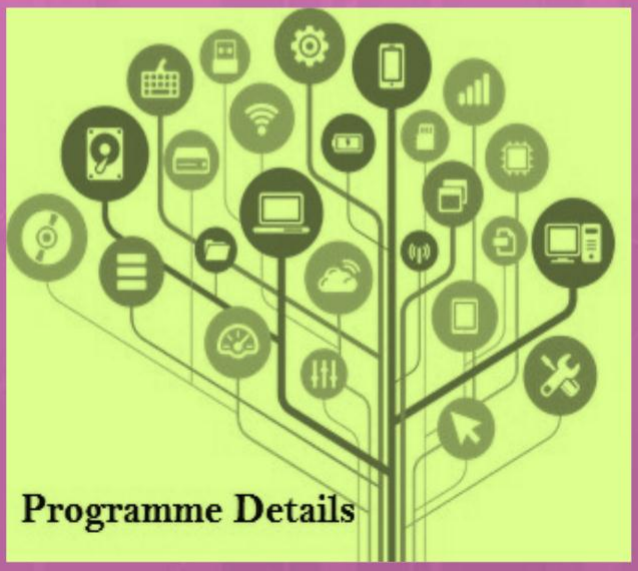
ಮೈಸೂರು ವಿಶ್ವವಿದ್ಯಾನಿಲಯ

University of Mysore

(Estd.1916)

M.Sc. POLYMER SCIENCE

Choice Based Credit System (CBCS)



UNIVERSITY OF MYSORE

Department of Studies in Polymer Science

Manasagangotri, Mysuru-570006

Regulations and Syllabus
Master of Science in Polymer Science
(Two-year semester scheme)

Under
Choice Based Credit System (CBCS)

Dr. T. Demappa. M.Sc., PH.D.
Professor of Polymer Science
University of Mysore
Sir M. Visvesvaraya Post Graduate Center
Industrial Area, Tubinakere, Mandya-571 402

UNIVERSITY OF MYSORE

GUIDELINES AND REGULATIONS

M.Sc. POLYMER SCIENCE

(TWO-YEAR SEMESTER SCHEME UNDER CBCS)

Programme Details

Name of the Department	: Department of Studies in Polymer Science
Subject	: Polymer Science
Faculty	: Science
Name of the Programme	: Master of Science in Polymer Science
Duration of the Programme	: 2 years- divided into 4 semesters

Programme objectives

The main objective of this M.Sc., programme is to furnish strong foundation in the subject **Polymer Science** to become

- Teaching faculties in Academic Institutions.
- Researchers in research institutions or industries.
- Entrepreneur to start their own company.

Programme Outcomes

The M.Sc., programme in Polymer Science is highly required programme among Material Sciences in the University. On successful completion of this programme each student will:

- Have a strong foundation in understanding the basic chemical and polymer reactions that occurs in both macro molecular and micro molecular systems at molecular level. Further the student will be able to learn cutting edge technology in the field of polymer science and technology, molecular biology, physical chemistry, inorganic, organic, physics , pharmaceuticals , engineering , medical and biomedical , space engineering , paramedical , paints, coatings, rubber technology, fiber technology .
- Develop practical skills along with their theory components, which will help in their research programme both in academic institutions and in R & D programmes of industries.
- Inculcate skills for teaching in academic institutions and industries.
- Develop confidence in taking competitive examination in the field of material science both in India and abroad so that they can pursue higher education.

Programme Specific Outcomes

Get hands on experience in various aspects of plastics technology viz. plastic materials manufacturing, properties, applications, processing, product design, mold design, testing & quality control, and recycling.

1. Take up responsibilities in production, testing, design and marketing in the plastics industries and contribute for the growth of industry.
2. Acquire ability to become entrepreneurs as they can easily start up processing, compounding, design and marketing units.

Pedagogies employed in the M.Sc., programme

- Class room teaching will be using black board and chalk, power point presentation and information and communications technology.
- One on one interaction in tutorial classes.
- Individual student performs experiments as per the protocol in practical classes.
- Student seminar/research paper presentation in each semester.
- Students will be tested for their writing abilities to answer precise and essay type questions.
- Every semester the students will be subjected to viva voce examinations by external examiners.
- Project work on a small research problem.
- Literature review in the form of Dissertation.
- Invited talks from eminent scientists.
- Industrial visit in every semester or every year
- Job placement for all the students in suitable industries.

Syllabus for M.Sc., Polymer Science

I Semester

Paper Code	HC/SC/ E/OE Pr./etc.	Subject	Credits			Total Credits
			L	T	P	
18501	**HC**	Principles of Polymer Chemistry	2	0	2	4
18502	**HC**	Polymer Compounding	3	1	0	4
18503	**HC**	Polymeric materials	2	0	2	4
Any two given below.						
18504	**SC**	Physical chemistry of polymers	3	1	0	4
18505	**SC**	Inorganic & Natural Polymers	3	1	0	4
18506	**SC**	Flocculants and Dispersants	3	1	0	4
18507	**SC**	Advanced Spectroscopic Methods	3	1	0	4

II Semester

Paper Code	HC/SC/ E/OE Pr./etc.	Subject	Credits			Total Credits
			L	T	P	
18511	HC	Chemistry of High Polymers	2	0	2	4
18512	HC	Structure – Property relationship in polymers	3	1	0	4
18513	HC	Polymer Characterization	3	1	0	4
Any One of the below;						
18514	SC	Polymer Identification & Analysis	2	0	2	4
18515	SC	Polymer Physics & Rheology	2	2	0	4
18516	SC	Engineering Plastics	2	2	0	4
	SC	Term Work	0	1	3	4

(For Non-Polymer Students Only)

Paper Code	HC/SC/E /OE Pr./etc.	Subject	Credits			Total Credits
			L	T	P	
18556	OE	Latex and foam Technology	3	1	0	4

III Semester

Paper Code	HC/SC/E /OE Pr./etc.	Subject	Credits			Total Credits
			L	T	P	
18521	HC	Polymer Testing	2	0	2	4
18522	HC	Specialty & Functional Polymers	3	1	0	4
18523	HC	Smart Polymers	3	1	0	4
Any One of the below;						
18524	SC	Polymer Blends & Composites	2	0	2	4
	SC	Term Work			4	4
18526	SC	Adhesive materials	3	1	0	4

OPEN-ELECTIVES
(For Non-Polymer Students Only)

Paper Code	HC/SC/E/ OE Pr./etc.	Subject	Credits			Total Credits
			L	T	P	
18527	OE	Fundamentals of Polymer Chemistry	3	1	0	4
18528	OE	Introduction to Polymer Composites	1	1	0	2
18529	OE	Industrial Polymers	1	1	0	2

IV Semester

Paper Code	HC/SC/E/ OE Pr./etc.	Subject	Credits			Total Credits
			L	T	P	
18551	HC	Principles of Polymer Processing	2	2	0	4
	HC	Project Work	**0**	**2**	**6**	8
Any Two of the below;						
18525	SC	Nano Science	3	1	0	4
18552	SC	Surface Coatings & Adhesion Technology	2	2	0	4
18553	SC	Polymer Membrane & Drug Delivery	2	2	0	4
18554	SC	Rubber Technology	2	2	0	4

OPEN-ELECTIVES
(For Non-Polymer Students Only)

Paper Code	HC/SC/E/ OE Pr./etc.	Subject	Credits			Total Credits
			L	T	P	
18555	OE	Basics of Polymer Processing	3	1	0	4

I SEMESTER

HARD CORE

COURSE-I : PRINCIPLES OF POLYMER CHEMISTRY

Objectives are:

- To study the fundamental concepts of polymer chemistry.
- To study the structure of monomers, functionality, and classification of polymers basis of source, composition, conditions, molecular weight, geometry, and Nomenclature of polymers.
- To study the various methods and techniques of polymerization reactions, their chemistry, mechanism, structures, properties and applications.

COURSE OUTCOME:

The student will:

- Understand the basic concept of chemical reactions and polymerization reactions involved in the macromolecules and micro molecular reactions
- Understand the stereochemistry and physical status of polymer molecules, molecular weight, stereo specificity and stability of polymer compounds.
- Understand the study of methods of polymerization reaction and their properties, advantages, disadvantages, modifications and applications.

COURSE CONTENT:

UNIT-I: General introduction to polymers with emphasis on important concepts such as monomer, functionality and physical state (amorphous and crystalline), classification of polymers on the

basis of source, elemental composition, heat, pressure, chemical reactivity, chemical/monomer composition, geometry and stereo regularity. Concept of molecular weight, Nomenclature of Polymers.

16hrs

UNIT-II: Chemistry and mechanism of Polymerization - Definition of polymerization, Factors affecting on polymerization, Addition polymerization (free radical, ionic and co-ordination polymerizations), Condensation polymerization-molecular weight in step growth polymerization, Ring opening polymerization. Redox Polymerization, Living radical polymerization, Co-polymerization, co-polycondensation (with Examples). Plasma polymerization, Photo polymerization, Electrochemical Polymerization, Metathesis polymerization, Group transfer polymerization. 16hrs

UNIT-III: Reactions of synthetic polymers -chemical modification; preparation of polymer derivatives, ATRP, Macromers in polymer synthesis. Isolation and purification of Polymers, Polymer fractionation: Fractional precipitation technique, Partial Dissolution (extraction) technique 16hrs

UNIT IV: Methods of Polymerization – Bulk, solution, precipitation polymerization, Suspensions, emulsion, melt polycondensation, interfacial polymerization, solution Polycondensation, solid phase, gas phase and (formulation, mechanism, properties of the polymer produced advantages and disadvantages of each technique). 16hrs

REFERENCE BOOKS:-

1. Introduction to polymers - R.J.Young & P.A.Lovell, Chapman & Hall, London. second edition. wiley online library 1991.
2. Text book of Polymer Science - Fred W.Billmeyer, J.R.John Wiley & Sons, New York. Third edition. wiley online library 1994.
3. Principles of Polymer Systems - F. Rodrignek, McGraw Hill, N.Y. 2nd edition. wiley online library 1981.
4. Polymer Chemistry - Seymour & Carreher, Marcel Dekkar, NY. Library of congress.
5. Principles of Polymerization - Odian G. ,4th edition. Wiley Inter Science, New Delhi
6. Polymer Science - V. R Gowarikar, Wiley Eastern Ltd. New Delhi. John wiley & sons. 1986.
7. Fundaments of Polymer Science and Engineering - Anil Kumar & S.K.Gupta, Tata Mc Graw Hill, New Delhi. 1978.
8. Introduction to polymer chemistry, G.S. Mishra, Wiley Eastern Ltd., New Delhi. Newage publishers 1993.
9. Principle of polymer science-P Bahadur, N.V Sastry 2nd edition Narosa Publishing House. 2002.
10. Polymers : Chemistry &Physics of Modern Materials-J.M.G. Cowie-Nelson Thornes Ltd. 1990
11. Preparation methods of polymer chemistry-Wayne. R. Sorenson, Fred Sweeny, Tod. W. Campbell.-A John Wiley & son, INC., Publication. 2001.

