

ANNEXURE II

5 (2+ Minimum 3) Year Integrated MS-PhD in Paint and Coating Technology**1st Semester**

Sl. No	Subject code	Subject Name	Class Load/Week			Total load	Credit
			L	T	P		
1.	To be decided	Polymer Science and Polymer Chemistry (Core)	3	1	0	4	4
2.	TBD	Introduction to Nano Sci. and Technology (Core)	3	1	0	4	4
3.	TBD	Polymer Composites and Blends (Core)	2	1	0	3	3
4	TBD	Corrosion Science and Corrosion Prevention (Core)	2	1	0	3	3
5.	TBD	Course from another department (CBCS)	4	0	0	4	4
6.	TBD	LAB-1: Polymer Science and Polymer Chemistry	0	0	2	2	2
1ST SEMESTER TOTAL							20
Seminar / SkillX							02

2nd Semester

Sl. No	Subject code	Subject Name	Class Load/Week			Total load	Credit
			L	T	P		
1.	TBD	Advanced Paint and Coating Technology (Core)	3	1	0	4	4
2.	TBD	Chemistry of Dyes and Pigments including spectroscopy of colors (Core)	3	1	0	4	4
3.	TBD	Surface Engineering and Interfaces Polymers (including paints and coatings) (Core)	2	1	0	3	3
4.	TBD	Polymer Characterizations (Core)	2	1	0	3	3
5.	TBD	Course from another department (CBCS)	4	0	0	4	4
6.	TBD	LAB-2 : Polymer Characterizations	0	0	2	2	2
2ND SEMESTER TOTAL							20
Seminar / SkillX							02

3rd Semester

Sl. No	Subject code	Subject Name	Class Load/Week			Total load	Credit
			L	T	P		
1.	TBD	Recent Development in Paints and Coating (Core)	1	1	0	2	2
2.	TBD	Literature Review and Technical Writing for Scientific Communications (Core)	1	1	0	2	2
3.	TBD	Term Paper on Project work	0	0	10	10	12
4.	TBD	Term Paper Viva	0	0	4	4	4
3rd SEMESTER TOTAL							20
Seminar / SkillX							02

4th Semester

Sl. No	Subject code	Subject Name	Class Load/Week			Total load	Credit
			L	T	P		
1.	TBD	Project	0	0	16	16	16
2.	TBD	Project Grand Viva	0	0	4	4	4
4th SEMESTER TOTAL							20
Seminar / SkillX							02

Total Credits for MS = [20+20+20+20] = 80

Total credit (Theoretical)= 40

Lab. Based credit= 40

For PhD:

From the 1st Semester of PhD (i.e. 5th Semester of MS-PhD), 14 credits to be undertaken as mandatory course work for PhD [including two compulsory courses i.e. Research Methodology (4 credits) and Research Ethics (2 Credits); as per JIS University PhD Regulation]. The 14 credit to be completed within maximum 2 semesters.

Subjects to be offered for PhD must be different from MS curriculum.

Detailed Syllabus

SEMESTER I

Polymer Science and Polymer Chemistry

History of macromolecular science.

Concept of macromolecules. Degree of polymerization, Concept of molecular mass, polydispersity, number average and weight average, viscosity average molecular weight and their statistical equations, molecular weight distribution in linear polymers (step growth and chain polymers), Nomenclature of polymers.

Basic concepts in polymer science. Different ways in classification of polymers depending on – a) The origin (natural, Semisynthetic, synthetic etc.) b) The structure (linear, branched, network, hyperbranched, dendrimer.)

c) The type of atom in the main chain (homochain, heterochain). d) The formation (condensation, addition). e) Homopolymers, copolymers. f) The behaviour on application of heat and pressure (thermoplastic and Thermosetting). g) The form and application (plastics, fiber, elastomers and resin).

Chemical bonding in polymers – ionic (ionomers), covalent, coordinate, metallic (Metallocene polymers), hydrogen bonding.

