber Compound- by injection molding technique of metal to rubber bonded products
13. Curing Process of Rubber mounts / Rubber Gaskets / Rubber Seals / Rubber Gauntlets

Elective course - I

PROGRAM(s): M.Sc.-II			SEMESTER: III
			Course Code: CHEM 68511 Course Title: - Biopolymers and Biocomposites
Teaching Scheme			Evaluation Scheme
Lectures (Hours per week)	Credit	Continuous Assessment (CA) (Marks- 50)	Semester End Examination (Marks- 50)
04	04	50	50
Course Outcomes: At the end of the Course, 1. To understand the basic principles and definitions of biopolymers and biocomposites. 2. To understand the physical, chemical, and mechanical properties of biopolymers and biocomposites. 3. To understand the applications of biopolymers and biocomposites in various industries (e.g., packaging, biomedical, automotive). 4. To understand the environmental benefits and challenges associated with biopolymers and biocomposites. 5. To understand the concepts of biodegradability, life cycle assessment, and sustainability.			
Course Learning Outcomes. 1. The learners will understand the fundamental principles and classifications of biopolymers and biocomposites. 2. The learners will be familiar with the sources, synthesis methods, and applications of biopolymers and biocomposites. 3. The learners will demonstrate proficiency in synthesizing and characterizing biopolymers and biocomposites using standard laboratory techniques. 4. The learners will use characterization data to evaluate the suitability of biopolymers and biocomposites for specific applications. 5. The learners will critically analyze experimental data to understand the properties and behavior of biopolymers and biocomposites. 6. The learners will present case studies and research projects related to biopolymers and biocomposites, highlighting their applications and sustainability.			

Semester – III

Paper -V

Course Code: CHEM 68411

Course Title:- Biopolymers and Biocomposites

Unit I BIOPOLYMERS & BIODEGRADATION [15L]

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

Biodegradation: Mechanism of biodegradation (polyesters, polycarbonates, polyvinyl alcohol, polyurethanes and polyether's) factors influencing biodegradation. Types of biodegradable polymers – properties and application.

Unit II CHARACTERIZATION & TESTING FOR BIODEGRADABILITY [15L]

Test methods and standards for bio-degradable plastics, Criteria used in evaluation of biodegradable plastics, Description of current test methods – Scanning test for ready biodegradability, Test for inherent biodegradability, Test for simulation studies, Other methods for assessing polymer biodegradability.

Unit III BIOCOMPOSITES [15L]

Definition- classification- natural bio, fibre and nano fillers as reinforcement, biodegradable/ bio-based resins as matrices. Properties of biocomposites. Applications in automobile & buildings.

Unit IV APPLICATIONS OF BIOPOLYMERS [15L]

Biopolymer Films, Biodegradable mulching, Advantages and Disadvantages, Chemical sensors – Biosensors, Functionalized Biopolymer Coatings and Films, Applications of biopolymers in horticulture Food Packaging, Functional Properties, safety and Environmental aspects, Shelf life, Films and coatings in Food Applications, Materials for edible films and coatings, Biopolymer coatings for paper and paperboard, Bio-nanocomposite films and coatings

References:

- 1) R. Smith, Biodegradable polymers for industrial applications, Woodhead Publishing Ltd, CRC Press, 2005.
- 2) A. J. Domb, J. Kost and D. M. Wiseman, Handbook of Biodegradable polymers, Harwood Academic Publishers, 1997.
- 3) R. P. Wool, X. S. Sun, Bio-Based Polymers and Composites, Elsevier, 2005.
- 4) A. S. Singha and V. K. Thakur, Green Polymer Materials, Studium Press, 2012.

- 5) A. K. Mohanty, M. Misra and L. T. Drzal, Natural Fibers, Bio Polymers and Bio Composites, CRC Press, 2005.