PRINCIPLES OF POLYMER CHEMISTRY PRACTIALS – Experiments list

Objectives are:

- To develop skills in the practical components and to learn good laboratory practices
- To learn the preparations of various reagents and polymer products.
- To learn the synthesis, characterization and estimations of polymeric materials.

COURSE OUTCOME:

The student will:

- Understand the basics of laboratory reagents/solutions and their preparations with respect to percent solution, molar and normal solutions, Millimoles, micromoles.
- Understand the isolation and analysis of various polymers and copolymers by spectroscopic methods.

COURSE CONTENTS:

1. Heat of solution of benzoic acid by solubility method.
2. Viscosity method of determining the molecular weight of polystyrene.
3. Comparison of strengths of acids by studying the kinetics of hydrolysis of an ester.
4. Kinetics of reaction between potassium per sulphate and potassium iodide (I and II orders).
5. Conducto metric titration of sodium sulphate against barium chloride.
6. Determination of dissociation constant of a weak acid by conductivity method.
7. Potentiometric titration of determining the dissociation constant of a weak acid.
8. Redox polymerization synthesis: preparation of poly (acrylamide) by free Radical polymerization.
9. Precipitation polymerization of acrylonitrile.
10. Suspension polymerization of methyl methacrylate.
11. Emulsion polymerization of methylmethacrylate, polyacrylonitrile.
12. Preparation of polyaniline.
13. Preparation of poly (ethylene terephthalate).
14. Preparation of polystyrene by redox method.
15. Preparation of poly(acryl amide) and poly (acrylic acid) copolymers.
16. Fractional distillation: separation of a mixture of benzene and toluene.
17. Chromatographic techniques: TLC and column chromatography.
25. Preparation of adipic acid from cyclohexanone.
26. Preparation of caprolactum from cyclohexanone.
27. Preparation of terepthalic acid from p-xylene and esterification to dimethyl terephthalate.
28. Determination of iodine values of oils and fats by chloramine-T method.
29. Estimation of mixture of acid and ester.
30. Estimation of amine and phenolic groups by acetylation technique.
31. Solution polymerization of acrylamide.

REFERENCE BOOKS ::

1. Expermintals in polymer science -D.G. Hundiwale, V.D.Athawale, U. R. Kapadi, V.V.Gite., Newage International(P) Limited, Pubilishers 2009.
2. Experiments in physical chemistry- James and Pritchard.
3. Selected experiments in physical chemistry-Latham
4. Experimental inorganic/physical chemistry-M. A. Malathi- Horwood publishing chichester, England 1999.
5. Preparative method in polymer science- Wayne R. Sorenson, Tod W. Campbell.
6. Practical physical chemistry- A Findlay, 2018

COURSE-II : POLYMER COMPOUNDING

Objectives are:

- Polymer compounding is the process of mixing or blending of polymers and additives and is essential for test trials.
- To impart the knowledge of compounding and mixing processes for the polymers and to study various mixing devices from the point of view of optimization of mixing time and power consumption.

- It is a powerful tool that will eventually be required for students with a wide array of state-of-the-art strategies to develop their knowledge about compounding and the use of polymers while minimising wastage during processing. Details about polymer properties and additives are assembled to provide a one-source repository for compounding.
- Another important skill to buildup students is the combination of polymers and additives and the essentials required for the development of economic and environmental incentives in polymer processing.

COURSE OUTCOME:

The student will:

- Understand various methods of compounding
- To encourage the students to Visit the various polymer industries and should know the tools, equipments, machines, and instruments.

COURSE CONTENT:

UNIT-I: Introduction - Limitations of raw polymer (plastics and elastomers) materials – need for compounding. Properties and technical requirements of additives. Compounding additives – Classification, role, mechanism, suitability and examples of following additives.

a) Additives which assist processing – stabilizers, lubricants- lubricants and their application in the processing of plastics, the technical and economic significance of lubricants, mechanism of lubricants and processing aids.
b) Additives which modify mechanical properties – plasticizers- definition of term, solvency and gelation properties, effects on hardness, effects on tensile strength and elongation,effect on low temperature resistance, effects on electrical resistance, reinforcing fillers, toughening agents or impact modifiers- impact modifiers for PVC.

22hrs

UNIT-II:

a) Additives which reduce formulation costs – fillers-theory of the action of fillers and reinforcements, properties of filled and reinforced plastic, application criteria for fillers in thermoplastics, extenders.
b) Additives, which modify surface properties – anti- static agents-chemical structure of antistatic agents, application, measurements of the antistatic agents, anti wear additives, adhesion promoters, anti-slip additives. Additives which modify optical properties – colorants-white pigments, black colorants, carbon blacks, lamp blacks, pigments- oxidic black pigments ,organic color pigments, optical brighteners.
c) Anti-aging additives – antioxidants- autoxidation and mechanisms of antioxidation action, testing of antioxidants, mechanisms of U.V stabilization- UV absorbers, quenches, hydroperoxide decomposers, free redical scavengers.
d) Other additives –light stabilizer testing- accelerated weathering, outdoor weathering, influence of pigments on light stabilizer performance, blowing agents, flame retardant, specialty additives, .
e) Vulcanizing agents- vulcanization and its effects, vulcanization reaction stages, determination of state of vulcanization, vulcanization systems. 24hrs

UNIT-III: Compounding – criterion, costs- quality balancing, analysis of quality costs, quality cost elements, prevention cost, appraisal costs, internal costs, external failure cost. Compounding procedures for different polymers and products. Curing characteristics 10hrs

UNIT-IV: Compounding machineries and parameters – Different types of mixing role mills, Internal mixers and solution mixers. Testing and evaluation of compounds. 8hrs

REFERENCE BOOKS ::

1. Plastic materials and processing – Brydson.1999
2. Rubbery materials and their compounds – Brydson.-Elsevior Applied Science.1988
3. Rubber technology and manufacture – C.M. Blow.- Institution of Rubber Industry.1971
4. Rubber technology – Morice Morton.-Springer-Science+.1973
5. Plastic additives handbook – Gachter /Muller.-Carl Hanser Verlag GmbH & Co 1990.
6. Handbook of plastic materials and technology – I I Rubin.-Wiley-Inter Science 1990.
7. PVC technology 4th Edition – Titow W. V.-Elsevier Applied Science.1985
8. Plastic additives and modifiers hand book – Van Nostrand Reinhold.-Springer 1992.
9. Design Formulas for Plastics Engineers- Natt S,Rao- Hanser publishers. NY.2004
10. Rubber Engineering- IRI- TMH Publishing company limited.1998
11. Plastic additives handbook- stabilizers, processing aids, plasticizers, fillers reinforcements, colorants for thermoplastics – R. Gachter and H. Muller- Hanser publishers, Munich Vienna New York. 1988
12. Introduction of polymer science & rubber technology (volume 1)- Dr. R.Mukhopadhyay- Indian Rubber Institute.
13. Plastic additives handbook- stabilizers, processing aids, plasticizers, fillers reinforcements, colorants for thermoplastics (3rd edition) – R. Gachter and H. Muller- Hanser publishers, Munich Vienna New York. 1993

COURSE-III : POLYMERIC MATERIALS

Objectives are: Polymeric materials are ubiquitous in our society, from nature-made proteins and polysaccharides to synthetic plastics and fibers. Their applications range from day-to-day consumables to high-performance **materials** used in critically demanding areas, such as aviation, aerospace, and medical devices.

- To study the polymers as materials by comparison of plastics with conventional materials like metals ,alloys, ceramics.
- To study the classifications of plastics like thermo plastics, thermo sets elastomers and fibers.
- To synthesis/fabricate these materials in lab scale and studied their properties and applications.

COURSE OUTCOME:

The student will:

- Understand the principles of synthesis and characterization.
- Understand structural properties of materials by theory and experimental analysis by XRD,FT-IR, SEM, Molecular weight by viscosity method.
- Understand the mechanical properties such as tensile strength, elongation break, impact strength, Young's modulus, flexural ,tear strength, by UTM

COURSE CONTENT:

UNIT-I: Introduction- polymers as materials, comparison of plastics with conventional materials like metals alloys ceramics etc. Classification of polymers / plastics, structural aspects, manufacture properties and applications of the following: 16hrs

UNIT-II: Thermoplastics- Polyolefins and allied polymers, Vinyl polymers, Styrene and its copolymers, Acrylics, Polyamides, Polyesters, PU, Fluoropolymers, Cellulose and its derivatives, Polycarbonates, Polyacetals, PES, PEI, PEEK, Polyacrylic acid, PVA, Poly vinyl acetals. 16hrs

UNIT-III: Thermosets- PF, MF, UF, Epoxy resins, Unsaturated polyester, Vinyl esters, Cyanate esters, Furan resins and silicone polymers. 16hrs

UNIT-IV: Elastomers- Natural Rubber, isoprene rubber, butyl rubber, Nitrile rubber, chloroprene rubber and Styrene-butadiene Rubber, EPDM, Vulcanization, Rubber chemicals. 16hrs

REFERENCE BOOKS :s:

1. Plastic materials 7th Edition –Brydson.-Elsevier 1965.
2. Rubbery materials and their compounds – Brydson.- Elsevior Applied Science.1988
3. Rubber technology and manufacture – C.M. Blow. .- Institution of Rubber Industry.2011
4. High performance polymers, their origin and development- R.B. Seymour and G.S. Krishenbaum. -Elsevier 1986.
5. Hand book of plastics materials and technology – Rubin. .-Wiley-Inter Science1990.
6. Plastics in Packaging – A.S.Athalye (Tata Mc Graw - Hill Publishing company, New Delhi).1992
7. Polymer science- V.R Gowrikar, N V viswanathan, Jayaadev sreedhar-New age International Publishers.1986
8. Polymer A Property Data Base-Bryan ellis, Ray Smith- CRS Press.1999

COURSE – IV : PHYSICAL CHEMISTRY OF POLYMERS

Objectives are:

- To study the thermodynamic behaviors of polymers in solutions at low concentrations (<1%)
- To study the solubility and solubility parameters, nature of crystallinity, effects of radiation on polymers and cross-linking of polymers.

COURSE OUTCOME:

The student will:

- Understand the structure and properties of polymer molecules and micro molecular compounds
- Understand the thermodynamic properties of polymers in low concentration solution compared to conventional chemical moieties.
- Students Understand that the difference between polymers and conventional micro molecular structure, size, molecular weight and thermo dynamic behaviors.

