Syllabus of Third Year

B. Tech. (Paint Technology)

(Overall Structure and Revised Syllabus w. e. f. 2020-2021)

Faculty of Science and Technology

University Institute of Chemical Technology
Kavayitri Bahinabai Chaudhari
North Maharashtra University, Jalgaon

(Academic Year 2020–21)

Third Year B. Tech. (Paint Technology) Revised Syllabus w.e.f. 2020-21							
Fifth Semester							
Course Code	**Title of Course**	**Teaching Hours**	**Tutorial**	**Credits**	**Practical Hours**	**Credits**	**Total Credits**
CHL-314	**Mass Transfer Operations**	**03**	**-**	**03**	**-**	**-**	**03**
CHP-315	**Mass & Momentum Transfer Operations**	**-**	**-**	**-**	**03**	**1.5**	**1.5**
CHL-312	**Process Design & Project Management**	**03**	**-**	**03**	**-**	**-**	**03**
PTC-301	**Architectural Coatings**	**03**	**-**	**03**	**03**	**1.5**	**4.5**
PTC-302	**Chemistry & Technology of Polymers**	**03**	**-**	**03**	**03**	**1.5**	**4.5**
Elective I	**Open Elective**	**03**	**-**	**03**	**-**	**-**	**03**
NC-303	**Essence of Indian Traditional Knowledge**	**-**	**-**	**-**	**-**	**-**	**NC**
Total							**19.5**
Sixth Semester							
Course Code	**Title of Course**	**Teaching Hours**	**Tutorial**	**Credits**	**Practical Hours**	**Credits**	**Total Credits**
CHL-316	**Chemical Reaction Engineering**	**03**	**01**	**04**	**-**	**-**	**04**
HML-309	**Psycho-social Dimensions of Industrial Management**	**03**	**-**	**03**	**-**	**-**	**03**
PTL-303	**Ecofriendly Coating Technologies**	**03**	**-**	**03**	**-**	**-**	**03**
PTP-304	**Formulation and Processing of Paints**	**-**	**-**	**-**	**06**	**03**	**03**
Elective II	**Open Elective**	**03**	**-**	**03**	**-**	**-**	**03**
Elective III	**Professional Core Elective**	**03**	**-**	**03**	**-**	**-**	**03**
Total							**19**

List of Electives

Elective I (Open Elective)

OTL-305 Technology of Perfumery and Cosmetics
FTL-305 Advanced Technology in Food Packaging
PTL-305 Specialty Pigments and Additives in Coatings
PLL-304 Polymer Rheology
CHL-320 Nanoscience and Nanotechnology

Elective II (Open Elective)

OTL-306 Biochemistry & Biotechnology of Lipids
FTL-306 Treatment and Disposal of Food Industrial Waste
PTL-306 Technology of Printing Inks
PLL-305 Plastics Waste Management
CHL-321 Water Conservation and Management

Elective III (Professional Core Elective)

PTL-307 Engineering of Pigmented Dispersion
PTL-308 Synthesis and characterization of Polymers

FIFTH SEMESTER

Course Code	**: CHL-314**
Course Title	**: Mass Transfer Operations**
Course Type	**: Theory**
Total Hrs/week	**: 03 hr (TH)**
Course Credit	**: 03**

Course objectives:
Objective of this subject is to expose students to understand the basic mass transfer operation like diffusion, absorption, drying, humidification distillation, liquid-liquid extraction, adsorption, leaching and crystallization and its application to chemical engineering.

Course Prerequisites:
Material and energy Balances Computations (CHL-206)

Course Content:

Unit-I
Constitutive laws of diffusion: Equimolecular counter diffusion and diffusion in stationary gas; Diffusivities in liquid, vapor and gases; Local and average overall mass transfer coefficients
Interphase mass transfer process: Mass transfer equilibrium, Mass transfer theories, Mass transfer and chemical reaction
Material balance: Steady state co-current and counter current processes, stage wise and differential contacts, Number of theoretical stages, Stage efficiency, Height of transfer units.

Unit-II
Distillation of binary mixtures: Vapor–liquid equilibria, Raoult's law, X-Y, T-X-Y & H-X-Y diagrams, Boiling point diagram and azeotropes
Types of distillation, Fractionating column and multistage column, MaCabe-Thiele method, Operating and feed lines, feed conditions, reflux ratio, minimum and optimum reflux ratio, Tray and column efficiency.

Unit-III
Absorption: Solubility, choice of solvent, concept of driving force and mass transfer coefficient, Material balance for transfer of one component -counter current and concurrent flow, minimum gas-liquid ratio for absorber. absorption with & without chemical reaction. Determination of height of columns, transfer units and HETP.
Packed towers: General construction & working, types of packing merits & demerits, operational difficulties, pressure drop & limiting G-L flow rates.
Plate towers: General construction & working, types of plate, merits and demerits, operational difficulties

Unit IV
Liquid-Liquid Extraction: fundamentals, solvent selection, triangular diagram representation, Single stage extraction- maximum and maximum solvent, Equipment for liquid-liquid extraction. (Mixer settler, Rotating Disc Contractor, Packed column, spray column) equipment selection criteria.

Solid–Liquid Extraction fundamentals, Solvent selection, equilibrium relationship, triangular diagram representation, single stage operation,

Unit-V

Crystallization: Theory of solubility and crystallization, phase diagram (temp/solubility relationship), methods of achieving Supersaturation, phenomenon of crystal formation, crystal structure. Material & heat balance over crystallizer & related problems.

Drying: Drying mechanism, Constant rate and falling rate periods, drying rate curves, estimation of drying time, moisture contents, drying equipments- rotary dryers, drum dryers, vacuum dryers, Spray dryer, fluidized bed dryers.

Text/ Reference Books

1. Dutta, Binay K. *Principles of mass transfer and seperation processes*. PHI Learning Pvt. Ltd., 2007.
2. Treybal, Robert E. "Mass transfer operations." *New York* 466 (1980).
3. Cussler, Edward Lansing, and Edward Lansing Cussler. *Diffusion: mass transfer in fluid systems*. Cambridge university press, 2009.
4. Foust, Alan S., Leonard A. Wenzel, Curtis W. Clump, Louis Maus, and L. Bryce Andersen. *Principles of unit operations*. John Wiley & Sons, 2008.
5. Geankoplis, Tansport. "Processes and unit Operations, 3rd Editions Prentice hall." *Englewood Cliffs, NJ* (1993).

Course Outcomes (COs):

Upon completion of the course students will be able to:

1. **Recognize** laws of diffusion, **apply** them in mass transfer operation and **estimate** the number of stages in distillation.
2. **Interpret** the fundamentals of gas absorption and **evaluate** the height of packed column for absorption.
3. **Analyze** liquid–liquid extraction and **solve** problems on single stage extraction.
4. **Understand** the basics of crystallization and drying technology.

Course Code	**: CHP-315**
Course Title	**: Mass & Momentum Transfer Operations**
Course Type	**: Practical**
Total Hrs/week	**: 03 hr (PR)**
Course Credit	**: 1.5**

Course objectives:
To provide the hand-in-hand experience of lab-scale experiments on various types of equipment based on the theoretical understanding and its application learned in theory course.

Experiments:

1. Determination of diffusivity of Acetone in air; Acetic acid in water.
2. Determination of rate of drying of given sample.
3. Determination of Mass transfer coefficient in wetted wall column.
4. Determination of loading and flooding point in packed column.
5. Validation of Rayleigh equation (Differential distillation).
6. Determination of distribution coefficient of Single stage liquid -liquid extraction for Acetic acid- water-benzene system.
7. Determination of Reynolds Number & prediction of flow behaviour.
8. Determination of coefficient of discharge of Venturimeter and Orifice Meter.
9. Determination of the coefficient of discharge for Triangular, Rectangular and Trapezoidal Notch.
10. Study of characteristics of pumps & compressors (Centrifugal & Reciprocating)

Reference Books

1. Departmental Practical Manual.

Course Outcomes (COs):
Upon completion of the course students will be able to:

1. **Develop** the ability regarding analytical and data interpretation skills.
2. **Understand** the scaling approach of understanding from Experimental to Industry applications.
3. **Plan** an appropriate approach to experiment work and **justify** plans in the light of preliminary findings.
4. **Demonstrate** safe working in the choice of method and apparatus

Course Code	**: CHL-312**
Course Title	**: Process Design & Project Management**
Course Type	**: Theory**
Total Hrs/week	**: 03 hr (TH)**
Course Credit	**: 03**

Course objectives:
The objective of the course is to provide students with a firm grasp of the essential principles of management, project identification project feasibility and project scheduling technique with suitable examples. Students will able to understand HAZOP design and read the PID of the plant. Students will able to understand economics for chemical processes.