Monomer structure and polymerizability. Concept of functionality. Writing the structure of the polymer formed for a given monomer and its classification. Raw materials for monomers with specific example viz. acrylonitrile, vinyl chloride, methyl methacrylate, isobutylene, isoprene, styrene, hexamethylene diamine and adipic acid, caprolactum, ethylene oxide and sebacic acid, ethylene glycol and terephthalic acid and their Polymerization reactions.

Basic Concepts in Organic Chemistry

Review of basic concepts in organic chemistry: bonding, hybridisation, MO picture, inductive effect, electromeric effect, resonance effect, hyperconjugation, steric effect. Bonding weaker than covalent bonds.

The formalism of curved arrow mechanisms. Practicing of line diagram drawing.

Concept of aromaticity: delocalization of electrons - Hückel's rule, criteria for aromaticity, examples of neutral and charged aromatic systems - annulenes. NMR as a tool for aromaticity. Anti- and homo-aromatic systems - Fullerenes, Carbon nanotubes and Graphene.

Mechanism of electrophilic and nucleophilic aromatic substitution reactions with examples. Arenium ion intermediates. SN1, S_NAr, SRN1 and Benzyne mechanisms.

Physical Organic Chemistry and Photochemistry

Energy profiles. Kinetic versus thermodynamic control of product formation, Hammond postulate, kinetic isotope effects with examples, Hammett equation, Taft equation.

Photoreactions of carbonyl compounds: enones, dienes, dienones and arenes. Norrish reactions of acyclic ketones. Paterno-Büchi reaction. Barton, Di- π -methane and photo Fries rearrangements. Photochemistry of nitro and azo groups.

Topicity and prostereoisomerism, topicity of ligands and faces as well as their nomenclature. NMR distinction of enantiotopic/diastereotopic ligands.

Stereoisomerism: definition based on symmetry and energy criteria, configuration and conformational stereoisomers.

Geometrical isomerism: nomenclature, E-Z notation, methods of determination of geometrical isomers. Interconversion of geometrical isomers.

Preparations and applications of following reagents: Aluminium tertiary butoxide, BF₃, DCC, Ozone, Per benzoic acid, Pt & Pd, Selenium, Per iodic acid, PPA, Di azo acetic ester.

Books recommended:

- I. F.W. Billmeyer, Jr. Textbook of polymer science, Wiley- Interscience, N.Y. (1971)
- II. Introduction to polymer chemistry, R. Seymour, Wiley –Interscience (1981)
- III. Physical chemistry of Macromolecules, by D.D. Deshpande, Vishal publications, (1985)
- IV. Principles of polymer chemistry by P.J. Flory.
- V. Polymer Science –V R Gowariker.
- VI. Principles of polymerization, G. Odian, Wiley – Interscience (1981)
- VII. R. Bruckner, Advanced Organic Chemistry: Reaction Mechanisms, Academic Press, 2002.
- VIII. F.A. Carey, R.A. Sundberg, Advanced Organic Chemistry, Part A: Structure and Mechanisms, 5th Edn., Springer, 2007.
- IX. J. Clayden, N. Greeves, S. Warren, P. Wothers, Organic Chemistry, Oxford University Press, 2004.
- X. T.H. Lowry, K.S. Richardson, Mechanism and Theory in Organic Chemistry, 2nd Edn., Harper & Row, 1981.
- XI. D. Nasipuri, Stereochemistry of Organic Compounds: Principles and Applications, 3rd Edn., New Age Pub., 2010.
- XII. D.G. Morris, Stereochemistry, RSC, 2001. 08. E.L. Eliel, S.H. Wilen, Stereochemistry of Organic Compounds, John Wiley & Sons, 1994.
- XIII. N.J. Turro, V. Ramamurthy, J.C. Scaiano, Principles of Molecular Photochemistry: An Introduction, University Science books, 2009.
- XIV. N.J. Turro, Modern Molecular Photochemistry, Benjamin Cummings, 1978.
- XV. K.K.R. Mukherjee, Fundamentals of Photochemistry, New Age Pub., 1978.
- XVI. Organic Synthesis based on Name reaction and unnamed reaction, A. Hassner & C. Stummer, Pergamon press. 2nd edition
- XVII. Advanced Organic Chemistry- Reaction Mechanism & Structure, J. March, John Wiley & Sons. 4th edition
- XVIII. Reaction mechanism and reagents in organic chemistry, G. Chatwal, Himalaya publishers.
- XIX. Organic chemistry, Warren, Oxford university press.