Elective course - II

PROGRAM(s): M.Sc.-II			SEMESTER: III
			Course Code: CHEM 68512 Course Title:- Advanced Topics in Rubber Chemistry-I Circular Economy for End-of-Life Tyres
Teaching Scheme			Evaluation Scheme
Lectures (Hours per week)	Credit	Continuous Assessment (CA) (Marks- 50)	Semester End Examination (Marks- 50)
04	04	50	50
Course Outcomes: At the end of the Course, 1. To understand the principles and importance of circular economy as applied to end-of-life tyres. 2. To gain knowledge of the lifecycle of tyres from production to end-of-life stages, including environmental impacts and regulations. 3. Aware of different energy recovery methods from end-of-life tyres and their environmental implications. 4. To design sustainable practices for the management of end-of-life tyres, considering environmental and economic factors.			
Course Learning Outcomes. 1. To understand the concept of circular economy and its application in managing end-of-life tyres. 2. To apply recycling and reuse techniques to minimize waste and maximize resource recovery from end-of-life tyres. 3. To evaluate the economic viability and sustainability of various practices in end-of-life tyre management. 4. To apply the knowledge gained about innovative solutions for sustainable tyre design and end-of-life management practices. 5. To understand global trends and innovations in circular economy approaches to sustainable tyre management.			

Semester – III

Paper -VI

Course Code: CHEM 68412

Course Title: - Advanced Topics in Rubber Chemistry-I: Circular Economy for End-of-Life Tyres

Unit 1: Introduction to Circular Economy and End-of-Life Tyres (12 L)

- Overview of Circular Economy: Principles, importance, and global perspective.
- End-of-Life Tyres (ELT): Definition, challenges, and environmental impact.
- Lifecycle of Tyres: From production to end-of-life.
- Legislation and Policies: Key international and national regulations on ELT management.
- Case Studies: Successful implementations of circular economy principles in tyre industry.

Unit 2: Collection and Sorting of End-of-Life Tyres (12 L)

- Collection Systems: Types of collection systems, logistics, and infrastructure.
- Sorting and Segregation: Techniques for sorting tyres based on condition and type.
- Stakeholder Roles: Responsibilities of manufacturers, consumers, and waste management companies.
- Economic Aspects: Cost-benefit analysis of collection and sorting systems.
- Technological Innovations: Advances in tyre collection and sorting technologies.

Unit 3: Recycling and Reuse of End-of-Life Tyres (12 L)

- Recycling Methods: Mechanical, thermal, and chemical recycling processes.
- Material Recovery: Techniques for recovering valuable materials from ELTs.
- Reuse Applications: Innovative ways to repurpose tyres in construction, sports, and other industries.
- Environmental Benefits: Reduction in carbon footprint and resource conservation through recycling and reuse.
- Case Studies: Examples of successful recycling and reuse projects.

Unit 4: Energy Recovery from End-of-Life Tyres (12 Marks)

- Energy Recovery Techniques: Pyrolysis, gasification, and incineration.
- Energy Output and Efficiency: Comparison of different energy recovery methods.
- Environmental Impact: Emissions, pollution control, and environmental regulations.
- Economic Viability: Cost analysis and market potential of energy recovery from ELTs.
- Innovations and Future Trends: Emerging technologies and future prospects in energy recovery.

Unit 5: Sustainable Practices and Future Directions (12 Marks)

- Sustainable Design: Designing tyres for a circular economy.
- Extended Producer Responsibility (EPR): Role of manufacturers in ELT management.
- Consumer Awareness and Engagement: Strategies to promote sustainable tyre usage among consumers.
- Research and Development: Current trends and future research directions in ELT management.
- Global Perspectives: Comparison of ELT management practices in different countries and regions.

Research Project

PROGRAM(s): M.Sc.-II			SEMESTER: III
			Course Code: CHEM 686 Course Title:- Research Project
Teaching Scheme			Evaluation Scheme
Lectures (Hours per week)	Credit	Continuous Assessment (CA) (Marks- 50)	Semester End Examination (Marks- 50)
04	04	50	50
Course Outcomes: At the end of the Course, 1. To enable the student to be able to extract information from journals and digital resources. 2. Understanding tools to analyse the data, writing and presenting scientific papers. 3. Safe working procedure and ethical handling of chemicals. 4. Describe research, identification of research problems, and preparation of proposals. 5. Practice ethics in all the domains of research. 6. Analyze the results using mathematical and statistical tools.			
Course Learning Outcomes. 1. To create awareness and understanding the terms like intellectual property, patents, copyright, industrial designs, trademarks, geographical indications etc. 2. To know trade secrets, IP infringement issues, economic value of intellectual property and study of various related international agreements. 3. To explore cheminformatics to facilitate molecular modeling and structure elucidations. 4. To apply the knowledge gained about various polymer chemistry principles, techniques and tools in selection of polymers, additives, processing conditions etc.			

