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**NORTH MAHARASHTRA UNIVERSITY,  
JALGAON - 425 001**

**SYLLABUS  
FOR**

**M. Sc. [Polymer Chemistry]  
From June, 1993**

**Semester I to IV**

**Department of Chemical Sciences**

NORTH MAHARASHTRA UNIVERSITY, JALGAON

Syllabus for M.Sc. (Polymer Chemistry)

Eligibility/Pre-requisit: (a) Candidate must have passed B.Sc. degree with chemistry or polymer chemistry as principal subject and preferably with physics as subsidiary subject securing more than 50% marks.

General Introduction to the Course.

Syllabus for two years M.Sc. course in polymer chemistry has been prepared as per the guidelines of U.G.C. and considering the requirements of the national needs. The students will be exposed to the basic as well as advanced knowledge of the subject covering synthesis, characterization and processing of polymers.

Oppertunities for employment for successful student exist in India's expanding public and private enterprises dealing with polymer (Rubbers and Plastics) industries. There also exists ample scope for self-employment in starting own units and in small scale processing plants.

The M.Sc. syllabus comprises of 20 courses spread over 4 semesters. These courses are so structured as to cover the important and modern aspects of the subject with practical demonstration. There are 5 courses per semester. The examination pattern includes internal as well as university examination. A student has to pass separately in the internal as well as external examinations of courses.

## SYLLABUS

for

M.Sc. [Polymer Chemistry]

### SEMESTER I

- PCH 101 : Introduction to Polymers
- PCH 102 : Applied chemistry
- PCH 103 : Basic Principles of Chemical Processes.
  
- PCH 104 : Computer Programming and Utilization
- PCH 105 : Laboratory - I

### SEMESTER II

- PCH 201 : Principles of Polymerization
- PCH 202 : Physical Chemistry
- PCH 203 : Organic Reactions & Synthesis
- PCH 204 : Instrumental Methods of Analysis
- PCH 205 : Laboratory - II

### SEMESTER III

- PCH 301 : Characterization Techniques
- PCH 302 : Plastics Additives
- PCH 303 : Industrial Polymers-I
- PCH 304 : Special Laboratory-I
- PCH 305 : Project (Part-I)

### SEMESTER IV

- PCH 401 : Rubber Chemistry and Technology
- PCH 402 : Processing of Polymers
- PCH 403 : Industrial Polymers-II
- PCH 404 : Special Laboratory-II
- PCH 405 : Project (Part-II)

M.Sc. [ POLYMER CHEMISTRY ]

[ TWO YEAR COURSE ]

FIRST YEAR (SEMESTER I)

Subject Code	Subjects	Scheme of Exam.		Total Marks
		Internal	External	
PCH 101	Introduction to Polymers	40	60	100
PCH 102	Applied Chemistry	40	60	100
PCH 103	Basic Principles of Chemical Processes	40	60	100
PCH 104	Computer Programming and Utilization.	40	60	100
PCH 105	Laboratory - I	40	60	100
Total		200	300	500

## PCH 101 : INTRODUCTION TO POLYMERS

### 1. Basic Concepts and Polymer Nomenclature :

Concept of functionality and reactivity, Degree of polymerisation, Homopolymers, Co-polymers, Linear polymers, Branched Polymers, Cross linked or three dimensional polymers, Block co-polymers.

### 2. Classification of Polymers :

Organic polymers, Elemento-organic polymers, Regular and irregular polymers, Chemical Heterogeneity, Polar and non-polar polymers.

Introduction to Plastics (Thermoplastics and Thermosets), fibers, foams, adhesives and elastomers, Natural Polymers, Stress-strain curves.

### 3. Polymerization Phenomenon :

Types of Polymerisation, Chain (Addition) Polymerisation, Step (Condensation) Polymerisation, oxidative coupling.

4. (a) Chain Polymerisation : Radical Polymerisation and ionic polymerisation, basic concepts of Cationic and Anionic methods of polymerisation, Initiation, propagation and termination, living polymers.

