

Faculty of Engineering & Technology

**NORTH MAHARASHTRA UNIVERSITY,
JALGAON.**

Syllabus For

**M. Tech.
Polymer Tech.
(W.E.F.2009-2010)**

UNIVERSITY DEPARTMENT OF CHEMICAL TECHNOLOGY
NORTH MAHARASHTRA UNIVERSITY, JALGAON
M. Tech. (Polymer Tech.)

FIRST SEMESTER

Sub. No.	Paper	Teaching Scheme Hrs. / week	Exam. Scheme Hrs.	Marks		Total	Credit Points
				Internal	External		
PT – 1.1	Newer Techniques Of Synthesis & Curing Of Polymers	03	03	40	60	100	3
PT- 1.2	Processing and Sophisticated Testing of Polymers and Paints (P)	06	06	40	60	100	3
PT-1.3	Automotive and Insulation Coatings	03	03	40	60	100	3
PT- 1.4	Theory of Colour and Architectural Coatings	03	03	40	60	100	3
PT- 1.5	Tyre Technology	03	03	40	60	100	3
PT- 1.6	Fibre Technology	03	03	40	60	100	3
CT- 1.1	Modern Methods of Instrumental Analysis	03	03	40	60	100	3
CT- 1.2	Research Methodology and IPR	03	03	40	60	100	3
Grand Total						500	15

Note:- PT-1.1, PT-1.2, CT-1.1 are compulsory. Select any two papers out of PT-1.3, PT-1.4, PT-1.5, PT- 1.6 and CT- 1.2. The particular elective course will be offered provided the minimum number of students choosing that Elective is five.

SECOND SEMESTER

Sub. No.	Paper	Teaching Scheme Hrs./ week	Exam. Scheme, Hrs.	Marks		Total	Credit Point
				Internal	External		
PT-2.1	Polymer Recycling And Waste Management	03	03	40	60	100	3
PT-2.2	Science And Technology of Nano Composites, and Nano Pigments	03	03	40	60	100	3
PT- 2. 3	Polymer Reaction Engineering	03	03	40	60	100	3
PT- 2. 4	Specialty And High Performance Polymers	03	03	40	60	100	3

PT- 2. 5	Biopolymers	03	03	40	60	100	3
PT-2.6	Chemistry & Technology of Powder Coatings.	03	03	40	60	100	3
PT-2.7	Theory of Corrosion and Marine and Maintenance Coatings	03	03	40	60	100	3
PT 2.8	Radiation Curing Coatings	03	03	40	60	100	3
Grand Total						500	15

Note:- PT-2.1, PT-2.2, PT-2.3 are compulsory. Select any two papers out of PT-2.4, PT-2.5, PT-2.6, PT-2.7 and PT-2.8. The particular elective course will be offered provided the minimum number of students choosing that Elective is five.

Third Semester

Sub. No	Paper	Teaching Schme, Hrs/ Week	Marks		Total Marks	Credit Point
			Internal	External		
PT:3.1	Seminar	10	-	100	100	5
PT:3.2	Project	20	80	120	200	10
Grand Total					300	15

Fourth Semester

Sub. No	Paper	Teaching Scheme, Hrs/ Week	Marks		Total Marks	Credit Point
			<i>Internal</i>	<i>External</i>		
PT4.1	Project	30	120	180	300	15

UNIVERSITY DEPARTMENT OF CHEMICAL TECHNOLOGY
NORTH MAHARASHTRA UNIVERSITY, JALGAON
M. Tech. – Polymer Technology

Admission

Candidates holding B. Tech. / B.E. degree in Polymer Technology/ Plastics Technology/ Paint Technology or M.Sc. in Polymer Science or M. Sc. (Chemistry) or equivalent with 55 % marks are eligible for admission. However M. Sc. (Chemistry) [excluding Polymer Chemistry] will have to qualify additional two UG (B. Tech. Plastics/ Paints Tech.) Courses- PT-703 Evaluation of Surface Coatings and Paint Defects (Old Course) or PL604 Testing of Plastics (Old Course) or PTL-404 Quality Assurance & Analysis of Surface Coatings (New Course) or PLC-404 Polymer Testing (New Course) and PT/PL Chemistry & Technology of Polymers (Old Course) or PLL-201 Introduction to Polymer Technology(New Course) or PTC-201 Anatomy of Paints (New Course). Those students, who have not studied Mathematics course at either undergraduate or post-graduate level, will have to opt and qualify mathematics course-CHE 404 Mathematics-II (Old Course) or BSL201 Mathematics-II (New Course). Preference will be given to candidates holding valid GATE score.

