KAMARAJ
COLLEGE OF ENGINEERING & TECHNOLOGY

(An Autonomous Institution - AFFILIATED TO ANNA UNIVERSITY, CHENNAI)
S.P.G.Chidambara Nadar - C.Nagammal Campus
S.P.G.C. Nagar, K.Vellakulam – 625 701 (Near VIRUDHUNAGAR).

DEPARTMENT OF POLYMER TECHNOLOGY
B.Tech. POLYMER TECHNOLOGY
REGULATIONS –2020 - AUTONOMOUS
CHOICE BASED CREDIT SYSTEM
V & VI SEMESTERS CURRICULUM AND SYLLABUS

Vision of the Department:

To make the Department of Polymer Technology of this Institution the unique of its kind in the field of Research and Development activities in this part of the world.

Mission of the Department:

To impart highly innovative and technical knowledge in the field of Polymer Technology to the urban and unreachable rural student folks through Total Quality Education.

Program Educational Objectives (PEOs):

PEO 1: Graduates will be technically proficient in Polymer Technology with a commitment to quality, timeliness and compete with confidence in their career

PEO 2:. Graduates will contribute towards research and Professional development and entrepreneurship

PEO 3: Graduates will engage in lifelong learning or continuous education Opportunities.

Program Specific Outcomes (PSOs):

PSO1. Polymer industry oriented preparedness: Reveal an ability to identify careers in polymer technology's domains like, synthesis of polymers, processing and quality with adept skills required to work in polymer technology laboratory or manufacturing facility.

PSO2. Higher Education Preparedness: Demonstrate an ability to appear for competitive examinations to pursue higher studies.

The credit requirement for the programme B.Tech. Polymer Technology (as per Regulation 2020) is outlined below:

SEMESTER-V

S.NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
		THEORY						
1	PT1501	Design of Moulds and Dies for Polymers	PC	3	3	0	0	3
2	PT1502	Plastics Processing Technology-II	PC	3	3	0	0	3
3	PT1503	Polymer Compounding	PC	3	3	0	0	3
4	PT1504	Testing of Polymers	PC	3	3	0	0	3
5		Professional Elective I	PE	3	3	0	0	3
6		Open Elective I	OE	3	3	0	0	3
		PRACTICALS						
7	PT1511	Polymer Testing Lab	PC	4	0	0	4	2
8	PT1512	Plastics Processing Laboratory	PC	4	0	0	4	2
9	HS1521	Professional Communication	EEC	1	0	0	1	1
			TOTAL	27	18	0	9	23

SEMESTER-VI

S.NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
		THEORY						
1	PT1601	Characterization of Polymers	PC	3	3	0	0	3
2	PT1602	Polymer Blends and Alloys	PC	3	3	0	0	3
3	PT1603	Polymer Product Design	PC	3	3	0	0	3
4	PT1604	Rubber Processing and Testing	PC	3	3	0	0	3
5		Professional Elective II	PE	3	3	0	0	3
6		Online course-I	OL	3	3	0	0	3
		PRACTICALS						
7	PT1611	Computer Aided Mold Design Laboratory -I	PC	4	0	0	4	2
8	PT1612	Rubber Processing and Testing Laboratory	PC	4	0	0	4	2
9	PT1621	Technical Seminar	EEC	2	0	0	2	1
			TOTAL	28	18	0	10	23

PROFESSIONAL ELECTIVE COURSES (PE)

SEMESTER-V, PROFESSIONAL ELECTIVE – I

S.NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	PT1531	Fundamentals of Nano Science	PE	3	3	0	0	3
2	PT1532	Latex Technology	PE	3	3	0	0	3
3	PT1533	Plastics Recovery And Recycling Techniques	PE	3	3	0	0	3
4	PT1534	Polymers for Biomedical applications	PE	3	3	0	0	3
5	PT1535	Polyurethane Technology	PE	3	3	0	0	3

SEMESTER-VI, PROFESSIONAL ELECTIVE – II

S.NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	PT1631	Footwear Technology	PE	3	3	0	0	3
2	PT1632	Polymer Reaction Engineering	PE	3	3	0	0	3
3	PT1633	Polymers in Electrical and electronics applications	PE	3	3	0	0	3
4	PT1634	Specialty Polymers	PE	3	3	0	0	3
5	PT1635	Thermoplastic Elastomers	PE	3	3	0	0	3

SEMESTER-V, Open ELECTIVE – I (Offered by PT department)

S.NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
Offered to Mech, Civil, MTR								
1	OPT151	Basics of Polymer Recycling	OE	3	3	0	0	3
2	OPT152	Fiber Reinforced Plastics	OE	3	3	0	0	3
Offered to all discipline								
3	OPT153	Fundamentals of Plastic Packaging	OE	3	3	0	0	3
4	OPT154	Introduction to Elastomer Engineering	OE	3	3	0	0	3

SEMESTER V

PT1501	DESIGN OF MOULDS AND DIES FOR POLYMERS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To enable the students to learn the design of moulds such as injection, compression, transfer, blow mould and extrusion dies .

UNIT I INJECTION MOULDS 9

Classification of Injection Moulds - Design of mould components – Methodical Mould Design – Calculation related to-Number of Cavities, Clamping force, shot weight, Selection of Injection Moulding Machine, Layout of Cavities in multi-impression Mould, Feed Systems - Design of Runners & gate, Ejection Systems, Cooling Systems, Venting.

UNIT II COMPRESSION MOULDS 9

Classification of Compression Moulds - Factors that Influence Thermoset Moulding – Materials. Selection in Relation to Moulding Conditions- Calculation related to Clamping force, shot weight- Advantages and Disadvantages of Compression moulds.

UNIT III TRANSFER MOULDS 9

Transfer Mould - Types, principles, Design of Pot and Plunger, Feed System, Economic determination of the number of cavities, Technological determination of the number of cavities, design of mould cavity, design of loading chamber, Transfer tonnage, shot weight- Heat losses and energy requirement to heat the mould - Advantages and disadvantages of Transfer mould.

UNIT IV BLOW MOULDS 9

Blow Mould Design - Materials Selection, Mould Cooling, Clamping Force, Mould Venting, Pinchoff, Head die design, Parison Diameter Calculation, Wall Thickness, Vertical-load strength, Blow ratio, Base pushup, Shapes, Design based consideration - Shrinkage, Neck and Shoulder Design, Thread and beads, Bottom Design.

UNIT V DIES 9

Extrusion die design-Construction features of an extruder, Process, Characteristics of Polymer melt, Die geometry, Die head Pressure, characteristics of land length to Profile thickness, Extrudate die swell, Die materials, Classification of dies-Dies for Solid

Section, Dies for Hollow Profiles, Blown film dies, Flat film dies, Parison dies, Wire and cable Coating dies, Spiral mandrel die, Fish tail die, Adjustable Core die.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of this course, students will be able to

CO1 **:** Select the injection moulding machine and describe the design of feed system

CO2 **:** Distinguish the classification of compression moulds with design features

CO3 **:** Determine the no. of cavities for transfer mould and describe the design of transfer mould

CO4 **:** Select the suitable material for blow mould and describe design of blow mould

CO5 **:** Distinguish the dies for extruder and describe the construction of an extruder

TEXT BOOKS:

1. László Sors, László Bardócz, István Radnóti, 1981. *Plastics Moulds & Dies* - Van Nostrand Reinhold Co.
2. Ronald George William Pye, 1989. *Injection Mould Design*, Longman Scientific & Technical.
3. Glanvill, A. and Denton, E., Injection Mould Design Fundamentals, 1965.
4. S.C. Sharma 2004. *Plastic Design and Processes* Standard Publishers Distributors

REFERENCES:

1. Michel, J., 1985. A review of:“Plastics Product Design: Engineering Handbook” S. LEVY & JH DUBOIS, 1984 (2nd edn) New York, Chapman & Hall.
2. Belofsky, H.B.A.U.O.A., 1995. Plastics: product design and process engineering. *Hanser, Carl, Verlag, Plastics: Product Design and Process Engineering(Germany), 1995,*, p.647.

PT1502	PLASTIC PROCESSING TECHNOLOGY-II	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To make the students to acquire knowledge in injection moulding techniques
- To impart knowledge in blow moulding and thermoforming process
- To make the students to acquire knowledge in ancillary equipments

UNIT I EXTRUSION 9

Extrusion - Principle - Types of Extruders - Single screw and twin-screw extruders - Screw design- L/D ratio-compression ratio- Metering zone - process control variables - Die swell -Types of dies. Extrusion of Plastic Pipes, profiles, cables, Blown films, Flat film, Cast film, sheet film, Filament extrusion.

UNIT II COMPRESSION AND TRASFER MOULDING 9

Compression moulding – Basic principle-Types-machinery and equipment- moulding of thermosets and rubber, Type of compression mould, Automatic compression molding- Advantages & limitations. Transfer moulding – Types – Pot type-Plunger type-Screw transfer type-Trouble shooting operations.

UNIT III ROTATIONAL MOULDING 9

Rotational moulding - Basic process, Rotational moulding – Basic principle- Types: Shuttle type-Swing arm type-Carousel type-Clamshell type-Rock and roll type;

Rotational molding process parameters on product quality, control of bubble formation, multilayer rotational moulding, rotational moulding of PE, PVC and Nylon. Rotational mouldingequipments, batch and continuous type machines.

UNIT IV CALENDERING 9

Calendaring - Basic process, material and products, calendaring plant, types of calendars, roll construction, roll configurations, sheet lines, laminating and embossing lines, process parameters, control and their effect on quality, defects, causes and remedy. Methodologies to take care of roll bending & deflection.

UNIT V FINISHING, DECORATION & JOINING OF PLASTICS 9

Finishing of plastics - Filing, grinding, buffing, drilling, turning, slitting.

Decoration of plastics - Preparation for decorating - Printing: Silk screen printing, Pad printing, Rotogravure printing and flexographic printing - Hot stamping - Vacuum metalizing - Electroplating - In mould labeling.

Welding of plastics - Ultrasonic welding - Vibration welding - Heat sealing - Thermal heat sealing – Dielectric sealing.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of this course, students will be able to

CO1 : Apply the extrusion principles for making plastic pipes, films, sheets and profiles

CO2 : Demonstrate compression and transfer moulding principles for making thermost products

CO3 : Illustrate rotational molding equipments to make thermoplastic products

CO4 : Apply calendaring principles to make laminated and embosses plastic sheets

CO5 : Demonstrate the techniques for finishing, decoration & joining of plastic products

TEXT BOOKS:

1. Muccio, E.A., 1994. *Plastics processing technology*. ASM international.
2. Agassant, J.F., Avenas, P., Carreau, P.J., Vergnes, B. and Vincent, M., 2017. *Polymer processing: principles and modeling*. Carl HanserVerlag GmbH Co KG.
3. Baird, D.G. and Collias, D.I., 2014. *Polymer processing: principles and design*. John Wiley & Sons.