Semester – III

Paper -VII

Course Code: CHEM 686

Course title: Research Project

Guidelines for the conducting the research project.

1. Each student will perform project separately.
2. **Students should devote enough time to their project work (08 hours each week).**
3. Select a topic that is relevant to your interests and social relevance considering the constraints of available resources and time.
4. Consult with faculty members or mentors to select a relevant research topic that has the potential to contribute to the discipline of chemistry.
5. Literature survey for the research project is suggested to be from Journals indexed in globally recognised databases including recently published research papers.
6. Participation in national and international conferences and other project competitions is encouraged.
7. Project report must be written systematically and presented in bound form.
8. Continuous evaluation of the research project will be done by the internal examiner or mentor.
9. Student must do presentation of the research work in external exam.

Evaluation of Research Project Semester - III

Internal Continuous Assessment: 50% (50 Marks)

Sr. No	Criteria for evaluation	Marks
1.	Attendance (DPR to be maintained)	10
2.	Literature Survey	25
3.	Scheme/ Outline of project / Methodology	15
Total		50

Semester End External Examination: 50% (50 Marks)

Sr. No	Criteria for evaluation	Marks
1.	Presentation	15
2.	Dissertation	20

3.	Viva	15
Total		50

Semester – IV

PROGRAM(s): M.Sc.-II		SEMESTER: IV		
Course: Paper-I		Course Code: CHEM 687 Course Title:- Design and Development of Rubber Products		
Teaching Scheme				Evaluation Scheme
Lectures (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks- 50)	Semester End Examination (Marks- 50)
04	–	04	50	50
Learning Objectives: 1. To enable learners to understand the basic principles of rubber chemistry and material science. 2. To enable learners to understand about the considerations and constraints in rubber product design, including mechanical properties, durability, and environmental resistance. 3. To understand the impact of processing conditions on the properties and performance of rubber products. 4. To understand about prototyping, scaling up production, and quality control in rubber product development.				
Course Outcomes: 1. The learners will understand the fundamental principles of rubber chemistry and material science relevant to product design. 2. The learners will demonstrate proficiency in designing rubber products considering material properties and application requirements. 3. The learners will use processing and testing techniques to ensure the quality and performance of rubber products. 4. The learners will critically analyze the design and development process to identify areas for improvement. 5. The learners will present case studies and research projects related to rubber product design and development.				

Semester – IV

Paper -I

Course Code: CHEM 687

Course Title:- Design and Development of Rubber Products

Unit I FORMULATION DESIGN OF RUBBER COMPOUNDS [15L]

Basics of compounding, Approach for compounding, Selection of Rubbers, Fillers, Curing agents and Special additives in Rubber Compounding. Rubber compounds feasibility for static and dynamic application, Rubber compounds for general purpose, oil resistant, heat resistant, fire resistant and weather resistance purposes.

Unit II DESIGN & DEVELOPMENT OF TYRES [15L]

Different components of tyres and their compounding, Tyre materials & Tyre processing techniques.

Unit III CONVEYOR BELT TECHNOLOGY [15L]

Different types of conveyor belts, Mixing, Compounding and Calendaring, Building, Curing and Testing, Finishing and Packaging. **V-belt—Building**

Unit IV PRODUCT DEVELOPMENT OF HOSES [15L]

Different kind of hoses, Extrusion of cover, Reinforcement, curing by autoclave.

References:

1. Setright J. K., Automobile Tyres, Champan & Hall, 1972.
2. The Pneumatic Tire, (Ed) A N Gent & J D Walter, The University of Akron, August. 2005, published by NHTSA, DOT, USA
3. Elastomers: Criteria for Engineering Design, C Hepburn & R J W Reynolds, Applied Science Publishers, London, 1979.
4. Khairi Nagdi, Rubber as an Engineering Material: Guideline for Uses, Hanser Publishers, 1993.