Introduction to Nano Sci. and Technology

Amorphous and Nano-crystalline Materials

Production techniques for amorphous and nano-crystalline materials: vapour deposition techniques, nanoparticles, decomposition of supersaturated solid solutions and glass crystallisation, sol-gel methods, nanoporous materials; microstructural stability in nanomaterials; colloidal nanoparticles; Catalysis: principles and applications of nano-crystalline

materials; mechanical properties and microstructure-mechanical property relationships in nano-crystalline materials.

Electronic, Opto-electronic and Superconducting Materials

Band theory; Energy band diagrams; Nature of chemical bonds and their relation to crystal structure; Band gap; Fermi level carrier mobility, Extrinsic & intrinsic semiconductors; doping techniques. Optical properties of semiconductors; absorption & emission processes; radiative & non-radiative transitions; photoconducting & non-photoconducting materials materials; Phosphors preparation and applications. Superconductivity, Cooper-pair instability, BCS theory, Josephson Effects, Ginzburg-Landau Theory, Superconductor in magnetic field, Type I and Type II superconductors, flux quantization, d-wave superconductors, high temperature superconductors.

Books Recommended:

- 1) "The Physics of Polymers, 2nd Edition, Concepts for Understanding Their Structure and Behavior" G. Strobl, Springer Press 1997.
- 2) Nanomaterials Nanotechnologies and Design, An Introduction for Engineers and Architects, MFAshby

Polymer Composites and Blends

Difference between blends and composites, their significance, choice of polymers for blending, blend miscibility-miscible and immiscible blends, thermodynamics, phase morphology, polymer alloys, polymer eutectics, plastic-plastic, rubber-plastic and rubber-rubber blends, FRP, particulate, long and short fibre reinforced composites.

Books Recommended: Polymer Blends and Composites: Chemistry and Technology; Muralisrinivasan Natamai Subramanian, ISBN: 978-1-118-11889-4

Corrosion Science and Corrosion Prevention

Fundamentals of corrosion phenomenon, Various types of corrosion. Methods of osion prevention and control. Polymers used in corrosion prevention. Corrosion inhibitors and various methods of corrosion inhibition, Treatment of metal surface for corrosion protection, Pigments pigmented coatings, Inorganic coatings Testing and specifications.

Powder coatings and other high performance coatings & their importance, Polymers used in powder coatings, thermoplastic, Powder coatings based on vinyls, polyolefins, nylons, polyesters etc., Thermosetting powder coatings based on epoxy, urethanes, acrylics etc., Curing reactions, monitoring of curing process, crosslinkers used in thermosetting powder coating. Industrial thermoplastic and thermosetting powder coatings, parameters influencing powder coating properties, thermosetting powder coatings, Parameters influencing powder coating properties, Technology of production of powder coating, application techniques, newer developments

Coatings required for specific industries and their formulations, testing and specifications. Industrial coatings. Appliance Finishes, Automotive finishes. Coil Coatings, Can Coatings, Aircraft Coatings Paints for water proofing etc. formulation testing and specifications thereof.

