PREAMBLE

The objective of any programme at Higher Education Institute is to prepare their students for the society at large. The University of Delhi envisions all its programmes in the best interest of their students and in this endeavour, it offers a new vision to all its Under-Graduate courses. It imbibes a Learning Outcome-based Curriculum Framework (LOCF) for all its Under Graduate programmes.

The LOCF approach is envisioned to provide a focused, outcome-based syllabus at the undergraduate level with an agenda to structure the teaching-learning experiences in a more student-centric manner. The LOCF approach has been adopted to strengthen students' experiences as they engage themselves in the programme of their choice. The Under-Graduate Programmes will prepare the students for both, academia and employability.

Each programme vividly elaborates its nature and promises the outcomes that are to be accomplished by studying the courses. The programmes also state the attributes that it offers to inculcate at the graduation level. The graduate attributes encompass values related to well-being, emotional stability, critical thinking, social justice and also skills for employability. In short, each programme prepares students for sustainability and life-long learning.

The new curriculum of B.Sc. (Hons) Polymer Science accomplishes excellence in education and research to meet the growing needs of the society. This course provides an environment conducive to innovation, creativity, implementation of new ideas and team spirit so as to foster young and fresh talents. It also promotes high standards of professional ethics. This course further offers an awareness and understanding of the contemporary trends and growth in the field of polymer science. This will further be substantiated by enabling students in relevant academic and professional skills by self- reflections and prepare them to contribute to the growing discipline of polymer science and its application in everyday life. It has been framed to maintain the teaching standards, assessment of students and keeping the interface of polymer science-individual/community for the human welfare in forefront. The syllabus has been designed to cover the different fields of polymer science along with practical understanding wherever required and possible within the CBCS framework. It also inculcates the knowledge provided to them via classroom lectures, workshops or seminars and applies the same in real life settings.

The University of Delhi hopes the LOCF approach of the programme B.Sc. (Hons) Polymer Science will help students in making an informed decision regarding the goals that they wish to pursue in further education and life, at large.

INTRODUCTION:

The Choice Based Credit System (CBCS) opens up various prospects to a student to choose courses from the syllabus comprising Core, Elective and Skill based courses. It offers a flexible course structure ensuring that each student gets a strong base in the subject and thorough knowledge. The learning outcome based curriculum framework will provide students with a clear vision to make a wise choice regarding the course they wish to study. This will make the students more competent to fulfil present day needs of acquiring knowledge to achieve their goal through higher studies or employment and research.

PROGRAMME DURATION AND DESIGN:

The B.Sc. (Hons) Polymer Science course is a six semester course to be taught in three academic years. The curriculum of this course is designed to engage students in theory, practical, discussions and presentations in addition to conventional teaching-learning process. Students will be encouraged to carry out short projects and industrial training. As a part of the curriculum industrial and R & D lab visits will also be organized. Students will also be motivated to participate in seminars, conferences and workshops. Each theory paper consists of 100 marks out of which 25 marks are kept for internal assessment (class test, presentation, group discussion, quiz, assignment etc.) and a practical paper will be of 50 marks of which 25 marks will be internally assessed.

PROGRAMME STRUCTURE:

The programme offers Core Courses and Elective Courses. The Core Courses are compulsory in nature. There are three types of Elective Courses – Discipline Specific Elective (DSE), Generic Elective (GE) and Skill Enhancement Courses (SEC). In addition, there are two mandatory Ability Enhancement Courses (AEC) namely English/MIL Communication and EVS. The Core, DSE and GE papers are of six credits each; while the SEC and AEC are of four credits each.

To graduate in B.Sc. (Hons.) Polymer Science, the students will be studying fourteen Core papers, four Discipline Specific Elective papers, four Generic Elective papers, two Skill Enhancement papers and two Ability Enhancement papers.

The distribution of papers is as follows: two Core papers each, in Semesters I and II, three Core Courses each in Semesters III and IV and two Core Courses each in Semesters V and VI. The programme offers nine Discipline-Specific Electives, of which the student will study two in each of the Semesters V and VI.

Various Generic Elective Courses are floated for the students of B.Sc. (Hons.) Polymer Science Programme by other Departments of the College and each student will have the option to select one GE Courses each in Semesters I, II, III, and IV. The Department of Polymer Science offers ten GE Courses to students of other disciplines (refer to * on page 5).

Students will study one Skill Enhancement paper in Semesters III and IV.

B.Sc. (H) POLYMER SCIENCE PROGRAMME STRUCTURE AND COURSE DISTRIBUTION

Semester	Core Course (14)	Ability Enhancement Course (AEC) (2)	Skill Enhc. Course (SEC)(2)	Discipline Specific Elective (DSE) (4)	Generic Elective (GE) (4)
I	Introduction to Polymer Science	English/MIL Communication or EVS			GE-1
	Raw Materials of Polymers				
II	Polymer Technology	English/MIL Communication or EVS			GE-2
	Unit Operations				
III	Polymer Rheology		SEC – 1		GE-3
	Polymer Additives				
	Polymer Degradation				
IV	Polymer Processing & Mold Design		SEC – 2		GE-4
	Polymer Testing				
	Recycling and Waste Management				
V	Polymer Characterization			DSE-1	
	Specialty Polymers			DSE-2	
VI	Polymer Blends and Composites			DSE -3	
	Fibre Science and Rubber Technology			DSE-4	

COURSES OFFERED UNDER B.Sc. (H) POLYMER SCIENCE PROGRAMME (CBCS)

CORE COURSES –14 (six credits each) – Each course has 4 Periods/week for Theory, 4 Periods/week for Practical			
SEMESTER	**COURSE CODE**	**NAME OF THE COURSE**	**CREDITS T=Theory Credits P=Practical Credits**
I	C-101	Introduction to Polymer Science	T=4 P=2
	C-102	Raw Materials of Polymers	T=4 P=2

II	C-201	Polymer Technology	T=4 P=2
	C-202	Unit Operations	T=4 P=2
III	C-301	Polymer Rheology	T=4 P=2
	C-302	Polymer Additives	T=4 P=2
	C-303	Polymer Degradation	T=4 P=2
IV	C-401	Polymer Processing & Mold Design	T=4 P=2
	C-402	Polymer Testing	T=4 P=2
	C-403	Recycling and Waste Management	T=4 P=2
V	C-501	Polymer Characterization	T=4 P=2
	C-502	Specialty Polymers	T=4 P=2
VI	C-601	Polymer Blends and Composites	T=4 P=2
	C-602	Fibre Science and Rubber Technology	T=4 P=2
			Credits: 14× 6 = 84

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE) – 4 (six credits each, refer to ** on page 5)
Each course has 4 Periods/week for Theory, 4 Periods/week for Practical

SEMESTER	COURSE CODE	NAME OF THE COURSE	CREDITS T=Theory Credits P=Practical Credits
V, VI	DSE: Paper 1	Conducting Polymers	T=4 P=2
	DSE: Paper 2	Fibre Manufacturing Technology	T=4 P=2
	DSE: Paper 3	Paints, Coatings and Adhesives	T=4 P=2
	DSE: Paper 4	Polymeric Nanomaterials	T=4 P=2
	DSE: Paper 5	Tyre Technology	T=4 P=2
	DSE: Paper 6	Packaging Technology	T=4 P=2
	DSE: Paper 7	Fabrication of Polymeric Products	T=4 P=2
	DSE: Paper 8	Polymer in Biomedical Applications	T=4 P=2
	DSE: Paper 9	Dissertation	P=6
			Credits: 4 × 6 = 24

GENERIC ELECTIVES COURSES (GE)– 4(six credits each) –offered by other Departments

Each course has 4 Periods/week for Theory, 4 Periods/week for Practical			
SEMESTER	**COURSE CODE**	**NAME OF THE COURSE**	**CREDITS** **T=Theory Credits** **P=Practical Credits**
I		GE 1	6
II		GE 2	6
III		GE 3	6
IV		GE 4	6
			Credits: 4 × 6 = 24

SKILL ENHANCEMENT ELECTIVE COURSES (SEC) – 2 (four credits each, refer to * on page 6)**			
SEMESTER	**COURSE CODE**	**NAME OF THE COURSE**	**CREDITS** **T=Theory Credits** **P=Practical Credits**
III-IV	SEC: Paper 1	Biopolymers	T=2 P=2
	SEC: Paper 2	Estimation of Polymers and Polymeric Compounds	T=2 P=2
	SEC: Paper 3	Wire and Cable Technology	T=2 P=2
	SEC: Paper 4	Footwear Technology	T=2 P=2
			Credits: 2 × 4 = 08

ABILITY ENHANCEMENT COURSES (AEC) – 2 (4 credits each)			
SEMESTER	**COURSE CODE**	**NAME OF THE COURSE**	**CREDITS** **T=Theory Credits** **P=Practical Credits**
I-II	AECC1	English/MIL Communication or EVS	T = 4
	AECC2	English/MIL Communication or EVS	T = 4
			Credits: 2 × 4 = 08
TOTAL CREDITS = 148			

***Generic Elective Papers (GE) (Minor-Polymer Science) (any four) for other Departments/Disciplines: (Credit: 06 each – 4T + 2P)**

GE: Paper 1- Basics of Polymer Science

GE: Paper 2- Chemistry of Polymers
GE: Paper 3- Polymer Testing and Characterization
GE: Paper 4- Polymer Modifiers and Waste Management
GE: Paper 5- Product Manufacturing and Processing
GE: Paper 6- Material Science
GE: Paper 7- Biomedical Applications of Polymers
GE: Paper 8- Fibres and Rubbers
GE: Paper 9- Polymers in Packaging
GE: Paper 10 - Polymers for Electrical and Electronic Applications

****Discipline Specific Elective Courses: (Credit: 06 each) (4 courses to be selected)-DSE 1-4**

DSE 1 & DSE 2: Any two of the following

DSE: Paper 1- Conducting Polymers

DSE: Paper 2- Fibre Manufacturing Technology

DSE: Paper 3- Paints, Coatings and adhesives

DSE: Paper 4- Polymeric Nanomaterials

DSE 3 & DSE 4: Choose any two of the following

DSE: Paper 5- Tyre Technology

DSE: Paper 6- Packaging Technology

DSE: Paper 7- Fabrication of Polymeric products

DSE: Paper 8- Polymer in Biomedical Applications

DSE: Paper 9- Dissertation

*(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

The college will offer four DSE papers in semester V (DSE: Paper 1-4) and five DSE papers in semester VI (DSE: Paper 5-9). Out of which two papers in each semester i.e., V & VI are to be selected. (Refer to **Discipline Specific Elective Courses at page no. 6). Students may also opt for a dissertation as a DSE course in Semester VI. It will be a six credit course. The number of students who will be allowed to opt for this paper will vary depending upon the infrastructural facilities and may vary each year. The college may announce the number of seats for project work well in advance and choose students for the same. It will involve experimental work under the supervision of a faculty member and will involve eight hours of work per week. The project will be evaluated by internal and external examiners and the report should be sent to examiners in advance (prior to the day of examination).

*****Skill Enhancement Courses** - emphasis is given to **Hands on Exercises** in the following disciplines:

SEC: Paper 1	Biopolymers
SEC: Paper 2	Estimation of Polymers and Polymeric Compounds
SEC: Paper 3	Wire and Cable Technology
SEC: Paper 4	Footwear Technology

LEARNING OUTCOME BASED APPROACH TO CURRICULUM PLANNING

NATURE OF PROGRAMME

Content: Polymer Science is an interdisciplinary undergraduate science course that covers from synthesis to application and every process in between related to polymers. The scope of the subject is very broad. The key areas of study within the disciplinary/subject area of polymer science include course on Introduction to Polymer Science, Polymer Technology, Polymer Additives, Processing, Waste Management etc. Each topic area deals in detail with all the variants. The curriculum for this programme also includes learning experiences that offer opportunities for a period of study in association with industry. These may involve both a major work-related polymer based project and some guided study.

AIM OF BACHELOR'S DEGREE PROGRAMME IN (CBCS) B.Sc. (HONOURS) POLYMER SCIENCE

The Learning Outcomes-based Curriculum Framework (LOCF) for the B.Sc. (Honours) degree in Polymer Science offers a broad structural outline which can address to the current curricular requirements with ample scope to include modifications in content. The inherent flexibility in the context permits each student to choose their preferences depending on their individual capacity. The uniformity in core design ensures smooth transfer across universities in the country. The B.Sc. (Honours) Polymer Science programme covers a wide range of basic and applied courses as well as courses of interdisciplinary nature. While the core papers build a strong base of the students, the contents of electives and skill enhancement courses help them explore their eligibility and suitability to pursue higher studies in these areas.

GRADUATE ATTRIBUTES IN SUBJECT

>> Disciplinary knowledge

A student pursuing an undergraduate degree in a science discipline is inherently curiosity driven and has the ability to observe and integrate rationally. A student graduating with an honours degree in polymer science is distinguished by the following additional attributes:

- **Thorough knowledge of the discipline:** Graduates with in-depth knowledge in the field of polymer engineering science and technology applicable for successful career in the field of Polymers.
- **Laboratory skills and techniques:** A graduate in polymer science is expected to be capable of handling all basic synthesis, processing, testing and analytical techniques and precise in operating the same.
- **Digital literacy:** Increasing use of instruments having interface with computers and use of computers in laboratory work creates this attribute. A student with degree in polymer science should have the knowledge and skills of computers for a variety of situations such as data analysis, computing as well as information retrieval, presentations, technical writing and Library use.
- **Awareness of ethical issues:** Graduates with integrity and strong ethical values who are members and contribute to professional society.
- **Safety and environmental concerns:** Does the student know the importance of working with safety awareness in Laboratory? Students actively seek information about health hazards and environmental safety of chemicals that are used in the Laboratories and follow standard protocols for their safe disposal and recycling.
- **Research oriented:** Graduates who contribute towards research and professional development and who are entrepreneurial engineers.

QUALIFICATION DESCRIPTION

- Development of a clear understanding of the basic concepts of polymer science and creating an awareness of the emerging areas of the field.
- Improving the ability to read, understand and discuss scholarly articles and research papers of polymer science and related areas.
- Learning laboratory skills, enabling the accurate design of an experiment and systematic collection of experimental data and its interpretation.
- Demonstration of strong oral and written communication skills inculcating the ability to present studies in the field of polymer science using the concepts and knowledge acquired.
- Demonstration of the ability to work effectively and productively, independently or as part of a team.

  The qualification description for B.Sc. (Hons) programme in Polymer science includes:
- Creation of a clear understanding of machineries and tools related to manufacturing, processing, quality assurance and testing of polymers.
- To develop creative and innovative abilities of students by incorporating Academia – industrial interactions, project activities as crucial component of curriculum.
- Enabling graduates to become entrepreneurs.

PROGRAMME LEARNING OUTCOME IN COURSE

The B.Sc. (Hons) programme in polymer science is designed to nurture the in depth knowledge in students with the core concepts and principles. Undergraduate students pursuing this programme undergo through laboratory training to develop quantitative and qualitative skills. This provides vast scope for critical thinking, team work and exposes students to techniques useful for applied areas of scientific study.

- **Knowledge:** Students acquire theoretical knowledge and understanding of the fundamental concepts, principles and processes in main branches of polymer science namely, basics of polymers science, processing and applications, and biopolymer science. Width results from the choice of electives that students are offered.
- **Laboratory Skills:** During the course students develop laboratory skills as a much valued learning outcome of this programme. Quantitative techniques gained through hands on training opens choice of joining the industrial laboratory work force.
- **Communication:** In today's world communication is a highly desirable attribute to possess. Opportunities to enhance students' ability to write methodical, logical and precise reports are inherent to the structure of the programme. Techniques that effectively communicate scientific chemical content to large audiences are acquired through oral and poster presentations and regular laboratory report writing.
- **Research skills:** Students of this discipline will also get exposure to develop their research skills through DSE paper: Dissertation

TEACHING – LEARNING PROCESS

B.Sc. (Hons) Polymer Science programme is a three-year degree programme designed to train the students with a thorough theoretical background and practical training in all

aspects of polymer science. This is an interdisciplinary course and includes fundamental as well as in-depth knowledge of the course. Along with the above core courses there are discipline specific elective courses, generic elective courses and ability enhancement courses to address the need of the hour.

