Third Year Paints Technology (PT) Syllabus
(Effective from 2016-17)

B. Tech. (Paint Technology) III Year Course Structure w.e.f. 2016-17 (Overall Structure and Revised Syllabus w.e.f. 2016-17)							
Course Code	**Title of Course**	**Teaching Hours**	**Tutorial**	**Credits**	**Practical Hours**	**Credits**	**Total Credits**
Fifth Sem.							
CHL 308	**Mass Transfer Operations**	**04**		**04**			**4**
CHP 309	**Mass & Momentum Transfer Operations**				**03**	**1.5**	**1.5**
CHC-310	**Instrumentation and Process Control**	**04**		**04**	**03**	**1.5**	**5.5**
PTC-301	**Trade Sales Paints**	**04**		**04**	**03**	**1.5**	**5.5**
PTL 302	**Chemistry & Technology of Polymers-II**	**04**		**04**	**-**	**-**	**04**
PTP-303	**Synthesis of High Performance Polymers**	**-**		**-**	**05**	**2.5**	**2.5**
ELECTIVE	**Elective-I**	**04**		**04**	**-**	**-**	**4**
Total		**20**		**20**	**14**	**7.0**	**27**
Sixth Sem							
CHL-311	**Reaction Engineering**	**04**		**04**	**-**	**-**	**04**
HML-301	**Industrial Management & Economics**	**03**		**03**	**-**	**-**	**03**
HML-302	**Managerial Behaviour: Psycho-social Dimensions**	**03**		**03**	**-**	**-**	**03**
PTL-304	**Ecofriendly Coating Technologies**	**04**		**04**	**-**	**-**	**04**
PTL-305	**Engineering of Pigmented Dispersion**	**04**		**04**	**-**	**-**	**04**
PTP-306	**Formulation & Processing of Paints**	**-**		**-**	**06**	**03**	**03**
ELECTIVE	**Elective - II**	**04**		**04**	**-**	**-**	**04**
Total		**22**		**22**	**06**	**3.0**	**25**

Third Year Paints Technology (PT) Syllabus
(Effective from 2016-17)

Department	**: Department of Paint Technology**
Course code	**: CHL-308**
Course Title	**: Mass Transfer Operations. (TH)**
Course Type	**: Theory**
Total Hrs	**: 04**
Course credit	**: 04**

Course Objectives:

At the end of the course student will understand the basic fundamental of mass transfer operations carried out in chemical industries, design of plate and packed column used for mass transfer operations, Distillation, Liquid-liquid extraction, Solid-liquid operation, Crystallization and Adsorption drying operation.

Course Content:

Unit-I **(10 hrs)**

Diffusion

Principles of diffusion, Fick's law, diffusion in binary mixture, equimolecular counter diffusion, mass transfer through stationary gas, mass transfer velocities, gas phase mass transfer cases, thermal diffusion, Maxwell law, diffusion in solids, Diffusion in liquids: Mass transfer across phase boundary, penetration theory, two film theory, surface renewal theories, film-penetration theory of mass transfer, mass transfer coefficients & correlation,

Unit-II **(10 hrs)**

Distillation

Distillation methods, Vapour liquid equilibria, ideal and non-ideal systems, relative volatility, partial vaporisation/condensation, calculation of number of theoretical plates by McCabe Thiele method. Importance of reflux ratio, minimum reflux ratio, optimum reflux ratio. Murphree plate efficiency and overall plate efficiency. Effect of feed condition of 'q' line.

Unit-III **(10 hrs)**

Absorption

Mechanism of absorption, choice of solvent for absorption, rate of absorption & material balance over absorption tower, minimum gas-liquid ratio for absorber, The absorption with & without chemical reaction,

Packed towers: General construction & working, types of packing merits & demerits, operational difficulties, pressure drop & limiting gas-liquid flow rates, Determination of height of columns, transfer units, capacity.

Plate towers: General construction & working, types of plates merits & demerits, operational difficulties

Unit-IV **(10 hrs)**

Extraction

Liquid-Liquid Extraction: Principle, selection of solvent for extraction, estimation of mass transfer coefficients, triangular diagram representation, Equipment for liquid-liquid extraction. (Mixer settler, Rotating Disc Contractor, Packed column, spray column). Single stage extraction calculation.

Adsorption: Fundamentals, adsorbent, adsorption equilibria and isotherms.

Unit-V **(10 hrs)**

Drying:

Drying characteristics of material, theory and mechanism of drying, Performance of batch and continuous dryer, time of drying.

Crystallization

Crystallization:- Principle, Super saturation, methods of achieving super saturation, phenomenon of crystal formation, crystal structure, material & heat balance over crystalliser & related problems

References:

1. Treybal R.E. “Mass Transfer Operations” McGraw Hill Book Co., New York 1980
2. McCabe W.L. and Smith J.C. & Harriot, “Unit Operations of Chemical Engineering”, McGraw Hill Book Co., New York 1980
3. Principles of Unit Operations: Foust A.S.

4. Coulson J.M. and Richardson J.F., “Chemical Engineering Vol. I, II & III”, Pergamon Press, New York 1977
5. Unit Operation: Mc Cetta Vol. I
6. Badger W.L. and Banchero J.T., “Introduction to Chemical Engineering”, Tata McGraw Hill Book Co.
7. Chattopadyay P., “Unit Operations of Chemical Engineering”, Vol. 1 & 2, Khanna Publishers, New Delhi.

Course Outcomes:

1. Students will learn about the fundamentals of diffusional mass transfer in solids and fluids.
2. Student will understand the application of mass transfer theories in various unit operations.
3. Student will understand the mechanism and operation of absorption/stripping column.
4. Student will understand the design of binary plate and packed distillation column.
5. Student will understand the design of liquid-liquid and solid-liquid extraction column.
6. Student will understand the design crystallization and adsorption column.

Department	**: Department of Paint Technology**
Course code	**: CHP-309**
Course Title	**: Mass and Momentum Transfer Operations. (PR)**
Course Type	**: Practical**
Total Hrs	**: 03**
Course credit	**:1.5**

Experiments: (Minimum 10 experiments)

1. Determination of vapour diffusivity
2. Study of Liquid –liquid diffusion through porous pot.
3. Batch/Tray drying.
4. Wetted wall column.
5. To verify Rayleigh's equation,
6. To study boiling point diagram/ vapour-liquid equilibria.
7. To study distribution coefficient in liquid-liquid. Extraction.
8. To Construct bimodal curve for ternary system.
9. Laboratory Batch Crystallisation,
10. To Study Burnoullistheorem
11. To calculate coefficient of discharge of Venturimeter, orifice meter.
12. To study the type of flow using Reynold's experiment.
13. To calculate various losses through pipe fittings
14. To calculate coefficient of discharge through triangular/trapezoidal/rectangular notches.