PROGRAM(s): M.Sc.-II	SEMESTER: IV			
Course: Paper-II	Course Code: CHEM 688 Course Title:- Latex Science and Adhesives			
Teaching Scheme				Evaluation Scheme
Lectures (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks- 50)	Semester End Examination (Marks- 50)
04	–	04	50	50
Learning Objectives: 1. To understand the basic principles and chemistry of latex materials and adhesives. 2. To learn about the physical, chemical, and mechanical properties of latex materials. 3. To understand the formulation and compounding of latex products for specific applications. 4. To understand the principles of adhesion and the factors affecting adhesive performance.				
Course outcomes: 1. The learner will demonstrate proficiency in synthesizing and characterizing latex materials and adhesives using standard laboratory techniques. 2. The learner will apply their knowledge to design and develop latex materials and adhesive formulations. 3. The learner will critically analyze experimental data to understand the properties and behavior of latex materials and adhesives. 4. The learner will present case studies and research projects related to latex science and adhesive technology, highlighting their applications and innovations.				

Semester – IV

Paper -II

Course Code: CHEM 688

Course Title:- Latex Science and Adhesives

Unit I LATEX SCIENCE [15L]

Definition of Latex, classification, Latex particle size and distribution, stability and destabilization of latices, Comparison between latices and polymer solution. Characteristic and processing of natural rubber latex.

Unit II LATEX APPLICATION [15L]

Latex dipped products, latex foam rubber, latex thread, latex and textile based rubber products, latex based surface coating, latex and paper.

Unit III RUBBER BASED ADHESIVES [15L]

Natural rubber adhesive, butyl rubber and polyisobutylene, nitrile rubber adhesive, styrene butadiene rubber adhesive, thermoplastic rubber in adhesive, carboxylic polymers in adhesive, neoprene based solvent and latex adhesive, polysulfide sealant and adhesives

Unit IV RESIN BASED REACTIVE ADHESIVES [15L]

Phenolics, epoxies, acrylics, anaerobics, cyanoacrylates – Uses of adhesives in civil engineering, automobile, aerospace, electrical & electronic industries.

References:

1. D. C. Blackley, High Polymer Latices, Vol 1 and 2, Maclaren & Sons, 1966.
2. R. F. Mausser, The Vanderbilt Latex Hand book, 3rd Edn.
3. R. Waterman, R. F. Mausser & E. E. Miller, Vanderbilt Latex Book on Process and Compounding Ingredients, R T Vanderbilt Publishers.
4. K. O. Calvert, Polymer Latex and Applications, 1985.
5. I. Skiest (Ed), Hand book of Adhesives, Van Nostrand Reinhold, 1990.
6. Shields, Hand Book of Adhesives, Butterworths, 1984.

PROGRAM(s): M.Sc.-II			SEMESTER: IV
Paper III			Course Code: 689 Course Title:- Tyre Science and Technology
Teaching Scheme			Evaluation Scheme
Lectures (Hours per week)	Credit	Continuous Assessment (CA) (Marks- 50)	Semester End Examination (Marks- 50)
04	04	50	50
Course Objectives: 1. To enable learners to understand the materials used in tyre construction, including different types of rubber and reinforcements. 2. To understand the basic principles of tyre design and function. 3. To enable learners to understand the key components of a tyre, including tread, sidewall, beads, and carcass. 4. To understand the methods used to test tyre performance, including traction, durability, rolling resistance, and wear. 5. 5. To understand the current trends and innovations in tyre technology, including advancements in materials, design, and manufacturing processes.			
Course Learning Outcomes. After completing the course students will be able to: 1. Understand the principles of sustainable tyre design and the use of eco-friendly materials. 2. The learners will be familiar with the various materials and additives used in tyre manufacturing and their properties. 3. apply testing and characterization techniques to evaluate the performance and quality of tyres. 4. effectively communicate their design concepts and development processes through reports and presentations.			

Semester – IV

Paper -III

Course Code: CHEM 689

Course Title:- Tyre Science and Technology

Unit I TYRE STRUCTURE [15L]

A historical introduction on the design and development of tyres of various kinds and type the current status of tyre industry in India and its future prospects, tyre sizing and marking on the tyres, different types of tyres bias-belted tyre, tube and tubeless tyre, their basic functions and performance comparisons. Different components of a tyre, its geometry, basic functions. Functions of a pneumatic tyre-load carrying, vibration and noise reduction, tyre function as a spring, contribution to driving control and road adhesion, the tyre friction contribution to driving control, steering control and self aligning torque.

