UNIVERSITY OF DELHI

DEPARTMENT:CHEMISTRY

A.C.-03.08.2022
Appendix-68

COURSE NAME: B.Sc(H) POLYMER SCIENCE

Semester-I

Based on

Undergraduate Curriculum Framework 2022 (UGCF)

(Effective from Academic Year 2022-23)

University of Delhi

Course Name: B.Sc(Hons.) Polymer Science (Semester-I)

List of DSC Papers

Course Title	Nature of the Course	Total Credit	Components			Eligibility Criteria Prerequisite	Contents of the course and reference is in
			Lecture	Tutorial	Practical		
Introduction to Polymer Science	DSC-1	4	3	0	1	Physics, Chemistry, Maths	Annexure-I
Raw Materials of Polymers	DSC-2	4	3	0	1		Annexure-II
Unit Operations	DSC-3	4	3	0	1		Annexure-III

Generic Elective: Odd Semesters

Course Title	Nature of the Course	Total Credits	Components			
			L	T	P	
Basic of Polymer Science	GE 1	4	2	0	2	Annex.-IV
Chemistry of Polymers	GE 2	4	2	0	2	Annex.-V
Polymer Testing	GE 3	4	2	0	2	Annex.-VI
Advanced Analytical Techniques	GE 4	4	2	0	2	Annex.-VII
Polymer Modifiers	GE 5	4	2	0	2	Annex.-VIII
Polymer and Environment	GE 6	4	2	0	2	Annex.-IXI

Syllabus for Undergraduate Programme in Polymer Science
DISCIPLINE SPECIFIC CORE (DSC) COURSES

SEMESTER-I

Course Code: DSC-1: IPS

Course Title: INTRODUCTION TO POLYMER SCIENCE

Total Credits: 04 (Credits:Theory-03, Practical-01)

Total Lecture: Theory-45, Practical-15 classes of 2 hours each

COURSE OBJECTIVES:

1. To familiarize with the 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 physical state of polymers
2. Develop fundamental knowledge of thermal transitions of temperature
3. Understand structure-property relationship of polymers
4. Apply mathematical formulae to depict polymer solution properties

THEORY: (75 MARKS)

UNIT 1: INTRODUCTION TO POLYMERS 8 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 7 L

Crystal morphologies, extended chain crystals, chain folding, lamellae, spherulites, crystallization, crystallinity, crystallizability & orientation, crystalline melting point, crystallization kinetics, effect of orientation and crystallinity on polymer properties, determination of crystallinity.

UNIT 3: PROPERTIES OF POLYMERS 8 L

Physical properties, introduction of mechanical properties (stress–strain curves, tensile, flexural, impact, fatigue, hardness, creep and abrasion), electrical properties (dielectric strength, volume resistivity and power factor)

UNIT 4: POLYMER MOLECULAR WEIGHT 7 L

Nature and structure of polymers: structure-property relationships, molecular weight of polymers (M_n, M_w, M_V and M_Z), polydispersity, molecular weight distribution and determination of molecular weight by solution viscosity and end group analysis,

UNIT 5: SOLUTION PROPERTIES OF POLYMERS 8 L

Polymer solutions, solubility parameter, athermal solvents, theta solvents, solution viscosity, thermodynamics of polymer solutions, Flory-Huggins theory

UNIT 6: GLASS TRANSITION BEHAVIOUR OF POLYMERS 7 L

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

PRACTICALS: (25 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 number average molecular weight by end group analysis.
7. To find out the acid number and hydroxyl number of a given polymer.
8. To measure volume resistivity of polymer samples.

REFERENCES:

1. Odian, G., (2004) Principles of Polymerization, Wiley-interscience.
2. Gowarikar V.R., (2019) Polymer Science, New Age International Publishers Ltd, 3rd Edition.
3. Billmeyer F.W., (2007) Textbook of Polymer Science, Wiley, India.
4. Shah V., (1998) Handbook of Plastics Testing Technology, Wiley Interscience.
5. Seymour R.B., Carraher C.E., (2003) Polymer Chemistry, Marcel Dekker.
6. Teraoka, I. (2002). Polymer solutions: an introduction to physical properties.
7. Hiemenz, P. C., & Lodge, T. P. (2007). Polymer chemistry. CRC press.

ADDITIONAL RESOURCES:

1. Brydson J.A., (2016) Plastics Materials, Butterworth Heinemann, 8th Edition.
2. Schultz J.M., (2001) Polymer Crystallization, American Chemical Society.
3. Ghosh P., (2010) Polymer Science and Technology: Plastics, Rubbers, Blends andComposites, Tata McGraw Hill.
4. Shah V., (2006) Handbook of Plastics Testing and Failure Analysis,John Wiley & Sons, Inc., 3rd Edition.