Department	**: Department of Paint Technology**
Course code	**: CHC-310**
Course Title	**: Instrumentation and Process Control. (TH)**
Course Type	**: Theory**
Total Hrs	**: 04**
Course credit	**: 04**

Course Objectives:

To study the different Instruments like temperature , pressure, level and flow measuring instruments and their working and applications. The utilization of chemical process control and dynamics in automatic , advanced chemical process and study of response of various forcing functions for first, second and higher order control system and study of various types of control mechanism for optimize control of chemical process and their stability

Course Content:

Unit - I **(10 hrs)**

Measuring instruments:

Elements of measuring instruments, Static and dynamic characteristics of measuring instruments

Temperature measurement: Temperature scales, Thermocouples, bimetallic thermometer, resistance thermometer, vapour pressure thermometer, mercury in glass thermometer, constant volume gas thermometer, radiation and optical pyrometers.

Pressure measurement: Manometers, Elastic pressure transducers: Bourdon tube, diaphragm, and bellows; Electrical pressure transducer.

Unit -II **(10 hrs)**

Level measurement: Direct and indirect methods, float type, bubbler systems, air purgemethod.

Laplace transform: Inversion by Partial Fractions, first order control system, Mercury thermometer, development of transfer function and response, forcing functions- step, impulse, ramp, sinusoidal and their responses.

Unit -III **(10 hrs)**

Physical examples of first order systems – Liquid level and mixing process, Interacting and non interacting systems and their transient response and numericals based on theory.

Unit -IV **(10 hrs)**

Second order control systems- transfer function of damped vibrator and U-tube manometer and development of step response equations for underdamped overdamped and critical damped system,

Unit -V ` **(10 hrs)**

Linear closed loop system, simple control system negative feedback vs. positive feedback, Servo problems, regulator problem, development of Block diagrams representing transfer functions.

Pneumatic and electronic controllers and final control elements, choice of controllers, On off, Proportional, PI, PID & PD.

Reference Books

1. Process Systems Analysis and Control: Donald R. Coughanowr
2. Industrial Instrumentation: Eckman
3. Process Control and Instrumentation: R.P. Vyas

Course Outcomes:

1. Students will able to know the construction, working, application and advantages and disadvantages of temperature, pressure, level and flow measuring instruments.
2. From the course the students will able to know the complete dynamics of the chemical process and understand the different kinds of forcing function and responses.
3. The student will understand the method for obtaining the transfer function, response equation and physical behavior of first, second and higher order control system.
4. Students understand feedback control system and various types of control actions like ON OFF, P, PI, PD, PID and their applications and usefulness in the different chemical process and Industries.

Department : Department of Paint Technology
Course code : CHC-310
Course Title : Instrumentation and Process Control. (PR)
Course Type : Practical
Total Hrs : 03
Course credit : 1.5

Course Objectives:

To study the basic controls systems through the experiments of first order and second order control systems. How the systems responds to change in inputs.

Experiments:

1. To study the Dynamic study of mercury thermometer and determine time constant

2. To study step response in Single tank liquid level system

3. To Study the liquid level two tank Non-interacting systems

4. To Study the liquid level two tank Interacting systems

5. To Study the control system of mixing Process and to determine time constant

6. To study linear and equal control valve characteristics

7. To study the dynamic response of second order system (U-Tube manometer etc.)

8. To study response of mercury thermometer and bimetallic thermometer

9. To determine the time constant and damping coefficient of second order system (U-Tube manometer etc.)

10. To study impulse response in Single tank liquid level system

Course Outcome:

Students come to know by performing various practical, how the basic control systems and instruments are applicable in chemical process industries.

Department	**: Department of Paint Technology**
Course code	**: PTC-301**
Course Title	**: Trades Sales Paints (Th)**
Course Type	**: Theory**
Total Hrs/week	**: 04**
Course credit	**: 04**

Course Prerequisite: PTC-201, PTC-202

Course Objectives:

a. The Paint Technocrat will have in depth exposure to Architectural Coatings.

b. The student will learn the constitution of Decorative paint and the basic role of paint ingredients.

c. The Technocrat will have in-depth exposure to manufacture, characterisations and applications of Trades Sales Paints.

Course Content:

Unit- I: Formulation Mathematics & steps **(10 hrs)**

Cumulative specific gravity, drier additions, percentage volume solids; spreading rate and film-thickness; PVC & pigment binder ratio calculations, concept of CPVC & its determination, CPVC for latex paints, effect of CPVC on various properties of coatings.

Formulation steps: Pre-requisites; Basic planning & initial decisions, Daniel flow point, perspectives of coating designs, Fault diagnosis & formula adjustment.

Unit- II: Substrate- Coating Relations **(10 hrs)**

Different types of substrates for decorative coating applications (glass, wood/plywood/ particle board/ chipboard/hardboard, metal, plastics, cement/Masonry etc.): Nature and morphology characteristics of surfaces, substrate – coating interactions, coating adhesion, specifications for preparation of surfaces

Requirement & salient characteristics of putty, sealer, stoppers/ fillers, primers, undercoats & topcoats,

Unit-III: Solvent borne architectural coatings **(10 hrs)**

Selection of binders, solvents, additives and pigmentation for formulation of solvent thinnable flat, semigloss and gloss coatings for for different surfaces in buildings: putty, sealer, stoppers/

fillers, primers, undercoats & finishing coats/ enamels for steel work, masonry, timber & non ferrous metal substrates (exterior & interior), oil bound distemper Calculations related to Paint Formulary, tint bases and tinters, stainners

Unit– IV: Latex based decorative paints **(10 hrs)**

Comparison of latex paints vs oil-based paints

Manufacture of latexes: emulsion polymerization, Mechanism of micelle formation, plant setup, Formulation and characteristics of acrylic, vinyl, styrene–acrylic, and styrene–butadiene latexes, changes in latex properties with order of addition of monomers, latex nanocomposites, stability of emulsions, minimum film formation temperature

Formulation of Latex paints for exterior and interior decorative paints for different surfaces in buildings: Sealers, Primers, Stoppers/ Fillers, Undercoats and latex gloss enamels, distempers, texture coatings, Calculations related to Paint Formulary

Unit - V: **(10 hrs)**

Colour Matching: colour perception, metamerism, spectral colour match, mathematics of colour matching, Munsell and Ostwald Colour Atlas, CIE chromaticity and Lab diagram, instrumentations for colour measurement, colour cards, procedure for shade matching at plant and paint shop, shade sensing and decision in relation to interior decoration. Special Effect Paints Order of applications and preparation of surfaces, Brushes, pads, and hand rollers as application devices, Brief idea of spray painting, Control of Levelling and Sagging, General idea of paint Defects; Weather resistance of Exterior Decorative Coatings, DIY Market, Coating Calculations and Costing for Paint Contractor

Course Outcome: On completion of this course, the Technocrat will display the

a. awareness of Coating Formulation Mathematics & steps .

b. understanding of formulations of Solvent borne/ Water borne architectural coatings in relation to their functions/end uses

c. understanding of role and selection of polymers, pigments, solvents and additives in formulations of Solvent borne/ Water borne architectural coatings

d. understanding of DIY Market, Coating Calculations and Costing for Paint Contractor in reference to end use.