Unit II TYRE CARCASS AND BUILDING [15L]

Manufacturing techniques of various tyres like two wheeler and car tyres, truck tyres, OTR, farm tyres, aircraft tyres. Principles of designing formulations for various rubber components. Tyre reinforcement materials (Textile, steel, glass etc.). Criteria of selection, different styles and construction, textile treatment. Tyre mould design, green tyre design principles, methods of building green tyres for bias, bias belted, radial and tubeless tyres, green tyre treatments. Tyre curing methods, post cure inflation, quality control tests. Tyre related products, their design and manufacturing techniques, tubes, valves/flaps, bladders. Different types, their features and operation of tyre building machines, bead winding machine, wire/glass processing machines, bias cutters, curing presses.

Unit III : Tyre Properties [15L]

Tyre wear, rubber friction and sliding mechanism, various factors affecting friction and sliding. Tyre stresses and deformation, tyre noise, mechanism of noise generation, effect of tread pattern, vehicle speed etc. on Tyre wear, rubber friction and sliding mechanism, various factors affecting friction and sliding. Tyre stresses and deformation, tyre noise, mechanism of noise generation, effect of tread pattern, vehicle speed etc. on

Unit IV TESTING OF TYRE [15L]

Measurement of tyre properties, dimension and size-static and loaded. Tyre construction analysis, endurance test, wheel and plunger tests, traction, noise measurements. Force and moment characteristics, cornering coefficient, aligning torque coefficient, load sensitivity and load transfer sensitivity. Rolling resistance, non uniformity, dimensional variations, force variations, radial force variation, lateral force variation, conicity and plysteer. Type, balance, mileage, evaluations. Tyre flaws and separations. X-ray holography etc. Foot print pressure distribution. BIS standards for tyres, tubes and flaps.

References:

1. Tyre Science&Technology (Journal oftheTyreSociety) Akron,Ohio.
2. Tyre Technology 'Tom French', Adam Higher, New York.
3. Tyre Mechanics & Testing (Sponsored Course, Feb. '83) Roorke....
4. Mechanics of Pneumatic Tyres, Samuel C Lark, US Department of Transportation Washington. .
5. (a) Year Book, (b) Engineering Design Informations, The Tyre & Rim Association.
6. Tyre, Valve & Rim data, ITTAC, New York.
7. LJK Setright. "Automobile Tyres". Chapman & Hall, London.
8. Tyre Technology, F.J.Kovac, GOODYEAR Tyre and Rubber Com- pany, USA.

Elective course - I

PROGRAM(s): M.Sc.-II			SEMESTER: IV
			Course Code: CHEM 69011 Course Title: - Polymer Nano Composites
Teaching Scheme			Evaluation Scheme
Lectures (Hours per week)	Credit	Continuous Assessment (CA) (Marks- 50)	Semester End Examination (Marks- 50)
04	04	50	50
Course Outcomes: At the end of the Course, 1. To enable the student to be able to understand the basic principles and definitions of nanocomposites. 2. Understanding how nanoparticles influence the properties of the polymer matrix. 3. To understand the various methods for the synthesis and fabrication of polymer nanocomposites (e.g., in-situ polymerization, melt compounding, solution blending). 4. To understand the factors influencing the dispersion and distribution of nanoparticles within the polymer matrix. 5. To explore the applications of polymer nanocomposites in various industries (e.g., automotive, aerospace, electronics, biomedical). 6. To understand the principles of sustainable design and the use of eco-friendly materials in nanocomposites.			
Course Learning Outcomes. 1. The learners will understand the fundamental principles of polymer nanocomposites and the role of nanoparticles in enhancing material properties 2. The learners will demonstrate proficiency in synthesizing and characterizing polymer nanocomposites using standard laboratory techniques 3. To explore characterization data to evaluate the performance and quality of polymer nanocomposites. 4. To apply their knowledge to develop and optimize polymer nanocomposites for specific applications. 5. The learners will critically analyze experimental data to understand the properties and behavior of polymer nanocomposites.			