COURSE CONTENT:

UNIT-I: Thermodynamics of polymers solutions: introduction to thermodynamics- Maxwell relations, Gibbs - Helmholtz equation. Clausius - clapeyron equation. Vant hoff's equation. Third law of thermodynamics and its validity. Entropy and probability. Partial molar quantities, methods of calculation. Ideal and non-ideal solutions. Thermodynamic criteria of polymer solubility, solubility parameter. 16hrs

UNIT-II : General survey of inorganic polymers, comparision of organic polymers wit inorganicpolymers, inorganic chains, rings and cages, fluorocarbons, carbides, borazenes, isopoly and heteropoly acids and their salts, silicates, zeolites. 16hrs

UNIT-III: Natural polymers: Classification, biopolymers - introduction – functions – Cellulose, cotton, wool, silk, paper, rubber, collagen, hyaluroran- melanin, lignin –applications. Polymer from renewable resource: Introduction – Monomers and polymers from renewable resource materials: castor oil, natural gums, oleo chemicals, cashew nut shell liquid, carbohydrate derived monomers, furfural as a raw material for monomers and polymers 16hrs

UNIT-IV: Structure of biopolymers: Proteins, nuclic acids and polysaccharides – the macromolecular structure and biological functions of polymers- primary, secondary, tertiary and quaternary structures – structure maintenance and transmission of the biological informations- structure and enzymatic activity – mechano structural function of biopolymers-viruses and phages – living macromolecules.

16hrs

REFERENCE BOOKS:-

1. Inorganic Polymers – by J.E.Mark, H.R.Alcock and R.West, Prentice Hall Publishers.2005
2. Contemporary Polymer Chemistry- By J.E.Mark, H.R.Alcock and F.W.Lampe, Prentice Hall Publishers, 3rd Edition; 2005.
3. Introduction to Polymer Chemistry-by Charles E.Carroher Jr., CRC Press, Taylor & Francis, Boca Raton, 2010.
4. Principles of Bio-Chemistry – by L Lehninger, David L. Nelson, Michael M. Cox 1970
5. Introduction to Biological Chemistry – by Awapara.- Prentice Hall,1968.
6. Contemporary Polymer Chemistry – by H.R.Allcock and F.W.Lampe, Prentice-Hall Inc.2003
7. Organic Polymer Chemistry – by K.J.Saunders, 2nd Edition, Chapman & Hall.1973
8. Polymeric Materials from Renewable Resources – RAPR Technology Ltd., 4 (7) 1991.J.M.Methven, Pergamon Press, New York (1991).
9. Polymer Applications of Renewable Resource Materials – by E.D. Carrahar and L.H. Sperling, Plenum Press, New York (1981).
10. Priciples of Polymer Science-P. Bahadur, N V Sastry- Narosa Publishing House.2002

COURSE –VI : FLOCCULANTS AND DISPERSANTS

Objectives are:

- To study the introduction, classification, mechanism and uses of flocculants or clarification agents and their legal and Economical aspects.
- To study the modern trends in purification of water, juice clarification of sugarcane juice in sugar industry to improve the quality and yield of sugar products.
- To study the clarification of industrial effluents, recycling of water in mines, treatment of sewage water to portable water.

COURSE OUTCOME:

The student will:

- Understand the structure properties and applications flocculating and dispersant polymers in potential and wide range applications of various fields.
- Understand the synthesis and mechanism of clarifications polymeric materials.

COURSE CONTENT:

UNIT-I: Flocculants Introduction, Classification, Flocculation mechanism, Uses, Choice of optimum flocculants, Legal aspects, Economic aspects.

12hrs

UNIT-II: Dispersants and Disperse systems Production of disperse systems, Stabilization of disperse systems, Stabilizers, Uses of dispersants.

12hrs

UNIT-III: Surfactants Properties and mode of action, Classification, Applications, Comparison of surfactants Vs dispersants, Chelants and precipitation inhibitors, Dispersants, Flocculants Vs dispersants. Emulsions, CMC and its importance in polymer chemistry.

20hrs

UNIT-IV: Polymer colloids: lyophilic and lyophobic colloids, dispersion ,coagulation, kinetics of coagulation, practical applications, adsorption, polymer adsorption of macromolecular materials. stability of colloidal latex. kinetic stabilility of electrically charged hydrophobic colloids, kinetic stability of electrically neutral hyderphobic colloids, electrostatic stabilization.

20hrs

REFERENCE BOOKS:

1. Ionic Polymers-Edited by L.Holiday-Applied Science Publishers.1975
2. Principles of polymer chemistry – P.J. Flory. Cornell university press.1953
3. Macromolecules in solution – H.merawetz. Interscience. N.Y.1965
4. Principles of polymer science – G. Odian.John wiley & sons. 2004
5. Polymer colloids, A comprehensive Introduction: Rober M. Fiteh (Academic Press) 1971

COURSE –VII: ADVANCED SPECTROSCOPIC METHODS

Objectives are:

- Characterization and analysis of polymers have a special place in the wide ranging field concerning the analysis of thermoplastics and elastics for various reasons (developing highly refined polymers, attaining special properties, product substitution, customer service, plant disturbances, environmental protection etc.).
- A special way of characterization of polymers by means of spectroscopic methods (IR, NMR, UV, XRD) is described. The top method is the IR spectroscopy
- Identification polymers by spectroscopic methods.

COURSE OUTCOME:

The student will:

- Understand the structure properties and interactions of polymers by FT-IR, and crystallinity and micro-structural properties by XRD techniques.

Students should aware about UV, DSC, TGA for polymer stability.

COURSE CONTENT:

UNIT-I: Ultraviolet Spectroscopy Woodward-Fieser- rules for conjugated dienes and carbonyl compounds; Calculation of **λ max. Ultraviolet spectra of aromatic and vibrational frequencies**

of carbonyl compounds such as ketones; aldehydes; esters; amides; acids; anhydrides; lactones; B-lactam and conjugated carbonyl compounds etc. Effect of hydrogen bonding and solvent effect on vibrational frequencies; overtones; combination and Fermi resonance bands. FTIR, of gases; solids and polymeric materials. 16 hrs

UNIT-II: NMR Spectroscopy General introduction and definition; chemical shift; spin-spin interaction; shielding mechanism of measurement of chemical shift values and correlation for protons bonded to carbons [aliphatic; olefinic; aldehydic and aromatic] and other nuclei[alcohols; phenols; enols; acids; ammines; amides and mercapto compounds.]; chemical exchange; effect of deuteration; complex spin-spin interaction between two; three; four; and five nuclei [first order spectra]; virtual coupling. Stereochemistry; hindered rotation; Karplus curve variation of coupling constant with dihedral angle. Simplification of complex spectra; nuclear magnetic double resonance; shift reagent; solvent and field strength effect. Fourier transform technique; nuclear overhauser effect [NOE], Resonance of other nuclei - F; P 16 hrs

UNIT-III: Carbon-13 NMR Spectroscopy General considerations; chemical shift [aliphatic; olefinic; alkyne; aromatic; heteroaromatic and carbonyl compounds]; problems associated with C-13, FT-NMR, proton decoupled off resonance, DEPT spectra. 16hrs

UNIT-IV: Mass Spectrometry **:** Introduction, ion production-EI, CI, FD and FAB, factor affecting fragmentation, ion analysis, ion abundance. Mass spectral fragmentation of organic compounds, common functional groups, molecular ion peak, metastable peak, Mc Lafferty rearrangement, nitrogen rule. High-resolution mass spectrometry. Examples of mass spectral fragmentation of organic compounds with respect to their structure determination 16 hrs

REFERENCE BOOKS :S :

1. V. M. Parikh: Absorption spectroscopy of Organic molecules. (Mehata) addision-Wesley pub.co., 1974
2. D.H. Williams and Flemming:Spectroscopic methods of Organic compound. Mc Graw Hill.2005
3. Robert M. Silerstein and Basallar: Spectroscopic identification of Organic compounds.Wiley 7th edition 2005
4. Application of absorption spectroscopy of Organic compounds- John R. Dyer 1978, prentice Hall India Learning private limited.
5. P. S. Kalsi : Spectroscope of organic compounds (New Age) 2007
6. J. R. Dyer: Application of absorption spectroscopy of organic compounds.1965
7. L. M Jackman and Sternineil: Application of NMR spectroscopy. 1969 Elsevier
8. J. D. Roberts:Nuclear magnetic resonance (J. Wiley)1959
9. Hans H. Jafee and M.Orchin: Theory and application of U. V.1966 John wiley & sons.

SECOND SEMESTER

HARD CORE

COURSE-I : CHEMISTRY OF HIGH POLYMERS

Objectives are:

- To study the structure of polymers, Molecular weight and their types, polymer dispersity, degree of polymerization, chain length and polymerization techniques.
- To study the synthesis of polymer support reagents or polymer bound reagents it includes/avails both chemical reagent and polymer reagents that means micro to macro structures and properties.
- Molecular weight can be controlled and extended (tailor made requirements)
- Poly peptide synthesis and isolation by conventional chemical method is limitation, this can be overcome by polymer support /polymer bound reagents method.

COURSE OUTCOME:

The student will:

- Understand the concept of difference between chemical moieties(low molecular weight compounds) and polymer compounds.
- Understand Low molecular weight compounds have specific /sharp molecular weight and their properties and applications are also narrow and specific.
- Understand Whereas the same Polymers have different molecular weights, their properties and applications are also wide range of applications, molecular weight can be tailor made and properties and applications also, depending on the customer desire or customer specifications.
- Understand Molecular weight can be altered by using inhibitors and activators, and chain extenders.