Notes:-

1. The students of M. Tech. Course have to attend 80% of lectures, practical and any other term work as may be prescribed by the university. The conduct and behaviour of the student must satisfy the Head of the Department.
2. The head of the Department certifies that the student has attended the course as prescribed and has conducted himself satisfactorily. In absence of such certificate the student shall not be permitted to the University examination.
3. The University examinations for all the terms shall be conducted at the end of the term.
4. The student shall have to appear personally to all parts of the examination.
5. The Credit Structure is based on M. Tech. Credit Guidelines sanctioned by University Academic Council.

UNIVERSITY DEPARTMENT OF CHEMICAL TECHNOLOGY
NORTH MAHARASHTRA UNIVERSITY, JALGAON
M. Tech. – Polymer Tech. Syllabus
I Semester

PT-1.1, PT-1.2, CT-1.1 are compulsory. Select any two papers out of PT-1.3, PT-1.4, PT-1.5 and PT- 1.6.

PT – 1.1 Newer Techniques of Synthesis & Curing of Polymers (3hrs/ week) (Credits 3)

(I) Mechanism, Kinetics and Applications of following Synthesis Techniques.

- i] Anionic polymerization, ii] Cationic polymerization
- iii] Ring – opening polymerization, iv] Dendrimers
- v] Metathesis polymerization, vi] Group transfer polymerization
- vii] Reaction Injection Molding, viii] ATRP

(II) Cross linking / curing mechanism: Resin-Hardner curing, Thermal curing, Oxidative polymerization, Cross linking of epoxy resin, Instrumental Monitoring of Curings.

PT- 1.2 Processing and Sophisticated Testing of Polymers and Paints (P) (Practical) (6hrs/ week) (Credits3)

Minimum five Sophisticated Instrumental experiments based on Instruments Studied in CH 1.3 “ Modern Instrumental Analysis.” Determination of MFI, Rheology Analysis.

Processing of Plastics- Compounding of Polymers on Extrusion, and Two Roll Mill, Injection Moulding, Compression Moulding.

Minimum three experiments on various techniques of Polymer Synthesis

Formulation and processing of Paints –use of Ball Mill, Triple Roll Mill, High Speed Disperser, Bead Mill, Application and Testing of Paints.

PT-1.3 Automotive and Insulation Coatings (3hrs/ week) (Credits 3)

I. Automotive Coatings:

Preparation and Pre-treatment of Surfaces-Degreasing, Activation, Phosphating, Passivation, Plant Layout Ecofriendly conversion coatings

Electrodeposition –Electro Chemistry, Electrodeposition Variables, Resin Synthesis, Paint Formulation, Plant layout; Recent Developments in Electrodeposition

Binders, Pigments and additives for automotive coats, Surfacer, Antichip Coatings, Solid Colour Monocoats, Basecoat-clear coat formulations for topcoats, High solid top coats, waterborne/ powder surfacers and topcoats, Paints for Plastics, Refinish/Repair paints, Testing Methods.

Paint Shop- Overall Operation, Design of Convection Ovens, Spray Systems, Use of Robotics

II. Insulation Coatings: Fundamental of Electrical Insulation, Binders used in electrical insulation, Formulation of Insulating varnishes, Wire enamels, Impregnating Compounds, Casting & Potting Compounds etc., Application & Testing methods, Other insulations: Thermal, aquatic & vibrational. Recent Developments

Role of Nanotechnology in Automotive and Insulation Coatings

TEXTBOOKS

1. ‘**Automotive Paints and Coatings**’ Edited by Hans-Joachim Streitberger and Karl-Friedrich Dossel,, Second Edition, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim 2008.
2. McBane, B. N., **Automotive Coatings**, Federation of Societies for Coatings Technology, Blue Bell, PA, 1987.
3. ‘**Surface Coatings**’, Vol. I & II, Oil and Colour Chemists’ Association, Tafe Educational Books, NSW, Australia, 1987.
4. ‘**Coating Technology Handbook**’, Edited by D. Satas and A. A. Tracton, Second Edition, Marcel Dekker, Inc., New York, 2001
5. ‘**Polymers for Electrical Insulations**’, Edited by Horst Sulzbach, Ser. 314, DIE BIBLIOTHEK DER TECHNIK, Elantas GmbH, 2008.

References: 1.Related US/European/ Japanese/ Indian Patents.

2.Review/ Research Papers in *J. Coat. Technol.*, *Macromolecules*, *Prog. Org. Coat.*, *J. Oil Colour Chem. Assoc.*, *Paint Coat. Ind.*, *Polym. Mater. Sci. Engg.*, *J. Appl. Polym. Sci.*, *JCT Res.*, *Surf. Coat. Int.*, *Pigments and Resins*, *JCT Coat. Tech.*, *Org. Coat. Sci. Technol.*, etc.

3.Invited Talk/ Research Paper Presentations at International Conferences such as Proc. Waterborne High Solids Powder Coat. Symp., Proc. Int. Conf. Org. Coat. etc.