Semester – IV

Elective -I

Course Code: CHEM 69011

Course Title:- Polymer Nano Composites

Unit I COMPOSITES [15L]

Characteristics, advantages, and need of composites –Polymer composite materials, classification and theory of composite materials; Polymer matrices - thermoplastics and thermosetting plastics; Fiber reinforcement of elastomers - short and long fiber composites – Other additives

Unit II NANOMATERIALS USED IN POLYMERS [15L]

Nanofillers in bulk polymers - overview of potential nanostructured fillers - types - nanoparticles, nanofibers, nanotubes, nanosheets; surface features and layers and its modification. Techniques used to characterize nanostructured materials –XRD, AFM, etc.

Unit III CARBON NANOTUBES & THEIR APPLICATIONS [15L]

Structure of carbon nanotubes, processing methods for nanotube based polymer nanocomposites, nanotube alignment, characterization, properties and applications,

Unit VI PREPARATION & APPLICATION OF POLYMER NANO COMPOSITES [15L]

Preparations of polymer nanocomposites - melt blending, solution blending, latex coagulation, in-situ polymerization, characterization, properties and application.

Polymers in nanoelectronics, Magnetic polymer nanocomposites, Wear resisting polymer nanocomposites, Packaging, Bio-medical, surface coatings, etc.

References:

- 1) Yiu-Wing Mai and Zhong-Zhen Yu, Polymer Nanocomposites, Woodhead Publishing Limited, 2006.
- 2) K. Friedrich, S. Fakirov and Zhong Zhang, Polymer Composites from Nano to Macro, Springer 2005.
- 3) C. N. R. Rao, A. Muller, and A. K. Cheetham, The chemistry of Nanomaterials, Vol 1 & Vol. 2, Wiley-VCH, 2005.
- 4) J. H. Kao, Polymer Nanocomposites, McGraw-Hill Publishers, 2006.

Elective course - II

PROGRAM(s): M.Sc.-II			SEMESTER: IV
			Course Code: CHEM 69012 Course Title:- Advanced Topics in Rubber Chemistry-II: Sustainability in Rubber & Rubber Chemicals
Teaching Scheme			Evaluation Scheme
Lectures (Hours per week)	Credit	Continuous Assessment (CA) (Marks- 50)	Semester End Examination (Marks- 50)
04	04	50	50
Course Outcomes: At the end of the Course, 1. To understand the various chemicals used in rubber manufacturing and their roles. 2. Understanding sustainability and explain its importance in the context of the rubber industry. 3. To identify biobased and non-toxic alternatives to conventional rubber chemicals. 4. To perform lifecycle assessments to evaluate the environmental impact of rubber products. 5. To understand emerging technologies and trends in sustainable rubber production.			
Course Learning Outcomes. 1. To demonstrate a comprehensive understanding of the types of rubber and the chemicals used in their production. 2. Utilize green chemistry principles to identify and implement safer, more sustainable alternatives in rubber manufacturing 3. Identify emerging trends and innovations in sustainable rubber production. 4. Develop a global perspective on sustainability challenges and solutions in the rubber industry. 5. Understand the importance of industry partnerships and collaboration in promoting sustainability.			

Semester – IV

Elective - II

Course Code: CHEM 69012

Course Title:- Advanced Topics in Rubber Chemistry-II: Sustainability in Rubber & Rubber Chemicals

Unit 1: Introduction to Rubber and Rubber Chemicals (12 L)

- **Types of Rubber:** Natural vs. synthetic rubber, properties, and applications.
- **Rubber Chemicals:** Overview of chemicals used in rubber manufacturing (vulcanization agents, antioxidants, accelerators, etc.).
- **Sustainability Concepts:** Definition, importance, and key principles.
- **Environmental Impact:** Impact of rubber production and rubber chemicals on the environment.
- **Regulations and Standards:** Key international and national regulations concerning rubber and rubber chemicals.

Unit 2: Sustainable Rubber Production (12 L)

- **Sustainable Sourcing:** Sustainable practices in natural rubber harvesting and synthetic rubber production.
- **Energy Efficiency:** Techniques to reduce energy consumption in rubber production.
- **Waste Management:** Strategies for reducing, reusing, and recycling waste in rubber manufacturing.
- **Eco-friendly Technologies:** Innovations in sustainable rubber production.
- **Case Studies:** Examples of companies implementing sustainable rubber production practices.