These courses are delivered through classroom, laboratory work, projects, case studies and industry visits in a challenging, engaging and inclusive manner that accommodates a variety of learning styles and tools (PowerPoint presentations, audio visual resources, e-resources, seminars, workshops).

The Laboratory training complements the theory learned in the classroom and includes synthesis of polymers, processing, testing and applications with modern instruments, computational data analysis, modelling and laboratory safety procedures.

In addition to traditional teaching procedures, presentations, demonstrations, group discussions, research lab/industrial visits, models etc.

ASSESSMENT METHODS

The assessment of students' performance in polymer science will assessed over the duration of the program by several methods. A variety of assessment methodology within the domain of polymer science will be used. Learning outcomes will be assessed using the following direct measures:

Theory:

1. Internal assessment (class test, presentations, assignments, group discussion, attendance, Literature surveys etc. 25 % weightage
2. Written examination 75 % weightage

Practical: 50 marks

1. Internal assessment (continuous evaluation, viva-voice, attendance): 25 marks
2. Practical Exam - Observation of practical skills, Experimental design planning, Execution of experiments, computerized adaptive testing, Case study, Portfolios on industrial visits undertaken etc.: 25 marks

Paper	Credits		Total Lectures per Semester		Marks	
	T	P	T	P	T	P
Core/DSE/GE	4	2	60 (4 L /Week)	60 (4 L/Week)	100	50
SEC	2	2	30 (2 L/Week)	60 (4 L/Week)	50	50
AEC	4	0	60 (4 L /Week)	-	100	-

SEMESTER-I

INTRODUCTION TO POLYMER SCIENCE

(UPC: 31141101)

Core Paper: C-101

Total Credits: 6 (Theory-4, Practical-2)

(Total Lectures: Theory-60, Practicals-60)

COURSE OBJECTIVES:

1. To familiarize with structure of polymers.
2. To acquaint students with knowledge of molecular weight determination and polymer solubility.

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Understand concept of crystalline and amorphous state of polymers
2. Correlate flexibility with the glass transition temperature
3. Understand structure-property relationship of polymers
4. Apply mathematical formulae to depict polymer solution properties

THEORY: (100 MARKS)

UNIT 1: INTRODUCTION TO POLYMERS 15 L

Introduction and history of polymeric materials, classification of polymers, configuration and conformation of polymers, nature of molecular interaction in polymers, cumulative interaction, entanglement, random chain model and RMS end-to-end distance. Various structures of copolymers such as linear branched and cross-linked copolymers and their types

UNIT 2: POLYMER CRYSTALS 6 L

Crystal morphologies, extended chain crystals, chain folding, lamellae, spherulites, crystallization, crystallinity & crystallizability, determination of melting point and degree of crystallinity

UNIT 3: PROPERTIES OF POLYMERS 15 L

Physical properties, stress–strain behaviour, introduction to flow & mechanical properties (tensile, flexural, impact, fatigue, hardness, creep, abrasion), electrical properties (dielectric strength, surface resistivity, volume resistivity, power factor, arc resistance)

UNIT 4: POLYMER MOLECULAR WEIGHT 10 L

Nature and structure of polymers: structure-property relationships, molecular weight of polymers (M_n, M_w etc.), polydispersity, molecular weight distribution and determination of molecular weight by viscosity, end group analysis, cryoscopy, ebulliometry, osmometry, light scattering & ultracentrifugation method

UNIT 5: SOLUTION PROPERTIES OF POLYMERS 10 L

Polymer solutions, solubility parameter, solution viscosity, thermodynamics of polymer solutions

UNIT 6: GLASS TRANSITION BEHAVIOUR OF POLYMERS 4 L

Glass transition temperature (T_g) and measurement of T_g, factors affecting the glass transition temperature, WLF equation

PRACTICALS: (50 MARKS)

1. Chemical identification of polymers- • Unsaturation • Testing of functional groups (associated with polymers).
2. Measurement of glass transition temperature (T_g).
3. To determine the melting point of crystalline polymers.

4. To check the solubility of the given polymeric sample in different solvents.
5. Determination of molecular weight by solution viscosity.
6. Determination of molecular weight by end group analysis.
7. Determination of heat deflection temperature, vicat softening point.

REFERENCES:

1. Brydson J.A., (1999) Plastics Materials, Butterworth Heinemann.
2. Gowarikar V.R., (2010) Polymer Science, New Age International Publishers Ltd.
3. Billmeyer F.W., (2007) Textbook of Polymer Science, Wiley, India.
4. Shah V., (1998) Handbook of Plastics Testing Technology, Wiley Interscience.

ADDITIONAL RESOURCES:

1. Schultz J.M., (2001) Polymer Crystallization, American Chemical Society.
2. Seymour R.B., Carraher C.E., (2000) Polymer Chemistry, Marcel Dekker.
3. Ghosh P., (2010) Polymer Science and Technology: Plastics, Rubbers, Blends and Composites, Tata McGraw Hill.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

End to End Distance, Lamellae, Glass Transition Temperature, Molecular Weight Distribution, Viscosity Average Molecular Weight

RAW MATERIALS OF POLYMERS

(UPC: 31141102)

Core Paper: C-102

Total Credits: 6 (Theory-4, Practical-2)

(Total Lectures: Theory-60, Practicals-60)

COURSE OBJECTIVES:

1. To learn about the resources of polymers
2. To learn about basic concepts of polymer latex
3. To gain knowledge of properties of monomers and their synthesis

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Apply the knowledge of latex manufacturing and compounding
2. Apply the knowledge of techniques used in monomer production

THEORY: (100 MARKS)

UNIT 1: INTRODUCTION TO CRUDE OIL AND IT'S REFINING **10 L**

Petroleum oil, natural gas, coal: capabilities and limitations. general consideration of petrochemicals, an overview of petroleum refining, desalting, distillation, cracking and its types

UNIT 2: SYNTHESIS OF MONOMERS FROM PETROCHEMICALS **20 L**

Formaldehyde, ethylene, vinyl acetate, vinyl chloride, ethylene oxide and ethylene glycol, acrylonitrile, glycerol, toluene diisocyanate, methyl methacrylate, isoprene, phenol, styrene, terephthalic acid, adipic acid

UNIT 3: LATEX **10 L**

Natural rubber latex: collection process, composition, concentration and stabilization of latex

UNIT 4: LATEX ADDITIVES AND IT'S COMPOUNDING **10 L**

Vulcanizing agents, fillers, coagulating agent, wetting, dispersing and emulsifying agents, stabilizers, thickening agents and other additives, few compounding formulations for product manufacturing, compounding equipments

UNIT 5: LATEX PRODUCT MANUFACTURING TECHNIQUES **10 L**

Spreading, casting, dipping, latex thread, latex coated coir and latex foam

PRACTICALS: (50 MARKS)

1. Fractional distillation of crude oil.
2. To calculate dry rubber content (DRC) of latex.
3. To determine the coagulation strength of latex.
4. Preparation of balloon by dipping process.
5. Latex compounding for gloves & balloons, products.

REFERENCES:

1. Kumar D., Chandra R., (2001) Latex Technology, Dhanpat Rai & Co.
2. Rao B.K.B., (2007) Text book on Petrochemicals, Khanna Publishers.

ADDITIONAL RESOURCES:

1. Rao B.K.B., (2007) Modern Petroleum Refining Processes, Oxford and IBH

2. Maiti S., (2002) Introduction to Petrochemicals, Oxford & IBH Publ. Co.
3. Speight J.G., (2006) Chemistry and Technology of Petroleum, CRC Press.
4. Martin J. M., Smith W.K., (2007) Hand book of Rubber Technology, CBS Publishers.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Latex, Thickening Agent, Vinyl Acetate, Cracking

SEMESTER-II

POLYMER TECHNOLOGY

(UPC: 31141201)

Core Paper: C-201

Total Credits: 6 (Theory-4, Practical -2)

(Total Lectures: Theory- 60, Practicals-60)

COURSE OBJECTIVES:

1. To learn about the production, properties and applications of thermoset and thermoplastic polymers
2. To study kinetics of chain growth and step growth polymerization
3. To learn about the chemistry and manufacturing of flexible and rigid polyurethane foams

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Understand mechanism of chain growth and step growth polymerization
2. Apply the knowledge of synthesis, thermoplastic, thermoset & engineering polymers and investigate their properties to obtain desired applications

THEORY: (100 MARKS)

UNIT 1: INTRODUCTION 5 L

Criteria for polymer synthesis, nomenclature, addition and condensation polymerization, chain growth, ring opening, step polymerization, polymerization techniques: mass (bulk), suspension, emulsion and solution processes

UNIT 2: KINETICS OF POLYMERIZATION 10 L

Concept of functionality, Carother's equation and its applications in polymerization reactions, kinetics of step growth polymerization and chain growth polymerization, photo polymerization (mechanism, initiation), cage effect, ionic polymerization, effect of gegen ions and solvent on ionic polymerization, Mayo's equation, auto-acceleration, inhibition and retardation, co-polymerization, reactivity ratios, Zeigler-Natta catalyst and coordination polymerization

UNIT 3: THERMOPLASTIC POLYMERS 15 L

Brief introduction to preparation, structure, properties and applications of the following polymers: polyolefins (PE, PP), polystyrene and its copolymers, poly (vinyl chloride) and related polymers, poly (vinyl acetate) and related polymers

UNIT 4: THERMOSETTING POLYMERS 15 L

Brief introduction to preparation, structure, properties and applications of the following polymers: unsaturated polyester resins, phenol formaldehyde resins, polymers from amines, polyurethane, silicones, epoxides

UNIT 5: ENGINEERING POLYMERS 15 L

Brief introduction to preparation, structure, properties and applications of the following polymers: acrylic polymers, fluoropolymers, aliphatic polyamides, saturated polyesters

PRACTICALS: (50 MARKS)

1. Suspension polymerization of styrene/MMA.

2. Preparation of UF/PF/MF resins.
3. Preparation and testing of diglycidyl ether of bis phenol-A (DGEBA).
4. Bulk and solution polymerization of methyl methacrylate/styrene.
5. Emulsion polymerization of styrene/ methyl methacrylate.
6. Copolymerization of styrene & MMA and determination of reactivity ratios.
7. Preparation of Poly (vinyl butyral).

REFERENCES:

1. Odian, G., (2004) Principles of Polymerization, Wiley-interscience.
2. Brydson J.A., (1999) Plastics Materials, Butterworth-Heinemann.
3. Seymour R.B., Carraher C.E., (2003) Polymer Chemistry, Marcel Dekker.

ADDITIONAL RESOURCES:

1. Billmeyer F.A., (2011) Text book of Polymer Science, John-Wiley & Sons.
2. Flory P.J., (2007) Principles of Polymer Chemistry, Asian Books Private Limited.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Industrial Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Chain Growth Polymerization, Mayo's Equation, Fluoropolymers, Epoxides

UNIT OPERATIONS

(UPC: 31141202)

Core Paper: C-202

Total Credits: 6 (Theory-4, Practical-2)

(Total Lectures: Theory-60, Practicals-60)

COURSE OBJECTIVES:

1. To understand concepts of unit operations and their importance in polymer industries
2. To learn about the concepts of separation equipments used in the process industry

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Select suitable criteria for solving material and energy balance problems
2. Illustrate energy and material balance equations for open and closed systems

THEORY: (100 MARKS)

UNIT 1: INTRODUCTION TO UNIT OPERATIONS **5 L**

Unit operations: concept and requirement, material and energy balances (with and without chemical reactions), energy transport in non-isothermal systems

UNIT 2: FLUID DYNAMICS **15 L**

Velocity distribution in flow system, Reynolds number, interfaces transport, flow of fluids in pipes – continuity equation, Bernoulli's equation and calculations for pipe size and pressure drop, flow measuring instruments: manometers and measurement of flow and pressure, flow meters, principles and construction of venturimeter, orifice meter, various types of pumps

UNIT 3: MECHANICAL OPERATIONS **10 L**

Size reduction and its equipment (ball mill, jack crusher, end and edge roller mill), filtration: theory of filtration, filter aids, filter media, industrial filters including filter press, rotary filter, edge filter, etc., factors affecting filtration

UNIT 4: HEAT TRANSFER **15 L**

Conduction (Fourier law, Reynolds number), convection, radiation, heat exchangers (tube shell, shell plate)

UNIT 5: MASS TRANSFER MECHANISM **15 L**

Mass transfer: diffusion and its mechanism, factors effecting diffusion, gas absorption (Henry's Law, Langmuir Absorption Isotherm, BET equation), various types of distillation, drying

PRACTICALS: (50 MARKS)

1. Handling of jaw crusher, ball mill for crushing and grinding.
2. Distillation of various liquid mixtures.
3. To evaluate diffusion percentage of a plasticizer in a PVC.
4. Filtration of solids from slurry.
5. Calculation of pressure drop and pipe size.
6. Heat Transfer through different materials like glass and plastics.

7. Analysis of different adsorption isotherm.

REFERENCES:

1. Mccabe W., Smith J., Harriott P., (2005) Unit Operations in Chemical Engg., McGraw-Hill Education.
2. Chattopadhaya P., (2003) Unit Operations in Chemical Engg., Vol. 1 & Vol. 2, Khanna Publishers.
3. Coulsan J.M., Richardson J.F., (2010) Chemical Engg., Vol. 1, Elsevier.

ADDITIONAL RESOURCES:

1. Kumar D. S., (2009) Heat and Mass Transfer, S K Kataria & Sons.
2. Rao G. K., (2002) Solved Example in Chemical Engg., Khanna Publishers.
3. Treybal R., (2012) Mass Transfer Operations, Tata McGraw Hill.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Mass Transfer, Energy Transfer, Distillation, Reynolds Number

SEMESTER-III

POLYMER RHEOLOGY

(UPC: 31141301)

Core Paper: C-301

Total Credits: 6 (Theory-4, Practical-2)

(Total Lectures: Theory-60, Practicals-60)

COURSE OBJECTIVES:

1. To enhance fundamental knowledge of flow behaviour of polymer melts
2. To understand the concept of mixing of polymers

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Apply the knowledge of measurement of viscosity in handling of rheological instruments
2. Interpret rheology of polymer melts by mechanical models

THEORY: (100 MARKS)

UNIT 1: RHEOLOGICAL PRINCIPLES **10 L**

Viscosity and polymer processing, rheological properties of fluids, shear stress in polymers, Newtonian & non-Newtonian flow, polymer melt viscosities, flow in channels, simple shear flow, melt-flow index, Weissenberg effect, die swell, melt fracture, creep & creep compliance, stress relaxation, isochronous stress-strain curves

UNIT 2: MELT FLOW ANALYSIS **15 L**

Types of fluid & rheological models, rheological measurements by capillary, parallel plate and cone & plate viscometers, simple elongational flow and its significance, dynamic flow behavior, time dependent fluid behavior

UNIT 3: RHEOLOGICAL PRINCIPALS AND MODELS **15 L**

The elastic and viscoelastic state of polymers – viscoelasticity, viscoelastic models: Maxwell model, Voigt-Kelvin model, Boltzmann superposition principles, dynamic mechanical testing

UNIT 4: MIXING OF POLYMERS **10 L**

Types of mixing, concept and importance of master batches, mixing of additives with the polymers, melt compounding

UNIT 5: TYPE OF MIXERS **10 L**

Two roll mill, high speed mixer, internal batch mixer, single screw & twin screw extruders, flow mechanism, analysis of flow (drag, pressure and leak flow)

PRACTICALS: (50 MARKS)

1. Determination of melt flow index of a polymer such as PP, PS, LDPE etc.
2. Determination of intrinsic viscosity by Ubbelohde viscometer.
3. Determination of rheological properties of polymer melts by rheometers.
4. Measurement of resin/paint viscosity by Ford cup 4.
5. Measurement of dynamic viscosity by Brookfield Viscometer.
6. Compounding of polymers and investigation of their rheological behavior.
7. Industry/R&D organization visit.