4. Websites such as <http://www.specialchem4coatings.com>, websites of Paint Industries (e.g. <http://automotive.dupont.com>), www.census.gov (for Industrial Reports on Coatings), www.epa.gov etc.

PT- 1.4 Theory of Colour and Architectural Coatings (3hrs/ week) (Credits 3)

- i] Colour Matching : colour perception, metamerism, spectral colour match, mathematics of colour matching, chromaticity diagram, instrumentations for colour measurement. Procedure for shade matching at plant and paint shop, shade sensing and decision in relation to interior decoration.
- ii] Morphology of surfaces : Masonary, wooden and metal substrate – coating interaction, preparation of surfaces – techniques and specifications.
- iii] Coatings for buildings: Sealers, Primers, Stoppers/ Fillers, Undercoats and topcoats for different surfaces – formulation, and manufacture of Waterborne/ Solventborne Paints. Calculations related to Paint Formulary, Methods of Applications, Control of Leveling and Sagging, Paint Defects
- iv] Weather resistance of Exterior Decorative Coatings, Powder Coating in Decorative Sector, Special Effect Paints, Coating Calculations and Costing for Paint Contractor
- v] Nanotechnology in Architectural Coatings- Self Cleaning / Hygienic Coatings, Lotus Effect, Self Healing Coating, Smart Coatings

TEXTBOOKS

1. **‘Organic coatings : science and technology’**, Edited by Zeno W. Wicks, Jr., Frank N. Jones, S. Peter Pappas; Douglas A. Wicks, Third Edition, John Wiley & Sons, Inc., Hoboken, New Jersey. 2007.
2. **‘Paint Technology Handbook’**, Rodger Talbert, CRC Press, Taylor and Francis Group, 2008.
3. Feist, W. C., *Finishing Exterior Wood*, Federation of Societies for Coatings Technology, Blue Bell, PA, 1996.
4. **‘Surface Coatings’**, Vol. I & II, Oil and Colour Chemists’ Association, Tafe Educational Books, NSW, Australia, 1987.
5. **‘Coating Technology Handbook’**, Edited by D. Satas and A. A. Tracton, Second Edition, Marcel Dekker, Inc., New York, 2001

References: 1. Related US/European/ Japanese/ Indian Patents.

2. Review/ Research Papers in *J. Coat. Technol., Macromolecules, Prog. Org. Coat., J. Oil Colour Chem. Assoc., Paint Coat. Ind., Polym. Mater. Sci. Engg., J. Appl. Polym. Sci., JCT Res., Surf. Coat. Int., Pigments and Resins, JCT Coat. Tech., Org. Coat. Sci. Technol.* etc.

3. Invited Talk/ Research Paper Presentations at International Conferences such as Proc. Waterborne High Solids Powder Coat. Symp., Proc. Int. Conf. Org. Coat. etc.

4. Websites such as <http://www.specialchem4coatings.com>, websites of Paint Industries (e.g. <http://automotive.dupont.com>), www.census.gov (for Industrial Reports on Coatings), www.epa.gov etc.

PT 1.5 Tyre Technology (3hrs/ week) (Credits 3)

Tyre design, tyre mechanics, tyre friction and wear hydroplaning. Carcas design, contour shape, tyre cord and their characteristics. Cord tension. Load capacity of tyre. Stresses in Tyre. Tread design, Bead design – bead tension, Tyre wear, rubber friction and sliding mechanism, various factors affecting friction and sliding. Tyre stresses and deformation, tyre noise, mechanism of noise generation, effect of tread pattern, vehicle speed etc., on noise level, Tyre in plane dynamics. High frequency properties, basic yaw and camber analysis.

Principles of designing formulations for various tyre components. compounding and mixing of rubber. Tyre reinforcement materials (Textile, steel, glass etc.). Criteria of selection - textile treatment - adhesion promoters. Tyre mould design

Manufacturing techniques of various tyres like two wheeler and car tyres, truck tyres, OTR, Farm tyres, aircraft tyres - different styles and construction - green tyre design principles, methods of building green tyres for bias, bias belted, radial and tube-less tyres, green tyre treatments. Tyre curing methods, post cure inflation, quality control tests, Tyre related products, their design and manufacturing techniques, tubes, valves, flaps and bladders. Different types, their feature and operation of tyre building machines, bead winding machine, wire/glass processing machines, bias cutters, curing presses.

Measurement of tyre properties, dimension and size-static and loaded, Tyre construction analysis, Endurance test wheel and plunger tests, traction, noise measurements. Force and moment characteristics, cornering coefficient aligning torque coefficient, load sensitivity and load transfer sensitivity, Rolling resistance, non uniformity dimensional variations, force variations- radial force variation, lateral force variation concentricity and ply steer. Type balance, mileage, evaluations, tyre flaws and separations, X-ray holography etc., Foot print pressure distribution. BIS standards for tyres, tubes and flaps.

TEXTBOOKS

1. Samuel K. Clark, Mechanics of pneumatic Tires, National Bureau of standards, Monograph, US Govt. printing office, 1971.
2. Tom French, Tyre Technology, Adam Hilger, New York, 1989.

REFERENCES

- 1.F.J. Kovac, Tire Technology, 4th edition, Good year Tire and Rubber company, Akron, 1978.
- 2.E. Robecchi, L.Amiki, Mechanics of Tire, 2 Vols, Pirelli, Milano, 1970

PT-1.6 Fibre Technology (3hrs/ week) (Credits 3)

Production of PVC, PET fibres , Polyamide fibres -Melt spinning – Polymer feed – melt spinning equipment – high speed spinning – spin draw processes – crystallisation method – melt spinning of PET & PP staple fibres – wet and dry spinning – comparison. Spin finishes – functions of spin finish – methods of application of spin finish – spin finish for polyester staple fibres – spin finish for texturing process – effect of spin finish on dyeing. Stretching or drawing – conditions of drawing – machines for draw warping – texturing – false twist process – draw texturing – other methods – staple fibre production – melt spinning – drawing – heat setting – crimping in fibre line –polyester tops for wool blending – Mass coloration and tow dyeing – polyester – nylon – acrylic – polypropylene – dyeing in loose fibre and yarn forms – of polyester, nylon – acrylic – PP – loose fibre dyeing.

Measurement system in fibres – Direct System – Indirect System – Modified Synthetic fibres – modified polyester, Nylon, PP, analysis – Hydrophilic – Hollow – Low pilling – flame retardant.

Quality control – testing raw material – testing polymers – testing yarns & fibres – waste utilization of polyester – nylon 6 – 66 – acrylics – PP ; Energy conservation during polymerization and fibre production – pollution control measures.

TEXTBOOKS

1. A.A. Vaidya, Production of synthetic fibres, Prentice Hall of India Pvt. Ltd., New Delhi, 1988

REFERENCES

1. R.W.Moncrieff , Man made fibres , 6th Ed , Hey wood Books, UK 1975
2. Encyclopedia of Polymer Science and Tech Vol 1-12 John Wiley and Sons 2003

CT- 1.1 Modern Methods of Instrumental Analysis (3hrs/ week) (Credits 3)

Detail study of following sophisticated instruments with reference to construction, operation principle, applications and merits and demerits:

Gas Liquid Chromatography, High Performance Liquid Chromatography

Infra Red & FTIR Spectroscopy

NMR Spectroscopy

UV Visible Spectroscopy

Mass Spectroscopy

Differential Scanning Calorimeter, Thermogravimetric Analysis

Scanning Electron Microscope, Transform Electron Microscope & Atomic Force Microscopy

XRD – crystalline phase analysis

Surface area determination by BET- method, Particle size by light scattering method, Zeta potential

Colour Matching and Lovibond Tintometer

References:

- Hari Singh Nalwa - Encyclopedia of Nanotechnology.
- Introduction to Nanotechnology - Charles P. Poole Jr. and Franks. J. Qwens
- Novel Nanocrystalline Alloys and Magnetic Nanomaterials- Brian Cantor

- Nanomaterials Handbook- Yury Gogotsi
- Springer Handbook of Nanotechnology - Bharat Bhushan
- Processing & properties of structural nanomaterials by Leon L. Shaw (editor)
- Chemistry of nanomaterials : Synthesis, properties and applications by CNR Rao et.al.
- Synthesis of Nanostructured Materials –Cao
- Handbook of Nanoscience, Engineering- Goddard et al

CT- 1.2 Research Methodology and IPR (3hrs/ week) (Credits 3)

Research: Meaning, Objective of research, types of research

Selecting a problem and preparing research proposal for different types of research

Literature survey: Use of library, books and journals, use of internet (different useful sites) patent search

Methods and tools in research: Qualitative and quantitative studies enquiry forms, questionnaire, opinionnaire

Data analysis: Parametric and non parametric data, Hypothesis testing

Descriptive and inferential analysis, Statistical analysis of data including standard deviation, student t test, f test, ANOVA, Multiple regression and correlation coefficient

Documentation:

Research paper/ Thesis writing: Different parts of the research paper

Presentation: Oral, poster

Sources of procurement of research grants

Industrial Institution Interaction

Introduction to intellectual property and its relation with regulations

Introduction to patent, patent system in India and worldwide (Paris convention and TRIPS agreement)

II Semester

PT-2.1, PT-2.2, PT-2.3 are compulsory. Select any two papers out of PT-2.4, PT-2.5, PT-2.6 and PT-2.7.

PT – 2.1 Polymer Recycling and Waste Management (3hrs/ week) (Credits 3)

1. Introduction, Sources of plastics waste (Industrial waste, post consumer waste, scrap waste and nuisance waste), Plastic identification and Separation techniques – (density - float sink and froth floatation methods, optical, spectroscopic, electrostatic, sorting by melting temperature, sorting by size reduction, sorting by selective dissolution and other methods), recycling codes.
2. Plastics Waste Management - 4R's approach (reduce, reuse, recycle – mechanical and chemical, recover), recycling classification- - primary - secondary - tertiary - quaternary recycling with examples. Energy from waste – incinerators-pyrolysis, factors affecting incineration.
3. Recycling of polyolefins - PVC, PET, polystyrene, polyamides-nylon-6 and nylon-6,6, polyurethanes, mechanical process, applications of recycled materials.
4. Recycling of rubber – comparison of thermoset and thermoplastic composites, reclaiming of rubber – fuel source – pyrolysis, Depolymerization of scrap rubber, tyre retreading, uses of recycled rubber – asphalt and other uses.
5. Recycling of plastics by surface refurbishing - coating application, influence on plastics properties by coating, polishing of the plastics surface, commercial process. Plastics aging - environmental aging, thermal aging, weathering of plastics, mechanical degradation, chemical degradation and environmental stress cracking, wear and erosion, influence of plastic aging in recycling, energy from waste - incinerators

TEXTBOOKS

1. John Scheirs., - "Polymer Recycling" John Wiley and Sons, 1998
2. Nabil Mustafa – "Plastics Waste Management" Marcel Dekker Inc., 1998.
3. Steven Blow, Handbook of Rubber Technology, Galgotia Publications Pvt. Ltd., New Delhi, 1998.
4. Chandra R. and Adab A., Rubber and Plastic Waste, CBS Publishers & Distributors, New Delhi, 1994.

REFERENCES

1. Muna Bitter, Johannes Brandup, Georg Menges "Recycling and Recovery of plastics" 1996
2. Attilio L. Bisio, Marino Xanthos, "How to manage plastics waste: Technology and market Opportunities" Hanser Publishers, 1994
3. Francesco La Mantia., "Handbook of Plastics Recycling" Chem Tec Publishing, 2002

PT - 2.2 Science and Technology of Nano composites and Nano Pigments (3hrs/ week) (Credits 3)

Nanocomposites: Comparison with conventional composites.

Manufacture and Characteristics of thermoplastic and thermoset nanocomposite products: Fiber reinforced nanocomposites, copolymer / clay nanocomposites, latex / ZnO nanocomposites, hybrid nanocomposites, PVC / CaCO₃ nanocomposites, etc. Effect of modifier concentration on structure, mechanical and viscoelastic properties of nanocomposites, Development and Optimization of Polymer melt process, Nanocomposite preparation by injection molding.

Applications of Nanocomposites : Flame retardant textiles, toughened plastics, automotive bodies, mirror housing on various vehicles, belts, vacuum cleaners, covers for mobile phones, power tools.

Nanoextenders and Transparent Pigments : Manufacture and properties of Alumina, Silica, Titanium Dioxide, Carbon Black, Iron Oxides, Zinc Oxides, Nanosilver, CaCO₃ etc. on Nano scale; Bimodally porous nanoparticles (e.g. titanium tetraisopropoxide), variables affecting particle size aggregation and crystal structure. Their use as spacing extenders / pigments in paints, reinforcing agent in polymers, heat & wear resistant materials etc. Coating nanoparticles with layers of polymers and machines for dispersion .

References:

- Nanocomposites Science and Technology - P. M. Ajayan, L.S. Schadler, P. V. Braun
- Physical Properties of Carbon Nanotubes- R. Saito
- Carbon Nanotubes (Carbon , Vol 33) - M. Endo, S. Iijima, M.S. Dresselhaus
- The search for novel, superhard materials- Stan Veprjek (Review Article) JVST A, 1999
- Electromagnetic and magnetic properties of multi component metal oxides, hetero
- Nanometer versus micrometer-sized particles-Christian Brosseau, Jamal Ben, Youssef, Philippe Talbot, Anne-Marie Konn, (Review Article) J. Appl. Phys, Vol 93, 2003
- Diblock Copolymer, - Aviram (Review Article), Nature, 2002

PT- 2. 3 Polymer Reaction Engineering (3hrs/ week) (Credits 3)

Classification of polymerization reactions. addition polymerization reaction mechanisms and rate equations; Dead – end radical polymerization; molecular weight distribution in batch and continuous reactors; avg. molecular weight and experimental determination based on viscosity, osmotic pressure etc. semi-batch reactor operation; Design of batch and continuous reactors. Heat removal from polymerization reaction.

Heterogeneous polyaddition reactions; Suspension and emulsion polymerization; Smith- Ewart's theory and Stock Mayer's equation; continuous emulsion polymerization; Anionic and Cationic poly addition; Co-polymerization; Mayo's equation and reactivity ratio; Alfred- Price equation; Rate of co polymerization and y factor; Skiest's equation.

Polycondensation reactions; Flory's equation and molecular weight distribution; Molecular weight regulations. Typical case studies of polymers like PE, PP and PS .

Reference books:

1. G. M. Burnett, Mechanism of polymer Reactions, Interscience, 1954.
2. F. M. Bovey, A. K. Medalia, I. M. Kolthoff, Emulsion Polymerisation, Interscience, 1955.
3. G. E. Harn, Co polymerization, Interscience, 1969.
4. F. W. Billmeyer, (Ed.) Encyclopaedia of Polymer science and Technology, Interscience, 1969.

PT-2.4 Specialty And High Performance Polymers (3hrs/ week) (Credits 3)

Ionic Polymers: Ionic Polymers, synthesis, physical properties and applications, Ion-exchange, Hydrophilicity, Ionomers based on polyethylene, elastomeric ionomers. Ionomers based on polystyrene, ionomers based on PTFE, ionomers with polyaromatic backbones, polyelectrolytes for ion exchange, polyelectrolytes based on carboxylates, polymers with integral ions, polyelectrolyte complexes. Biological and inorganic ionic polymers. Polymer supported synthesis, polymer supported catalysts and reagents.

Conducting Polymers: Conducting polymers, polyacetylene, polyparaphenylene polypyrrole, organometallic polymers, photo conducting polymers, polymers in non-linear optics, polymers with piezoelectric ferroelectric and pyroelectric properties, photoresists for semi conductor fabrication – liquid crystalline polymers.

High Temperature Resistant Polymers: High temperature and fire resistant polymers improving low performance polymers for high temperature use – polymers for low fire hazards – polymers for high temperature resistance – Fluoropolymers. Aromatic polymers, polyphenylene sulphide, polysulphones, polyesters, polyamides, polyketones, Heterocyclic polymers.

Polymers In Aerospace: Polymers used in aerospace – polymer binders for solid propellants, requirements of a polymer to be used as propellant binder, types of polymer binders, their energetics and combustion characteristics, high energy propellant binders, ablative plastics.

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

TEXTBOOKS

1. H.F.Mark, (Ed), Encyclopedia of polymer Science & Engineering, John Wiley & Sons, New York, 1989.
2. Matrin.T.Goosey, Plastics for Electronics, Elsevier, Applied Science, 1985.
3. R.W. Dyson, Specialty Polymers, Chapman & Hall, 2nd edition, 1998.

REFERENCES

1. Manas Chanda, Salil.K.Roy, Plastics Technology Hand book, 2nd edition, Marcel Dekker, New York, 1993
2. Sanjay Palsule, Aerospace Polymers and composites, Fundamentals and Aerospace Applications, John Wiley & Sons, NY, 1995.
- 3.G.F.Dalelio, J.A.Parker (Eds), Ablative Plastics, Marcel Dekker, 1971.

PT-2.5 Biopolymers (3hrs/ week) (Credits 3)

Chemistry And Biochemistry Of Polymer Degradation : Introduction, enzymes – enzyme nomenclature – enzyme specificity – physical factors affecting the activity of enzymes – enzyme mechanism, Chemical degradation initiates biodegradation, Hydrolysis of synthetic biodegradable polymers.

Particulate Starch Based Products - Development of Technology, Current objectives, relative starch technology, Manufacture of master batch, Conversion technology – processing precautions – moisture and temperature – rheological considerations, cyclic conversion process, physical properties of products – sample preparation – physical testing methods – test results, Quality control testing of degradation – auto oxidation measurement – biodegradation assessment – soil burial test.

Biopolyesters: Introduction, History, biosynthesis, Isolation – solvent extraction - sodium hypo chloride digestion, enzymatic digestion, Properties – crystal structure – nascent morphology, degradation - Intracellular biodegradation - extra cellular biodegradation – thermal degradation – hydrolytic degradation – environmental degradation – effects of recycling, applications, economics, future prospects.

Test Methods & Standards For Biodegradable Plastics Introduction, defining biodegradability, criteria used in the evaluation of biodegradable polymers, tiered systems for evaluating biodegradability, choice of environment, choosing the most appropriate methodology, description of current test methods – screening test for ready biodegradability, tests for inherent biodegradability, tests for simulation studies, other methods for assessing biodegradability – petri dish screen – environmental chamber method – soil burial tests, Test method developments for the future.