Unit 3: Green Chemistry in Rubber Production (12 L)

- **Principles of Green Chemistry:** Application of green chemistry in rubber manufacturing.
- **Biobased Chemicals:** Use of renewable resources in the production of rubber chemicals.
- **Non-toxic Alternatives:** Development and use of safer chemicals in rubber production.
- **Process Optimization:** Techniques for minimizing the environmental impact of chemical processes.
- **Case Studies:** Successful implementation of green chemistry in the rubber industry.

Unit 4: Lifecycle Analysis and Circular Economy (12 L)

- **Lifecycle Assessment (LCA):** Methodology for assessing the environmental impact of rubber products throughout their lifecycle.
- **Circular Economy Principles:** Application of circular economy in rubber production and usage.
- **End-of-Life Management:** Recycling and disposal of rubber products.

- **Product Design for Sustainability:** Designing rubber products for longevity and recyclability.
- **Case Studies:** Examples of lifecycle analysis and circular economy in the rubber industry.

Unit 5: Future Trends and Innovations in Sustainable Rubber (12 L)

- **Emerging Technologies:** New technologies and innovations in sustainable rubber production.
- **Sustainable Product Development:** Trends in the development of sustainable rubber products.
- **Research and Development:** Current research directions in sustainable rubber and rubber chemicals.
- **Industry Collaboration:** Role of industry partnerships in promoting sustainability.
- **Global Perspectives:** Comparison of sustainable rubber practices in different countries and regions.

Research Project

PROGRAM(s): M.Sc.-II			SEMESTER: IV
			Course Code: CHEM 691 Course Title:- Research Project
Teaching Scheme			Evaluation Scheme
Lectures (Hours per week)	Credit	Continuous Assessment (CA) (Marks- 50)	Semester End Examination (Marks- 50)
06	06		
Course Outcomes: At the end of the Course, 1. To enable the student to be able to extract information from journals and digital resources. 2. Understanding tools to analyse the data, writing and presenting scientific papers. 3. Safe working procedure and ethical handling of chemicals. 4. Describe research, identification of research problems, and preparation of proposals. 5. Practice ethics in all the domains of research. 6. Analyze the results using mathematical and statistical tools.			
Course Learning Outcomes. 1. To create awareness and understanding the terms like intellectual property, patents, copyright, industrial designs, trademarks, geographical indications etc. 2. To know trade secrets, IP infringement issues, economic value of intellectual property and study of various related international agreements. 3. To explore cheminformatics to facilitate molecular modeling and structure elucidations. 4. To apply the knowledge gained about various polymer chemistry principles, techniques and tools in selection of polymers, additives, processing conditions etc.			

Semester – IV

Course Code: CHEM 691

Course: Research Project

Guidelines:

1. Students are to work on research project individually and should be the continuity of the research project selected in the semester.
2. Research Project is of 6 credits which equals to project working hours of 180.
3. The title of the research project should be descriptive, appropriate and concise as possible.
4. A detailed description of Chemicals, equipment, experimental procedures should be mentioned in the project report.
5. The project report should be well-structured, should present an accurate and complete account of the research performed with data, discussion and conclusions.
6. The publications of earlier work should be cited.
7. Record of attendance and continuous performance of the student is monitored by the mentor.
8. At the end of the semester, the student has to present the project report in a bound form for external evaluation.
9. Participation in national and international conferences and other project competitions is encouraged.

Evaluation of Research Project Semester - IV

A) CONTINUOUS ASSESSMENT - 50%

Sr. No.	Evaluation Type	Marks
1	Attendance (DPR* to be maintained)	20
2	Experimental/ Interpretation	35
3	Conclusion/ output	20
Total		75

DPR: Daily Progress Report

B) SEMESTER ENDEXAMINATION - 50%

Sr.No	Evaluation Type	Marks
1	Presentation	20
2	Dissertation	30
3	Viva	25
Total		75

Theory Examination Pattern:
A. Internal Assessment- 50%- 50 Marks per paper

Sr.No.	Evaluation Type	Marks
1	Written Objective/Short Answer Examination	25
2	Assignment/ Case study/ field visit report/ presentation/ project	25
	Total	50

External Examination- 50%-

Paper Pattern:

Question	Options	Marks
Q.1	2 out of 4	10
Q.2	2 out of 4	10
Q.3	2 out of 4	10
Q.4	2 out of 4	10
Q.5	4 out of 4	10
	TOTAL	50

Semester End Practical Examination:

Particulars	Continuous assessment (CA)	Semester end external examination
Laboratory work	15	15
Viva	05	05
Journal	05	05
Total	25	25

PRACTICAL BOOK/JOURNAL

The students are required to perform 75% of the Practical for the journal to be duly certified. The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

Letter Grades and Grade Points

Semester GPA/ Program CGPA/Semester	% Marks	Letter Grade Result
9.00-10.00	90.0-100.0	O (Outstanding)
8.00<9.00	80.0<90.0	A+ (Excellent)
7.00<8.00	70.0<80.0	A (Very Good)
6.00<7.00	60.0<70.0	B+ (Good)
5.50<6.00	55.0<60.0	B (Above Average)
5.00<5.50	50.0<55.0	C (Average)
4.00<5.00	40.0<50.0	P (Pass)
Below 4.00		F (Fail)
Ab (Absent)		Absent

Sign of HOD

Prof. Shivram S. Garje
Head of Department,
Department of Chemistry,
University of Mumbai

Sign of Dean,

Prof. Shivram S. Garje
Dean, Science and Technology
University of Mumbai

Team for Creation of Syllabus

Name	College Name	Sign
Dr. K. Rajkumar	IRMRI, Thane	
Dr. Bharat Kapgate	IRMRI, Thane	
Dr. Debdipta Basu	IRMRI, Thane	

Sign of HOD

Sign of Dean,

Prof. Shivram S. Garje
Head of Department,
Department of Chemistry,
University of Mumbai

Prof. Shivram S. Garje
Dean, Science and Technology
University of Mumbai

Justification for M.Sc. (Industrial Polymer Chemistry)

1.	The necessity for starting the course:	M.Sc. (Industrial Polymer Chemistry) course is necessary for those who seek to deepen their knowledge, specialize in a particular area, and pursue advanced careers in research, industry, academia, or other chemistry-related fields. It offers numerous opportunities for personal and professional growth, enabling you to make a positive impact on the world through scientific exploration and discovery.
2.	Whether the UGC has recommended the course:	Yes
3.	Whether all the courses have commenced from the academic year 2023-24	The course has already commenced from the academic year from 2016 and in the academic year 2022-23 it is restructured under NEP 2020
4.	The courses started by the University are self-financed, whether adequate number of eligible permanent faculties are available?:	This course is a self-financed collaborative course with IRMRA Thane. Currently, twelve permanent faculty members are working in the department out of 26 sanctioned faculty positions. The second year (semesters III and IV) is run by scientist / Faculty members from IRMRA, Thane at their campus
5.	To give details regarding the duration of the Course and is it possible to compress the course?:	The duration of the program is two years (4 semesters). It is not possible to compress the course. Under NEP 2020 students have option of exit at the end of the first year with PG Diploma in Industrial Polymer Chemistry.
6.	The intake capacity of each course and no. of admissions given in the current academic year:	The intake capacity of the program is 15. Number of admission for the academic year 2022-23 is 15.
7.	Opportunities of Employability / Employment available after undertaking these courses:	M.Sc. (Industrial Polymer Chemistry) students have a wide range of employment opportunities across various sectors. The skills and knowledge acquired during their master's program make them well-equipped for diverse roles. Some of the common areas where M.Sc. (Industrial Polymer Chemistry) students can find employment include; Research and Development (R&D), Pharmaceutical Industry, Chemical Manufacturing, Environmental and Analytical Chemistry, Quality Assurance and

		Control, Materials Science and Nanotechnology, Teaching and Academia, Healthcare and Clinical Research etc. The key to employability for M.Sc. (Industrial Polymer Chemistry) students is to build a strong resume through internships, research projects, and networking. Additionally, staying updated with the latest advancements in the field and continuously improving their skills can enhance their competitiveness in the job market.
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Sign of HOD

Sign of Dean,

Prof. Shivram S. Garje
Head of Department,
Department of Chemistry,
University of Mumbai

Prof. Shivram S. Garje
Dean, Science and Technology
University of Mumbai