Course Prerequisites:
Industrial Management and Economics (HML-202)

Course Content:

Unit -I
Project identification and its feasibility; project testing based on viability, risk & cost estimation; evaluation of project by different methods on the basis of visibility i) Net present value method, ii) Method of rate of return on initial investment, iii) Pay out period, iv) Method of discount cash flow, v) Capitalized cost method, vi) Internal rate of return method, vi) Break even chart; evaluation of project by different methods on the basis of risk i) Profitability index, ii) Demand fore casting, iii) Standard deviation approach; evaluation of project by different methods on the basis of cost i) Preparation of cost sheet and statements, ii) Preparation of profit loss statement.

Unit –II
New developments in management, CPM & PERT, principle and objective of CPM and PERT network diagram for calculation time duration.
Linear programming problem (Numerical based on each method) i) General simplex method ii) Primary& dual technique method iii) Direct simplex method iv) Graphical method.

Unit –III
Cost analysis, fixed capital, working capital, preparation of store ledger account by pricing issue methods, LIFO, FIFO, simple average, weighted average.
Depreciation, significance of inadequacy and obsolescence, and depreciation methods.

Unit -IV
Layout and location, objective, principle; layout and location factors, equipment layout diagram (ELD); tank firm cum utility block diagram for different processes.

Unit -V
HAZOP: Introduction and guide word, application of HAZOP to processes with examples. PID: Basic symbols for various piping and instruments; development of PFD, P&ID, PDS for different processes.

Text/ Reference Books

1. S.D. Dawande *Process equipment Design*. Denett and Co Fifth Edition
2. B.V. Pathak & amp; M.S. Mahajan *Industrial Organization & amp; Management,* Nirali Prakashan First Edition 1986
3. Peters, Max Stone, Klaus D. Timmerhaus, Ronald Emmett West, Klaus Timmerhaus, and Ronald West. *Plant design and economics for chemical engineers*. Vol. 4. New York: McGraw-Hill, 1968.
4. Shreve, Randolph Norris, and Joseph A. Brink Jr. *Chemical Process Industries*. No. 4th Edition. McGraw-Hill Book Co., 1977.
5. Drydens *Outlines of Chemical Process Technology*, Third Edition, 1997
6. D.B.Dhone *Plant Utilities* Nirali Prakashan, First Edition 2008.

Course Outcomes (COs):

Upon completion of the course students will be able to:

1. **Evaluate** feasibility of project.
2. **Apply** various methods of profitability evaluation.
3. **Identify** the new development in project management and optimization techniques.
4. **Apply** HAZOP analysis for safety of the process.

Course Code	**: PTC-301**
Course Title	**: Architectural Coatings**
Course Type	**: Theory**
Total Hrs/week	**: 03 hr (TH)**
Course Credit	**: 03**

Course Objectives:

1. The Paint Technocrat will have in depth exposure to Architectural Coatings.
2. The student will learn the constitution of Decorative paint and the basic role of paint ingredients.
3. The Technocrat will have in-depth exposure to manufacture, characterizations and applications of Trades Sales Paints.

Course prerequisites:

Introduction to Coating Technology (PTC-201)
Technology of Pigments (PTC-202)

Course Content:

Unit- I: Formulation Mathematics & Steps

Cumulative specific gravity, drier additions, percentage volume solids; spreading rate and film-thickness; PVC & pigment binder ratio calculations, Oil absorption value, 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, perspectives of coating designs, fault diagnosis & formula adjustment; development of Paint formulations, multicoat systems.

Unit- II: Substrate- Coating Relations

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

Selection of binders, solvents, additives and pigmentation for formulation of solvent based coatings for different surfaces in buildings: putty, sealer, stoppers/fillers, primers, undercoats & finishing coats/ enamels for metal, masonry, timber substrates; Physical drying paints, oxidative curing coatings, two component systems, stoving enamels.

Unit– IV: Latex Based Decorative Paints

Comparison of latex paints vs oil-based paints, manufacture of latexes: emulsion polymerization, mechanism of micelle formation, formulation and characteristics of different latexes, latex nanocomposites, stability of emulsions, formulation of latex paints for exterior

and interior decorative paints for different surfaces in buildings: sealers, primers, stoppers/ fillers, undercoats; latex gloss enamels ; distempers, alkyd emulsions, flat wall paints; texture coatings, Calculations related to Paint Formulary.

Unit - V: 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 Outcomes (COs):

On completion of this course, the Technocrat will display the knowledge related to

1. **Design** of coating formulation and **understanding** mathematics & steps.
2. **Formulation** development of solvent borne/water borne architectural coatings in relation to their functions/end use.
3. Selection, **comparison** and **assessment** of polymers, pigments, solvents and additives in Formulations of solvent borne/water borne architectural coatings.
4. **Understanding** of DIY Market, coating calculations and costing for paint contractor in reference to end use.

Text/ Reference Books:

1. Jones, Frank N., Mark E. Nichols, and Socrates Peter Pappas. *Organic Coatings: Science and Technology*. John Wiley & Sons, 2017.
2. Malshe, V. C. *Basics of Paint Technology part I*. Color Publications, 2010.
3. Swaraj, Paul. *Surface Coatings: Science and Technology*. J. Wiley & sons, 1985.
4. Lambourne, Ronald, and T. A. Strivens, eds. *Paint and Surface Coatings: Theory and Practice*. Elsevier, 1999.
5. Müller, Bodo, and Ulrich Poth. *Coatings Formulation*. Hanover: Vincentz Network, 2011.
6. Freitag, Werner, and Dieter Stoye, eds. *Paints, Coatings and Solvents*. John Wiley & Sons, 2008.

Course Code	**: PTC-301**
Course Title	**: Architectural Coatings**
Course Type	**: Practical**
Total Hrs/week	**: 03 hr (PR)**
Course Credit	**: 1.5**

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

1. The determination of physical and chemical characteristics of solvents, plasticizers and coating additives.
2. The general characteristics of trade sales paints / architectural coatings.
3. Processing and characterisation of varnishes and lacquers

Course Prerequisites:

Introduction to Coating Technology (PTC-201)
Technology of Pigments (PTC-202)

Course Content:

Minimum of ten experiments with due coverage of following:

1. Analysis of solvents - solvent power, distillation range, evaporation rate (evaporation of mixed solvent, retarder solvent, evaporation of solvents from coating films, flash point, refractive index, moisture content/ hygroscopicity, acidity/ alkalinity etc.

2. Determination of surface tension and analysis of surface additives, dispersing agents and antifoams; Use of Ford Cup/ Gardner Tubes for estimation of viscosity; Analysis of rheological additives in paints.

3. Surface and Hard Dry for air drying paints. Estimation of covering power, wet opacity & dry hiding (chequer board/ contrast ratio/ spectral methods) and coating calculations related to practical painting

4. Processing and Characterization of Varnishes such as french polish, knotting, copal varnish, synthetic resin varnishes, preparation of lacquers etc. alkyd enamel, nitrocellulose-based fillers, stoving enamels for metal and wood substrates.

Reference Books

1. Departmental Practical Manual.

Course Outcomes (COs):

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

1. **Understanding** of general properties/characteristics of architectural coatings.
2. **Evaluation** of solvents, plasticizers and other additives in paint formulations.
3. The techniques of **analysis** of general coating characteristics.
4. Empirical skills for **formulations** of varnishes and lacquers.

Course Code	**: PTC-302**
Course Title	**: Chemistry & Technology of Polymers**
Course Type	**: Theory**
Total Hrs/week	**: 03 hr (TH)**
Course Credit	**: 03**

Course Objectives:

1. The paint technocrat will have in depth exposure to high performance polymers.
2. The student will learn the structure and properties relationship of various organic and inorganic polymers.
3. The technocrat will have in-depth exposure to manufacture, characterisations and applications of high-performance polymers.

Course Prerequisites:

Introduction to Coating Technology (PTC-201)
Technology of Pigments (PTC-202)

Course Content:

Unit - I: Polyurethane resin

Structures and characteristics of different Isocyanate, Isocyanate prepolymers, commercial polyisocyanate, polyols and catalysts for polyurethane coatings, polyurea, urethane oils and alkyds, polyols adducts, blocked isocyanates, moisture curing polyisocyanates, formulation of solvent borne and waterborne PU coatings, PU dispersions, curing mechanism for PU coatings, safety aspects of handling of isocyanates, applications in surface coating.

