5.1 SPECIAL PURPOSE COATINGS

L T P
4 - -

RATIONALE

This subjectis designed to make the students aware of speciality applications which are now being used in industries. This will make the students understand the wider scope of paints apart from regular application.

DETAILED CONTENTS

1) **Exterior coatings** – Formulation of exterior coating, solvent and water based coatings, roof coatings.   (08 Periods)

2) **Interior coatings** - Factors determining selection of coatings, coatings for wood metal, masonry etc., wall coating, floor paints, sealer, primers, stoppers, under coats, finish coats.   (07 Periods)

3) **Decorative paints** – selection of decorative paints, formulation of decorative paint, water borne coatings.   (07 Periods)

4) **Industrial Coatings** –Application techniques, curing methods, forced drying or stoving, furniture finishes, lacquers, automotive coatings, industrial structures and industrial buildings(chemical paints).   (07 Periods)

5) **Aircraft Coatings** - Air craft finishes, modern aircraft finishes application.
                                                                                    (05 Periods)

6) **Marine Coatings** – ship's paints, fouling organisms, leaching rate, types of antifouling paints, recent developments.   (08 Periods)

7) **Primer coatings for special purpose** - Red oxide primers, zinc chromate, zinc rich primers, etch primers, maintenance paintings, painting of concrete.
                                                                                    (07 Periods)

8. **Power Coatings –** Definition, raw material, Manufacturing steps for powder, application methods of powder coatings, applications.   (08 Periods)

9. **Recent Developments -** Radiation curable coatings, photo polymerization, Optical coating-traffic/rail roads, nuclear power plant, radiation resistance coatings. (09 Periods
                                                                                    (07 Periods)

INSTRUCTIONAL STRATEGY

Actual application should be shown by visits to sites.

RECOMMENDED BOOKS

1. Organic Coating Technology, Vol. I & . II by R.F. Paynl
2. Surface coating vol. I and II OCCA, Australia
3. Outlines of Paint Technology by W.M. Margans
4. Surface coatings science and technology by Swaraj Paul

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (Periods)	Marks Allotted (%)
1	8	12
2	7	10
3	7	10
4	7	10
5	5	14
6	8	10
7	7	10
8	8	12
9	7	12
Total	**64**	**100**

5.2 NATURAL RESIN

L T P
4 - 4

RATIONALE

This subject is designed for students who will be involved in development of coatings in their daily professional life This involves the chemistry, raw materials, formulations and applications of various resins which are important component of the coatings.

1. **Fundamentals of film formers**- monomers, functionality and its determination, degree of polymerization, molecular weight, convertible and non-convertible film former.   (10 Periods)

2. **Polymer** - linear, branched and cross linked, natural and synthetic, homo-polymers and copolymers.   (10 Periods)

3.   **Natural resin**- classification and properties of natural resins, processing of natural resins like copal, congo etc. Rosin sources, oleo resin and its composition. Recovery of resin and turpentine from oleoresin, modification of rosin calcium, rosin zinc and polymerized rosin, Shellac origin, different kinds of lacs and their properties, composition of lac, chemical modification of shellac for use in coatings, oleo resinous varnishes.   (14 Periods)

4. **Bitumen**- pitches, gums and glues, natural bitumen's and petroleum Bitumen pitches, general properties of gums and glues.   (10 Periods)

5. **Cellulose**- source, properties, modification of cellulose for use in surface coatings like cellulose esters, ethers, water soluble cellulose derivatives, their properties, testing and uses in lacquers.
                                                             (10 Periods)

6. **Rubber resins**- source of natural rubber, properties and modifications of rubber like chlorinated rubber, cyclised rubber or isomerised rubber. Their properties and uses.   (10 Periods)

   LIST OF PRACTICALS
   1. To test softening point of natural resins.
   2. To determine acid value of natural resins.
   3. To test the acid value and softening point of ester gum.
   4. To test the penetration of natural resins.
   5. To prepare varnish and test the acid value.

RECOMMENDED BOOKS

1. Organic Coating Technology, Vol. II by H.F. Payne
2. Surface Coating, Science and Technology, Ed. 2, Swarj Paul(john Wiley), 1997.
3. Outlines of Paint Technology by W.M. Morgans
4. Orgnic Coatings Wicks W; Jones FN.; Pappas S.P.; & Wicks D.A. (John Wiley 3rd Edn. 2007).

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (Periods)	Marks Allotted (%)
1	10	16
2	10	16
3	14	20
4	10	16
5	10	16
6	10	16
Total	**64**	**100**

L T P
5 - -

RATIONALE

This specialized subject will enable the students to study the paint technology in detail along with its applications and defects. This subject is of importance in view of the increasing job potential in paint industry

DETAILED CONTENTS

1. **Introduction**   (06 Periods)
    Definition of paint, primers, varnish, solvent, binder (resin) and additives and functions of each component. Pigment volume, concentration (PVC) and critical pigment concentration (CPC)

2. **Synthetic resin-** Introduction, raw material, basic chemistry, properties and uses of such types of resins like alkyd resin, Epoxy resin, phenolics resins, polyester resin, silicone.   (12 Periods)

3. **Solvents**   (06 Periods)
    Classification of solvent and general properties of solvent

4. **Pigments**   (06 Periods)
    Introduction, general physical Properties like colour, tinting strength, opacity, particle size, oil absorption. Classification of Pigment and name of pigments (organic and inorganic).

5. **Manufacturing Process**   (06Periods)
    Paint manufacturing by ball mill and sand mill

6. **Coatings**   (06 Periods)
    Type of coating –under coating, finishing coating.

7. **Primers**   (08 Periods)
    Introduction, purpose of Primer, classification of Primer and uses.

8. **Paints**   (08 Periods)
    Classification of paint(such as Latex, Emulsion, Glossy) and formulation and uses.

9. Application Methods   (09 Periods)
    Introduction and different application methods such as brush coating, rolling coating, spray coating, Dip coating, powder coating, CED (cathodic electro disposition), advantages and disadvantages of these methods.

10. **Paint Defects** (06 Periods)

Introduction, causes and remedies methods of paint defects such as Settling, Brush drag, cracking, cratering, peeling, Pin holding, Wrinkling

11. **Testing Method** (07 Periods)

Introduction and testing of different properties of paint and different coatings like viscosity, hardness,flexibility,covering power,gloss,impact resistance.

INSTRUCTIONAL STRATEGY

Extension lectures by a person from a paint industry will provide valuable inputs regarding latest techniques and new types of coatings/paints . Visits to paint industry like ICI paints, Asian Paints will provide the outlook of a paint plant, new equipment and techniques used in the plants and know how about the latest application technologies of paint. Visit to fully automated plants like ICI will also provide inputs about process control and instrumentation.

RECOMMENDED BOOKS

a)   Surface Coating by Swaraj Paul

b)   Outline of Paint Technology, Vol. 2 by WM Morgans

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (Periods)	Marks Allotted (%)
1	06	05
2	12	15
3	06	10
4	06	10
5	06	10
6	06	10
7	08	08
8	08	08
9	09	08
10	06	08
11	07	08
Total	**80**	**100**

L   T   P
6   -   4

RATIONALE

In this subject the basic concepts of mass transfer are covered to enable the students to understand working of various mass transfer equipment like distillation column, gas absorption column, dryers, cooling towers and extraction column etc. which are used in industries for purification of products.

DETAILED CONTENTS

1-Mass transfer   **(20 Periods)**

Definition of diffusion, Rate of diffusion in Mass Transfer, Fick's law, Maxwell law of diffusion, diffusivity, diffusion in the gas phase-Equimolecular counter diffusion and nondiffusing diffusion, diffusion in the liquid phase-Equimolecular counter diffusion and nondiffusing diffusion., Mass Transfer Coefficient. Film theory and penetration theory of Mass Transfer,

2- Gas Absorption   **(20 periods)**

Condition of equilibrium between liquid and gas, mechanism of absorption two film theory. Diffusion of a gas through a stagnant gas, diffusion in liquid phase, rate of absorption, relation between film and overall coefficients, rate of absorption in terms of mole fraction, factors affecting transfer coefficients.

Packed Tower

Properties of tower packing, types of packing, Channeling ,Minimum liquid gas ratio Loading and Flooding Capacity of packed tower Material balance and design equation, height of column based on conditions in gas film and liquid film, height of column based on overall coefficient, the operating line and graphical integration for height of column. Concept of transfer unit. H.E.T.P. for packed column of distillation, relation of H.T.U. to H.E.T.P... Derivation of the following relations

$$1. \quad \frac{1}{K_G a} = \frac{1}{k_G.a} + \frac{m}{k_L.a}$$

$$II. \quad \frac{1}{K_L a} = \frac{1}{k_L.a} + \frac{m}{k_G.a}$$

3.   **Distillation**   **(30 Periods)**

a)   **Various distillation methods**
i)   Equilibrium or flash distillation
ii)   Differential distillation
iii)   Batch distillation
iv)   Vacuum and Steam distillation
v)   Azeotropic and Extractive distillation.

b)   **Types of distillation columns**

i)   Perforated plate or sieve plate column

    ii)   Bubble cap plate column

    iii)   Packed column and fractionating column accessories.

c)   Boiling point diagrams

Raoult's law; Henry's law, Relative volatility, constant boiling mixtures, equilibrium diagram and construction of equilibrium diagram, Fractionating column calculation- Heat & material balance, Reflux ratio, equilibrium plate, Location of feed plate. Sub cooled reflux; effect of reflux ratio, Total reflux, Minimum reflux ratio Entrainment; McCabe Thiele diagram-section above and below feed plate; Intersection of operating line. Location of q-line, derivation of q line, optimum reflux ratio, calculation of no. of equilibrium plates by Mc-Cable Thiele diagram. Overall plate efficiency.

4.   Extraction   **(08 Periods)**

    i)   Applications of this extraction

    ii)   Choice of solvent

    iii)   Steps of extraction operation

    iv)   Solid Liquid extraction, construction and description of
- Moving solid bed Basket type oil seed extractor or Boll man extractor
- Rotocel extractor

    v)   Liquid extractor; description and construction of
- Mixer settler extraction system
- Spray and packed extraction tower

5.   Humidification   **(10 Periods)**

Definition and calculation of

    i)   Humidity

    ii)   Percentage humidity

    iii)   Relative humidity

    iv)   Humid volume

    v)   Humid heat

    vi)   Enthalpy and its calculation

    vii)   Dry bulb and wet bulb-temp

    viii)   Adiabatic saturation temperature

    ix)   Use of humidity chart. Dew point, simple numerical problem
using humidity chart, construction and description of cooling towers
(Natural and induced draft)

6.   Drying   **(08 Periods)**

General drying behavior-Critical moisture content, equilibrium moisture contents, description and construction of dryer.

    i)   Tray dryer

    ii)   Screen conveyor dryer

    iii)   Rotary dryer.

NOTE: - At least one question from each topic

LIST OF PRACTICALS

1. To study the rate of drying in a vacuum dryer
2. To determine the pounds of volatile compounds distilled per unit pounds of steam distilled in a steam distillation operation
3. To determine rate of setting of crystals in a crystallizer
4. To study the rate of drying in rotary dryer
5. To determine drying rate for a wet materials
6. To determine drying rate for a wet material in a tray dryer
7. To study packed tower in various industries
8. To study various extractors in solvent extraction plant
9. To study a spray pond in a sugar and other industries for cooling system
10. To find out the drying characteristics of given sample and draw drying rate curve by infra-red moisture meter and rapid moisture meter
11. To study sketch and operation of strip chart recorder and directing pen recorder

INSTRUCTIONAL STRATEGY

Field visit will make the students familiar with different types of column (packed/tray) and different types of packings/trays used in the column. This will also make the students aware of auxiliary equipment/manholes/supports used for the columns. Along with the theoretical part, emphasis should be given to problem solving and practices especially for distillation column, absorption and humidification.

RECOMMENDED BOOKS

1. Mass Transfer Operations by Trybal
2. Unit Operation by McCabe and Smith
3. Mass Transfer I & II by Bhattacharya
4. Mass Transfer by Gavhane
5. Mass Transfer by Badger

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time period Allotted	Marks Allotted (%)
1	20	15
2	20	15
3	30	35
4	08	10
5	10	15
6	08	10
Total	**96**	**100**

5.5. SYNTHETIC RESIN

	L	T	P
	5	-	4

RATIONALE

This subject deals with chemistry, raw materials, synthesis and formulation of various industrial resins used in coating industry.

DETAILED CONTENTS

1. Phenolic Resins - Introduction, raw material, basic chemistry, manufacturing process, types of phenolic, properties and applications.   (10 Periods)

2. Amino Resins - Introduction, raw material, basic chemistry, manufacturing process of urea formaldehyde, Melamine formaldehyde resins, properties and applications.   (10 Periods)

3. Silicon Resins - Introduction, raw material, basic chemistry, manufacturing process, properties and applications.   (10 Periods)

4. Epoxy Resins - Introduction, raw material, basic chemistry, manufacturing process of single pack and double pack systems, properties and applications.
                   (10 Periods)

5. Acrylic Resins: Introduction, raw material, basic chemistry manufacturing process of thermoplastic and thermosetting acrylic, properties and applications.   (10 Periods)

6. Alkyd resins - Introduction, raw material, basic chemistry manufacturing process, properties and applications.
                   (10 Periods)

7. Vinyl Resins: Introduction, raw material, basic chemistry manufacturing process, properties and applications.
                   (10 Periods)

8. Fluoropolymers- Introduction and properties of Fluoropolymers Importance and applications in high temperature and fire resistance coatings.   (10 Periods)

INSTRUCTIONAL STRATEGY

As the subject involves synthesis of various resin used in paint industry. It can be made more interacting by showing various paint samples (automotive, wall coatings, high duty coatings etc.)so that students can appreciate different types of resin and their properties.

LIST OF PRACTICALS
   d) To synthesize alkyd resins and test acid value and drying value
   e) To synthesize urea formaldehyde resin and test the solubility
   f) To synthesize phenolic resin and test the solubility and softening point

g) To prepare medium oil alkyd resin and test the acid value

h) To prepare oil and resins varnish.

RECOMMENDED BOOKS

vi) Organic Coating Technology, Vol. II by H.F. Payne

vii) Surface Coating, Science and Technology, Ed. 2, Swarj Paul(john Wiley), 1997.

viii) Outlines of Paint Technology by W.M. Morgans

ix) Orgnic Coatings Wicks W; Jones FN.; Pappas S.P.; & Wicks D.A. (John Wiley 3rd Edn. 2007).

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (Periods)	Marks Allotted (%)
1	10	12
2	10	12
3	10	12
4	10	14
5	10	14
6	10	12
7	10	12
8	10	12
Total	**80**	**100**

5.6   REACTION ENGINEERING

L T P
5 - -

RATIONALE

It is a core subject of chemical engineering and is essential for understanding the kinetics of various types of reaction vessels and the performance of reactive system used in industry.

DETAILED CONTENTS

1. **Introduction:** (5 periods)

What is reaction engineering? Chemical kinetics & their dynamics classification of chemical reactions. Based on (i) Phases involved, (ii) Catalytic and non-catalytic reactions, (iii) Molecularity of a reaction, (iv) Heat effect, (v) based on order of reactions, (vi) reversible and irreversible reactions.

2. **Homogeneous Reactions:** (20 periods)

Rate of chemical reaction, factors affecting the rate of reaction. Concentration dependent term of a rate equation. Rate constant, Elementary and non-elementary reaction. Difference between elementary and non-elementary reactions. Molecularity of a reaction, order of a reaction. Difference between molecularity & order of reaction. Representation of an elementary & non-elementary reaction. Temperature dependent term of a rate of equation, Temperature dependency from Arrhenius law, collision theory & thermodynamics. Activation energy & its significance, activation energy & temperature dependency. Simple numerical problems,

3. **Interpretation of constant volume batch reactor data:** (35 periods)

Kinetic run, kinetic data or rate data, integral method of analyses of rate of data, differential method of analysis of rate of data. Integral V/s differential method, Constant volume batch reactor, conversion, relation of concentration and conversion for constant volume batch reactor.

Find out the concentration of component B, C & D in
   (a) Chemical reaction of the type aA+bB → cC+dD   and for
   (b) For flow systems.
Analysis of total pressure data obtained in a constant volume system, use of ideal gas law. To calculate C_{Ao}.

Integral method of analysis of rate data; integrated rate expression for different order of reactions:

(A) Irreversible unimolecular type first order reactions:
   i.   Integrated rate equation or expression for the first order reaction in terms of concentration, relation between half-life and rate constant.
   ii. Integrated rate equation or expression for the first order reaction in terms of conversion
(B) Irreversible bimolecular type second order reaction:
   i.   Integrated rate equation or expression for the second order reaction in terms of concentration. Relation between half-life and rate constant and concentration.
   ii. Integrated rate equation or expression for the second order reaction in term of conversion.
   iii. Integrated rate equation for second order reaction with $C_{Ao} \neq C_{Bo}$ in terms of concentration.
   iv. Integrated rate equation or expression for second order reaction with C_{Ao}

$\neq C_{Bo}$. In term of conversion.

(C)   **Zero order reaction**: zero order reaction in terms of concentration & Conversion. Characteristics of zero order reaction.

(D)   Empirical rate equation of nth order. Determination of overall order of irreversible reaction from half-life, Irreversible reaction in parallel/series & homogeneous catalyzed reactions, Auto catalytic reactions, Reversible reactions: Reversible reactions of unimolecular type first order reactions, reversible unimolecular type second order reactions.

(E)   **Differential method of analysis of data** :
I)   Step by step procedure for analysis of the complete rate equation by differential method.
II) Variable volume batch reactor: - Unimolecular type general reaction expression in which the volume is a liner function of conversion of a reactant. An integrated rate expression for first order reaction for variable volume system. Integrated rate expression for zero order reaction for a variable volume system.
Bimolecular type reactions: integrated rate expression for first & second order reactions. Simple numerical problems.

4.   **Ideal Reactors**:   (20 periods)
Classification of reactors based on
   a.   Shape & size
      i.   Tank reactors
      ii.   Tubular reactors
   b.   Based on mode of operation
      i.   Batch reactors
      ii.   Semi batch reactors
      iii. Continuous flow reactors
Application, advantages, disadvantages and comparison of reactors.

      Relation between C_A & X_A. Ideal batch reactor: - Performance/design equation for batch reactor for constant volume/constant density and for variable volume/density reaction system. The performance measures of flow reactors: - Space time and space velocity. Steady state mixed flow reactors (CSTR):- The performance equation for constant and variable volume/density reaction system. Steady state plug flow reactor: - Performance equation for plug flow reactor for first order reaction in case of constant density and variable density system. Holding time and space time for flow reactors.

INSTRUCTIONAL STRATEGY
Simple models can be made to show batch reactors, plug flow reactors and continuous reactors. Emphasis should be laid on problem solving / numerical solving for rate constants and temperature dependence of rate constant.

RECOMMENDED BOOKS

1.   Chemical Reaction Engineering by Levenspiel, Job Wiley Publications

2.   Chemical Engineering Kinetics by Smith, McGraw Hill Publication

3.   Elements of Chemical Reaction engineering by Fogler, Prentice Hall of India

4.   Reaction Kinetics for Chemical Engineering by Wales, McGraw Hill Publication

5.   Chemical Reactin Theory – An Introduction by Denbigh and Turner, Cambridge University Press Publication

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (Periods)	Marks Allotted (%)
1	05	10
2	12	20
3	35	50
4	20	20
Total	**80**	**100**