FACULTY OF SCIENCE
Mohanlal Sukhadia University, Udaipur
M.Sc. Polymer Science Program as per NEP-2020
(Valid from session 2023-24 onwards)

1. **Duration of the Course:** The Master of Science Polymer Science program will be of four semester's duration as per New Education Policy-2020, which will be conducted in two years. Each semester will be of approximately 5 months (minimum 90 working days in a semester) duration.
2. **Eligibility:** Candidates seeking admission to the first semester of M.Sc. Polymer Science must have a B.Sc. with Chemistry as one of the optional subjects or as an honor's subject (Level 5.5 or equivalent) with minimum 48% marks from a UGC recognized University.
3. **Admissions:** Admissions to the first semester of M.Sc. (Polymer Science) will be made as per admission rules for M.Sc.
4. **Medium of Instruction:** The medium of instruction and examination shall be English.
5. **No. of Seats:** Total number of normal fee seats: As per information bulletin
6. **Curriculum:** M.Sc. (Polymer Science) program has two years or four semesters prescribed course structure. M.Sc. (Polymer Science) program shall have a curriculum and course contents (Table-1) for the courses recommended by the committee courses in Chemistry and approved by the academic council of the university. The program shall follow NEP and will be governed by the Common Rules and Regulations of Master's program under NEP approved by the Academic Council of the University.
7. **Examination of Practical Papers:** End of semester (EoS) practical examination will be conducted by a board of examiners (one internal and one external). Internal examination (three hours test) will be conducted at the departmental level.
8. **Internal Examination of Theory Papers:** Internal examination (one hour test) of theory papers will be conducted at the departmental level.
9. **Exit and Lateral Entry Policy:** Exit and lateral entry policy shall be as prescribed in course structure and framework approved by academic council held on June 26, 2023.
10. **Choice of the DSE Courses:** The DSE courses listed in the program shall be offered depending upon the resources available in the department. A minimum of the 15 students should be opt the specific DSE.

Table 1: Proposed M.Sc. Polymer science Program: Semester wise course types, Course codes, Course title, Delivery type, Workload, Credits, Marks of Examination, and Remarks if any

Level	Semester	Course Type	Course Code	Course Title	Delivery type per week			Total hours	Credits	Total Credits	Internal marks	EoSE Marks	Max. Marks	Remarks
					L	T								
6	I	DCC	POL8000T	Inorganic Chemistry-I	L	T	-	60	4	24	20	80	100	
			POL8001T	Organic Chemistry-I	L	T		60	4		20	80	100	
			POL8002T	Physical Chemistry-I	L	T		60	4		20	80	100	
			POL8003T	Spectroscopy in analysis-I	L	T		60	4		20	80	100	
			POL8004P	Practical-A-I			P	120	4		20	80	100	
			POL8005P	Practical-B-I			P	120	4		20	80	100	
	II	DCC	POL8006T	Fundamentals of Polymer Chemistry	L	T	-	60	4	24	20	80	100	
			POL8007T	Instrumental techniques	L	T		60	4		20	80	100	
			POL8008T	Spectroscopy in analysis-II	L	T		60	4		20	80	100	
			POL8009P	Practical-A-II			P	120	4		20	80	100	
			POL8010P	Practical-B-II			P	120	4		20	80	100	
		GEC	POL8100T	Environmental and Green Chemistry	L	T		60	4		20	80	100	
			POL8101T	Polymer processing management	L	T		60	4		20	80	100	
		Exit with PG diploma in Polymer Science												
6.5	III	DCC	POL9011T	Physical and Chemical properties of Polymer	L	T		60	4	24	20	80	100	
			POL9012T	Specialty Polymers	L	T		60	4		20	80	100	
		DSE	POL9102P	Practical-A-III			P	120	4		20	80	100	
			POL9103P	Analytical Chemistry Lab-I			P	120	4		20	80	100	
		DSE	POL9104T	Materials for compounding and Reinforcement	L	T		60	4		20	80	100	
			POL9105T	Compounding and uses of Plastics	L	T		60	4		20	80	100	
		DSE	POL9106T	Tyre and rubber processing operations	L	T		60	4		20	80	100	
			POL9107T	Plastic Processing technology	L	T		60	4		20	80	100	
		GEC	POL9108P	Testing of Latex and identification of rubbers			P	120	4		20	80	100	

Level	Semester	Course Type	Course Code	Course Title	Delivery type per week			Total hours	Credits	Total Credits	Internal marks	EoSE Marks	Max. Marks	Remarks
			POL9109P	Identification of plastics			P	120	4		20	80	100	
	IV	DCC	POL9013T	Polymer and Environment	L	T		60	4	24	20	80	100	
		DSE	POL9110P	Practical-A-IV			P	120	4		20	80	100	
			POL9111P	Polymer Synthesis and Extraction of Natural Products Lab			P	120	4		20	80	100	
		DSE	POL9112T	Rubber Product Technology	L	T		60	4		20	80	100	
			POL9113T	Identification and testing of plastics	L	T		60	4		20	80	100	
		DSE	POL9114T	Testing and characterization of rubber product	L	T		60	4		20	80	100	
			POL9115T	Textile Technology	L	T		60	4		20	80	100	
		DSE	POL9116P	Mechanical properties and testing of rubber			P	120	4		20	80	100	
			POL9117P	Mechanical properties and testing of plastics			P	120	4		20	80	100	
		DSE	POL9118S	Project Work(at Research Laboratory or Industry or Institute of repute)(60DAYS)			S	120	4		20	80	100	

DCC- Discipline Centric Compulsory Course (001 to 099); **DSE-** Discipline Specific Core Course (100 to 199); **GEC-**Generic Elective Course

NOTE:

1. In the semester III, all the students have to select two elective papers from DSE groups (one from each group).
2. In the semester IV, all the students have to select three elective papers from DSE groups (one from each group.) and the project work (60 days) in a DSE is a compulsory paper for all and this work has to be completed during summer vacation (May to June)
3. In the theory paper, 60 Hours includes 40 Hours Lectures and 20 Hours diagnostic and formative assessment.
4. Student may exit with PG diploma in Chemistry after earning 48 credits in I and II semesters.

SEMESTER-I
DCC: POL8000T
Inorganic Chemistry-I

Code of the Course: POL8000T

Title of the Course: Inorganic Chemistry-I

Level of the Course: NHEQF Level 6.0

Credit of the Course: 4

Type of the Course: Discipline Centric Compulsory (DCC) Course for PG Polymer Science.

Delivery Type of the Course: 60 hours (40 hours for lectures and 20 hours for diagnostic and formative assessment).

Prerequisites*: Chemistry courses of under graduate or equivalent. The students should have knowledge in basic inorganic chemistry, such as coordination chemistry, crystal field theory.*

Course Objectives: *This course provides an introduction to the concepts of bonding in main group compounds. It covers topics such as ligand field theory of coordination compounds, complex equilibrium, and reaction mechanism of transition metal complexes including octahedral and tetrahedral complexes. This course also aims to develop student's understanding of the fundamental principles of electronic spectra and magnetic properties of transition metal complexes.*

Learning Outcomes:

- *After studying this paper, students would learn-*
- *Structure and bonding in covalent inorganic compounds, based on various bonding theories viz. VSEPR theory, bent rule and correlation diagram.*
- *Basics of coordination chemistry and bonding theories in coordination compounds viz. MOT*
- *Stability of metal complexes, with reference to nature of metal and ligand.*
- *Reaction mechanism of transition metal complexes of octahedral and tetrahedral geometry*
- *Basics of electronic spectra and magnetism.*

SYLLABUS:

UNIT-I

(12 Lecture Hours)

Stereochemistry and Bonding in Main Group Compounds: VSEPR Theory, Walsh diagrams (tri and penta-atomic molecules), dπ-pπ bonds, Bent rule and energetics of hybridization, some simple reactions of covalently bonded molecules.

Metal-Ligand Bonding: Limitation of crystal field theory, molecular orbital theory, octahedral, tetrahedral, square planar complexes, π-bonding and molecular orbital theory.

UNIT-II

(12 Lecture Hours)

Metal-Ligand Equilibria in Solution: Stepwise and overall formation constants and their interaction, trends in stepwise constants, factors affecting the stability of metal complexes with reference to the nature of metal ion and ligand, chelate effect and its thermodynamic origin, determination of binary formation constants by pH-meter and spectrophotometry.

UNIT-III

(12 Lecture Hours)

Reaction Mechanism of Transition Metal Complexes: Energy profile of a reaction, reactivity of metal complexes, inert and labile complexes, kinetic application of valence bond and crystal field theories, kinetics of octahedral substitution, acid hydrolysis, factors affecting acid hydrolysis, base hydrolysis, conjugate base mechanism, direct and indirect evidences in favor of conjugate mechanism, anation reactions and reactions without metal ligand bond cleavage.

UNIT-IV

(12 Lecture Hours)

Square Planar Complexes: Substitution reactions, trans effect, mechanism of the substitution reaction. Redox reactions, electron transfer reactions, mechanism of one electron transfer reactions, inner sphere type reactions, outer sphere type reactions, cross reactions and Marcus-Hush theory.

UNIT-V

(12 Lecture Hours)

Electronic Spectra and Magnetic Properties of Transition Metal Complexes: Spectroscopic ground states, correlation, Orgel and Tanabe-Sugano diagrams for transition metal complexes (d^1-d^9 states), calculations of Dq, B and β parameters, charge transfer spectra, spectroscopic method of assignment of absolute configuration in optically active metal chelates and their stereochemical information, anomalous magnetic moments, magnetic exchange coupling and spin crossover.

E-resources:

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA
2. https://www.slideshare.net/ShivajiBurungale/stereochemistry-in-main-group-compounds
3. https://chempedia.in/metal-ligand-equilibria-in-solution/
4. https://cbpbu.ac.in/userfiles/file/2020/STUDY_MAT/CHEM/Sem-II.pdf
5. https://www.uou.ac.in/lecturenotes/science/MSCCH-17/CHE
6. https://www.youtube.com/playlist?list=PLDjIJRH6sIC75nF-oDbyievkNyz1YAot8

Books Recommended:

1. Advanced Inorganic Chemistry, F.A. Cotton and Wilkinson, John Wiley.
2. Inorganic Chemistry, J.E. Huhey, Harpes & Row.
3. Chemistry of the Elements, N.N. Greenwood and A. Earnshow, Pergamon.
4. Inorganic Electronic Spectroscopy, ABP Lever, Elsevier.

5. Magnetochemistry, R.L. Carlin, Springer Verlag.

SEMESTER-I
DCC: POL8001T
Organic Chemistry-I

Code of the Course : POL8001T

Title of the Course : Organic Chemistry-I

Level of the Course : NHEQF Level 6.0

Credit of the Course : 4

Type of the Course: Discipline Centric Compulsory (DCC) Course for PG Polymer Science.

Delivery Type of the Course: 60 hours (40 hours for lectures and 20 hours for diagnostic and formative assessment).

Prerequisites: *Basics of organic chemistry taught at under graduate level.*

Course Objectives: *This course provides an introduction to the fundamental concepts of organic chemistry, nature of bonding, different types of reactions and their mechanism and formation of carbon-carbon and carbon-hetero multiple bonds. The course aims to develop student's understanding of the fundamental principles underlying chemical bonding and reaction mechanism.*

Learning Outcomes:

- *After studying this paper, students would-*
- *Understand the nature of bonding in organic molecules and they will be able to justify the aromatic, anti-aromatic and non-aromatic behaviors of organic molecules.*
- *Learn various methods to determine the rate of an organic reaction and the factors affecting the rate of an organic reaction, nature of transition state and intermediates.*
- *Have sound knowledge about the types and mechanism of various organic reactions such as substitution reactions, additions reactions and elimination reactions.*
- *Receive a good knowledge about the organic reactions and their mechanism occurring on aromatic compounds.*
- *Gain detailed knowledge about different name reactions involving carbon-carbon and carbon-hetero multiple bonds.*

SYLLABUS:

UNIT-I

(12 Lecture Hours)

Structure and bonding : localized and delocalized chemical bond, Vander walls interaction, charge transfer complexes ,resonance, hyper conjugation, aromaticity, electomeric, inductive and field effects, hydrogen bonding, types of organic reactions, energy consideration, brief idea of reactive

intermediates (formation and stability), neighboring group participation.

UNIT-II

(12 Lecture Hours)

Reagents in organic synthesis: use of the following reagents in organic synthesis and functional group transformation, Gilmans reagent,LDA,DCC,1,3-dithiane trimethylsilyl iodide, tributyltin hydride, DDQ, Baker yeast, Petersons synthesis, Merrifield resins, Wilkinsons catalyst, seleniumdioxide, Osmium tetraoxide, Lithiumdiisopropyl amide, Phase transfer catalyst, crown ethers.

UNIT-III

(12 Lecture Hours)

Addition to carbon –carbon multiple bond : mechanistic and stereo chemical aspects of addition reaction involving electrophiles, nucleophiles and free radicals .region and chemo selectivity , orientation and reactivity.
Addition to carbon – hetero multiple bonds .Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds, acids, esters and nitriles.

UNIT-IV

(12 Lecture Hours)

Free radical reaction: Type of free radical reactions. Free radical substitution mechanism ,neighbouring group assistance ,reactivity for aliphatic and aromatic substrate at a bridgehead ,reactivity in the attacking radicals, effects of solvents on the reactivity, allylic halogination (NBS) ,oxidation of aldehydes to carboxylic acids , auto-oxidtion,coupling of alkynes and arylation of aromatic compounds by diazonium salts , Sandmeyer reaction , free radical rearrangement , Hunsdiecker reaction.

UNIT-V

(12 Lecture Hours)

Green chemistry: principles, design for polymer degradation, polymers from renewable resources, and polymer recycling, industrial case studies in context with green chemistry.

Photochemistry : cis-trans isomerisation , Paterno – Buchi reaction , Norrish type I and II reaction , photo reduction of ketones , dimethane rearrangement , photochemistry of alkanes .

