Delhi Technological University

Department of Applied Chemistry

Program: M.Tech. by Research in "Chemical Engineering/ Polymer Technology"

Semester-I														
Group	S. No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
	1.	MSR501	Research and publication ethics	UCC	-	0	0	0	-	-	50	50	0	18
	2	MSR503	Research methodology	UCC	4	4	0	0	25	-	25	50	0	
	3	RPTE 505	Polymer Chemistry	DCC	4	3	0	2	15	25	20	40	0	
	4	RPTE 507	Polymer Processing	DCC	4	3	0	2	15	25	20	40	0	
	5	MSR509	Dissertation-1	DCC	6			6		50			50	

Semester-II														
Group	S. No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
	1.	RPTE 502	Polymer Structure and Properties	DCC	4	3	0	2	15	25	20	40	0	18
	2	RPTE 504	Polymer Testing & Characterization	DCC	4	3	0	2	15	25	20	40	0	
	3	MSR506	Dissertation-2	DCC	6	0	0	6		50			50	
	4	RPTE 510	Elective-1	DEC/GEC	4	3	1/0	0/2	15	25	20	40	0	
	5	MSR 508	MS(R) Project -1	DEC/GEC	4	4/3	0	0/2	25/15	-/25	25/20	50/40	0	

Semester-III														
Group	S. No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group A	1	MSR601	MS(R) Project -2	DEC/ GEC	4	4/ 3	0	0/ 2	25/ 15	-/25	25/ 20	50/ 40	0	16
	2	MSR 603	Dissertation - 3	DCC	12	0	0	12	-	40/ 50	-	-	60/ 50	

Semester-IV														
Group	S. No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group A	1	MSR602	Final Dissertation	DCC	24	0	0	24	-	-	-	-	100	24

Detailed Syllabus

Polymer Chemistry	
Teaching Scheme	L-T-P: 3-0-2

Course Outcome
After completing this course, students will be able to • Elaborate on step-growth and chain polymerization with respect to mechanism and kinetics. • Explain the general reaction course for ring-opening, cycloaddition, and coordination polymerization • Compare and value the homogenous, heterogenous, and interfacial polymerization techniques. • Evaluate copolymer composition and predict copolymerization behavior considering different parameters of copolymerization. • Develop sustainable polymers using new monomers

Syllabus Content:
Unit 1: Introduction- Nomenclature, classification, general characteristics of polymers, ring-opening polymerization, coordination polymerization, and cyclopolymerization.
Unit 2: Step-Growth Polymerization- General characteristics & chemistry of condensation polymerization, Ring vs Chain formation, Requirement of high conversion & high molecular weight polymer, step copolymerization, polymerization kinetics: the concept of equal reactivity of functional group, non-linearity in step growth polymerization, step growth polymerization other than poly-esterification, catalyzed vs uncatalyzed, kinetics analysis of polymerization of A-A with B-B' and non-stoichiometric polymerization
Unit 3: Chain growth polymerization- General characteristics & chemistry of chain growth polymerization, Ionic vs radical polymerization, nature of radical chain polymerization, the effect of substituents, constitutional isomerism: experimental evidence and synthesis; Initiator and initiation systems, initiator efficiency, types of radical initiation; kinetic expression for the rate of initiation and polymerization
Unit 4: Copolymerization- General considerations, types of copolymers, significance of copolymerization, kinetic equation, copolymerization behavior for alternate, random, block, graft copolymer
Unit 5: Polymerization techniques- solution, emulsion, bulk, suspension
Unit 6: Purification techniques- Solvent-Nonsolvent extraction, isolation, centrifugation

References:
➢ Textbook of Polymer Science, F.W. Billmeyer, John Wiley, 2008
➢ Polymer Science, V.R. Gowarikar, New Age International, 2016
➢ Polymer Chemistry, M.P. Stevens, Oxford University Press,1999
➢ Principle of Polymerization, G. Odian, Wiley, 2004

Polymer Structure and Properties	
Teaching Scheme	L-T-P: 3-0-2

Course Outcome
After completing this course, students will be able to • Predict polymer properties such as mechanical, rheological, thermal based on their structure. • Acquire in-depth knowledge of the molecular weight of the polymer and its relation with mechanical properties • Analyze the structure of polymers using modern analytical techniques and able to explain the data.