Methods of Initiation : Thermal decomposition of initiators, Radox initiation, Photochemical initiation, Initiation of ionising radiation, thermal initiation, Electroionisation and plasma, Initiation using special initiators, determination of efficiency of initiation.

Methods of Termination : Inhibitions, Retardation and termination by chain transfer.

(b) Step (Condensation) polymerisation: Degree of polymerisation. polydispersity, Comparison of Chain and Step polymerisation.

5. Ring Opening Polymerisation : Polymerisation mechanism of cyclic ethers, cyclic amides, N-carboxy- and amino acid anhydrides, cyclosiloxanes.

6. Methods of Polymerisation : Solution polymerisation, Bulk polymerisation, Emulsion polymerisation, Suspension polymerisation, Interfacial polymerisation.

7. Polymer Degradation : Thermal, mechanical, photochemical and chemical.

8. Polymer alloys and blends

## BOOKS RECOMMENDED :

1. Physical Chemistry of Polymers - A.Tager, Mir Pub. Moscow
2. Principles of Polymer Chemistry - P.J.Floory
3. Principles of Polymerisation - G.Odian, Wiley Inter-Sci.
4. Text Book of Polymer Science - F.W.Billmeyer, Wiley Inter-Sci
5. Polymer Science & Materials - A.V.Tobolsky

### PCH - 102 APPLIED CHEMISTRY

(1) Water Treatment : Soft water, hard water, methods of softening of hard water, lime-soda, zeolite and ion exchange processes. Calculation of softening reagents. Estimation of hardness of water - EDTA and soap titration method. Characteristics of boiler feed water and boiler troubles.

(2) Fuels : Fuels and their classifications, calorific value, types of coal and its analysis, preparation and properties of metallurgical coke, classification origin and refining of petroleum, methods of cracking, synthetic gasoline, purification of gasoline, knocking, octane number, cetane number. Natural gas, coal gas, producer gas water gas. Simple problems based on calorific value and combustion calculations.

(3) Synthetic Fibers : Classification, types of polymerisation, classification of plastics, constituents of plastics. Fabrication of plastics. Engineering properties and uses of plastics. Manufacture, properties and uses of plastics. Manufacture, properties and uses of thermoplastics like polyethylene, polystyrene, and thermosetting resins like urea-formaldehyde, phenol-formaldehyde. Common types of synthetic rubber like neoprene, Thiokol, Silicone, polyurethane. Industrial uses of rubber recovery of waste rubber.

(4) Lubricants : Mechanism of lubrication, classification, properties, testing and selection of lubricants.

(5) Refractories : Definition, Criteria of good refractory, classification, properties, conditions which lead to failure of refractories and testing of refractories, manufacture, properties and uses of common refractories.

(6) Corrosion : Electrochemical corrosion, factors affecting the rate of corrosion, different types of corrosion, Metallic, in-organic and organic coating for corrosion protection.

(7) Environmental Pollution :

- i. Air pollution : Introduction, environmental segments, composition of the atmosphere, atmospheric structure, classification of air-pollutants and their effects. control of air pollution, techniques employed for the control of air pollution.
- ii. Water pollution: Introduction, classification of water pollutants, methods used in waste water treatment.
- iii. Soil pollution : Introduction, causes of soil pollution, control of soil pollution.

### Recommended Books :

- 1) Engineering Chemistry - P.C. Jain, Dhanpatrai & Sons
- 2) Engineering Chemistry -S.S. Dara, S.Chand & Sons
- 3) Engineering Chemistry -Agrawal
- 4) Polymer Chemistry-V.R.Gowariker, Wiley Eastern Ltd.

### PCH-103 Basic Principles of Chemical Processes.

Importance of Chemical Industry, its Development and Growth.  
-Importance of the chemical Industry, New Developments in Chemical Technology, The Quality and production cost of Chemical products,

### Basic Principles of Chemical Technology

-A Chemical Technological process, Classification of Chemical Technological process, Chemical Equilibrium, Rates of Technological Processes, Method of increasing the process rates, Technological Schemes.

### Reactors types

-For homogeneous processes, Heterogenous processes in Gas-liquid, liquid-solid & Gas-Solid.

### Introduction to unit processes and unit operations

### Industrial Processes

Sulphur Industries - Production of Sulphuric acid  
Nitrogen Industries - Production of Nitric acid, Ammonia, Urea, Ammonium Nitrate.  
Phosphorus Industries - Production of calcium phosphates  
Cement and lime industries  
Starch and sugar industries  
Inorganic pigments - white, blue & yellow.  
Chlor-alkali Industries - Soda ash Bicarbonates, alkalies, Chlorine, Caustic Soda.

### Recommended Books

1. C.E.Dryden, Outline of Chemical Technology- Ed. by M. Gopal Rao & Marshall Sittig Affiliated East-West Press.
2. R.N.Shreve & J.A. Brink - Chemical Process Industries, McGraw Hill, 3rd Ed.

### PCH 104 : COMPUTER PROGRAMMING & UTILISATION

1. Logical Organisation of Computer system, introduction to number system, introduction to computer programming. Algorithms & flow charts, program development process.

224 Introduction to FORTRAN-77, character set, data types, expressions, operations, standard functions.

3. Sequential Structures :
  - \* Assignment Statement
  - \* Input & output Statements (list - directed )
  - \* STOP Statement
  - \* END Statement
4. Selective Structures
  - \* GOTO Statements : Assigned GOTO, Computed GOTO
  - \* IF Statement : Logical IF, Block IF, Arithmetic IF
  - \* Nested Block IF structure
  - \* Multi-alternative selective structure
5. Repetitive Structures :
  - \* IF Loop
  - \* DO Loop
  - \* Nested DO Loop
6. Subscripted variables : Notation
  - \* Arrays
  - \* DIMENSION Statement
  - \* Input/Output of arrays
  - \* PARAMETER Statement
7. Format - Directed Input & Output
  - \* Input/output Statements
  - \* FORMAT Statement
  - \* Format Specifications
8. Subprograms
  - \* Purpose & Use
  - \* Function : Library, Statement, Function subgroups
  - \* Subroutines : CALL Statement
  - \* DATA, SAVE, COMMON Statement
9. File Processing
  - \* Opening & closing files
  - \* Obtaining information about a file
  - \* File Input & Output
  - \* File positioning
10. Additional Features
  - \* PROGRAM Statement
  - \* PAUSE Statement
  - \* EQUIVALENCE Statement

TEXT BOOKS :

1. V.Rajaraman - Computer Programming in FORTRAN-77, PHI (1990)
2. Ram Kumar - Programming with FORTRAN-77, TMH



REFERENCES :

1. Deive & Hoffman FORTRAN-77 : A structured Disciplined style  
Mc Graw Hill
2. Kernighan B.W. & Plughter P.J. : Elements of Programming  
style, Mc Graw Hill, N.Y.

PCH 105 : Laboratory I

1. Kinetics (Volumetric and colourimetry).
2. Saponification value.
3. Refractometry
4. Determination of C.O.D.
5. Ore Analysis
6. Iodine Value
7. Complex preparation
8. Spectrophotometry
9. Conductometric titration of mixture of acids (4)
10. Column chromatography
11. pH metric titrations.
12. Potentiometry
13. Separation techniques
14. Flame photometry

LIST OF EXPERIMENTS FOR COMPUTER PROGRAMMING

1. Finding Largest/Smallest of given numbers using array & without array.
2. Arranging numbers in ascending & descending order using array & without array.
3. Matrix Multiplication
4. To find Transpose of a given matrix
5. Find  $\sin(x)$  using Taylor Series Expansion & Compare the obtained value with the value obtained using standard function.
6. To accept any integer number & write it in reverse order. Also find sum of its digits.
7. Generate first 100 prime numbers starting from any prime number.
8. Find GCD of given numbers.

FIRST YEAR (SEMESTER II)

Subject Code	Subject	Scheme of Exams		Total Marks
		Internal	External	
PHC 201	Principles of Polymerization	40	60	100
PHC 202	Physical Chemistry	40	60	100
PHC 203	Organic Reactions and Synthesis	40	60	100
PHC 204	Instrumental Methods of Analysis	40	60	100
PHC 205	Laboratory Course II	40	60	100
Total		200	300	500

## PRINCIPLES OF POLYMERIZATION

## Step polymerization:

Reactivity of functional groups, kinetics of step polymerization, cyclization & linear polymerization, molecular weight control in linear polymerization, molecular weight distribution in linear polymerization, process condition, multichain polymerization, crosslinking, molecular weight in non-linear polymerization, crosslinking technology, step copolymerization.

## Radical chain polymerization:

Nature of radical chain polymerization, structural arrangement of monomer units, overall kinetics of chain polymerization, initiation (various methods), molecular weight in terms of kinetic chain length, mode of termination, chain transfer to monomer/initiator, chain transfer agent, inhibition & retardation, autoacceleration, molecular weight distribution.

## Emulsion polymerization:

Process, kinetics, number of polymer particles, other characteristics of emulsion polymerisation

## Ionic chain polymerization ;

Comparison with radical chain polymerization, cationic polymerization of alkenes, initiation, propagation, termination, kinetics, absolute rate constant, effect of reaction media.

Anionic polymerization of alkenes, comparison between cationic, anionic & radical polymerization.

## Chain copolymerization:

Introduction, copolymer composition, copolymer equation, monomer reactivity ratio, copolymerization behaviour.

Radical copolymerization - Reaction condition, reactivity rate of copolymerization.

Ionic copolymerization- Cationic copolymerization: monomer reactivity, effect of solvent, gegenion, temperature.

Anionic copolymerization: monomer reactivity, solvent effect,.

## Stereochemistry of polymerization:

Types of stereoisomerism in polymer, properties of stereoregular polymer, Z-N polymerization of non-polar alkene, stereospecific polymerization of polar alkenes, stereospecific polymerization of 1,3 dienes.



## Recommended Books

1. Principles of Polymerization: G. Odian, John Wiley
2. Polymer Chemistry: Stevens M.P. Oxford Univ. Press.
3. Text book of Polymer Science: F.W. Billmeyer Jr. Wiley Interscience.

### PCH 202 PHYSICAL CHEMISTRY

#### Thermodynamics:

First law of thermodynamics, relation between  $C_p$  and  $C_v$ , enthalpies of physical & chemical changes, temperature dependence of enthalpies, second law of thermodynamics and calculation of entropy.

#### Chemical Equilibrium:

Free energy and entropy of mixing, partial molar quantities, Gibbs-Duhem equation. Equilibrium constant and its temperature-dependence, phase diagram of one and two component system. phase rule.

#### Ideal and Non Ideal Solution:-

Excess functions; activities, concept of hydration number, activities in electrolytic solution, mean ionic activity coefficient, Debye - Huckel treatment of dilute electrolyte solution.

#### Equilibrium in Electrochemical cells

Cell reaction; Nerst equation, application of cell EMF measurement.

#### Surface phenomena :-

Surface tension, adsorption solids, electrical phenomena at interfaces including electron kinetics, micelles and reverse micelles; solubilization micro-emulsions, application of photoelectron, ESCA and Auger Spectroscopy to the study of surfaces.

#### Statistical Thermodynamics :-

Thermodynamic probability of entropy; Maxwell - Boltzmann distribution of velocities; average, most probable and root-mean-square velocities. Maxwell - Boltzmann, Bose - Einstein and Fermi Dirac Statistics. Partition function; rotational, translational, vibrational and electronic partition functions for diatomic molecules calculations of thermodynamic functions and equilibrium constant. Theories of specific heat for solids.

### Non-equilibrium Thermodynamics:-

Postulates and methodologies; linear laws, Gibbs equation, Onsager reciprocal theory.

### Reaction Kinetics:-

Methods of determining rate laws. mechanisms of photochemical, chain and oscillatory reactions. collision theory of reaction rates. Steric factor, treatment of unimolecular reactions. Theory of absolute reaction rates, comparison of results with Eyring and Arrhenius equations. Ionic reactions; salt effect. Homogeneous catalysis and Michaelis - Menten Kinetics. heterogeneous catalysis.

### Recommended Books

1. Fundamentals of Physical Chemistry: Maron & Prutton
2. Physical Chemistry - P.W. Atkins. EL/BS 4th Ed.

### PCH-203 ORGANIC REACTIONS AND SYNTHESIS

Aromaticity: Huckel's rule and concept of aromaticity; (n) annulenes and heteroannulenes: fullerenes (C<sub>60</sub>).

Stereochemistry and conformational analysis: Newer methods of asymmetric synthesis (including enzymatic and catalytic nexus), enantio and diastereo selective synthesis. Effects of conformation on reactivity in acyclic compounds and cyclohexanes.

Selective Organic Name Reactions: Feavorskii reaction, Stock examine reaction, Michael addition, Mannich reaction, Sharpless asymmetric epoxidation, Ene reaction, Barton reaction, Hofmann-Löffler-Freytag reaction, Shapiro reaction, Bayer-Villiger reaction, Chichibabin reaction.

Mechanisms of Organic Reactions; Labelling and kinetic isotope effects, Hammett equation (sigma-rho) relationship, non-classical carbonium ions, neighbouring group participation.

Pericyclic Reactions; Selection rules and stereochemistry of electrocyclic reactions, cycloaddition and sigmatropic shift; Sommelet, Hauser, Cope and Claisen rearrangements.

Heterocyclics; Synthesis and reactivity of furan, thiophene pyrrole; pyridine, quinoline, isoquinoline and indole; Skraup synthesis, Fischer indole synthesis.

Reagent in Organic Synthesis. Use of following reaction in organic synthesis and functional group transformation. Complex metal hydrides, Gilman's reagent, lithium dimethylcuprate, **lithium diisopropylamide**, (LDA), dicyclohexylcarbodiimide, 1,3-dithiane (reactivity umpolung), trimethylsilyl iodide, tri-n-butyltin hydride, Woodward and Prevost hydroxylation, osmium tetroxide,

DDQ, selenium dioxide, phase transfer catalysis, crown ethers and Merrifield resin. Peterson's synthesis, Wilkinson's catalyst; Baker yeast.

Chemistry of Natural Products; Familiarity with methods of structure elucidation and biosynthesis of alkaloids, terpenoids, steroids, carbohydrates and proteins. Components of proteins and nucleic acids.

#### Recommended Books

1. Organic Chemistry : Morrison & Boyd, Allyn & Bacon Inc. Universal Book Stall.
2. Principle of Organic Synthesis - R.O.C. Norman, Chapman & Hall London.
3. Some Modern Methods of Organic Synthesis - W. Carruthers Cambridge University Press.

#### PCH-204 Instrumental Methods of Analysis :

1) Chromatography - Fundamentals and types of chromatography classification : liquid partition chromatography, paper thinlayer & reversed phased partition chromatography, chemical constitution and  $R_f$  value, adsorption chromatography, gas-liquid chromatography efficiency & resolution, various types of detectors, gel permeation & ion exclusion technique, Ion exchange chromatography HPLC.

2) IR Spectroscopy - Molecular vibrations, Factor influencing vibrational frequencies, instrumentation, IR sources, optical system, detectors process analysis, sampling techniques. interpretation of spectra : - Quantitative analysis, ATR & MIR reflectance, FTIR spectroscopy.

3) UV & Visible spectroscopy - Theory of electronic spectroscopy, instrumentation & sampling applications, visual spectroscopy, vsual colorimetry, Photometric filter photometry, spectrophotometry, simultaneous spectrophotometry, differential spectrophotometry, photometric titrations.

4) NMR Spectroscopy - Proton NMR spectroscopy, The NMR phenomenon, theory . Chemical shifts and its measurement, factors influencing chemical shifts, sample handling & instrumentation, solvent used in NMR, spin spin coupling, spin spin splitting, Bond multiplicity, applications, derivative curves of values, Hyperfine splitting.