Department	**: Department of Paint Technology**
Course code	**: PTC-301**
Course Title	**: Trades Sales Paints (Pr)**
Course Type	**: Practical**
Total Hrs/week: 03	
Course credit	**: 1.5**

Course Prerequisite: PTC-201, PTC-202

Course Objectives: The Technocrat will be exposed to laboratory practices related to:

a) the determination of physical and chemical characteristics of solvents, plasticizers and coating additives.

b)the general characteristics of trade sales paints.

c) Processing and Characterisation of Varnishes and lacquers

Course Content:

Minimum of ten experiments with due coverage of following:

1Analysis of solvents and plasticizers such as - solvent power, distillation range, evaporation rate (Evaporation of Mixed Solvents-Front-end solvent,Middle solvent, Tail-end solvent, Retarder Evaporation of Solvents from Coating Films, Evaporation of Solvents from High-Solids Coatings, Volatile Loss from Waterborne Coatings), flash point, refractive index, moisture content/ hygroscopicity, acidity/ alkalinity etc.

2. Determination of surface tension in reference to use of dispersing agents and other additives; Use of Ford Cup/ Gardner Tubes for estimation of viscosity; Surface and Hard Dry for air drying paints.

Determination of Gloss (specular gloss, sheen, contrast ratio, DOI gloss); Estimation of covering power, wet opacity & dry hiding (chequer board/ contrast ratio/ spectral methods) and coating calculations related to practical painting

3.Processing and Characterisation of Varnishes such as french polish, knotting, synthetic resin varnishes, bitumens varnishes, stoving blacks, aluminium insulating varnishes, preparation of lacquers etc.

Course Outcomes: On completion of this course, the Technocrat will develop laboratory skills and good practices related to

a. determination of analytical and processing parameters of solvents and additives

b. evaluation of solvency and plasticization.

c. the techniques of analysis of general coating characteristics.

d. empirical skills for formulations of Varnishes and lacquers

Department	**: Department of Paint Technology**
Course code	**: PTL-302**
Course Title	**: Chemistry & Technology of Polymers-II (Th)**
Course Type	**: Theory**
Total Hrs/week	**: 04**
Course credit	**: 4**

Course Prerequisite: PTC-201, PTC-202

Course Objectives:

a. The Paint Technocrat will have in depth exposure to High Performance Polymers.

b. The student will learn the structure and properties of PU, Epoxy, Acrylics, polyesters, polyamides, NC and inorganic polymers.

c. The Technocrat will have in-depth exposure to manufacture, characterisations and applications of High Performance Polymers.

Course Content:

Unit - I: Polyurethane resin (10 hrs)

Structures and characteristics of differentIsocyanate, Isocyanurate prepolymers, polyols and catalysts for PU polymers, polyurea, Urethane oils and alkyds, polyols adducts, blocked isocyanates, Curing mechanism for PU resin, safety aspects of handling of isocyanates, applications in surface coating and plastics

Unit -II Epoxy resins (10 hrs)

Use of epichlporhydrin, bisphenol A/F and novolac derivatives, glycidal metacrylate, p-amino phenol in epoxy resins suitable for surface coatings, chemistry of synthesis, Plants and processes for manufacture, Use of hardeners and their selection. One pack and two pack systems, Epoxy ester, applications in surface coating and plastics

Unit -III Thermoplastic and Thermosetting Acrylics (10 hrs)

Structure & properties of Acrylic monomers, Role of initiators, solvents, chain transfer agents, & catalysts study of chemical reactions involved in polymerization, Mechanism of polymerisation (free radical/ anionic /cationic/ thermal / redox etc)

Methods of acrylic and vinyl polymerization: Bulk, solution, Emulsion, suspension, nonaqueous dispersion, Plant and process with due emphasis on heat transfer. properties and applications in surface coating

Unit - IV Polyester and Polyamides (10 hrs)

Polyester resins: Selection of polyols & polybasic acids and polyesterification chemistry, manufacturing process and plant, Properties, crosslinking, formulations and applications of hydroxyl/ carboxyl terminated saturated and unsaturated polyesters, High solids and water reducible polyesters.

Polyamides: Selection of polybasics acids and polyamines, Chemistry and Technology of Manufacture of reactive & non-reactive polyamides, Nylon 6, nylon 66, nylon 610, nylon 11, nylon 12; properties and applications in surface coating and plastics.

Unit -V Cellulose Esters and Inorganic Polymers (10 hrs)

Cellulose Esters**:** Manufacturing of cellulose nitrate with detail plant and process setup, classification and characterization of cellulose nitrate, solvents and plasticizers for cellulose lacquers, Modifying resins for cellulose nitrate, Cellulose acetate and cellulose acetobutyrate, Formulation of lacquers for automotive and furniture coating, Evaluation of lacquers, safety regulations.

Inorganic Polymers:Formulation, Properties and uses of silicone rubbers and resins, water glass coatings, alkyl silicates, Orthosilicates, Reactive Silanes, silicone and silicate modified resin for coatings, moisture cure silicone resin, thermosetting Fluorinated resins, Sol-Gel Coatings

Course Outcomes:

Upon completion of the course the students will learn about:

1. Preparation /manufacturing techniques of different high performance polymers.
2. The structure-property relation of different high performance polymers and poylmerisation/ curing methods .
3. The applications of different high performance polymers in general and their utilizations in Surface Coating Industries in particular.

Department	**: Department of Paint Technology**
Course code	**: PTP-303**
Course Title	**:Synthesis of High Performance Polymers (Pr)**
Course Type	**: Practical**
Total Hrs/week	**: 5**
Course credit	**: 2.5**

Course Prerequisite: PTC-201, PTC-202

Course Objective: The Technocrat will be exposed to laboratory practices related to the synthesis and analysis of acrylic, epoxy, urethane and polyamide resins.