REFERENCES:

1. Lafleur, P.G. and Vergnes, B. eds., 2014. *Polymer extrusion*. John Wiley & Sons.
2. Thomas, S. and Yang, W. eds., 2009. *Advances in polymer processing: from macro-to nano-scales*. Elsevier.
3. Tadmor, Z. and Gogos, C.G., 2013. *Principles of polymer processing*. John Wiley & Sons.
4. Berins, M. ed., 1991. *Plastics engineering handbook of the society of the plastics industry*. Springer Science & Business Media.
5. Stevens, M.J. and Covas, J.A., 2012. *Extruder principles and operation*. Springer Science & Business Media.

PT1503	POLYMER COMPOUNDING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To impart knowledge in importance of various additives and compounding principles
- To develop an understanding of the various mixing devices used in polymer compounding
- To impart knowledge in selecting the various additives based on the performance and property requirements.
- To provide knowledge on the mechanism involved in incorporation of additives into polymeric materials.

UNIT I PRINCIPLES OF COMPOUNDING 9

Introduction to rubber compounding- The ingredients and formulation of a mix: Compounding to meet processing requirements – Compounding for Vulcanizate properties

additives for plastics : Technical requirements of Additives, types and uses of additives, general effects of additives on the properties of a compound

UNIT II COMPOUNDING INGREDIENT OF RUBBERS -I 9

Vulcanizing agents - sulphur and peroxides – activators, accelerators, conventional and efficient vulcanization systems – retarders, Peptizing agent, antioxidants, antiozonants, Mechanism of degradation- Mechanism of ozone attack

UNIT III COMPOUNDING INGREDIENT OF RUBBERS -II 9

Fillers: Carbon black, Non carbon black – Colors & Pigments – Plasticizers, Process aids, Softeners. Special purpose additives: Chemical blowing agents - Flame retardants – Antistatic agent Integral bonding additives

UNIT IV COMPOUNDING INGREDIENT OF PLASTICS 9

Types, mechanism, advantages and limitations of antioxidants – lubricants – heat stabilizers – UV stabilizers – plasticisers – fillers – reinforcements - flame retardants – processing aids – blowing agents – toughening agents – colourants – anti-static and anti-slip agent, oxidation techniques.

UNIT V MIXING DEVICES 9

Different types of mixing devices - twin drum tumblers, ribbon blenders, Z-blade

Mixer, High speed mixer, Ball mill, two roll mill, Banbury Mixer, internal mixing and screw mixing – twin screw compounding machines blending, kneading and granulating equipment

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of this course, students will be able to

CO1 : Apply the knowledge in compounding for Vulcanizate properties

CO2 **:** Suggest a suitable additive based on the performance and property requirement of the specific rubber

CO3 **:** Apply knowledge in the compounding of various rubbers to enhance reinforcement, softening, Flame retardants property to attain desired performance.

CO4 **:** Suggest a suitable additive based on the performance and property requirement of the specific plastics

CO5 **:** Select suitable equipment for compounding specific polymer.

TEXT BOOKS:

1. John. S Dick., 2001., *Rubber Technology- Compounding and Testing for Performance*, Hanser Publishers.
2. Morton-Jones D.H., 1989., *Polymer Processing*, Chapman and Hall, London.
3. John Murphy., 2003., *Additives for Plastics Handbook***,** Elsevier Advanced Technology.

REFERENCES:

1. Richard G.Griskey., 1995., *Polymer Process Engineering*, Chapman and Hall.
2. Brendan Rodgers., 2015., *Rubber Compounding: Chemistry and Applications*, Second Edition., Taylor and Francis Group.
3. Natamai Subramanian Muralisrinivasan., 2014.,.*Introduction to Polymer Compounding: Raw Materials,* Volume 1., Smithers Rapra Technology Ltd.

PT1504	TESTING OF POLYMERS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To familiarize the students with standards and methodology in preparing various polymers specimen
- To enable the students to understand the testing of mechanical properties
- To provide the knowledge on thermal and electrical properties of polymers
- To acquire knowledge in the field of optical properties, weathering and chemical test
- To understand the testing of products and predicting their performance

UNIT I STANDARDS AND SPECIMEN PREPARATION STANDARDS 9

Standards - BIS, ASTM, ISO, SPE, SPI, UL. Preparation of test specimen by various techniques for thermoplastics, thermo sets, and elastomers, conditioning and test atmospheres- Analytical tests: determination of specific gravity, water absorption.

UNIT II MECHANICAL PROPERTIES 9

Tensile, compression, flexural, shear, impact, abrasion, hardness, permanent set, rebound resilience, Dematti flex and cut growth. fatigue. Heat buildup, swelling test

UNIT III THERMAL AND FLAMMABILITY PROPERTIES 9

Vicat softening temperature, heat distortion temperature, coefficient of expansion, thermal conductivity, brittleness temperature, flammability- non rigid solid plastics self supporting plastics in horizontal position solid plastics in vertical position- smoke density, oxygen index test

UNIT IV ELECTRICAL, OPTICAL AND OTHER PROPERTIES 9

Volume and surface resistivity, dielectric constant and dielectric strength, arc resistance, tracking resistance, Refractive index, transparency, haze, gloss, Environmental stress crack resistance (ESCR) - weathering and chemical resistance, aging, ozone resistance, permeability- adhesion.

UNIT V TESTING OF PRODUCTS 9

Plastic films, pipes, foams, containers, and Rubber hose, tyres and tubes.

Non-destructive testing: ultrasonic testing, X-ray fluorescence, Acoustic emission (AE) testing

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of this course, students will be able to

CO1 **:** have the knowledge of standard and conditioning of polymers

CO2 **:** demonstrate the mechanical testing of polymer

CO3 **:** evaluate the flammability and thermal properties of polymers

CO4 **:** describe the electrical and optical properties of polymers

CO5 **:** develop the skills in testing of polymer products.

TEXT BOOKS:

1. Vishu Shah., 2007. *Hand book of Plastics Testing and Failure Analysis.* John-Willey & Sons, New York.
2. ASTM: 8.01 & 8.04; 9.01 & 9.02,2005

REFERENCES:

1. Roger Brown., 2006. *Physical Testing of Rubber*. Springer.

2. Cheremisinoff. P., 1990. *Product Design and Testing of Polymeric Materials*, Marcel Dekker, Inc, New York.

PT1511	POLYMER TESTING LAB	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To familiarize the students with standard and methodology in preparing various polymers specimen
- To emphasize the importance of testing the mechanical and thermal characterization of polymers.
- To emphasize the importance of testing electrical and optical characterization of polymers.
- To provide an understanding of various properties of polymers.

LIST OF EXERCISES

1. Testing of Mechanical Properties

Plastics – Tensile, Compression, Flexural, Impact, Hardness. Rubber – Tensile, Abrasion, Rebound resilience, Flex resistance, Hardness, Heat Build up

2. Testing of Thermal properties

Vicat softening point, Heat Distortion Temperature

3. Testing of Electrical & Optical properties

Volume & Surface resistivity, Dielectric strength, Arc resistance, opacity

4. Testing of weathering properties

Chemical resistance, ESCR, Thermal ageing resistance

(Any Ten from the above all experiments) ***(Any 10 experiments from above)***

TOTAL: 60 PERIODS

OUTCOMES:

Upon successful completion of this course, students will be able to

CO1 : Prepare the test sample for various polymer test

CO2 : Have knowledge on latex testing

CO3 : Will acquire skills in various polymer testing

CO4 : Explain the Significance of the test, detailed procedure for conducting the test and interpretation of results

CO5 : Execute various tests to verify the quality of the products.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S. No.	Description of Equipment	Quantity Required
1.	Universal tensile testing machine (UTM)	1
2.	Shore - A hardness tester	1
3.	Shore - D hardness tester	1
4.	Izod and charpy impact tester	1
5.	Falling dart impact tester	1
6.	Din Abrader	1
7.	Rebound Resilience tester	1
8.	De-Mattia Flex Resistance tester	1
9.	Vicat softening point tester (VSP)	1
10.	HDT Tester	1
11.	Environmental stress crack resistance tester (ESCR)	1
12.	Volume and surface resitivity tester	1
13.	Arc resistance tester	1
14.	Dielectric Strength tester	1
15.	Opacity tester	1
16.	Oven	1

REFERENCES:

1. Vishu Shah., 2007. *Hand Book of Plastics Technology*. John Wiley Intersciencs Inc. New York.
2. Bershtein. V.A., Berry. G.C., 2013*. Polymer Analysis and Characterization.* Advances in Polymer Science.
3. ASTM - Vol. 8.01 - 8.04, Vol.

PT1512	PLASTICS PROCESSING LABORATORY	L	T	P	C
		0	0	4	2

OBJECTIVES:

- To train the students on different plastic processing techniques such as extrusion, injection, compression moulding, FRP processing etc.

LIST OF EXPERIMENTS

Part –A

1. Injection moulding of thermoplastics – Hand, semiautomatic and Fully automatic
2. Preparation of Blow moulded products-Hand & Semiautomatic
3. Compression moulding of thermo set resin and Thermo plastic materials
4. Extrusion of thermoplastics

Part –B

1. Compounding of plastics
2. Recycling of plastic – Scrap grinder
3. Post processing techniques

TOTAL: 60 PERIODS

OUTCOMES:

Upon successful completion of this course, students will be able to

CO1 : Operate the automatic injection, blow moulding machine

CO2 : Prepare the blow mould, thermoformed products

CO3 : Demonstrate the plastic sealing & welding and preparation of polymer films by casting method

CO4 : Describe the mould maintenance and manufacturing practices

CO5 : Dramatize the scrap grinder by using the recycling of plastics

REFERENCES:

1. Harper, C.A., 2006. *Handbook of plastic processes*. John Wiley & Sons.

2. Rosato, D.V. and Rosato, M.G., 2012. *Injection molding handbook*. Springer Science & Business Media.

3. Abdel-Bary, E.M. ed., 2003. *Handbook of plastic films*. iSmithers Rapra Publishing.

4. Willoughby, D.A., 2002. *Plastic piping handbook*. McGraw-Hill Education.

5. Rubin, I.I. ed., 1990. *Handbook of plastic materials and technology* (p. 1745). New York: Wiley.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S. No.	Description of Equipment	Quantity Required
1.	Injection moulding (Hand injection moulding machine, Semi Automatic injection moulding machine,Fully automatic injection moulding machine)	1
2.	Extruder for compounding of thermoplastics	1
3.	Hand blow moulding machine	1
4.	Fully automatic blow moulding machine	1
5.	Air compressor	1
6.	Scrap grinder	1
7.	Crane for mould handling	1
8.	Bench grinding machine	1
9.	Bench wise	1
10.	Sheet cutter	1
11.	Moulds for hand injection moulding	3
12.	Mould for automatic injection moulding	1
13.	Mould for semiautomatic injection moulding	1
14.	Mould for hand blow moulding	1
15.	Mould for fully automatic blow moulding	1
16.	Electronic balance	1

HS1521	PROFESSIONAL COMMUNICATION	L	T	P	C
		0	0	2	1

OBJECTIVES:

- Enhance the Employability and Career Skills of students
- Orient the students towards grooming as a professional
- Make them Employable Graduates
- Develop their confidence and help them attend interviews successfully

UNIT I SOFT SKILLS **6**

Introduction to Soft Skills– Hard skills & soft skills – employability and career Skills—Grooming as a professional with values—Time Management—General awareness of Current Affairs- Error Spotting.

UNIT II EFFECTIVE PRESENTATIONS **6**

Self-Introduction-organizing the material – Introducing oneself to the audience – introducing the topic – answering questions with clarity and appropriate pharases – individual presentation practice— presenting the visuals effectively – 5 minute presentations.

UNIT III GROUP DISCUSSION **6**

Introduction to Group Discussion— Participating in group discussions – understanding group dynamics – brainstorming the topic -– questioning and clarifying –GD strategies- activities to improve GD skills.

UNIT IV INTERVIEW ETIQUETTE **6**

Interview etiquette – dress code – body language – attending job interviews– telephone/skype interview -one to one interview &panel interview – FAQs related to job interviews.

UNIT V CAREER PLAN **6**

Recognizing differences between groups and teams - managing stress- networking professionally- respecting social protocols-understanding career management-developing a long-term career plan-making career changes.

TOTAL: 30 PERIODS

OUTCOMES:

Upon successful completion of this course, students will be able to

CO1 : Apply hard and soft skills to enhance their employability

CO2 : Utilize adequate presentation skills to present a PPT

CO3 : Demonstrate the proper usage of grammar in GD

CO4 : Make use of the acquired skills while attending interviews

CO5 : Develop adequate Soft Skills required for the workplace

REFERENCES:

1. Butterfield, Jeff Soft Skills for Everyone. Cengage Learning: New Delhi, 2015
2. E. Suresh Kumar et al. Communication for Professional Success. Orient Blackswan: Hyderabad, 2015
3. Interact English Lab Manual for Undergraduate Students,. OrientBalckSwan: Hyderabad, 2016.
4. Raman, Meenakshi and Sangeeta Sharma. Professional Communication. Oxford University Press: Oxford, 2014
5. S. Hariharanet al. Soft Skills. MJP Publishers: Chennai, 2010.

SEMESTER VI

PT1601	CHARACTERIZATION OF POLYMERS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To introduce basic introduction, techniques for materials characterization and its importance
- To provide basic descriptions for determination of the structure and composition of solids by spectroscopy techniques
- To acquire the interpretation of the characterization technique of molecular weight of polymers
- To equip the interpretation of thermal properties of polymers
  To describe the operations and uses of TEM, SEM contact angle and atomic force microscopy.

UNIT I ANALYSIS OF POLYMERS 9

Thermoplastics - melting point, density, viscosity, melt flow index, K-value. Moisture analysis, particle size, apparent density, Thermo sets - spiral flow test, cup flow test, gel time and peak exothermic temperature. Resins - acid value, hydroxyl value, isocyanate index, epoxy equivalent

UNIT II SPECTRAL ANALYSIS OF POLYMERS 9

Principle, experimental technique and applications of UV, FTIR spectroscopy & NMR spectroscopy, $-^{1}H$ and ^{13}C – Instruments

UNIT III MOLECULAR CHARACTERIZATION OF POLYMERS 9

Determination of molecular weight- molecular weight distribution- gel permeation chromatography (GPC) high-performance liquid chromatography (HPLC)-. X-ray diffraction analysis -wide and small angle X-ray diffraction techniques-Vapour phase osmametry-gas chromatography

UNIT IV THERMAL ANALYSIS OF POLYMERS 9

Thermal Analysis: Characterizing polymer using differential thermal analysis (DTA), differential scanning calorimeter (DSC), thermogravimetric analysis (TGA), thermomechanical analysis (TMA), and dynamic mechanical analysis (DMA).

UNIT V MICROSCOPY AND SURFACE PROPERTIES 9

Microscopy: Basic principle of electron microscopy; specimen preparation, instruments, working and applications of scanning electron microscope (SEM), transmission electron microscopy (TEM) and atomic force microscopy (AFM), contact angle measurements

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of this course, students will be able to

CO1 : Explain the fundamental testing of materials

CO2 : Interpret the basic spectra of materials characterizations

CO3 : Describe the determination of molecular characterization techniques

CO4 : Analyze the thermal properties of polymers and critically discuss data interpretation.

CO5 : Familiar with basic elements, operation and applications of microscopy techniques

TEXT BOOKS:

1. Chermisinoff., 1996. *Polymer Characterization - Laboratory Techniques and Analysis*. Elsevier, 1st Edition.
2. Campbell. and White, J. R., 2017. *Polymer Characterization Physical Techniques*. Chapman and Hall, London.
3. Crompton, T.R., 2008. *Characterization of Polymers*. SmithersRapra technology limited

REFERENCES:

1. ASTM - 9.01 & 9.02; 8.01 & 8.04, 2000
2. Kampff, 1998. *Characterization of Plastics using physical methods, Experimental Techniques and practical applications*. Oxford University Press, USA.
3. Turi, E.A., 2012. *Thermal Characterization of Polymeric Materials.* Academic Press, New York.

PT1602	POLYMER BLENDS AND ALLOYS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To learn the basic of ideas in selecting the polymer for blends techniques.
- To acquire the knowledge in types and preparation of polymer blends
- To learn the application of polymer blends in emerging technology.

UNIT I CLASSIFICATION OF POLYMER BLENDS AND ALLOYS 9

Definition of polymer blends and alloys - Classification - Criteria for selection of polymer – Thermodynamics of miscibility – Phase morphology – Phase separation behavior - Determination of morphology of polymer blend – Mechanical compatibility - Electron Microscopy

UNIT II PREPARATION OF POLYMER BLENDS AND ALLOYS 9

Principles and methods involved in preparation of Polymer blends and alloys - Introduction to polymer rheology in blend – Interpenetrating polymer network: Synthesis, Morphology, Properties and application of polymer blend - Enhancement of polymer miscibility – utilization of miscible polymers.

UNIT III TYPES OF POLYMER BLENDS 9

Liquid Crystalline Polymer, Blends-Ternary Polymer – Elastomer, Blends-Polymer blends containing block copolymers-– Biodegradable polymer blends- Recycled polymer blends

UNIT IV TOUGHENED THERMOPLASTICS AND THERMOSETS 9

Toughened polymers- Specific examples for toughened thermoplastics and thermosets - specific interaction - hydrogen bonding interaction, dipole-dipole interaction, ion–dipole & ion-ion interaction and additional specific interaction

UNIT V APPLICATION OF BLENDS AND ALLOYS 9

Application of Blends in Emerging technology - Photovoltaic, Light Emitting Diode, Electro chromic, Electric conductivity polymer and blends, Lithium battery & Fuel cells Applications

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of this course, students will be able to

CO1 : Apply the basic concepts of polymer blend

CO2 : Express the preparation of Polymer blends and alloys

CO3 : Classify the types of polymer blends

CO4 : Demonstrate with examples involved in toughened thermosets and thermoplastics and specific interactions

CO5 : Construct the application of polymer blends in emerging technology

TEXT BOOKS:

1. Robeson, L.M., 2007. Polymer blends. *A Comprehensive Review*.
2. Newman, S. and Paul, D.R. eds., 1978. *Polymer Blends: Vol. II*. Academic Press.
3. Utracki, L.A. and Wilkie, C.A. eds., 2002. *Polymer blends handbook* (Vol. 1, p. 2). Dordrecht: Kluwer academic publishers

REFERENCES:

1. Utracki, L.A. and Favis, B.D., 1989. Polymer alloys and blends. *Handbook of polymer science and technology*, *4*, pp.121-185.
2. Folkes, M.J. and Hope, P.S. eds., 1993. *Polymer blends and alloys*. London: Blackie Academic & Professional.
3. Shonaike, G.O. and Simon, G.P. eds., 1999. *Polymer blends and alloys* (Vol. 52). CRC Press.
4. Barlow, J.W. and Paul, D.R., 1981. Polymer blends and alloys—a review of selected considerations. *Polymer Engineering & Science*, *21*(15), pp.985-996.
5. Utracki, L.A., 2002. Compatibilization of polymer blends. *the Canadian journal of chemical Engineering*, *80*(6), pp.1008-1016.
6. Thomas, S., Grohens, Y. and Jyotishkumar, P. eds., 2014. *Characterization of polymer blends: miscibility, morphology and interfaces*. John Wiley & Sons.
7. Finlayson, K., 1994. *Advances in Polymer Blends and Alloys Technology* (Vol. 5). CRC Press.

8. Singh, R.P., 2000. Polymer blends and alloys: An overview. *POPULAR PLASTICS AND PACKAGING*, *45*(3), pp.64-74.
9. Kulshreshtha, A.K. and Vasile, C. eds., 2002. *Handbook of polymer blends and composites* (Vol. 1). iSmithers Rapra Publishing
10. Paul, D.R., 2012. *Polymer Blends Volume 1* (Vol. 1). Elsevier.

PT1603	POLYMER PRODUCT DESIGN	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the concepts of plastic and elastomer product design
- To learn the design for threaded moulds and insert moulded products.

UNIT I STRUCTURE AND PROPERTIES OF POLYMERS 9

Introduction to structure and physical properties of polymers, stress - strain behaviour of polymers, effect of fillers on properties of polymers, stress analysis of polymers, structural design of beams, plates and other structural members.

UNIT II DYNAMIC LOADING ON PLASTIC PARTS 9

Dynamic load response of polymers, effects of cyclic loading, other forms of stress applied to polymer parts, design for stiffness, processing limitations on polymers product design. performance in service and environmental exposure.

UNIT III DESIGN PROCEDURE FOR PLASTIC PARTS 9

Design procedure for plastic parts- Tolerance-Moulded holes-threads-radius- moulded hinges, integral hinge-snap fits Design of plastic structural parts for static loads, design of dynamically loaded plastic parts, design of plastic parts for electrical applications, design of plastic parts for optical applications.

UNIT IV DESIGN OF GEAR,BEARINGS AND PIPE 9

Gear Design: materials, strength and durability, moulded V/s cut plastic gearing inspection assembly and operation. Bearings: Self lubricated plastic materials rubber bearing, type of bearings, designers check list. PVC piping: Raw materials, pipe design, specification and test procedure, manufacturing process.

UNIT V DESIGN OF STATIC, DYNAMIC SEALS AND VIBRATION DAMPERS 9

Elastomeric ring seals: Basic configurations, design method, design consideration static and dynamic seals. Vibration dampers: Basic vibration damping relations, Octave rule for damped systems, Estimating damping in structures, controlling resonant peaks with damping, response of damped structures to shock. Flexible Coupling - Vibration of two mass system, specification and selection of couplings, types of couplings

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of this course, students will be able to

CO1 : Identify the appropriate polymers for structural design based on the stress-strain behaviour.

CO2 : Distinguish the dynamic and cyclic load and identify the processing limitation in product design

CO3 : Describe the design parts such as moulded hole, insert and undercut

CO4 :Evaluate the plastic products for load bearing applications

CO5 :Paraphrase the elastomeric products for load bearing applications

TEXT BOOKS:

1. Malloy, Robert A. 1994. *Plastic Part Design For Injection Moulding*. New York : Hanser Publisher, Munich Vienna New York
2. Levy, S., DuBois, J.H. and Saunders, H., 1984(2nd edn). *Plastics Product Design Engineering Handbook*, New York, Chapman & Hall.
3. Paul A. Tres, 1994. *Designing Plastic Parts for Assembly*, 2nd Revised Edition, Hanser Publishers, Munich Vienna New York.

REFERENCES:

1. McCrum, N.G., Buckley, C.P., Bucknall, C.B. and Bucknall, C.B., 1997. *Principles of polymer engineering*. Oxford University Press, USA.
2. Belofsky,1995 H. Belofsky. *Plastics: product design and process engineering*, Hans er Publishers, Munich, Vienna, New York.
3. Belofsky, H.B.A.U.O.A., 1995. *Plastics: product design and process engineering*. *Hanser, Carl, Verlag, Plastics: Product Design and Process Engineering(Germany), 1995.*

PT1604 RUBBER PROCESSING AND TESTING

L	T	P	C
3	0	0	3

OBJECTIVES:

To provide understanding the importance and technical classification of rubber mixes

To make students conversant with the manufacture of different rubbers.

To impart knowledge on testing of rubbers and rubber products

UNIT I MIXING AND INTERNAL MIXER 9

Two roll mill – Rubber mixing mechanism - Mixing mills – Mastication on the mixing mill – compound preparation on the mixing mill – Pre-heating on the mixing mill – Internal Mixer – Mastication in internal mixer – compound preparation in internal mixer

UNIT II FORMING OPERATIONS 9

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

UNIT III MOULDING AND OTHER VULCANISING TECHNIQUES 9

Compression, transfer and injection moulding of rubber articles Curing: Autoclaves, Hot air chambers, continuous vulcanization, L.C.M. (Liquid Curing Media), Fluidized Bed, microwave curing, Electron beam, High pressure steam tube and roto cure

UNIT IV Test on unvulcanized rubber 9

Test on unvulcanized rubber – Scorch and cure rate: Rotational viscometer, MDR, capillary rheometer, and torque rheometer – Viscoeleastic behavior: Plastimeter and PRI – Tack – Density – Hardness, Dispersion analysis

UNIT V DESTRUCTIVE AND DURABILITY TESTS IN ELASTOMER 9

Abrasion resistance, Tear resistance, Fatigue – Flex cracking and cut growth – Heat build up – Principle and applications. Effect of environment – Oxygen, heat, ozone

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of this course, students will be able to

CO1 **:** Demonstrate skills to use rubber processing machinery and develop a rubber compound

CO2 **:** Apply the calendaring and extrusion principles to make rubber products

CO3 : Select the suitable moulding technique and vulcanization method for end applications

CO4 : Demonstrate the testing procedure for unvulcanized rubber compound and vulcanizate.

CO5 : Do testing of rubber and asses' quality of rubber compound

TEXT BOOKS:

1. Philip K.Freakley., 1985., *Rubber Processing and Production Organization*., Plenum Press, Newyork.
2. Brown,.R.P., 1986., *Physical Testing of Rubber*, Elsevier.

REFERENCES:

1. Steven Blow., 1998., *Handbook of Rubber Technology*, Galgotia Publication Pvt. Ltd.
2. Blow..C.M., and Hepburn, C., 1982., *Rubber Technology and manufacture*, Butterworths.

PT1611	COMPUTER AIDED MOLD DESIGN LAB-I	L	T	P	C
		3	**0**	**0**	**3**

OBJECTIVES:

To enable the students to,

- Design core and cavity for injection mold
- Assemble injection mold parts using CAD software
- Design various types of injection mold for the products

LIST OF EXERCISES

1. Drawing of sprue bush and register ring for injection mold
2. Drawing of a guide bush and guide pillar for injection mold
3. Drawing of ejection system components for injection mold
4. Design of core insert for given products
5. Design of cavity insert for given products
6. Design of core plate and cavity plate with cooling system for given product
7. Assembly of guide bush and guide pillar for injection mold
8. Assembly of core and cavity insert for injection mold
9. Assembly of ejection system for two plate injection mold
10. Calculation of No of cavities, clamping tonnage and plasticizing rate
11. Design of two plate injection mold for given product
12. Design of three plate injection mold for given product
13. Design of split mold for product with undercuts
14. Design of hot runner mold for given product

(Any 10 experiments from above)

TOTAL: 60 PERIODS

OUTCOMES:

Upon successful completion of this course, students will be able to

CO1 **:** Draw injection mold parts using CAD software

CO2 **:** Calculate No of cavities, clamping tonnage and plasticizing rate for injection molding

CO3 **:** Design core and cavity for given product using CAD software

CO4 : Assemble injection mold parts using CAD software

CO5 : Design various types of injection mold for given product

LIST OF EQUIPMENT FOR A BATCH OF 60 STUDENTS:

S. No.	Description of Equipment	Quantity Required
1	CAD Software License	1 No
2	Printer	1 No

TEXT BOOKS:

1. R.G.W.Pye, *Injection Mold Design*, East West Press Pvt. Ltd., New Delhi.3rd Edition, 1983
2. KlusStokhert (Edt.), *Mold making handbook for Plastic Engineers*, Hanser Publishers, 2nd edition, 1998.

REFERENCES:

1. Rosato, D.V. and Rosato, M.G., 2012. *Injection molding handbook*. Springer Science & Business Media.
2. Crawford, R.J. and Martin, P.J., 2020. *Plastics engineering*. Butterworth-Heinemann.
3. Agassant, J.F., Avenas, P., Carreau, P.J., Vergnes, B. and Vincent, M., 2017. *Polymer processing: principles and modeling*. Carl HanserVerlag GmbH Co KG.

PT1612	RUBBER PROCESSING AND TESTING LABORATORY	L	T	P	C
		0	0	4	2

OBJECTIVES:

- To impart rubber compounding skills
- To operate the compression moulding press to manufacture rubber product
- To enable students to get hands on experiments on latex products
- To acquire knowledge in testing of dry rubbers and latex.

LIST OF EXPERIMENTS

Part-A

1. Mastication of NR on two roll mill
2. Mixing of rubber compounds
3. Compression moulding of rubber compounds
4. Preparation of dry rubber products –Play Ball
5. Preparation of dry rubber products – Hawaii sheet
6. Preparation of latex products - Hand Gloves and Rubber band
7. Preparation of latex products - Balloon
8. preparation of rubber blends

PartB:

1. Determination of Total solid content(TSC) of NR Latex
2. Determination of Dry Rubber Content (DRC) of Natural rubber latex 3. Determination of Total Alkalinity of Natural Rubber Latex (NR)
4. Determine the specific gravity of the given rubber sample.
5. Determine the hardness of the given sample.

(Any six experiments in Part –A and four experiments in Part –B)

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of this course, students will be able to

CO1 : Demonstrate the mixing of raw rubber with additives in two roll mill

CO2 **:** Apply the knowledge in operating rubber processing machinery and testing

CO3 : Develop different rubber products and latex products

CO4 : Demonstrate the testing procedure for latex and Dry rubber products

CO5 : prepare rubber blends based on the required properties

REFERENCES:

1. Siddaramaiah., 2007., *Practical's in Polymer Science*, CBS Publishers & Distributors.

PT1621 TECHNICAL SEMINAR L T P C

0 0 2 1

The seminar power point presentation shall be fundamentals oriented and advanced topics in the appropriate branch of engineering with references of journal papers. Presentation is to be planned for duration of 15 minutes including a question answer session of five minutes. The marks will be awarded based on the presentation of the seminar.

ELECTIVE I

PT1531	FUNDAMENTALS OF NANO SCIENCE	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To learn about basis of nanomaterial science, preparation method, types, characterization and application.

UNIT I **INTRODUCTION TO NANOSCIENCE & NANOTECHNOLOGY** **9**

Introduction – distinction between molecules, bulk materials and nanoparticles – Classifications of nanostructured materials- nano particles- quantum dots, nanowires ultra-thin films- carbon nanotubes, graphene -multilayered materials.

Types of nanomaterial-Metal oxides and metal nano particles - Ceramic nano particles - Semi conducting quantum dots - Core-shell quantum dots - Nanocomposites - Micellar nanoparticles.Length Scales involved and effect on properties: Mechanical, Electronic, Optical, Magnetic and Thermal properties. Introduction to properties and motivation for study (qualitative only).

UNIT II **GENERAL METHODS OF PREPARATION** **9**

Bottom-up Synthesis-Top-down Approach: Co-Precipitation, Ultrasonication, Mechanical Milling, sol-gel, thermolysis (hydrothermal and solvothermal), electrodeposition,Colloidal routes, Self-assembly, Vapour phase deposition, MOCVD, Sputtering, Evaporation,Molecular Beam Epitaxy, Atomic Layer Epitaxy, MOMBE.

UNIT III **NANOMATERIALS** **9**

Nanoforms of Carbon - Buckminster fullerene- graphene and carbon nanotube, Single wall carbon Nanotubes (SWCNT) and Multi wall carbon nanotubes (MWCNT)-methods of synthesis(arcgrowth, laser ablation, CVD routes, Plasma CVD), structure-property Relationships applications- Applications of Carbon based nanomaterials (CNT, CNF, Graphene) - Polymers nanofibers and their applications in bioengineering – Functional polymers for bone tissue engineering applications – DNA- RNA- Nanoproducts polymer nanocomposite membranes

Nanometal oxides-ZnO, TiO_2,MgO, ZrO_2, -preparation, properties and applications.

UNIT IV NANOMATERIAL PROPERTIES and FABRICATION 9

Properties and application of nanomaterials – Optical - Mechanical – Electronic And Electrical - Quntum Dot (QD) Sensitized Solar Cells (QD-SSC) - Smart Coatings (Self Cleaning) - Superhyrophobic Coating For Drag Reduction – Application Of Polymer-Nanocomposites for Improvement in Properties - Smart Sensors. Nanomaterial Fabrication: Bottom-up vs. top-down -Epitaxial growth -Self-assembly- nanoparticle synthesis -RF plasma, thermolysis, chemical induced, and pulse laser.

UNIT V NANOMATERIAL CHARACTERIZATION 9

Nanomaterial Characterization: Structural characterization- X-Ray diffraction, electron microscopy-TEM, SEM,FEG-SEM, STM, Atomic Force Microscopy AFM , Chemical characterization- Infrared Spectroscopy, Raman Spectroscopy- Optical characterization -Photoluminescence, NMR, ESR and Light Scattering methods - Dielectric characterization – Magnetic characterization – Chemical analysis.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of this course, students will be able to

CO1 **:** familiarize about the science of nanomaterials

CO2 **:** illustrate the various synthesis methods applicable to different nano materials

CO3 **:** Apply the knowledge on physical, mechanical and chemical methods of production of nano materials

CO4 **:** Apply the knowledge gained in different types of nanomaterial properties for various engineering applications.

CO5 **:** Acquire the knowledge of various methods of characterization of nano materials.

TEXT BOOKS:

1. Edelstein A.S and Cammearata, R.C eds 1996*., "Nanomaterials: Synthesis, Properties and Applications"*, Institute of Physics Publishing, Bristol and Philadelphia,
2. John Dinardo N , 2nd edition 2000 "*Nanoscale Charecterisation of surfaces & Interfaces*", ,Weinheim Cambridge, Wiley-VCH,

3. Akhlesh Lakhtakia, 2007 *"The Hand Book of Nano Technology, Nanometer Structure,Theory, Modeling and Simulations"*. Prentice-Hall of India (P) Ltd, New Delhi,
4 H.S. Nalwa (Ed)2005 *Handbook of Nanostructured Biomaterials and their applications in nanobiotechnology,* American Scientific Publishers.
5 Pradeep. T.,2012 *"Textbook of Nanoscience and Nanotechnology"*, McGraw Hill Education (India) Private Limited, New York, 2012
6 Charles P. Poole and Frank J. Owens,2009 *"Introduction to nanotechnology",* Wiley (India), 2009.
7 C.Dupas, P.Houdy, M.Lahmani,2007 *Nanoscience: "Nanotechnologies and Nanophysics",* Springer-Verlag Berlin Heidelberg, 2007
8 Rao C N R, A.Muller, & A.K.Cheetham,2005 *"The chemistry of Nanomaterials",Vol1 & Vol2* .Wiley-VCH.

REFERENCES:

1. Ozin G Aand A.C. Arsenault, A. C,2005 *"Nanochemistry: A Chemical Approach to Nanomaterials*", RSC Publishing, Thomas Graham House, Cambridge.
2. Cao. G.,2004 "*Nanostructures & Nanomaterials: Synthesis, Properties & Applications*", Imperial College Press.
3. Gaddand. W., Brenner. D., Lysherski. S. and Infrate. G.J.,2002 *"Handbook of NanoScience Engineering and Technology"*, CRC Press.
4. Bandyopadhyay A.K.,2008 *"Nano Materials"*, New Age International Publishers, New Delhi.
5. Guozhong Cao,2011 *"Nanostructures and Nano materials-Synthesis, Properties and Applications",* Imperial College Press.
6. Zhong Lin Wang, 2002*"Handbook of Nanophase and Nanomaterials (Vol 1 and II)*", Springer, 2002
7. Michael Köhler and Wolfgang Fritzsche 2Rev Ed edition 2007 *Nanotechnology: An introduction to nano structuring techniques,* Wiley-VCH.
8. Mick Wilson, Kamali Kannangara, Geoff Smith, and Michelle Simmons, I edition, 2002*Nanotechnology: basic science and emerging technologies*, Chapman & Hall/CRC.

9. Ajayan, P.M, Schadler, L.S, Braun,P.V 2003 “*Nanocomposite Science and Technology”,* WILEY-VCH Verlag GmbH,

10. Richard A. Pethrick, First edition 2013 “*Polymer Structure Characterization: From Nano to Macro Organization in Small Molecules and Polymer*”, , Royal Society of Chemistry.

PT1532	LATEX TECHNOLOGY	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the basic knowledge concept of latex and synthetic lattices
- To acquire the concepts on, latex compounding, latex dipping
- To learn the basics terms of Latex foam, spreading and casting
- Latex threads and adhesives

UNIT I LATEX CHARACTERISTICS AND SYNTHETIC LATTICES, 12

Natural rubber latex- Definition of Latex, classification, origin, composition of field latex tapping and properties, Specification and testing- (National and ISO) for latex grades (ASTM D 1076) -Determination of total solid content of NR latex, dry rubber content of NR latex. total alkalinity of NR latex, Mechanical stability of Latex, KOH number, density and viscosity of latex.Synthetic Lattices, Styrene Butadiene Lattices, Nitrile Lattices, Polychloroprene Lattices and Polyvinyl Chloride Lattices

UNIT II LATEX COMPOUNDING 9

Latex compounding-Ingredients, and other compounding ingredients, Preparation of Dispersions, Emulsion, Slurries; Machineries- Ball mill, and colloid mill Preparation, properties and application of Prevulcanized latex, MG Latex, Evaluation of quality dispersion - Chloroform number, swelling index test;

UNIT III LATEX DIPPING PROCESS 7

Principle and types of dipping process, (Gloves, Condoms, Catheters, Balloons) , Manufacture ,properties , formulations , specification , defects and remedies

UNIT IV LATEX FOAM, SPREADING AND CASTING 9

Principle and Manufacture of Latex Foam-Dunlop process and Talalay process, testing of latex foam ,compounding for latex foam, Latex Casting, Latex Casting using Plaster Mould, Latex Casting using a Metal Mould , latex Spreading- carpet backing, typical carpet backing compounds

UNIT V LATEX THREADS AND ADHESIVES 9

Principle and Manufacture of latex elastic threads; Technical Specifications of Latex Extruded Rubber Thread, Testing of Latex Thread Latex adhesives , Formulator

Ingredients for Latex-based Adhesives, Testing the Quality of the Adhesive Latex-based Adhesives for Paper

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of this course, students will be able to

CO1 : Analysis the specification and testing of latex grades and preparation of synthetic lattices

CO2 : Demonstrate the function of Prevulcanized latex compounding material with a suitable compounding machineries

CO3 : Express the basic formulation of latex products of Gloves, catheters, balloons and elucidate the dipping process

CO4 : Compute the compounding design for latex foam, sheeting

CO5 : describe manufacturing of synthetic latex products like toys and extrusion latex products like elastic threads

TEXT BOOKS:

1. Joseph, R., 2013. *Practical Guide to Latex Technology*. Smithers Rapra.
2. Morton, M., 1999. Introduction to polymer science. In *Rubber Technology* (pp. 1-19). Springer, Dordrecht.
3. Blow, C.M., 1971. *Rubber technology and manufacture.*

REFERENCES:

1. De, S.K. and White, J.R. eds., 2001. *Rubber technologist's handbook* (Vol. 1). iSmithers Rapra Publishing.
2. Roland, C., 2007. Rubber technologist’s handbook, vol. 2. *Rapra, Shrewsbury, UK*.
3. White, J., De, S.K. and Naskar, K., 2009. Rubber Technologist’s Handbook, Vol. 2. *Smithers Rapra, Shawbury, Shrewsbury, Shropshire*, p.452.
4. Thomas, S., Chan, C.H., Pothen, L.A., Rajisha, K.R. and Maria, H. eds., 2013. *Natural Rubber Materials: Volume 1: Blends and IPNs* (Vol. 7). Royal society of Chemistry.
5. Gelling, I.R., 1985. Modification of natural rubber latex with peracetic

acid. *Rubber Chemistry and Technology*, *58*(1), pp.86-96.

6. Warner, W.C., 1994. Methods of devulcanization. *Rubber Chemistry and Technology*, *67*(3), pp.559-566.
7. Manuel, H.J. and Dierkes, W., 1997. *Recycling of rubber* (Vol. 99). iSmithers Rapra Publishing.

PLASTICS RECOVERY AND RECYCLING TECHNIQUES

L	T	P	C
3	0	0	3

PT1533

OBJECTIVES:

- To provide the basics of Fundamentals in Plastic Recycling
- To basic concepts of industrial reprocessing technology and sort techniques
- To impart knowledge on application recycling , energy recovery and waste management

UNIT I MATERIALS FUNDAMENTALS IN PLASTIC RECYCLING 9

Materials fundamentals, chemical structure of polymers , structure of thermoplastic polymers , important properties in solid and molten states , virgin state of delivery , mixed plastic waste solubility of polymers, bio degradable polymers, elements of chemical recycling of plastics waste- Thermochemical properties, thermal decomposition ,chemical induced breaker down

UNIT II REPROCESSING TECHNOLOGY 9

Industrial method of separation - factors determining the choice techniques, detection and separation techniques of whole containers, size reduction of waste plastics by size reduction machines and application, classification screen and flow classification sorting techniques – according to density, wettability, electrostatic sorting.

UNIT III METHODS OF MECHANICAL RECYCLING 9

Filtration system of recyclates processing –polymer impurities, function of the screen, types of screen , screen packs , large area screen ,problem in extruding recyclates, process technology processing regrind, processing mixtures, processing recyclates on single screw extruder ,twin screw extruder , processing of co extrusion select examples of extrusion of recylate into pipe, form profile , foam sheet or film

UNIT IV APPLICATION OF RECYCLATES 9

Properties and application of recycled PE-HD, describe materials , structural an general properties , mechanical properties, application area and processing of polyethylene , PE-recycling –factors affecting PE Recycling , quality of recycled materials processing of recycled materials, current and future market for recycled PE.

UNIT V ENERGY RECOVERY AND WASTE MANAGEMENT 9

Energy recovery from plastics wastes in incineration plant , method of waste

incineration , process technology combustion technology , influence of plastics on the calorific values of wastes , emission reduction technology , sewage sludge incineration processes , recent incineration , The history of waste management , general requirement for management practices

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of this course, students will be able to

CO1 **:** Describe the basic fundamental of recycling

CO2 **:** Express the reprocessing and sorting techniques

CO3 **:** Discuss the methods involved in mechanical recycling

CO4 **:** Explain the application of recycling of materials

CO5 **:** Illustrate the energy recovery from materials and waste management

TEXT BOOKS:

1. Brandrup, J., Bittner, M., Michaeli, W. and Menges, G. eds., 1996. *Recycling and recovery of plastics*. Hanser Verlag
2. Goodship, V., 2007. Plastic recycling. *Science progress*, *90*(4), pp.245-268.
3. Francis, R. ed., 2016. *Recycling of polymers: methods, characterization and applications*. John Wiley & Sons.

REFERENCES:

1. Francis, R. and Sethi, B., 2012. Catalytic Feedstock Recycling of Polymers. *A First-Principles Study of Structure-Property Correlation and the Origin of Ferrimagnetism in Gallium Ferrite*, *13*, p.249.
2. Francis, R. and Sivadas, A., 2017. Ecoprofiles of Recycled Polymers at a Glance. *Recycling of Polymers*.
3. Wicaksono, S.T., Ardhyananta, H. and Rasyida, A., 2018, April. Study on mechanical and physical properties of composite materials with recycled PET as fillers for paving block application. In *AIP Conference Proceedings* (Vol. 1945, No. 1, p. 020066). AIP Publishing LLC.
4. Balakrishnan, P. and Sreekala, M.S., 2016. Recycling of Plastics. *Recycling of Polymers*, pp.115-139.
5. Dehon, O. and Latteur, P., *Recycled plastics in structural engineering.*

PT1534	POLYMERS FOR BIOMEDICAL APPLICATIONS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand Biomaterials, classification, requirements and its biocompatibility.
- To understand the various natural and synthetic polymers used for biomedical applications and their compatibility with biological system
- To study about the polymeric lenses
- To study about the dental polymers
- To familiarize about the various biomaterials used as implants in cardiovascular, ophthalmology, and other artificial organs

UNIT I BIOMATERIALS 9

Biomaterials, classification, requirements, biocompatibility, sterilisation, inflammation and wound healing, blood clotting system, kinin system, biological responses to implants, implantdesign and applications.Effects of physiological fluid on the properties of biomaterials. Biologicalresponses. Surface, physical and mechanical properties, Standards of implant materials.

UNIT II BIOMEDICL POLYMERS 9

Criteria for the Selection of Biomedical Polymers Physicochemical Aspects of the BloodCompatibility of Polymeric Surface.Biomedical Polymers from biological source, Poly hydroxyl Alkanoic Acids, Microbialpolysaccharides, Silk, Collagen. , Microbial Cellulose, Hyaluronic Acid, Synthetic Polymers suchas PMMA, Silicone Rubber, Polyethylene, Natural Rubber, Hydrogels.

UNIT III POLYMERIC LENSES 9

Contact Lenses, Hard Lenses, Gas Permeable Lenses, Flexible Lenses, Soft Lenses, Hydrogels,Equilibrium Swelling, Absorption And Desorption, Oxygen Permeability, Types of Soft Lenses,Manufacture, Cleaning And Disinfection.

UNIT IV DENTAL POLYMERS 9

Dental applications, denture base, denture reliners, crown and bridge resins, plastic teeth, mouth protectors, maxillofacial prosthetic materials, restorative materials, polyelectrolyte based restorative sealants, adhesives, dental impression and duplicating materials, agar,

algmater elastomers

UNIT V BIOMEDICAL APPLICATIONS OF POLYMERS 9

Biomedical applications of polymers, orthopaedics, cardio vascular, silicone implants, polymer membranes, polymer skin, polymeric blood, poly (vinyl pyrollidone), bioerodable polymers and application , silicone polymer implants

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of this course, students will be able to

CO1 **:** to describe the criteria for selection of bio medical polymers

CO2 **:** to identify the biomedical polymers from biological source.

CO3 **:** to attain the skill on polymeric lenses used in medical applications

CO4 **:** to be familiarized with the polymers used in dental applications

CO5 **:** to explain the biomedical applications of polymers

TEXT BOOKS:

1. Park, J.B,2003, Bio-materials, An Introduction –, CRC Press.
2. YocumR.H,andNyquist,E.BEdsVol1. Chapter 3, PP 299-487.1973, *Functional Monomers*, Marcel Dekker.
3. GalinM.A,andRuben, M Ed1978, *Soft contact lenses: Clinical and Applied Technology*, John Wiley.

REFERENCES:

1. ManasChanda, Salil K. Roy (Ed) Second Ed. *1993Plastic Technology Hand Book* Marcel Dekker,Inc. New York.
2. Chiellini; Emo, Sunamoto; Junzo, Migliaesi; Claudio, Ottebrite; Raphael and Cohn; Daniel (Eds.), 2001*Biomedical Polymers and Polymer Therapeutics*, KluwerAcademic/Plenum Publishers, New York.
3. Galaev; Igor and Mattiasson; Bo (Eds.), 2008*Smart Polymers; Applications inBiotechnology and Biomedicine,* CRC Press, Boca Raton.
4. Lehninger, 2005 *Principles of Biochemistry*, W. H. Freeman.
5. SinaEbnesajjad2012*Handbook of Biopolymers and Biodegradable Plastics properties, processing, and Applications*William Andrew.
6. Galin and M. Ruben Ed., 1978*Soft compact lenses clinical and applied*

Technology, John Wiley.

7. Wilfred Lynch, 1978*Hand book of Silicone rubber fabrication*, Van Nostrand Reinhold.
8. Park and LakesThird edition2007*Biomaterials* Springer.
9. DordrechtEds 1986 *Polymeric Biomaterials*MartinusNijhoff Publishers
10. Sharma C.P &Szycher M, 1991,*Blood compatible materials and devices*Technomic Publishing Co. Ltd.

PT1535	POLYURETHANE TECHNOLOGY	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To enable the students to understand the principles of PU chemistry and its applications.
- To get the knowledge in PU raw materials and processing techniques.
- To understand the concepts of PU foams, coatings and adhesives.

UNIT I PRINCIPLES OF PU CHEMISTRY AND APPLICATIONS 9

Reactions of isocyanate group-building blocks for PUs-polyols, isocyanates, chain extenders –Preparation methods like prepolymer process, one shot process-preparation of aqueous twophase systems – Special areas like ionomers,LCP based on PUs, hydrogels, promoters- Uses in medical areas, bio technology, optical lenses etc Structure-property relationships in hard and softsegments - Morphology of domains-Effect of cross links on PU properties, structure-property relationships in ionomers

UNIT II RAW MATERIALS AND AN OVERVIEW OF PROCESSING OF PU 9

Polyols, isocyanates – Their preparation and characteristics, conversion products of the rawmaterials – Additives – Industrial hygiene –Principles of PU processing. Polyurethane processing-basic design principles of polyurethane processing equipment -steps in the polyurethane processing-Themanufacturer of polyurethanes (the process, parameters and controls)

UNIT III PU FOAMS 9

Rigid polyurethane foams-chemistry of raw materials, manufacturing of rigid PU (manufacturing of buns, panels, foaming of applications, molded rigid foams), properties, application of rigidpolyurethane. Polyurethane skin integral foam- production, properties and applications.Flexible foams-(production, properties and application slabstock foam, carpet backing, flexible molded foams & semi rigid molded foams.

UNIT IV SOLID PU MATERIALS 9

Solid polyurethane materials- polyurethane casting systems (cast elastomers and casting resins)- thermoplastic polyurethane elastomers: productions / processing, properties and applications. elastomers fibers, manufacture / processing and applications

UNIT V PU COATINGS AND ADHESIVES **9**

Solvent based coatings, air dried coatings, solvent free paints and coatings, applications of PU based coatings two components and one component adhesives based on PUs, solvent basedadhesives, dispersion adhesives, hot melts, PU binders.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of this course, students will be able to

CO1 **:** Know about building blocks for Polyurethanes

CO2 **:** Learn about Various types of raw materials used in preparation of PU

CO3 **:** Study about the production of flexible and rigid polyurethane foam

CO4 **:** Will have the knowledge of production, properties and uses of solid polyurethane

CO5 **:** Will have the knowledge of PU applications as coatings and adhesives

TEXT BOOKS:

1. Gumter Oertal (ed.),2nd ed.1994 Polyurethane Hand Book, Hanser Publication Munich.
2. George woods, The ICI Polyurethane book -published journals by ICI, John Wiley and sons, New York.
3. Hepburn C, 1992"*PU Elastomers II" Edition*, Springer Science.
4. Szycher'M 2nd ed 2013 Handbook ofPolyurethanes CRC Press

REFERENCES:

1. Benjamin M. Walker, 1988*Handbook of Thermoplastic Elastomer*, Springer US.
2. Legge, N.R, Holden, G,. Sehroeder,H.E,1987 *Thermoplastic Elastomers: A Comprehensive Review*.
3. BrydsonJ. A.1988, *Rubber Materials & Their Compounds*, Springer Netherlands.
4. Bruins; Paul F. (Ed.),1969*Polyurethane Technology*, Interscience Publishers, NewYork.
5. Kaneysoshi Ashida, 2006, *Polyurethane and Related Foams Chemistry and Technology* by Taylor & Francis Group.

ELECTIVE II

PT1631	FOOTWEAR TECHNOLOGY	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To make the students to understand the production of footwear.
- To impart basic knowledge on cellular and microcellular materials.
- To make students familiar in manufacturing of shoe
- To provide an exposure of speciality shoes

UNIT I PRODUCTION OF FOOTWEAR 9

Operations involved in making footwear – 'Built-up' footwear – DVP/DIP (Direct Vulcanising /Direct injection Moulding) process – Materials used in manufactures of footwear (Other than
rubber)

UNIT II ADHESIVES AND SYNTHETIC FABRICS IN FOOTWEAR 9

Fabrics used – Cotton, Rayon, Nylon, Polyester – treatment of textiles for combining with rubber – types of adhesives water, chloroprene, NBR, PU passed adhesives – NR and synthetic rubber latex based adhesives.

UNIT III CELLULAR AND MICROCELLULAR MATERIALS 9

Natural and Synthetic Rubber based microcellular materials – PU, PVC, EVA in microcellular soling – Direct vulcanizing / injection processes

UNIT IV MANUFACTURE OF FOOTWEAR COMPONENTS 9

Process manufacture of different footwear – traditional and modern methods.- Hand Assembled And Hot Air Vulcanized Product- Compression Moulded Industrial Rubber Boots Direct Moulded Process For Shoe Bottoming- Injection Moulded Rubber Sole And Heel Unit-Resin Rubber And Micro Cellular Soiling

UNIT V SPECIALITY SHOES 9

Sports / athletics shoes, mountaineering / hiking shoes, fireman, hospital (operating heater) and oil refinery shoes

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of this course, students will be able to

CO1 : select the appropriate materials and process in production of rubber footwear

CO2 : Choose the suitable fabric and adhesives for manufacturing of footwear

CO3 : Illustrate the cellular and microcellular moulding process

CO4 : Describe the manufacturing components of footwear

CO5 : Apply the manufacturing process of different speciality shoes.

TEXT BOOKS:

1. Thornton, J.H., 1970., *Text Book of Footwear Manufacture*, National Trade Press Ltd., London.

2. Ravindra Goontilleke., 2013., *Science of Footwear*., CRC Press.

PT 1632	POLYMER REACTION ENGINEERING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To learn the fundamental reactions involved in chemical engineering
- To attain the knowledge in reaction mechanism
- To obtain the ideas in the design of reactors
- To learn the multiple reactor system.
- To learn about various mechanisms in polymerization reactors.

UNIT I KINETICS OF HOMOGENOUS REACTIONS 9

Introduction to chemical kinetics – Classification of chemical reactions – Rate of Reaction -Temperature dependent term of a rate equation - Concentration dependent of a rate equation.

UNIT II INTERPRETATION OF BATCH REACTOR DATA 9

Interpretation of Batch Reactor data for irreversible reactions taking place in constant volume and variable volume batch reactors – Integral and Differential method of Analysis.

UNIT III DESIGN FOR SINGLE IDEAL REACTORS 9

Chemical Reactors - Performance equations for Batch Reactor – Stirred Tank Reactor - MFR/CSTR - Plug flow reactors (PFR).

UNIT IV DESIGN FOR SINGLE REACTIONS 9

Multiple reactor system – CSTR in series (Equal & Unequal Size) - PFR in series – Residence time distribution in non-ideal flow reactors.

UNIT V POLYMERIZATION REACTORS 9

Polymerization reactors - Free radical polymerization - stepwise addition and condensation polymerization and copolymerization

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of this course, students will be able to

CO1 **:** Explain the kinetics of various reactions involved in Polymer reactions.

CO2 **:** Interpret the various kinetic parameters in Constant volume and variable volume batch reactors

CO3 **:** Demonstrate the different types of reactors used in Polymer Industries.

CO4 : Illustrate the multiple reactor system used in polymer industries

CO5 : Compare the different types of polymerization mechanisms occur in reactors.

TEXT BOOKS:

1. Davis, M.E. and Davis, R.J., 2012. *Fundamentals of chemical reaction engineering*. Courier Corporation.
2. Fogler, H.S., 2010. *Essentials of Chemical Reaction Engineering: Essenti Chemica Reactio Engi*. Pearson Education.
3. Asua, J. ed., 2008. *Polymer reaction engineering*. John Wiley & Sons.

REFERENCES:

1. Meyer, T. and Keurentjes, J.T., 2005. *Handbook of polymer reaction engineering*. Wiley-VCH Verlag.
2. Salmi, T.O., Mikkola, J.P. and Wärnå, J.P., 2019. *Chemical reaction engineering and reactor technology*. CRC Press.
3. Salmi, T.O., Mikkola, J.P. and Wärnå, J.P., 2019. *Chemical reaction engineering and reactor technology*. CRC Press.
4. Carberry, J.J., 2001. *Chemical and catalytic reaction engineering*. Courier Corporation.
5. Kumar, A. and Gupta, R.K., 2018. *Fundamentals of polymer engineering*. CRC Press.

PT1633	POLYMERS IN ELECTRICAL & ELECTRONICS APPLICATIONS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To make the student acquire knowledge on conducting polymers.
- To provide exposure on synthesis of conducting polymers.
- To impart a thorough understanding of doping process of conducting polymers.
- To provide knowledge on properties of conducting polymers.
- To facilitate the students to understand the use of conducting polymers for various applications.

UNIT I BASICS OF CONDUCTING POLYMERS 9

Introduction - Electrically conducting polymers- Chain growth polymerisation, step growth polymerization, electrochemical polymerization, Metathesis polymerization(Ring opening metathesis polymer (ROMP). Advantages and disadvantages of conducting polymers, methods to enhance the processability of conducting polymers. Effect of polymer structure on electrical properties- Chemical and physical variant, conformation and hindered rotation, co polymers, crystallization and orientation.

UNIT II SYNTHESIS OF CONDUCTING POLYMERS 9

Theories of conduction -Band theory of conduction, properties of semi conductors, hopping conduction .Synthesis and properties of conducting polymers-Polyacetylene, Poly p-phenylene, Polyheterocyclic and polyaromatic conducting polymers like polythiophene, poly vinyl carbazole, polypyrene, polyaniline, Polypyrrole, Poly phenylene vinylene, Polypyridine

UNIT III CONDUCTING POLYMER DOPING PROCESS 9

Valance Band theory- basic concepts of band model, band model of conductor, semiconductor and insulator. Carrier mobility, intrachain conductivity, interchain conductivity. Concept of doping- Charge carriers: polarons, bipolarons and solitons. Types of dopants, oxidative dopants and reductive dopants, mechanism of doping, p-type doping and n-type doping, inorganic and organic dopants, effect of doping on the dielectric properties of conducting polymers.

UNIT IV PROPERTIES OF CONDUCTING POLYMERS 9

Dielectric properties of conducting polymers in the high and very high frequency fields (a.c field), ultra high frequency field (Microwave field) . Dielectric constant, dielectric loss and absorption property of conducting polymers in the a.c and microwave fields. Applications of Electro-active polymers – xerography, OLEDS and Solar cells. Non-linear optics, intrinsically conductive polymers – soft electronics, LEDs, Photovoltaic devices, Sensors.

UNIT V APPLICATIONS OF CONDUCTING POLYMERS 9

Basic structural characteristics and properties of conjugated polymers- electrical conductivity, photoconductivity, charge storage capacity, photoluminescence, and electroluminescence. Applications of conducting polymers- Polymer rechargeable batteries, sensors, electrochemical actuators, electro luminescent applications. Conductivity applications: antistatic coatings- conducting adhesives-artificial nerves. Electronic applications: EMI shielding, Frequency selective surfaces, satellite communication links.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of this course, students will be able to

CO1 **:** Attain the basic knowledge on conducting polymers

CO2 **:** Demonstrate synthesis of conducting polymers

CO3 **:** Develop the capacity of doping of conducting polymers

CO4 **:** Analyze the properties of conducting polymers

CO5 **:** Identify the use of conducting polymers for various applications

TEXT BOOKS:

1. Fink, J.K., 2013. *Polymeric sensors and Actuavtors* , John Wiley & Sons, Inc.
2. Jiri George Drobny, 2012.*Polymers for electricity and electronics :Materials, Properties, and Applications,* by John Wiley & Sons, Inc
3. Evaristo Riande Ricardo Dı´az-Calleja,2004. *Electrical properties of Polymers,* Marcel Dekker, Inc.

REFERENCES:

1. Chandrasekhar, P., 1999. *Conducting polymers, fundamentals and applications*. Kluwer academic publishers
2. Skotheim, T.A. ed., 1997. *Handbook of conducting polymers*. CRC press Nalwa, H.S., 1997. *Handbook of organic conductive molecules and polymers*. Wiley.

PT1634	SPECIALITY POLYMERS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To enable the students to learn properties and applications of special polymers such ashigh performance, conducting, electrical and electronics properties of polymers, ionicpolymers polymers in concrete, polymers as binders.

UNIT I HIGH PERFORMANCE POLYMERS 9

High temperature and fire resistant polymers –Requirement for heat resistance-polymers, forlow fire hazards - polymers for high temperature Resistance - applications of heat resistantpolymers like, polyimides, polyquinolines, polyquinoxalines, PBO, PBI, PPS, PPO, PEEK

UNIT II CONDUCTING POLYMERS 9

Conducting polymers preparation and applications, conducting mechanisms, requirements forpolymer to work as conductor, types of conducting polymers - doping of polymeric systems,polyaniline, polyacetylene, polyparaphenylene, polypyrrole, organometallic polymers, polysiloxanes and metal chelate polymers. Photosensitive polymers

UNIT III OPTOELECTRONIC POLYMERS 9

Polymers with electrical and electronic properties, polymers in non-linear optics, polymers with piezoelectric, pyroelectric and ferroelectric properties, photoresists for semi conductor fabrication -Polymers in telecommunications and power transmission - liquid crystalline polymers- structure, types, applications, structural requirements of LCP, types of liquid crystalline(LC) phases, Types of liquid crystalline polymers, main chain and side chain LC polymers,

UNIT IV IONIC POLYMERS 9

Ionic Polymers, synthesis, physical properties and applications, Ion-exchange,Hydrophilicity, Ionomers based on polyethylene, elastomeric ionomers. Ionomers based onpolystyrene, Ionomers based on PTFE, ionomers with polyaromatic backbones, polyelectrolytesfor ion exchange, polyelectrolytes based on carboxylates, polymers with integral ions,polyelectrolyte complexes.

UNIT V BIOPOLYMERS **9**

Polymer concrete, polymer impregnated concrete ultra high modulus fibres, natural biopolymers and synthetic biopolymers and their biomedical applications -polymeric binders for rocket propellants, polymer supported reagents.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of this course, students will be able to

CO1 **:** Will have the knowledge of high performance polymers applied in special application

CO2 **:** Will correlate the conducting polymer preparation, properties, and applications

CO3 **:** Will acquire skills of electrical and electronic properties of polymers to suitable application

CO4 **:** Will have the knowledge of ionic polymers preparation, properties and applications.

CO5 **:** Will have the knowledge of applications of polymers in concrete, fibers, biomedical and binders for rocket propellants.

TEXT BOOKS:

1. Manas Chanda, Salil.K.Roy, 2nd edition1993"*Plastics Technology Hand book",* Marcel Dekker,New York,
2. Matrin.T.Goosey, 1985"*Plastics for Electronics*", Elsevier, Applied Science,
3. Dyson, R.W 2nd edition 1998 "*Specialty Polymers*", Chapman & Hall,

REFERENCES:

1. Mark, H F (Ed), 1989*Encyclopedia of polymer science & engineering*, John Wiley & Sons.
2. Goosey, M. T 1985*Plastics for Electronics*, Elsevier, Applied Science.
3. Ku C &Liepins,R 1987*Electrical Properties of Polymers*, Hanser Publications.
4. Bueche, F 1962 *Physical properties of polymers*, Wiley.

5. Mort J & .Pfister, G eds1982. *Electronic properties of polymers*, Wiley Interscience.
6. Shibaev, V, Hashmi S(Ed.), 2016 *Liquid Crystalline Polymers*, Reference Module in Materials Science and Materials Engineering. Elsevier.

PT1635	THERMOPLASTIC ELASTOMERS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To enable the students to understand the structural properties of thermoplastic elastomers.
- To acquire knowledge in synthesis method, compounding, processing characteristics and application of elastomeric blends.
- To develop an understanding of processing of thermoplastic elastomers
- To impart knowledge on application and recycling of TPE

UNIT I THERMOPLASTIC STYRENIC BLOCK COPOLYMER and PU 9

Synthesis, morphology, Properties, formulating, and compounding styrenic block copolymers Thermoplastic Polyurethane – Synthesis – Morphology –thermal transition – Properties – – Blends of TPU with other polymer – Bonding and welding.

UNIT II THERMOPLASTIC POLYAMIDES AND POLYESTERS 9

Thermoplastic Elastomer based on polyamides and Thermoplastic Polyether ester elastomers – Synthesis – Morphology – Properties – Compounding - Bonding and welding –- Blends

UNIT III THERMOPLASTIC POLYOLEFINS AND BLENDS 9

Synthesis, Morphology, Property, Blends of TPE based on Polyolefin – TPE based on Halogen: PVC/NBR, FKM – Ionic TPE - Other TPEs – Elastomeric stat block copolymers – TPEs based on Interpenetrating Network – Based on Polyacrylates.

UNIT IV THERMOPLASTIC ELASTOMERS PROCESSING 9

Processing Methods –Introduction – Mixing and blending equipment – Extrusion – Injection molding – Compression molding – Transfer molding – Blow molding - Foaming – Thermoforming – secondary manufacturing process

UNIT V APPLICATIONS AND RECYCLING 9

Applications of Styrenic Thermoplastic Elastomers – Thermoplastic Vulcanizates – Thermoplastic Polyolefin elastomers – Melt-Processable Rubber –Thermoplastic Polyurethanes –Polyamide Thermoplastic Elastomers – Recycling of Thermoplastic Elastomers.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of this course, students will be able to

CO1 **:** Demonstrate the synthesis methods of block copolymers and Polyurethane.

CO2 **:** Analyse the properties of elastomers based on their morphology and structure.

CO3 **:** Apply the knowledge of Synthesis, Morphology, Property of thermoplastic polyolefin and blends

CO4 **:** Demonstrate the processing methods for different thermoplastic elastomers

CO5 **:** State the applications and recycling methods of thermoplastic elastomers.

TEXT BOOKS:

1. Jiri George Drobny., 2007., *Handbook of thermoplastic Elastomers,* William Andrew Publication.
2. .Kear. K.E., 2003., *Developments in Thermoplastic Elastomers*, Rapra Technology.

REFERENCES:

1. Hoffman., 1996., *Rubber Technology Handbook* -, Hanser Pub., Munich.
2. Stoyko Fakirov, 2006., *Handbook of Condensation Thermoplastic Elastomers.,* John Wiley & Sons.
3. Anil K. Bhowmick.,& Howard Stephens, 2001., *Handbook of elastomers*, 2nd edition., Marcel Dekker.

OPEN ELECTIVE I

OPT151	BASICS OF POLYMER RECYLING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To know various sources of plastics waste generation
- To know segregation methods for recycling the plastics
- To know recycling polyolefin's plastics
- To learn recycling of engineering plastics.

UNIT I PLASTIC WASTE GENEATION &SEPARATION TECHNIQUES 9

Plastics production and consumption- Plastic wastes generation source and types – Plastic waste composition, quantities - Plastics identification methods physical, chemical and instrumental – sorting and separation technologies - disposal alternatives – Recycling methods – Primary, Secondary and tertiary recycling of plastics-Plastic road.

UNIT II PROCESSING OF COMMINGLED PLASTIC WASTE 9

Size reduction of recycled plastics – cutting / shredding, densification, pulverization and chemical size reduction processes- municipal solid waste and composition – recycling of plastics from urban solid wastes - household waste – industrial sector – density and mechanical properties of recyclable plastics– Processing of commingled / mixed plastic waste – super wood, plastic lumber

UNIT III RECYCLING OF POLYOLIFINS, PET &PVC 9

Recycling of polyolefins – polyethylene films – Polypropylene battery recyling- Recycling of HDPE fuel tanks - PET recycling methods – PET film recycling - Applications of polyolefin and PET recyclate – PVC recycling.

UNIT IV RECYCLING OF ENGINEERING THERMOPLASTICS 9

Engineering thermoplastics and their major areas where engineering polymers are recycled – major recyclers of engineering plastics – GE/ Bayer/ MRC Polymers – PC, PBT, Nylon, PPO, ABS and polyacetals and their blends.

UNIT V RECYCLING OF THERMOSET COMPOSITES 9

Recycling of Polymer thermoset composites – regrind processes - SMC scrap – pyrolysis and energy recovery –Types of rubber products – rubber grinding methods

– tyre grinding – rubber crumb applications – Reclaiming and de-vulcanization processes tyre derived fuel and energy recovery – Pyrolysis of scrap tyres-Act on plastic waste management.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of this course, students will be able to

CO1 **:** Select the suitable sorting and separation technologies for plastic recyling

CO2 **:** Suggest the suitable processing methods for recycle of both commercial and engineering plastics.

CO3 **:** identify the recycling methods for polyolefines plastics

CO4 **:** Apply the concept of recycling for engineering plastics

CO5 **:** Develop the recycling of thermoset plastic process

TEXT BOOKS:

1. Scheirs, J., 1998. Polymer recycling: science, technology and applications. *John! Wiley & Sons Ltd, Journals, Baffins Lane, Chichester, Sussex PO 19 1 UD, UK, 1998. 591*.
2. La Mantia, F.P., 1993. *Recycling of plastic materials*. ChemTec Publishing.
3. Manas Chanda, SalilK.Roy., 1993. *Plastics Technology Hand book*, 2nd edition, Marcel Dekker, New York.

REFERENCES:

1. Owen, S., Masaoka, M., Kawamura, R. and Sakota, N., 1995. Degradable Polymers Recycling, and Plastics Waste Management, ed AC Albertsson and SJ Huang.
2. Anand,J.S., 1997. *Recycling & Plastics Waste Management*. CIPET

		L	T	P	C
OPT152	**FIBRE REINFORCED PLASTICS**	**3**	**0**	**0**	**3**

OBJECTIVES:

- To introduce basic fundamentals of Fibre reinforced plastics.
- To impart knowledge of reinforcements and matrix systems used in FRP.
- To develop an understanding on processing of polymer composites.
- To impart skills in testing of polymer composite material for various applications.
- To provide an understanding in usage of FRP in various fields.

UNIT I INTRODUCTION AND MATRIX PHASE 9

Definition, Reason for composites, Classifications of composites, Thermosets - Epoxy; Unsaturated polyester resin; vinyl ester, polyimides etc., - preparation, properties, and uses.

UNIT II FIBRE REINFORCMENTS 9

Types, Properties, chemistry and applications of fillers such as silica, titanium oxide, talc, mica etc., Manufacturing process, Properties, structure and uses of Glass fiber-. Carbon, Aramid, Boron, jute, sisal, cotton

UNIT III MANUFACTURING METHODS OF COMPOSITES 9

Hand lay up method, compression and transfer molding, pressure and vacuum bag process, filament winding, protrusion, reinforced RIM, RRIM, Injection molding, of thermosets, SMC and DMC, Advantages and disadvantages of each method.

UNIT IV TESTING OF COMPOSITES 9

Destructive and non-destructive tests; Destructive- tensile, compression, flexural, impact strength, Hardness – Fatigue- toughness HDT ,basic concepts of fracture mechanisms

UNIT V APPLOCATION OF COMPOSITES 9

Aerospace, land transport, marine, structural, chemical plants and corrosion resistant products, mechanical engineering and energy applications sports, electrical, electronic and communication applications, biomedical applications, repairs and maintenance etc.,

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of this course, students will be able to

CO1 **:** Identify the suitable resins for specific applications.

CO2 : Apply the reinforcements suitable for particular applications

CO3 : Demonstrate the different manufacturing methods for the production of FRP products.

CO4 : Distinguish various methods used for the testing of FRP products.

CO5 : Demonstrate the applications of FRP in different fields.

TEXT BOOKS:

1. Rosato, D.V. and Rosato, D.V., 2004. *Reinforced plastics handbook*. Elsevier.
2. Lubin, G., 2013. *Handbook of composites*. Springer Science & Business Media.
3. Weatherhead, R.G., 2012. *FRP technology: fibre reinforced resin systems*. Springer Science & Business Media.

REFERENCES:

1. Pritchard, G. ed., 2012. *Developments in reinforced plastics—4*. Springer Science & Business Media.
2. Bunsell, A.R. and Renard, J., 2005. *Fundamentals of fibre reinforced composite materials*. CRC Press.
3. Astrom, B.T., 1997. *Manufacturing of polymer composites*. CRC press.
4. Kar, K.K. ed., 2016. *Composite materials: processing, applications, characterizations*. Springer.
5. Nicolais, L., Meo, M. and Milella, E. eds., 2011. *Composite materials: a vision for the future*. Springer Science & Business Media.

OPT153	FUNDAMENTALS OF PLASTIC PACKAGING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To make the student acquire knowledge on plastic packaging.
- To provide exposure on packaging of plastics
- To impart a thorough understanding of process of packaging.
- To provide knowledge on properties of packaging materials.
- To facilitate the students to understand the use of polymers for various applications.

UNIT I Introduction & Raw Material Selection Criteria 9

INTRODUCTION : definition of packaging as an integral part of production & marketing. Materials used, Advantages, limitations of various plastics like PE, PP, PVC, PS, POLYESTER, NYLON, EVA COPOLYMER, EVOH, PC, PVDC.

UNIT II CONVERSION PROCESSES-I 9

Injection moulding- containers, closures, containers with safety closures, small size containers. Extrusion process- Mono layer, multi layer, shrink, oriented films, cast, coating films, tapes, woven sacks, aluminium foil, laminations, sheet, tubes & profiles, twist wrap film, plasma barrier coating.

UNIT III CONVERSION PROCESSES-II 9

Blow molding process- composite containers, composite drums, small hollow containers , medical & pharmaceutical bottles, stretch blow moulding.

Foam moulding process – expanded polyethylene, poly styrene, structural & decorative foams. Rotary thermo forming, Batch & continuous thermo forming, Compression Moulding, Transfer moulding

UNIT IV Fabrication & decorative Techniques 9

Cutting, sealing, welding, adhesive bonding. Printing, metallising, embossing, labeling, painting, lacquring, foil in lay moulding, hot stamping, Inmould decoration

UNIT V Testing Of Plastics Packages 9

Introduction; General test methods, Heavy duty packages, laminates, drop tests, stack test, load test, vibration test, Testing of flexible films, Indian standard for food containers

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of this course, Students will be able to

CO1 : Attain the basic knowledge on plastic packaging materials

CO2 : Demonstrate the conversion processes of packaging

CO3 : Develop the capacity of packaging polymers

CO4 : Analyze the packaging plastics by various techniques

CO5 : Identify the use of packaging plastics for various applications

TEXT BOOKS:

1. O'Hanlon, J.F., 2005. *A user's guide to vacuum technology*. John Wiley & Sons.
2. Mark, J.E. ed., 2009. *Polymer data handbook* (Vol. 2). New York: Oxford university press.
3. Briston, J., 1992. *Advances in Plastics Packaging Technology*. Pira International.

REFERENCES:

1. Robillard, J., Ralston, C. and Walden, G., Procter and Gamble Co, 2006. *Packages*. U.S. Patent Application 11/435,526.
2. Farmer, N. ed., 2013. *Trends in packaging of food, beverages and other fast-moving consumer goods (FMCG): markets, materials and technologies*. Elsevier.

PT154 INTRODUCTION TO ELASTOMER TECHNOLOGY

L	T	P	C
3	0	0	3

OBJECTIVES:

- To impart knowledge in predicting and modifying the properties of rubber.
- To make students familiar in different rubber materials
- To provide understanding on rubber compounding ingredients, their importance
- To develop an understanding of elastomer products and recycling methods

UNIT I FUNDAMENTALS OF RUBBERS 9

Basics*:* Criteria for a polymer to behave as a rubber – structure vsTg, chemical, mechanical and electrical properties - Classification of rubbers .

Structure property relationship: Effect of structure on Tg – Effect of chemical structure on the performance properties of rubbers – Effect of structure on processing properties of elastomers

UNIT II NATURAL AND SYNTHETIC RUBBER 9

***Natural rubbers*:** Natural rubber latex, tapping – Conversion to dry rubber – Properties, grading and specifications of NR .

Synthetic rubbers: SBR: preparation, types, properties and applications– BR: polymerization, properties and applications – IR: Manufacture, properties and applications.

UNIT III ELASTOMER COMPOUNDING 9

Compounding ingredients: General principles of rubber compounding – Various compounding ingredients and their classification – Preparation, properties and uses of carbon black – Non-black fillers, plasticizers, accelerators, activators, cross-linking agents – Special purpose additives.

UNIT IV ELASTOMER PRODUCTS AND MANUFACTURING PRACTICES 9

Manufacturing methods of Belting and hoses, Sports Goods - Tennis Balls, Latex Products –Dipped goods- rubber band, Gloves, balloon - Manufacturing of Latex Foam -Rubber thread,Good manufacturing practices - Effluent- Control and Treatment- Safety in rubber industry

UNIT V ELASTOMER RECYCLING 9

Tyre size reduction – Application of ground Rubber crumb – Filler – Bound Rubber products – Thermoplastics binder – Civil engineering applications – Surface treated crumb rubber – applications – Rubber reclaiming and devulcanization scrap rubber and fuel source (Tyre derived fuel TDF) – Pyrolysis.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of this course, students will be able to

CO1 **:** Apply the solution for behavioral changes of elastomer based on the structure

CO2 **:** Select the suitable natural and synthetic rubber materials for applicaitokns

CO3 **:** Select the elastomer compound for the elastomer product.

CO4 **:** Choose the suitable manufacturing process for sports goods and latex products.

CO5 : Solve the recycling problems for elastomer.

TEXT BOOKS:

1. Bhowmick, A.K., and Stephens, H.L., 2001. *Hand Book of Elastomers*. 2nd ed. New York: Marcel Dekker
2. Kothandaraman, B., 2010. *Rubber Materials*. New Delhi: Ane Books Pvt. Ltd.
3. Brydson, J. A.. 1978, *Rubber Chemistry*, Applied Science Publishers

REFERENCES:

1. Martin, J.M.,and.Smith, W.K., 2004. *Handbook of Rubber Technology*. Vol. 1 & 2, CBS Publishers & Distributors.
2. Maurice Morton., 1987*. Rubber Technology*, Van Nostrand Reinhold.