COURSE CONTENT:

UNIT-I: Basic Principles of molecular weight : Importance of molecular weight control. Arithmetic mean-molecular weight average Mw, Mn, and Mv. Molecular weight distribution and its importance from the point of applications, Polydispersity index, determination of molecular weight- Theory, procedure and problems. 16 hrs

UNIT-II: Polymerisation techniques: Design criteria, polymer reactors, gas phase polymerisation,comparison of the above. Batch and continuous processes, kinetics of cross-linking reactions in thermosets and influence of additives. Kinetics of Polymerization, addition, condensation, redox polymerization and CFR polymerization. 16 hrs

UNIT-III: Introduction: Polymer Support materials, styrene based polymers, functionalizations of styrene based polymers via chloromethylation and other methods, determination of functionalizations in polymer supports. Polymer bound reagents. Introduction: polymeric oxidizing reagents, oxidation-reduction reagents, polymeric reducing agents, polymeric group transfer reagents, polymeric coupling agents, miscellaneous reagents, retardation inhibition, chain transfer branching effect, control of molecular weight, kinetic chain length, regulation and control, MWD, carothers equation. 16 hrs

UNIT-IV: Polypeptide synthesis on polymer support: Introduction, principles of merrifield's solid-Phase peptide synthesis, supports for solid phase peptide synthesis, linkage of first amino acid, protecting groups coupling of successive amino acids, cleavage of the resin- Peptide bond, purification, peptides synthesis using polymeric active esters, basics of oligonucleotide synthesis, oligosaccharide synthesis, sequencing of peptides and proteins. 16 hrs

REFERENCE BOOKS ::

1. Textbook of polymer science – F.W. Bilmeyer.-Wiley- India edition 1957.
2. Polymer science – V.R. Gowrikar, N V viswanathan, Jayaadev sreedhar-New age international Publishers.1986
3. Plastic materials and processing – brydson.-Elsevier 1965
4. Manufacture of plastics –Vol. I and Vol. II W. Mayo and Smith, van Nostrand reinhold 1964
5. Chemical process industries – Shreve R. Norris, Mc Graw- Hill education 1945.
6. Rubber technology and manufacture – C.M. Blow.-Institution of Rubber Industry.1971
7. Organic Chemistry and Synthetic Polymers by Lenz-Journal of chemical Education 1968.
8. Polymers as Aides in Organic Chemistry. N.K.Mathur, C.K.Narang, R.E.Williams, Academic Press, NY, 1980.-Elsevier

Chemistry of High Polymers
Practicals – Experiment List

1. Determination of molecular weight by viscosity method.
2. Determination of rate of polymerization.
3. Determination of energy of activation by chemical kinetics.
4. Redox polymerization kinetics.
5. Molecular weight control by chain modifier.
6. Estimation of monomers.(Aniline, Phenol, Urea, Formaldehyde)
7. Suspension polymerization kinetics.
8. Polymerization kinetics of bulk polymerization.
9. Partial molar quantities of a ternary system/ three components system.
10. Retardation inhibition of polymerization reaction.
11. Control of molecular weight.
12. Determination of degree of polymerization.
13. Estimation of Glucose and Albumin by Colorimetric
14. Estimation of Amino acid and Protien by Colormitric.
15. Estimation of peptide.
16. Estimation of Amino acid.
17. Analysis and estimation of phenolic group by bromination method.
18. Analysis and estimation of keto group by iodination method.
19. Analysis and estimation of formaldehyde by oxidative method.

Reference:

1. Practicals in Polymer Science- Synthesis and qualitative & quantitative analysis of macromolecules- siddaramaiah- CBS publishers & distributors. New Delhi, banglore. 2005.
2. Advanced Practical Polymer – Dr. Kuruvilla Joseph and Dr. G. D. Gem Mathew- Polymer publications Kottayam -1st edition 2001.

3. Experimental in Polymer Science- D. G. Hundiwale, V.D. Athawale , U. R. Kapadi, V.V. Gite – International (p) limited publishers, New Delhi 2009.
4. Analysis of synthesis polymer & plastics- J. Urbanski W. Czerwinski, K. Janicka, F. Majewska & H. Zowall- Ellis Horwood limited- 1st edition 1977.
5. Laboratory manual of organic chemistry- B. B. Dey and M. V. Sitaraman- Central press, Madras- 2nd edition 1941.
6. Systematic lab experiments in Organic Chemistry- Arun Sethi- New age international 2006.

COURSE –II: STRUCTURE –PROPERTY RELATIONSHIPS IN POLYMERS

Objectives are:

- To study the basic concept of structure of the polymer molecules /compounds or materials
- To study the molecular structure, properties and applications are depending on structure. If structure changes (modify) properties and applications also changes.
- Polymeric materials are resistance towards many external agencies such as heat, fire, acid ,alkali, sound, water, etc.
- Polymeric materials are smart materials or intelligent materials such as heat sensors, pressure sensors ,light sensors, temperature, pH sensors, humidity, elctrical, magnetic ,depending on structure.

COURSE OUTCOME:

The student will:

- Understand the concept of synthesis of homo polymers, co -polymers, ter-polymers, block co-polymers ,etc , .
- Understand the structural modification by synthesis of various polymerization techniques, copolymerization, blending, grafting depending on customer specifications.
- Understand the importance of structural modifications like chemical and physical modification the properties and applications changes.

COURSE CONTENT:

UNIT-I: Polymer properties - Approach and the concept. Chemical structure of polymers – Introduction: Shapes and energy consideration, copolymers, heteroatomic polymers. Physical structure of polymers– introduction: Melt viscosity, interchain and intrachain forces; Glass transition temperature; Crystallinity; Elastomers, fibers, plastics and their correlation with Tg and Tm (structural features). Physical properties of polymers in relation to chemical structure: Volumetric properties– Volume and density, thermal expansion;16hrs

UNIT-II: Calorimetric properties – Heat capacity, enthalpy and entropy; Transition temperatures – Tg, Tm, and relationship between Tg and Tm of polymers; Solubility– The solubility parameter, solubility limits. The crystallinity of polymers – Molecular aggregation,molecular arrangement in crystallites– Polyethylene, syndiotactic vinyl polymers,PTFE, PVA, polyesters, polyamides, polydienes,; The principles of crystallite structure, single crystals of polymers, determination, mechanism and kinetic treatment of crystalisation. Properties of polymers in fields of force: 16hrs

UNIT-III: Mechanical (viscoelastic) properties, effect of shape and structure on material properties like modulus of elasticity, tensile properties, fracture toughness, impact strength, crazing, ductile-brittle transition. Influence of molecular structure on electrical and optical properties. Influence of the process variables, orientation, measurement, quantitative relationships for some physical quantities after orientation, generalized stress-strain relationship for polymers.

16hrs

UNIT-IV: Diffusion of gasses and vapors in polymers, influence of molecular structure to predict the properties of specialty polymers- Water soluble polymers, oil soluble polymers, oil insoluble polymers, flame retardant polymers, flexible polymers, water repellant polymers, heat resistant polymers, transparent polymers. 16hrs

REFERENCE BOOKS:

1. Properties of polymers : correlation's with chemical structure by Van Krevelen, - Elsevier. 4th Edition1972
2. Polymers: structure and bulk properties – Patrick Mearos. Journal of chemical education, 1966
3. Structure properties relationships in polymers – Raymond B. Soymour and Charles E. Carraher, Plenum Press Newyork.1984
4. Plastics: how structure determines properties – Gruenwald 1993. Hanser publishers
5. Injection moulding theory and practice – I Rubin 1973.
6. Handbook of engineering Polymeric materials by Nicholas P. chermisinoff.1997
7. Injection moulding hand book by Rosato.-Springer 1985.
8. Properties and behaviour of polymer science-vol 2-A John Wiley & sons, INC., Publication.2011
9. Property of polymers- D W Van Krevelen, K.te Nijenhuis Elsevier.1972

COURSE-III : POLYMER CHARACTERIZATION

Objectives are:

Polymer characterization is the analytical branch of polymer science. The discipline is concerned with the characterization of polymeric materials on a variety of levels. The characterization typically has as a goal to improve the performance of the material.

- To study the instrumentation theory, principle and applications of DSC and TGA for thermal analysis and thermal stability of Polymers.
- To study the chromatographic technique like GC, GPC, and HPLC for analysis of the purity of monomers, polymers, additives, Mechanism of separation, Molecular weight distribution(MWD), purity and composition.
- To study the morphology of polymers by SEM, Microstructural prpoerties by X-ray diffraction analysis; WAXS, SAXS, etc.

COURSE OUTCOME:

The student will:

- Understand the theory, principle and instrumentation technique of DSC and TGA.
- Understand the Theoretical and instrumentation technique on various types chromatography.
- Understand both theoretical method of various types of molecular weight determination of polymers.
- Understand the theory and experimental method to determine molecular weight of polymers (by viscosity method).
- Students visit industries to understand the concepts of above techniques.

COURSE CONTENT:

UNIT-I. DSC: Instrumentation, theory, practice and applications of thermal analysis : DSC:

Physical transitions, melting thermograms, heat of fusion and degree of crystalanity or isotacticity. Random copolymer structure. Block copolymer structure. Polymer mixture melting point depression by diluents, crystallization, melt crystalisation, cold crystalisation. Glass transition- Crystal-crystal transition. Chemical reactions- Curing, polymerisation. Kinetics of Curing (Broido's Method, Kissinger's Method), plasticizer effect. 16hrs

UNIT-II TGA: Determination of degradation kinetic parameters. Method of Freeman and Carrolmethods involving maximization rates. Method of multiple heating rates. Method of variable heating rate for a single thermogram. Estimation of thermal stability from TGA curves. Quantitative methods- Semiquatitative and qualitative methods, thermal degradation behavior of some polymers by TGA methods. Kinetics of thermal degradation, IPDT, OI, purity, fiber content, composition of compounded rubber. 16hrs

UNIT-III. Chromatography – GC, GPC and HPLC – Analysis of the purity of monomers, additives, principle's of GPC, mechanism of separation, theory and technique, instrumentation. Molecular weight distribution(MWD), purity and composition. 16hrs

UNIT-IV. Polymer Morphology: Optical microscopy, TEM. SEM, AFM, X-ray diffraction analysis: Wide angle X-ray scattering (WAXS) and small angle X-ray scattering (SAXS), analysis of molecular structure of simple polymers, chain conformation, chain packing, disorder in crystals, degree of crystalinity, micro- structural parameters, degree of orientation. Basic principles of TMA and DMA. 16hrs

REFERENCE BOOKS:

1. Thermal charactrisation of polymeric materials – E.A. Turi.-Jornal of Polymer Science.1981
2. Analysis of polymers – an introduction- T.R.Crompton.-Springer.1971
3. Instrumental methods of analysis – Willard, dean and merit.- Journal of chemical Education 1975.
4. Polymer charactrisation – D. Cambell and J.R. White.2nd edition CRC Press, 2000
5. Experimental methods in polymer chemistry – J.F. Rabek.-Wiley Online Library.1980
6. NMR Frank A.Bcovey, 2nd edition Academic Press 1988.
7. Nano Technology-Fundamentals and Applications-Manasi Karakare- I. K. International.2010

SOFT CORE

COURSE-IV : POLYMER IDENTIFICATION AND ANALYSIS

Objectives are:

- To study the Identify and analysis of polymeric materials by chemical methods such as qualitative analysis and color test analysis, end group analysis, molecular weight, acid value, iodine number and saponification value(by experimental determination).
- Physical methods by Refractive index value, density, melt flow index ,moisture content, viscosity, surface area, sieve analysis(experimental)

COURSE OUTCOME:

The student will:

- Understand to characterize the polymeric materials by the above methods.
- Understand to identify the rubbers, flexible thermoplastics, rigid thermoplastics, thermosetting plastics can learn to take the students to industries like JK tyres, CEPET (

Central Institute of Plastics and Engineering Technology) , other polymer industries and polymer exhibitions.