Course Content:

Minimum of twelve experiments with due coverage of following:

1. Preparation of acrylic and vinyl resins by different methods: suspension, emulsion, bulk, solution, nonaqueous dispersion
2. Synthesis of epoxy resin, Preparation of reactive and non-reactive polyamides; Curing of epoxy resins
3. Synthesis of blocked isocyanates, polyol adduct isocyanates, polyurethane(single pack, two pack)
4. Synthesis of cellulose derivatives, epoxy esters, urethane alkyds
5. Analysis of synthetic resins: amine value, epoxide equivalent weight, isocyanate value, determination of degree of polymerisation, curing time and pot life, changes in properties with changes in resin-hardener ratio mechanical properties, viscosity and molecular weight determination etc.
6. Ostwald Viscometry for polymer molecular weight determination

Course Outcomes: On completion of this course, the Technocrat will develop laboratory skills and good practices related to

a. empirical skills for synthesis of acrylic, epoxy, urethane and polyamide resins.

b. the techniques of polymerisations

c. evaluation of curing and degree of polymerisation.

d. analytical skills for characterisation and testing of high performance polymers.

Department	**: Department of Paint Technology**
Course code	**: Elective-I PTL-307**
Course Title	**: Natural Resins, Drying Oils and Solvents (Th)**
Course Type	**: Theory**
Total Hrs/week	**: 04**
Course credit	**: 4**

Course Prerequisite: PTC-201, PTC-202

Course Objective: a. The Paint Technocrat will have in depth exposure to Natural Resins, Drying Oils and Solvents.

b. The student will learn about the sources and utilisation of natural resins and vegetable oils in surface coatings.

c. The Technocrat will have exposure to properties and handling practices related to utilisation of true solvents, reactive diluents and plasticizers in surface coatings.

Course Content:

Unit - I :Natural resins **(10 hrs)**

Occurrence, composition and classification of natural Resins. Sources, properties, modifications and uses of Shellac, Rosin, Copal, Dammer and other natural resins in surface coatings

Unit - II: Oils and Fats in Surface Coatings **(10 hrs)**

Classification of vegetable oils as drying, semidrying, and non drying. Sources, fatty acid Composition, physical and chemical properties and uses of some commonly used drying, semidrying and non drying oils. Refining of drying oils. Chemistry of thermal and oxidative Polymerization of drying oils, Yellowing of oils. Modification of oils (Dehydrated castor oil, Stand Oils, Boiled Oils and Blown Oils. Bodying rate and viscosity relationship). Type and Role of driers, manufacture of driers.

Unit - III: Solvents **(10 hrs)**

Classification of solvents with examples- Weak hydrogen-bonding solvents, hydrogen-bond acceptor solvents, and hydrogen-bond donor–acceptor solvents; true solvents, diluents, and latent solvents; Theory of Solubility parameters (Small, Burrell, 3D Solubility Parameters, Other Solubility Theories), Effect of Solvent on the viscosity of resin solutions, shear viscosity of dilute & concentrated resin solutions; density, surface tension, dipole moment and refractive

Index and other characteristics of solvents; Solvent Evaporation Rates (Boiling range and volatility, Relative Evaporation Rates

Unit - IV: Plasticizers and Reactive Diluents (10 hrs)

Monomeric and polymeric plasticizers, Mechanism of plasticisation, plasticizers for thermoplastic polymers

Mono and Multi functional acrylate monomers – Characteristics(viscosity reduction, Shrinkage Reactivity and performance properties, Surface Tension and HLB of monomers, Weatherability and Colour Stability etc.) Synthesis of UV cure multifunctional acrylate monomers by esterification and transesterification

Non-acrylated reactive diluents- NVP, vinyl ethers, Styrene, N-vinyl-2-caprolactam, vinyl acetate

\Unit - V: Safety, handling and emission characteristics (10 hrs)

Flash point, flammability, toxic hazards, skin and eye irritation potential of solvents and reactive diluents, Draize rating, Storage and handling of solvents, atmospheric photochemical effects of VOC and reactive organic compounds emissions, Determination of VOC, photochemical ozone creation potential, VOC guidelines, Air Pollution Control Act, EPA regulations, National Ambient Air Quality Standard

References:

1.Ash, M.; Ash, I., Handbook of Solvents, 2nd ed., Synapse Information Resources, Endicott, NY, 2003.

2.Ellis, W. H., Solvents, Federation of Societies for Coatings Technology, Blue Bell, PA, 1986.

3.Wypych, G., Ed., Handbook of Solvents, ChemTech, William Andrew, New York, 2001.

Course Outcomes: Upon completion of the course, the students will learn about:

a. knowledge of occurrence, composition, classification and physico-chemical modifications of natural resins and vegetable oils.

b. different characteristics of solvents, reactive diluents and plasticizers in reference to coating formulations

c. Safety, handling and emission characteristics of solvents

Department	**: Department of Paint Technology**
Course code	**: Elective-I PTL-308**
Course Title	**: Specialty Pigments and Additives in Coatings (Th)**
Course Type	**: Theory**
Total Hrs/week	**: 04**
Course credit	**: 4**

Course Prerequisite: PTC-201, PTC-202

Course Objective: a. The Paint Technocrat will have in depth exposure to Specialty Pigments and Additives in Coatings.

b. The student will learn about the metallic and pearl effect and changes in pigmentary properties in reference to nano size.

c. The Technocrat will have exposure to Mechanism, dosing and Trade information of coating additives and surfactants.

Course Content:

Unit -I Metallic, Interference and Cholesteric Pigments **(10 hrs)**

Aluminum, copper, zinc dust, bronze, nickel stainless steel, lead powders and pastes,

Nacreous, luminescent (fluoresecent/phosphorescent) pigments-optical principles, substrate free pearlescent pigments, Special effect pigments based on mica (pigments formed by coating of substrates), pigments based on liquid crystal polymer

Unit -II Functional and Nano pigments **(10 hrs)**

Antifouling pigments-cuprous oxide, other copper compounds, mercuric oxide, barium metaborate, organotin pigments,

Manufacture and properties of nanopigments: alumina, silica, titanium dioxide, iron oxides, zinc oxides, silver, $CaCO_3$, etc. on Nano scale; Bimodally porous nanoparticles (e.g. titanium tetraisopropexide), variables affecting particle size aggregation and crystal structure. Their use as spacing extenders / functional pigments in paints, reinforcing agent in polymers, heat & wear resistant materials, etc.

Unit - III Surfactants **(10 hrs)**

Anionic, cationic, non-ionic and amphoteric surfactants; polymeric surfactants, Gemini surfactants, HLB value, CMC, Kraft point.

Role of surfactants as- emulsifier, wetting agents, dispersing agents.

Unit - IV **(10 hrs)**

Mechanism, dosing and Trade information of coating additives: Antisettling agents, additives for rheology control, flow and levelling control agents, slip additives, adhesion promoters, antiskinning agents, light stabilizers (UV absorbers, antioxidants, HELS), moisture scavengers, hammer and wrinkle finish additives, conductivity control additives etc.

Unit - V **(10 hrs)**

Mechanism, dosing and Trade information of Additives for Water Borne Coating: Auxiliary and coalescing solvents, neutralization agents, thickeners, flow and levelling control agents, antifoam, antifreeze-thaw, Preservatives (In- can/film)-fungicides, mildew agents, corrosion inhibitors etc.