TEXTBOOKS

1. G.J.L Griffin Blackie(ed.), Chemistry & Technology of biodegradable polymers Academic & Professional London 1994.
2. Yoshiharu Doi , Kazuhiko Fukuda(ed.) Biodegradable plastics & Polymers Elsevier 1994

REFERENCES

- 1.Abraham J.Donb & others(ed.) Handbook of Biodegradable polymers
- 2.Harvard academic publishers Australia 1997.

PT-2.6 Chemistry & Technology of Powder Coatings. (3hrs/ week) (Credits 3)

Thermoplastic Binders – Formulation & coating properties.

Thermosetting Binders – Epoxy-DICY/ Phenolic Resins, Hybrid Polyester, Polyester-TGIC, PU Polyester, Acrylics, Newer Crosslinking Systems, Curing Mechanism, correlation amongst M_N , M_w , functionality, Tg, melt flow viscosity, resin /crosslinker ratio, catalyst level, PVC, etc. in relation to powder stability and film properties, UV curable powder coatings for wooden surfaces.

Manufacture of Powder Coating: Premixer, Design, Construction & operation of twin & single screw extruders; Fine Grinding & particle size classification.

Application Methods: Design and operation of Carona & Tribo charging guns, Fluidised bed process, Newer Developments in Application techniques.

Recovery & Recycling of Powder Waste.

TEXTBOOKS

1. **'Powder coatings : chemistry and technology'**, Misev, T. V., Third Edition, John Wiley & Sons, New York, 1991.
2. **'Powder Coating Systems'**, William D. Lehr, McGraw-Hill, New York 1991.
3. **'Surface Coatings'**, Vol. I & II, Oil and Colour Chemists' Association, Tafe Educational Books, NSW, Australia, 1987.
4. **'Coating Technology Handbook'**, Edited by D. Satas and A. A. Tracton, Second Edition, Marcel Dekker, Inc., New York, 2001

References: 1. Related US/European/ Japanese/ Indian Patents.

2. Review/ Research Papers in *J. Coat. Technol., Macromolecules, Prog. Org. Coat., J. Oil Colour Chem.*

Assoc., Paint Coat. Ind., Polym. Mater. Sci. Engg., J. Appl. Polym. Sci., JCT Res., Surf. Coat. Int., Pigments and Resins, JCT Coat. Tech., Org. Coat. Sci. Technol., etc.

3. Invited Talk/ Research Paper Presentations at International Conferences such as Proc. Waterborne High Solids Powder Coat. Symp., Proc. Int. Conf. Org. Coat. etc.

4. Websites such as [http:// www.specialchem4coatings.com](http://www.specialchem4coatings.com), websites of Paint Industries (e.g. [http:// automotive.dupont.com](http://automotive.dupont.com)), www.census.gov (for Industrial Reports on Coatings), www.epa.gov etc.

PT-2.7 Theory of Corrosion and Marine and Maintenance Coatings (3hrs/ week) (Credits 3)

I. Corrosion Mechanism for various types of corrosion, Methods of corrosion prevention & control, Adhesion for corrosion protection; factors affecting oxygen and water permeability, Polymers & pigments used in corrosion prevention, Corrosion inhibitors, Testing & Specifications.

II. Marine Paints: Types of Sea, Corrosion phenomenon in marine environment, Coatings for Ship Bottom, boot topping, topside, and Superstructure, Tanks Ballast

Antifouling Agents/biocides, Self-polishing paints, Mechanism of antifouling based on prevention of adhesion of fouling organisms. Formulation and performance.

Marine Coatings for Gas/Crude Oil Exploration Plants

III. Maintenance Paints: Barrier, and Galvanic Mechanism of Corrosion Resisting paints, Anticorrosive Pigments. Maintenance Paints for highway bridges, refineries, power plants, tanks, farms, pipe lines etc.; Coil Coatings; Coatings for Aircrafts-Formulation and performance.

TEXTBOOKS

1. **'Organic coatings : science and technology'**, Edited by Zeno W. Wicks, Jr., Frank N. Jones, S. Peter Pappas; Douglas A. Wicks, Third Edition, John Wiley & Sons, Inc., Hoboken, New Jersey. 2007.
2. Kearne, J. D., Ed., **Steel Structures Painting Manual**, Vol. I, **Good Painting Practices**, 3rd ed., 1993; Vol. II, **Systems and Specifications**, 7th ed., Steel Structures Painting Council, Pittsburgh, PA, 1995. Hare, C. H., **Protective Coatings**, Steel Structures Painting Council, Pittsburgh, PA, 1995.
3. Martin, J. W.; et al., **Methodologies for Predicting Service Lives of Coating Systems**, Federation of Societies for Coatings Technology, Blue Bell, PA, 1996.
4. **'Surface Coatings'**, Vol. I & II, Oil and Colour Chemists' Association, Tafe Educational Books, NSW, Australia, 1987.
5. **'Coating Technology Handbook'**, Edited by D. Satas and A. A. Tracton, Second Edition, Marcel Dekker, Inc., New York, 2001

References: 1. Related US/European/ Japanese/ Indian Patents.