COURSE CONTENT:

UNIT-I: Chemical methods: Qualitative analysis and colour tests, end group analysis, molecularweight, vinyl content, carboxyl, epoxy, acetyl, amino and hydroxyl content, acid value, iodine number, saponification value. Physical methods: R.I., specific gravity, bulk density, MFI, aniline point, solution viscosity, water content, surface area, estimation of monomers, ash content, moisture content, DBP value and sieve analysis.

16hrs

UNIT-II: Identification of Polymers: Rubbers, flexible thermoplastics, rigid thermoplastics, thermosetting plastics. Analysis: Preliminary tests, burning tests, solubility tests, elemental analysis, transition temperatures, chemical Tests.

16hrs

UNIT-III: UV/Visible spectroscopy introduction, principles, Lambert law, Beers law, theory, instrumentation, procedures, advantages and disadvantages, interpretation of spectrum, applications- Qualitative analysis, quantitative analysis, puriety, Cis and Trans- conformation, molecular weight determination, polymer degradation analysis, orientation, crystallinity.IR spectroscopy: Introduction, principles, theory, instrumentation, procedures, methods of sample preparation, advantages and disadvantages, interpretation of spectrum, applications- Establishment of chemical structure of polymers, reaction, kinetics, polymer linkages, hydrogen bond formation, purity, co-polymerization, qualitative and quantitative results. 16hrs

UNIT-IV: NMR (^{1}H NMR and ^{13}C NMR) introduction, principle, theory, spin-spin coupling,coupling constant, instrumentation, procedure, methods of sample preparation, advantages and disadvantages, applications- Chemical structure, purity, tacticity.

16hrs

REFERENCE BOOKS : :

Polymer Identification:

1. Simple methods of Identification of Plastics- Dietrich Braun- Hanser GardnerPublishers.1986
2. Testing of Polymers- By Vishu Shah.wiley interscience, 1984
3. Handbook of Analysis of Synthetic Polymers and Plastics- By J.Urbanski.1977, Ellis Horwood ltd, publisher.

Polymer spectroscopy :

4. Polymer Science- P.L.Nayak, Kalyani Publishers, New Delhi.2012
5. Spectroscopy of Polymers- Jack L. Koenig, Elsevier Science Inc., N.Y.1992
6. Text Book of Polymer Science-Fred W. Billmeyer, John wiley & sons, 2007
7. Polymer Characterization- Physical Techniques by D.Campbell and J.R.White (Chapman and Hall)2000
8. Identification and Testing of plastics- A.S. Athalaye-Multi Tech Publishing Co.1992
9. Advanced Practical polymer chemistry- John Leonard, Barry Lygo, Garry Procter CRC Press 1994.
10. Practicals in Polymer science- Siddramaiah-CBS Publishers and Distributors. 2007

COURSE-IV : POLYMER IDENTIFICATION AND ANALYSIS

PRACTIALS – Experiment list

COURSE OUTCOMES

COURSE CONTENTS

1. Synthesis of phenyl ethylene (styrene) from phenyl ethyl alcohol.
2. Synthesis of terpthalic acid.
3. Preparation of poly (glycerylphthalate) and determination of its acid value.
4. Preparation of polyethylene tetrasulphide and analysis by chemical methods.
5. Kinetics of polymerization of polyesterification reaction between ethylene glycol and phthalic acid.
6. Preparation of nylon 6, 10/6, 6 salt using HMDA- sebasic acid/ adipic acid.
7. Interfacial polymerization of polyester from IPC and phenolphthalein.
   a) Preparation of IPC (iso phthaloyl chloride).
   b) Purification of IPC.
   c) Interfacial polymerization.
8. Interfacial polymerization on hexamethylene diamine and sebacoyl chloride.
9. Solution and bulk preparation of a polyester/ polyether based polyurethane.
10. Preparation of cross linked polymers:
    a) Poly (styrene-co-vinyl benzene).
    b) Poly (ethylacrylate-co-ethylene glycoldimethyl acylate).
11. Preparation of urea formaldehyde resin.
12. Preparation of acid catalysed phenol formaldehyde resin.
13. Preparation of bisphenol-A based epoxy resin from bisphenol-A and epichlorohydrin.
14. Determination of epoxy equivalent weight of the epoxy resin.
15. Determination of hydrolysable chlorine content.
16. Determination of saponification value of oil.
17. Estimation of hydroxyl value by PVA and Cyclohexanol.
18. Determination of density of a polymer.
19. Estimation of iodine value.
20. Determination of DBP value of carbon black.
21. Determination of an acid value the of polymer sample.
22. Validification of Beer's law.
23. Synthesis adipic acid from cyclohexanol using Conc. HNO_3.
24. Estimation of carbohydrate by phenol sulphuric acid.
25. Estimation of lactose.

REFERENCE BOOKS : :

1. Practical physical chemistry-A. Findlay.2018
2. Experiments in physical chemistry- James and Pritchard.
3. Selected experiments in physical chemistry-Latham
4. Experimental inorganic/physical chemistry-M. A. Malathi- Horwood publishing chichester,England 1999.
5 Preparative method in polymer science- Wayne R. Sorenson, Tod W. Campbell.
6 Expermintals in polymer science -D.G. Hundiwale, V.D.Athawale, U. R. Kapadi,
7 V.V.Gite., Newage International(P) Limited, Pubilishers 2009.
8 Systematic Lab experimentas in organic chemistry- Arun Sethi- Newage International 2006.
9 Practical organic chemistry – Dey & Sitaraman, Publisher- S. Viswanathan, 1993.

COURSE-V : POLYMER PHYSICS AND RHEOLOGY

Objectives are:

- To study the physics and rheological concepts of polymeric materials.

- The micro structural properties ,thermodynamic and flow properties of polymers were studied.
- To study the basic concept of rheology properties like viscosity, density, molecular weight and mechanical properties of polymeric materials in the dilute solution form.

COURSE OUTCOME:

The student will:

- Understand the concept of rheological properties of dilute polymeric materials such as viscosity, density, determination of molecular weight, refractive index.
- Understand the nucleation and growth of crystals and their properties by XRD analysis.
- Understand the concepts of mechanical properties of polymeric materials by preparing polymer thin films by solution cast technique.

COURSE CONTENTS:

UNIT-I: Structural morphology, dilute solution properties, thermodynamics, kinetics of chain and step polymers, concentrated polymer solutions and polymer melts, amorphous and crystalline state, glass transition. 16hrs

UNIT-II: Nucleation and growth of crystals, cross-linked polymers and theory of rubber elasticity, mechanical behavior of polymers.

16hrs

UNIT-III: Basic concepts of rheology: Dependence of shear viscosity on temperature, pressure, molecular weight, flow curve, theory of linear viscoelasticity. Newtonian, Non-Newtonian and viscoelastic fluids.

16hrs

UNIT-IV: Continuum Theories and related models, non-Newtonian liquid flow through cylindrical pipes, couette flow, rheology of calendering and extrusion, viscometry, cone and plate viscometers.

16hrs

REFERENCE BOOKS :

1. Future Mechanics of Polymers- J.G Williams, Horwood, Chisester, 1984. Ellis Horwood ltd.
2. The Chemistry & Physics of Polymers- V.N. Kuleznev & V.A Shershnev, Mir Pub, Moscow,1990.
3. Introduction to Polymer Physics- I.L Perpechko, Mir Pub, Moscow, 1981.
4. Physical Chemistry of Polymers- A. Tager, Mir Pub, Moscow, 1978.
5. Introduction to Physical Polymer Science- L.H Sperling, John & Wiley, 2001
6. Viscoelastic Properties of Polymers, 3rd Ed.- J.D Ferry, Wiley, New York, 1980
7. Polymer Melt Rheology- F.N. Cogswell, Woodhead Publishing, 1983.
8. Rheology- Christopher W. Malosko, John & Wiley, 1980.

COURSE-VI : ENGINEERING PLASTICS

Objectives are:

- Engineering plastics as a field focuses on designing, developing, and manufacturing of plastic parts that satisfy the requirements of the intended application. This means that each plastic product that is designed for specific application has to satisfy the three "F's" as form, fit, and function for that application.

COURSE OUTCOME:

The student will:

- Understand that engineering plastics are weight –to- strength ratio, excellent chemical resistance, heat and fire resistance, creep compliances and moderate cost.
- Understand the engineering plastics are high performance properties and long shelflife.

COURSE CONTENTS :

UNIT-I: Polymers for high temperature applications. Polymers for high temperature resistance– Fluoro polymers– Aromatic polymers– Heterocyclic polymers– Polymers as building materials– Ultrahigh fibres – Aramids– Technora– Carbon fibres. 16hrs

UNIT-II: Genaral purpose Polymers: Chemistry, structure-property relationship of the following polymers: Polyamides, EVA, EPDM, UHMW-HDPE, polycetals. 16hrs

UNIT-III: High performance polymers: Chemistry, structure-property relationship of the following Polymers: Aromatic ethers, aromatic thioethers, polysulfones, polyether sulfones, polyimides, bismeleimides, PEEK, etc. 16hrs

UNIT-IV: Polymers for biomedical applications– Polymers in dentistry – Tissue adhesives – Dialysis membrane – Blood oxygenators –Bone cement – Prostheses – Biodegradable sutures – Control drug delivery systems. 16hrs

REFERENCE BOOKS :

1. Encyclopedia of Polymer Science and Engineering- H.F. Mark (Ed), Wiley – Interscience, New York, 1991.
2. Recent Advances in Liquid Crystalline Polymers- L.L. Chapoy (Ed), Chapman and Hall, London, 1985.
3. Speciality Polymers- R.W. Dyson, Chapman and Hall, New York, 1987.Springer.

4.Polymers for Electronic and Photonic Applications- C.P.Wong, Academic Press, New York,1992.

TERM-WORK

Objectives are:

- To study and consolidate a research problem by collecting the available research data.

COURSE OUTCOME:

The student will:

- Be trained to review literature of a research problem.
- Understand the research problem so that one can plan for future course of the research work.

Students will be assigned/they will select a recent topic on which they will write a review and submit in the form of a booklet for evaluation

Each student/group of two students shall undertake a project related to Polymer science under the supervision of a faculty member and complete the same during the course of the final (even) semester. The thesis shall be submitted by the student/ group (of two students) before the commencement of the examination. The project report shall be evaluated by the Chairman BOS,

Internal (Guide) and external examiner. A viva-voce shall be conducted jointly by the three examiners along with the theory and practical examination at the end of the course.

OPEN ELECTIVE

COURSE-VII : LATEX AND FOAM TECHNOLOGY

Objectives are:

- The objective is to study the effect of various natural fibers on natural rubbers.

COURSE OUTCOME:

The student will:

- Understand the synthesis of latex foam, laminated paper, latex coated with natural fibers.
- Understand the concept of compounding by visiting the rubber industries like JK Tyres Mysore, CiPET Mysore and other rubber industries in and around Mysore.