Course Outcomes: Upon completion of the course, the students will learn about:

a. optical effects of Metallic, Interference and Cholesteric Pigments.

b. manufacture and properties of Functional and Nano pigments

c. constructive and corrective role of surfactants and additives in solvent thinable, waterborne and powder coatings.

d. dosing and trade information of Additives in Coatings

Department	**: Department of Paint Technology**
Course code	**: CHL-311**
Course Title	**: Reaction Engineering. (TH)**
Course Type	**: Theory**
Total Hrs	**: 04**
Course credit	**: 04**

Course Objective:

At the end of the course student will understand the basic fundamental of reaction engineering, design and performance of batch, CSTR and plug flow reactor, methods of analysis of reactor data to solve the problem aroused in chemical industry.

Course content:

Unit -I: (10 hrs)

Kinetics: Rate of reaction, types of reactions, Variables affecting the rate of reaction, order and molecularity,Temperature and concentration dependency of rate equation, theories of temperature dependency- Arrhenius theory, Bimolecular theory and Transition state theory, comparison between various theories of temperature dependancy of rate equation.

Unit -II: (10 hrs)

Interpretation of kinetic data in batch and flow systems, integral and differential methods of analysis, kinetics of unimolecular, bimolecular reactions, series, parallel, reversible, autocatalytic reactions, constant volume batch reactor, variable volume batch reactor. Rate equation.

Unit -III: (10 hrs)

Introduction to reactor design. Single ideal reactors: Ideal batch reactor, space time and space velocity, steady state mixed flow reactor, steady state plug flow reactor. Holding time & space time for flow systems.Comparison between mixed and plug flow reactor advantages and limitation in application.

Unit -IV: (10 hrs)

Plug flow reactors in series and or in parallel, equal size mixed reactors in series, mixed flow reactors of different sizes in series. Reactors of different types in series, recycle reactor, autocatalytic reactions.Principles of reactor stability and optimization. Residence time distribution: Residence time function and relation amongst their application to ideal reactors.

Unit -V: **(10 hrs)**

Catalysis:

Concept of catalyst selection, classification and characteristics of catalyst, preparation of a catalyst and its deactivation, poisoning of catalyst and regeneration. Different types of isotherms, determination of catalyst surface area By BET method.

Solid-catalyzed reaction:

Rate equations, diffusion within porous catalyst, experimental methods for finding rates, product distribution in multiple reactions.

Reference Books:

1. Chemical Reaction Engineering,Wiley Eastern : O. Levenspiel
2. Chemical Reaction Engineering. : Fogler
3. Chemical Reaction Engineering. : S. D. Dawande
4. Chemical Reaction Kinetics. : J.M. Smith

Course Outcome:

1. To enhance the ability of students to understand the classification of reactions, effects of various parameters on rate of reactions with different reaction rate theories.
2. To get the students well acquainted with collection and analysis of rate data using integral, differential, half-life method of analysis of rate data. To understand the kinetics of fast reactions.
3. To enhance the knowledge of students about ideal reactors, autocatalytic reactor, various parameters affecting the reactor performance, combine reaction system and comparison of various reactors.
4. The get the students well acquainted with thermal characteristics of reactors, residence time distribution, catalysis and modeling of real systems.
5. To enhance the ability of students to identify and solve various engineering problems during product optimization.

Department	**: Department of Paint Technology**
Course code	**: HML-301**
Course Title	**: Industrial Management And Economics (Th)**
Course Type	**: Theory**
Total Hrs	**: 03**
Course credit	**: 03**

Course Objective

Upon successful completion of this course the student will be able to:

1. Identification and selection of management & administration with aspect towards the Production planning and management Quality control and maintenance. Processes/operations according to job requirement in various departments.
2. Identification, selection and understanding of financial management capital structure. Sources of Industrial finance including institutional feature inside the organisation as well as outside the organisation.
3. Understanding Cost Analysis Cost statement and sheet Cost control and various type of approach of the Industrial relation Quality management techniques Entrepreneurship Development Management information
4. Identification, understanding Micro and Macro economics Demand and Supply factors of market economy Functions of money w.r.t. organisation.

Course Content:

Unit -I

Introduction meaning management & administration Functions of Management Planning and Organising staffing c monitoring and leading co-ordinating & communication tool Functional of management Production Material Finance personnel Marketing Management concept of productivity wages .Production planning and management Quality control and maintenance.

Unit -II

Types of management Different approaches of management Functional areas of management Forms of business organisation production management work study productivity measurement material management Inventory analysis Financial Management capital structure Sources of Industrial finance including institutional feature.

Unit -III

Marketing management consumer satisfaction sales and advertising Marketing Research personnel management Industrial relation Quality management techniques Entrepreneurship Development Management information system Information technology In Management Cost Analysis Cost statement and sheet Cost control , Cost projection.

Unit -IV

Nature and significance of Economics Basic problem in Economics Introduction of Micro and Macro economics Demand and Supply factors of market economy Functions of money Banking types and Functions

Unit -V

Indian Economy Liberalisation privatisation and Globalisation Mixed Economy Public Sector Reforms National income determinants Economic planning nature and Entrepreneurship small scale Industries and SSI.

References:

1. Modern **Economics** by H.L.Ahuja.
2. Modern **economics** theory by K.K.Dewett.
3. Monitory **economics** by M.L.Seth.
4. **Industrial Management** by I.K. Chopde, A.M. Sheikh.
5. Business Organisation and **Management**by S.A. Sherlekar.
6. Marketing Management by Philip Kotler.

Course Outcomes:

Upon successful completion of this course the student will be able to:

1. Identification and selection of management & production management work study productivity with aspect towards the material management &Inventory analysis Production planning Quality

control and maintenance. Processes/operations according to job requirement in various departments in organisation.

2. Identification, selection and understanding the meaning and utility of Marketing management, consumer satisfaction, sales and advertising Marketing Research personnel management features of the organisation.
3. Understand the importance of Cost Analysis Cost statement and sheet Cost control and various type of approach of the Industrial relation Quality management techniques Entrepreneurship Development Management information system
4. Identification, understanding Micro and Macro economics Demand and Supply factors of market economy National income determinants Economic planning nature and Entrepreneurship Functions of money w.r.t. organisation
5. Identification, selection and understanding according to requirement in Different organisation Financial Management, capital structure Sources of Industrial finance including institutional feature. Understanding of the working principle of Entrepreneurship Development and S.S.I.

Department	**: Department of Paint Technology**
Course code	**: HML-302**
Course Title	**: Managerial Behaviour and Psychosocial Dimension (TH)**
Course Type	**: Theory**
Total Hrs	**: 03**
Course credit	**: 03**

Course Objectives:

This subject aims at developing students with the required commitment and competencies for working towards the objectives within an organizational framework in order to improve both individual and organizational performance.