Recommended Textbooks/Sourcebooks:

- I. Electroactive Polymers for Corrosion Control by Peter Zarras, John D. Stenger-Smith, Yen Wei
- II. Corrosion of Polymers and Elastomers by Philip A. Schweitzer
- III. Handbook of conducting polymers, Volume 1 edited by Terje A. Skotheim, John R. Reynolds.
- IV. Fundamental of corrosion Mechanisms, Causes, and Preventative Methods, Philip A. Schweitzer, CRC press, International Standard Book Number: 978-1-4200-6770-5
- V. Ionomers: characterization, theory, and applications by Shulamith Schlick
- VI. Introduction to ionomers by Adi Eisenberg, Joon-Seop Kim.
- VII. A Guide to High-performance Powder Coating by Bob Utech
- VIII. User's Guide to Powder Coating, Fourth Edition by Nicholas Liberto
- IX. Beginning Powder Coater's Handbook: An Introduction to Powder Coating by Tracy
- X. Norris.

LAB-1: Polymer Science and Polymer Chemistry

- Identification of polymeric materials by evaluating physical state
- Detection of Elements: Lassaigne's Test
- Physical testing of polymer (burning test odour test etc.)
- Solvents for thermoplastic dissociation
- Classification of polymeric materials
- Determination of acid values of given polymer samples
- Determination of Iodine number of given polymeric sample

SEMESTER II

Speciality Polymers for advanced applications

LIQUID CRYSTALLINE POLYMERS (LCPS) Concept of liquid crystalline (LC) phase, liquid crystalline polymers and their classification. theories of liquid crystallinity, characteristics of LC state and LCs, blends of LCs, applications of LCs.

CONDUCTING POLYMERS Theory of conduction, band theory, requirements for polymer to work as conductor, types of conducting polymers -doping of polymeric systems, Polyaniline, Polyacetylene, Polypyrrole, organometallic polymers – Photo conducting polymers- Polymers with Piezzo, ferro and pyro electric properties.

HEAT RESISTANT POLYMERS Requirements for heat resistance, determination of heat resistance, synthesis, structure-property relationships, applications of heat resistant polymers like polyamides,

polyimides and its derivatives, polyquinolines, polyquinoxalines, Polymers for high temperature resistant-PBT, PBO, PBI, PPS, PPO, PEEK, Fluoro polymers

PHOTOSENSITIVE POLYMERS AND POLYMERS AS COATING ADDITIVES Photosensitive

polymers - synthesis, curing reactions, applications in various fields. Photo resist for semiconductor fabrication. Membranes, their types, methods of casting and their applications. Polymer as coating additives - types, synthesis, requirements for polymer to work as coating additives and applications

POLYMERS IN MISCELLANEOUS SPECIALTY APPLICATIONS Polymers in agricultural applications: green houses, control release of agricultural chemicals, seed coatings, etc., polymers in construction and building applications, polymer concrete, polymeric materials used in telecommunication and power transmission applications, polymer composites in aerospace.

Shape memory polymer, Polymers responding to various stimuli such as heat, light, pressure, fluids/chemicals etc.

Polymers in telecommunications and power transmission: Polymers as insulators electrical breakdown strength, capacitance, dielectric loss and cable attenuation, submarine cable insulation, low fire risk materials, polymers in power transmission, optical fibre telecommunication cables.

Polymer concrete, polymer impregnated concrete, ultra-high modulus fibers, polymers for biomedical application, polymeric binders for rocket propellants, polymer supported reagents.

Books recommended:

- I. Faiz Mohammad, Specialty Polymers: Materials and Applications, I.K. International Pvt Ltd, 2008
- II. Johannes Karl Fink, Hand book of Engineering and Specialty Polymers, John Wiley & Sons, Vol.2, 2011
- III. Manas Chanda, Salil K. Roy, Industrial Polymers, Specialty Polymers, and their Applications, CRC Press, 2008
- IV. Norio Ise, Iwao Tabushi, An Introduction to Speciality Polymers, Cambridge University Press, 1983 food applications.
- V. Robert William Dyson, Speciality Polymers, 2nd ed., Springer verlag, 2011
- VI. Smart Polymers: Applications In Biotechnology And Biomedicine by Igor. Galaev, Bo Mattiasson
- VII. Smart polymers for bioseparation and bioprocessing by Igor Yu Galaev, Igor Galaev, Bo Mattiasson
- VIII. Encyclopedia of Polymer Science & Engineering H.F. Mark (Ed) John Wiley & Sons, New York (1989) Relevant Volumes

Chemistry of Dyes and Pigments including spectroscopy of colours

Part A: Paint Technology

Unit- I

A. Paints – Introduction and Definitions of paints, pigments, varnishes, lacquers, Anatomy of paints, functions & requirements of constituents of paints, classification of paints on the basis of order of application/ methods of curing / nature of solvent/ uses etc.