Unit -II: Epoxy resins and Polyamides

Use of epichlorohydrin, bisphenol A/F and novolac derivatives, glycidyl methacrylate, Chemistry of synthesis: Plants and processes for manufacture, chemistry and their selection one pack and two pack systems, epoxy ester, hardeners for epoxy coatings, applications in surface coating. Polyamides: Polyamides as hardener for epoxy resin, chemistry and technology of adducts, properties and applications in surface coating.

Unit -III: Acrylics and Polyester

Structure & properties of acrylic monomers, role of initiators, solvents, chain transfer agents, mechanism of polymerization (free radical/ anionic /cationic/ thermal / redox etc), thermoplastic and thermosetting acrylic, water reducible acrylics, application in coatings.

Polyester resins: Selection of polyols & polybasic acids, 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.

Unit IV: Phenolic & Amino Resin

Phenolic resins: Chemistry of novolac and resols, plant and process for manufacture, properties and characterization of phenolic resins; modified phenolics, synthesis and application in coatings.

Amino resins: Urea, benzoguanamine and melamine formaldehyde resins, chemistry of methylolation and etherification, plant and process for manufacture, self-condensation; MF–polyol reactions in coatings, properties and characterization of amino resins; coating formulations and properties of acrylic/ polyester /alkyd amino stoving coatings.

Unit -V: Cellulose Esters and Inorganic Polymers

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, safety regulations.

Inorganic Polymers: Formulation, properties and uses of silicone 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 (COs):

Upon completion of the course the students will learn about:

1. **Synthesis** techniques of different high-performance polymers.
2. **Assessing** the structure-property relationship in high-performance polymers and polymerization/ curing methods.
3. The **applications** of different high-performance polymers in general and their utilizations in surface coating industries.
4. **Selection** of resin chemistry in paint formulation for specific **applications**

Text / Reference Books:

1. Jones, Frank N., Mark E. Nichols, and Socrates Peter Pappas. *Organic Coatings: Science and Technology*. John Wiley & Sons, 2017.
2. Stoye, Dieter, Werner Freitag, and Günter Beuschel, eds. *Resins for coatings: chemistry, properties, and applications*. Hanser Verlag, 1996.
3. Swaraj, Paul. *Surface Coatings: Science and Technology*. J. Wiley & sons, 1985.
4. Lambourne, Ronald, and T. A. Strivens, eds. *Paint and Surface Coatings: Theory and Practice*. Elsevier, 1999.
5. Oldering, P. K. T., and G. Hayward. "Resins for surface coatings." *Volume II, SITA Technology, London* (1987).

Course Code	**: PTC-302**
Course Title	**: Chemistry & Technology of Polymers**
Course Type	**: Practical**
Total Hrs/week	**: 03 hr (PR)**
Course Credit	**: 1.5**

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

Course Prerequisite:

Introduction to Coating Technology (PTC-201)
Technology of Pigments (PTC-202)

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, curing of epoxy resins, preparation of reactive and non-reactive polyamides, epoxy esters
3. Synthesis of urethane alkyds, blocked isocyanates, isocyanates adduct, polyurethane (single pack, two pack)
4. Analysis of synthetic resins: amine value, epoxide equivalent weight, isocyanate content, curing time and pot life, changes in properties with changes in resin-hardener combinations, viscosity and molecular weight determination etc.

Reference Books

1. Departmental Practical Manual.

Course Outcomes (COs):

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

1. **Synthesis** of acrylic, epoxy, urethane and polyamide resins.
2. **Understanding** of various techniques of polymerizations
3. **Evaluation** of curing and degree of polymerization.
4. **Characterization** and testing of high- performance polymers.

Elective-I (Open Elective)

Course Code : PTL-305
Course Title : Specialty Pigments and Additives in Coatings
Course Type : Theory
Total Hrs/week : 03 hr (TH)
Course Credit : 03

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

1. The student will learn about the metallic and pearl effect and changes in pigmentary properties in reference to nano size.
2. The Technocrat will have exposure to Mechanism, dosing and Trade information of coating additives and surfactants.

Course Prerequisites: ----Not Applicable----

Course Content:

Unit -I : Metallic, Interference and Cholesteric Pigments
Aluminum, copper, zinc dust, bronze, nickel stainless steel, lead powders and pastes; Nacreous, luminescent (fluorescent/phosphorescent) pigments, optical principles; substrate free pearlescent pigments, special effect pigments based on mica, metal oxides etc., pigments based on liquid crystal polymer.

Unit -II : Functional and Nano pigments
Antifouling pigments-cuprous oxide, other copper compounds, mercuric oxide, barium metaborate, organotin pigments. Manufacture and properties of nano pigments: alumina, silica, titanium dioxide, iron oxides, zinc oxides, silver, $CaCO_3$, etc., variables affecting particle size aggregation and crystal structure, use of nano pigments as spacing extenders / functional additive in coatings.

Unit - III : Surfactants and surface additives
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 and surface additive; polyacrylate, silicone and fluoropolymers as flow and levelling agents.

Unit - IV : Specialty additives in solvent borne coatings
Antisettling agents, additives for rheology control, adhesion promoters, antiskinning agents, light stabilizers (UV absorbers, antioxidants, HALS), moisture scavengers, slip additives, hammer and wrinkle finish additives, conductivity control additives etc.

Unit - V : Specialty additives for Water Borne Coating
Auxiliary and coalescing solvents, neutralization agents, thickeners, antifoaming agents, antifreeze-thaw, preservatives (in- can/film), mildew agents, corrosion inhibitors etc.

Text/ Reference Books

1. Jones, Frank N., Mark E. Nichols, and Socrates Peter Pappas. *Organic Coatings: Science and Technology*. John Wiley & Sons, 2017.
2. Swaraj, Paul. *Surface Coatings: Science and Technology*. J. Wiley & sons, 1985.
3. Karsa, D. R.; Davies, W. D., Eds., *Waterborne Coatings and Additives*, Royal Society of Chemistry,Cambridge, 1995.
4. Buxbaum, Gunter, ed. *Industrial inorganic pigments*. John Wiley & Sons, 2008.
5. Berte, J. N. "*High Performance Pigments*, ed Smith HM." (2002): 27-40.
6. Bieleman, Johan, ed. *Additives for coatings*. John Wiley & Sons, 2008.
7. Herbst, Willy, and Klaus Hunger. *Industrial organic pigments: production, properties, applications*. John Wiley & Sons, 2006.
8. Calbo, Leonard J. *Handbook of coatings additives*. 1987.

Course Outcomes (COs):

Upon completion of the course the students will be able to:

1. **Understand** the optical effects and **evaluate** Metallic, Interference and Cholesteric Pigments in coatings.
2. **Propose** synthesis methods of Functional and Nano pigments, and their applications in specialty coatings.
3. **Understand** constructive, corrective and comparative role of various additives in solvent borne, waterborne and other coatings.
4. **Assess** dosing and trade information of Additives in Coatings.

Elective-I (Open Elective)

Course Code : FTL-305
Course Title : Advanced Technology in Food Packaging
Course Type : Theory
Total Hrs/week : 03 hr (TH)
Course Credit : 03

Course Objectives:

1. To study basic packaging materials, their properties, types of packaging, sealing and lamination process.
2. To study newer packaging technologies used for food products.
3. To estimate shelf life of packaged products.
4. To study packaging of soft drink and alcoholic beverages.

Course Prerequisites: ----Not Applicable----

Course Content:

Unit –I

Packaging as a method for conservation and protection of foods, different packaging material and their properties including barrier properties, strength properties, optical properties etc. Glass, Aluminium, tin, paper, plastic and composites. Sealing of metallic and plastic containers. Types of food packaging

Unit –II

Flexible packaging, laminated packaging and retortable pouches and biodegradable packaging material. Concept and calculation of shelf life of laminate, wine in PET, glass bottle; shelf life based on browning, vitamin loss and microbial count in food container. Safety and testing of packaging containers.

Unit –III

Active packaging system: - Packaging requirement for different moisture level food products, Aseptic processing and packaging of fruits & vegetables, milk and milk products

Unit – IV

Product- Package compatibility: - Microwavable Packaging, MAP of fresh fruit and vegetable, vacuum and MAP of meat and meat products. Packaging of breakfast cereals, bakery and confectionary products

Unit –V

Packaging of soft drink, alcoholic beverages, distilled spirits, frozen food, future trends in food packaging: intelligent/ smart packaging.