Syllabus Content:
Unit 1: Polymer molecular weight and its importance, molecular weight and its distribution method of determining different molecular weights, number average, weight average, viscosity average, z-average molecular weights, and polydispersity index and its significance.
Unit 2: Polymer Structure analysis, configuration, the conformation of polymers, structure, and properties of amorphous, semi-crystalline, and cross-linked polymers, crystal morphologies: unit cell structure, extended chain crystals, chain folding, lamellae, and spherules
Unit 3: Thermal properties of polymers, glass transition temperature (Tg), melting temperature (Tm), softening temperature (Ts), degradation temperature, flow temperature, tack temperature, flex at lower temperature, factors affecting the Tg and Tm of polymers, thermal analysis of polymer by dilatometer, TGA, DSC, DTA and HDT, determination of crystallinity and crystallization Kinetics
Unit 4: Types of fluids, viscoelastic properties of the polymer, basics of rheological characteristics, experimental determination, mechanical models (Maxwell model, Kelvin-Voigt model), determination of rheological properties through viscometers and DMTA.

Unit 5: Mechanical properties of polymer strength (creep, fatigue, stress relaxation tensile, flexural, and compressive), hardness, resilience, impact properties, factors affecting these properties, methods of determination of these properties
Unit 6: Optical properties of polymers (haze, glaze, refractive index).

References:
➢ Polymer Science & Technology, P. Ghosh, Tata McGraw Hill, 2001
➢ Thermal Analysis of Polymeric Materials, Wunderlich, Springer, 2005
➢ Handbook of Plastic Testing & Failure Analysis, V. Shah, Wiley Inter-science, 2006
➢ Testing & Evaluation of Plastics, Mathur & Bhardwaj, Allied Publishers Pvt Ltd, 2003

Polymer Processing	
Teaching Scheme	L-T-P: 3-0-2

Course Outcome
After completing this course, students will be able to • Prepare polymeric recipes to meet required product properties. • Identify the polymer compounding operations depending on the material and final product requirements. • Solve simple flow problems and calculations in the extrusion process • To describe the working principle of the Polymer Processing Machines. • Identify and solve the problems related products developed through Polymer Processing Machines • Create and apply appropriate polymer processing techniques to give engineering solutions for new polymers.

Syllabus Content:
Unit 1: The importance of polymer compounding, the additives used in compounding, their functions in compounded products, and mixing techniques.
Unit 2: Working principle of single screw extruder, twin screw extruder, vent extruder, process of manufacturing films, tubes, rods, laminates, coatings

Unit 3: Compression molding machine: types, principles of operations, molding cycle, the meaning of terms bulk factor and flow properties as applied to molding materials, the interplay of heat, pressure, friction, catalysts, etc. for thermosetting materials; troubleshooting
Unit 4: Injection molding machine-machine description study, types and limitations, working principles, process variables, troubleshooting, gas-assisted injection molding, structural foam molding, reaction injection molding process, their industrial applications; troubleshooting
Unit 5: Blow molding process, principles and description of blow mold, extrusion &injection stretch blow molding, parison control, troubleshooting
Unit 6: Miscellaneous processing methods: casting, rotational molding, decoration of polymers, working principles of calendaring and thermoforming process

References:
➢ Handbook of Plastic Processes, Harper, Wiley Inter science, 2006
➢ Principles of Polymer Processing, Tadmor & Gogos, Wiley Inter science, 2013
➢ Plastics Engineering, R.J. Crawford, Butterworths, 2013
➢ Handbook of Plastic Technology, Allen & Baker, CBS Publications, 2004
➢ Plastic Materials, J.A. Brydson, Butterworth-Heinemann, 1999

Polymer Testing & Characterization	
Teaching Scheme	L-T-P: 3-0-2

Course Outcome
After completing this course, students will be able to • Identify different polymers based on their different chemical and physical properties. • Characterize Polymers' structural and morphological properties by using different testing methods. • Identify the proper testing method for characterizing the specific properties of polymers. • Handle the testing and characterization equipment properly.

Syllabus Content:
Unit 1: Introduction to national and international standards, BIS, ISO, ASTM for testing of polymers, identification of common polymers by simple tests

Unit 2: UV-visible, IR and Raman spectroscopy: Principle and Applications in polymer characterization,
Unit 3: NMR spectroscopy in liquid and solid phase (1H and 13C): Principle and Applications in polymer characterization.
Unit 4: Mass spectrometry, separation techniques (GC, LC), Principle and Applications in polymer characterization.
Unit 5: X-ray diffraction method, scanning electron microscopy, transmission electron microscopy, and atomic force microscopy, Principle and Applications in polymer characterization.

References:
➢ Polymer Characterization, P. Nicholas Cheremisinoff, Elsevier, eBook ISBN: 9780815518693; Hardcover ISBN: 9780815514039, 1996
➢ NMR Spectroscopy of Polymers, Kitayama, Tatsuki, Hatada, Koichi, Springer, 2004
➢ Analytical Methods for Polymer Characterization, R. Yang, CRC Press, 2018