COURSE CONTENTS :

UNIT-I. Introduction to NR & Synthetic lattices: molecular and physical structure; Methods of manufacture and machineries, and stabilization of dispersion. Artificial dispersion, vulcanized latex. Compounding of latex – micro and nano fillers, Vulcanizing ingredients. Dispersing agents Stabilizing agents.

16hrs

UNIT-II. Testing on latex mechanical stability, pH, particle size of dispersion and size distribution. Manufacture of latex based products. Latex thread, Dipped goods, casting spraying, spreading, adhesives, rubberized coir, rubberized hair, Micro-porous Ebonite, Can sealing, Latex cements, 16hrs

UNIT-III. Latex foam, Latex laminated paper & boards, Latex coated fabrics & cords. SBR, Nitrile, Neoprene, Thiokol, High styrene resin, PVAc, PVC, Acrylic, Carboxylated SBR & vinyl pyridine latex. 16hrs

UNIT-IV. Compounding for Neoprene latex, Neoprene latex coated paper, latex mixed with cement, Emulsion paints, Electro deposition of latex, Urethane foam, Cold foam, integral skin foam, Semi rigid foam, Rigid PU foam etc. Foam testing, concepts of micro-cellular structure, closed and open cell structures. Industrial uses of latex and foam technologies.

16hrs

REFERENCE BOOKS :

1. *Latex Foam Rubber,* E.W. Madge, , MacLaren and Sons Ltd., London, 1962.
2. Polymeric Foams and Foam Technology, 2nd Ed., Daniel Klempner and Vahid Sendijarevic (eds.), ISBN: 1 569 90336 0, Hanser Gardner, 2004.
3. Basic Elastomer Technology, Edited by K.C. Baranwal and H.L. Stephens, Rubber Division, Published by American Chemical Society.

SEMESTER – III

HARD CORE

COURSE-I : POLYMER TESTING

Objectives are:

- Polymer Testing focuses on the testing, analysis and characterization of polymeric materials ,including both synthetic and natural or bio-based polymers.

COURSE OUTCOME:
The student will:

- Understand the need for testing of polymers and required for different standards and specifications for different products and different properties such as national and international standards.
- Understand specimen preparation with condition, shape and size of test specimen.
- Understand the standard test specimen preparation like mouldings for films, specimens for mechanical prpoperties like tensile strength, flexural, young's modulus ,impact strength etc. .

COURSE CONTENTS :

UNIT-I: Introduction – Need for testing, need for standards and specifications, national and international standards, quality control, limitation of test data, accuracy and validity of best methods. Specimen preparation and conditioning, shape and size of test specimen, standard for test specimen preparation like moulding, machining, stamping and punching of specimens, conditioning of specimen. 16hrs

UNIT-II: Mechanical properties :

a) Short term strengths: Tensile properties, compression properties, flexural properties, shear properties, impact resistance, toughness; Tear resistance, abrasion resistance and hardness.
b) Long term strengths: Dynamic stress and strain properties and their measurements, creep, stress relaxation, fatigue properties, flexing, and resilience. 16hrs

UNIT-III: Flammability properties: Oxygen index, critical temperature index, smokes density flammability test, ignition properties, and surface burning characteristics. Electrical properties: Insulation resistance, volume resistively, surface resistively, break down voltage, dielectric strength, arc resistance, dielectric constant, power factor. Optical properties: Gloss, haze, refractive index, and degree of yellowness, transmittance, photoelectric properties, and color. 16hrs

UNIT-IV: Miscellaneous properties: MFI, MVI, specific gravity, bulk density, ESCR, weathering properties, toxicity, resistance to chemicals, abrasion, tearing, Co- efficient of friction, VST, HDT, Destructive & Nondestructive testing methods. Polymer product testing**:** Films, pipes, containers, laminates, adhesives, tyres and tubes. 16hrs

REFERENCE BOOKS :

1. Hand book of plastics test methods – R.P. Brown.-Longman 1989.John wiley & sons.
2. Hand book of rubber test methods – R.P. Brown.- Longman scientific & Techical 1988.
3. Plastics testing technology hand book – Vishu shah.-Wiley- Backwell 1988.
4. Rubber and plastics testing – Klucknow, Chapmen and hall.-Delhi Test House 1975.
5. ASTM and IS standards.

6. Testing of plastics and elastomers in handbook of plastics and elstomers4th edition – Charles A. Harper, McGraw Hill.- The M C Graw Hill Companies, Inc.2002
7. Practical Non- Destructive Testing – Baldev Raj, T.Jaya kumar, M. Thavasimuthu- Narosa Publishing House.1997
8. Identification and testing of plastics- A.S. Athalye Multi-Tech Publishing Co.1992
9. Polymer A property Data Base 2nd edition –Brayan Ellis, Ray Smith – CRC Press. 2008

COURSE-II : SPECIALTY AND FUNCTIONAL POLYMERS

Objectives are

- **Specialty Polymers** are the class of some High Performance **Polymers** (HPP), including plastics, **polymers**, fluids, membranes, smart hydrogels and elastomers that are designed to meet the critical requirements that engineers face every day in key industries including, Plastics, Automobiles, Aeronautics, Smart Devices, liquid crystals, supramolecules, biomolecules, electricals and electronics applications,optoelectronics,drugdelivery.

COURSE OUTCOME:

The student will:

- Fabricate the polymer blends and composites for high temperature and fire resistant polymers and characterizations.
- Synthesis of polymer composite films for electrical and optical properties.
- Preparation polymer composite films for micro-structural and morphological properties.
- Preparation of polymer composite films for EMI and RFI shielding applications and also for mechanical properties like tensile strength, flexural, young's modulus ,impact strength etc.

COURSE CONTENTS :

UNIT-I: High Temperature and fire resistant polymers: Liquid crystal polymers: Smectic, nematic, cholesteric crystals, theromotropic main chain liquid crystal polymers, side chain liquid crystal polymers, chiral nematic liquid crystal polymers, properties of Commercial LCPs. Electro active polymers: Filled polymers, EMI shielding, electrochromic devices, sensors photo conductive polymers, conductive coating, inherently conductive polymers, doping conducting mechanism, rechargeable batteries. Electro-chromic devices, sensors, microelectronics, electrostatic discharge devices. 16hrs

UNIT-II: Polymers in photo-resist applications, negative photoresists, positive photoresists, plasma developable photoresists, photoresists applications for printing, polymers in Fiber optics, polymers in Nonlinear optics, polymers in adhesion, degradable polymers. 16hrs

UNIT-III: Ionic Polymers, ionic cross linking, ion-exchange, hydrophilicity, ionomers different types, polyelectrolytes, applications, optical information storage, ionomers, scavenger resins, medical related applications, telechilic polymers. 16hrs

UNIT-IV: Principles and applications of micro-encapsulation, process for micro-encapsulation and applications, functional fillers and Functional colorants, dendritic polymers, nano-composites. 16hrs

REFERENCE BOOKS :

1. Plastics Technology hand book, Manas chanda and Salil K Roy, (4th edition), CRC press, New York. 1993

COURSE-III : SMART POLYMERS

Objectives are:
The goal for these endeavors is to mimic the "smartness" of biological systems and ultimately moderate complex systems such as immune responses at desired levels. The versatility and untapped potential of smart polymeric materials makes them one of the most exciting interfaces of chemistry and biology.

COURSE OUTCOME:

The student will:

- Understand the polymer hydrogels for temperature and pH responsive hydrogels.
- Understand the hydrogels for biomedical applications like drug delivery
- Understand the hydrogels for controlled release fertilizers for agriculture

COURSE CONTENTS :

UNIT-I: Introduction functionally graded polymer blends: Mechanism of the preparation, diffusion-dissolution method-polymerization- Diffusion method, preparation and characterization, application. Gels, micro-gels and Hydro gels introduction- Supramolecular interactions and gel formation, applications. Hydro gels, preparation, characterization and applications. Controlled release materials, separation membranes, immobilization supports, ECM for tissue engineering, field- responsive materials. 16hrs

UNIT-II: Smart adhesives, films, coatings, thermoelectric materials, electrically conductive adhesives, smart drug delivery systems, smart windows. Polymer stents : Flip-chip under fill: Materials, process and reliability, intelligent processing of materials, shape memory polymers. Carbon microtubes and conical carbon nanotubes, synthesis and applications. 16hrs

UNIT-III: Smart corrosion protective coatings. Smart polymers for bio-technology and elastomers (sensing, actuating), piezoelectricity in polymers. Molecular imprinting technology, biomedical sensing, intilligent chemical indicators, piezoelectric polymer PVDF micro actuators, (smart polymers). Stimuli sensitive intelligent textiles – their production, properties and applications. Smart textile incorporating functional devices. 16hrs

UNIT-IV: Electrochemistry of conducting Polymers, general synthesis of conducting polymers characterization of conducting polymers, synthesis, processability and applications, organicelectrics applications. 16hrs

REFERENCE BOOKS :

Smart Polymeric Materials:

1. Smart Materials, Edited by-Mel Schwartz, CRC Press, Taylor & Francis Group, NW, 2008.
2. Plastics Technology Handbook, 4th - Edition, Manas Chanda, Salil K.Roy. CRC Press, Taylor & Francis Group, NW, 2006.
3. T.A. Skotheim, R.L. Elsenbaumer and J.R. Reynolds, Hand book of Conducting Polymers – 2nd Edn, Revised and enlarged, Marcel Dekker Inc., New York, 1998.
4. J.M. Margolis (Ed.), Conducting Polymers and Plastics, Chapman and Hall, London, 1989.
5. R.B. Seymour, ed., Conductive Polymers", Plenum Press, New York, 1981.
6. Z.Tadmore Principles of Polymer Processing, Wiley – Interscience, New York, 1979.

7. B. Wessling, Electronic Properties of Conjugated Polymers, Vol.3, Springer, Berlin, 1989.
8. H.G. Kiess (Ed.), Conjugated Conducting Polymers, Springer, Berlin, 19926.
9. D.S.Soane and Z. Martynenko (Eds.), Polymers in Microelectronics, Elsevier, Amsterdam,1989.
10. Plastics Materials – John Brydson – Elsevier. 1965

SOFT CORE

COURSE-IV : POLYMER BLENDS AND COMPOSITES

Objectives are:.

- A polymer blend is a mixture of two or more polymers that have been blended together to create a new material with different physical properties.
- Polymer blends and composites are the physical mixture of two or more homopolymers or copolymers without any covalent linkages .
- No need of new chemicals or monomers , just waste materials can mix and get new products. So that it may reuses or recycling the materials hence to reduces the solid waste.
- Polymer blends and composites are environment friendly materials.