5) Flame photometry : - Principle , different burners used, events in flame, application , interferences, Factor influencing intensity of emitted radiation, limitations of flame photometry.

### Recommended Books

- 1) Basic concepts in Analytical Chemistry - S.M.Khopkar, Wiley Eastern.
- 2) Application of Absorption Spectroscopy of Organic Compounds - John R.Dyer, Prentice Hall of India
- 3) Physical Biochemistry - Friefeldor
- 4) Organic Spectroscopy - William Kemp
- 5) Analytical Biochemistry - D. Holme & H. Peck
- 6) Instrumental Methods of Chemical Analysis - Willard, Merit, Dean
- 7) Instrumental Methods of Analysis - Chatwal & Anand

### 205 Laboratory - II

1. Viscosity measurement and relationship of viscosity with molecular weight of polymers.
2. End group analysis
3. Viscosity measurement by Brookfield viscometer.
4. Flash point measurement by Pensky Marken s apparatus
5. Flash point measurement by Abel's apparatus
6. Synthesis of PF/UF/MF polymers
7. Synthesis of polyethylene terephthalate
8. Determination of B.O.D.
9. Measurement of relative surface tension of solvents.
10. Synthesis of glyptal resin.
11. Estimation of monomer concentration.
12. Determination of degree of swelling of a polymer.
13. Kinetics of condensation polymerization.
14. Reactivity ratios determination.
15. I.R. spectroscopy
16. N.M.R. spectroscopy
17. Solution polymerisation of styrene
18. Suspension polymerisation of styrene
19. Co polymerization of styrene and MMA
20. Emulsion polymerisation of vinyl acetate
21. Synthesis of epoxy resin
22. Interfacial Polycondensation. (synthesis of Nylon 6,6.)

SECOND YEAR (SEMESTER III)

Subject Code	Subject	Scheme of Exams		Total Marks
		Internal	External	
PCH 301	Characterization Techniques	40	60	100
PCH 302	Plastics Additives	40	60	100
PCH 303	Industrial Polymers-I	40	60	100
PCH 304	Special Laboratory Course-I	40	60	100
PCH 305	Project (Part-I)	40	60	100
Total		200	300	500



## PCH 301 : Characterization Techniques

Solubility chart for identification of polymers, Specific chemical tests for various polymers and group analysis.

Molecular weight determination using viscometry, osmometry, light scattering, ultracentrifuge and gel permeation chromatography.

Thermal behaviour of polymers DTA, TGA, DSC and TMA studies, pyrolytic gas chromatography

Mechanical behaviour of polymers, internal friction, swelling phenomenon, crosslink density.

Methods to study tacticity, stereoregularity and crystallinity, Electrical resistivity, dielectric behaviour.

Viscoelastic behaviour: Introduction, linear viscoelasticity

generalized Maxwell model, mechanical spectra, effect of different factors on mechanical behaviour, experimental methods.

Dynamic mechanical Analysis - DDV, DMA.

### Recommended Books

1. Experiments in Polymer Science, Collins. Interscience,
2. Physical Chemistry of Macromolecules. D.L. Deshpande. Vishal Publications.
3. Physical Chemistry of Polymers - Hiemenz.
4. Mechanical Properties of Polymers & Composites L.E.Nielsen. Marcel Dekker,

## PCH 302 : Plastics Additives :

Classification, chemistry, mechanism of action and applications of the following.

1. Fillers:
2. Plasticizers
3. Antioxidants
4. Heat stabilizers
5. Ultraviolet stabilizers
6. Flame retardants
7. Colourants
8. Curing agents
9. Miscellaneous additives (lubricants)
10. Compounding of resins (Masterbatch preparations)
11. Compounding of elastomers (recipe formulation)
12. Processing aid material

### Recommended Books

1. Polymer Additives
2. Reinforcement in Polymers - G.Kraus Elsevier Publishers
3. Encyclopedia of PVC -I, Nass. Marcel Dekker Publishers.
4. Polymer Technology - D.C.Miles Chemical Publishing Com. New York.

## PCH 401 : RUBBER CHEMISTRY AND TECHNOLOGY

Historical development of rubber industry. Natural rubber, biosynthesis, plantation, tapping latex and solid rubber, types of solid rubber, properties, chemistry and structure of NR hardening of NR, CVNR, LVNR.

Rubber derivatives : Depolymerized rubber, cyclized rubber, chlorinated rubber, rubber hydrochloride, modified rubber (AC, grafted, SP) technically specified rubber.

Synthetic Rubbers : Chemical structure, processing, compounding and properties of cured products (SBR, Nitrile, EPDM, Butyl, Neoprene, Thiokol, acrylic rubber, viton, fluorocarbon, silicon, urethanes, Polybutadienes, Polyisoprene).

Compounding and Vulcanization : Principles of rubber compounding, Chemistry of mastication, compounding ingredient (fillers, curatives, accelerators, antioxidant, softners, special purpose additives etc.)

Rheological measurements and raw rubber, Mooney viscometry and parallel plate. Plastimers processing and vulcanization test methods, rheometer, aging of rubber.

Theory of filler reinforcement of rubber. Chemistry of vulcanization of rubber. Correlation between vulcanizate structure and properties.

### Recommended Books

1. Synthetic Rubbers, G.S. Whitby, John Wiley & Sons.
2. Polymer Science and Technology of Plastics and Rubbers, P. Ghosh, Tata McGraw Hill.
3. Rubber Chemistry J.A. Brydson, Applied Science Pub.
4. Rubber Technology and Manufacture, C.M. Blow, C. Hepburn, Batterowth Scientific Pub.

## PCH 402 : Processing of Polymers :

Various forms of polymers in practical applications; conversion of cellulose pulp to paper and board; Regeneration of Cellulose, rayon, Different cellulose films, rubber processing; synthetic polymers - molding;

Thermoplastic and thermoset resin films, Fibres and Foams.

1. Extrusion : General features of single screw extrusion; Mechanism of flow, analysis of flow in extruder general features of twin screw extruder.

2. Injection Molding : Introduction, details of the process, moulds, structural foam injection moulding, sandwich moulding, Reaction injection moulding, injection blow moulding, injection Moulding of thermosets,

3. Thermoforming, analysis of thermoforming
4. Calendering, Analysis of calendering
5. Rotational Moulding
6. Compression moulding
7. Transfer moulding
8. Processing Reinforced thermoplastics & thermosets
8. The effects of processing
  - (a) Microstructural changes
  - (b) Shrinkage & Distortion
  - (c) Residual stresses

#### Recommended Books

1. Science & Technology of Polymer Films. O.J. Sweeting, Vol. II, Noyes, 1971
2. Pulp and Paper- Chemical Technology Vol. I, II, III, J.P. Casey, 3rd Ed. Interscience, 1980.
3. Polymer Processes, Interscience, C.E. Schildnecht, 1956.
4. Encyclopedias of Polymer Science and Technology, Vol. 1 to XIV, H.F. Mark and N. Gaylord, Interscience, 2nd Ed. 1988.
5. Rubber Technology, C.M. Blow, Butter worth, London, 1980.
6. Plastics Engineering, R.J. Crawford, Maxwell- Maxmillon International Edi.

#### PCH 403: INDUSTRIAL POLYMERS - II

Manufacture, properties and applications of the following classes of polymers.

1. Polyvinyls.
2. Polystyrene and copolymers
3. Fluorocarbon Polymers
4. High performance thermoplastics
5. Polyamides
6. Polyolefins

#### Recommended Books

1. Introduction to Polymer Chemistry - R.B.Seymour & C.Carrihar, McGraw Hill.
2. Text book of polymer science - Billmeyer
3. Encyclopedia of polymer science - H.Mark.
4. Polymer Technoogy - D.C.Miles Chemical Publishing Co., York.

#### PCH 404 :Special Laboratory - II

1. Mastication & Vulcanization of rubbers using two roll mill.
2. Compression moulding of thermoplastics
3. Injection moulding of thermoplastics
4. Extrusion
5. Calendering
6. Coating on polymer films
7. Analysing the coated film
8. Lamination making of polymer films

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## PCH 401 : RUBBER CHEMISTRY AND TECHNOLOGY

Historical development of rubber industry. Natural rubber, biosynthesis, plantation, tapping latex and solid rubber, types of solid rubber, properties, chemistry and structure of NR hardening of NR, CVNR, LVNR.

Rubber derivatives : Depolymerized rubber, cyclized rubber, chlorinated rubber, rubber hydrochloride, modified rubber (AC, grafted, SP) technically specified rubber.

Synthetic Rubbers : Chemical structure, processing, compounding and properties of cured products (SBR, Nitrile, EPDM, Butyl, Neoprene, Thiokol, acrylic rubber, viton, fluorocarbon, silicon, urethanes, Polybutadienes, Polyisoprene).

Compounding and Vulcanization : Principles of rubber compounding, Chemistry of mastication, compounding ingredient (fillers, curatives, accelerators, antioxidant, softeners, special purpose additives etc.)

Rheological measurements and raw rubber, Mooney viscometry and parallel plate. Plastimers processing and vulcanization test methods, rheometer, aging of rubber.

Theory of filler reinforcement of rubber. Chemistry of vulcanization of rubber. Correlation between vulcanizate structure and properties.

### Recommended Books

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2. Polymer Science and Technology of Plastics and Rubbers, P. Ghosh, Tata McGraw Hill.
3. Rubber Chemistry J.A. Brydson, Applied Science Pub.
4. Rubber Technology and Manufacture, C.M. Blow, C. Hepburn, Batterworth Scientific Pub.

## PCH 402 : Processing of Polymers :

Various forms of polymers in practical applications; conversion of cellulose pulp to paper and board; Regeneration of Cellulose, rayon, Different cellulose films, rubber processing: synthetic polymers - molding;

Thermoplastic and thermoset resin films, Fibres and Foams.

1. Extrusion : General features of single screw extrusion; Mechanism of flow, analysis of flow in extruder general features of twin screw extruder.

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3. Thermoforming, analysis of thermoforming
4. Calendering, Analysis of calendering
5. Rotational Moulding
6. Compression moulding
7. Transfer moulding
8. Processing Reinforced thermoplastics & thermosets
9. The effects of processing
  - (a) Microstructural changes
  - (b) Shrinkage & distortion
  - (c) Residual stresses

#### Recommended Books

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2. Pulp and Paper- Chemical Technology Vol. I, II, III, J.P. Casey, 3rd Ed. Interscience, 1980.
3. Polymer Processes, Interscience, C.E. Schildnecht, 1956.
4. Encyclopaedia of Polymer Science and Technology, Vol. 1 to XIV, H.F. Mark and N. Gaylord, Interscience, 2nd Ed. 1988.
5. Rubber Technology, C.M. Blow, Butter worth, London, 1980.
6. Plastics Engineering, R.J. Crawford, Maxwell- Maxwell International Edi.

#### PCH 403: INDUSTRIAL POLYMERS - II

Manufacture, properties and applications of the following classes of polymers.

1. Polyvinyls.
2. Polystyrene and copolymers
3. Fluorocarbon Polymers
4. High performance thermoplastics
5. Polyamides
6. Polyolefins

#### Recommended Books

1. Introduction to Polymer Chemistry - R.B.Seymour & C.Carrihar, McGraw Hill.
2. Text book of polymer science - Billmeyer
3. Encyclopedia of polymer science - H.Mark.
4. Polymer Technoogy - D.C.Miles Chemical Publishing Co., York.

#### PCH 404 :Special Laboratory - II

1. Mastication & Vulcanization of rubbers using two roll mill.
2. Compression moulding of thermoplastics.
3. Injection moulding of thermoplastics
4. Extrusion
5. Calendering
6. Coating on polymer films
7. Analysing the coated film
8. Lamination making of polymer films

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