B. Paint Properties - color, tinting strength, reducing power, pigments classification of pigments, pigments properties-oil absorption, refractive index, particle size shape, bleeding, resistance to light and heat.

Unit-II

A. Manufacture of Paints

Ball mill, triple roll mill, bead mill, titrator, high speed and heavy-duty disperser.

B. Important Resins or Modifications of Resins for Paints and Coatings

- a. Epoxy Resins (BPA based resin, curing agents & flame retardant epoxy resins)
- b. Alkyds – Introduction of alkyds, different components of it, Modification with rosin, maleic anhydride, acrylics, vinyls, imides etc.
- c. Polyester resins - Unsaturated polyester resins
- d. Modification of phenolics such as novolac-epoxy oil soluble and oil reactive Modification of aminor resins (UF & MF) with alcohols and phenols.

C. Oils/Solvents for Paints

- a. Source and composition of oils, non-glyceride: classifications.
- b. Extraction and refining of oils.
- c. Chemical reactions of oils like oxidation, hydrolysis, glycerolysis, saponification, etc.
- d. Evaluation and characterization of oils.

Part B: Coating Technology:

Newer developments in chemistry and synthesis of surface coating binders such as epoxies, urethans, acrylics, silicones and others. Various formulations based on these binders for different applications. Inorganic binders. Developments in pigments for typical end applications. Concept of ecofriendly pigments in surface coatings. Developments in Resin & Testing Methods.

Types of Environment Friendly Coatings, Water Borne Coatings, High solid coatings, powder coatings. Techniques of preparation. Different Techniques for preparation of High Solid and Powder coatings. Fundamentals of emulsions. Functions of ingredients in emulsion polymers Functions and importance of surface active agents, Types of polymers used in water borne coatings, Solubilizations of binders in water. Application methods & Rheology Issues related Conventional Coatings. Testing and characterization coatings etc.

Type of additives, additives like Uv stabilizer, antioxidants, anti-ozonents, Coupling agents etc. Rheological modifiers etc. Anti-microbial etc, Chemistry of additives, Evaluation of additives, Mechanism of additives, Newer trends in additives, Functional additives.

Developments in formulation and methods of manufacture of coatings such as radiation cure, automotive paints, OEM paints. Developments in high solids, waterborne and such eco-friendly

coating compositions. Various functions and importance of ingredients used in the formulations. Advances in methods of application and film formation of surface coatings.

Theory of radiation curing. Methods of radiation curing and radiation curing techniques, selection of uv source. UV-curing-: Fundamentals of Photo polymerisation, Photo initiators types oligomer-polymers used, pigmentation. Electron-beam curing, EB-generators, Factors affecting EB-curing, application, polymers used Application

Introduction to marine paints, Types of marine paints. Marine paints for different submerged structure. Formulation and performance. Corrosion phenomena in marine environment. The recent developments in marine paints

Part-C: Chemistry of Dyes and Pigments

Origin of colour in organic molecules. Chromatic and achromatic colors. Red shift, blue shift, hyperchromic effect, solvatochromism, halochromism. Beer-Lambert's law, absorptivity, oscillator strength, and half band width. Spectroscopy of colors

Early theories of color and constitution - empirical correlations between the chemical structures and their color. Chromophores, auxochromes, distribution rules, chromogens. $n \rightarrow \pi^*$, donor acceptor, acyclic and cyclic polyene, and cyanine type chromogens.

Resonance theory of color, failures of resonance theory. Steric effects in electronic absorption spectra – some general considerations.

Textile dyes, pigments and dye intermediates with textile printing technology.

I. Textbooks/Sourcebooks:

- II. Chemistry of Synthetic Dyes and Pigments, Lubs H. A., Robert E Krieger Publishing Company, New York, 1977.
- III. Colour and Chemical Constitution of Organic Dyes, Griffiths J., Academic Press, 1976.
- IV. Handbook on Natural Dyes for Industrial Applications (Extraction of Dyestuff from Flowers, Leaves, Vegetables) - Dr. Padma S Vankar, Publisher: NIIR Project Consultancy Services; 2nd Revised Edition, 2016.
- V. A Concise Guide on Textile Dyes, Pigments and Dye Intermediates with Textile Printing Technology Paperback – Dr. H. Panda, Publisher: NIIR Project Consultancy Services, 2013.
- VI. Paints, Coatings and Solvents - Werner Freitag and Dieter Stoye, John Wiley & Sons, 2008.
- VII. Outlines of Paint Technology, W. M Morgan 3rd edn CBS Publishers.
- VIII. Paints, Coatings and Solvents - Werner Freitag and Dieter Stoye, John Wiley & Sons, 2008.
- IX. Introduction to Paint Chemistry by Turner
- X. Pigment Hand Book Part 1, 2,3 by Patton
- XI. Encyclopedic Hand book of Emulsions Technology by Sjoblom
- XII. Paint Film Defects by Hess

- XIII. Industrial Organic Pigments by W. Herbst
- XIV. High Performance Pigments by Huge M. Smith
- XV. Application Properties of Pigments by A. Karnik
- XVI. Coatings Technology Handbook by Arthur A. Tracton
- XVII. Paint and Coatings: applications and Corrosion Resistance by Philip A. Schweitzer
- XVIII. Paints, coatings, and solvents by Dieter Stoye, Werner Freitag

Surface Engineering and Interfaces Polymers (including paints and coatings)

General classification of surface coating, mechanism of film formation.

Source and composition of oils, non –glyceride, component of oils, classification, extraction and refining of oils, Chemical reactions of oils, like oxidation, hydrolysis, glyceralysis, saponification etc, and their evaluation, characterization of oils.

Function of additives, additives for solvent-thinned coating like wetting, and dispersing agents, anti settling and bodying agents, anti skinning agents, anti flooding agents etc, additives for latex paints like surface – active agents, antifoam agents, emulsifier, thickening agents, preservatives coalescing agents etc.

Surface chemistry I: Surface Phenomena, Gibbs adsorption isotherm, types of adsorption isotherms, solid-liquid interfaces, contact angle and wetting, Methods of surface tension and contact angle measurements Young Laplace, Kelvin Equation and implications of wetting, Nanostructure influence on wetting Lotus effect, rose petals and birds Marangoni effect, solid-gas interface, physisorption and chemisorption, Freundlich, derivation of Langmuir and BET isotherms, surface area determination. Kinetics of surface reactions involving adsorbed species, Langmuir-Hinshelwood mechanism, Langmuir-Rideal mechanism, Rideal-Eley mechanism.

Surface chemistry II: Surface Films, Langmuir-Blodgett films, self-assembled mono layers, collapse pressure, surface area and mechanism of heterogeneous catalysis, phase transfer catalysis. Chemical analysis of surfaces: Surface preparations - spectroscopic surface characterization methods, electron spectroscopy, ion scattering spectrometry, secondary ion scattering microscopy (SIMS) - Auger electron spectroscopy - instrumentation and application. Electron stimulated micro analysis, scanning probe microscopes.

Surfactants, detergency and foams, Micellization, self-assembly, liquid crystals, Emulsion, microemulsion, flotation, Adhesion, biofouling, adhesives, gecko effect, self-cleaning, Electric double layer, zeta potential, electrophoresis and electroosmosis DLVO theory, colloids and nanoparticles stabilization

Textbooks References:

- I. Outline of Paint Technology, W.M. Morgans (3rd Edition – Recently CBS Publishers.
- II. Paints, Coatings and Solvents, Dieter Stage (ED.) – 2nd Edition – Wernon Freitag Ltd.,(Eds).
- III. Principle & Paint Formulation, R. Woodbroidge (Ed.) – 1991.
- IV. Performance Enhancement in Coatings by Edward W. Orr
- V. Paints, Coatings, and Solvents by Dieter Stoye, Werner Freitag
- VI. European coatings handbook By Thomas Brock, Michael Groteklaes, Peter Mischke
- VII. UV coatings: basics, recent developments and new applications By Reinhold Schwalm

Polymer Characterizations

Importance of Quality Control

Importance of specification & standards in quality control of polymers; Preparation of polymer test specimens and conditioning.

Molecular Mass Determination

Number average molecular weight, weight average molecular weight, and polydispersity; Common methods for determining these parameters: colligative property measurements, static light scattering techniques, viscometry, and size exclusion chromatography (gel permeation chromatography); End Group Analysis, Ebulliometry, Cryoscopy, Osmometry, and Viscometry; Molar mass determination of copolymers.

Molecular Structure Determination

Identifying common functional groups, Analytical techniques and Spectroscopic techniques: ultraviolet-visible spectroscopy, infrared spectroscopy, Raman spectroscopy, nuclear magnetic resonance spectroscopy, electron spin resonance spectroscopy, X-ray diffraction, and mass spectrometry.

Morphology Characterization

Amorphous or crystalline portions of the polymer; Polymer morphology on a mesoscale (nanometers to micrometers); Microscopic techniques for determining microscale properties: X-ray diffraction, Transmission Electron Microscopy, Scanning Transmission Electron Microscopy, Scanning Electron Microscopy, and Atomic Force Microscopy.

Optical Properties and Analytical Tests

Refractive index, haze, gloss, density, water absorption, moisture analysis, sieve analysis, apparent density, melting point, Shrinkage, Melt Flow Index test, Particle size, Density, and bulk factor.

Thermal Properties Characterization

Polymer characterization through thermal analysis, particularly Differential scanning calorimetry; Melting transitions or glass transitions; Measuring crystallinity for semicrystalline polymers; Thermogravimetric analysis to indicate of polymer thermal stability and the effects of additives such as flame retardants; Differential thermal analysis, thermomechanical analysis, dynamic mechanical thermal analysis, and dielectric thermal analysis; Heat deflection temperature, Vicat softening temperature, thermal conductivity thermal expansion, brittleness temperature, surface and volume resistance.

Mechanical properties

Measuring strength, elasticity, viscoelasticity, and anisotropy of a polymeric material; Van der Waals interactions of the polymer chains, and the ability of the chains to elongate and align in the direction of the applied force; Elastomers, plastics, or rigid polymers.

Stress-strain properties of polymeric materials: Tensile strength, yield strength, and Young's modulus; stress strain graph; Hardness, Compression strength, Flexural strength, Impact strength.

The fracture properties of crystalline and semicrystalline polymers: Charpy impact testing or Charpy tests; brittle and ductile polymers.

Dynamic mechanical analysis: Characterization of viscoelastic behavior of polymeric systems; Temperature dependence of polymers' mechanical behavior; Measuring storage modulus and glass transition temperature, confirming crosslinking, determine switching temperatures in shape-memory polymers, monitor cures in thermosets, and determine molecular weight.

Viscometry, rheometry, and pendulum hardness.

Electrical and Flammability Test: Dielectric strength, Dielectric constant, dissipation factor, Insulation resistance and arc resistance, Ignition properties, Oxygen index test and smoke generation tests.

Chemical and Weathering Properties: Immersion test, Stain resistance test, Solvent stress cracking resistance test, Environmental stress cracking resistance test, Accelerated weathering test, Outdoor weathering of polymers.

Books Recommended:

- I. Handbook of plastics test method, R. P. Brown, Longman Scientific and Technical.
- II. Handbook of plastics testing technology, Vishu Shah, John Wiley & Sons, New York.
- III. Instrumental methods of Analysis, Will and Merritt, CBS Publisher, New Delhi.
- IV. Principles of Instrumental Analysis, Douglas A. Skoog, F. James Holler and Timothy A. Nieman,

LAB-2: Polymer Characterizations

- Spectrophotometric Analysis of a Mixture: Determination of Caffeine and Benzoic Acid in a Soft Drink
- Determination of acid value
- Determination of hydroxyl value
- Determination of saponification value
- Determination of iodine value
- Spectroscopy Trading Rules: Signal-to-Noise, Resolution, Ensemble Averaging, Digital Smoothing
- Performance Characteristics of a Spectrophotometer or Introduction to Ultraviolet—Visible Spectrometry (UV-Vis)
- Applications of Absorption Spectroscopy: Estimation of Monomer Concentrations and Measurement of purities
- Applications of Absorption Spectroscopy: Determination of Dissociation Constants of Acids and Bases

Semester III

Recent Development in Paints and Coating

1. Study of polymerization techniques – Bulk, Solution, Suspension, emulsion polymerization
2. Synthesis of polyesters,
3. Preparation of alkyd resin, epoxy resin

4. Synthesis of Prussian blue, the first modern synthetic pigment, Characterization and purity checking.
5. Synthesis of Mauve dye, Characterization and purity checking.
6. Synthesis of a green pigment Verdigris, Characterization and purity checking.
7. Extraction of natural pigment Curcumin from turmeric, Characterization and purity checking.
8. Preparation of Tempera paint, Analysis and characterization.
9. Environmental stress cracking
10. Surface coating
11. Photo-stability of coating
12. Mechanical and weathering failure of coating
13. Lamination (dry lamination), Lamination (wet lamination), Thermoplastic lamination

References:

- i. Experiments in Polymer Science, D. G. Hundiwale, V. D. Athawale, U. R. Kapadi, V. V. Gite, New Age International Pvt. Ltd., New Delhi, 2009.
- ii. Polymer Chemistry-Practical Approach in Chemistry, F. J. Davis, Oxford University Press, Oxford, 2004.
- iii. Polymer Science – V. R. Gowarikar, N. V. Viswanathan, Jayadev Shreedhar, New Age International Pvt. Ltd., New Delhi, 1997. 12
- iv. Principles of Polymerisation, P. Bahadur, N. V. Sastry, Narosa Publishing House, New Delhi, 2002.
- v. Laboratory Manual of Dyeing and Textile Chemistry by Joseph Merritt Matthews, John Wiley & Sons, London.

Literature Review and Technical Writing for Scientific Communications

1. Foundation of Research: What is Research, Objectives of Research, Scientific Research, Research and Theory Conceptual and Theoretical Models, Research Process, Problem definition, Research Questions, Research design, Approaches to Research, Importance of reasoning in research.
2. Types of Research: Classification of Research, Descriptive vs. Analytical Research, applied vs. Fundamental Research, Quantitative vs. Qualitative Research, Conceptual vs. Empirical Research, Exploratory vs. Confirmatory Research, Experimental vs Theoretical Research, Surveys, Case Study, Field Studies, Understanding Theory, Building and Validating Theoretical Models.
3. Review of Literature: Significance for Reviewing Literature, What to Review and its Purpose, Literature Search Procedure, Sources of Literature, Tools for identifying literatures, Note Taking, Role of libraries in Information Retrieval, Referencing, Indexing and abstracting services, Citation indexes.
4. Research formulation and design: Selection of a Problem for Research, Formulation of the Selected Problems, Hypothesis Formation, Measurement, Research Design/Plan.

Textbook

Research Methodology : Methods And Techniques (Multi Colour Edition) CR Kothari and G Garg