TEACHING LEARNING PROCESS:

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

ASSESSMENT METHODS:

- Presentations by Individual Student/ Group of Students
- Class Tests at Periodic Intervals.
- Written assignment(s)
- Continuous evaluation during laboratory classes.
- Mock Practical
- Viva-voce
- End semester University Theory/ Practical Examination

KEYWORDS:

End to end distance, Lamellae, Glass transition temperature, Molecular weight distribution, Viscosity average molecular weight

Course Code: DSC-2: RMP

Course Title: RAW MATERIALS FOR POLYMERS

Total Credits: 04 (Credits:Theory-03, Practical-01)

Total Lecture: Theory-45, Practical-15 classes of 2 hours each

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: (75 MARKS)

UNIT 1: INTRODUCTION TO CRUDE OIL AND IT'S REFINING 5 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 15 L

Ethylene, vinyl acetate, vinyl chloride, ethylene oxide and ethylene glycol, acrylonitrile, methyl methacrylate, isoprene, phenol, styrene, terephthalic acid, adipic acid, caprolactam, hexamethylenediamine

UNIT 3: LATEX 5 L

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

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

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

UNIT 5: LATEX PRODUCT MANUFACTURING TECHNIQUES 10 L

Latex compound formulation, process of manufacturing, finishing and applications of spreading, casting and dipping (Dipping-principle and procedure of dipping process-different types of dipping –after treatment of latex deposits -Manufacture of dipped goods with formulation and flow chart-defects and remedies . latex casting –principle and procedure of casting-production of cast articles –mould preparation, latex thread and latex foam

PRACTICALS: (25 MARKS)

1. Analysis of formalin/phenol/epichlorohydrin/Plasticizer
2. Determination of hydroxyl value/carboxyl value/ester value/epoxy value
3. Determination of colour and viscosity by gardner's tube method
4. Fractional distillation of crude oil.
5. To calculate dry rubber content (DRC) of latex.
6. To determine the coagulation strength of latex.
7. Preparation of balloon by dipping process.
8. Latex compounding for preparation of gloves & balloons.
9. Synthesis of adipic acid from cyclohexanol using Conc. HNO_3.
10. To prepare monomers from C_4 hydrocarbons.
11. Determination of percentage purity of phenol.

REFERENCES:

1. Kumar D., Chandra R., (2001) Latex Technology, Dhanpat Rai & Co.
2. Rao B.K.B., (2007) Textbook on Petrochemicals, Khanna Publishers.
3. Blackley, D.C., "High Polymer Latices", Vol 1 and 2, Chapman and Hall, 1997
4. Mausser,R.F., "The Vanderbilt Latex Hand book" 3rd edn.R.T. Vanderbilt Company, 1987.

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) Handbook of Rubber Technology, CBS Publishers.

TEACHING LEARNING PROCESS:

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

ASSESSMENT METHODS:

Presentations by Individual Student/ Group of Students

- Class Tests at Periodic Intervals.
- Written assignment(s)
- Continuous evaluation during laboratory classes.
- Mock Practical
- Viva-voce
- End semester University Theory/ Practical Examination

KEYWORDS: Latex, Thickening agent, Vinyl acetate, Cracking

Course Code: DSC-3: UO

Course Title: UNIT OPERATIONS

Total Credits: 04 (Credits:Theory-03, Practical-01)

Total Lecture: Theory-45, Practical-15 classes of 2 hours each

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: (75 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: 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 3: HEAT TRANSFER 15 L

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

UNIT 4: MASS TRANSFER MECHANISM 15 L

Mass diffusion, factors affecting diffusion, gas absorption (Henry's Law, Langmuir Absorption Isotherm, BET equation), types of distillation, drying

PRACTICALS: (25 MARKS)

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

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:

- Presentations by Individual Student/ Group of Students
- Class Tests at Periodic Intervals.
- Written assignment(s)
- Continuous evaluation during laboratory classes.
- Mock Practical
- Viva-voce
- End semester University Theory/ Practical Examination

KEYWORDS:

Mass Transfer, Energy Transfer, Distillation, Reynolds Number

11.4 Generic Elective Courses (GECs)

11.4.1: BASICS OF POLYMER SCIENCE

(UPC:)

Generic Elective – GE: Paper I

Total Credits: 4 (Theory-2 Hrs/week, Practical -4 Hrs/week)

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

Total Marks: 100 (Theory - 50, Practical - 50)

COURSE OBJECTIVES:

1. To familiarize with the 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: (50 MARKS)

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

Introduction and classification of polymers, configuration and conformation of polymers, nature of molecular interaction in polymers, entanglement, various structures of copolymers such as linear branched and cross-linked copolymers, Polymer solutions, solubility parameter, solution viscosity, polymer solubility, thermodynamics of polymer solutions

UNIT 2: PROPERTIES OF POLYMERS **10 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 3: MOLECULAR WEIGHT OF POLYMERS **10 L**

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

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.
6. Acid value of acrylic acid
7. Estimation of hydroxyl value by PVA and Cyclohexanol
8. Determination of epoxy equivalent weight of the epoxy resin.
9. Determination of saponification value of oil.
10. Study of three component systems.