Course content:

Unit-I

Psychosocial dimension of work in organisation Introduction and background

Unit-II

Approaches in Organisational analysis Organisational behaviour approach

Unit- III

Early practises in Management Theories of Organisation Organisational process and Function The structural variables context. Environment of work organisation Socio-cultural Environment Its impact on Organisation Social dimension of organisational and Behaviour Formal and Informal organisation Group Dynamics and terms

Unit - IV

Motivational Process and Theories Communication Technology and Interpersonnel process Leadership process and style. and T.Q.M.

Unit-V

Decision making behaviour, Decision making techniques creativity.

References:

1. Psychosocial Dimensions for management by T.V.Rao
2. Appraising and Developing Managerial Performance Management and Organisational Behaviour by Laurie J. Mullins

3. Managerial Behaviour and Effectiveness by E Ananda Raja, N R V Prabhu, P Kameshwara Rao.
4. Managerial Behaviour by O.P. Khanna

Course Outcome:

1. It emphasis on understanding of the issues, problems and practice of managing, working and organising across cultures in organisations.
2. It develops the understanding of psychosocial dimensions in people of organization to sustain relationship.
3. It contributes in developing interpersonal behaviours.
4. The subjects helps students to learn organizational whesiveness, pursuing goal and understand behaviour.

Department : Department of Paint Technology
Course code : PTL-304
Course Title : Ecofriendly Coating Technologies (Th)
Course Type : Theory
Total Hrs/week : 04
Course credit : 4

Course Prerequisite: PTC-201, PTC-202

Course Objective: a. The Paint Technocrat will have in depth exposure to diverse Ecofriendly Coating Technologies.

b. The student will learn about the formulation and manufacture of Electrodeposiion, Radiation Cure and Powder Coatings.

c. The Technocrat will have exposure to diverse applications and emerging trends of ecofriendly surface coatings.

Course Content:

Unit I Waterborne coatings for Industrial /OEM applications **(10 hrs)**

Properties of water as solvent, Classification and Characteristics of waterborne coatings, Water soluble polymers- Starch, gums, cellulose ethers (CMC, HEC), PVA, hydrosols; water-reducible coatings based on anionic/cationic water soluble binders (e.g. alkyds, polyesters, polyacrylates, epoxides, and epoxy esters), viscosity anomaly of water-reducible paints; Polymer Dispersions (Emulsion Polymers), PU dispersion, Internally and Externally Emulsified Binders; Hybrid Systems; crosslinking /oven curing of Water-borne coatings, film defects, Industrial Uses and Environmental Aspects

Unit -II Electrodeposition Coatings **(10 hrs)**

Anionic and Cationic: detail characterization and comparison, chemistry of Electrodeposition, effect of different variables on Electrodeposition throw and rupture voltage, Plant set up, Synthesis of resins and crosslinkers for Electrodeposition, self crosslinking systems, autophoretic coatings, typical paint formulations; Discussion of electrodeposition with reference to automotive primer formulations and other applications; Recent developments in Electrodeposition

Unit - III: Radiation cure coatings **(10 hrs)**

Fundamentals of Photopolymerisation-UV curing (free radial & Cationic) & electron beam cure coating,

Free Radical, and Cationic Photoinitiators: Structure and Charecterisation

Mono and Multi functional Monomers ; Free radical Curing Oligomers and Polymers; Epoxy Resin for Cationic Cure; Inhibitory Effects in reference to radiation curing and remedial measures;

Formulation Principles and 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.

Unit - IV: High solid coatings and binders for powder coatings **(10 hrs)**

High solid coating, functional group selections, control of molecular weight & molecular weight distribution, High solid alkyd, polyester & acrylics; High solid primers and topcoats; control of sagging

Introduction to powder coating; Binders for thermoplastic (PVC/PVDF/Nylons/Polyolefins) & thermosetting powder coating (Epoxy-DICY/ Phenolic Resins, Hybrid Polyester, Polyester-TGIC, PU Polyester, Acrylics)

Unit -V Formulation and Manufacture of Powder Coatings **(10 hrs)**

Additives for powder coatings, Formulations of powder coatings, Correlation amongst M_N, M_W, functionality, Tg, melt flow viscosity, resin / crosslinker ratio, catalyst level, PVC, control of gloss 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.

Applications of Powder Coatings.

Course Outcomes: Upon completion of the course, the students will learn about:

a. formulation of waterborne coatings for Industrial /OEM applications.

b. chemistry and technology of Electrodeposition coatings

c. structure and properties of radiation cure monomers, prepolymers, and photoinitiators,

d. chemistry and technology of high solid and thermoplastic/ thermosetting powder coatings.

Department : Department of Paint Technology
Course code : PTL-305
Course Title : Engineering of Pigmented Dispersion (Th)
Course Type : Theory
Total Hrs/week : 04
Course credit : 4

Course Prerequisite: PTC-201, PTC-202

Course Objective: a. The Paint Technocrat will have in depth exposure to Engineering of Dispersion of Pigments in Polymeric Binders using different machineries.

b. The student will learn about the mathematical modeling, comparative evaluation & selection of dispersion machineries.

c. The Technocrat will have exposure to outline and layout of paint manufacturing plant.

Course Content:

Unit-I **(10 hrs)**

Immersion & wetting of pigments, penetration and separation of agglomerates, statistical considerations of mechanical deagglomeration, Stabilisation of colloidal pigment dispersion-entropic & charged double layer mechanism of stabilization, variables affecting stabilization, stabilization of dispersion of high solid coatings, dispersion of nanopigments, adhesion & cohesion phenomenon associated with dispersion; initial dispersion, millbase & letdown compositions; flow point curves, instrumental analysis of fineness of dispersion

Unit-II **(10 hrs)**

High speed mixers: underlying fluid mechanics, millbase rheology, tank & impeller dimensions, different impeller geometries & orientations, power input, preparation of latex & TiO_2 dispersions

Heavy duty & miscellaneous mills: sigma kneaders, pug mixers, change can, planetary, cavitation mixers, edge runners, colloid mills, stone mills, bridge-banbury mixers etc.

Unit-III **(10 hrs)**

Ball & pebble mills: Cascading principle, size, speed & design of ball mill; size, shape & composition of balls; millbase composition, power consumption, batch & continuous operation.

Roll mills: single, Double, Triple& multiple roll mills, flow of millbase through rolls, material balance, millbase composition, roll design, power inputs, sophistication in temperature, pressure & safety controls, waste minimisation

Unit-IV **(10 hrs)**

Attritor: mechanism of attrition, batch && continuous operation, design aspects, comparison with ball mill.