COURSE OUTCOME:

The student will:

- Understand and synthesis and fabricate new polymer blends and composites by waste discarded materials and achieve the best performance products.
- Understand the standard test specimen preparation like mouldings for films, specimens for mechanical properties like tensile strength, flexural, young's modulus ,impact strength etc.

COURSE CONTENTS :

UNIT-I: Polymer Blends: Definition, difference between polymer blends and alloys, classification of polymer blends and alloys, principle of polymer compatibility, miscibility effect of molecular structure on polymer-polymer interaction, thermodynamics of polymer-polymer mixing, Blend morphology & characterization. Techniques for determination of polymer-polymer miscibility, preparation and manufacture of polymer blends, characterization of blends and applications. 16hrs

UNIT-II: Polymer composite systems: Defination, reason for composities, chemistry, properties & applications. Types of composites, reinforced thermoplastic, thermoset, elastomer - Resins (polyesters, epoxide, vinyl ester, phenol formaldehyde, polyimide, semicrystalline and amorphous polymers - PEEK, PP, PEK, PBT, PC, ABC, nylon etc.) additives, reinforcements (particulate, fibrous, gaseous). Factors affecting the performance of composities . 16hrs

UNIT-III: Processing techniques: Open mould, hand layup and spray layup, vacuum bag moulding, pressure bag moulding, autoclave moulding, closed mould, SMC, DMC, RTM. Continuous manufacturing process- Pultrusion, filament winding, centrifugal casting, Application.

16hrs

UNIT-IV: Mechanical behavior of composites: Analysis of continuous fiber composites and Short fiber composites. Deformation behavior of single ply and laminates. Creep, fatigue impact. Electrical and thermal properties. 16hrs

REFERENCE BOOKS :

1. Paul D.A., and Newman S., "Polymer Blends", Academic press. Elsevier 1978.
2. Dyson, R.W., "Engineering Polymers", Blackie, 1990. Champam & Hall, NY.
3. Crawford, R.J., Plastics Engineering 2nd edition, Pergamon Press.1987.
4. Richardson, T., Composites– a design guide industrial press Inc., New York, 1987.
5. Polymer engineering composites. Ed.M.O.W.Richardson, Applied science publishers, London.1977
6. Hand book of composites- G.lubin,Van Nostrand,New York,1982.
7. Mohar J.G et al SPI Hand book of technology and engineering of Reinforced plastic composites, Van Nostrand,New York. Polymer blends, Paul D.R and Newman S .Academic.2nd edition 1973
8. Polymer Blends and Alloys- R.P. Singh, C.K. Das, S. K. Mustafi- Asian Book Private Limited.2002

SOFT CORE

COURSE-IV : POLYMER BLENDS AND COMPOSITES PRACTIALS – EXPERIMENT LIST

1. Determination of molecular weight distribution by fractionation/ viscosity method, light scattering method, osmometry, ultracentrifugation and end group analysis.
2. To study the miscibility of the polymer blend using ultrasonic method.
3. To study the miscibility of the polymer blend using viscosity method.
4. To study the miscibility of the polymer blend using refractive index method.
5. Determination of miscibility of polymer blends by density measurement method.
6. To determine the epoxy equivalent of the given resin.
7. To determine the intrinsic viscosity, molecular weight and hence root mean square end to the length and expansion coefficient of given polymer using ubbelhold viscometer.
8. To determine the heat capacity of the given polymers using a thermo couple and spot reflection galvanometer.
9. To determine the thermal conductivity of the given polymers using the method of less and carlton.
10. Mechanical properties of polymer like tensile strength, compression strength, elongation at break, brinell hardness, young modules by cantilever beam method, network parameter of vulcanized rubber, flex crack resistance, heat distortion temp., softening point.
11. Elastic properties of polymers.
12. To determine the flexural strength of epoxy/ polyester composite.
13. Determine the refractive indices of polymer samples by using abbe's refractometer.
14. Determination of refractive indices of polymer samples by using density bottle.
15. Determination of gel time in thermosets.
16. Determination of TG by dilotometric method.
17. Effect of degree of polymerization on the mean polarisability-refractometry.
18. Potentiometric titration acid-base, end group analysis.
19. Conductometric - acid-base titration and end group analysis.
20. Separation of impurities from polymers by soxhlet method.
21. Determination of specific gravity, density, bulk density of a polymer samples.
22. Thermal analysis of polymers:

DSC: physical transition, melting thermograms, heat of fusion and degree of crystallinity or isotactivity. Melting point depression by diluents, crystalisation-melt crystalisation, effect of nucleating agents, glass transition, crystal-crystal transition chemical reactions-curing polymerization.

TGA: determination of degradation kinetic parameters. Method of freeman and carrol. Methods involving maximization rate. Method of multiple heating rates. Method of variable heating rate for a single thermogram.Estimation of thermal stability from TGA curves.

Qualitative methods-semi quantitative methods and quantitative methods, thermal degradation behavior of some polymers by TGA.

REFERENCE BOOKS :

1. Practicals in Polymer Science- Synthesis and qualitative & quantitative analysis of macromolecules- siddaramaiah- CBS publishers & distributors. New Delhi, banglore. 2005.
2. Advanced Practical Polymer – Dr. Kuruvilla Joseph and Dr. G. D. Gem Mathew- Polymer publications Kottayam -1st edition 2001.
3. Experimental in Polymer Science- D. G. Hundiwale, V.D. Athawale , U. R. Kapadi, V.V. Gite – International (p) limited publishers, New Delhi 2009.
4. Analysis of synthesis polymer & plastics- J. Urbanski W. Czerwinski, K. Janicka, F. Majewska & H. Zowall- Ellis Horwood limited- 1st edition 1977.
5. Laboratory manual of organic chemistry- B. B. Dey and M. V. Sitaraman- Central press, Madras- 2nd edition 1941.
6. Systematic lab experiments in Organic Chemistry- Arun Sethi- New age international 2006.

COURSE-V : ADHESIVE MATERIALS

Objectives are: .

- **Adhesives** are designed for specific applications. Besides their role in the **adhesion** process, they can be used for other **purposes**, such as sealing agents, in order to eliminate the effect of self-loosening caused by dynamic loads, sealing of areas to prevent oxidation and corrosion, waterproofing, etc.

COURSE OUTCOME:

The student will:

- Understand the concept of definition and mechanism of adhesion materials.
- Understand the synthsis of bio-adhesive materials like dextrose adhesives, starch based paper adheision, envelops, bookbinding ,cellophane adhesives.

COURSE CONTENTS :

UNIT-I: Adhesion mechanism definition and mechanisms of adhesion- Mechanical interlocking – Interdiffusion theories –Adsorption and surface reaction. Surface topography, wetting and setting, thermodynamic work of adhesion – Influence of constitution on adhesion–Interfacial bonding Coupling agents. 16hrs

UNIT-II: Characterization of adhesives Principle of fracture mechanics, peel, lap sheen and butttensile tests. Pull out of an extendable fibre, various testing of adhesives, energy dissipation – Plasticity – Strength of elastomers. Industrial adhesives inorganic adhesives – Animal glues – Caesin – Starch – Cellulosics. Principle of compounding – Role of resin – Fillers – Antioxidants – Accelerator systems. 16hrs

UNIT-III: Adhesive types: Adhesive from natural, butyl, nitrile, styrene – Butadiene – Carboxylic polymers and Neoprene rubbers, polysulphide, phenolic resin, epoxy, polyurethane, polyvinyl acetate, polyvinyl alcohol, polyvinyl acetal, acrylic, high temperature silicone adhesives. Water based – Pressure sensitive – Hot melt adhesives – Anaerobic adhesives. 16hrs

UNIT-IV: Applications of adhesives: Adhesives for building construction, medical use, automobile industry bonded and coated abrasives – Fabrics, cyanoacrylate based adhesives, bonding technology for textile, metal, plastics, wood, paper and glass. 16hrs

REFERENCE BOOKS :

1. Handbook of adhesive bonding -V.Cagle Charles- McGraw Hill Book Company, New York, 1978.
2. Treatise on adhesion and adhesives, Vol.5- R.L.Patrick- Marcel Dekker Inc., New York, 1981
3. Adhesives in engineering design- W.A.Lees, Springer Verlag, Berlin, 1984.
4. Industrial adhesion problems- D.M. Brewis and D.Briggs (Ed.), Wiley-Interscience Publication, New York, 1985.

OPEN ELECTIVE

COURSEE-VI : FUNDAMENTALS OF POLYMER CHEMISTRY

Objectives are: .

- History of macromolecular science, importance of monomers and polymers structure and properties and also classifications.
- Understand basic aspects of the solution properties of polymers, interactions and the relationship to chemical structure, including phase behaviour and the measurement of molecular weight.

COURSE OUTCOME:

The student will:

- Understand the basic concept of definition of monomers, polymers, structure,properties and classifications of polymers by origin, IUPAC nomenclature.
- Understand the different techniques of polymerization methods.

COURSE CONTENTS:

UNIT-I: History of macromolecular science, importance of monomers and polymers, basic concepts, nomenclature of polymers, inter-molecular forces and chemical bonding in polymers. : Classification of polymerization reactions: addition polymerization, condensation polymerization. Co-ordination polymerization, ring-opening polymerization, co-polymerization. 16hrs

structural adhesive, pressure sensitive adhesive, high temperature adhesive, adhesion mechanism. 16hrs

UNIT-III: Fabrication techniques of composites: hand lay-up spray coating, prepeg formation, lamination, filament winding, vacuum bag molding. 16hrs

UNIT-IV: SMC, BMC and DMC, RRIM, RTM, polymer nanocomposites, analysis and testing of composites, applications. 16hrs

REFERENCE BOOKS :

1. An Introduction to Composite Materials- D. Hull, Cambridge University Press, Cambridge, 1981.
2. Mechanical Properties of Polymers and Composites, Vols. 1 & 2, I.E Nielsen, Dekker, New York, 1955.

COURSE-VIII : INDUSTRIAL POLYMERS

Objectives are: .

- Major **industrial polymers**, chemical compounds **used** in the manufacture of synthetic **industrial** materials. In the commercial production of plastics, elastomers, man-made fibres, adhesives, and surface coatings, a tremendous variety of **polymers** are **used**. There are many ways to classify these compounds.

COURSE OUTCOME:

The student will:

- Understand the basic concept of raw materials for industrial polymers, production technology.
- Understand the concept of properties and applications of commodity polymers eg; HDPE, PE, PP, PVC etc.
- Understand the Industrial polymer resins and their applications.
- Understand the properties and applications of engineering polymers.

COURSE CONTENTS:

UNIT-I: Raw materials for industrial polymers, production technology. PEEK, PPO, PPS, Epoxy. 16hrs

UNIT-II: Properties and applications of commodity polymers: LDPE, HDPE, LLDPE, PP, PVC, PS, SAN. 16hrs

UNIT-III: Unsaturated polyester resin, epoxy resins, phenolics, amino resins, alkyds. 16hrs

UNIT-IV: Properties and applications of engineering polymers: Nylons, polyesters, PAN, PC, PU, ABS, polyacrylates and allied polymers, fluoropolymers, modification of industrial polymers. 16hrs

REFERENCE BOOKS :

1. Plastics Materials- 4th Ed., J.A Brydson, Butterworths, London, 1982.
2. Rubber Technology Handbook- W. Hofman, Hanser, Munich, 1988.
3. Plastics Technology- R.V Milby, McGraw Hill, New York, 1973

FOURTH SEMESTER

HARD CORE

COURSE-I : PRINCIPLE OF POLYMER PROCESSING

Objectives are:

- The paper talks about principles of **polymer processing**. Most **polymeric** raw materials are available in the solid state as granules, flakes, or powders. Solid raw materials have to be transformed into a fluid or **plastic** state, which is accomplished by heating
- **Polymer processing** is commonly defined as the "activity performed on polymeric materials to increase their usefulness"

COURSE OUTCOME:

The student will:

- Understand the basic concept of polymer rheology, visco elastic properties of polymers and need for processing.
- Understand the role additives and their properties in raw material to process and get desire end product.
- Understand the various types of moulds and their operations to processing and applications.

COURSE CONTENTS:

UNIT-I: Polymer rheology: Viscous flow kinetic theory of elasticity, viscoelasticity, application of theology in polymer processing. Principles of polymer processing: Introduction to processing, need for processing, and requirements for processing. The following areas are to be covered in brief. 14hrs

UNIT-II: Processing of thermoplastics: Raw material – types of forms, products, and applications. Moulding – compression moulding, injection moulding, blow moulding, rotational moulding, thermoforming. Extrusion – coextrusion, film extrusion, pultrusion, calendaring, casting, coating. Reaction Injection Moulding (RIM)- Principle and application structural reaction injection molding, gas assist injection, foaming. Processing condition advantages & disadvantages,film foaming 16hrs

UNIT-III: Processing of thermosets : Raw materials, compression moulding, transfer moulding, injection moulding, moulding of DMC and SMC and other thermoset processing operations. Principle, Technology, advantages and disadvantages of the following techniques; melt spinning, dry spinning, wet spinning process, electro spinning techniques. 14hrs

UNIT-IV: Fiber science: fibre structure, property & application of natural and synthetic fibre, organic and inorganic fibre examples: glass, carbon, aramid, boron, aluminium, carbide, jute, sisal. Drawing of fibers. Requirement of fibre forming polymers. Morphological structure of cotton, wool, silk, regenerated cellulose, polyester, nylon, PP, PAN, definition

The student will:

- Understand the introduction to nanotechnology, definition, types, classifications, surface modification and their applications.
- Understand the different techniques of preparation of nano composites.
- Understand the electrical , optical, mechanical, thermal, morphological, micro-structural properties of nano composites.

COURSE CONTENTS:

UNIT-I: Introduction: Introduction to nanotechnology, definition, types, classification, surface modification of nanoclay with different organic compounds and their properties. Nanomaterials synthesis, chemical approaches, molecular switches nanowires- Synthesis,

properties, characterization and applications nanoparticle, nanoplatelet, nanofiber reinforced composites. 16hrs

UNIT-II: Techniques used for the characterization of noncomposites; Preparative methods and morphological study- Intercalation of polymer or pre-polymer from solution, in-situ intercalative polymerization method, Melt intercalation, properties of polymer- clay nano composites. 16hrs

UNIT-III: Nanocomposite properties- Mechanical properties, dynamic mechanical analysis, tensile properties, flexural properties, heat distortion temperature, thermal stability, fire retardant properties, gas barrier properties, conductivity, optical transparency, biodegradability of biodegradable polymers-based nanocomposites. Crystallization behavior and morphology of Nanocomposites – Rheology, melt rheology and structure–property relationship.16hrs

UNIT-IV: Carbon nanotubes (CNTs)- Chemistry, types, structure, properties and applications. Comparison of CNT properties with graphite fibers, preparation of CNTs, purification, Surface modification of CNTs, properties- Mechanical, thermal, morphological, electrical properties. Methods of fabrication of CNT-polymer composites, properties of CNTs composites, characterizations of Nanocomposites by x-ray, electrical, thermal, optical, raman spectra and TEM. Application of CNT- polymar composites. 16hrs

REFERENCE BOOKS :

1. Polymer layered silicate and silica nano composites- Y.C. Ke, P. Stroeve and F.S. Wang, Elsevier, 2005.
2. *Formation and properties of clay-polymer complexes*. B. K. G. Theng- Elsevier, Amsterdam, 1979.
3. *Chemistry of clay-organic reactions*- B.K.G. Theng. Wiley, New York, 1974.
4. Vapour grown carbon nanofibres-polypropylene composites and their properties in Carbon nanotubes edited by V.N. Popov and P.Lambin, p.227- V.Chirala, G.Marginean, W.Brandl and T.Iclanzan, Springer (2006), Netherlands.
5. Recent Advances in Polymer Nanocomposites; Editors: S. Thomas, G.E. Zaikov and S.V. Valsaraj, CRC Ptress, 2009
6. Progress in Polymers Nanocomposites Research Editors: Sabu Thomas, Gennady E. Zaikov See web site address: Novapublishers, 2009
7. Nanotechnology Fundamentals and Application-Manasi Karkare- I. K. International.2008

COURSE-IV : SURFACE COATING AND ADHESION TECHNOLOGY

Objectives are:

- A coating is a covering that is applied to the surface of an object, usually referred to as the substrate. The purpose of applying the coating may be decorative, functional, or both. The coating itself may be an all-over coating, completely covering the substrate, or it may only cover parts of the substrate.
- Coatings are not only for decorative purpose but also mainly protective from corrosion and degradation or deterioration of substrates.

COURSE OUTCOME:

The student will:

- Understand the basic concept of industrial coating resin synthesis, formulations and applications as coatings.
- Understand the manufacturing and properties of organic and inorganic pigments and their dispersions.
- Understand the surface preparation and coating applications and also testing and evaluation of coatings.

COURSE CONTENTS:

UNIT-I: Industrial coating resins- Synthesis, properties, formulations and applications as coatings of the following resins to be discussed. Alkyds and polyesters, phenol formaldehyde, silicon resin, epoxy resin, chlorinated rubber, polyurethanes and acrylic resins 16hrs

UNIT-II: Pigments & their dispersion - Manufacturing and properties of organic and Inorganic pigments. Factors affecting dispersions, preparation of pigment dispersion, grinding equipment. 16hrs

UNIT-III: Coating processes –

(a) Surface preparation: Mechanical cleaning, solvent cleaning, alkali cleaning and acid pickling. Chemical conversion treatment.
(b) Coating application: Mechanism of film formation
  (i) Applying processes: Brushing, dip coating and flow coating, curtain coating, roller coating and spray coating
  (ii) Fixation
  (iii) Curing: Physical, chemical and oxidative
(c) Factors affecting coating properties. 16hrs

UNIT-IV: Testing and evaluation of coatings – Physico- mechanical, optical, and environmental. Application of paints- Appliance finishes, automotive finishes, coil coating, can coating, marine coating, Curtain coatings and aircraft coating. 16hrs

REFERENCE BOOKS :

1. Organic coatings- Science and Technology - Swaraj Paul, WILEY 1985.
2. Handbook of Plastics- Elastomers and Composites - Charles A Happer, Mc Graw- Hill, 1968.
3. Formulation of organic coatings- Norman I. Geynes, Glenn N. Danziger, Frederick C. Kinsler- Van Nonstrand Co.1967
4. The technology of paints- Varnishes and lacquers-Ed., by Morgan & Martens, Reinhold,1968
5. Hand book of Adhesive technology, Pizzi, A. (ed); Mittal, K.L. (ed), Marcel Dekker, New York, 1996.
6. Adhesion and adhesives technology: an introduction, A.V. Pocius, Hanser/Gardner, Munich, 1997.
7. Adhesion and Adhesives - Science and Technology, Kinloch, A.J., Chapman and Hall, 1987.

COURSE-V : POLYMER MEMBRANES AND DRUG DELIVERY

REFERENCE BOOKS :

1. Rubber Technology- M.Morton, Van Nostrand Reinhold, 1987.
2. Developments in Rubber Technology, Vol. 1 – 4, A. Whelan and K.S.Lee, Applied Science Publishers, London 1981.
3. Hand Book of Elastomers- A.K. Bhowmick and H.L.Stephens, Marcel Dekker, New York, 1988.
4. Rubbery Material and their Compound- J. A. Brydson, Kluwer Academic Publishers Group, 2001.
5. "Rubber Technology and Manufacture", 2rd -C. M. Blow and C.Hepburn-Edn.,Butterworths, London, 1982.
6. Injection Moulding Machine- A. Whelan- Elsevier Publications, London, 1989.

OPEN ELECTIVE

COURSE-VII : BASICS OF POLYMER PROCESSING

Objectives are:

- **Polymer processing** is defined as an "engineering activity concerned with operations.
- The common **goal** of the above operations is to deliver thermoplastics or thermosets.
- The **fundamental** stability issue can be addressed by either using an ethylene or any olefin.

COURSE OUTCOME:

The student will:

- Understand the fundamental concept of additives , pre compounding operations.
- Understand the extrusion, injection moulding,blow moulding and other types of mouldings.

COURSE CONTENTS:

UNIT-I: Nature and role of additives, pre-compounding operations, compounding of plastics and rubber, type, mixing of polymers and additives. 16hrs

UNIT-II: Extrusion, injection molding, blow molding, compression molding. 16hrs

UNIT-III: Transfer molding, calendering, thermoforming, roto-molding, ultra-sonic welding.16hrs

UNIT-IV: Casting, sintering and compaction, dip coating, powder coating, analysis of defects in molded products. 16hrs

REFERENCE BOOKS :

1. Plastic technology – Manas Chandra & Salil K Roy, 4th edition –CRC Press NY 1993.
2. Polymer plastics technology and engineering vol. II – Naturman, L.M.dekkar (1979).
3. Polymer science, a material science K.B. vol. I and II – Jankins, A.D.North-Holland Publishing Company, London. 1972.
4. Principles of polymer processing –Fenner R.T.Chemical Pub.,
5. Synthetic rubber – G.S. Witby, Wiley Online Library.
6. Essential fiber chemistry – Mery E. Carter, Marcel Decker, Wiley Online Library.

Dr. T. Demappa. M.Sc., Ph.D.
Professor of Polymer Science
University of Mysore
Sir M. Visvesvaraya Post Graduate Center
Industrial Area, Tubinakere, Mandya-571 402