REFERENCES:

1. Gupta B.R., (2004) Applied Rheology in Polymer Processing, Asian Books.
2. Rosen S.L., (2012) Fundamental Principles of Polymeric Materials, Wiley-Interscience.
3. Ghosh P., (2010) Polymer Science and Technology of Plastic and Rubber, Tata McGraw Hill.
4. Aklonis J., Macknight W.J., (2005) Introduction to Polymer Viscoelasticity, John Wiley & Sons

ADDITIONAL RESOURCES:

1. Dealy J.M., Wissbrum K.F., (1999) Melt Rheology and its Role in Plastic Processing, Springer.
2. Bird R.B., Armstrong R.C., Hassager O., (1977) Dynamics of Polymeric Liquids (volume 1), John Wiley & Sons, New York.
3. Shaw M.T., (2012) Introduction to Polymer Rheology, John Wiley & Sons.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Boltzmann Superposition, Weissenberg Effect, Power Law Model, Drag Flow, Maxwell Model

POLYMER ADDITIVES

(UPC: 31141302)

Core Paper: C-302

Total Credits: 6 (Theory-4, Practical -2)

(Total Lectures: Theory- 60, Practicals-60)

COURSE OBJECTIVES:

1. To introduce the basics of polymer additives and their significance
2. To study different additives and their representative formulations

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Understand the role of various compounding additives used for plastics and rubbers
2. Describe various steps & variables for mixing and blending of additives
3. Utilize understanding of compounding additives and methods for modification of polymer properties

THEORY: (100 MARKS)

UNIT 1: INTRODUCTION TO ADDITIVES AND COMPOUNDING 10 L

Importance of additives and their selection criteria for commercial polymers and technical requirements of additives, limitation of polymer additives, physical behavior of polymer additives (solubility etc.), limitation of polymers, master batch and compounding techniques (two roll mill, extruder, intermix, high speed mixture, calendar etc.)

UNIT 2: COLOURANTS 10 L

Dyes and pigments, coloring properties (heat resistance, transparency and opacity, water fastness, abrasion, chalking, plate out, effect on rheological properties), classification of pigments, inorganic and organic pigments: titanium dioxide, zinc oxide, carbon black, metal oxide pigments, chromium and cadmium pigments, organic dyes ultra-marine blue etc., method of incorporation (dispersion, pre mixing, agglomerate breakdown, compaction and wetting)

UNIT 3: ADDITIVES FOR RUBBERS 10 L

Vulcanizing agents (sulphur, peroxide and metal oxide, phenolic curatives, benzoquinone derivatives, bismaleimides), accelerators (benzothiazoles, benzothiazolesulfenamide, dithiocarbamates, amines), lubricants, retarders (pre-vulcanized inhibitor), activators, stabilizers (UV, antioxidants, thermal), softners, tackifying agents, blowing agents, surface property modifiers etc.

UNIT 4: ADDITIVES FOR PLASTICS 16 L

Plasticizers, theories of plasticization, types of plasticizer (phthalate, polymeric, hydrocarbon oil, vegetable oil, phosphates trimellitic etc.), methods of incorporation, fillers, introduction, classification, selection criteria (particle size, shape & geometry, packing fraction, hardness and abrasiveness, optical properties), impact of fillers on properties (mechanical properties, thermal properties, moisture content and electrical properties), Foaming agents, blowing agents, stabilizers (UV, heat, antioxidants and light), metal deactivator etc.

UNIT 5: ADDITIVES FOR SPECIAL NEEDS 10 L

Flame retardants (halogen based, metal oxides, hydrated salts etc.), impact modifier, lubricants, dry bonding agent and antistatic agents, conductive additives, metal deactivator

UNIT 6: CASE STUDY 4 L

Compounding techniques with illustration of few formulations like:

i. Rigid PVC pipes
ii. Clear bags and flexible films
iii. Acrylic sheet and display board
iv. Rubber sole
v. Air water hose
vi. Conveyor belt

PRACTICALS: (50 MARKS)

1. Determination of bulk density of fillers.
2. Determination of pore size and net size of fillers.
3. Determination of thermal stability of polymer stabilized by heat stabilizer.
4. Measurement of flash point of a plasticizer.
5. Identification of additives using chromatography.
6. Determination the plasticizer and filler content in plastic materials.
7. Evaluate the bleeding and blooming properties of an additive.
8. Evaluate the effect of fillers/plasticizer on the properties of a plastic/rubber.
9. To prepare PVC master batch.

REFERENCES:

1. Lutz J.T., (2001), Polymer Modifiers and Additives, Marcel Dekker.
2. Zweifel H., Amos S.E., (2001) Plastics Additives Handbook, Hanser.
3. Gachter R., Muller H., (1987) Plastics Additive Handbook, Hanser Publishers.
4. Martin J.M., Smith W.K., (2007) Handbook of Rubber Technology, volume 2, CBS Publisher.

ADDITIONAL RESOURCES:

1. Mascia L., (1974) The Role of Additives in Plastics, Edward Arnold Publishers Ltd., U.K.
2. Murphy J., (2001) Additives for Plastics Handbook, Second Edition, Elsevier Advanced Technology, Oxford.
3. Gerard J. F., (2001) Fillers and Filled Polymers, Wiley-VCH verlag GmbH
4. Brydson J., (1999) Plastic Materials, Butterworth-Heinemann.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Master Batch, Fillers, Plasticizer, Pigment, High Speed Mixture

POLYMER DEGRADATION

(UPC: 31141303)

Core Paper: C-303

Total Credits: 6 (Theory-4, Practical-2)

(Total Lectures: Theory-60, Practicals-60)

COURSE OBJECTIVE:

1. To familiarize with the usage of importance of polymer degradation
2. To learn about the reactions of degradation of polymers

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Learn the factors responsible for degradation
2. Understand the handling of various polymers without affecting the properties
3. Evaluate degradation of polymers by various methods

THEORY: (100 MARKS)

UNIT 1: CONCEPT OF DEGRADATION 15 L

Introduction to degradation, classification of degradation based on

a) Pattern of degradation:
- **i.** Random degradation
- **ii.** Side chain degradation
- **iii.** Chain end degradation

b) Cause of degradation (mechanism, factors affecting thermal degradation, example)
- **i.** Thermal degradation
- **ii.** Oxidative degradation
- **iii.** Degradation by radiation
- **iv.** Mechanical degradation
- **v.** Chemical degradation
- **vi.** Biological degradation

UNIT 2: DEGRADATION OF A FEW THERMOPLASTICS 25 L

Different types of degradation patterns with mechanism of the polymers:
- **i.** Polyolefins (PE and PP)
- **ii.** PVC
- **iii.** Polyamides
- **iv.** PMMA
- **v.** Cellulose
- **vi.** Polyacrylonitrile (PAN)
- **vii.** Polystyrene (PS)
- **viii.** PET

UNIT 3: DEGRADATION OF ELASTOMERS 10 L

i. PU ii. Natural rubber iii. SBR

UNIT 4: QUANTITATIVE AND QUALITATIVE EVALUATION OF DEGRADATION 10 L

Degradation studies using DSC, TGA, viscosity, chromatography and FTIR.

PRACTICALS: (50 MARKS)

1. Biodegradation of polymers.
2. Mechanical degradation of polymers and its effect on properties.
3. Thermal degradation of polymer under various conditions.
4. Thermal analysis by DSC/ TGA.
5. Photo-degradation of PVC.
6. Evaluate chemical degradation of condensation polymers.
7. Determine environmental stress cracking resistance of polymers.

REFERENCES:

1. Pesce W.J., (2007) Encyclopedia of Polymer Science and Technology, Wiley.
2. Turi E.A., (1997) Thermal Characterization of Polymeric Materials, Academic Press.

ADDITIONAL RESOURCES:

1. Hamid S.H., Amin M.B., (1992) Handbook of Polymer Degradation, Marcel Dekker.
2. Ehrenstein G.W., Riedel G., Trawiel P., (2004) Thermal analysis of plastics, Hanser.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Thermoplastic, Elastomer, Oxidative Degradation, Stability, PMMA

SEMESTER-IV

POLYMER PROCESSING & MOLD DESIGN

(UPC: 31141401)

Core Paper: C-401

Total Credits: 6 (Theory-4, Practical -2)

(Total Lectures: Theory- 60, Practicals-60)

COURSE OBJECTIVES:

1. To learn about the various processing techniques and their components
2. To acquaint with the concepts of mold & die design and their key features

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Understand significance of the single screw and multiple screw extruder systems
2. Understand the fundamentals of injection and compression molding process and interpret processing variables for upgradation of quality of products
3. Apply design features in structure of injection molds with materials
4. Apply design features in structure of extrusion dies

THEORY: (100 MARKS)

UNIT 1: EXTRUSION AND DIE 10 L

Extrusion process, film and sheet extrusion, the extrusion die, classification of extrusion dies, multi-layer extrusion and die defects.

UNIT 2: INJECTION, BLOW, COMPRESSION & TRANSFER MOLDING 13 L

Principles, injection molding cycle, injection molding machine, some aspects of product quality, reaction injection molding (RIM), blow molding, extrusion blow molding, injection blow molding, stretch blow molding, compressing molding process, transfer molding

UNIT 3: THERMOFORMING, CASTING AND ROTATIONAL MOLDING 10 L

Principles, types and applications

UNIT 4: MOLD DESIGNING AND MAKING 10 L

Materials selection for mold and die, mold making processes: casting, electro deposition, cold hobbing, pressure casting, spark machining, bench fitting, defects and remedy. Feed system: runner, gates and cooling unit

UNIT 5: EJECTION SYSTEM 7 L

Ejector grid, ejector plate assembly, ejection techniques, ejection from fixed half and sprue pullers

UNIT 6: MOLDING WITH UNDER CUTS 10 L

Form pin, split cores, side cores, stripping internal undercuts, molds for threaded components. Day light molds–general, under feed molds, double & triple day light mold

PRACTICALS: (50 MARKS)

1. Compounding of PVC and rubbers in two roll-mill with fillers and reinforcing agents.
2. Preparation of polymeric sheet/ specimen by compression, transfer and injection molding.
3. Process a plastic from extruder and determine the different properties like production rate, residence time etc.
4. Prepare a polymer film/ membrane by solution casting method.
5. Preparation of thermo formed polymeric product.
6. Demonstration software used in mold and die design (Auto CAD, solid works,

etc.)

7. Tool room/industrial visit and to design well labelled mold from clay/POP/resin etc.

REFERENCES:

1. Pye R.G.W., (2000) Injection mould design, Affiliated East West Press Pvt. Ltd.
2. Strong A.B., (2005) Plastics: Materials & Processing, Prentice Hall.
3. Rosato D.V., Rosato D.V., (2000) Injection Moulding Handbook, CBS Publisher.

ADDITIONAL RESOURCES:

1. Morton-Jones D.H., (2007) Polymer Processing, Chapman & Hall.
2. Crawford R.J., (1998) Plastic Engg, Butterworth-Heinemann.
3. Rees H., (1995) Mould Engineering, Hanser Publisher.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Injection Molding, Die Designing, Triple Day Light Mold, Die Defects

POLYMER TESTING

(UPC: 31141402)

Core Paper: C-402

Total Credits: 6 (Theory-4, Practical-2)

(Total Lectures: Theory-60, Practicals-60)

COURSE OBJECTIVES:

1. To learn about the fundamentals of polymer testing
2. To understand testing of polymeric materials on various testing instruments

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Evaluate testing of polymeric materials on testing instruments
2. Elucidate the mechanical, thermal, optical, electrical properties of polymers

THEORY: (100 MARKS)

UNIT 1: BASIC AND TESTING STANDARDS — 10 L

Principles and methods of standardization, preparation of sample, different standards: BIS and ASTM standards testing methods, evaluation of errors in polymer testing, correction of errors

UNIT 2: THERMAL AND MECHANICAL ANALYSIS OF POLYMERS — 15 L

a. Short term strengths: tensile, flexural, impact, tear resistance, abrasion, etc.

b. Long term strengths: creep and fatigue properties, compression set

c. Thermal properties: thermal stability, thermal conductivity, thermal diffusivity, specific heat capacity, linear thermal expansion, heat distortion temperature, vicat softening point, low temperature flexibility etc.

UNIT 3: FLOW PROPERTIES — 5 L

Melt flow index, cup flow test, solution and inherent viscosity, melt viscosity etc.

UNIT 4: FLAMMABILITY PROPERTIES — 5 L

Burning behavior, flammability tests, UL-94, oxygen index, critical temperature index, smoke density

UNIT 5: OPTICAL AND ELECTRICAL PROPERTIES — 15 L

Different optical properties (reflection, refraction, diffraction etc), color matching, refractive index, gloss, haze, degree of yellowness etc., dielectric strength, surface and volume resistivity, electro active properties

UNIT 6: GAS BARRIER AND ENVIRONMENTAL ASSESSMENT — 10 L

Definitions, permeability to gases, standard methods of measuring the permeability of gases, other methods of measuring permeability, environment resistance – cause of deterioration of polymer by aging & weathering, assessment of deterioration, natural weathering, artificial weathering, chemical resistance

PRACTICALS: (50 MARKS)

1. Determine the melt flow index of LLDPE, PP etc.
2. Evaluate limiting oxygen index (LOI)/ UL-94 of plastic sample: PVC, PE, PP etc.
3. Determination the heat distortion temperature (HDT), vicat softening point (VSP) and thermal stability of polymer film.

4. Measurement of abrasion resistance of polymer sheets.
5. Measurement of dielectric strength of polymer films/sheets.
6. Determination the coefficient of friction and Izod impact strength of polymeric samples.
7. Determination of environment stress cracking resistance of PE/PP films.
8. Determination of shore hardness and Rockwell hardness of plastics.

REFERENCES:

1. Shah V., (2007) Handbook of Plastic Testing & Technology, Wiley-Inter science.
2. Hylton D., (2004) Understanding Plastic Testing, Hanser publication
3. Grellmann W., Seidler S., (2013) Polymer Testing, Hanser publication.

ADDITIONAL RESOURCES:

1. Berins M. L., (1991) SPI Plastic Engineering Hand book, Springer.
2. Ward I.M., Sweeney J., (2004) An Introduction to the Mechanical Properties of Solid Polymers, Wiley.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Tensile Strength, UL-94, Glass Transition Temperature, ESCRA

RECYCLING AND WASTE MANAGEMENT

(UPC: 31141403)

Core Paper: C-403

Total Credits: 6 (Theory-4, Practical-2)

(Total Lectures: Theory-60, Practicals-60)

COURSE OBJECTIVES:

1. To learn about various sources of polymer waste generation and their management
2. To learn about various waste disposal and treatment methods

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Understand policies and legislations related to polymeric waste management and their impact on environment
2. Apply the 4 R's approach (reduce, reuse, recycle, recover) for polymeric waste management

THEORY: (100 MARKS)

UNIT 1: INTRODUCTION TO WASTE MANAGEMENT 10 L

Definition of plastic wastes and litter, basis for assessing plastic wastes, global policies and regulations, social and environmental challenges of plastic waste in India, applications of plastics and their potential as sources of waste, sorting techniques and classification (density - float sink and froth floatation methods, selective dissolution, optical, spectroscopic, sorting by melting temperature, triboelectric separator etc.)