REFERENCES:

1. Brydson J.A., (2016) Plastics Materials, Butterworth Heinemann, 8th Edition.
2. Ghosh P., (2010) Polymer Science and Technology: Plastics, Rubbers, Blends and Composites Tata McGraw-Hill.
3. Gowarikar V.R., (2019) Polymer Science, New Age International Publishers Ltd, 3rd Edition
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, PowerPoint 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

11.4.2: CHEMISTRY OF POLYMERS

(UPC:)

Generic Elective – GE: Paper 2

Total Credits: 4 (Theory-2 Hrs/week, Practical -4 Hrs/week)

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

Total Marks: 100 (Theory - 50, Practical - 50)

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: (50 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: THERMOPLASTIC POLYMERS **10 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 3: THERMOSETTING POLYMERS **10 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 4: ENGINEERING POLYMERS **5 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).
9. Preparation of nylon 6, 10/6, 6 salt using HMDA- sebacic acid/ adipic acid.
10. Solution and bulk preparation of a polyester/ polyether based polyurethane.

REFERENCES:

1. Odian, G., (2004) Principles of Polymerization, Wiley-Interscience.
2. Brydson J.A., (2016) Plastics Materials, Butterworth Heinemann, 8th Edition.
3. Flory P.J., (2004) Principles of Polymer Chemistry, Asian Books Private Limited.

ADDITIONAL RESOURCES:

1. Billmeyer F.A., (2011) Textbook 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, PowerPoint 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

11.4.3: POLYMER TESTING

(UPC:)

Generic Elective – GE: Paper 3

Total Credits: 4 (Theory-2 Hrs/week, Practical -4 Hrs/week)

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

Total Marks: 100 (Theory - 50, Practical - 50)

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: (50 MARKS)

UNIT 1: MECHANICAL AND THERMAL ANALYSIS **15 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 2: FLOW AND OPTICAL PROPERTIES **5 L**

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

UNIT 3: ELECTRICAL AND MAGNETIC PROPERTIES **5 L**

Dielectric strength, Surface and Bulk resistance, conductance, diamagnetism and paramagnetism

UNIT 4: STABILITY AND BURNING BEHAVIOUR **5 L**

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

PRACTICALS: (50 MARKS)

1. To measure the M.F.I of polymers.
2. Determination of the LOI and Smoke density of polymeric samples.
3. Determination of the HDT and vicat softening point (VSP) of polymer samples.
4. Measurement of abrasion resistance and burning behavior of polymer samples.
5. Determination of 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. Calculate fatigue of polymer sample
9. Determine the dielectric strength of polymer sample
10. Determination of tensile strength of polymer samples.

REFERENCES:

1. Shah V., (2007) Handbook of Plastic Testing, Technology, Wiley-Interscience.
2. Grellmann W., Seidler 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, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

ASTM, FTIR, Impact Test, Dielectric Strength

11.4.4: ADVANCED ANALYTICAL TECHNIQUES

(UPC:)

GE: Paper 4

Total Credits: 4 (Theory-2 Hrs/week, Practical -4 Hrs/week)

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

Total Marks: 100 (Theory - 50, Practical - 50)

COURSE OBJECTIVES:

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

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Learn the electronic microscope for characterization of morphology of polymeric materials
2. Elucidate crystallinity of various polymers and their characterization on the basis of their thermal stability and glass transition temperature

THEORY: (50 MARKS)

UNIT 1: INTRODUCTION **5 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 **7 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 **8 L**

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

PRACTICALS: (50 MARKS)

1. Study of UV stabilization of polymer samples by UV-visible spectrophotometer.
2. Calculate weight percentage of inorganic and organic ingredients in polymeric compounds.
3. Determination of K-value of PVC.
4. Quantitative determination of impurities by UV-Vis. spectrophotometer.
5. Characterization of Filler Content /Ash Content of common polymers by Thermogravimetric Analysis, (TGA).
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., Merritt 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, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Gel Permeation Chromatography, FT-IR, Scanning Electron Microscope, Transmission Electron Microscopy.

11.4.5: POLYMER MODIFIERS

(UPC:)

Generic Elective – GE: Paper 5

Total Credits: 4 (Theory-2 Hrs/week, Practical -4 Hrs/week)

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

Total Marks: 100 (Theory - 50, Practical - 50)

COURSE OBJECTIVES:

1. To gain knowledge of various compounding additives used for plastics and rubbers
2. To introduce the basics of polymer additives and their significance
3. To study different additives and their representative formulations

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 the role of various additives used for plastics and rubbers

THEORY: (50 MARKS)

UNIT 1: INTRODUCTION TO ADDITIVES AND COMPOUNDING **8 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 polymer compounding.