Text/ Reference Books

1. Handbook of food packaging by F. A Paine and H.Y paine., Publisher: Blackis and Son Ltd London (1983)
2. Food Packaging Principles and Practice: Gordon L. Robertson
3. Modern processing and distribution system for food edited by F. A Paine
4. Food and packaging interaction by Risch. S. H., Publisher: American chemical Society, Washington (1991)
5. Packaging materials and containers by Paine F. A., Publisher: Blackis and sons Ltd, London (1983)
6. Mathlouthi, M. Food Packaging and Preservation. Gaithersburg: Aspen, 1999
7. Paine F. A . Packaging media Publisher: Blackis and son Ltd; Bishop Briggs (1977)
8. Bureau, G., and J. L. Multon. Food Packaging Technology. New York, n.d. (1996)
9. Chemistry of Food Packaging by Swalam C.M., American Chemical Society, Washington D. C. 1974.
10. Packaging. Rockport, MA: Rockport Publishers, 1995.

Course Outcomes (COs):

Upon completion of the course students will be able to:

1. **Recognize** and **classify** food packaging materials and their use.
2. **Differentiate** active packaging, aseptic packaging, MAP, vacuum packaging, smart packaging, microwavable packaging.
3. **Estimate s**helf life of food packaged.
4. **State** packaging of, soft drink, alcoholic beverages, and frozen food.

Elective-I (Open Elective)

Course Code : OTL-305
Course Title : Technology of Perfumery and Cosmetics
Course Type : Theory
Total Hrs/week : 03 hr (TH)
Course Credit : 03

Course Objectives: This course provides a thorough knowledge about different essential oil, perfumery synthetics and cosmetic ingredients. Students shall acquire various extraction methodologies in recovery of essential oils, their physio-chemical properties and applications. Also, the course will cover raw material for different cosmetic preparations.

Course Prerequisites: ----Not Applicable----

Course Content:

Unit -I
Essential oils: Chemistry, source materials, production methods
Production, properties and applications of essential oils (Rose, Jasmine, Khus, Sandalwood, Palmarosa, Lemongrass, Peppermint, Orange)

Unit –II
Physio-chemical properties of essential oils: Colour, specific gravity, refractive index, optical rotation, solubility, congealing point, evaporation residue, acid value and ester value.
Analysis of essential oils: Alcohol, Aldehyde, Ketones and Phenol content.

Unit- III
Grading and standardization of essential oils; common adulterants and their detection.
Perfumery: History and its function, mechanism of smelling, classification & blending of perfume ingredients, perfumery isolates (Menthol, Geraniol and Musk)

Unit- IV
Synthetic perfumery materials and fixatives (Camphor, Thymol, Citral, Vanillin, Cumarin, Benzyl acetate, Benzyl benzoate)
Production, properties and applications: Hair oil & dyes, Shaving creams and Depilatories

Unit –V
Production, function and properties of cosmetic products: Face cream, Face powder, Talcum powder, Tooth paste/powder, Shampoo, Lipsticks and Nail polish

Text/ Reference Books

1. Valerie Ann Worwood "The Complete Book of Essential Oils and Aromatherapy"
2. Ernest Guenther "The Essential Oils" Volume-I
3. Sonia Malik "Essential Oil Research" Springer International Publishing
4. "Hand Book of Perfumes with Formulations" Engineers India Research Institute.
5. Nigel Groom "The Perfume Handbook" Springer
6. Steffen Arctander "Perfume and Flavor Materials of Natural Origin"

7. S.K. Singh “Handbook on Cosmetics (Processes, Formulae with Testing Methods)”
8. H. W. Hibbott. “Handbook of Cosmetic Science” 1st Edition

Course Outcomes (COs):

Upon completion of the course students will be able to:

1. **Understand** the fundamental of essential oils and **propose** methods of their production.
2. **Differentiate** the principles behind the physio-chemical analytical techniques in estimation of quality parameters of essential oils.
3. **Devise** the concepts of perfumery, blending of perfumes and **outline** the use of synthetic perfumery materials.
4. **Propose** the production techniques and **illustrate** the functions of ingredients in cosmetics products.

Elective-I (Open Elective)

Course Code : PLL-304
Course Title : Polymer Rheology
Course Type : Theory
Total Hrs/week : 03 hr (TH)
Course Credit : 03

Course Objectives:

1. To understand the flow properties of polymers in terms of various models to study viscoelastic behavior of the polymers.
2. To know the thermo viscoelastic behavior of polymers during processing and selection of design of processing device.
3. To understand the processing of various types of polymers, selection of device for processing on the basis of flow properties.

Course Prerequisites: ----Not Applicable----

Course Content:

Unit -I
Rheological Principles: Rheological Parameters, relationship between rheological parameters, Rheological systems: purely elastic, viscous, Types of fluids: Newtonian and Non Newtonian fluids, Viscoelastics fluids, Rheological or Constitutive equations.

Unit -II
Viscoelastic Nature of Polymers: Elasticity moduli and their time dependence, static and dynamic experiments to understand the time dependence , tan, its significance and method of determination, models of viscoelasticity, mechanical models such as Maxwell, voight, combinations of Maxwell and voight models to simulate viscoelastic behavior, salient features of molecular theories of viscoelasticity.

Unit -III
Glass Transition, Theories to determine the glass transition i.e. Dillatometric, Heat capacity, measurement, Thermomechanical, Measurement of modulus of elasticity, effect of Tg on molecular mass, kinetic chain flexbility and chemical constituent, Importance of Tg and Tm.

Unit -IV
Viscoelastic behavior of Polymer solution and melts stress-strain curves for Polymers, creep curves of Polymeric material, elastic deformation, irrecoverable follow deformation.
Rubber like deformation, Time-temp superposition (WLF Equation)

Unit -V
Methods to determine shear viscosity by capillary, parallel plate and cone and plate Rheometer, Measurement of normal stresses, Application of rheology to polymer processing.

Text/ Reference Books

1. P.N.Cogswell, Polymer Melt Rheology, A guide for Industrial Practice, George Godwin, Second Edition, 1981.

2. Richard C. Progelhof and James L. Throne, Polymer Engineering Principles, Hanser Publishers, New York, 1993.
3. John M. Dealy and Kurt F. Wissburn, Melt rheology and its role in plastics processing, Chapman, London, 1995.
4. R.S. Lenk, Polymer Rheology, Applied Science, London, 1978.
5. J.D. Ferry, Viscoelastic Properties of Polymers, john Wiley & Sons, New York, 1986.
6. Chang Dae Han. Rheology in Polymer Processing, Academic Press, New York, 1976.
7. R.J. Crawford, Plastics Engineering, Butterworth - Heinemann, Oxford, 1998
8. B.R. Gupta, Applied Rheology in Polymer Processing, Asian Books Pvt. Ltd. 1st Edition, 2005.

Course Outcomes (COs):

Upon completion of the course the students will be able to:

1. **Recognize** flow behavior of the polymers and various models used for determination of flow properties.
2. **Design** features of the processing device on the basis of processing parameter as temperature, pressure, shear rate.
3. **Select** the processing equipment with respect to change in polymer, polymer flow properties.
4. **Differentiate** the transition behavior of various polymeric materials.

Elective-I (Open Elective)

Course Code : CHL-320
Course Title : Nanoscience and Nanotechnology
Course Type : Theory
Total Hrs/week : 03 hr (TH)
Course Credit : 03

Course Objectives:
The objective of the course is to introduce students about emerging field of Nanoscience and Technology. Students will learn about properties of nanomaterials and their applications.

Course Prerequisites: ----Not Applicable----

UNIT-I
Quantum chemistry, Solid state Physics, Nanomaterial & Manufacturing, Renewable energy generation, Nanotechnology in drug delivery, Nanotechnology in cosmetics, Bio-nanotechnology, Nanotechnology & information technology, Nanotechnology in agriculture and food industry, Environmental nanotechnology, Nanotechnology Health risk.

UNIT-II
Synthesis methods of nanostructures: Top-Down and Bottom-up approach of synthesis, Chemical Routes for Synthesis of Nanomaterials: Chemical precipitation and co-precipitation; Sol-gel synthesis; Microemulsions or reverse micelles; Solvothermal synthesis.

UNIT-III
Nanostructures and its applications: Carbon Nanotubes (CNT), Graphenes, Fullerenes, Nano Peapods, Quantum Dots and Semiconductor Nanoparticles Metal-based Nanostructures (Iron Oxide, Silver, Copper Nanoparticles) Nanowires Polymer-based Nanostructures including dendrimers, nanofillers like clay, $CaCO_3$, $CaSO_4$.

UINT-IV
Nanocatalysis: Nanomaterials as catalysts for a variety of homogeneous and heterogeneous catalysis applications. Impact of the intrinsic properties of nanomaterials on catalysis, Various methods like Chemical Reduction Method, Thermal, Photochemical and Sonochemical Reduction Method, Applications of Nanocatalysis in Chemical Industry.

UNIT-V
Characterization techniques in analysingNanomaterials: Scanning/transmission electron microscopy (SEM/ TEM), XRD, Atomic Force Microscopy, Particle size analyser (PSA) and their applications.

Text/ Reference Books

1. Nanochemistry: A Chemical Approach to Nanomaterials, Geoffrey A. Ozin, Andre C. Arsenault, Royal Society of Chemistry, Cambridge, UK, 2005.
2. Chemistry of Nanomaterials: Synthesis, Properties and Applications C. N. R. Rao, Achim Muller, A. K Cheetham, Wiely-VCH, 2004.
3. Metal Nanoparticles: Synthesis Characterization & Applications, Daniel L. Fedlheim, Colby A. Foss, Marcel Dekker, 2002.

4. Nanostructures and Nanomaterials - Synthesis, Properties and Applications - Cao, Guozhong, Ying Wang, World Scientific, 2011.
5. Nanoparticles and Catalysis, Didier Astruc (Editor), Wiley-VCH Verlag GmbH & Co. KGaA, 2008

Course Outcomes (COs):

Upon completion of the course the students will be able to:

1. **Choose** appropriate synthesis technique to synthesize nanostructures of desired size, shape and surface properties.
2. **Correlate** properties of nanostructures with their size, shape and surface characteristics.
3. **Select** appropriate analytical tools for characterization of nanomaterials.
4. **Appraise** on application of nanomaterials as catalyst.

Course Code	**: NC-303**
Course Title	**: Essence of Indian Traditional Knowledge**
Course Type	**: Audit**
Total Hrs/week	**: ----**
Course Credit	**: NC**

Course Objectives:

1. The course aims at imparting basic principles of thought process, reasoning with emphasis on sustainability connecting society and nature.
2. To facilitate the students with the concepts of Indian traditional knowledge and to make them understand the importance of roots of knowledge system.
3. To focus on Indian Knowledge System, Indian perspective of modern scientific worldview and basic principles of Yoga and holistic health care system.

Course Prerequisites: ----Not Applicable----

Course Content:

Unit-I

Introduction to traditional knowledge: Traditional knowledge, nature and characteristics, scope and importance, kinds of traditional knowledge, physical and social contexts in which traditional knowledge develop, historical impact of social change on traditional knowledge systems. Indigenous Knowledge (IK), characteristics, traditional knowledge vis-à-vis indigenous knowledge, western knowledge. Indian personalities in traditional knowledge, linking science and the rural

Unit-II

Protection of traditional knowledge: Need for protecting traditional knowledge (TK), significance of TK protection, global mechanisms of protection and sharing, recognition and protection value of TK in global economy, role of government to harness TK.

Unit-III

Legal framework and TK: Scheduled Tribes and Other Traditional Forest Dwellers (Recognition Of Forest Rights) Act (2006); Plant Varieties Protection and Farmer's Rights Act (2001) (PPVFR Act); Biological Diversity Act (2002) and Rules (2004); Protection of Traditional Knowledge Bill (2016); Geographical Indicators Act (2003).

Unit-IV

Traditional knowledge and intellectual property: Systems of TK protection, Legal concepts for the protection of TK, Certain non IPR mechanisms of traditional TK, Patents and TK, Strategies to increase protection of TK, Global legal fora for increasing protection of Indian Traditional Knowledge.

Unit-V

Traditional knowledge in different sectors: Traditional knowledge and engineering, Traditional medicine system, TK and biotechnology, TK in agriculture, Food and healthcare needs of Traditional societies, Importance of conservation and sustainable development of environment, Management of biodiversity, Food security of the country and protection of TK.

Text/ Reference Books

1. Sengupta, Nirmal, and Ghosh. *Traditional Knowledge in Modern India*. Springer India, 2019.
2. Jha, Amit. *Traditional knowledge system in India*. Atlantic Publishers & Distributors, 2009.
3. Basanta Kumar Mohanta and Vipin Kumar Singh *Traditional Knowledge System and Technology in India*, Pratibha Prakashan 2012.
4. Kapoor, Kapil, and Michel Danino. "Textbook of" Knowledge Traditions and Practices of India"." *Ancient Science of Life* 32, no. 1 (2012): 59.

E-Resources:

1. https://www.youtube.com/watch?v=LZP1StpYEPM
2. http://nptel.ac.in/courses/121106003/

Course Outcomes (COs):

Upon completion of the course the students will be able to:

1. **Understand**, **correlate** and **explain** basics of Indian Traditional knowledge modern scientific perspective
2. **Recognize** the need and importance of protecting traditional knowledge.
3. **Propose** the various enactments related to the protection of traditional knowledge.
4. **Describe** the concepts of Intellectual property to protect the traditional knowledge.

SIXTH SEMESTER

Course Code	**: CHL-316**
Course Title	**: Chemical Reaction Engineering**
Course Type	**: Theory**
Total Hrs/week	**: 03 hr (TH) and 01 hr (Tutorial)**
Course Credit	**: 04**

Course objectives:

1. This course will highlight basic concepts of kinetics and rate laws along with interpretation of rate data.
2. The course will deal with problems involving design & rating of ideal reactors including heat effects, multiple reactions.
3. The course will also provide basic understanding of catalysts and their applications to industrial processes.

Course Prerequisites:

Material and Energy Balance Calculations (CHL-206)
Chemistry-I (BSC-103)

Course Content:

Unit –I

Reactions and reaction rates - stoichiometry, extent of reactions, conversion, Selectivity Reaction rate fundamentals - elementary reaction sequences, steady state approximation and rate limiting step theory.

Unit –II

Analysis and correlation of experimental kinetic data - data collection & plotting, linearization of rate equations, differential and integral method of analysis**.**

Unit –III

Ideal reactors - generalized material balance, design equations, graphical interpretation. Sizing and analysis of ideal batch, mixed (CSTR), plug flow and recycle reactors – solving design equations for constant and variable density systems, reactors in series and parallel.

Unit –IV

Multiple reactions - conversion, selectivity, yield, series, parallel, independent and mixed series-parallel reactions.

Unit –V

Introduction to Catalysis, homogeneous and heterogeneous catalysis. Preparation and characterization of catalysts. Physical and chemical adsorption, Adsorption isotherms, Determination of BET surface area and pore volume of the Catalyst .

Text/Reference Books

1. H. Scott Fogler *Elements of Chemical Reaction Engineering* 2nd Edition, Prentice Hall 2001.

2. Octave Levenspiel *Chemical Reaction Engineering* by, 3rd Edition, John Wiley & Sons 2001

Course Outcomes (COs):

Upon completion of the course the students will be able to:

1. **Design** chemical reactors involving heat effects optimally using minimum amount of data
2. **Fix** some problems related to operability and productivity.
3. **Apply** methods of Catalysts' synthesis and catalyst characterization
4. **Understand** and **interpret** kinetics data.

Course Code	**: HML-309**
Course Title	**: Psycho-Social Dimensions of Industrial Management**
Course Type	**: Theory**
Total Hrs/week	**: 03 hr (TH)**
Course Credit	**: 03**

Course Objectives:

1. To prepare and develop the students for successful career that meets the global Industrial and Corporate requirements.
2. To guide the students about perception and attitude development to excel in organisation setting
3. To provide an environment for students to work on Multidisciplinary projects as part of different teams to develop their team building capabilities like leadership, motivation, teamwork etc.
4. To introduce professional ethics and codes of professional practices in Industry.

Course Prerequisites:

Industrial Management and Economics (HML-202)

Course Content:

Unit –I

Concept and meaning of organisation behaviour, Features & foundations of organisation behaviour, Role of organisation behaviour, Theories of organisation behaviour, Behaviour Process, Innovation & creativity in organization

Unit –II

Perception: Meaning and definition, Factors influencing perception process, Perception Process, Perception and individual decision making, Nature of attitudes, Components of attitude, Formation of attitudes, Functions of attitudes, Work related attitudes: Job satisfaction & organizational commitment, Attitudes, values & organization behaviour

Unit –III

Motivation: Nature & Importance, Theories of Motivation, Content Theories and Process theories: Evaluation & criticism, Self motivation

Unit –IV

Leadership: Nature, Leadership and management, Importance, Leadership styles and their implications, Trait and behavioural approach of leadership, Decision making: Nature, types & conditions of decisions, Decision making process & styles

Unit –IV

Nature and sources of ethics, Ethical dilemmas, Resolving dilemmas, Ethical decision making, Ways of managing ethics, Corporate social responsibility

Text/ Reference Books

1. Aswathappa, Kalupally, and G. Sudarsana Reddy. *Organisational behaviour*. Vol. 20. Himalaya Publishing House, 2009.
2. Martin, John. *Organizational behaviour and management*. Cengage learning EMEA, 2005.
3. Saiyadain, Mirza S. *Organisational behaviour*. Tata McGraw-Hill Education, 2003.
4. Mishra, Maha Narain. *Organisational behaviour*. Vikas Publishing House Pvt Ltd, 2001.
5. Robbins, Stephen P. *Organisational behaviour: global and Southern African perspectives*. Pearson South Africa, 2001.
6. Stoner, *Management-II*. Pearson Education India.

Course Outcomes (COs):

Upon completion of the course the students will be able to:

1. **Develop** the process of individual behaviour and perpetual process along with conditioning of thinking process
2. **Identify** the concept and process of motivation and leadership
3. **Correlate** human behaviour, social skills, innovations, and creativity to improve workplace dynamics.
4. **Develop** the knowledge of ethical considerations and administrative regulations by applying the theories and principles of Management in practice to improve performance of individual employee at a workplace.

Course Code	**: PTL-303**
Course Title	**: Eco-friendly Coating Technologies**
Course Type	**: Theory**
Total Hrs/week	**: 03 hr (TH)**
Course Credit	**: 03**

Course Objective:

1. the paint technocrat will have in depth exposure to diverse eco-friendly coating technologies.
2. The student will learn about the formulation and manufacture of electrodeposition, radiation cure and powder coatings.
3. The technocrat will have exposure to diverse applications and emerging trends of eco-friendly surface coatings.

Course Prerequisites:

Introduction to Coating Technology (PTC-201)
Technology of Pigments (PTC-202)
Architectural Coatings (PTC-301)

Course Content:

Unit I: Waterborne coatings for Industrial /OEM applications

Properties of water as solvent, classification and characteristics of waterborne coatings, solubility and dispersibility of paint resins in water, water soluble polymers- starch, gums, cellulose ethers (CMC, HEC), PVA, hydrosols; water-reducible binders (e.g. alkyds, polyesters, polyacrylates, epoxides, and epoxy esters), viscosity anomaly of water-reducible paints; PU dispersion, non-aqueous dispersions; hybrid systems, crosslinking /oven curing of water-borne coatings, film defects, industrial uses and environmental aspects

Unit -II: Electrodeposition Coatings

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; electrodeposition automotive primer formulations and other applications; recent developments in electrodeposition coatings.

Unit - III: Radiation Cure Coatings

Fundamentals of photopolymerization-UV curing (free radial & cationic) & electron beam cure coating, free radical, and cationic photo initiators: structure and characterization mono and multi-functional monomers; free radical curing oligomers and polymers; epoxy resin for cationic cure; inhibitory effects and remedial measures; formulation principles, application of radiation curable coatings in various industries.

Unit – IV: High solid coatings

High solid coating, VOC regulations, necessities and possibilities, control of molecular weight & molecular weight distribution, functional group selections; high solid alkyd, polyester & acrylics; high solid primers and topcoats; control of sagging, sag control agents, acrylic microgels; formulation of solvent borne coatings for low VOC.

Unit -V: Powder Coatings

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), additives for powder coatings, formulations of powder coatings, UV curable powder coatings for wooden surfaces, manufacture of powder coating, applications of powder coatings.

Course Outcomes (COs):

Upon completion of the course, the students will be able to:

1. **Assess** various environmental compliant practices in coating industry.
2. **Propose** ecofriendly coating formulations for Industrial /OEM applications.
3. **Interpret** chemistry of binders to **develop** green coatings.
4. **Compare** properties of various radiation cure monomers, prepolymers, and photo initiators to formulate coatings.

Text / Reference Books:

1. Jones, Frank N., Mark E. Nichols, and Socrates Peter Pappas. *Organic Coatings: Science and Technology*. John Wiley & Sons, 2017.
2. Swaraj, Paul. *Surface Coatings: Science and Technology*. J. Wiley & sons, 1985.
3. Lambourne, Ronald, and T. A. Strivens, eds. *Paint and Surface Coatings: Theory and Practice*. Elsevier, 1999.
4. Müller, Bodo, and Ulrich Poth. *Coatings Formulation*. Hanover: Vincentz Network, 2011.
5. Misev, Tosko Aleksandar. *Powder coatings: chemistry and technology*. John Wiley & Sons Inc, 1991.
6. Lehr, William D. *Powder coating systems*. McGraw-Hill Companies, 1991.
7. *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.
8. Koleske, Joseph V. *Radiation curing of coatings*. No. 45. West Conshohocken, PA: ASTM international, 2002.

Course Code	**: PTP-304**
Course Title	**: Formulation and Processing of Paints**
Course Type	**: Practical**
Total Hrs/week	**: 06 hr (PR)**
Course Credit	**: 03**

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 Prerequisites:

Introduction to Coating Technology (PTC-201)
Technology of Pigments (PTC-202)
Architectural Coatings (PTC-301)

Course Content:
Minimum of twelve experiments with due coverage of following:
Formulations, calculations of mill base compositions and processing of Architectural Coatings (covered under PTC-301) on different paint dispersion machineries: sealers, putties, distempers, emulsion paints, solvent borne primers/ undercoats/ topcoats.

Reference Books
1. Departmental Practical Manual.

Course Outcomes:
On completion of this course, the Technocrat will develop laboratory skills related to
1. **Understanding** and calculation of mill base compositions of architectural coatings.
2. **Formulation** and processing of sealers, putties, primers, undercoats and topcoats.
3. Constructive and **comparative** use of ball mills, pug mill, triple roll mill, bead mill etc as paint processing and dispersion machineries
4. **Proposing** cost effective dispersion of different paint formulations using various mills

Elective-II (Open Elective)

Course Code : FTL-306
Course Title : Treatment and Disposal of Food Industrial Waste
Course Type : Theory
Total Hrs/week : 03 hr (TH)
Course Credit : 03

Course Objectives:

1. To study composition, sources, permissible and health hazards of industrial wastewater pollutants
2. To study various techniques of wastewater treatment by physical chemical and biological methods
3. To study, design and operational problems of biological treatment and value addition to waste
4. Estimation of kinetic coefficients for treatment with design problem.

Course Prerequisites: ----Not Applicable----

Course Content:

Unit-I

Physical, chemical and biological characteristics of food industry waste. Composition of typical industry waste.BOD /COD and characterization of effluent. Typical BOD of some food industrial effluents and their discharge limit, types and point sources of industrial pollutants and adverse effect by their discharge.

Unit-II

Primary treatment, secondary and tertiary treatments by physical, chemical and biological methods. Process design criteria. Sanitary disposal of sludge.

Unit-III

Role of micro-organisms in food industry waste. Application of kinetics to biological treatment. Determination of kinetic coefficients with some design problems.

Unit -IV

Activated sludge process and modified activated sludge process. Nitrification and denitrification, Aerobic lagoons, aerated aerobic lagoons, aerated facultative lagoons, Design criteria for A.S.P and stabilization ponds

Unit-V:

Trickling filters, Rotating biological contactors, design criteria and problem on RBC and trickling filter design. Byproduct recovery and value addition to the waste.

Text/ Reference Books

1. Rao, C. S. Environmental Pollution Control Engineering. New Delhi: New Age Internat., 2011
2. Arceivala Sol J., AsolekarShyam R. Wastewater Treatment for Pollution Control and Reuse Tata McGraw-Hill Education, 2006

3. Green, John H., and Amihud Kramer. Food Processing Waste Management. Westport, Conn: AVI Pub. Co, 1979
4. Bartlett, Ronald Ernest. Wastewater Treatment: Public Health Engineering Des In Metric., Applied Science Publishers Ltd, 1971
5. Metcalf, L., H. P. Eddy, and Georg Tchobanoglous. Wastewater Engineering: Treatment, Disposal, and Reuse. New Delhi: McGraw-Hill, 2010
6. Waldron Keith W.,Handbook of Waste Management and Co-Product Recovery in Food Processing, Elsevier, 2007
7. Herzka, A., and R. G. Booth. Food Industry Wastes, Disposal and Recovery. London: Applied Science Publishers, 1981
8. Bhattacharyya Bimal C., Banerjee Rintu, Environmental Biotechnology; Oxford University Press, 2007

Course Outcomes (COs):

Upon completion of the course, the students will be able to:

1. **Explore** composition of industrial effluent and health hazards of pollutants in effluent.
2. **Recognize** primary, secondary and tertiary treatment for industrial effluent treatment and design parameters.
3. **Access** principle, design and working of fixed film biological reactor efficiency.
4. **Manage** industrial effluent for recovery of biological as value addition to waste.

Elective-II (Open Elective)

Course Code : PTL-306
Course Title : Technology of Printing Inks
Course Type : Theory
Total Hrs/week : 03 hr (TH)
Course Credit : 03

Course Objective: The Paint Technocrat will have in depth exposure to

1. Formulation and manufacture of Printing Inks.
2. Various techniques of printing processes.
3. Different applications of printing inks

Course Prerequisites: ----Not Applicable----

Course Content:

Unit-I

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

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

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

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

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

Text/ Reference Books

1. Jones, Frank N., Mark E. Nichols, and Socrates Peter Pappas. *Organic Coatings: Science and Technology*. John Wiley & Sons, 2017.
2. Leach, Robert. *The printing ink manual*. Springer Science & Business Media, 2012.

3. Thompson, Robert. *Printing materials: science and technology*. Pira International, 2004.
4. Flick, Ernest W. *Printing ink and overprint varnish formulations*. William Andrew, 1999.

Course Outcomes (COs):

Upon completion of the course, the students will be able to:

1. **Understand** nature, characteristics and classification of printing inks.
2. **Recognize** principles of ink formulations and **propose** manufacturing of Inks for various substrates.
3. **Assess** press configuration and applications of printing inks.
4. **Compare** and **select** various printing processes.

Elective-II (Open Elective)

Course Code : PLL-305
Course Title : Plastics Waste Management
Course Type : Theory
Total Hrs/week : 03 hr (TH)
Course Credit : 03

Course Objective:

1. To understand the concept of plastics recycling.
2. To understand about various sources of plastics waste.
3. To understand various identification and separation method for waste plastics.
4. To learn about different recycling methods for plastics recycling.

Course Prerequisites: ----Not Applicable----

Course Content:

Unit- I

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.

Unit- II

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.

Unit- III

Recycling of polyolefins - PVC, PET, polystyrene, polyamides-nylon-6 and nylon-6,6, polyurethanes, mechanical process, applications of recycled materials.

Unit- IV

Recycling of rubber – comparison of thermoset and thermoplastic composites, reclaiming of rubber – fuel source – pyrolysis, Depolymerisation of scrap rubber, tyre retreading, uses of recycled rubber – asphalt and other uses.

Unit- V

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

Text/ Reference Books

1. John Scheirs., - "Polymer Recycling Science, Technology and applications" John Wiley and Sons, 1998
2. Nabil Mustafa – "Plastics Waste Management Disposal Recycling and Reuse" Marcel

Dekker Inc., First Edition 1993.
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.
5. Muna Bitter, Johannes Brandup, Georg Menges "Recycling and Recovery of plastics" 1996
6. Attilio.L.Bisio, Marino Xanthos, "How to manage plastics waste: Technology and Market Opportunities" Hanser Publishers, 1994
7. Francesco La Mantia., "Handbook of Plastics Recycling" Chem Tec Publishing,2002

Course Outcomes (COs):

Upon completion of the course, the students will be able to:

1. **Identity** the sources of plastics waste and its separation methods.
2. **Choose** the sustainable approaches of plastic waste management.
3. **Propose** methods of mechanical and chemical recycling of polymers.
4. **Evaluate** recycling of plastics by surface refurbishing.

Elective-II (Open Elective)

Course Code : CHL-321
Course Title : Water Conservation and Management
Course Type : Theory
Total Hrs/week : 03 hr (TH)
Course Credit : 03

Course objectives:
The Objective of this course is to:

1. Understand current water scenarios
2. Need for water conservation and management
3. Strategies for water conservation from source to sink in different sector.

Course Prerequisites: ----Not Applicable----

Course Content:

Unit- I:
Introduction: water cycle, water storage, water quality. Water conservation, Current Demand of water for Domestic, Irrigation and Industries.
Current supply available, Shortage of water, water conservation process and ways to conserve water.

Unit -II:
Understanding water conservation and water quality parameter like TDS, pH, etc. Water management-water quality, controlling use and quality of water, water flow management, water quality control, testing water salinity, preserving water quality. Managing water quality in different sectors.

Unit- III:
Water conservation in agriculture-Reuse of wastewater for irrigation (Methods, Precautions), Irrigation system (Components) and Water user's participation in irrigation system management. Current Supply, utilization and shortage of water

Unit- IV:
Water conservation in construction industry: Importance of saving water in the construction industry in India, reduce and recycle water at construction sites, saving water during wall construction.

Unit- V:
Water Conservation in process industry: Water treatment, recycling, and reuse
Water saving equipment, economics of water, minimising evaporation, water audits.

Text/Reference Books

1. Irrigation Engineering-R.K. Sharma and T.K. Sharma, S.Chand & Company Ltd., New Delhi.
2. Water Resources Systems: Modeling Techniques and Analysis Vedula, S.and Mujumdar, (2005); Tata McGraw Hill, New Delhi.

3. Economics of Water Resources Planning, James, L.D., and Lee, R. R., Mc Graw Hill.
4. Agriculture and water management, P.Verma, Amiga Press Inc.
5. Industrial water treatment process technology, Parimal Pal, Elsevier Science.

Course Outcomes (COs):

Upon completion of the course, the students will be able to:

1. **Understand** the importance of water conservation and management in different sectors.
2. **Identify** the thrust area for water conservation
3. **Develop** management strategies to achieve effective water conservation.
4. **Implement** the developed strategies effectively.

Elective-II (Open Elective)

Course Code : OTL-306
Course Title : Biochemistry & Biotechnology of Lipids
Course Type : Theory
Total Hrs/week : 03 hr (TH)
Course Credit : 03

Course Objectives:
This course is designed to gain the insights about various bio-simulated reactions, pathways, and mechanisms in natural way. Also, the use of enzymes for synthetic modification and applications several fatty products will be studied. Environmental issues from bio-technological industries will also be discussed.

Course Prerequisites: ----Not Applicable----

Course content:

Unit-I
Biosynthesis of fatty acids and phospholipids; Mechanism of chain elongation and desaturation of acyl chains; Regulation of lipid metabolism; Biological role of fat in human nutrition; Atherosclerosis.

Unit-II
EFA, MUFA, PUFA –Sources and biological activities in human health; Biochemical aspects of vitamins in nutrition; Toxic constituents in oilseeds and oils: Sources, structures, toxicological effects and methods of detoxification.

Unit-III
Microbial production of fats and other lipids; Biotransformation of fats and lipids using whole microbial cells; General aspects of Microbial Lipases: Sources, isolation and purification and industrial applications

Unit-IV
Enzymatic Interesterification: Chemistry, reaction in (aqueous/organic) solvent systems, immobilization of enzymes, factors affecting enzyme activity, enzyme kinetics, reactor design.

Unit-V
Structured lipids: Synthesis, analysis and applications
Genetically modified lipids: Physical, chemical and nutritional functionality modifications.
Environmental biotechnology concept: Principles in bioremediation and biological water & waste treatment.

Text/ Reference Books

1. Lehninger's Principles of Biochemistry by David L Nelson; A.L.Lehninger and Michael M. Cox, 5th edition, Worth Publishing.
2. Outline of Biochemistry by Eric.E. Conn and P.K. Stumpf, 5thedition, Wiley India.

3. Lipids: Biochemistry, Biotechnology and Health, 6th Edition by Michael I. Gurr, John L. Harwood, Keith N. Frayn, Denis J. Murphy, Robert H. Michell, Wiley-Blackwell
4. Fatty Acids in Fish Oğuz Taşbozan and Mahmut Ali Gökçe http://dx.doi.org/10.5772/68048
5. Food Lipids Chemistry, Nutrition, and Biotechnology, Fourth Edition Edited Casimir C. Akoh Taylor & Francis Group

Course Outcomes (COs):

Upon completion of the course the students will be able to:

1. **Acquire** the fundamental knowledge of scholarly discourse in lipid synthesis, **recognize** the biological roles vitamins and **examine** the toxicology of lipid components.
2. **Combine** the theories and concepts of microbial lipase in industrial applications.
3. **Illustrate** the critical skills in solving the reaction kinetics and optimizing the enzymatic process.
4. **Differentiate** between structured and genetically modified lipids, and **identify** ethical issues in environmental bioremediation.

Elective-III (Professional Core Elective)

Course Code : PTL-307
Course Title : Engineering of Pigmented Dispersion
Course Type : Theory
Total Hrs/week : 03 hr (TH)
Course Credit : 03

Course Objective:

1. The paint technocrat will have in depth exposure to engineering of dispersion of pigments in polymeric binders using different machineries.
2. The student will learn about the mathematical modelling, comparative evaluation & selection of dispersion machineries.
3. The technocrat will have exposure to outline and layout of paint manufacturing plant.

Course Prerequisites:

Introduction to Coating Technology (PTC-201)
Technology of Pigments (PTC-202)
Architectural Coatings (PTC-301)

Course Content:

Unit-I

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

Unit-II

High speed mixers: underlying fluid mechanics, mill base rheology, tank & impeller dimensions, different impeller geometries & orientations, power input, preparation of latex dispersions on HSD. 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

Ball & pebble mills: Cascading principle, size, speed & design of ball mill; size, shape & composition of balls; mill base composition, power consumption, batch & continuous operation. Roll mills: single, double, triple & multiple roll mills, flow of mill base through rolls, material balance, mill base composition, roll design, power inputs, sophistication in temperature, pressure & safety controls, waste minimization

Unit-IV

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 distribution, nature of premix processing, mill base composition, fineness and stability of microbead dispersion; design of discs & seals in different variants-dyno mill, centri mill, pearl mill etc., sophistication in temperature, pressure, discharge & safety controls, power consumption, cascading of mills; dispersion of nano pigments, ultrasound dispersion.

Unit- V

Comparative evaluation & selection of dispersion machineries, mathematical modeling, Thinning, tinting, straining & filling of finished products, design & operation of tinting machines. 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 (COs):

Upon completion of the course, the students will able to:

1. **Formulate** stable pigment dispersion and **understand** various theories of stabilization.
2. **Design** and **compare** high shear rate and shear stress paint processing machineries.
3. **Compare** and **select** mills for paint processing based on mill base composition
4. **Plan** and **propose** safe handling and safety practices in paint industry.

References:

1. Patton, Temple C. *Paint Flow and Pigment Dispersion*, pp. 479-479. 1964.
2. Jones, Frank N., Mark E. Nichols, and Socrates Peter Pappas. *Organic Coatings: Science and Technology*. John Wiley & Sons, 2017.
3. Malshe, V. C. *Basics of Paint Technology part II*. Color Publications, 2010.
4. Doroszkowski, A. "The physical chemistry of dispersion." In *Paint and Surface Coatings: Theory and Practice*. Woodhead Publishing Cambridge Cambridge, 1999.

Elective-III (Professional Core Elective)

Course Code : PTL-308
Course Title : Synthesis and characterization of Polymers
Course Type : Theory
Total Hrs/week : 03 hr (TH)
Course Credit : 03

Course Objective:

The paint technocrat will have in depth exposure to

1. Synthesis techniques of polymers.
2. Physicochemical characterisation of polymers.
3. Qualitative and quantitative analysis of polymers.
4. Various sophisticated tools used in the analysis of polymers.

Course Prerequisites:

Chemistry and Technology of Polymers (PTC-302)

Course Content:

Unit-I: Mechanism, and applications of various techniques: Anionic polymerization, cationic polymerization, ring-opening polymerization, metathesis polymerization, group transfer polymerization, ATRP

Unit-II

Concept of average molecular weight, determination of number average, weight average, viscosity average and Z-average molecular weights, Molecular weight and molecular weight distribution determination by dilute solution viscometry, GPC/SEC with a RI/ Light scattering detector, vapor phase osmometry.

Unit- III

Polymer crystallinity, morphology analysis of polymers using XRD; thermal characteristics of crystalline/ amorphous 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- IV

Identification of the type of functional groups present in a polymer using IR, attenuated total reflection (ATR), 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- V: Curing and mechanism of film formation, functionality concept, resin-hardener 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

Text/Reference Books:

1. R. 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
3. Barth, Howard G., and Jimmy W. Mays, eds. *Modern methods of polymer characterization*. Vol. 115. John Wiley & Sons, 1991.
4. Yang, Rui. *Analytical methods for polymer characterization*. CRC Press, 2018.

Course Outcomes (COs): Upon completion of the course, the students will be able to:

1. **Review** various types of polymerization techniques
2. **Demonstrate** various techniques for determination of molecular weights of polymers.
3. **Analyse** structure**,** mechanical, thermal and electrical properties of polymers.
4. **Propose** high end scientific tools in physicochemical characterisation of polymers and coatings

General Textbook

1. Jones, Frank N., Mark E. Nichols, and Socrates Peter Pappas. *Organic Coatings: Science and Technology*. John Wiley & Sons, 2017.
2. Malshe, V. C. *Basics of Paint Technology part I*. Color Publications, 2010.
3. Swaraj, Paul. *Surface Coatings: Science and Technology*. J. Wiley & sons, 1985.
4. Lambourne, Ronald, and T. A. Strivens, eds. *Paint and Surface Coatings: Theory and Practice*. Elsevier, 1999.
5. Müller, Bodo, and Ulrich Poth. *Coatings Formulation*. Hanover: Vincentz Network, 2011.
6. Freitag, Werner, and Dieter Stoye, eds. *Paints, Coatings and Solvents*. John Wiley & Sons, 2008.

Reference Books

1. Talbert, Rodger. *Paint Technology Handbook*. CRC Press, 2007.
2. Feist, William C. Painting and finishing exterior wood. *Journal of Coatings Technology* 68, no. 856 (1996): 23-26.
3. Satas, Donatas, Tracton, and Rafanelli. "*Coatings Technology Handbook*." (2002): 67-68.
4. Streitberger, Hans-Joachim, and Karl-Friedrich Dossel, eds. *Automotive Paints and Coatings*. John Wiley & Sons, 2008.
5. McBane, B. N. Automotive Coatings Monograph, *Federation of Societies for Coatings Technology.* Blue Bell, PA: SAE (1987): 39.
6. Polymers for Electrical Insulations", Edited by Horst Sulzbach, Ser. 314, DIE BIBLIOTHEK DER TECHNIK, Elantas GmbH, 2008.
7. Lehr, William D. *Powder coating systems*. McGraw-Hill, 1991.
8. SSPC, B. "Steel Structures Painting Manual, Vol. 1, Good Painting Practice." *Society for Protective Coatings* (1993).
9. Hare, Clive H. "Protective Coatings: Fundamentals of Chemistry and Composition." *Surface Coatings International* 78, no. 4 (1995): 157-165.
10. Martin, J. W., S. C. Saunders, F. L. Floyd, and J. P. Wineburg. "Methodologies for Predicting the Service Life of Coatings Systems *Federation of Societies for Coatings Technology." Blue Bell, PA, USA* (1996).
11. *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.
12. Sangermano, M. "In Photoinitiated Polymerization; Belfield, KD; Crivello, JV, Eds." In *ACS Symposium Series*, vol. 847, p. 242..
13. Koleske, Joseph V. *Radiation curing of coatings*. No. 45. West Conshohocken, PA: ASTM international, 2002..
14. Scranton, Alec B., Christopher N. Bowman, and Robert W. Peiffer, eds. *Photopolymerization: fundamentals and applications*. American Chemical Society, 1997.
15. N.R. Kondekar *A Window to Paints & Coatings Technology*, Colour Publications., Mumbai 2010

16. Dr. Ashok B. Karnik *Essentials of Pigments - Application and Selection* Colour Publications Mumbai
17. Glass, J. E., Ed., *Technology for Waterborne Coatings*, American Chemical Society, Washington, DC, 1997.
18. Karsa, D. R.; Davies, W. D., Eds., *Waterborne Coatings and Additives*, Royal Society of Chemistry,Cambridge, 1995.
19. Pruskowski, S. J., Jr., Ed., *Waterborne Coatings Technology*, Federation of Societies for Coatings Technology, Blue Bell, PA, 2005.
20. Buxbaum, Gunter, ed. *Industrial inorganic pigments*. John Wiley & Sons, 2008.
21. Berte, J. N. "*High Performance Pigments*, ed Smith HM." (2002): 27-40.
22. Bieleman, Johan, ed. *Additives for coatings*. John Wiley & Sons, 2008.
23. Herbst, Willy, and Klaus Hunger. *Industrial organic pigments: production, properties, applications*. John Wiley & Sons, 2006.