UNIT 2: CLASSIFICATION OF WASTE MANAGEMENT 10 L

Thermoplastic waste management: 4 R's approach (reduce, reuse, recycle, recover), recycling classification - primary, secondary, tertiary, quaternary recycling with examples (mechanical, chemical and thermal processes)

UNIT 3: DISPOSAL AND WASTE TREATMENT TECHNIQUES 15 L

Controlled tipping, pulverization, composting, incinerators, pyrolysis, gasification, on-site disposal methods, compacting and bailing

UNIT 4: PLASTIC RECYCLING 15 L

Recycling of polyolefins, PVC, PET, polystyrene, polyamides (nylon-6 and nylon-6, 6) etc

UNIT 5: WASTE MANAGEMENT OF THERMOSET 10 L

Recycling of thermosets, reclaiming of rubber, tire retreading, uses of recycled rubber

PRACTICALS: (50 MARKS)

1. Primary recycling of various waste collected from environment.
2. Secondary recycling of MSW by incorporating and blending the recyclable waste with virgin polymers.
3. To study composting of natural/biopolymers.
4. Separation of polymer mixture by sink flotation technique.
5. Separation of polymer mixture by selective dissolution technique.

REFERENCES:

1. Chandra R., Adab A., (2004) Rubber and Plastic Waste: Recycling, Reuse and Future

Demand, CBS Publisher.
2. NIIR Board of Consultant and Engineers, (2007) Medical, Municipal and Plastic Waste Management Handbook, National Institute of Industrial Research.

ADDITIONAL RESOURCES:

1. Scheirs J., (1998) Polymer Recycling, John Wiley & Sons.
2. Blow S., (2000) Handbook of Rubber Technology, Hanser Gardner.
3. Bandrup J.E., (1996) Recycling and Recovery of Plastics, Hanser Gardner.
4. Goodship V., (2007) Introduction to plastics recycling, Rapra.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Triboelectric Separator, 4 R's Approach, Incinerators, Tire Retreading

SEMESTER-V

POLYMER CHARACTERIZATION

(UPC: 31141501)

Core Paper: C-501

Total Credits: 6 (Theory-4, Practical-2)

(Total Lectures: Theory-60, Practicals-60)

COURSE OBJECTIVES:

1. To acquaint the students with the modern instrumental techniques and their applications in characterization of polymeric materials

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Interpret NMR, Raman, Mass and IR–Spectra for characterization of molecular structure of polymeric materials
2. Elucidate stability of various polymers and their characterization on the basis of their thermal stability and glass transition temperature

THEORY: (100 MARKS)

UNIT 1: INTRODUCTION 10 L

Basic principle of spectroscopy, molecular and atomic spectra, Lambert-Beer's law, Frank-condon principle, electromagnetic radiation and it's properties, interaction of radiation with matter, statistical method of analysis

UNIT 2: SPECTROSCOPIC TECHNIQUES 10 L

Principles and applications in structural determination of polymers (functional group, tacticity, molecular structure, purity, unsaturation etc.): Infra-red spectroscopy, UV-Vis spectroscopy, electron spin resonance, raman, nuclear magnetic resonance spectrometer

UNIT 3: CHROMATOGRAPHY TECHNIQUES IN POLYMER 10 L

Thin layer chromatography, high performance liquid chromatography, gel permeation chromatography (GPC), gas chromatography and size exclusion chromatography

UNIT 4: MICROSCOPIC AND X-RAY TECHNIQUES 10 L

Optical microscopy, electron microscopy (SEM, TEM, AFM) and XRD: basics and applications (size, morphology, crystallinity etc.) in polymers characterization

UNIT 5: THERMAL & THERMO-MECHANICAL CHARACTERIZATION 10 L

Thermal gravimetric analysis (TGA): Estimation of thermal stability from TGA curves, qualitative methods, semi quantitative and quantitative methods, Thermal behaviour of styrenated polyester, poly(tetraflouroethylene) by TGA, Differential thermal analysis (DTA): physical transitions, melting thermo grams. Heat of fusion and degree of crystallinity or isotacticity, Random copolymer structure, block copolymer structure, polymer mixture, melting point depression by diluents, crystallization, melt crystallization, cold crystallization, glass transition, differential scanning calorimeter (DSC), dynamic mechanical analyser (DMA) and thermal mechanical analyser (TMA): principle and applications in polymer characterization

UNIT 6: MOLECULAR MASS AND MASS SPECTROSCOPY 10 L

Gas chromatography-mass spectrometer (GC-MS), MALDI-TOF, ESI-MS and methods

for determination of molecular mass (principles and applications in polymer characterization)

PRACTICALS: (50 MARKS)

1. To verify Lambert-Beer's law by UV-Vis. spectrophotometer.
2. Calculate weight percentage of inorganic and organic ingredient in polymeric compound.
3. Analyze thermal behavior of polymers.
4. Quantitative determine of impurities by UV-Vis. spectrophotometer.
5. Evaluate percentage crystallinity of polymeric sample by XRD, DSC (Interpretation).
6. Identification of additives in a processed polymer by chromatography.
7. Interpretation of FTIR, NMR and Raman spectra of polymers.

REFERENCES:

1. Willard H.H., Merrit L.L., Dean J.A. (1988) Instrumental method of analysis, Wads worth Publishing Company.
2. Skoog D.A, (1997) Principle of Instrumental Analysis, Harcourt College Pub.
3. Shah V., (2007) Handbook of Plastic Testing, Technology, Wiley-Inter science.
4. Banwell C.N., McCash E.M., (2008) Fundamentals of Molecular Spectroscopy, Fourth Edition, Tata McGraw-Hill.

ADDITIONAL RESOURCES:

1. Tanaka T., (1999) Experimental Methods in Polymer Sciences, Academic Press.
2. Silverstein R.M., (1991) Spectrometric identification of organic compounds, John Wiley.
3. Macomber R.S., (2008) A complete introduction to NMR spectroscopy, Wiley-inter science.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

GC-Mass, Thermal Analyzer, FT-IR, Size Exclusion Chromatography, TEM

SPECIALITY POLYMERS

(UPC: 31141502)

Core Paper: C-502

Total Credits: 6 (Theory-4, Practical -2)

(Total Lectures: Theory- 60, Practicals-60)

COURSE OBJECTIVES:

1. To study basic concepts of speciality polymers including temperature & fire-resistant high-performance polymers, biopolymers and conducting polymers
2. To learn about applications of speciality polymers

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Understand the chemistry, preparation, properties and applications of high temperature resistant polymers
2. To analyze the properties of specialty polymers for specific application such as aerospace, telecommunication, biomedical, defense etc.

THEORY: (100 MARKS)

UNIT 1: PREPARATION, PROPERTIES AND APPLICATIONS OF SPECIALITY POLYMERS 20 L

Introduction to engineering/speciality polymers, high temperature and fire resistant polymers, preparation, properties and applications of the following polymers:

i. Polycarbonate (PC)
ii. Poly(ether ether ketone) (PEEK) and poly(ether-ketone) (PEK)
iii. Sulphur based polymers (Polysulphone and polyphenylenesulfide)
iv. Polyamide, polyamideimide resins (PAI) and polyimide resins
v. Polyacetals
vi. Polyphenylene oxide (PPO)
vii. Silicones, fluoropolymers and polyphsophazenes
viii. High performance thermosetting resins such as epoxides, polyesters, polybenzoxazineetc.

UNIT 2: CONDUCTING POLYMERS 10 L

Synthesis, properties and applications of polyaniline, polypyrrole, polythiophene and poly (p-phenylenevinylene)

UNIT 3: BIOPOLYMERS 10 L

Basic concepts of biopolymers/biodegradable polymers (poly lactic acid, polycaprolactone, starch, etc.), hydrogels, smart hydrogels and their applications

UNIT 4: RECENT ADVANCES IN SPECIALITY POLYMERS 10 L

High performance polymer blends and nanocomposites

UNIT 5: LIQUID CRYSTAL POLYMERS 10 L

Introduction, polymers, chemistry of liquid crystal polymerization, synthesis, properties, characteristics of liquid crystal polymers

PRACTICALS: (50 MARKS)

1. Synthesis of conducting polymers.

2. Synthesis of heat resistant polymers.
3. To determine conductivity of polymeric sample.
4. Preparation of nylon- 6, 10 by interfacial polymerization.
5. Investigation of performance properties of speciality polymers such as thermal stability and fire resistance.

REFERENCES:

1. Brydson J. A., (1999) Plastic Materials, Butterworth-heinemann.
2. Dyson R. W., (1990) Engg. Plastics, Blackie, Chapman and Hall.
3. Mohammad, F., (2007) Specialty Polymers: Materials and Applications, I.K. International Publishing House Pvt. Ltd.

ADDITIONAL RESOURCES:

1. Domb. A.J., (1997) Handbook of Biodegradable Polymer, Gordon and Breach Science Publishers.
2. Seymour R.B., Kirshenbaum G.S., (1986) High Performance Polymers: their origin and development, Springer.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Polysulfones, Polyaniline, PEEK, Smart Hydrogels, Polycarbonate

SEMESTER-VI

POLYMER BLENDS AND COMPOSITES

(UPC: 31141601)

Core Paper: C-601

Total Credits: 6 (Theory-4, Practical-2)

(Total Lectures: Theory-60, Practicals-60)

COURSE OBJECTIVES:

1. To gain knowledge of polymer composite and its basic construction
2. To learn about polymer blend and its basic construction

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Understand modification techniques for preparation of polymer blends
2. Understand the types and forms of reinforcement materials used in composites
3. Apply different production techniques for composite structures like hand-layup and bag molding

THEORY: (100 MARKS)

UNIT 1: BASIC CONCEPT OF BLENDS — 15 L

Definition of blends, types of blends (plastic-plastic, rubber-rubber and plastic-rubber blends), differences between copolymer, and IPNs, blends and alloys, composites, concept of miscibility, concept of free energy of mixing, phase equilibria, Flory-Huggins theory, spinodal and critical phase, Gibb's phase rule

UNIT 2: PREPARATION AND PROPERTIES OF BLENDS — 10 L

Methods of blending, compatibilizers, methods of compatibilization, factors effecting miscibility of polymer blends, composition and properties (rheology, morphology, mechanical and thermal)

UNIT 3: CHARACTERIZATION TECHNIQUES OF BLENDS — 10 L

IR, microscopy (TEM, SEM and optical), TGA, DSC, DMA, viscosity, refractive index

UNIT 4: POLYMER COMPOSITES — 10 L

Definition; classification of composites; dispersed phase: (reinforcing fillers, non-reinforcing fillers), and (particulate matter, fibrous structure and platelet structures), continuous phase: thermoset matrix, thermoplastic matrix and high-performance resins, mechanism of reinforcement, various factors affecting reinforcements

UNIT 5: DESIGN AND FABRICATION OF COMPOSITES — 15 L

Fabrication techniques: Prepreg technology, injection and compression molding, vacuum bag molding, hand-lay-up process, spray-up technique, filament winding process, fibre placement process, Pultrusion, reaction transfer molding, laminating techniques, expansion processes, fabrication processes: adhesion, cohesion and mechanical processes & FRPs.

Design of a few polymer composite: basic design practice – material considerations, product considerations and design considerations, rule of mixture

PRACTICALS: (50 MARKS)

1. To prepare polymer blends by melt, solution and latex blending.
2. To check the compatibility of blends.
3. Preparation of FRP laminates by hand lay-up technique.
4. Evaluate the effect of filler loading on mechanical properties of a composite.
5. Fabrication of composite by various techniques.
6. Characterization (thermal and mechanical) of blends and composites.

REFERENCES:

1. Paul D.R., Bucknall C.B., (2000) Polymer Blends Vol. 1 & Vol. 2, Wiley-Interscience.
2. Robeson L.M., (2007) Polymer Blends, Hanser Gardner.
3. Singh R.P., Das C.K., Mustafi S.K., (2002) Polymer Blends and Alloys, Asian Books Private Limited.

ADDITIONAL RESOURCES:

1. Utracki L.A., (2003) Polymer Blends Handbook Vol. 1 & Vol. 2, Kluwer Academic Pub.
2. Bhowmick A.K., De S.K., (1990) Thermoplastic Elastomers from Rubber-Plastic Blends, Ellis Horwood Publishers Ltd.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Flory-Huggins Theory, Compatibilizers, TEM, Hand Lay-up Process, Reinforcing Fillers

FIBRE SCIENCE AND RUBBER TECHNOLOGY

(UPC: 31141602)

Core Paper: C-602

Total Credits: 6 (Theory-4, Practical-2)

(Total Lectures: Theory-60, Practicals-60)

COURSE OBJECTIVES:

1. To study the basic concepts of natural and synthetic fibres
2. To learn about the concept of vulcanization and properties of rubbers

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Explain classification, structure and properties of natural and synthetic fibres
2. Apply the knowledge of preparation of rubbers and fibres

THEORY: (100 MARKS)

UNIT 1: INTRODUCTION TO FIBRES **10 L**

Introduction, classification, structure and general properties of a fibre such as moisture absorption, tex, denier, tenacity, elongation at break, elastic recovery etc.

UNIT 2: NATURAL FIBRES **10 L**

Brief introduction to structure, properties and application of naturally occurring fibres: vegetable fibres, animal fibres and mineral fibres

UNIT 3: SYNTHETIC FIBRES **10 L**

Structure, properties and applications of synthetic fibres: viscous rayon, cellulose acetate, nylon 6, nylon – 66, polyester, acrylic, carbon fibre and aramid fibres

UNIT 4: RUBBERS: PREPARATION, PROPERTIES AND APPLICATIONS **15 L**

Natural rubber and synthetic rubbers (styrene-butadiene rubber, polybutadiene rubber, ethylene propylene diene rubber, butyl rubber, nitrile rubber, neoprene, silicone rubber, fluorocarbon rubber, Thermoplastic elastomers: SBS, SIS, SEBS and polyurethane elastomers)

UNIT 5: VULCANIZATION OF RUBBER **15 L**

Theory and mechanism of sulphur and non-sulphur vulcanization (with and without accelerators), rheocurve of compounded rubber, properties of vulcanized rubber

PRACTICALS: (50 MARKS)

1. Determination of tensile strength, modulus, elongation at break, tear strength, abrasion resistance, heat build-up, resilience, hardness, flex resistance for rubber compounds.
2. Determination of curing time and physical properties of rubber compounds.
3. Identification of fibres through elemental analysis.
4. Analysis of reaction of fibres towards heat & flame.
5. To determine mooney viscosity of rubber using Mooney viscometer.
6. To determine physical properties of fibres: tex, tenacity, denier, moisture content, density etc.
7. To investigate the diametric swelling of fibres.
8. R & D Lab visit (demonstration of spinning & testing).

REFERENCES:

1. Martin J.M., Smith W.K., (2007) Handbook of Rubber Technology, CBS Publisher.
2. Mark J. E., Erman B., Eirich F.R., (2005) The Science and Technology of Rubber,

Elsevier Academic Press.
3. Cook J.G., (2009), Hand Book of Textile Fibres, Woodhead Publishing.
4. Blow S., (2000), Hand Book of Rubber Technology, Hanser Gardner.

ADDITIONAL RESOURCES:

1. Collier B.J., Martin J.B., Tortora P.G., (2009) Understanding Textiles, Prentice Hall.
2. Morton W.E., Hearle J.W.S., (2008) Physical Properties of Fibres, Woodhead Publishing.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Tenacity, Viscous Rayon, EPDM, Rheo-Curve, Asbestos

DSE PAPERS

CONDUCTING POLYMERS

(UPC: 31141901)

Discipline Specific Elective - DSE: Paper 1

Total Credits: 6 (Theory-4, Practical -2)

(Total Lectures: Theory- 60, Practicals-60)

COURSE OBJECTIVE:

1. To impart knowledge of electrical properties of polymeric materials
2. To learn about applications of conducting polymers

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Understand synthesis and doping of polymers required for electrical properties
2. Analyze properties of conducting polymers

THEORY: (100 MARKS)

UNIT 1: BASIC ASPECTS OF CONDUCTING POLYMERS **10 L**

Historical background, band structure, band alignment, conduction mechanism, theory of electrical conduction in conducting polymers

UNIT 2: SYNTHESIS OF CONDUCTING POLYMERS **10 L**

Chemical and electrochemical polymerizations: polyaniline, polypyrrole, polythiophene etc.; doping and its effects on properties of conducting polymers

UNIT 3: PROPERTIES OF CONDUCTING POLYMERS **10 L**

Electrical properties, resistance, impedance, capacitance, magnetic properties and optical properties

UNIT 4: BLENDS OF CONDUCTING POLYMERS **10 L**

Blends of conducting polymers, nanoblends, blends of polyaniline, polyaniline derivatives and their blends, comparison of the morphological and conductivity characteristics of polyaniline blends, blends of polythiophene and polypyrrole

UNIT 5: COMPOSITES **10 L**

Composites of conducting polymers, conducting polymers based bio-composite, properties and applications of conducting polymer composites, bio-components, matrices and effect of reinforcements

UNIT 6: APPLICATIONS **10 L**

Electronic devices, sensors, rechargeable batteries, solar cells, light emitting devices, biomedical devices, bio-system, organ transplant, artificial mussels and EMI shielding etc.