2. Review/ Research Papers in *J. Coat. Technol., Macromolecules, Prog. Org. Coat., J. Oil Colour Chem.*

Assoc., Paint Coat. Ind., Polym. Mater. Sci. Engg., J. Appl. Polym. Sci., JCT Res., Surf. Coat. Int., Pigments and Resins, JCT Coat. Tech., Org. Coat. Sci. Technol., etc.

3. Invited Talk/ Research Paper Presentations at International Conferences such as Proc. Waterborne High Solids Powder Coat. Symp., Proc. Int. Conf. Org. Coat. etc.

4. Websites such as [http:// www.specialchem4coatings.com](http://www.specialchem4coatings.com), websites of Paint Industries (e.g. [http:// automotive.dupont.com](http://automotive.dupont.com)), www.census.gov (for Industrial Reports on Coatings), www.epa.gov etc.

PT-2.8 Radiation Curing Coatings. (3hrs/ week) (Credits 3)

Fundamentals of Photopolymerisation-UV and Electron Beam Technique
Free Radical, and Cationic Photoinitiators: Structure and Characterisation
Mono and Multi functional Monomers – Characteristics, Synthesis, Hazard Analysis
Radiation Curing Oligomers and Polymers- Polyester/ Polyurethane/ Epoxy/ Polyether Acrylics, Thiol-Ene system, Epoxy Resin for Cationic Cure- Characteristics, Synthesis, Hazard Analysis
Inhibitory Effects in reference to radiation curing and remedial measures,
Formulation Principles for Radiation Curing solvent less/ high solids/ waterborne/ powder coatings, and Printing Inks
Design of UV Lamp, Application Plant Setup for UV and Electron Beam Cure, Dual Cure, Experimental Techniques to monitor degree of Cure, Health and Safety Aspects
Utilisations of Radiation Curing Paints in Electronics & Telecommunication Ind., overprint varnishes for magazines and cartoons, coating systems for kitchen cabinets/ credit cards/ compact discs, etc.

TEXTBOOKS

1. **‘Chemistry and Technology of formulating UV Cure Coatings, Inks, and Paints’**, Edited by PKT Oldring, Vol.1-5, Sita Technology Limited, London UK 1991-94.
2. **‘Photoinitiated Polymerization’**, Belfield, K. D.; Crivello, J. V., Eds., ACS Symp. Ser. 847, American Chemical Society, Washington, DC, 2003.
3. Koleske, J. V., ‘Radiation Curing of Coatings’, ASTM International, West Conshohocken, PA, 2002.
4. Scranton, A. B.; et al., Eds., Photopolymerization Fundamentals and Applications, ACS Symp. Ser. 673, American Chemical Society, Washington, DC, 1997.
5. **‘Radiation Curing of Polymers’**, Edited by D. R. Randell, Ser. 89, The Royal Society of Chemistry, Cambridge 1991.

References: 1. Related US/European/ Japanese/ Indian Patents.

2. Review/ Research Papers in *J. Coat. Technol.*, *Macromolecules*, *Prog. Org. Coat.*, *J. Oil Colour Chem. Assoc.*, *Paint Coat. Ind.*, *Polym. Mater. Sci. Engg.*, *J. Appl. Polym. Sci.*, *JCT Res.*, *Surf. Coat. Int.*, *Pigments and Resins*, *JCT Coat. Tech.*, *Org. Coat. Sci. Technol.*, etc.
3. Invited Talk/ Research Paper Presentations at International Conferences such as Proc. Waterborne High Solids Powder Coat. Symp., Proc. Int. Conf. Org. Coat. etc.
4. Websites such as [http:// www.specialchem4coatings.com](http://www.specialchem4coatings.com), websites of Paint Industries (e.g. [http:// automotive.dupont.com](http://automotive.dupont.com)), www.census.gov (for Industrial Reports on Coatings), www.epa.gov etc.

Third Semester

PT-3.1 Seminar Presentation on selected topics in with due emphasis on latest developments.
(5 Credits) (10 Hrs/week)

PT 3.2 Project : finalization of particular research problem, thorough literature review, preliminary experimental work, Presentation of Project report and viva - voce based on project work.
(10 Credits) (20 Hrs/week)

Fourth Semester

PT 4.1 Project : (15 Credits) (30 Hrs/week)

The entire semester will be devoted for detail experimental work on a research problem selected in III semester. The student will present his/her findings in the form of neatly typed and bound thesis within one month after approval of his synopsis. He/ She will have to appear before panel of experts for defending his Thesis.

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