UNIT 2: ADDITIVES FOR PLASTICS AND RUBBERS **7 L**

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

UNIT 3: STABILIZERS **8 L**

Antioxidants, antiozonants, heat stabilizers, UV stabilizers etc.

UNIT 4: CASE STUDY **7 L**

Compounding techniques with illustration of few formulations like:

1. Rigid PVC pipes
2. Clear bags and flexible films
3. Acrylic sheet and display board
4. Rubber sole
5. Air water hose
6. Conveyor belt

PRACTICALS: (50 MARKS)

1. To study the effect of fillers on physical and mechanical properties of plastics and rubbers.
2. To determine the bulk density and surface property of fillers.
3. To identify additives.
4. To perform sorting of mixed plastics.
5. Determination particle size
6. To find out refractive index of fillers
7. To analyze surface area of filler
8. To find out Volatile loss of plasticizer
9. To design 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.A., (2016) Plastics Materials, Butterworth Heinemann, 8th Edition.
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, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:

As per the assessment method mentioned in introduction

KEYWORDS:

Heat Stabilizers, Plastisizers, Fillers, Flame retardant, Bailing, Pulverization, Tipping, Chemical recycling

11.4.6: POLYMERS AND ENVIRONMENT

(UPC:)

Generic Elective – GE: Paper 6

Total Credits: 4 (Theory-2 Hrs/week, Practical -4 Hrs/week)

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

Total Marks: 100 (Theory - 50, Practical - 50)

COURSE OBJECTIVES:

1. To give understanding of basics of care to be taken while handling polymer products.
2. To know the Safety and hazardous of their manufacturing processes.
3. To impart Knowledge of the subject will help students to see the environmental impact of plastic and resin.
4. To understand the current benefits and concerns surrounding the use of plastics and look to future priorities, challenges and opportunities.

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Understand basics of environmental and safety issues in the chemical industry.
2. Understand safety in handling monomer and resins
3. Impact of final product of polymer on environment after use and its waste management

THEORY: (50 MARKS)

UNIT 1: ENVIRONMENTAL APPROACH OF PLASTIC WASTE **10 L**

Health and safety, Plastics in the society, Plastics in the environment, Plastic waste management, Plastic waste in the marine and terrestrial environment, Plastic material degradation, regulations for hazardous chemicals in articles/plastic products, coated articles. Separation techniques of plastic wastes (density, float sink and froth floatation methods, optical, spectroscopic, sorting by melting temperature etc.).

UNIT 2: PLASTIC SEGREGATION **10 L**

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

UNIT 3: RECYCLING **10 L**

Disposal processes and Various waste treatment methods – controlled tipping, pulverization, compositing, Energy from waste – (incinerators- pyrolysis, factors affecting incineration), new developments in thermal disposal of refuse, on-site disposal methods, compacting and baling. Recycling of Polyolefins, PVC, PET, Polystyrene, Polyamides (Nylon-6 and Nylon-6,6). Recycling of Thermosets –reclaiming of rubber –pyrolysis, depolymerization of scrap rubber, tyre retreading, uses of recycled rubber.

PRACTICALS: (50 MARKS)

1. Primary recycling of plastic waste collected from the 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.
6. Recovery of BHET from PET by chemical recycling process
7. Recovery of Adipic Acid from Nylon 66 by chemical recycling technique
8. To study the effect of vulcanized rubber at varying ratio (in powder form) on mechanical properties of rubber vulcanizate
9. Preparation of plasticizer from polyester waste.
10. Preparation of reclaim from tyre waste.

REFERENCES:

1. Chandra, R., & Adab, A. (1994). Rubber & Plastic Waste: Recycling, Reuse and Future Demand. CBD Publishers.
2. Scheirs, J., & Long, T. E. (Eds.). (2005). Modern polyesters: chemistry and technology of polyesters and copolyesters. John Wiley & Sons.

ADDITIONAL RESOURCES:

1. Blow, S. (1998). Handbook of Rubber Technology.
2. Brandrup, J., Bittner, M., Michaeli, W., & Menges, G. (1996). Recycling and Recovery of Plastics, Hanser. Gardner, München.
3. Goodship, V. (2007). Introduction to plastics recycling. iSmithers Rapra Publishing.
4. Brydson J.A., (2016) Plastics Materials, Butterworth Heinemann, 8th Edition.

TEACHING LEARNING PROCESS:
Conventional Chalk and Board Teaching, PowerPoint Presentation, Quiz, Interaction and Discussions, Demonstration, Visits

ASSESSMENT METHODS:
As per the assessment method mentioned in introduction

KEYWORDS:
4 R's approach, Incineration, Degradation, Selective dissolution technique, Chemical recycling