PRACTICALS: (50 MARKS)

1. Synthesis of conducting polymers: polyaniline, polypyrrole, polythiophene etc.
2. Preparation of film/ sheet of conducting polymers.
3. Evaluation of mechanical properties of conducting polymer films/sheet.
4. Determination of the thermal properties of conducting polymers.
5. Measurement of the electrical conductivity and resistance of conducting polymer films/sheet.

REFERENCES:

1. Chandrasekhar P., (1999) Conducting Polymers, fundamentals and applications: A

practical approach, Springer.
2. Nalwa H.S., (1997) Handbook of Organic Conductive Molecules and Polymers: Conductive polymers: synthesis and electrical properties, Vol. 2, Wiley.
3. Skotheim T.A., Elsenbaumer R.L., Reynolds J.R., (2007) Handbook of Conducting Polymers, CRC Press.

ADDITIONAL RESOURCES:

1. Fernandez O.T., (2015) Conducting Polymers, Royal Society of Chemistry.
2. Almeida L.C., (2013) Conducting Polymers: Synthesis, Properties & Applications, Nova Publishers.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Capacitance, Polythiophene, Band Alignment, Nanoblends, EMI Shielding

FIBRE MANUFACTURING TECHNOLOGY

(UPC: 31141902)

Discipline Specific Elective - DSE: Paper 2

Total Credits: 6 (Theory-4, Practical-2)

(Total Lectures: Theory-60, Practicals-60)

COURSE OBJECTIVES:

1. To learn about the basic concepts of spinning including melt and solution spinning.
2. To understand various parameters affecting spinning, drawing and heat setting of fibre structure and properties

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Apply the knowledge of spinning of fibers with desire properties
2. Understand the various spinning variables and post spinning operations

THEORY: (100 MARKS)

UNIT 1: INTRODUCTION TO FIBRES 5 L

Manmade fibres: definition of man-made fibres, brief history of manmade fibres, relative merits and demerits of manmade and natural fibres

UNIT 2: BASICS OF SPINNING & RHEOLOGICAL PROPERTIES OF FIBRE FORMING MATERIALS 25 L

Spinnability of fluids and hydrodynamic stability**,** introduction to polymer viscoelasticity, stress relaxation, polymer entanglements, shear flow in a capillary, factors affecting shear viscosity of polymer fluids, elongational flow, elongational viscosity, flow instabilities in polymer fluids.

Basic concept of melt spinning, dry spinning and dry jet wet spinning process, different components of spinning process, i.e., extruder, gear pump, filters, manifold, spinning head, quenching chamber, winders, variables of spinning, quenching/solidification techniques, factors influencing selection of a particular process for fibre formation, various parameters effecting fibre breakage and fibre structure.

Concept of drawing and heat setting of fibres, neck drawing, effect of drawing and heat setting conditions on the structure and properties of fibre, spin finish application

UNIT 3: MELT SPINNING 10 L

Melt spinning process, crystallization in spin line, stress induced crystallization, melt spinning of PP, polyester and nylon-6 and nylon -66, effect of process parameters on structure and properties of melt spun filament, characteristic features of PET and polyamide spinning

UNIT 4: SOLUTION DRY SPINNING 10 L

Dry spinning of cellulose acetate, acetylation of cellulose, dope preparation and spinning of cellulose diacetate and triacetate, dry spinning of acrylic, significance and types of co-monomers used during polymerization of acrylic

UNIT 5: SOLUTION WET SPINNING 10 L

Wet spinning of acrylic, wet spinning of viscose rayon, formation of structure in viscose, influence of various additives and temperature of the regeneration bath and their influence on the process and properties of viscose rayon

PRACTICALS: (50 MARKS)

1. Melt spinning of Polypropylene.
2. Melt spinning of Nylon 6/66.
3. Solution spinning of Acrylic fibre.
4. Drawing and heat setting of fibres.
5. Effect of drawing and heat setting on properties of fibres.
6. Chemical modification of fibres.

REFERENCES:

1. Gupta V.B., Kothari V.K., (1997) Manufactured Fibre Technology, 1st Ed., Chapman and Hall.
2. NPTEL course material on Manufactured fibre Technology.
3. Macintyre J.E., (2005) Synthetic Fibres: Nylon, Polyester, Acrylic, Polyolefin, Elsevier Science.
4. Kothari V.K., (2000), Textile Fibres: Developments and Innovations, IAFL Publications.

ADDITIONAL RESOURCES:

1. Vaidya A.A., (1988) Production of Synthetic Fibres, First Edition, Prentice Hall of India.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Melt Spinning, Dope, Drawing, Heat Setting, Fibre Quenching

PAINTS, COATINGS AND ADHESIVES

(UPC: 31141903)

Discipline Specific Elective - DSE: Paper 3

Total Credits: 6 (Theory-4, Practical -2)

(Total Lectures: Theory- 60, Practicals-60)

COURSE OBJECTIVES:

1. To learn about of basics of paints, coatings and adhesives and their applications
2. To gain knowledge of formulations of various types of paints, coatings and adhesives

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Make formulations of various types of paints, coatings and adhesives for desired applications
2. Evaluate quality assessment of paints, coatings and adhesives
3. Understand the challenges and scope of paints, coatings and adhesives industry

THEORY: (100 MARKS)

UNIT 1: INTRODUCTION TO PAINTS, COATINGS AND ADHESIVES 15 L

General information about paint, paint composition, types of paints, function and properties of paints, types of adhesives (structural, elastomeric and pseudo plastic), definition and importance of coating, composition of coating, challenges and future scope of paints, coatings and adhesives industry

UNIT 2: RAW MATERIALS OF PAINTS, COATINGS AND ADHESIVES 15 L

Pigments (natural and synthetic), binders (natural and synthetic: thermoset and thermoplastic eg., polyester, epoxy, alkyd, phenolic, vinyl etc.) solvents, thinners, dryers, drying oils

UNIT 3: SURFACE TREATMENT 10 L

Surface preparation (plastic, metal, wood and cemented), heat treatment, corona discharge treatment, flame treatment, mechanical treatment types and preparations of adhesive, adsorption and surface reaction. surface topography, wetting and setting, interfacial bonding

UNIT 4: PREPARATION PAINTS, COATINGS AND ADHESIVES 10 L

Formulations, selection and water solubility, manufacturing and uses of paints, coatings (manufacture, criteria and type), adhesive (manufacturing of structural and elastomeric), manufacturing equipments: high-speed mixers, mill (vertical, horizontal, continuous, sand mill and ball mill)

UNIT 5: COATING OPERATIONS 10 L

Coating operations: brush, roller, both side roller, spray (manual/airless/air guns), dip coating (advantages & limitations), flow coating

PRACTICALS: (50 MARKS)

1. Formulation of paints (water and solvent based).
2. To determine adhesive strength by peel test method.
3. To prepare adhesive of different formulations.
4. Measurement of wettability of adhesives.
5. Measurement of resin/paint viscosity by Ford cup 4 and Brookfield viscometer.
6. To test film hardness of a coated adhesive film.
7. Measurement of impact resistance of painted films.
8. To calculate weight percent of paint in a painted film.

9. To analyze humidity of painted films.

REFERENCES:

1. Morgan W.M., (2000) Outline of Paint Technology, CBS Publisher.
2. Stoye D., (2008) Paints, Coatings and Solvents, Wiley-VCH.

ADDITIONAL RESOURCES:

1. Pocius A.V., Carl H., (2002) Adhesion and Adhesives Technology, Hanser-Verlag.
2. Ryntz R.A., Yaneff P.V., (2003) Coatings of polymers and plastics, Marcel Dekker.
3. Mittal K.L., (2003) Adhesion aspects of polymeric coatings, VSP.
4. Talbert R., (2008) Paints technology Handbook, CRC Press.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Structural Adhesives, Wettability, Dip Coating, Sand Mill

POLYMERIC NANOMATERIALS

(UPC: 31141904)

Discipline Specific Elective - DSE: Paper 4

Total Credits: 6 (Theory-4, Practical -2)

(Total Lectures: Theory- 60, Practicals-60)

COURSE OBJECTIVES:

1. To make students understand the basic concepts of nanomaterials and polymer nanocomposites.
2. To learn the effect of shape, size, dispersion and percolation of nanomaterials on polymer nanocomposites
3. To understand modification techniques of nanomaterials

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Synthesize polymeric nanomaterials
2. Demonstrate the knowledge of properties and structural aspects of polymeric nanomaterials
3. Explore various areas of polymeric nanomaterial applications

THEORY: (100 MARKS)

UNIT 1: INTRODUCTION 10 L

Introduction to general aspects of nanostructured materials, e.g. nanocomposites, block copolymers, interaction parameter, phase behaviour morphology and phase diagrams, microphase separation transition

UNIT 2: NANO-REINFORCING AGENTS 15 L

Preparation, structure and properties of nano-reinforcing agents: 1 D, 2 D and 3 D nanomaterials eg. nanoparticles, nanotubes, nano-clays, POSS, carbon nanostructures (CNTS, graphene)

UNIT 3: FACTORS AFFECTING PROPERTIES OF NANOMATERIALS 10 L

Factors governing properties of nanocomposites such as loading, dispersion and percolation, influence of size, shape and diameter of nanoparticles nanotubes, functionalization of nanomaterials

UNIT 4: STRUCTURAL AND MORPHOLOGICAL CHARACTERIZATION 15 L

Morphology of crystalline polymers, X-ray scattering & diffraction technique analysis of Nanostructure developed in semi-crystalline polymers during deformation, nanostructure of two component amorphous block copolymers, effect of chain architecture

UNIT 5: POLYMER NANOCOMPOSITES 10 L

Basic concepts, preparation, characterization and applications of polymer nanocomposites, technical challenges and understanding of interfacial dynamics using LJ potential and many body problems approach

PRACTICALS: (50 MARKS)

1. Particle size analysis of nanomaterials (nanoparticles).
2. Preparation of polymer nanocomposites by solution casting & melt compounding.
3. Determination of mechanical properties of nanocomposites.
4. Characterization (morphology and thermal) of nanocomposites by optical microscope, SEM, TEM, DSC, DMA, TGA etc.

5. Determination of electrical properties of nanocomposites.
6. Photocatalysis/self-cleaning (contact angle/rolling angle measurements).

REFERENCES:

1. Koo J.H., (2010) Polymer Nanocomposites, Tata McGraw-Hill.
2. Bhattacharya S.N., (2008) Polymeric Nanocomposites-Theory and Practice, Hanser Gardner.
3. Michler G.H., Balta F.J., (2005) Mechanical Properties of Polymer based on Nanostructure and Morphology, CRC Press.
4. Owens F.J., Papoose C., (2003) Introduction to Nanotechnology, John-Wiley & Sons.

ADDITIONAL RESOURCES:

1. Tjong S.C., (2006) Nanocrystalline Materials, Elsevier Science.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

LJ Potential, Interaction Parameter, POSS, Percolation

TYRE TECHNOLOGY

(UPC: 31141905)

Discipline Specific Elective - DSE: Paper 5

Total Credits: 6 (Theory-4, Practical -2)

(Total Lectures: Theory- 60, Practicals-60)

COURSE OBJECTIVES:

1. Familiarizing various types of tyres and their components
2. Developing the knowledge of manufacturing techniques of various tyres

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Apply knowledge of basic concept of manufacturing technology of tyre
2. Understand designing and compounding of various tyre components
3. Evaluate testing and quality assessment of tyre

THEORY: (100 MARKS)

UNIT 1: INTRODUCTION AND TYRE TECHNOLOGY — 10 L

Classification: based on construction (pneumatic, radial, bias, cross ply, tube, tubeless, solid); based on application (scooter, motorcycle, light truck (LT), EMT, ADV, airplane tyre etc.), tyre components and its functions (tread, bead, ply, belt, inner liner (IL), sidewall, tube, bladder), tyre performances (rolling resistance, traction, mileage, wear, fatigue, load withstandability, etc.), tyre terminology (tyre indexing, aspect ratio, etc.), high performance radial tyres

UNIT 2: TYRE MANUFACTURING — 15 L

Mixing (Mixing instruments: two roll mill, kneader, internal mixers), processing (extrusion, calendaring, bead winding), building (building drum), Curing (molding machines etc.), mold sign

UNIT 3: TYRE DESIGN — 15 L

Compound design (selection of chemical ingredients); process design (process parameters correlating with properties); product design (constructions), latest advances in materials and technologies

UNIT 4: TYRE MECHANICS — 10 L

Cornering properties of tyres, slip angle, cornering force, aligning torque tractive (braking) effect and longitudinal slip (skid), camber and camber thrust, performance on wet surfaces, riding comfort

UNIT 5: TYRE TESTING — 10 L

Tyre testing: endurance, groove crack test, plunger test, traction: dry, wet and snow, air permeation, noise test, rolling resistance, drivability, road test, wet braking test, fuel economy test, tread to ply pull out, bead seating test

PRACTICALS: (50 MARKS)

1. Rubber material identification.
2. Rubber mixing and molding.
3. To test mechanical and physical properties of vulcanized rubber.
4. To perform air aging properties of rubber and rubber to fabric ply.
5. To determine bonding strength of rubber to fabric.
6. To calculate abrasion losses of tyre tread.

7. To calculate rebound resilience of a rubber.
8. Tyre indexing and cut section analysis.
9. To evaluate compression set of a rubber.

REFERENCES:

1. Clark S.K., (1971) Mechanics of Pneumatic Tires, National Bureau of Standards, Monograph, US Govt. printing office.
2. French T., (1989) Tyre Technology, Adam Hilger, New York.

ADDITIONAL RESOURCES:

1. Ford T.L., Charles F.S., (1988) Heavy Duty Truck TIRE Engineering SAE's 34th L. Ray Buckingdale Lecture, SP729.
2. Gent A.N., Walter J.D., (2006) The Pneumatic TIRE, U.S. Department of Transportation, National Highway Traffic Safety Administration.
3. Mark J.E., Erman B., Eirich F.R., (2005) The Science and Technology of Rubber, Elsevier.
4. Koutny F., Zling, (2007) Geometry and Mechanics of Pnumatic TIRE, CZE.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Radial Tyre, Tread, Rolling Resistance, Slip Angle

PACKAGING TECHNOLOGY

(UPC: 31141906)

Discipline Specific Elective - DSE: Paper 6

Total Credits: 6 (Theory-4, Practical-2)

(Total Lectures: Theory-60, Practicals-60)

COURSE OBJECTIVES:

1. To learn about the primary requirement and importance of packaging
2. To acquire knowledge of various types of packaging materials

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Apprehend the basic concept of packaging and its utilization for desired applications
2. Assess the quality of packaging material and packaged product

THEORY: (100 MARKS)

UNIT 1: INTRODUCTION AND MATERIAL — 10 L

Importance, scope of packaging (India and Global), packaging materials: types, properties, advantages and disadvantages

UNIT 2: PACKAGING SYSTEMS — 15 L

Types of packaging systems: box, bottle, tetra, pouch, shrink, vacuum, gas, controlled atmosphere packaging (CAP), modified atmosphere packaging (MAP), aseptic packaging

UNIT 3: POLYMERS IN PACKAGING — 15 L

Properties and Applications: LLDPE, LDPE, HDPE, HMHDPE, PP, PVC, Nylon, Polyester, Polycarbonate, PS, EPS

UNIT 4: PACKAGING PROCESS TECHNIQUES — 10 L

Thermoforming in packaging, co-extrusion, extrusion-stretch blow molding, injection molding, , BOPP films

UNIT 5: TESTING OF POLYMER PACKAGING MATERIAL — 10 L

Bursting strength, tensile strength, tear strength, puncture test, impact test (drop, falling dart), permeability test (water vapour, oxygen), biodegradability, sealing strength

PRACTICALS: (50 MARKS)

1. To identify packaging materials with the help of FT-IR, DSC, TGA etc.
2. Determination of physico-mechanical properties (density, bursting strength, tensile strength, tear strength, puncture test strength, impact strength etc) of packaging materials.
3. Determination of water vapor transmission rate of packaging material.
4. To test seal strength integrity of packaging materials.
5. To check biodegradability of packaging material.