E-resources:

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA
2. http://www.nou.ac.in/econtent/Msc%20chemistry%20Paper%203/MSc%20Chemistry%20Paper- III%20Unit-1.pdf
3. http://rguir.inflibnet.ac.in/bitstream/123456789/16764/1/9781984665911.pdf
4. https://edisciplinas.usp.br/mod/resource/view.php?id=4580073
5. https://edscl.in/pluginfile.php/2660/mod_resource/content/2/Teachers%20Notes.pdf
6. https://www.bhu.ac.in/Content/Syllabus/Syllabus_30063128202004140356 42.pdf

Books Recommended:

1. Advanced Organic Chemistry-Reactions, Mechanism and Structure, Jerry March, John Wiley.
2. Advanced Organic Chemistry, F.A. Carey and R.J. Sundberg, Plenum.
3. A Guide book of Mechanism in Organic Chemistry, Peter Sykes, Longman.
4. Structure and Mechanism in Organic Chemistry, Peter Sykes, Longman.
5. Modern Organic Reactions, H.O. House, Benjamin.
6. Principles of Organic Synthesis, R.O.C. Norman and J.M. Coxon, Blackie Academic and Professional.
7. Reaction Mechanism in Organic Chemistry, S.M. Mukherji and S.P. Singh.
8. Stereochemistry of Organic Compounds, D. Nasipuri, New Age International.
9. Stereochemistry of Organic Compounds, P.S Kalsi, New age International.
10. Organic Reaction and Their Mechanisms, P.S. Kalsi, New Age International.
11. Organic Reaction Mechanism, V.K. Ahluwalia and R.K. Parshar, New Age International.

SEMESTER-I
DCC: POL8002T
Physical Chemistry-I

Code of the Course : POL8002T
Title of the Course : Physical Chemistry-I
Level of the Course : NHEQF Level 6.0
Credit of the Course : 4
Type of the Course : Discipline Centric Compulsory (DCC) Course for PG Polymer Science.

Delivery Type of the Course: 60 hours (40 hours for lectures and 20 hours for diagnostic and formative assessment).

Prerequisites*: Chemistry courses of undergraduate level or equivalent.*

Course Objectives: *This course provides Schrödinger equation, angular momentum theory, Born- Oppenheimer approximation, Perturbation theory. Chemical kinetics part of the course is designed to provide students with the knowledge, theoretical background and modeling tools to understand experimental and theoretical aspects of chemical reaction kinetics reaction. Macromolecules part of the course provides synthesis, characterization, properties and also include discussion on the applications of polymers.*

Learning Outcomes:

- *After studying this paper, the student would learn –*
- *Concept of fugacity and variation with temperature and pressure.*
- *Numerical problems basis on rates of different reaction.*
- *Temperature and pressure effect on reactions.*
- *Differentiate between different theories of kinetics.*
- *Properties and applications of colloids.*

Syllabus:

UNIT-I

(12 Lecture Hours)

Thermodynamics: partial molar free energy, partial molar volume and partial molar heat content. Their significance and determination. Concept of fugacity and variation with temperature and pressure. Determination of fugacity by graphical method and in gas mixtures (Lewis Randall rule). Activity and activity coefficient. Debye Huckel theory for activity cofficient of electrolyte solution. Determination of activity and activity coefficients.

UNIT-II

(12 Lecture Hours)

Chemical kinetics :- theories of reaction rates; Activated Complex Theory (Equolubrium and statistical); Theory of Unimolecular reactions (Lindemann and Hinshelwood treatments). Gernal features of fast reactions; study of fast reaction by flow method. Relaxation , flash photolysis and

magnetic resonance method.

UNIT-III

(12 Lecture Hours)

Surface Chemistry :- surface tension and surface free energy, Young and Laplace equation, Kelvin Equation. Gibbs Adsorpation isotherm. The B.E.T. equation and determination of surface area. Method of determining surface structure and composition by SEM,LEED,AES and PES. Kinetics of gaseous reactions on solid surfaces (unimolecular and bimolecular)

UNIT IV

(12 Lecture Hours)

Micelles: - surface active agents, classification of surface active agents, micellization, critical micelles concentration (CMC) factors affect the CMC of the surfactants , thermodynamics of micellization, micro- emulsion, reverse micelles.

Collolidal state:- Defining and classification of colloids. Sol, gel and emulsions; preparation and properties. Application of colloids.

UNIT V

(12 Lecture Hours)

Chemical equilibrium :- free energy and entropy of mixing, partial molar quantities, Gibbs – Duhem equation, Equilibrium constant, temperature – dependence of equilibrium constant , phase diagram of one and two component system, phase rule.

E-resources:

1. https://homepages.iitb.ac.in/~shukla/qmech2_chap2.pdf
2. http://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/chemistry/02.physical_chemistry-i
3. https://theory.physics.manchester.ac.uk/~xian/qm/chapter2.pdf
4. https://egyankosh.ac.in/bitstream/123456789/72738/3/Unit-14.pdf
5. http://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000005CH/P000661/M019111/ET/15 15650810CHE_P6_M32_etext.pdf

Books Recommended:

1. Mortimer, R. G. Mathematics for Physical Chemistry 2nd Ed. Elsevier (2005).
2. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 8th Ed., Oxford University Press.
3. Engel, T. & Reid, P. Physical Chemistry Benjamin-Cummings (2005).
4. McQuarrie, D. A. & Simon, J.D. Physical Chemistry: A Molecular Approach 3rd Ed., Univ. Science Books (2001).
5. Chemical Kinetics, K.J. Laidler, Mcgraw-Hill.
6. Kinetics and Mechanism of Chemical Transformations, J. Rajaraman and Kuriacose, McMillan.

SEMESTER-I
DCC: POL8003T
Spectroscopy in analysis –I

Code of the Course: POL8003T
Title of the Course: Spectroscopy in analysis-I

Level of the Course: NHEQF Level 6.0

Credit of the Course: 4

Type of the Course: Discipline Centric Compulsory (DCC) Course for PG Polymer Science.

Delivery type of the Course: 60 lectures (40 hours for lectures and 20 hours for diagnostic and formative assessment).

Prerequisites*: Chemistry courses of under graduate or equivalent with study of group theory, vibrational spectroscopy, Raman spectroscopy.*

Course Objectives: *This course introduces the symmetry of element, electromagnetic radiation, spin interaction, infrared spectroscopy, Raman Effect, atomic spectroscopy, molecular spectroscopy it covers topics such as Mossbauer Spectroscopy bonding of compounds. This course also aims to develop student's understanding of coordination and oxidation state of molecules.*

Learning Outcomes:

- *After studying this paper, students would learn-*
- *the basic principles of electromagnetic radiations and its interaction with matter.*
- *Students will also the knowledge about the rotational spectroscopy.*
- *the basic principles, instrumentation and applications of various spectroscopic techniques including Infrared spectroscopy, Raman spectroscopy, electronic spectroscopy and Mass Spectrometry.*

Syllabus:

UNIT-I

(12 Lecture Hours)

Ultra-violet and visible spectroscopy : Electronic transitions, instrumentation, shift of bands with solvents, the isolated double bond, conjugated dienes, effects of geometrical isomerism (steric effect, effect of alkyl substitution and ring residues), exocyclic double bonds, Woodward-Feiser rule, effect of strain around the diene chromophore, polyenes, UV spectra of carbonyl compounds, unsaturated aldehydes and ketones, UV spectra of benzene and its derivatives, other applications of UV spectroscopy

UNIT-II

(12 Lecture Hours)

Atomic absorption spectroscopy – Principle, instrumentation and applications
Flame Photometry: Principle, instrumentation and applications
.

UNIT-III

(12 Lecture Hours)

Photoelectron spectroscopy: Franck Condon principle, types of electron spectroscopy, ESCA-theory, instrumentation and applications, Auger emission spectroscopy –theory, instrumentation and applications.

UNIT-IV

(12 Lecture Hours)

Infra-red spectroscopy: Molecular vibrations, calculation of vibrational frequencies, instrumentation, finger print region, IR of alkanes and effect of some functional groups, effect of hydrogen bonding, Fermi resonance, overtones, shifting of bands due to inductive and mesomeric effects, aromatic and heteroaromatic compounds, effect of ring strain, applications of IR spectroscopy, brief idea of FT-IR.

UNIT-V

(12 Lecture Hours)

Raman spectroscopy: Theory, Stokes and anti-Stokes lines, Raman depolarization ratio, instrumentation, intensity of Raman peaks, applications
Microwave spectroscopy : Theory, selection rules, diatomic molecule as non-rigid rotator, symmetric top molecules, P-Q-R-bands, instrumentation, limitations and application

E-resources:

1. http://www.gacariyalur.ac.in/econtent/Chemistry/pg/PG-I-P16CH13.pdf
2. https://www.studocu.com/in/document/sant-gadge-baba-amravati- university/chemistry/competative-chemistry/20797234
3. https://oms.bdu.ac.in/ec/admin/contents/1_P16CH22_2020053003300799.pdf
4. https://www.blogs.uni-mainz.de/fb09akguetlich/files/2017/11/Moessbauer_Lectures.pdf

Books Recommended:

1. Modern Spectroscopy, J.M. Hollas, John Wiley.
2. Chemical Applications of Group Theory, F. A. Cotton.
3. Symmetry and Group theory: Some chemical applications, Ramashankar and Suresh Ameta, Himanshu Publications, Udaipur, Delhi.
4. Introduction to Molecular Spectroscopy, G.M. Barrow, McGraw Hill.
5. Basic Principles of Spectroscopy, R. Chang, McGraw Hill
6. Theory and Applications of UV Spectroscopy, H.H. Jaffe and M. Orchin, IBH- Oxford.
7. Introduction to Photoelectron Spectroscopy, P. K. Ghosh, John Wiley.
8. Introduction to Magnetic Resonance, A Carrington and A.D. Maclachalan, Harper & Row.
9. Physical Methods for Chemistry, R.S. Drago, Saunders Company.
10. Infrared and Raman Spectra: Inorganic and Coordination Compounds, K. Nakamoto, Wiley

SEMESTER-I
DCC: POL8004P
Practical-A-1

Code of the Course: POL8004P
Title of the Course: Practical –A-I

Level of the Course: NHEQF Level 6

Credit of the Course: 4

Type of the Course: Discipline Centric Compulsory (DCC) Course for PG Polymer Science Practical.

Delivery Type of the Course: 120 hours (80 hours for the hands on experiments, observations and record of the data , 20 hours for the experiment, instruments demonstration, lab practices and the 20 hours for the diagnostic assessment, formative assessment, subject/ class activity and problem solving).

Syllabus:

30 Marks

I. Organic estimations & Synthesis

1. Two stage preparation (Yield, Crystallization, M.P. Determination)
2. Three stage Preparation: Any three including Crystallization, Percent Yield and M.P.

30 Marks

II. Oil analysis

1. Determination of Aniline point of processing oil.
2. Determination of flash point / fire point and point of given oil.
3. Determination of specific gravity, Surface tension, Viscosity of polymer sample /oil.

III. Viva-voce **10 Marks**

IV. Evaluation of record book of experiments performed in semester **10 Marks**

Virtual Labs:

1. https://www.slideshare.net/DrSSreenivasa/msc-laboratory-manual-organic-chemistry-binary- mixture-seprations
2. https://www.youtube.com/watch?v=b-0dqL4ZaNg
3. https://www.youtube.com/watch?v=kK0dEhv-9Do
4. https://www.youtube.com/watch?v=YnUnOOgJIp4
5. https://www.science.gov/topicpages/p/practical+two-step+synthesis.html
6. https://www.youtube.com/watch?v=Y9AJtsheGIE

Books Recommended:

1. Vogel's Textbook of Practical Organic Chemistry by B.S. Furniss, Pearson.
2. Practical Organic Chemistry by J.T. Sharp, Springer.
3. Advanced Practical Organic Chemistry, O.P. Agarwal, Krishna Publications.
4. Advanced Practical Organic Chemistry, N.K. Vishnoi, Vikas Publishing House.

SEMESTER-I
DCC: POL8005P
Practical-B-I

Code of the Course: POL8005P

Title of the Course: Practical-B-I

Level of the Course: NHEQF Level 6.0

Credit of the Course: 4

Type of the Course: Discipline Centric Compulsory (DCC) Course for PG Polymer Science Practical

Delivery Type of the Course: 120 hours (80 hours for the hands on experiments, observations and record of the data , 20 hours for the experiment, instruments demonstration, lab practices and the 20 hours for the diagnostic assessment, formative assessment, subject/ class activity and problem solving.)

Syllabus:

60 Marks

1. **Water analysis**
a. Total hardness of water
b. Alkalinity-OH^- /CO_3^{2-}/OH^-+HCO_3^-
c. Chloride contents

2. **Coal Analysis**
a. Moisture contents/Volatile matter-C-Coal Analysis
b. Ash contents
c. Fixed carbon

3. Acid strength by conduct metric analysis
4. Colorimetric analysis of Rock phosphate
5. Colorimetric analysis of Iron
6. Determination of Total acid number of Oil
7. Saponification value of vegetable Oils
8. Iodine value

9. Viva-voce **10 Marks**

10. Evaluation of record book of experiments performed in semester **10 Marks**

Virtual Labs:

1. https://ncert.nic.in/pdf/publication/sciencelaboratorymanuals/classXII/chemistry/lelm107.pdf
2. https://egyankosh.ac.in/bitstream/123456789/79535/1/Unit-1.pdf
3. https://egyankosh.ac.in/bitstream/123456789/79544/1/Unit-10.pdf
4. https://www.slideshare.net/mithilfaldesai/determination-of-equivalence-conductance-degree-of- dissociation-and-dissociation-constant-of-weak-acid-

185659712

5. https://www.youtube.com/watch?v=ezXDuUmWJS8

Books Recommended:

1. Vogel's Textbook of Quantitative Analysis, J. Bassett, R.C. Denney, G.H. Jeffery and J. Mendham
2. Synthesis and Characterization of Inorganic Compounds, W.L. Jolly. Prentice Hall.
3. Macro scale and Micro scale Organic Experiments, K.L. Williamson, D.C. Health.
4. Practical Physical Chemistry, A.M. James and F.E. Prichard, Longman.
5. Findley's Practical Physical chemistry, B.P. Levitt, Longman.
6. Experimental Physical Chemistry, R.C. Das and B. Behera, Tata McGraw Hill.
7. Advanced Practical Physical Chemistry; Eighteenth Edition J.B.Yadav; Goel Publishing House, Meerut, 2015.

SEMESTER-II
DCC: POL8006T
Fundamentals of polymer chemistry

Code of the Course : POL8006T

Title of the Course **:** Fundamentals of polymer chemistry

Level of the Course : NHEQF Level 6.0

Credit of the Course : 4

Type of the Course : Discipline Centric Compulsory (DCC) Course for PG Polymer science

Delivery Type of the Course : Sixty lectures including diagnostic and formative assessment during lecture hours.

Prerequisites: *Chemistry courses of under graduate or equivalent. The students should have knowledge in basic Polymer chemistry such as definition, classification, types of reaction, applications etc.*

Course Objectives*: This course is mainly focuses on basic facts and concepts of classification of polymer, bonding in polymer, application, coordination polymerization, types of reaction, raw materials.*

Learning Outcomes:

After studying this paper, students would learn-

- *History ,Classification and types of reaction of a polymer*
- *preparation, properties and application of polymer*
- *Oil, Natural gas, Coal, Types, Grades and indication of manufacturing, Source of natural Polymers and derivatives*
- *Coordination polymerization types, it extent and kinetics of it*
- *Copolymerization Mechanism, reactivity ratio and composition, copolymers and Kinetics of copolymerization.*
- *Polymerization techniques*

Syllabus:

Unit –I

(12 Lecture hours)

Introduction of Polymer:Definition of Polymer,Classification of Polymer,Bonding in Polymer,History of Polymer.
Raw Materials: Oil, Natural gas, Coal, Types, Grades and indication of manufacturing, Source of natural Polymers and derivatives

Unit–II

(12 Lecture hours)

Addition Polymerization: Cationic, Anionic, and Free-radical. Kinetics of Polymerization –Free radical, cationic, anionic.

Unit –III

(12 Lecture hours)

Coordination Polymerization: ZieglerNatta Catalysts and Stereoregular polymers Condensation Polymerization: Types, extent and degree of Polymerization and kinetics. Carother's equation, ring opening Polymerization.

Unit –IV

(12 Lecture hours)

Copolymerization: Mechanism, reactivity ratio and composition – Block and graft copolymers.Kinetics of copolymerization.

Unit –V

(12 Lecture hours)

Polymerization techniques : Bulk, Solution, Suspension, Emulsion, Melt Polycondensation, Solution Polycondensation, Interfacial condensation, solid and gas phase polym
erization. Their advantages and disadvantages with application.

E-resources:

1. https://onlinelibrary.wiley.com/doi/10.1002/pi.4980200122
2. https://books.google.co.in/books/about/Textbook_of_Polymer_Science.html?id=cRh0CgAAQBAJ&redir_esc=y
3. https://www.oreilly.com/library/view/polymer-science-and/9780137039975/

Books Recommended:

1. Polymer science:V.R. Goowarikar,N.V.Viswanathan,JayadevSridhar
2. Textbook of polymer science: FredW.Billmeyer
3. Polymer science & Technology: Joel R. Fried
4. Polymer Science and Technology: Premamoy Ghosh

SEMESTER-II
DCC: POL8007T
Instrumental techniques

Code of the Course : POL8007T
Title of the Course : Instrumental techniques
Level of the Course : NHEQF Level 6.0
Credit of the Course : 4
Type of the Course : Discipline Centric Compulsory (DCC) Course for PG Polymer science
Delivery Type of the Course: Sixty lectures including diagnostic and formative assessment during lecture hours.

Prerequisites: *Basics of instrumentation techniques taught at UG level.*

Course Objectives*: This course provides an introduction to the fundamental and advanced concepts of instrumentation techniques like TGA, DTA, HPLC, GLC, Polarography, application of this techniques.*

Learning Outcomes:

- *After studying this paper, students would learn-a comprehensive knowledge on instrumentation techniques used in the differentiation and characterization of synthesized compounds in laboratory.*
- *Their application and procedure about the instrument.*

Syllabus:

UNIT-I

(12 Lecture hours)

Thermo Gravimetry Analysis (TGA) and Derivative. Hermogravimetry (DTG): Principle, instrumentation and application, factor affecting TG curves,
Differential Thermal Analysis (DTA): Principle, instrumentation and application, factor affecting TA curves
Differential Scanning Calorimeter (DSC): Principle, instrumentation and application, factor affecting DC curves, comparison with DTA.

UNIT-II

(12 Lecture hours)

D.C. Polarography: Basic principle, types of currents, experimental technique, Illovicequation (noderivation) and application of polarography
Principle, technique and application of Voltametric and cyclicvoltametery, Amperometry, Anodicstripping voltametery

UNIT-III

(12 Lecture hours)

High Performance Liquid Chromatography (HPLC): Introductory knowledge of adsorption basic principle, instrumentation and applications of HPLC, comparison with gas liquid chromatography
Gas Liquid Chromatography: Principle, instrumentation and applications
Gel Permeationor Size Exclusion Chromatography: Introduction, theory and application

UNIT-IV

(12 Lecture hours)

Ion Exchange :Introduction, types-cationic, anionic, chelating and liquid ion exchangers, preparation, action and properties of exchangers and applications of ion exchangers, Solvent Extraction, ion association complexes

Gel Electrophoresis: Introduction, Factors affecting ionic migration, detection of separated components and applications of Gel electrophoresis.

UNIT-V

(12 Lecture hours)

Radioactive Technique: Tracer technique, neutron activation analysis, counting technique such Geiger-Muller, ionization and proportional counters

Light Scattering Techniques: Principle, instrumentation and application so fne phelometery and Raman spectroscopy.

E-resources:

1. https://www.abebooks.com/Ion-Exchange-Separations-Analytical-Chemistry-Olof/16894565345/bd
2. https://www.wiley.com/en-ae/Modern+Size+Exclusion+Liquid+Chromatography%3A+Practice+of+Gel+Permeation+and+Gel+Filtration+Chromatography%2C+2nd+Edition-p-9780470442838

Books recommended:

1. Ion exchange separations in Analytical Chemistry. O. Samuelson, John Wiley
2. Exchangers and Solvent Extractions, J.A. Marinsky and Y. Parcus, Marcel Dekker
3. Polagraphic Techniques, I. Metes, Interscience
4. Gel Chromatography, Tibor Kremmer and Laszol Boross, Wiley.

SEMESTER-II
DCC: POL8008T
Spectroscopy in analysis-II

Code of the Course : POL8008T
Title of the Course : Spectroscopy in analysis-II
Level of the Course **:** NHEQF Level 6.0
Credit of the Course : 4
Type of the Course : Discipline Centric Compulsory (DCC) Course for PG Polymer science
Delivery Type of the Course : Sixty lectures including diagnostic and formative assessment during lecture hours.

Prerequisites*: Basic of spectroscopy taught in UG classes.*
Course Objectives*: This course provides an introduction and discussion of mass spectroscopy ,NMR, Electron spin resonance spectroscopy ,X-ray diffraction ad all other types of diffraction, moss beaur spectroscopy etc, and their application in identification of all the compounds structure and characterization and others.*

Learning Outcomes:

- *After studying this paper, students would learn-about the NMR spectroscopy and its rolein structure elucidation.*
- *Basic principle of mossbear, X-ray diffraction , neutron diffraction , ESR , mass spectroscopy and their applications .*

Syllabus:

UNIT-I

(12 Lecture hours)

Mass Spectrometry: Introduction, ion production- El, Cl, FD and FAB, factors affecting fragmentation, ion analysis, ion abundance. Mass spectral fragmentation of organic compounds, common functional groups, molecular ion peak, metastable peak, McLaffer tyre arrangement. Retro Diel-Alder reaction, Nitrogen rule. High resolution mass spectrometery. Examples of mass spectral fragmentation of organic compounds with respect to their structure determination.

UNIT II

(12 Lecture hours)

Nuclear Magnetic Resonance Spectroscopy: General introduction and definition, chemical shift, spin-spin interaction, shielding mechanism, mechanism of measurement, chemical shift values and correlation for protons bonded to carbon(aliphatic, olefinic, aldehydic and aromatic) and other nuclei (alcohols, phenols, enols, carboxylic acids, amines, amides & mercapto), chemical exchange, effect of deuteration, complex spin-spin interaction between two, three, four and five nuclei(first order spectra),virtual coupling. Stereochemistry, hindered rotation, Karplus curve-variation of coupling constant with dihedral angle. Simplification of complex spectra-nuclear magnetic double resonance, contact shift reagents, solvent effects. nuclear Overhauser effect (NOE).
Carbon-13NMRSpectroscopy:General considerations, chemical shift (aliphatic, olefinic, alkyne, aromatic, heteroaromatic and carbonyl carbon), coupling constants.

UNIT III

(12 Lecture hours)

Electron Spin Resonance Spectroscopy: Hyperfine coupling, spin polarization for atoms and transition metal ions, spin-orbit coupling and significance of g-tensors, application to transition metal complexes(having one unpaired electron) including biological systems and inorganic free radicals such as PH4, F2 and [BH3].

UNIT IV

(12 Lecture hours)

X-ray Diffraction: Bragg condition, Miller indices, Laue method, Bragg method, Debye-Scherrer method of X-ray structural analysis of crystals, index reflections, identification of unit cells from systematic absences in diffraction pattern. Structure of simple lattices and X-ray intensities, structure factor and its relation to intensity and electron density, phase problem. Description of the procedure for an X-ray structure analysis, absolute configuration of molecules, Ramchandran diagram.
Electron Diffraction: Scattering intensity vs. scattering angle, Wierl equation, measurement technique, elucidation of structure of simple gas phase molecules. Low energy electron diffraction and structure of surfaces.
Neutron Diffraction: Scattering of neutrons by solids and liquids, magnetic scattering, measurement techniques. Elucidation of structure of magnetically ordered unit cell.

UNITV

(12 Lecture hours)

Mössbauer Spectroscopy: Basicprinciples, spectral parameters and spectrum display. Application of the technique to the studies of (1) bonding and structures of Fe+2 and Fe+3 compounds including those of intermediates pin, (2) Sn+2 and Sn+4 compounds-nature of M-Lbond, -coordination number, structure (3) detection of oxidation state and equivalent MB atoms

E-resources:

1. https://epgp.inflibnet.ac.in/
2. https://archive.nptel.ac.in/
3. https://swayam.gov.in/
4. http://www.extension.harvard.edu/courses
5. https://spectrabase.com/
6. https://webbook.nist.gov/chemistry/
7. https://nmrshiftdb.nmr.uni-koeln.de/
8. http://www.nou.ac.in/econtent/Msc%20Chemistry%20Paper%20IX/MSc%20Chemistry%20Paper -IX%20Unit-4.pdf
9. http://www.nou.ac.in/econtent/Msc%20Chemistry%20Paper%20IX/MSc%20Chemistry%20Paper -IX%20Unit-5.pdf

Books Recommended:

1. Physical Methods for Chemistry, R.S. Drago, Saunders Company.
2. StructuralMethodsinInorganicChemistry,E.A.V.Ebsworth,D.W.H.Rankinand S. Cradock, ELBS
3. Infrared and Raman Spectra: Inorganic and Coordination Compounds, K. Nakamoto,Wiley.
4. Progress in Inorganic Chemistry vol., 8, ed., F.A.Cotton,vol.,15,ed.S.J.Lippard,Wiley.
5. Transition Metal Chemistry edi R.L.Carlin vol.3, Dekker

6. Inorganic Electronic Spectroscopy,. A.P.B. Lever, Elsevier.
7. NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R.V. Parish, Ellis Norwood.
8. Practical NMR Spectroscopy, M.L. Martin, J.J. Delpeuch and G.J. Martin, Heyden.
9. Spectrometric Identification of Organic Compounds, R.M. Silverstein, G.C. Bassler and T.C. Morrill, John Wiley
10. Introduction to NMR Spectroscopy, R.J. Abraham, J. Fisher and P. Loftus,Wiley.
11. Application of Spectroscopy of Organic Compounds, J.R. Dyer, Prentice Hall.
12. Spectroscopic Methods in Organic Chemistry, D.H. Williams, I. Fleming, Tata McGraw-Hill.
13. Applied Electron Spectroscopy for Chemical Analysis Ed. H. Windawi and F.L. Ho, Wiley Interscience.
14. NMR, NQR, EPR and Msssbauer Spectroscopy in Inorganic Chemistry, R.V. Parish, Ellis Harwood.
15. Physical Methods in Chemistry, R.S. Drago, Saunders College.
16. Chemical Applications of Group Theory, F.A. Cotton.
17. Introduction to Molecular Spectroscopy, G.M. Barrow, McGraw Hill.
18. Basic Principles of Spectroscopy, R. Chang, McGrawHill.
19. Theory and Applications of UV Spectroscopy, H.H. Jaffe and M. Orchin, IBH-Oxford.
20. Introduction to Photoelectron Spectroscopy, P.K. Ghosh, John Wiley.
21. Introduction to Magnetic Resonance, A Carrington and A.D. Maclachalan, Harper & Row.
22. Modern Spectroscopy, J.M. Hollas, John Wiley.

SEMESTER-II
GEC: POL8100T
Environmental and Green Chemistry

Code of the Course: POL8100T
Title of the Course: Environmental and Green Chemistry
Level of the Course: NHEQF Level 6.0
Credit of the Course: 4
Type of the Course: Generic Elective Course (GEC) for PG Polymer science.
Delivery Type of the Course: Sixty lectures including diagnostic and formative assessment during lecture hours.
Prerequisites*: Chemistry courses of undergraduate level (CHE7303T) or equivalent.*
Course Objectives*: This course aims to equip students with a thorough understanding of green chemistry principles, waste management, green solvents and reagents, green chemical synthesis, environmental chemistry, and pollution analysis.*

Learning Outcomes:

- *After studying this paper, students will be able to-understand the principles and importance of green chemistry in promoting sustainability.*
- *Analyze the environmental impact of waste production and develop strategies for waste reduction and safe disposal.*
- *Identify and utilize environmentally friendly solvents and reagents in chemical processes.*
- *Apply green synthesis approaches to minimize waste and enhance reaction efficiency.*
- *Understand the interactions between chemical substances and the environment.*
- *Perform analytical techniques to measure and assess pollutants in the environment.*

Syllabus:

UNIT-I

(12 lecture hours)

Principle and concepts of Green Chemistry: Introduction, definition, principles, atom economy. Waste- Production, Problems and Preventions: Introduction, problem caused by waste, source of waste, cost of waste, waste minimization techniques, on-site waste treatment, design for degradation, polymerrecycling. Introduction to catalysis, biocatalysit and phase transfer catalysis.

UNIT-II

(12 lecture hours)

Green Solvents: Organic solvents, solvent-free systems,controlling of solvent-free reactions, super critical fluids (H_2O and CO_2), fluorousbi phase solvents.
Green Reagents: Introduction, methods of designing safer chemicals, avoidance of toxic functional groups, examples of greener reagents including replacement of phosgene, methylations using dimethyl carbonates and other polymer supported reagents, solid state polymerization, alternative nitrile synthesis.

UNIT-III

(12 lecture hours)

Green Synthesis: Design for energy efficiency, classification and applications of Green Synthesis including Microwave Assisted Synthesis green synthesis of polycarbonates, paracetamol, ibuprofen, citral, urethane, adipic acid, styrene,$\alpha,\beta-$unsaturated nitro alkenes.

UNIT-IV

(12 lecture hours)

Environmental chemistry: Atmosphere –chemical and photochemical reactions in the atmosphere, oxgen and ozone Chemistry, green house gases and effect, hydrosphere-physical chemistry of sea water, eutrophication, sewage treatment, lithosphere and chemistry envolved, smoke formation acid rains. A brief idea of toxicological effects of arsenice, lead, cadmium mercury, ozone PAN, cyanide, pesticides.Oxide of nitrogen, sulphur and carbon, carcinogens

UNIT-V

(12 lecture hours)

Analysis of pollution: Sampling and monitoring of air and water, determination of total dissolved solids, conductivity, acidity, alkalinity, harnnes, chloride, sulphate, fluoride phosphate and different forms of nitrogen phenols, pestisides, surfactants DO, BOD, COD and microorganism. Catalysts of aquatic chemical reactions water pollution lows and standards.

E-resources:

1. https://www.acs.org/greenchemistry/principles/12-principles-of-green-chemistry.html
2. https://www.sciencedoze.com/2021/01/green-solvents-definition-examples-types-of-green- solvents.html
3. https://file.helpstudentpoint.com/wp-content/uploads/2022/01/Chemistry2.pdf
4. https://ncert.nic.in/textbook/pdf/kech207.pdf
5. http://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/chemistry/environmental_chemistry/10. part_1_analytical_techniques_for_measuring_water_quality_parameters/et/5508_et_et.pdf

Books Recommended:

1. Green Chemistry: An Introductory Text, Mike Lancaster, Royal Society of Chemicals, Cambridge,
2. Green Chemistry: Frontiers in Benign Chemical Synthesis and Processes, Edited by Paul T. Anastas & Tracy C. Williamson, Oxford University Press.
3. Green Chemical Syntheses and Processes: Edited by Paul T. Anastas, Lauren
4. G. Heine & Tracy C. Williamson, ACS Symposium Series.
5. Green Chemistry: Environment Friendly Alternatives, Edited by Rashmi Sanghi, M.M. Srivastava, Narosa Publishing House, New Delhi.
6. Green Chemistry:Microwave Synthesis, K.R. Desai, Himalaya Publishing House.
7. Green Chemistry: A Teaching Resource, Dorothy Warren, Royal Society of Chemicals, 2001.
8. Green Chemistry:Williams,Charlotte.
9. Environmental Chemistry, S.E. Manahan, Lewis Publishers.
10. Environmental Chemistry, Sharma & Kaur, Krishna Publishers.
11. Environmental Chemistry, A.K. De, Wiley Eastern.
12. Environmental Pollution Analysis, S.M. Khopkar, Wiley Eastern
13. Standard Method of Chemical Analysis, F.J. Welcher Vol.Ill,VanNostr and Reinhold Co.
14. Environmental Toxicology, Ed. J. Rose, Gordon and Breach Science Publication.
15. Elemental Analysis of Airborne Particles, Ed. S. Landsberger and M. Creatchman, Gordon and Breach Science Publication.
16. Environmental Chemistry, C. Baird, W.H. Freeman.

SEMESTER-I
GEC: POL8101T
Polymer processing management

Code of the Course: POL8101T
Title of the Course: Polymer processing management

Level of the Course: NHEQF Level 6.5

Credit of the Course: 4

Type of the Course: Discipline Centric Compulsory (DSE) Course for M.Sc. Polymer science Discipline

Delivery Type of the Course: Sixty lectures including diagnostic and formative assessment during lecture hours.

Prerequisites*: This course aims to study about the polymer processing and their management.*

Course Objectives*: This course provides an introduction and classification of polymers, rubber product manufacturing system, process and quality control method, storage and transportation mean of polymers, market research , management systems.*

Learning Outcomes:

- *By the end of this course, students would learn-basics of polymer chemistry. their market review, storage and transportation methods..*
- *Industrial manufacturing and properties of polymers.*

Syllabus:

Unit- I

(12 lecture hours)

Rubber product manufacturing system: The system concept, Prediction, Monitoring and control of process performance, Production organization
Process control and Quality control: The interaction of process control and quality control, Specifications, Process capability studies, Process monitoring, Process control, Quality control.

Unit-II

(12 lecture hours)

Plant layout and operation methods: General consideration, transport and storage in manufacture, Handling methods and operations at work stations, Planning and allocating space layout synthesis and evaluation, Installing and commissioning a layout.

Unit-III

(12 lecture hours)

Company Philosophy, Organization and Strategy: Philosophy, Company Organization, Market Research and Company Development.
The economics of manufacturing operations: The flow of cash through a company, Cost identification and analysis methods, Standard costs, Business plans and budgets, Budgetary control.

Unit-IV

(12 lecture hours)

Production management: Production planning, Purchasing and inventory control, implementing the production plan.

Unit-V

(12 lecture hours)

Quality Management Systems: Quality data, Quality audit, Quality costs, Quality policy, Quality objectives, Quality systems, Inspection, Certification and Accreditation. Basic concepts on ISO 9000, QS 9000, ISO 14000, TS 16949, EFQM model and TQM.

E-resources:

1. https://www.hanserpublications.com/Products/447-polymer-processing-ebook.aspx
2. https://www.hanserpublications.com/Products/462-polymer-processing-2e-ebook.aspx
3. https://link.springer.com/book/10.1007/978-3-662-60809-8

Books Recommended:

1. Physical testing of rubbers: R. P. Brown.
2. Rubber Technology and Manufacturing: C.M. Blow.
3. Introduction of Polymer Sc. & Rubber Technology, Vol. I, Ed. By Dr. R. Mukhopadhyay.

SEMESTER-II
DCC: POL8009P
Practical –A-II

Code of the Course : POL8009P
Title of the Course : Practical-A-II
Level of the Course : NHEQF Level 6.0
Credit of the Course : 4
Type of the Course : Discipline Centric Compulsory (DCC) Course for PG Polymer science Practical
Delivery Type of the Course: 120 practical hours

Syllabus

30 Marks

I. Synthesis of polymers:

a. Synthesis of PF resin.
b. Synthesis of UF resin.
c. PMMA synthesis by free radical polymerization.
d. Precipitation polymerization of acrylonitrile.
e. Solution polymerization of acrylamide in presence of are initiator.
f. Synthesis of polymethylacrylate by emulsion polymerization.

30 Marks

II. Determination method

a. Determination of free phenol content in PF resin
b. Determination of free formaldehyde in UF resin.
c. Spectral analysis :Characterization of organic compounds in the basis of given Xerox copies of spectra (UV,IR,NMR and Mass)
d. Identification of natural polymers : carbohydrate, Protein etc

III. Viva-voce **10 Marks**

IV. Evaluation of record book of experiments performed in semester **10 Marks**

Virtual Labs:

1. https://youtu.be/q8IMKft663I?si=Q9AN6_8UJusBCwFg
2. https://www.cbspd.co.in/practicals-in-polymer-science-9788123912721-siddaramaiah
3. https://books.google.co.in/books/about/Experiments_In_Polymer_Science.html?id=cANBPgAACAAJ&redir_esc=y

Books recommended:

1. Experiments in polymer science ,New age international publishers., D.G. Hundiwale, V.D. Athawale, U.R. Kapadi, V.V. Gite
2. Practicals in polymer science, CBS Publishers & distributors, Siddaramaiah

SEMESTER-II
DCC: POL8010P
Practical-B-II

Code of the Course: POL8010P
Title of the Course: Practical-B-II
Level of the Course: NHEQF Level 6.0
Credit of the Course: 4
Type of the Course: Discipline Centric Compulsory (DCC) Course for PG Polymer science Practical
Delivery Type of the Course: 120 practical hours.

Syllabus

30 Marks

I**. Synthesis of polymers:**

1. Oxidation polymerization of aniline at different rate condition
    a. Temperature
    b. Monomer to oxidant ratio
2. Preparation of aniline formaldehyde resin
3. Preparation of Epoxy resin using bisphenol A and epichlorohydrine.
4. Preparation of polyester resin
5. Preparation of Thiokol rubber.
6. Preparation of vinyl ester resin.

30 Marks

II. Determination method

1. Determine Epoxy equivalent weight of Epoxy resin.
2. Determine Acid value of unsaturated polyester resin.
3. Determination of swelling network polymers.
4. Determination of water absorption of polymers.

III. Viva-voce **10 Marks**

IV. Evaluation of record book of experiments performed in semester **10 Marks**

Virtual Labs:

1. https://youtu.be/q8IMKft663I?si=Q9AN6_8UJusBCwFg
2. https://www.cbspd.co.in/practicals-in-polymer-science-9788123912721-siddaramaiah
3. https://books.google.co.in/books/about/Experiments_In_Polymer_Science.html?id=cANBPgAACAAJ&redir_esc=y

Books recommended:

1. Experiments in polymer science ,New age international publishers., D.G. Hundiwale, V.D.Athawale, U.R. Kapadi, V.V. Gite
2. Practicals in polymer science, CBS Publishers & distributors, Siddaramaiah

SEMESTER III
DCC: POL9011T
Physical and chemical properties of polymer

Code of course: POL9011T
Title of Course: Physical and chemical properties of polymer
Level of Course: NHEQF Level 6.5
Credit of Course: 4
Type of Course: Discipline centric compulsory course (DCC) for PG Polymer science
Delivery type of the Course: Sixty lectures including diagnostic and formative assessment during lecture hours
Prerequisites*: Chemistry courses of under graduate or equivalent with basic knowledge of polymers.*
Course Objectives*: This course introduces the basic knowledge of polymer, formulas used ,polymer reaction and its application.*

Learning Outcomes:

- *After studying this paper, students would learn: detailed overview of mathematical approach of polymer methods used in chemistry to synthesize polymers*
- *Characteristics of polymer*
- *Study about the instrumental techniques to characterize the polymer.*

Syllabus:

Unit –I

(12 lecture hours)

Molecular mass of polymer: Number average and weight average molecular weight. Molecular weight distribution, Polydisparity, Colligative property determination and end group analysis. Light scattering, Ultracentrifugation, Osmotic pressure and viscosity method of molecular mass determination. Gel permeation chromatography.

Unit–II

(12 lecture hours)

PolymerReaction: Introduction, Hydrolysis, Acidolysis, Aminlysis, Hydrogenation, Addition and substitution reaction, Reaction of various specific group, Cyclisation reaction, Cross-linking reaction, Reaction leading to graft and block copolymer, Miscellaneous reaction.

Unit –III

(12 lecture hours)

Amorphous and Crystalline state: Polymer chain flexibility, glass transition temperature, Crystalline state, melting point and general structure property relationship
Electrical properties: Orientation, atomic and electronic polarization of polymeric dielectrics. Definition of relative permittivity and values for polymer processing. Various types of polarization .Electric strength and tracking.

Unit –IV

(12 lecture hours)

Diffusion in polymer: Diffusion of gases, liquids and solids in polymer, solubility parameter, effect of temperature and prediction of solubility parameter of solvent
Solution properties: Behavior of polymers in polar and non polar solvent. Effect of crystallinity and cross linking on solubility.

Unit –V

(12 lecture hours)

Rheology: viscosity, plasticity and non Newtonian flow. Time dependent flow. Power low. Effect of temperature and molecular mass on viscosity. Flow properties of polymers, application of rheology and viscometer to predict process ability of polymers.Visco elastic behavior, hysteresis, creep, stress relaxation.

Polymer degradation and stability: Thermal, photo degradation, oxidative and biological degradation. The role of antioxidant and stabilizer.

E-resources:

1. https://www.deepdyve.com/lp/wiley/polymer-science-by-v-r-gowariker-n-v-viswanathan-and-j-sreedhar-john-bJ8c5PWBJR
2. http://cryssmat.fq.edu.uy/ricardo/libro.pdf
3. https://www.eng.uc.edu/~beaucag/Classes/Properties/Books/Joel%20R.%20Fried%20-%20Polymer%20Science%20and%20Technology-Prentice%20Hall%20(2014).pdf
4. https://www.accessengineeringlibrary.com/content/book/9780070707047

Books Recommended:

1. Polymer science: V.R. Goowarikar, N.V.Viswanathan, Jayadev Sridhar
2. Textbook of polymer science: Fred W. Billmeyer
3. Polymer science & Technology: Joel R. Fried
4. Polymer Science and Technology : Premamoy Ghosh

SEMESTER-III
DCC: POL9012T
Specialty Polymers

Code of the Course: POL9012T
Title of the Course: Specialty Polymers
Level of the Course: NHEQF Level 6.5
Credit of the Course: 4
Type of the Course: Discipline Centric Compulsory (DCC) Course for PG Polymer science
Delivery Type of the Course: Sixty lectures including diagnostic and formative assessment during lecture hours.
Prerequisites*: Chemistry courses with basic polymer chemistry.*
Course Objectives*: This course introduces the types of polymer and their structure for different application as high temperature resistant and fire resistant polymer, hydrophilic polymer their introduction and application, conducting polymers ,ionic polymers and their synthesis methods.*

Learning Outcomes:

- *After studying this paper, students would learn: basics of high temperature resistant and fire resistant polymer .*
- *Polymer with conducting properties like electrical etc.*
- *About the difference and basic information about inorganic ad organic polymers*
- *And industrial and laboratory procedures to manufacture different types of polymers.*

Syllabus:

Unit –I

(12 lecture hours)

High temperature and fire resistant polymer: Introduction, Polymers for high temperature resistance,Fluropolymer,Aromaticpolymers,Hydrocarbonpolymers,Polyethers,Polyphenylsulphide,Polysulphones,Polyesters, Polyamides, Polyketones, Heterocyclic polmers.
HydrophilicPolymers: Introduction,Naturalpolymers–Carbohydrate,Proteins,Semi-syntheticpolymers,Hydrogel, Polyacrylamides hydrophilic polymers, Polyvinyl alcohol, Polyvinyl pyrrolidone.

Unit –II

(12 lecture hours)

Polymerswithelectricalandelectrometricproperties:Introduction,Conductivepolymers,Photoconducting Polymer, Polymers with piezoelectric, Piezoelectric and ferroelectrics properties, and Photoresists for semiconductor fabrication.
ConductingPolymer:Definition,Inherentlyconductingpolymer:polyacetylene,polydiacetylene,polyaniline,poly (p-phenylenesulphide), photo conducting polymers

Unit –III

(12 lecture hours)

Ionic Polymers: Introduction, Classification, Synthesis physical properties and application, Ionomers based on polyethylene, Polystyrene, Ionomers with Polyaromatic back bones, Polyelectrolyte, Polyelectrolyte complexes
Biopolymers: Introduction, Definition, classification, advantages and disadvantages, Applications of Biopolymersin : 1) Drug delivery system, 2) Disposable in Health Care, 3) Packaging, 4) Medication
Structure and properties of natural polymer: - polypeptides Proteins nucleic acid, based, poly lacticacid, PHBV, Carbohydrates.

Unit –IV

(12 lecture hours)

Inorganic and Organic Polymer: Introduction, Inorganic reaction mechanism, Condensation organ metallic, polymers, Addition polymers, coordination polymers, Sol Gel, Portl and cement, Silicates, Silicon dioxide, Asbestos, Diamond, Graphical, Polysulphur

Unit-V

(12 lecture hours)

Outline manufacturing and properties :
Polyethylene, Polyimides, Polypropylene, Polyacrylanitriles, Polystyrene, Polyvinylalcohol, Polymethylmethacrylate, Polyvinyl acetate Polyvinylchloride, Phenolformaldehyderesin, Polyurethanes, Urea formaldehyde resin, Polyesters, Melamine formal dehyde, Polycarbonates, Melamine formaldehyde resin, Polyamides and Epoxyresins.

E-resources:

1. https://www.scribd.com/document/393765460/Polymer-Science
2. http://cryssmat.fq.edu.uy/ricardo/libro.pdf
3. https://www.pearson.com/en-us/subject-catalog/p/polymer-science-and-technology/P200000000261

Books Recommended:

1. Polymerscience: V.R. Goowarikar,N.V. Viswanathan, Jayadev Sridhar
2. Textbook of polymerscience: Fred W. Billmeyer
3. Polymer science & Technology: Joel R. Fried
4. Polymer Science and Technology: Premamoy Ghosh
5. Special typolymers: R.W. Dyson

SEMESTER-III
DSE: POL9102P
Practical-A-III

Code of the Course: POL9102P
Title of the Course: Practical-A-III
Level of the Course: NHEQF Level 6.5
Credit of the Course: 4
Type of the Course: Discipline Specific Elective (DSE) for PG Polymer science Practical
Delivery Type of the Course: 120 practical hours

Syllabus:

30 Marks

I. Synthesis of polymers:

1. Preparation of Polyvinyl acetate.
2. Polymer modification-preparation of polyvinyl alcohol from polyvinyl acetate.
3. Depolymerization of polymethylmethacrylate
4. Synthesis benzoic acid-formaldehyde resin
5. Synthesis Aniline formaldehyde resin
6. Synthesis DGEBA Epoxy resin

30 Marks

II. Determination method

1. Determine of mol.Wt. by end group analyzing
2. Sheet casting using methylmethaacrylate
3. Mol.Wt. determination by non-aqueous conductometric titration.
4. Determine Saponification value of polyvinylacetate

III. Viva voice **10 Marks**

IV. Evaluation of record book of experiments performed in semester **10 Marks**

Virtual Labs:

1. https://youtu.be/q8IMKft663I?si=Q9AN6_8UJusBCwFg
2. https://www.cbspd.co.in/practicals-in-polymer-science-9788123912721-siddaramaiah
3. https://books.google.co.in/books/about/Experiments_In_Polymer_Science.html?id=cANBPgAACAAJ&redir_esc=y

Books recommended:

1. Experiments in polymer science ,New age international publishers., D.G. Hundiwale, V.D.Athawale, U.R. Kapadi, V.V. Gite
2. Practicals in polymer science, CBS Publishers & distributors, Siddaramaiah

SEMESTER-III
DSE: POL9103P
Analytical Chemistry Lab - I

Code of the Course: POL9103P

Title of the Course: Analytical Chemistry Lab - I

Level of the Course: NHEQF Level 6.5

Credit of the Course: 4

Type of the Course: Discipline Specific Elective (DSE) Course for PG Chemistry Practical.

Delivery type of the Course*:* 120 hours (80 hours for the hands on experiments, observations and record of the data , 20 hours for the experiment, instruments demonstration, lab practices and the 20 hours for the diagnostic assessment, formative assessment, subject/ class activity and problem solving).

Syllabus:

I. Instrumental Analysis: **30 Marks**

1. Estimation of Ca, Na and K by Flame photometry
2. Separation of amino acids by ion exchange and chromatographic method
3. Polarimetric estimation of sugar
4. Analysis of German silver (copper, zinc and nickel)

II. Volumetric Analysis: **15 Marks**

1. Analysis of oils and fats and determine saponification value and iodine values
2. Analysis of HCl extract of fusion with Na_2CO_3 for Al, Fe, Ca, Mg, P and K
3. Analysis of fertilizers

III. Gravimetric Analysis: **15 Marks**

1. Determination of fats, protein and solid in milk
2. Estimation of lead and tin in solder or bismuth, cadmium and lead in low melting alloys such as woods metal using EDTA (Volumetrically)

IV. Viva-voce **10 Marks**

V. Evaluation of record book of experiments performed in semester **10 Marks**

Virtual Labs:

1. https://www.liverpool.ac.uk/~agmclen/Medpracs/practical_2/practical_2.pdf
2. https://jru.edu.in/studentcorner/lab-manual/bpharm/7th-sem/INSTRUMENTAL%20METHODS%20OF%20ANALYSIS.pdf
3. https://labmonk.com/determination-of-saponification-value-of-the-given-oil-fat
4. https://egyankosh.ac.in/bitstream/123456789/15901/1/Experiment-14.pdf
5. https://egyankosh.ac.in/bitstream/123456789/9654/1/Experiment-4.pdf

Books Recommended:

1. Experiments in chemistry by D.V. Jahagirdar, Himalaya Publishing House
2. Instrumental Methods of Chemical Analysis B. K. Sharma
3. Analytical chemistry, 6th edition by Gary D. Christian, Wiley student Edition.
4. Analytical Chemistry by S.M. Khopkar, New Age International

SEMESTER-III
DSE: POL9104T
Materials for compounding and reinforcement

Code of the Course: POL9104T
Title of the Course: Materials for compounding and reinforcement
Level of the Course: NHEQF Level 6.5
Credit of the Course: 4
Type of the Course: Discipline Specific Elective (DSE) Course for PG Polymer science
Delivery Type of the Course: Sixty lectures including diagnostic and formative assessment during lecture hours.
Prerequisites*: this course aims to give knowledge of latex, reinforcing materials, thermoplastic and composite materials.*
Course Objectives*: This course provides an introduction to the fundamental concepts of latex, compounding ingredients fillers, curing agents , rubber ,textile reinforcement materials, textile to rubber bonding system ,thermoplastic rubber and their application.*

Learning Outcomes:

- *After studying this paper, students would learn-use of polymer as adhesive and bonding.*
- *Composite material introduction, and its application.*
- *Study about different types of curing systems and protective systems.*

Syllabus:

Unit-I

(12 lecture hours)

Latex: NRLatex, stability, concentration and preservation, nitrilelatex, latex foam rubber, latex adhesives
Outline Manufacturing, Vulcanization, and properties of NR/IR/SBR (Emulsion and solution type), BR/NBR/HNBR, and IIR, CR, CSM, and EPR/EPDM, EVA silicone, FKM,ACM and polysulfide rubbers.

Unit-II

(12 lecture hours)

Compounding ingredients: Fillers: Reinforcing and extending fillers, carbon black and non-black fillers
Curing systems: conventional, EV and semi EV, metal oxide and resincuring .
Protective System: Antioxidants, antioxidants and waxes.
Miscellaneous :Peptiser, activator, accelerator, softener, oil, retarder, blowing agent, Tackifier Mineral Rubbers, Reclaimed Rubber, Groundcrum, Release agents.

Unit-III

(12 lecture hours)

Textile/reinforcing materials: Textile terminology Definition of fibres, yarn, cord, twist, count, denier, tex, types of textile weaves and their application in different rubber products. properties and outline Manufacturing of cotton, Rayon ,Polyamides, polyesters, Glass Fiber, Aramid and Steel wire, their application in rubber products as a composite materials. Textile to rubber bonding systems –Dry and RFL.

Unit-IV

(12 lecture hours)

Adhesive and bonding: Solvent based, water based and other adhesives based on various polymers, epoxide resins and curing of epoxide resins. Diluents and other additives, Rubber cement for tyre application.

Unit-V

(12 lecture hours)

Thermoplastic Rubbers: - Classification, Advantage over simple elastomers and application. Application and properties of SBS, PVC blended SBR.

Composite Materials:- Introduction, advantage of composite materials over other polymeric materials, Basic principle of manufacturing, factors influencing the performance. Physical and functional properties of different composites, Fiber reinforced plastic and rubber their properties and application.

E- resources:

1. https://books.google.co.in/books/about/Rubber_Technology_and_Manufacture.html?id=fPxTAAAAMAAJ&redir_esc=y
2. https://catalogue.nla.gov.au/catalog/393108
3. https://books.google.co.in/books/about/Rubber_Engineering.html?id=LM5RAAAAMAAJ&redir_esc=y

Books Recommended:

1. Rubber Technology and Manufacturing: C.M. Blow.
2. Rubber Technology Handbook: Hoffman.
3. Introduction of Polymer Sc. & Rubber Technology, Vol. I, Ed By Dr. R.Mukhopadhyay.
4. Rubber Engineering, Ed. By K.S. Logonathan.
5. Rubber Technology, Ed. By Maurice Morton.
6. Rubber Processing: An Introduction, Peter S. Johnson.

SEMESTER-III
DSE: POL9105T
Compounding and uses of plastics

Code of the Course : POL9105T
Title of the Course : Compounding and uses of plastics
Level of the Course : NHEQF Level 6.5
Credit of the Course : 4
Type of the Course : Discipline Specific Elective (DSE) Course for PG Polymer science
Delivery Type of the Course: Sixty lectures including diagnostic and formative assessment during lecture hours.

Prerequisites*: Basics of compounding and uses of plastics.*
Course Objectives*: This course provides new insights about nano-composites, compounding, addition polymerization, condensation polymerization, co-polymerization , thermosets plastics ,dyes and pigments, method of polymerization, resin and powder coatings.*

Learning Outcomes:

- *After studying this paper, students would learn-comprehend about compounding, fillers, nanocomposites their introduction and basic need in their polymer manufacturing.*
- *Colour dyes and pigments introduction, classification and application*
- *Types of different coating in polymers.*

Syllabus:

UNIT-I

(12 lecture hours)

Compounding: Introduction, mixing theory, Fillers for Reinforcements, coupling agents,composites Nanocomposites, plasticizers, antioxidants, stabilizer (heat, ultraviolet), flame retardants, colorants, curing agents, blowing agent, lubricants, inhibitors.

UNIT-II

(12 lecture hours)

Addition polymerization: Introduction-Addition polymerization of Polyethylene, Poly-dependence of rate on the initiator and monomer concentration- degree of poly. And kinetics chain length- factors affecting chain poly. Inhibition and retardation.
Condensation polymerization: Introduction-types of Condensation Polymers-Condensation reactions for manufacture of Thermoset Plastics like UF, MF, PF, etc.
Co-polymerization: Introduction-Co poly. Composition equation-applications of co polymers composition equation-block and draft copolymers. Determination of reactivity ratios- reactivity ratios and co poly.
Methods of polymerization: Bulk - solution - Suspension - Emulsion - Gas phase polymerization techniques in detail with examples – Suspension polymerization of PVC, Bulk method for manufacture of PMMA sheet, etc. factors affecting the poly methods with respects to various parameters

UNIT-III

(12 lecture hours)

Advantages and disadvantages of plastics, Monomer preparation, polymerisation, properties and application of LDPE, HDPE, cross linked and chlorinated PE, PP and PS.
Monomer preparation, polymerisation, properties and application of PVC, polyvinilidine chloride, PVA, polyvinylacetate, PMMA and PAN

Monomer preparation, polymerisation, properties and application of PU, PTFE, PVF, ABS, PC, polyacetal, polyester, SAN, epoxies, PF, novolac, resol, MF and UF
Monomer preparation, polymerisation, properties and application of nylon-5, 6, 66, 612 and polyacrylamide Teflon, Terylene, Acrylics

UNIT-IV

(12 lecture hours)

Colourdyes and Pigments: Introduction–colour and constitution- modern theory of colour Dyes–Classification – Application - Pigments and application
Adhesive and bonding: Solvent based, water based and other adhesives based on various polymers, expoxide resins and curing of epoxide resins. Diluents and other additives.

UNIT-V

(12 lecture hours)

Resins and Powder coating: Vinyl dispersions-Introduction, rheology, dispersion and blending resin, stabilization, ingredients, spread coating and applications, roll coating, Fabric coating, film casting, deep coating and molding.
Powder coating: Introduction, manufacturing methods, Application methods, types of powder coating.

E-resources:

1. https://www.scribd.com/document/450784959/K-J-Saunders-auth-Organic-Polymer-Chemistry-An-Introduction-to-the-Organic-Chemistry-of-Adhesives-Fibres-Paints-Plastics-and-Rubbers-Spring
2. https://www.researchgate.net/publication/278319876_Encyclopedia_Of_Polymer_Science_and_Technology
3. https://www.goodreads.com/book/show/3164450-introductory-polymer-chemistry

Books Recommended:

1. K.J. Saunders,"Organic Polymer Chemistry, Chapman and Hall ", London.1973.
2. J.A. Brydson, " Plastic materials", Newnes Butter worths.
3. Encyclopaedia of Polymer Science and Technology.
4. V.R. Gowarikar and N.V.Viswanathan, "Polymer Science",Willey eastern limited.
5. G.S.Misra, "Introductory Polymer Chemistry", Willey eastern limited.
6. Polymers and Resins by Golding
7. Polymerschemistry by Stevens
8. An Introduction to Polymer Physics: I.I.Perepects.
9. "PolymerScience and Technology" by Premamoy Ghosh

SEMESTER III
DSE: POL9106T
Tyre and rubber processing operations

Code of the Course : POL9106T
Title of the Course : Tyre and rubber processing operations
Level of the Course : NHEQF Level 6.5
Credit of the Course : 4
Type of the Course : Discipline Specific Elective (DSE) Course for PG Polymer science
Delivery Type of the Course: Sixty lectures including diagnostic and formative assessment during lecture hours.
Prerequisites*: students will study the application of different polymer as rubber and tyre applications and operation procedure.*
Course Objectives*: This course provides an introduction to tyre and rubber chemistry. It covers topics such as mixing process, extrusion, die construction, trouble shooting, calendaring, molding, fabrication techniques.*

Learning Outcomes:
- *On completion of the course, students shall be able to-understand about Mixing and its Introduction, Material flow to the mixer, feeding, weighing and charging of materials, mixing process.*
- *The fabrication and vulcanization techniques use in industry.*
- *Different types of molding and their application*

Syllabus:

Unit– I

(12 lecture hours)

Mixing: Introduction, Material flow to the mixer, feeding, weighing and charging of materials.
Mixing process: Incorporation, dispersion, distribution and plasticization.
Internal mixer operation: Mixing procedure, temperature control, rotor speed, ram pressure, batch size, dump criteria, Take-off systems, dump mills, packaging, single pass system. Mill mixing and Continuous mixing.
Trouble shooting in mixing: Inadequated is persion or distribution, scorch compound, contamination, poor handling on dump mill and batch to batch variation.

Unit– II

(12 lecture hours)

Extrusion: Basic principles of extrusion. Extrude types Ram type and screw types General mechanical construction of a single screw extruder. Screw design, drive mechanism, temperature control, feed arrangement. Description of Die construction. Function and layout of ancillary equipments. Cold feed extruder, Hot feed extruder, Vented cold feed and Pinextruders.
Trouble shooting: Output rate, dimensional stability, excessive heat generation and rough extrudate, rough surface on extrudate, Contamination, porosity inextrudate.

Unit–III

(12 lecture hours)

Calendaring: Construction, function and uses of calendaring machinery. Types of calendar rolls, roll positioning and adjustments. Temperature control, bending corrections by different methods. Bearings, drives and lubrication systems. Power requirement. Comparison with extruder, cost–comparison with spreading process.

Calendaring operations: sheeting, fractioning, coating, profiling, embossing etc. Troubleshooting in calendaring: Scorch, blistering, rough or holed sheet, tack, bloom.

Unit– IV

(12 lecture hours)

Moulding: Molding of high viscosity materials: Compression, transfer, injection and bladder molding.
Molding of low viscosity material: Casting, reaction injection molding (RIM). Mould design and mould materials. Mould lubrication, mould cleaning, mould shrinkage. Advantages and disadvantages between different molding techniques.
Transfer molding: Equipment used, comparison, costing and safety.
Injection molding: Description, comparison of Ram and Screw Injection system. Typical drive systems and requirement of feed analysis. Molding temperature control, requirement of clamping and loading arrangements. Molding defects, their causes and remedies.

Unit–V

(12 lecture hours)

Fabrication Techniques: General description of fabrication techniques currently used in industrial practice.
Vulcanization Techniques: Thermal energy for vulcanization, saturated steam method, heated gas method, heat transfer fluid method, direct energy transfer method. Vulcanization methods: batch, semi-continuous and continuous vulcanizations and equipment. Open steam vulcaniser, steam tube (autoclave), function of steam trap, control system for steam pressure and temperature. Various allied instrumental control systems. Pressurized gas or liquid vulcaniser, Hot air vulcanising tunnel, continuous microwave oven, liquid or pseudo-liquid curing.

E-resources:

1. https://oa.mg/work/2169240732
2. https://www.scribd.com/document/227843850/R-mukhopadhyay2
3. https://books.google.co.in/books/about/Rubber_Processing.html?id=lShjcA0YQ-UC&redir_esc=y

Books Recommended:

1. Rubber Technology and Manufacturing: C.M. Blow.
2. Rubber Technology Handbook: Hoffman.
3. Introduction of Polymer Sc. & Rubber Technology, Vol. I, Ed By Dr. R. Mukhopadhyay.
4. Rubber Engineering, Ed. By K.S. Logonathan.
5. Rubber Technology, Ed. By Maurice Morton.
6. Rubber Processing: An Introduction, Peter S. Johnson.

SEMESTER-III
DSE: POL9107T
Plastic processing technology

Code of the Course: POL9107T
Title of the Course: Plastic processing technology
Level of the Course: NHEQF Level 6.5
Credit of the Course: 4
Type of the Course: Discipline Specific Elective (DSE) Course for PG Polymer science
Delivery Type of the Course: Sixty lectures including diagnostic and formative assessment during lecture hours.
Prerequisites*: Basics of plastic its classification and application.*
Course Objectives*: This course is designed to provide advanced knowledge and practical skills in the field of*
Plastic processing with additional information about various methods of processing and classification of plastics and also about the molding procedure like compression, transfer, thermoforming, blow molding with complete introduction, advantages and disadvantages and their applications.

Learning Outcomes:

- *On the completion of this course students will be able to learn-deep understanding of plastic processing, thermoplastics, and their applications.*
- *Molding methods such as blow, compression, thermoforming, and transfer molding their advantages and disadvantages with their application.*

Syllabus:

UNIT-I

(12 lecture hours)

What is Plastic Processing - Introduction to various processing methods for thermoplastics and thermo sets-consideration for selection of particular method of processing - flow behavior of polymer melts. Principle of processing of Plastic.

UNIT-II

(12 lecture hours)

Compression molding: Introduction - types of processes : up stroking, down stroking - materials used and selection criteria - preheating - bulk factor - performance -process steps - process advantages and disadvantages - process variables - molding machine details - mold types : flash, semi positive, positive -charging - post curing - cooling fixtures - finishing - molding defects : causes and remedies.

UNIT-III

(12 lecture hours)

Transfer molding: Introduction - transfer molding process types - techniques of transfer molding: pot and plunger types - advantages and disadvantages - process variables ,molding materials , types of molds -pot dimensions and its effects, trouble shooting ,comparison with compression molding.

UNIT-IV

(12 lecture hours)

Thermoforming: Introduction-definition-various process steps-types of materials-material selection criteria in detail with properties like melt stability, plastic memory, etc. sheet thickness in detail required by the process-limitations as regards the types of sheets that can be used, etc., - advantage and disadvantage with the injection molding process-types of machine, molds and its Material in

brief-various process variables-cold forming process With advantage and disadvantage-troubleshooting for the process-Rheology, its importance and applications. Types of thermoforming processes like plug assist, reverse draw forming, bubble type forming, twin sheet thermoforming, etc. Differences between pressure and vacuum forming techniques, types of vacuum forming techniques in detail along with advantages and limitations of each in detail. Engineering applications of thermoformed articles in detail, along with latest developments.

UNIT-V

(12 lecture hours)

Blow molding: Introduction-Basic process-Plastic materials for Blow molding Extrusion blow molding - Continues extrusion process, Intermittent extrusion process, Parison programming Injection Blow molding - Basic process of IBM, Stretch / orienting blow molding Processing parameters, Troubleshooting of blow molding Advantages & Dis-advantages of Bowmolding

E-resources:

1. https://www.isbns.net/isbn/9781447119173/
2. https://link.springer.com/book/9780412801907
3. https://shop.elsevier.com/books/plastics-engineering/crawford/978-0-08-100709-9

Books Recommended:

1. Thermosetting resins by J.F.Monk.
2. Plastics Processing Data Handbook by Rosato
3. Thermoforming by Throne.
4. Plastic engineering by Crawford.
5. “Process Heat Transfer” : D. Q. Kern, McGraw Hill.
6. “Fundamentals of Heat Transfer”: M. Mikheyev, MIR Publications.
7. Unit operations of Chemical Engineering”: W. L. Mccabe and J. C. Smith, McGraw Hill,
8. “Principles of Unit Operation” : A.S. Foust et al, Wiley International, 1990.
9. Plastics material and processes by Schwartz and Goodman
10. Plastics Engg. Handbook by Joel Frados 5.“Heat transmission” : W. H. Mcadams, McGraw Hill, 3rd edition

SEMESTER-III
GEC: POL9108P
Testing of latex and identification of rubbers

Code of the Course: POL9108P
Title of the Course: Testing of latex and identification of rubbers
Level of the Course: NHEQF Level 6.5
Credit of the Course: 4
Type of the Course: Generic Elective Course (GEC) Course for PG Polymer science Practicals
Delivery Type of the Course: 120 practical hours

Syllabus:

30 Marks

I. Testing of natural rubber latex:

1. Determination of total solid content (% TSC)
2. Determination of dry rubber content (% DRC)
3. Determination of mechanical stability
4. Termination of total alkalinity
5. Determination of KOH number
6. Determination of viscosity of latex by Brook field viscometer
7. Determination of coagulum content
8. Determination of magnesium in latex

15 Marks

II. Identification of rubber

1. Preliminary test.
2. Solubility test.
3. Elemental analysis.

15 Marks

III. Final identification by chemical test

1. Group1-Rubbercontainingnitrogen
2. Group 2- Rubber containing chlorine
3. Group 3- Rubber containing bromine
4. Group 4- Rubber containing fluorine
5. Group5-Rubbercontainingsulphur
6. Group6-Rubber not containing nitrogen, halogen and sulphur

IV. Viva voice **10 Marks**

V. Evaluation of record book of experiments performed in semester **10 Marks**

Virtual Labs:

1. https://www.cbspd.co.in/practicals-in-polymer-science-9788123912721-siddaramaiah
2. https://books.google.co.in/books/about/Experiments_In_Polymer_Science.html?id=cANBPgAACAAJ&redir_esc=y

Books recommended:

1. Experiments in polymer science ,New age international publishers., D.G. Hundiwale, V.D. Athawale, U.R. Kapadi, V.V. Gite
2. Practicals in polymer science, CBS Publishers & distributors, Siddaramaiah

SEMESTER-III
GEC: POL9109P
Identification of plastics

Code of the Course: POL9109P
Title of the Course: Identification of plastics
Level of the Course: NHEQF Level 6.5
Credit of the Course: 4
Type of the Course: Generic Elective Course (GEC) Course for PG Polymer science Practical
Delivery Type of the Course: 120 Practical hours

Syllabus

20 Marks

I. Identification of plastic

1. Preliminary test.
2. Solubility test.
3. Elemental analysis (test for heteroatom).
4. Final identification by chemical test

20 Marks

II. Specific identification test

1. Plastic containing nitrogen
2. Plastic containing chlorine
3. Plastic containing fluorine
4. Plastic containing sulphur
5. Plastic not containing nitrogen, sulphur and halogens.

20 Marks

III. Analysis techniques

1. **Spectral analysis:** Characterization of Plastics in the basis of given Xerox copies of spectra (UV, IR, NMR and Mass)
2. **Thermal characterization**: Study of polymer using TGA, DTA, and DSC on the basis of given data.
3. Determination of chlorine content of PVC resin

IV. Viva voice **10 Marks**

V. Evaluation of record book of experiments performed in semester **10 Marks**

Virtual Labs:

1. https://www.cbspd.co.in/practicals-in-polymer-science-9788123912721-siddaramaiah
2. https://books.google.co.in/books/about/Experiments_In_Polymer_Science.html?id=cANBPgAACAAJ&redir_esc=y

Books recommended:

1. Experiments in polymer science ,New age international publishers., D.G. Hundiwale, V.D. Athawale, U.R. Kapadi, V.V. Gite
2. Practicals in polymer science, CBS Publishers & distributors, Siddaramaiah

SEMESTER-IV
DCC: POL9013T
Polymer and Environment

Code of the Course : POL9013T
Title of the Course : Polymer and environment
Level of the Course : NHEQF Level 6.5
Credit of the Course : 4
Type of the Course : Discipline Centric Compulsory (DCC) Course for PG polymer science
Delivery Type of the Course: Sixty lectures including diagnostic and formative assessment during lecture hours.
Prerequisites*: Chemistry courses of basis of polymers and environment.*
Course Objectives*: This course introduces the various methods to manage the plastic waste, and separation techniques, recycling classification and application of recycled wastes.*

Learning Outcomes:

- *On the completion of this course students would learn-about the recycling methods of polymer to minimize the polymer wastage and application of the recycled waste as well.*
- *Also they will learn about the different methods use for plastic, rubber, tyre to disposed.*

Syllabus:

Unit I

(12 lecture hours)

Definition of plastic wastes and litter, basis for assessing plastic wastes, Applications of plastics and their potential as sources of waste. Separation techniques (density - float sink and froth floatation methods, optical, spectroscopic, electrostatic, sorting by melting temperature, sorting by size reduction, sorting by selective dissolution and other methods) ,recent trends in plastic industry, sources of plastics waste, waste management in the global , legislation, strategy, UNIDO programme on polymer

Unit II

(12 lecture hours)

Plastics waste management: 4 R's approach (reduce, reuse, recycle (mechanical and chemical),recover), recycling classification- - primary - secondary - tertiary - quaternary recycling with examples. Energy from waste –incinerators-pyrolysis, factors affecting incineration.
Disposal of plastic waste and litter – role of plastics in the collection of refuse; disposal process – controlled tipping, pulverization, compositing, incineration; air pollution, new developments in thermal disposal of refuse, on-site disposal methods, compacting and baling.
Equipmentforplasticsrecycling:-introduction,extruder,degassing,meltifilitring,pelletiser.

Unit III

(12 lecture hours)

Application of recycled plastics: Recycled LDPE, recycled PVC, recycled polystyrene (PS), recycled HDPE, recycled PET, commingled plastic waste.
Recycling technologies of plastics: Mechanical recycling, products of recycling, economics of recycling
Recycling processes: Advance recycling technology, super wood technology, recyloplast technology

Unit IV

(12 lecture hours)

Recycling of rubber: Introduction, recycling methods, devulcanistion
Recycling of rubber tyres and polyurethane: Process of recycling polyurethane, rubber recycling, novel rese of scraptyres.

Unit V

(12 lecture hours)

Rubber waste disposal: Introduction, physical waste reduction, waste tyre disposal, comparison of thermoses and thermoplastic composites, reclaiming of rubber–fuel source –pyrolysis, depolymerization of scrap rubber, tyre retreading, uses of recycled rubber –asphalt and other uses secondary recycling of MSW by incorporating and blending the recyclable waste with virgin polymers

E-resources:

1. https://www.cbspd.co.in/rubber-plastic-waste-recycling-reuse-and-future-demand-pb-2014
2. https://dokumen.tips/documents/plastics-waste-management-disposal-recycling-and-reuse-nabil-mustafa-ed.html
3. https://www.wiley.com/en-us/Polymer+Recycling%3A+Science%2C+Technology+and+Applications-p-9780471970545

Books Recommended:

1. Rubber and Plastic Waste : Recycling, Reuse and Future Demand by R.Chandra and A. Adab, CBS Publisher, (2004)
2. Plastic Waste Management by Nabil Mustafa, Marcel Dekker, Inc(1993).
3. Medical, Municipal and Plastic Waste Management Handbook by NIIR Board of Consultant and Engineers, National Institute Of Industrial Research (2007).
4. Polymer Recycling by John Scheirs, John Wiley & Sons(1998)
5. Handbook of Rubber Technology by Steven Blow, Hanser Gardner (2000).
6. Recycling and Recovery of Plastics by J Ed Bandrup, Hanser Gardner(1996).

SEMESTER-IV
DSE : POL9110P
Practical-A-IV

Code of the Course : POL9110P
Title of the Course **:** Practical-A-IV
Level of the Course : NHEQF Level 6.5
Credit of the Course : 4
Type of the Course : Discipline Specific Elective (DSE) Course for PG Polymer science Practical
Delivery Type of the Course: 120 practical hours

Syllabus

I. Determination of polymer **60 Marks**

1. Viscosity and mol. Wt. determination by ubbelhele/Ostwald viscometry
2. Study of antioxidants/amino acids by thin layer chromatography / Paper chromatography.
3. Estimation of some physical properties of polymers:
4. Determination of percentage of filler/fibre contents in the polymer composite.
5. Determination of ash content of given polymer.
6. Determination of moisture content of the polymer sample.
7. Determination of water absorption of the polymer sample
8. Determination of melting point of the polymer sample.
9. Determination of density of the polymer.
10. Determination of bulk density for polymer powder or granules.

II. Viva-voce **10 Marks**

III. Evaluation of record book of experiments performed in semester **10 Marks**

Virtual Labs:

1. https://www.cbspd.co.in/practicals-in-polymer-science-9788123912721-siddaramaiah
2. https://books.google.co.in/books/about/Experiments_In_Polymer_Science.html?id=cANBPgAACAAJ&redir_esc=y

Books recommended:

1. Experiments in polymer science ,New age international publishers., D.G. Hundiwale, V.D.Athawale, U.R. Kapadi, V.V. Gite
2. Practicals in polymer science, CBS Publishers & distributors, Siddaramaiah

SEMESTER-IV
DSE: POL9111P
Polymer Synthesis and Extraction of Natural Products Lab

Code of the Course: POL9111P

Title of the Course: Polymer Synthesis and Extraction of Natural Products Lab

Level of the Course: NHEQF Level 6.5

Credit of the Course: 4

Type of the Course: Discipline Specific Elective (DSE) Course for PG Chemistry Practical

Delivery Type of the Course: 120 hours (80 hours for the hands on experiments, observations and record of the data , 20 hours for the experiment, instruments demonstration, lab practices and the 20 hours for the diagnostic assessment, formative assessment, subject/ class activity and problem solving).

Syllabus:

I. Extraction of Organic Compounds from Natural Sources (Minimum-4) 25 Marks

1. Extraction of tea leaves and identification of caffeine.
2. Identification of casein in milk (the students are required to try some typical colour reactions of proteins).
3. Identification of lactose in milk (purity of sugar should be checked by TLC and Rf value reported).
4. Extraction of tobacco leaves and identification, isolation of nicotine and synthesize its dipicrate.
5. Extraction of black pepper and identification of piperine.
6. Extraction of tomato and identification of lycopene.

II. Polymer Synthesis (Minimum-5) 15 marks

1. Preparation of urea formaldehyde resin
2. Preparation of phenol formaldehyde resin
3. Preparation of thiol rubber
4. Preparation of condensation polymer
5. Preparation of epoxy resin
6. Preparation of polymerization of acrylonitrile
7. Preparation of solution polymerization of vinyl acetate
8. Preparation of free radical polymer

III. Coal Analysis 20 Marks

1. Moisture contents/Volatile matter
2. Ash contents
3. Fixed carbon

IV. Viva-voce 10 Marks

V. Evaluation of record book of experiments performed in semester 10 Marks

Virtual labs:

1. https://www.youtube.com/watch?v=sPhJWBL17OQ
2. https://mitrask.com/extraction-and-isolation-of-piperine-from-black-pepper/
3. https://www.youtube.com/watch?v=K9XehILQT5E
4. https://youtu.be/AR0vQ2EW4ZI?si=I0P4x1A0Uti2ofUn

Books Recommended:

1. Vogel's Textbook of Practical Organic Chemistry by B.S. Furniss, Pearson.
2. Practical Organic Chemistry by J.T. Sharp, Springer.
3. Advanced Practical Organic Chemistry, O.P. Agarwal, Krishna Publications.
4. Advanced Practical Organic Chemistry, N.K. Vishnoi, Vikas Publishing House

SEMESTER-IV
DSE: POL9112T
Rubber product technology

Code of the Course : POL9112T
Title of the Course : Rubber product technology
Level of the Course : NHEQF Level 6.5
Credit of the Course : 4
Type of the Course : Discipline Specific Core Course (DSE) Course for PG Polymer science
Delivery Type of the Course: Sixty lectures including diagnostic and formative assessment during lecture hours.
Prerequisites: *Chemistry courses of under graduate or equivalent with basic knowledge rubber product and their applicatios.*
Course Objectives*: This course enhancements the student with knowledge of various tyre design, their manufacturing process, analysis techniques, tubes, valves and different belts, Rubber to metal bonded components, rubber footwear, latex products.*

Learning Outcomes:

- *On the completion of this course students would learn: about tyre designing and manufacturing and their application and analysis methods.*
- *About flat, V-belt, their components and testing methods.*
- *Rubber footwear and sports goods compounding and process to manufacture them.*

Syllabus:

Unit–I

(12 lecture hours)

Pneumatic Tyre: Functions of tyre, tube and rim assembly. Components of a tyre and their function. Tyre Construction (Bias, Radial, Bias-belted). Tyre Types. Tread design (Lug, Rib and Semi Lug). Compounding for casing, tread and bead. Tyre reinforcing materials (Rayon, Nylon, Polyester, Aramid, Glass Fiber and Steel Wire).Organic cord treatment(Dipping), Metal to rubber bonding.
Tyre Design and performance: Criteria for cycle, motorcycle, truck, aircraft and tube-less tyres. Tyre Manufacturing process, Defects observed and remedial action.
Lateral Stiffness, Torsional Stiffness, Cornering power, Rolling Resistance, Friction and Wet Grip. Destructive and Non-destructive tests of tyre.

Unit–II

(12 lecture hours)

Tube and Valves: Principles of Tube Design, Manufacturing of Tubes: Tube extrusion, valving, splicing, inflation, curing. Compounding of tube and tube valve. Tube Defects and Tube Testing.
Conveyor Belting: Functions, Components, component requirement, compounding and Belt design. Defects and testing of belt.
Flat Belt and V-Belt: Functions, Components, component requirement, compounding and Belt design. Defects and testing of belt.

Unit– III

(12 lecture hours)

Hoses: Hose Compounding , Design and Construction, Reinforcing Materials, Moulded, Machine made, hand made and circular woven hoses.
Rubber Footwear: Hot air vulcanized, compression molded, direct molded. Process for shoe

bottoming, injection molded sole and heel units. Safety, conductive and anti static footwear. Footwear compounding.

Unit– IV

(12 lecture hours)

Rubber to metal bonded components: Metal cleaning, application of bonding medium, equipment lining and molding.
Cellular Rubber: Expansion technology, Compounding of sponge rubber, expanded rubber by nitrogengas and chemical blowing agents.
Sports Goods: Compounding and Process of Tennis Ball, Football, Basketball, Volleyball and Golf Ball.

Unit– V

(12 lecture hours)

Cables: Compound formulations and evaluations, application of insulator and sheath, curingtechniques and specialized cable components.
Latex Products: Manufacturing Process of Dipped Goods, Threads and Foams. Mix design of Rubber Rollers.
Dipping Process: Dipping process for Nylon and Polyester.

E-resources:

1. https://books.google.co.in/books/about/Rubber_Technology_and_Manufacture.html?id=fPxTAAAAMAAJ&redir_esc=y
2. https://www.scribd.com/document/227843850/R-mukhopadhyay2

Books Recommended:

1. Rubber Technology and Manufacturing: C. M. Blow.
2. Introduction of Polymer Sc. & Rubber Technology, Vol. I, Ed. By Dr. R. Mukhopadhyay.
3. Rubber Engineering, Ed. By K. S. Logonathan.

SEMESTER-IV
DSE: POL9113T
Identification and testing of plastics

Code of the Course: POL9113T
Title of the Course: Identification and testing of plastics
Level of the Course: NHEQF Level 6.5
Credit of the Course: 4
Type of the Course: Discipline Specific Elective (DSE) Course for PG Polymer science
Delivery Type of the Course: Sixty lectures including diagnostic and formative assessment during lecture hours.
Prerequisites*: Basics of plastic ad its classification with application.*
Course Objectives*: The main aim is to provide students with a basic understanding and knowledge of mechanical behavior of materials, mechanism of plastic deformation, stress-strain curve, Identification of materials by thermal, elemental and solubility analysis, thermal and spectral characterization.*

Learning Outcomes:

- *After studying this paper, students would learn-about the production and application of biodegradable plastics based on proteins, nucleic acid, etc.*
- *TGA,DTA,DSC,TMA instrumentation and application and spectroscopic characterization.*
- *Mechanical testing of polymer and chemical testing and their analysis methods*

Syllabus:

UNIT I

(12 lecture hours)

Mechanical Behavior of materials – Stress – Strain curve, Elastic deformation Characteristics of elastic deformations, atomic mechanism of elastic deformation, Inelastic deformation, Strain-Time curves, Damping capacity, Viscous deformation, Plastic deformation, Mechanism of plastic deformation- slip & twinning, Schmidt's law, critical resolved shear stress. determination of Meltflow index(MFI)

UNIT II

(12 lecture hours)

Mechanical testing and fracture of materials: Tensile test, stress-strain curves for ductile and brittle materials – mild steel, copper, proof stress, yield point phenomena, Luder's bands, compression test, hardness test – various hardness tests. Impact test – ductile-brittle transitions. Fatigue- Stress cycles for fatigue testing, endurance limit, fatigue limit, S-N curve, Creep-curve, primary creep, secondary creep, tertiary creep. Fracture – ideal fracture stress, brittle fracture- Griffith's theory- fracture toughness, ductile failure, cup & conetype fracture, fatigue failure.

UNIT-III

(12 lecture hours)

Chemical Characterization: Identification of materials by thermal, elemental and solubility analysis. Identification by colour tests. Estimation of specific chemical characteristics like acid number, saponification value and hydroxyl values. Solvent extraction and its analysis for polymers.

UNIT-IV

(12 lecture hours)

Thermal Characterization: Study of the instrumentation and application of the following techniques to polymer –TGA, DTA, DSC and TMA.

Spectroscopic Characterization: Basic principles, instrumentation and applications of the following techniques –UV and Visible, IR, FTIR with ATR, HPLC, GPC and GC-MS.

UNIT-V

(12 lecture hours)

Production and application of biodegradable plastics: Based on pvoh, lactic Acid, polypeptides, Proteins, nucleic acid, polylactic acid, PHBV, Carbohydrates.

E-resources:

1. http://www.issp.ac.ru/ebooks/books/open/Materials_Science_and_Technology.pdf
2. https://irp.cdn-website.com/de03f082/files/uploaded/9302285925.pdf
3. https://www.scirp.org/(S(351jmbntvnsjt1aadkposzje))/reference/ReferencesPapers.aspx?ReferenceID=486423
4. https://books.google.co.in/books/about/Polymer_Science.html?id=mvCzE_AflUIC
5. https://www.oreilly.com/library/view/polymer-science-and/9780137039975/
6. https://www.cipet.gov.in/academics/Handbook.pdf

Books Recommended:

1. M. Arumugham, Material Science, Anuradha Agencies, 1st Ed., 1987.
2. G.E. Dieter, Mechanical metallurgy, McGraw-Hill, 2000.
3. Klaus Stoeckhert, Mold making handbook for the Plastic engineers, Hanser Pub.
4. Databook on Plastics –CIPET, Chennai.
5. J.C. Anderson, K. D. Leaver, R. D. Rawlings, J. M. Alexander, Material Science,
6. Donald S. Clark and Wilbur R Warney, Physical metallurgy, Affltd. East west press.
7. C.W. Richards, Engineering Material Science, Prentice Hall of India.
8. Polymer science: V.R. Goowarikar, N.V. Viswanathan, Jayadev Sridhar
9. Text book of Polymer Science: Fred W. Billmeyer
10. Polymer science & Technology: Joel R. Fried
11. Polymer Science and Technology: Premamoy Ghosh

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SEMESTER-IV
DSE: POL9114T
Testing and characterization of rubber product

Code of the Course: POL9114T
Title of the Course: Testing and characterization of rubber product
Level of the Course: NHEQF Level 6.5
Credit of the Course: 4
Type of the Course: Discipline Centric Compulsory (DSE) Course for PG Polymer science.
Delivery Type of the Course: Sixty lectures including diagnostic and formative assessment during lecture hours.
Prerequisites*: This course deals with the testing and characterization of rubber product.*
Course Objectives*: This course provides an introduction of testing of tyres, tubes, footwear and other appliances .*

Learning Outcomes:

- *By the end of this course, students would learn-Demonstrate an ability to describe, with confidence, the features of the most common structure and testing of polymer like hose, rubber goods etc.*
- *Testing of tyres and determination of hardness of rubber and their analysis* methods.

Syllabus:

UNIT-I

(12 lecture hours)

Testing of Tyres: Pulley wheel and plunger testing for endurance, Pulley wheel testing for mileage and temperature build up, Measurement of stiffness, Rolling resistance.
Ply to plyadhesion, sidewall to ply adhesion. Breaker/ belt toply adhesion., Stress-Strain property of tread, side wall compound.
7 Determination of Mooney viscosity and moony scorch of Tread , side wall compound.
Determination of Rheometric properties of Tread, side wall by Rheometer.
Determination of hardness of rubber vulcanizate.

UNIT-II

(12 lecture hours)

Testing of Tubes: Airpermeability, testing, growth of tube testing, set and swelling. Aging test of tube, splice testing of tube, Valve testing.
Testing of power transmission belt and conveyor belt : Drum friction test, steel test, tensile testing, ply adhesion testing, Specific gravity test of compound. Heat buildup test by good rich flexometer.

UNIT-III

(12 lecture hours)

Testing of Footwear: Taber abrasion testing, Flexto fatigue test for sole compound by Rose Flexing machine.
Compression set measurement, Constant stress and constant strain test. Hardness testing of sole.

UNIT-IV

(12 lecture hours)

Testing ofHoses:Leakagetest,Burstingstrength,Impulsetest,Oilresistance,Flame resistance etc.

UNIT-V

(12 lecture hours)

Testing of Cables: Permittivity, resistivity, die electric strength, Corna discharge.
Testing of Moulded and Extruded Rubber Goods : Compression set, swelling, ageing in Ozone , aging test by heat.
Testing of Raw material : DBP Adsorption of Carbon Black, Dipped Pick up test for Nylon, H-Adhesion test for textile and rubber, Strip Adhesion Test.

E-resources:

1. https://pusdataspm.kemenag.go.id/e3//files/record?trackid=J06686a&readPDF=Tyre_Testing_T_V_Pdf.pdf
2. https://www.perlego.com/book/1855611/tire-and-vehicle-dynamics-pdf
3. https://www.qima.com/testing/footwear/physical-testing-methods
4. https://www.fddiindia.com/footwear-testing.php
5. https://www.ctcgroupe.com/en/our-services/physical-and-biomechanical-testing/footwear-physical-testing-240-1.html

Books recommended:

1. Tire and Vehicle Dynamics by Hans Pacejka
2. Footwear Testing Methods for Safety Regulations

SEMESTER-IV
DSE: POL9115T
Textile technology

Code of the Course: POL9115T
Title of the Course: Textile technology
Level of the Course: NHEQF Level 6.5
Credit of the Course: 4
Type of the Course: Discipline Specific core Course (DSE) Course for PG Polymer science
Delivery Type of the Course: Sixty lectures including diagnostic and formative assessment during lecture hours.
Prerequisites*: study about the linear polymer and raw material and general physical and chemical properties of textile fibres.*
Course Objectives*: This course provides an introduction to the linear polymer and raw material, textile fibres, general principle of manufacturing of manmade fiber, types of weaving etc.*

Learning Outcomes:

- *After studying this paper, students would learn-about principle and objective of carding, maintenance of machines, methods of mixing, construction and working of machines.*
- *Yarn manufacturing introduction and different methods of mixing.*

Syllabus:

UNIT-I

(12 Lecture hours)

Introduction to the linear polymer and raw material – DMT, TPA, MEG, Caprolactum. Process of polymerization and importance of Production process of PET polymer, Nylon 6, Nylon 66,Acrylic polymer, Polypropylene polymer etc.
Basic concept related to the structure of Textile Fibers like wool, silk, linen etc.
GeneralPhysicalandChemicalpropertiesofvarioustextilefibres–NaturalandManmadefibres.Brief idea of processing of raw silk & Jute Outline of degumming methods for silk.

UNIT-II

(12 lecture hours)

General principles of manufacturing manmade fibres by melt spinning, dry spinning and wet spinning. Object, process details and properties of end product for various processes such as bleaching, stitching, brushing, shearing, singeing, desizing, washing, pressure mangling, drying etc. Machines used for various processes.
Outline of steps for the manufacture of polyamide, polyeaster, polyacrylics & polypropylene fibres. Introduction to new fibres like Tencel, Lycra, Aramide, Model etc.

UNIT-III

(12 lecture hours)

Typeof Weaving Winding : (a) Warp Winders: Central idea of development of Winding Machines Precision Winding; Tension Control; Slub Catchers; Study of Automatic. Winders such as Barber & Auto-corner, Winding faults & remedies. (b) Pirn Winders: Need for Pirn Winding; Brief outline of non-automatic pirn winders; Study of automatic pirn commonly used. Modern developments in winding.
Plain Loom : Basic Weaving Mechanism such as shedding; picking & beating Shuttle and shuttle boxes; shuttle flight control; Slay movement; General idea of tappet design; Secondary motion. negative let off motion, brake motion; weft fork stop motion etc. Heads & reeds &Temples. Timings & Settings of plain looms. Simple cloth faults and their remedies.

UNIT-IV

(12 lecture hours)

Yarn Manufacturing: General idea of Ginning & Baling Processes, Characteristics of bales and importance of contaminations.
Objects of Mixing; Methods of Mixing; Different types of conventional feeders; openers &cleaners; Use of air currents for cleaning & Transportation; Blow Room sequence for different cotton & manmade fibres; Construction & working of machines for single process Blow Room, Modern openers & cleaners.

UNIT-V

(12 lecture hours)

Principles & objects of carding; construction of working of revolving flat card; card clothing and its effect on sliver quality., mounting; Grinding & stripping with integrated grinding system., card settings; High Production Cards. Card waste and importance of suction hood for waste optimization at. card
Recent developments, all modern attachment like pre and post carding elements etc, Tandem Card-Chute feeding system-Auto levelers at card. Common defects and remedies in product delivered at each machine. Maintenance of machines.

E-resources:

1. https://www.textileinstitute.org/product/a-practical-guide-to-the-blowroom-and-carding/
2. https://www.academia.edu/28688838/SPUN_YARN_TECHNOLOGY
3. https://www.academia.edu/45610348/Principles_of_Weaving_The_Textile_Institute

Books Recommended:

1. A practical guide to opening and carding-W. klein.
2. Spunyarn technology, volume I, Blowroom processes - A.Ventasubramani.
3. Spun yarn technology, volume II, carding -A.Ventasubramani
4. Principles of weaving by Marks & Robinson, Textile Institute
5. Plain Loom Motions by Aswani
6. Woven Fabric Production Part I, NCUTE Publication
7. Yarn Preparation Vol. I by Sengupta

SEMESTER-IV
DSE: POL9116P
Mechanical properties and testing of rubbers

(120 Hrs Practicals)

Code of the Course : POL9116P
Title of the Course : Mechanical properties and testing of rubbers
Level of the Course : NHEQF Level 6.5
Credit of the Course : 4
Type of the Course : Discipline Specific Elective (DSE) Course for PG Polymer science Practical
Delivery Type of the Course : 120 practical hours

Syllabus

60 marks

I. Testing of polymer

1. Mechanical testing and Processing of Polymers
2. Tensile impact strength of polymers
3. MFI of thermoplastics
4. Abrasion loss, Abrasion index of rubber Vulcanisate
5. Swell index and volume fraction of cured rubber stock
6. Stress–strain properties of organic Tyrecord
7. Textile to rubber adhesion by H-adhesion technique

II. Viva-voce **10 Marks**

III. Evaluation of record book of experiments performed in semester **10 Marks**

Virtual Labs:

1. https://www.cbspd.co.in/practicals-in-polymer-science-9788123912721-siddaramaiah
2. https://books.google.co.in/books/about/Experiments_In_Polymer_Science.html?id=cANBPgAACAAJ&redir_esc=y

Books recommended:

1. Experiments in polymer science ,New age international publishers., D.G. Hundiwale, V.D. Athawale, U.R. Kapadi, V.V. Gite
2. Practicals in polymer science, CBS Publishers & Distributors, Siddaramaiah

SEMESTER-IV
DSE: POL9117P
Mechanical properties and testing of plastics

(120 Hrs Practicals)

Code of the Course : POL9029P
Title of the Course : Mechanical properties and testing of plastics
Level of the Course : NHEQF Level 6.5
Credit of the Course : 4
Type of the Course : Discipline Specific Elective (DSE) Course for PG Polymer science
Delivery Type of the Course : 120 practical hours

Syllabus

30 Marks

I. Mechanical testing and Processing of Polymers

1. Tensile impact strength of polymers
2. MFI of thermoplastics

30 Marks

II. Determination method

1. Testing and characterization of polymer: volatile matter, ash content, MOISTURE CONTENT, mooney viscosity, water absorption
2. Determination of plastisizer in PVC
3. Estimation of resistance of plastic films to chemicals and to measure the weight change of films after immersion in chemicals as per ASTMD1239-55method

III. Viva-voce **10 Marks**

IV. Evaluation of record book of experiments performed in semester **10 Marks**

Virtual Labs:

1. https://www.cbspd.co.in/practicals-in-polymer-science-9788123912721-siddaramaiah
2. https://books.google.co.in/books/about/Experiments_In_Polymer_Science.html?id=cANBPgAACAAJ&redir_esc=y

Books recommended:

1. Experiments in polymer science ,New age international publishers., D.G. Hundiwale, V.D. Athawale, U.R. Kapadi, V.V. Gite
2. Practicals in polymer science, CBS Publishers & distributors, Siddaramaiah

SEMESTER-IV
DSE: POL9118S
Project work (at research laboratory or industry or institute of repute)
(60 days)

Code of the Course : POL9118S

Title of the Course : Project work (at research laboratory or industry or institute of repute) (60 days)

Level of the Course : NHEQF Level 6.5

Credit of the Course : 4

Type of the Course : Discipline Specific Elective (DSE) Course for PG Polymer science.

Delivery Type of the Course: Sixty lectures including diagnostic and formative assessment during lecture hours.

General Guidelines for Preparation of Project Report

(For specific details the students are advised to consult their respective supervisors)

1. Strictly follow the format given to write the manuscript of the project.
2. On the front page include title of the project (font size 21, centered). The title should not contain abbreviation and scientific names of organisms should be in *italics.* This page should not be numbered.
3. Starting from second page, the pages must be numbered consecutively, including figures and table.
4. Text should be 1.5 point spaced type written using Times New Roman Font, Font Size 12, on one side of A 4 Size paper, with 1.5 inch margins throughout. Scientific names of the organisms should be in *italics.* Main headings (Summary, Introduction, Chapter details, Conclusions and References) should be bold type, justified and separated from the text.
5. The full text of project should not exceed 20-25 one side typed pages.
6. Literature citation in the text should be cited in alphabetic order. The form and style of references should be as indicated below.

(a) Journal article

Carvalho, L.C., Goulao, L., Oliveira, C., Goncalves, C.J. and Amancio, S. 2004. Rapid assessment for identification of clonal identity and genetic stability of *in vitro* propagated chestnut hybrids. Plant Cell Tiss. Org. Cult. 77:23-27.

Chae, W.B., Choi, G.W. and Chung, I.S. 2004. Plant regeneration depending on explant type in *Chrysanthemum coronarium* L. J. Plant Biotech.6:253-258.

(b) Book reference

Salisbury, F.B., Ross, C.W. 1992. Plant Physiology. 4thedn.Wadsworth Publishing Company. Belmount.

(c) Edited books

Constantine, D.R. 1986. Micropropagation in the commercial environment. In : "Plant Tissue Culture and its Agricultural Applications". L.A. Withers and P.G. Alderson (Eds.) pp. 175-186.Butterworths,London, UK.

(d) Paper presented at a conference

Chaturvedi, H.C. 1992. Hardening of *in vitro* raised plants for transplant success. A state of art report. Paper presented in DBT Project Monitoring Committee Meeting held on 6th-7th July,1992 in DBT, New Delhi, India.

(e)Proceeding of a symposium

Rajsekharan, P. E., Ganeshan, S. 2005. Designing *ex situ* conservation strategies for threatened medicinal plant species of South India. In: " Proc. Natl. Symp. and 27th Annual Meeting of PTCA(I)." A.K. Kukreja *et al* (Eds). Pp.159-164. CIMAP, Lucknow, India.

(f)Thesis/ Dissertation

Dave, N. 2004. Factors influencing micropropagation of two varieties of *Achrassapota* and their root stock *Mimusopshexandra*. Ph. D. Thesis, Mohanlal Sukhadia University, Udaipur, India.

(g)Patent

Trepaginer, J.H. 2000.New surface finishings and coatings. US Pat 1276323 (to DuPont Inc, USA). 27June, 2000. ChemAbstr, 49 (2000) 27689.

(h)Reports

Anonymous,1976.The Wealth of India.Raw Meterials.Vo.X. pp. 44-48. CSIR, New Delhi, India

TITLE MUST BE IN CAPITAL LETTERS, SIZE 21 AND

CENTERED, WITH *Scientific names* IN ITALICS

A Project Report submitted
for the partial fulfillment of the Degree of Master of Science

By

(Name of student)
[M.Sc. Polymer Science]

DEPARTMENT OFPOLYMER SCIENCE
University College of Science
MOHANLAL SUKHADIA UNIVERSITYUDAIPUR
(SESSION)

INSTITUTE NAME AND LOGO

Ref no.-…….. Date……

CERTIFICATE

This is to certify that the dissertation/project report entitled "....." submitted towards the partial fulfillment for the award of the degree of Master of Science in Polymer Science, from Mohanlal Sukhadia University, Udaipur (Rajasthan) India is the result of bonafide work compiled by Mr./Ms. ……. carried out under the guidance of Dr./Mr./Ms.……. At ……. under my supervision in the academic year of ……. . It has no part the dissertation has been submitted for the award of any degree, diploma, fellowship or other similar titles or prizes and that the work has not been published in part or full in any scientific or popular journals or magazines.

Date

Name & Signature of the supervisor Seal of the supervisor

DECLARATION

I, …….. Roll No. ……..... student of M.Sc. IV Semester Polymer Science (Session 20XX-XX) hereby declare that the project entitled "…….....” is my own compilation. I have strictly adhered to the guidelines provided by the department for the preparation of the project report.

Dated: Signature of the Student

MARKING SCHEME FOR Project Work

S.No.		Maximum Marks	Marks Obtained
1	**Project Report** (i) Review of Literature (ii) Methodology (iii)Outcome (iv)Discussion	 10 10 10 20	
2	Presentation	25	
3	Viva–voce	25	
	TOTALMARKS	**100**	