Microbead mill: vertical open, vertical closed & horizontal mills, mechanism of bead milling; effect of retention time/ flow rate, grinding media size, shape & composition, pigment size and size didstribution, nature of premix processing, millbase composition on fineness and stability of microbead dispersion; design of discs & seals in different variants-dyano mill, centri mill, pearl mill etc., sophistication in temperature, pressure, discharge & safety controls, power consumption, cascading of mills; dispersion of nanopigments

Ultrasound dispersion, Cavitation mechanism

Unit- V **(10 hrs)**

Mathematical modeling, comparative evaluation & selection of dispersion machineries.

Thinning, tinting, straining & filling of finished products, design & operation of tinting mahines.

Factory layout: location of site, typical material & energy flow, plant layout

Fire, explosion & health hazards: general industrial hazards, prime causes of fire & explosion, safety considerations in arrangement of underground and above ground primary & secondary solvent storage tanks, design of piping, pumps & vessels from safety point of view, cleaning & disposal considerations, safety norms & regulations.

Course Outcomes: Upon completion of the course, the students will learn about:

a. theory of stabilisation of colloidal pigment dispersion.

b. high shear rate and shear stress machineries

c. ball and roller mills

d. attritor and bead mill

e. Fire, explosion & health hazards in paint plant

Department	**: Department of Paint Technology**
Course code	**: PTP-306**
Course Title	**: Formulation & Processing of Paints (Pr)**
Course Type	**: Practical**
Total Hrs/week	**: 6**
Course credit	**: 3**

Course Prerequisite: PTC-201, PTC-202

Course Objective: The Technocrat will be exposed to laboratory practices related to the formulations of decorative coatings and use of dispersion machineries in their processing.

Course Content:

Minimum of twelve experiments with due coverage of following:

Formulations, calculations of millbase compositions and processing of architectural coatings (covered under PTL303) on different paint dispersion machineries(covered under PTL305): sealers, putties, distempers, emulsion paints, solvent borne primers/ undercoats/ topcoats.

Course Outcomes: On completion of this course, the Technocrat will develop laboratory skills and good practices related to

a. empirical skills for calculations of millbase compositions of architectural coatings.

b. processing of sealers, putties, primers, undercoats and topcoats

c. use of ball mills, pug mill, triple roll mill, bead mill etc as paint processing and dispersion machineries.

Department : Department of Paint Technology
Course code : Elective-II PTL-309
Course Title : Newer Techniques of Synthesis of Polymers
Course Type : Theory
Total Hrs/week : 04
Course credit : 4

Course Prerequisite: PTC-201, PTC-202

Course Objective: a. The Paint Technocrat will have in depth exposure to Mechanisms and Applications of recent Techniques of Synthesis of Polymers.

b. The student will learn about the Kinetic Aspects of polymerisation.

c. The Technocrat will have exposure to Polymer reaction engineering.

Course Content:

Unit-I: Mechanism, and Applications of following Synthesis Techniques **(10 hrs)**

i] Anionic polymerization, ii] Cationic polymerization

iii] Ring – opening polymerization, iv] Dendrimers

Unit -II: Mechanism and Applications of following Synthesis Techniques **(10 hrs)**

i] Metathesis polymerization, ii] Group transfer polymerization

iii] Reaction Injection Molding, iv] ATRP

Unit - III: Kinetic Aspects of polymerisation **(10 hrs)**

Smith- Ewart's theory and Stock Mayer's equation; Anionic and Cationic poly addition; Co-polymerization; Mayo's equation and reactivity ratio; Alfred- Price equation; Rate of co polymerization; Skiest's equation.

Polycondensation reactions; Flory's equation and molecular weight distribution; Molecular weight regulations.

Unit - IV: Polymer reaction engineering **(10 hrs)**

Semi-batch reactor operation, design of batch and continuous reactors, Heat removal from polymerization reaction, polymerisation plant; molecular weight distribution in batch and continuous reactors.

Unit- V: Curing and Mechanism of film formation **(10 hrs)**

Functionality concept, Resin-Hardner curing, Thermal curing, Oxidative polymerization, radiation curing

Less commonly used cross linking agents: 2-hydroxyl alkyl amides, acetoacetate, acylamido glycolates, Polyaziridine, Polycarbodiimide etc.

Film formation by solvent evaporation from solutions of thermoplastic binders, film formation from solutions of thermosetting resins, film formation by coalescence of polymer particles, instrumental monitoring of curing.

Course Outcomes: Upon completion of the course, the students will learn about:

a. Mechanism, and Applications of various Polymerisation Techniques

b. Kinetic Aspects of polymerisation.

c. Curing and Mechanism of film formation

d. Polymer reaction engineering

Department	**: Department of Paint Technology**
Course code	**: Elective-II PTL-310**
Course Title	**: Physicochemical Characterisation of Polymers**
Course Type	**: Theory**
Total Hrs/week	**: 04**
Course credit	**: 4**

Course Prerequisite: PTC-201, PTC-202

Course Objective: a. The Paint Technocrat will have in depth exposure to Physicochemical Characterisation of Polymers.

b. The student will learn about the qualitative and quantitative analysis of polymers.

c. The Technocrat will have exposure to various sophisticated tools used in the analysis of polymers.

Course Content:

Unit- I **(10 hrs)**

Sample Preparation, Solubility and swelling, concept of average molecular weight, determination of number average, weight average, viscosity average and Z-average molecular weights, Molecular wt and molecular wt distribution determination by dilute solution viscometry, GPC/SEC with a RI/ Light scattering detector, Vapor phase osmometry.

Unit- II **(10 hrs)**

Polymer crystallinity, morphology analysis of polymers using XRD; thermal characteristics of crystalline/ amporphous polymer- differential thermal analysis (DTA), differential scanning calorimetry (DSC), thermogravimetric analysis (TGA), Analysis polymer nanocomposite using Atomic Force Microscopy (AFM), scanning electron microscopy (SEM), Transmission electron microscopy (TEM)

Unit- III **(10 hrs)**

Identification of the type of functional groups present in a polymer using IR,Attenuated total reflection (ATR) attachement, qualitative and quantitative analysis with respect to monomer composition and the average configuration of the polymer chain using NMR, assignment of the structure using pyrolysis-gas chromatography, Mass spectrometry (time-of-flight matrix-assisted

laser desorption/ ionization (TOF-MALDI)mass spectroscopy) analysis of polymers, Electrospray mass spectroscopy (ESMS) for biopolymers

Unit -IV **(10 hrs)**

Mechanical-static and dynamic tensile, flexural, compressive, abrasion, endurance, fatigue, hardness, tear, resilience, impact, toughness; Dynamic mechanical thermal analysis (DMTA)

Unit -V **(10 hrs)**

Conductivity-thermal and electrical, dielectric constant, dissipation factor, power factor, electric resistance, surface resistivity, volume resistivity, permeability, swelling, stability and ageing resistance, environmental stress cracking resistance, Flammability

Reference books:

1R. A. Pethrick and J. V. Dawkins, eds., *Modern Techniques for Polymer Characterization*, John Wiley & Sons, Inc., New York, 2003

2. D. Campbell, R. A. Pethrick, and J. R. White, *Polymer Characterization: Physical Techniques*, Stanley Thornes (Publishers) Ltd., Cheltenham, U.K., 2000

Course Outcomes: Upon completion of the course, the students will learn about:

a. various techniques for determination of molecular weights of polymers.

b. detail analysis of mechanical, thermal and electrical properties of polymers.

c. structural analysis of polymers.

d. use of various high end scientific tools in physicochemical characterisation of polymers.