REFERENCES:

1. Robertson G.L., (2012) Food Packaging – Principles and Practice, CRC Press Taylor and Francis Group.
2. Paine F.A., Paine H.Y., (1992) A Handbook of Food Packaging, Blackie Academic and Professional
3. Sharma S., Aggarwal M., Sharma D., (2019), Food Frontiers, New Delhi Publisher

ADDITIONAL RESOURCES:

1. Coles R., McDowell D., Kirwan M.J., (2003) Food Packaging Technology, Blackwell.
2. Sukhareva L.A., Yakolev V.S., Legonkova O.A., (2008) Polymers for packaging and containers in food industry, VSP.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Aseptic Packaging, Polyester, BOPP, Puncture Test

FABRICATION OF POLYMERIC PRODUCTS

(UPC: 31141907)

Discipline Specific Elective - DSE: Paper 7

Total Credits: 6 (Theory-4, Practical-2)

(Total Lectures: Theory-60, Practicals-60)

COURSE OBJECTIVES:

1. To learn about the various processing techniques and their components
2. To gain knowledge of handling of post processing applications

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Understand various polymer processing operations, process control and processing equipments
2. Apply knowledge of the basic concepts of cellular plastics, joining of plastics, laminates and injection molding etc.
3. Perform post molding operations such as printing and other decorative methods

THEORY: (100 MARKS)

UNIT 1: FRP LAMINATES — 10 L

Introduction, FRP processing methods, centrifugal casting, matched die molding laminates, high pressure laminating process, types of machinery, impregnation systems– decorative and industrial laminates, continuous high pressure laminating process, applications

UNIT 2: CELLULAR PLASTICS — 10 L

Process to create foaming resins, mechanical foaming, chemical foaming, physical foaming, processes to shape and solidify foams, low pressure foam molding, high pressure foam molding, RIM extrusion foaming, casting foams, steam chest molding, structural foam molding and applications

UNIT 3: MACHINERY AND JOINING OF PLASTICS — 10 L

Machining method seg, cutting, drilling, blending, filling, etc., principles: joining, cohesion, adhesion; cementing: solvent, dop; welding: vibration, hot plate, ultrasonic; adhesive bonding

UNIT 4: POST MOLDING OPERATIONS — 15 L

Printing and decoration of molded items - films, pipes, sheets, etc. hot stamping, pad printing, screen printing, rotogravure printing, heat sealing, ultrasonic welding, and limitations of post molding operations– their advantages

UNIT 5: ADVANCED PROCESSING TECHNIQUES — 15 L

Non-Conventional Injection Molding: Gas injection molding–types, process modeling, gas dissolution, gas fingering, unstable gas penetration, water injection molding, classification of different water injectors, injection foam molding-types, micro cellular injection foam molding, nucleation and pressure profiles during filling, powder metal injection molding - process and steps involved, microinjection molding- types and process details, reactive injection molding

PRACTICALS: (50 MARKS)

1. To prepare open and closed cell foam.
2. To prepare laminates such as epoxy, polyester and epoxy-polyester.

3. To prepare PMMA sheet using bulk polymerizations.
4. To join polymer products by molding.
5. Preparation of polymer products by different processing techniques.
6. Post curing of peroxide cured rubber.
7. To prepare PMMA sheet with in-situ polymerization.

REFERENCES:

1. Satar D., (1986) Plastics Finishing and Decoration, Van Nostrand Reinhold Company.
2. Margolis J.M., (1986) Decorating Plastics, Hanser Publishers.
3. Astrom B.T., (1995) Manufacturing of Polymer Composites, Chapman and Hall.
4. Rosato D.V. and Rosato D.V., (1990) Plastics Processing Data Book, Van Nostrand Reinhold.

ADDITIONAL RESOURCES:

1. Strong A.B., (1996) Plastics: Materials and Processing, Practice-Hall.
2. Watson M.N., (1988) Joining Plastics in Production, Welding Institute.
3. Gupta B.R., (2005) Applied Rheology in Polymer Processing, First Edition, Asian Book Pvt. Ltd.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Lamination, RIM Extrusion Foaming, Welding, Pad Printing, Microinjection Molding

POLYMERS IN BIOMEDICAL APPLICATIONS

(UPC: 31141908)

Discipline Specific Elective - DSE: Paper 8

Total Credits: 6 (Theory-4, Practical -2)

(Total Lectures: Theory- 60, Practicals-60)

COURSE OBJECTIVES:

1. To acquire knowledge of biopolymer and biodegradation
2. To learn about applications and testing of biopolymers

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Understand the basic concepts and requirement of biomaterials and biocompatibility
2. Apply the knowledge of various biomaterials for desired bio-application

THEORY: (100 MARKS)

UNIT 1: BASICS OF BIOMATERIALS **10 L**

Concept of biocompatibility and biodegradability, responsiveness, estimations of degradation and biocompatibility, important biomaterials: hydrogel, fibres, bio-ceramics, bio-elastomers and membrane

UNIT 2: PROPERTIES OF BIOMATERIALS **10 L**

Mechanical (elasticity, yield stress, ductility, toughness, tensile strength, fatigue, hardness), tribological (friction, wear, lubricity), morphology and texture, porosity, adsorption, physical properties, electrical properties, optical properties, magnetic properties, thermal properties, chemical and biological properties

UNIT 3: POLYMERS AS BIOMATERIALS **10 L**

Sources, properties and applications: polyamides, lipids, polyesters and carbohydrates, natural gums, polyurethanes, polylactic acid, alginates

UNIT 4: BIOMATERIALS FOR ORGAN TRANSPLANTS **20 L**

Properties and uses of polymers for organ transplant e.g. dental cement, orthopedic, skin, artificial kidney etc., basic concept of tissue engineering, uses of cellulose, chitosan and alginate

UNIT 5: DRUG DELIVERY **10 L**

Introduction to drug delivery, polymers in controlled drug delivery, dressing strips, polymer drug vessels, core shell and nanogels

PRACTICALS: (50 MARKS)

1. Evaluate the biocompatibility of polymeric samples.
2. Determination of the degradation behavior of polymers such as thermal, hydrolytic etc.
3. Preparation of membranes and measurement of their absorption behavior.
4. Preparation and characterization of dental cement.
5. Prepare a hydrogel and characterization.
6. Determination of mechanical strength of polymers.

REFERENCES:

1. Tiwari A., Tiwari A., (2013) Nanomaterials in drug delivery, Imaging and Tissue Engineering, Wiley.
2. Pilla S., (2011) Handbook of Bioplastics and Biocomposites Engineering Applications, Wiley.

ADDITIONAL RESOURCES:

1. Ratner B.D., Hoffman A.S., (1996) An Introduction to Materials in medicine, Academic Press.
2. Saltzman W.M., (2001) Drug delivery: Engineering principles for drug therapy, Oxford University Press.
3. Kalia S., Averous L., (2011) Biopolymers: Biomedical and Environmental Applications, John Wiley & Sons.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Hydrogel, Tribological, Tissue Engineering, Drug Delivery

DISSERTATION

(UPC: 31141909)

Discipline Specific Elective - DSE: Paper 9

Total Credits: 6

COURSE OBJECTIVES:

1. Understanding the basic knowledge of research and development work
2. To gain knowledge of literature survey

COURSE LEARNING OUTCOMES:

After doing dissertation, students will be able to:

1. Improve research skills
2. Acquire practical knowledge required for industry
3. Develop problem solving aptitude
4. Resolve problems in polymeric products and process

Students may opt for a dissertation as a DSE course in Semester VI. It will be a six credits course. The number of students who will be allowed to opt for this paper will vary depending upon the infrastructural facilities and may vary each year. The college may announce the number of seats for dissertation/ Project work well in advance and choose students for the same. It will involve experimental work under the supervision of a faculty member. The project will be evaluated by internal and external examiners and the report should be sent to examiners in advance (prior to the day of examination).

SEC PAPERS

BIOPOLYMERS

(UPC: 31143901)

Skill Enhancement Elective Course – SEC: Paper 1

Total Credits: 4 (Theory-2, Practical -2)

(Total Lectures: Theory- 30, Practicals-60)

COURSE OBJECTIVES:

1. To gain knowledge of synthetic biopolymers
2. To acquire knowledge on structure and properties of biopolymers
3. To understand the basic applications of various biopolymers

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Synthesize synthetic biopolymers
2. Characterize and analyze biopolymers

THEORY: (50 MARKS)

UNIT 1: BASICS TO BIOPOLYMERS **5 L**

Significance, classifications, properties and applications of biopolymers

UNIT 2: REPRESENTATIVE BIOPOLYMERS **5 L**

Starch, cellulose, chitosan, gelatine, protein, fatty acids, lipids, aliphatic polyesters (PLA, PHB) and cellulose

UNIT 3: CHARACTERIZATION **5 L**

Evaluation of biodegradability, molecular weight, functionality, biocompatibility, mechanical strength and transition temperature

UNIT 4: PROCESSING **5 L**

Processing of biopolymers: composite formation, blending and solvent casting

UNIT 5: APPLICATIONS **5 L**

Applications of biopolymers in packaging, biomedical testing and devices, agriculture: soil conditioning and micro-nutrient delivery

UNIT 6: CASE STUDY **5 L**

Biopolymer based film as substitute of polyethylene, oil conditioning by biopolymers, biopolymers in controlled drug delivery

PRACTICALS: (50 MARKS)

1. Determine the monomers and molecular weight of biopolymers.
2. Develop a bio degradable film by solution casting of biopolymers.
3. Estimate the bio degradability by soil burial test.
4. Evaluate the mechanical strength (swelling index, porosity, hardness and tensile) of a film.
5. Estimate the water vapour transmission rate of a film.

REFERENCES:

1. Byrom D., (1991) Biomaterials: Novel Materials from Biological Sources, First Edition, Macmillan Publishers Ltd.
2. Bastioli C., (1987) Hand Book of Biodegradable polymers, Rapra Technology.
3. Niaounakis M., (2015) Biopolymers: Processing and Products, First Edition, Elsevier Inc.

ADDITIONAL RESOURCES:

1. Johnson R.M., Mwaikambo L.Y., Tucker N., (2003) Biopolymers, Rapra Technology.
2. Pilla S., (2011) Hand Book of Bioplastics & Biocomposites for Engineering Applications, Wiley.
3. Alexander S., (2003) Biopolymers, Vol. 1, Wiley.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction nd Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Biodegradability, Starch, Chitosan, Soil Conditioning

ESTIMATION OF POLYMERS AND POLYMERIC COMPOUNDS (UPC: 31143902)

Skill Enhancement Elective Course – SEC: Paper 2

Total Credits: 4 (Theory-2, Practical-2)

(Total Lectures: Theory-30, Practicals-60)

COURSE OBJECTIVES:

1. To learn about various characterization techniques and methods to identify polymers and their compounds
2. To gain knowledge of isolation of various additives from polymeric compounds

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Apply knowledge of quantitative and qualitative estimation of compounding ingredients of polymer
2. Understand characterization and testing of polymers and their compounding ingredients

THEORY: (50 MARKS)

UNIT 1: BASIC OF POLYMER ANALYSIS 5 L

Quantitative and qualitative estimation of the monomer, fillers, plasticizers, initiators, inhibitors, antioxidants and heat stabilizers etc. used in polymer industries

UNIT 2: PHYSICAL TESTING 5 L

Determination physical properties such as softening point, melting point, viscosity, refractive index, specific gravity, swelling index, melt flow index of polymer materials

UNIT 3: SPECTROSCOPIC AND MORPHOLOGY ANALYSIS 5 L

Chemical composition, functional group, crystallinity and morphology (surface and bulk) by suitable methods (IR, XRD SEM etc)

UNIT 4: THERMAL PROPERTIES 5 L

Stability, conductivity, heat deformation temperature, glass transition temperature and heat capacity

UNIT 5: MECHANICAL PROPERTIES 5 L

Tensile strength, elongation, degradation, flexural and hardness of polymers

UNIT 6: STANDARDIZATION OF DIFFERENT POLYMER PRODUCTS 5 L

Estimation of polymer products for: iodine value, carbon black content, free sulfur content, total inorganic content, silica content, hydroxyl values, acid value, flash point, etc.

PRACTICALS: (50 MARKS)

1. Determine the plasticizer content in processed specimen.
2. Estimate the swelling index of a polymeric hydrogel.
3. Identify the functional group in a polymer.
4. Determine tensile strength of a polymer sample.
5. Estimate the iodine and acid value of polymer product.

REFERENCES:

1. Shah V., (2007) Handbook of Plastic Testing & Technology, Wiley-Interscience.
2. Forrest M.J., (2001) Rubber Analysis: Polymers, Compounds and Products, Rapra

Tech. Ltd.
3. Loadman M.J., (2012) Analysis of Rubber and Rubber-like Polymers, Springer.

ADDITIONAL RESOURCES:

1. Seidel A., (2008) Characterization and Analysis of Polymers, Wiley.
2. Chalmers J.M., Meier R.J., (2008) Molecular Characterization and Analysis of Polymers, Elsevier.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Plasticizers, Swelling Index, Tensile Strength, Structural and Morphology Estimation

WIRE AND CABLE TECHNOLOGY

(UPC: 31143903)

Skill Enhancement Elective Course – SEC: Paper 3

Total Credits: 4 (Theory-2, Practical-2)

(Total Lectures: Theory-30, Practicals-60)

COURSE OBJECTIVES:

1. To familiarize with the selection criteria of materials for cable
2. To acquire knowledge of insulation thermal and mechanical properties of cable materials

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Understand the basic concepts of conductors, semiconductors and insulators
2. Develop understanding of the properties and applications of cable materials

THEORY: (50 MARKS)

UNIT 1: INTRODUCTION 5 L

Introduction to Insulators, semiconductors and conductors, classification of wire and cables (eg., Electric, tele-communication etc.), cable characteristics

UNIT 2: PROPERTIES OF CABLE INSULATING MATERIALS 8 L

i. Electrical: Volume and surface resistivity, break down voltage, dielectric constant, dielectric loss
ii. Thermal: Heat resistance, permissible temperature, effect of overloading on the life of an electrical appliances and thermal conductivity
iii. Chemical: solubility, chemical resistance, weatherability
iv. Mechanical and physical: mechanical strength, porosity, density, brittleness.

UNIT 3: PROPERTIES OF CABLE MATERIAL 7 L

Factors affecting the electrical, thermal, chemical and mechanical properties of cable insulating materials, selection of cable insulating materials

UNIT 4: POLYMERIC MATERIALS USED FOR CABLE INSULATION 10 L

Chlorinated polyethylene (CM), chlorosulfonated polyethylene (CSM), HDPE, LDPE, PVC, NBR, PTFE, EPDM, EVA

PRACTICALS: (50 MARKS)

1. Determine the thermal stability of cable material.
2. Estimate the volume and surface resistivity of cable material.
3. Chemical identification of the cable insulating materials
4. Determination of fire resistance of cable insulating materials.
5. Evaluate weatherability of cable materials.
6. Determination of mechanical strength (tensile, compressive, elongation and hardness), porosity and density of cable materials.

REFERENCES:

1. Cousins K., (2000) Polymers for wire and cables- changes within an industry, Smithers Rapra Publishing.
1. Black R.M., (1983) The History of Electric wire and Cables, Peter Peregrinus Ltd.
2. Martin J.M., Smith W.K., (2007) Hand book of Rubber Technology, CBS Publishers.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:
As per the assessment method mentioned in introduction

KEYWORDS:
Cables, CSM, PVC, Insulators, Weatherability

FOOTWEAR TECHNOLOGY

(UPC: 31143904)

Skill Enhancement Elective Course – SEC: Paper 4

Total Credits: 4 (Theory-2, Practical -2)

(Total Lectures: Theory- 30, Practicals-60)

COURSE OBJECTIVES:

1. To impart knowledge of the basic concepts of raw material and manufacturing of footwear.
2. To learn design and design criteria of footwear

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Apply the knowledge of various type of polymers used in footwear manufacturing
2. Understand the soling and its material requirements

THEORY: (50 MARKS)

UNIT 1: SHOE SOLES 7 L

Soling requirements, soling materials, compounding and processing, individual soling compounding: PVC, thermoplastic rubber, polyurethane, ethylene vinyl acetate, etc

UNIT 2: SHOE ADHESIVES 8 L

Soling adhesives and their types, adhesion principle and selection criteria, heel covering, sole attaching: neoprene, PU, hot melt and liquid curing adhesives, adhesion problems, Coated fabrics: PVC, PU coated fabric

UNIT 3: SOLE MATERIALS 7 L

Molded and pre-fabricated units, individual solings–rubbers, vulcanized rubbers, nylons, polyesters, PVC, thermoplastic rubbers, PU, EVA

UNIT 4: PROCESSING TECHNOLOGY 8 L

Injection molding, sponge molding, direct molded shoes, thermoplastic molding, polyurethane injection molding, insert molding, HF flow molding

PRACTICALS: (50 MARKS)

1. Determination of bonding strength of sole.
2. Preparation of shoe components by various molding techniques.
3. Estimate tear strength and abrasion resistance of a sole.
4. To prepare different compounded sheet of EVA.
5. Determine low temperature flexibility of shoe materials.
6. To prepare sponge sole and calculate its specific gravity.
7. To prepare PU adhesive for sole bonding.

REFERENCES:

1. Martin J.M., Smith W.K., (2007) Hand Book of Rubber Technology, CBS Publisher.
2. Harvey A.J., (1982) Footwear Materials and Process Technology, A LASRA publication.
3. Cohn, W.E., (1969) Modern Footwear Materials & Process, Fairchild

Publications.

ADDITIONAL RESOURCES:

1. Enkatappaiah B., 1997, Introduction to Modern Footwear Technology, Sita Publishers.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Sponge Molding, Sol, EVA, Adhesion

GE PAPERS

BASICS OF POLYMER SCIENCE

(UPC: 31145901)

Generic Elective – GE: Paper 1

Total Credits: 6 (Theory-4, Practical -2)

(Total Lectures: Theory- 60, Practicals-60)

COURSE OBJECTIVES:

1. To familiarize with structure of polymers will be introduced to students.
2. To acquaint students with knowledge of molecular weight determination and polymer solubility

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Understand concept of crystalline and amorphous states of polymers
2. Correlate flexibility with the glass transition temperature
3. Understand structure-property relationship of polymers
4. Apply mathematical formulae to depict polymer solution properties

THEORY: (100 MARKS)

UNIT 1: INTRODUCTION TO POLYMERS 15 L

Introduction and classification of polymers, configuration and conformation of polymers, nature of molecular interaction in polymers, cumulative interaction, entanglement, random chain model and RMS end-to-end distance, various structures of copolymers such as linear branched and cross-linked copolymers

UNIT 2: POLYMER CRYSTAL 10 L

Crystal morphologies, extended chain crystals, chain folding, lamellae & spherulites, crystallization and crystallinity, determination of crystallinity

UNIT 3: PROPERTIES OF POLYMERS 15 L

Physical properties, stress–strain behaviour, mechanical properties (tensile, flexural, impact, fatigue, hardness, creep, abrasion), introduction to flow & glass transition temperature (T_g) and its measurement of T_g, factors affecting the glass transition temperature

UNIT 4: MOLECULAR WEIGHT OF POLYMERS 10 L

Nature and structure of polymers – structure-property relationships, Molecular weight of polymers (*M*n, *M*w etc.), polydispersity, molecular weight distribution and determination of molecular weight by viscosity, end group analysis, cryoscopy, ebulliometry, light scattering & ultracentrifugation methods

UNIT 5: SOLUTION PROPERTIES OF POLYMERS 10 L

Polymer solutions, solubility parameter, solution viscosity, polymer solubility, Thermodynamics of polymer solutions

PRACTICALS: (50 MARKS)

1. Chemical identification of polymers: Functional groups (associated with polymers).
2. Determination of molecular weight by solution viscosity/end group analysis.
3. To check the solubility of the given polymeric sample in different solvents.
4. To determine the melting point of crystalline polymers.

5. Determination of heat deflection temperature & vicat softening point of polymers.

REFERENCES:

1. Brydson J.A., (1999) Plastics Materials, Butterworth Heinemann.
2. Ghosh P., (2010) Polymer Science and Technology: Plastics, Rubbers, Blends and Composites Tata McGraw-Hill.
3. Gowarikar V.R., (2015) Polymer Science, New Age International Pvt.
4. Billmeyer F.W., (2007) Textbook of Polymer Science, Wiley, India.
5. Shah V., (1998) Handbook of Plastics Testing Technology, Wiley interscience publications.

ADDITIONAL RESOURCES:

1. Schultz J.M., (2001) Polymer Crystallization, American Chemical Society.
2. Seymour R.B., Carraher C.E., (2000) Polymer Chemistry, Marcel Dekker.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Crystallization, Glass Transition Temperature, Molecular Weight Determination, Polymer Solubility

CHEMISTRY OF POLYMERS

(UPC: 31145902)

Generic Elective – GE: Paper 2

Total Credits: 6 (Theory-4, Practical -2)

(Total Lectures: Theory- 60, Practicals-60)

COURSE OBJECTIVES:

1. To learn about the production, properties and applications of thermoset and thermoplastic polymers
2. To study kinetics of chain growth and step growth polymerization
3. To learn about the chemistry and manufacturing of flexible and rigid polyurethane foams

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Understand mechanism of chain growth and step growth polymerization
2. Apply the knowledge of synthesis, thermoplastic, thermoset & engineering polymers and investigate their properties to obtain desired applications

THEORY: (100 MARKS)

UNIT 1: INTRODUCTION TO POLYMERIZATION 5 L

Criteria for polymer synthesis, nomenclature, addition and condensation polymerization, chain growth and step polymerization, polymerization techniques: mass (bulk), suspension, emulsion and solution processes

UNIT 2: KINETICS OF POLYMERIZATION 10 L

Concept of functionality, Carother's equation and its applications in polymerization reactions, Kinetics of step growth polymerization and chain growth polymerization, Mayo's equation, auto-acceleration, inhibition and retardation, Co-polymerization, reactivity ratios, Zeigler-Natta catalysts and polymerization

UNIT 3: THERMOPLASTIC POLYMERS 15 L

Brief introduction to the preparation, structure, properties and applications of the following polymers:

a) Polyolefins (PE,PP)
b) Polystyrene and related polymers
c) Poly(vinyl chloride)
d) Poly(vinyl acetate) and related polymers

UNIT 4: THERMOSETTING POLYMERS 15 L

Brief introduction to the preparation, structure, properties and applications of the following polymers:

- Phenol formaldehyde resins
- Unsaturated polyesters
- Polymers from amines
- Polyurethanes (Foams)
- Epoxides

UNIT 5: ENGINEERING POLYMERS 15 L

Brief introduction to structure, properties and applications of polymers: acrylic polymers, fluoropolymers and aliphatic polyamides

PRACTICALS: (50 MARKS)

1. Bulk polymerization of methyl methacrylate/styrene.
2. Solution polymerization of methyl methacrylate/styrene.
3. Emulsion polymerization of styrene/ methyl methacrylate.
4. Suspension polymerization of styrene/MMA.
5. Preparation and testing of UF/PF
6. Preparation and testing of diglycidyl ether of bis-phenol-A (DGEBA).
7. Copolymerization of styrene & MMA.
8. Preparation of poly (vinyl butyral).

REFERENCES:

1. Odian, G., (2004) Principles of Polymerization, Wiley-Interscience.
2. Brydson, J.A., (1999) Plastics Materials, Butterworth-Heinemann.
3. Flory P.J., (2004) Principles of Polymer Chemistry, Asian Books Private Limited.

ADDITIONAL RESOURCES:

1. Billmeyer F.A., (2011) Text book of Polymer Science, John-Wiley and Sons.
2. Seymour R.B., Carraher, C.E., (2003) Polymer Chemistry, Marcel Dekker.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Chain Growth Polymerization, Suspension Polymerization, Thermoplastics, Thermosetting Polymers

POLYMER TESTING AND CHARACTERIZATION

(UPC: 31145903)

Generic Elective – GE: Paper 3

Total Credits: 6 (Theory-4, Practical -2)

(Total Lectures: Theory- 60, Practicals-60)

COURSE OBJECTIVES:

1. To learn about the fundamentals of polymer testing
2. To gain knowledge of testing of polymeric materials on various testing instruments

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Evaluate testing of polymeric materials on different testing instruments
2. Understand and apply testing of plastics materials for its mechanical, electrical, optical, and thermal properties

THEORY: (100 MARKS)

UNIT 1: INTRODUCTION **10 L**

Lambert Beers' law, accuracy, precision, errors and analysis, calibration of results, different standards like BIS, ASTM etc.

UNIT 2: THERMAL AND MECHANICAL ANALYSIS **10 L**

Stress- strain curve, measurement of tensile, flexural, impact, tear, abrasion resistance, creep and fatigue properties, thermal conductivity, thermal diffusivity, specific heat capacity, linear thermal expansion, heat distortion temperature, vicat softening point and thermal stability

UNIT 3: FLOW AND OPTICAL PROPERTIES **10 L**

Melt flow index, cup flow test, viscosity, gloss, haze, refractive index, degree of yellowness

UNIT 4: SPECTROSCOPY **10 L**

NMR, IR, ESR, UV and Mass spectroscopy: principle and application in polymer characterization

UNIT 5: ELECTRICAL AND MAGNETIC PROPERTIES **10 L**

Dielectric strength, Surface and Bulk resistance, conductance, diamagnetism and para magnetism

UNIT 6: STABILITY AND BURNING BEHAVIOUR **10 L**

Environmental stress crack resistance, dynamic and static weathering, burning behaviour, Limiting oxygen index, UL-94 and smoke density

PRACTICALS: (50 MARKS)

1. Measure the M.F.I of polymers.
2. Determination the LOI & Smoke density of polymeric samples.
3. Determination the HDT and vicat softening point (VSP) of polymer samples.
4. Measurement of abrasion resistance and burning behavior of polymer samples.
5. Determination the coefficient of friction and Izod impact strength of a polymer sample.
6. Determination of environment stress cracking resistance of PE/PP.
7. Determination of hardness of plastics.
8. Determination of tensile strength of polymer samples.

REFERENCES:

1. Shah V., (2007) Handbook of Plastic Testing, Technology, Wiley-Interscience.

2. Grellmann W., Seinder S., (1961) Polymer Testing, Hanser Publisher.
3. Martin J.M., Smith W.K., (2009) Handbook of Rubber Technology, CBS Publishers.

ADDITIONAL RESOURCES:

1. Berins M.L., (1991) Plastic Engineering Handbook, Springer-Verlag.
2. Ward I.M., Sweeney J., (2004) An Introduction to the Mechanical Properties of Solid Polymers, John Wiley & Sons Ltd.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

ASTM, FTIR, Impact Test, Dielectric Strength

POLYMER MODIFIERS AND WASTE MANAGEMENT

(UPC: 31145904)

Generic Elective – GE: Paper 4

Total Credits: 6 (Theory-4, Practical -2)

(Total Lectures: Theory- 60, Practicals-60)

COURSE OBJECTIVES:

1. To gain knowledge of various compounding additives used for plastics and rubbers
2. To learn about the various sources of polymer waste generation and their management
3. To learn about waste disposal and treatment methods

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Utilize understanding of compounding additives and methods for modification of polymer properties
2. Understand various policies legislation related to polymeric waste management and their impact on environment
3. Apply the 4 R's approach (reduce, reuse, recycle, recover) for polymeric waste management

THEORY: (100 MARKS)

UNIT 1: INTRODUCTION TO POLYMER ADDITIVES **5 L**

Importance of additives and their selection criteria for commercial polymers

UNIT 2: ADDITIVES FOR PLASTICS AND RUBBERS AND THEIR FUNCTIONS **30 L**

Stabilizers, Fillers, Plasticizers and Lubricants, Flame retardants, Vulcanizing agents and retardants, Accelerators, Activators, Softeners, Colors and pigments etc.

UNIT 3: PRODUCT DESIGN **5 L**

Illustration of few formulations and their compounding procedures

UNIT 4: BASICS OF WASTE MANAGEMENT **10 L**

Definition of Waste and litter, 4 R's approach (reduce, reuse, recycle (mechanical and chemical), recover), recycling classification- - primary - secondary - tertiary - quaternary recycling with examples

UNIT 5: WASTE DISPOSAL TECHNIQUES **10 L**

Role of plastics in the collection of refuse; Sorting of mixed plastic waste, disposal processes– controlled tipping, pulverization, compositing, incineration; compacting and baling

PRACTICALS: (50 MARKS)

1. Effect of fillers on physical and mechanical properties of plastics and rubbers.
2. Determination of bulk density and surface property of fillers.
3. Identification of additives.
4. Secondary recycling of MSW by incorporating and blending the recyclable waste with virgin polymers.
5. Sorting of mixed plastics.
6. Designing of rubber and plastic products.

REFERENCES:

1. Grossman R.F., Lutz J.T., (2018) Polymer modifiers and additives, CRC Press.

2. Chandra R., Adab A., (2004) Rubber and Plastic Waste: Recycling, Reuse and Future Demand, CBS Publisher.

ADDITIONAL RESOURCES:

1. Brydson J., (1999) Plastic materials, Butterworth-heinemann, Elsevier.
2. Martin J.M., Smith W.K., (2007) Handbook of Rubber Technology, CBS Publisher.
3. Ghosh P., (1990) Polymer Science and Technology: Plastic, Rubber Blends and Composites, Tata McGraw-Hill.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Selection Criteria for Fillers, Flame Retardant, Bailing, Pulverization, Tipping, Chemical Recycling, 4 R’s Approach

PRODUCT MANUFACTURING AND PROCESSING

(UPC: 31145905)

Generic Elective – GE: Paper 5

Total Credits: 6 (Theory-4, Practical -2)

(Total Lectures: Theory- 60, Practicals-60)

COURSE OBJECTIVES:

1. To learn about the various processing techniques and their components
2. To gain knowledge of different manufacturing techniques and quality control

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Understand significance of the single screw and multiple screw extruder systems
2. Apply design features in structure of injection molds with materials

THEORY: (100 MARKS)

UNIT 1: EXTRUDER **10 L**

Principle, Dies, different types of extruder, feeding and process monitoring

UNIT 2: INJECTION MOLDING **15 L**

Principles, the molding cycle, the injection molding machine, some aspects of product quality, Reaction injection molding (RIM)

UNIT 3: BLOW MOLDING **10 L**

Blow molding principles, extrusion blow molding, injection blow molding, stretch blow molding, blow molding of PET

UNIT 4: THERMOFORMING **15 L**

Principles, types and applications, Compression and transfer molding: Introduction, thermosetting compounds, compressing molding process, transfer molding

UNIT 5: MISCELLANEOUS PROCESSING METHODS **10 L**

Casting and rotational molding

PRACTICALS: (50 MARKS)

1. Compounding of additives in roll-mill with fillers and reinforcing agents.
2. Prepare a sheet by Compression molding.
3. Prepare a tensile specimen by Injection molding.
4. Extrusion on single screw and twin-screw extruders.
5. Design a product by Thermoforming.
6. Casting of a polymer membrane.

REFERENCES:

1. Strong A.B., (2005) Plastics: Materials & Processing, Prentice Hall.
2. Rosato D.V., Rosato D.V., (2000) Injection Moulding Handbook, CBS Publisher.
3. Morton-Jones D.H., (2007) Polymer Processing, Chapman & Hall.

ADDITIONAL RESOURCES:

1. Crawford R.J., (1998) Plastic Engg., Butterworth-heinemann.
2. Baird D.G., Collias D.I., (1998) Polymer Processing Principles and Design, Wiley-Interscience.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:
As per the assessment method mentioned in introduction

KEYWORDS:
RIM, Thermoforming, Extrusion, Injection and Blow Molding

MATERIAL SCIENCE

(UPC: 31145906)

Generic Elective – GE: Paper 6

Total Credits: 6 (Theory-4, Practical -2)

(Total Lectures: Theory- 60, Practicals-60)

COURSE OBJECTIVES:

1. To introduce the fundamentals of material science especially dielectric materials, semiconducting materials and nanomaterials
2. To impart knowledge of different types of materials, their properties and applications

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Discuss the structure, function, properties of various materials
2. Apply the knowledge of smart materials for desired applications

THEORY: (100 MARKS)

UNIT 1: BASIC OF MATERIALS STRUCTURE **15 L**

Amorphous and crystalline structure, unit cells and space lattices, x-ray diffraction of crystal structures, miller indices of planes and directions, packing geometry in metallic, covalent and ionic solids, single and polycrystalline materials, imperfections in crystalline solids magnetism, intrinsic and extrinsic semiconductors, dielectric properties, absorption and transmission of electromagnetic radiation.

UNIT 2: SOLUTIONS **5 L**

Ideal and real solutions, solubility limit, phase rule, phase diagrams, solid solution, intermediate phases, intermetallic compounds,

UNIT 3: ADVANCED MATERIALS **10 L**

Smart materials (ferroelectric, piezoelectric, optoelectric, semiconducting behaviour), lasers and optical fibres, photoconductivity and superconductivity) Nanomaterials (synthesis, properties and applications), biomaterials, super & shape memory alloys.

UNIT 4: POLYMERS **10 L**

Classification, polymerization, structure and properties, additives for polymer products, processing and applications

UNIT 5: CERAMIC AND COMPOSITE MATERIALS **10 L**

Ceramics: Structure, properties, processing and applications of traditional and advanced ceramics. Composites, classifications, properties and applications of various composites

UNIT 6: METAL AND ALLOYS **10 L**

Solid solutions, solubility limit, intermediate phases, intermetallic compounds, iron-iron carbide phase diagram, heat treatment of steels, cold, hot working of metals, recovery, recrystallization and grain growth. Microstructure, properties and applications of ferrous, non-ferrous alloys and polymer alloy

PRACTICALS: (50 MARKS)

1. To check hardness of composite materials s by Rockwell hardness tester.
2. To determine % composition of metals, fillers etc.
3. To determine magnetic properties of materials.
4. To determine mechanical properties (strength, modulus) of materials.
5. Preparation of advanced polymer composite material for different applications (packaging and biomedical).

6. To prepare safety glass and evaluate its properties.

REFERENCES:

1. Shackelford J.F., (2010) Materials Science And engineering Handbook, Third Edition CRC Press.
2. Mittemeijer E.J., (2011) Fundamentals of Materials Science: The Microstructure–Property Relationship Using Metals as Model Systems, Springer.
3. Sedha R.S., Khurmi R.S., (2004) Materials Science, S. Chand.

ADDITIONAL RESOURCES:

1. Kakani S.L., Kakani A., (2006) Material Science, New Age International.
2. Yao J., Zhou Z., Zhou H., (2019) Highway Engineering Composite Material and its Application, Springer.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Lattice Structure, Phase Diagram, Piezoelectric, Solubility Limit

BIOMEDICAL APPLICATIONS OF POLYMERS

(UPC: 31145907)

Generic Elective – GE: Paper 7

Total Credits: 6 (Theory-4, Practical -2)

(Total Lectures: Theory- 60, Practicals-60)

COURSE OBJECTIVES:

1. To acquire knowledge of biopolymer and biodegradation
2. To gain knowledge of applications and testing of biopolymers

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Understand the basic concepts and requirement of biomaterials and biocompatibility
2. Apply the knowledge of various biomaterials for a desired bio-application

THEORY: (100 MARKS)

UNIT: 1 BASICS OF BIOMATERIALS 10 L

Concept of biocompatibility and biodegradability, responsiveness, estimations of degradation and biocompatibility, important biomaterials: hydrogel, fibres, bio-ceramics, bio-elastomers and membranes

UNIT: 2 PROPERTIES OF BIOMATERIALS 10 L

Mechanical (elasticity, yield stress, ductility, toughness, strength, fatigue, hardness), tribological (friction, wear, lubricity), morphology and texture, porosity, adsorption, physical properties, electrical properties, optical properties, magnetic properties, thermal properties, chemical and biological properties

UNIT 3: POLYMERS AS BIOMATERIALS 10 L

Polyester and polysaccharides, natural gums, biodegradable polymers, polymers and hydrogels

UNIT: 4 BIOMATERIALS FOR ORGAN TRANSPLANTS AND TISSUE ENGINEERING 20 L

Properties and applications of polymers for organ transplant e.g. dental cement, orthopedic, skin, artificial kidney etc., basic concept of tissue engineering, important polymers for tissue engineering: cellulose, chitosan and alginates

UNIT: 5 DRUG DELIVERY AND WOUND CARE 10 L

Introduction to drug delivery, polymers in controlled drug delivery, dressing strips, polymer drug vessels, core shell and nanogels, antimicrobial polymers, bio-conjugates

PRACTICALS: (50 MARKS)

1. Evaluate the biocompatibility of polymeric samples.
2. Determination of the degradation behaviour of polymers such as thermal, hydrolytic etc.
3. Preparation of membranes and measurement of absorption behaviour.
4. Preparation and characterization of dental cement.
5. Preparation of a hydrogel and its characterization.
6. Determination of tensile strength of biopolymers.

REFERENCES:

1. Tiwari A., Tiwari A., (2013) Nanomaterials in drug delivery, Imaging and Tissue Engineering, Wiley.
2. Pilla S., (2011) Handbook of Bioplastics and Biocomposites Engineering Applications, Wiley.

ADDITIONAL RESOURCES:

1. Ratner D., Hoffman A.S., (1996) An Introduction to Materials in medicine, Academic Press.
2. Saltzman W.M., (2001) Drug delivery–Engineering principles for drug therapy, Oxford University Press.
3. Kalia S., Averous L., (2011) Biopolymers: Biomedical and Environmental Applications, John Wiley & Sons.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Chitosan, Tissue Engineering, Drug Delivery, Organ Transplant

FIBRES AND RUBBERS

(UPC: 31145908)

Generic Elective – GE: Paper 8

Total Credits: 6 (Theory-4, Practical -2)

(Total Lectures: Theory- 60, Practicals-60)

COURSE OBJECTIVES:

1. To study the basic concepts of natural and synthetic fibres
2. To learn about the concept of vulcanization and properties of rubbers

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Explain classification, structure and properties of natural and synthetic fibres
2. Apply the knowledge of preparation of rubbers and fibres

THEORY: (100 MARKS)

UNIT 1: INTRODUCTION **5 L**

Basic concepts, classification and terminology of fibres, salient features of fibre forming polymers and their properties, Basic structure of a fibre, properties of a fibre such as moisture absorption, tex, denier, tenacity, elongation at break and elastic recovery

UNIT 2: NATURAL FIBRES **10 L**

Natural occurring fibres – Plant, Vegetable fibres, animal fibres, mineral fibres

UNIT 3: SYNTHETIC FIBRES **15 L**

Man made and synthetic fibres–properties and uses of viscous rayon, cellulose acetate, nylon – 66, polyester, acrylic, carbon fibres and aramid fibres

UNIT 4: VULCANIZATION **15 L**

Rubber and mastication, vulcanization, rheocurve of compounded rubber, mechanism of sulphur vulcanization with and without accelerators, theories of non-sulphur vulcanization, properties of vulcanized rubber

UNIT 5: ENGINEERING POLYMERS **15 L**

Natural rubber and synthetic rubber, styrene-butadiene rubber, polybutadiene rubber, ethylene propylene diene rubber, butyl rubber, nitrile rubber, neoprene, silicone rubber, fluorocarbon rubber

PRACTICALS: (50 MARKS)

1. Determination of tensile strength, modulus, elongation at break, tear strength, abrasion resistance, heat build-up resilience, hardness, flex resistance for rubber compounds.
2. Determination of curing time on physical properties of NR compound.
3. Identification of fibres through solubility tests.
4. Identification of fibres by chemical methods.
5. Analysis of reaction of fibres towards heat & flame.
6. To determine viscosity using Mooney viscometer.
7. Qualitative analysis of Cellulose –Polyester blends.
8. Distinguish POY & FDY polyester filament yarn based on extensibility & shrinkage behavior.
9. Determination of Twist, elongation, TEX, Tenacity, Denier, and count of yarn, fibre& filament.

REFERENCES:

1. Martin J.M., Smith W.K., (2007) Handbook of Rubber Technology, CBS Publisher.
2. Mark J.E. Erman B., Eirich F.R., (2005) The Science and Technology of Rubber, Elsevier Academic Press.
3. Cook J. G., (2009) Handbook of Textile Fibres, Vol. 2, Woodhead Publishing.
4. Blow S., (2000) Handbook of Rubber Technology, Hanser Gardner.

ADDITIONAL RESOURCES:

1. Collier B.J., Bide J.M., Tortora P.G., (2009) Understanding Textiles, Prentice Hall.
2. Morton W.E., Hearle J.W.S., (2008) Physical Properties of Textile Fibres, Fourth Edition, Woodhead Publishing.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Cross-linking, Danier, Jute, Viscose, Rayon, Nylon

POLYMERS IN PACKAGING

(UPC: 31145909)

Generic Elective – GE: Paper 9

Total Credits: 6 (Theory-4, Practical -2)

(Total Lectures: Theory- 60, Practicals-60)

COURSE OBJECTIVES:

1. To learn about the basic necessities and importance of packaging
2. To acquire knowledge of various types of packaging materials

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Apprehend the basic concepts of packaging and its utilization for desired applications
2. Assess the quality of packaging material and packaged product

THEORY: (100 MARKS)

UNIT 1: INTRODUCTION AND MATERIAL **10 L**

Importance, scope of packaging (India and Global), packaging materials: types, properties, advantages and disadvantages

UNIT 2: PACKAGING SYSTEMS **15 L**

Types of packaging systems: box, bottle, tetra, pouch, shrink, vacuum, gas, controlled atmosphere packaging (CAP), modified atmosphere packaging (MAP), Aseptic packaging

UNIT 3: POLYMERS IN PACKAGING **15 L**

Properties and applications: LLDPE, LDPE, HDPE, HMHDPE, PP, PVC, nylons, polyester, Polycarbonate, PS, EPS, PLA, PVA and Starch

UNIT 4: PACKAGING PROCESS TECHNIQUES **10 L**

Thermoforming in packaging, co-extrusion, extrusion-stretch blow molding, injection molding, BOPP films

UNIT 5: TESTING OF POLYMER PACKAGING MATERIAL **10 L**

Bursting strength, tensile strength, tear strength, puncture test, impact test (Drop, falling dart), permeability test (water vapour, oxygen), biodegradability, sealing strength

PRACTICALS: (50 MARKS)

1. To identify packaging materials with the help of FT-IR, DSC, TGA etc.
2. Determination of physico-mechanical properties (density, burst strength, tensile strength, tear strength, puncture test strength, impact strength etc).
3. Determination of water vapor transmission rate of packaging material.
4. To test sealing strength integrity of packaging materials.
5. To check biodegradability of packaging material.

REFERENCES:

1. Robertson G.L., (2005) Food Packaging Principles and Practice, CRC press.
2. Paine F.A. and Paine H.Y., (1992) A Handbook of Food Packaging, Blackie Academic and Professional.
3. Sharma S., Aggarwal M., Sharma D., (2019), Food Frontiers, New Delhi Publisher

ADDITIONAL RESOURCES:

1. Robertson G.L., (2012) Food Packaging–Principles and Practice, CRC Press.
2. Coles R, McDowell D., Kirwan M.J., (2003) Food Packaging Technology, Blackwell.
3. Sukhareva L.A., Yakolev V.S., Legonkova O.A., (2008) Polymers for packaging materials for preservation of food stuffs, VSP.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Packaging Materials, Dart Tester, Sealing Strength

POLYMERS FOR ELECTRICAL AND ELECTRONIC APPLICATIONS

(UPC: 31145910)

Generic Elective – GE: Paper 10

Total Credits: 6 (Theory-4, Practical -2)

(Total Lectures: Theory- 60, Practicals-60)

COURSE OBJECTIVES:

1. To learn about basic concepts of polymer electrical and electronic properties
2. To gain knowledge of electrical and electronics applications of polymers

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Synthesize a conducting polymer for a specific application
2. Apply the knowledge of properties of polymers required for electrical and electronics applications

THEORY: (100 MARKS)

UNIT 1: INTRODUCTION TO POLYMERS **15 L**

Classification of polymers: Petro polymers, conducting polymers, biopolymers, composites, Band diagram, processing of polymers, doping (chemical and ion), Advantages and disadvantages of conducting polymers, limitations

UNIT 2: PREPARATION OF CONDUCTING POLYMERS **15 L**

Synthetic methods: chemical, electrochemical, Photochemical etc. (Polyaniline, polypyrrole, polythiophene, polyacetelene, etc.), methods to enhance the processability of conducting polymers

UNIT 3: PROPERTIES **15 L**

Dielectric strength, dielectric loss, charge storage capacity, electrical conductivity, heat capacity, magnetism, hysteresis loop, shape memory, mechanical properties, EMI shielding

UNIT 4: ELECTRONIC APPLICATIONS **15 L**

Semiconducting organic materials, Polymer based electronic devices, organic field effect transistor, organic transistors, plastic solar cell, light emitting diode, super capacitor, sensors etc.

PRACTICALS: (50 MARKS)

1. Preparation of polyaniline, polypyrrole and polythiophene and measurement of their conductivity.
2. Preparation and testing of conducting polymers for sensor applications.
3. Measurement of multilayer insulation of a thin film.
4. Measurement of dielectric strength of a polymer film.
5. Measurement of mechanical properties of insulating cable
6. Preparation of a conducting polymer nanocomposites.

REFERENCES:

1. Skotheim T.A., Elsenbaumer R.L., Reynolds J.R., (1998) Handbook of conducting polymers, Vol. 1 and Vol. 2, Marcel Dekker.
2. Nalwa H.S., (1977) Organic Conductive Molecules and Polymers, John Wiley & Sons.
3. Bredas J.L., Silbey R., (1991) Conjugated Polymers: The Novel Science and Technology of Highly Conducting and Nonlinear Optically Active Materials, Kluwer

Academic Publishers.
4. Bikales M., Menges O.B., (1986) Encyclopedia of Polymer science and Engineering, Second Edition, Vol.5, John Wiley & Sons.

ADDITIONAL RESOURCES:

1. Lyons M.E.O., (1994) Electroactive polymers, Plenum Press.
2. Margolis J., (1993) Conducting Polymers and Plastics, Chapman & Hall.

TEACHING LEARNING PROCESS:

Conventional Chalk and Board Teaching, Power Point Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Polyaniline, Polypyrrole, EMI Shielding, Light Emitting Diode, Shape Memory Polymers