Department : Department of Paint Technology

Course code : Elective-II PTL-311

Course Title : Technology of Printing Inks

Course Type : Theory

Total Hrs/week : 04

Course credit : 4

Course Prerequisite: PTC-201, PTC-202

Course Objective: a. The Paint Technocrat will have in depth exposure to formulation and manufacture of Printing Inks.

b. The student will learn about various techniques of printing processes.

c. The Technocrat will have exposure to different applications of printing inks.

Course Content:

Unit-I **(10 hrs)**

Nature of Printing ink, Visual characteristics of inks, Major printing systems, classification and characteristics of printing inks, mechanism of ink drying, adhesive nature of printing inks, resistance properties of printing inks, physical chemistry of printing inks, rheological properties of inks principles of printing

Unit- II **(10 hrs)**

Description and schematic diagram of printing processes, it's press configuration and applications e.g. Flexographic, lithographic, gravure, letterpress, planographic, screen , Inkjet printing, substrate selection principles of ink formulations, colour matching and process printing.

Unit-III **(10 hrs)**

Manufacture of inks, manufacturing process, mixing equipments such as High speed impeller, butterfly mixer, Rotar and stator high speed mixer and milling equipments such as three roll mill, bead mill etc. handling, storage and manufacture of UV ink, news paper inks, modern production trends and future of inks.

Unit-IV **(10 hrs)**

Inks for various substrates: paper, plastic, fabric, leather, glass and metal. Testing & Evaluation of finished ink and raw materials for ink manufacture. Inks for News paper (rotary and well offset), publication work, posters, labels, and packaging materials, heat set and quick set inks for multicolour printing.

Unit-V **(10 hrs)**

Metal decorating inks, after print varnishes and lacquers, magnetic inks, ceramic inks, inks for printed circuit boards, inkjet printing, laser printing, dot-matrix printing, and other miscellaneous inks. Identification of various ink troubles and remedial measures

Course Outcomes: Upon completion of the course, the students will learn about:

a. Nature, characteristics and classification of printing inks.

b. principles of ink formulations and manufacture of Inks for various substrates

c. press configuration and applications of printing inks

General Textbook

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. Morgans, W.M., 'Outline of Paint Technology', 3rd Edition, CBS Publishers and Distributors, New Delhi, 1996

3 . " Surface Coatings" Volume 1 " Raw material and their usages" Oil and Colour Chemists' Association, TAFE Educational Books, NSW, Australia,1987.

4 . Paul Swaraj, "Surface Coatings – Science and Technology", Wiley Interscience Publishers, John Wiley and Sons, Inc.1986.

5. 'Paints, Coatings and Solvents', Dieter Stoye; Werner Freitag (ed.), 2nd. Edition, Wiley-VCH. Weinheim ; (1998).

Reference Books

1. 'Paint Technology Handbook', Rodger Talbert, CRC Press, Taylor and Francis Group, 2008.

2. Feist, W. C., Finishing Exterior Wood, Federation of Societies for Coatings Technology, Blue Bell, PA, 1996.

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. ‘Automotive Paints and Coatings’Edited by Hans-Joachim Streitberger and Karl-Friedrich Dossel,, Second Edition, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim 2008.

6. McBane, B. N., Automotive Coatings, Federation of Societies for Coatings Technology, Blue Bell, PA, 1987.

7. ‘Surface Coatings’, Vol. I & II, Oil and Colour Chemists’ Association, TAFE Educational Books, NSW, Australia,1987.

8. ‘Polymers for Electrical Insulations’, Edited by Horst Sulzbach, Ser. 314, DIE BIBLIOTHEK DER TECHNIK, Elantas GmbH, 2008.

9. ‘Powder coatings : Chemistry and Technology’, Misev, T. V., Third Edition, John Wiley & Sons, New York, 1991.

10. ‘Powder Coating Systems’, Wiliam D. Lehr, McGraw-Hill, New York 1991.

11. 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.

12. Martin, J. W.; et al., Methodologies for Predicting Service Lives of Coating Systems, Federation of Societies for Coatings Technology, Blue Bell, PA, 1996.

13. ‘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.

14. ‘Photoinitiated Polymerization’, Belfield, K. D.; Crivello, J. V., Eds., ACS Symp. Ser. 847, American Chemical Society, Washington, DC, 2003.

15. Koleske, J. V., ‘Radiation Curing of Coatings’, ASTM International, West Conshohocken, PA, 2002.

16. Scranton, A. B.; et al., Eds., Photopolymerization Fundamentals and Applications, ACS Symp. Ser. 673, American Chemical Society, Washington, DC, 1997.

17. ‘Radiation Curing of Polymers’, Edited by D. R. Randell, Ser. 89, The Royal Society of Chemistry, Cambridge 1991.

18. A Window to Paints & Coatings Technology by Dr. N.R. Kondekar, COLOUR PUBLICATIONS PVT. LTD., Mumbai2010

19. Essentials of Pigments - Application and Selection by Dr. Ashok B. Karnik, COLOUR PUBLICATIONS PVT. LTD., Mumbai

20. Glass, J. E., Ed., Technology for Waterborne Coatings, American Chemical Society, Washington, DC, 1997.

21. Karsa, D. R.; Davies, W. D., Eds., Waterborne Coatings and Additives, Royal Society of Chemistry,Cambridge, 1995.

22. Pruskowski, S. J., Jr., Ed., Waterborne Coatings Technology, Federation of Societies for CoatingsTechnology, Blue Bell, PA, 2005.

23. G. Buxbaum (Ed.) Industrial Inorganic Pigments, Second, Completely Revised Edition1998 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim

24. H. M. Smith (Ed.) High Performance Pigments 2002 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim

25. J. Bieleman (Ed.) Additives for Coatings 2000 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim

26. Willy Herbst, Klaus Hunger, Industrial Organic Pigments- Production, Properties, Applications Third, Completely Revised Edition (With Contributions by Gerhard Wilker, Heinfred Ohleier, and Rainer Winter) 2004 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim.