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UNIVERSITY OF MYSORE

Established: 1916

Vishwavidyanilaya Karyasoudha
Crawford Hall, Mysore-570 005

No.AC.2(S)/151/2021-22

Dated: 18.08.2021

NOTIFICATION

Sub: Modified the Syllabus of Polymer Science (PG) from the academic year 2021-22.

Ref: 1. Decision of Board of Studies in Polymer Science (PG) meeting held on 28.11.2020.
2. Decision of the Faculty of Science & Technology Meeting held on 08.02.2021.
3. Decision of the Academic Council meeting held on 07.04.2021.

*****

The Board of Studies in Polymer Science (PG) which met on 28.11.2020 has approved the Modified the Syllabus of Polymer Science (PG) from the academic year 2021-22.

The Faculty of Science and Technology and Academic Council meeting held on 08.02.2021 and 07.04.2021 respectively have approved the above said proposal and the same is hereby notified.

The detailed Syllabus of Polymer Science (PG) course is annexed. The contents may be downloaded **from the University Website i.e., www.uni-mysore.ac.in**.

DRAFT APPROVED BY THE REGISTRAR

DEPUTY REGISTRAR (ACADEMIC)

Deputy Registrar (Academic)
University of Mysore
Mysore-570 005

To:

1. The Registrar (Evaluation), University of Mysore, Mysore.
2. The Dean, Faculty of Science & Technology, DoS in Psychology, MGM.
3. The Chairperson, DoS in Polymer Science (PG), Manasagangotri, Mysore.
4. The Deputy/Assistant Registrar/Superintendent, AB and EB, UOM, Mysore.
5. The P.A. to the Vice-Chancellor/Registrar/Registrar (Evaluation), UOM, Mysore.
6. Office file.

ಮೈಸೂರು ವಿಶ್ವವಿದ್ಯಾನಿಲಯ

2021-2022

University of Mysore

(Estd.1916)

M.Sc. POLYMER SCIENCE

Choice Based Credit System (CBCS)

UNIVERSITY OF MYSORE

Department of Studies in Polymer Science

Manasagangothri, Mysuru-570006

Regulations and Syllabus

Master of Polymer Science

(Two-year semester scheme)

Under
Choice Based Credit System (CBCS)

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 Course	: Master of Polymer Science
Duration of the Course	: 2 years - divided into 4 semesters

CBCS & CAGP Syllabus and Credit Pattern (70+15+15)

Eligibility for admission to M.Sc., in Polymer Science

B.Sc. Degree with Chemistry/Polymer chemistry/Biochemistry as one of the subject with minimum of 50% marks for General Merit (GM) Candidates and 45% for SC/ST Candidates.

Or

B.Sc. Degree with Add – on Diploma in Chemistry /Polymer chemistry/ Biochemistry

Syllabus for M.Sc, Polymer Science Entrance Examination

Choice –Based Credit System & Continuous Assessment and Grading Pattern

(CBCS-CAGP)

Eligibility for Admission to M.Sc in Polymer Science

B.Sc. Degree with Chemistry/Polymer Chemistry as one of the Subject with a minimum of 45% marks in Chemistry/Polymer Chemistry for General Merit (GM) candidates and 40% for SC/ST candidates.

Syllabus

Unit 1: History of macro molecular science, importance of monomers and polymers, basic concepts. Nomenclature of polymers, inter molecular forces and chemical bonding in polymers. Classification: addition polymerization, condensation polymerization, polymerization mechanism.

Unit 2: Techniques of polymerization: Bulk, solution, suspension, emulsion, co-ordination polymerization, ring-opening polymerization, co-polymerization, importance of molecular weight in polymers, molecular weight distribution, control of molecular weight and their determination.

Unit 3: Bonding in organic molecules- Hybridization, sigma, pi and conjugated bonds, taking ethane, ethene, ethyne, Butadiene and benzene as examples. Bond energy, bond length and bond angles. Concept of resonance, resonance energy.

Unit 4: Stereochemistry: Chiral concepts, D, L; R, S nomenclature. Geometrical isomers: E and Z nomenclatures, Classification of organic reagents and reactions: Nucleophiles, electrophiles, nucleophilicity and electrophilicity. Mechanism of SN1 and SN2 reactions, carbonium ions, carbanions and free radicals formation and stability.

Unit 5: Addition to carbon carbon double bonds, catalytic hydrogenation. Naming reactions like Aldol condensation, Claisen condensation, Grignard reaction, Beckmann rearrangement.

Unit 6: Thermodynamics: Laws of thermodynamics, spontaneous and non-spontaneous reactions. Gibbs free energy, relation between entropy and thermodynamic probability. Partition functions. Partial molar quantities: partial molar free energy. Thermodynamics of dilute ideal and non-ideal solutions.

Unit 7: Chemical kinetics: Transition state theory. Reaction in solution: collusion theory and transition state theory. Salt effects. Effect of pressure and dielectric constant on reaction rates. Electro chemistry: Debye-Huckel theory of strong electrolytes, Onsager equation, Debye- Huckel limiting equation for activity coefficient, electrical double layer, electro capillary and electro kinetics phenomena.

Unit 8: Chemical bonding in inorganic compounds, coordination compounds, catalysis, aqueous and non aqueous solutions, s, p, d, molecular orbitals and their shapes. Heisenberg uncertainty principle. Atomic orbitals, Schrodinger wave equations, Quantum numbers, Aufbu and Pauli Exclusion Principle, Hund's multiplicity rule, electronic configuration of the elements. Atomic and ionic radii, ionization energy, electron affinity and electro negativity.

Unit 9: Chromatography: general terms and parameter used in chromatography, classification of chromatographic methods. Stationary and mobile phases- nature of adsorbents, factors influencing the adsorbents, nature and types of mobile phases. Column chromatography and thin layer chromatography: principle and applications.

Unit 10: Need for testing, standard and specifications. National and international standards, quality control, accuracy and validity of best methods. Recycling and biodegradability methods.

References:

1. Chemical kinetics – K. J. Laidler
2. Thermodynamics- Kuriacose and Rajaram
3. Thermodynamics- S. Glasstone
4. Advanced Inorganic chemistry by J E .Huheey.
5. Advanced Inorganic chemistry by FA Cotton and G.Wilkinson
6. Organic chemistry- Morrison and Boyd (Prentice Hall)
7. Text Books of Polymer Science – Bill Meyer (Wiley Inter Science Publishers)
8. Polymer Science – V R Gowarikar

Ph.D. Entrance Examination
Syllabus

Unit 1: General- Introduction to polymers with emphasis on important concepts such as – monomers, 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. Nomenclature of polymers.

Unit 2: Chemistry and Mechanism of polymerization- Definition of polymerization, factors affecting on polymerization, Addition polymerization (free radical, ionic and co-ordination polymerization).Condensation polymerization. Ring opening polymerization. Redox polymerization. Living radical polymerization.
Co-polymerization- Co-polycondensation, plasma polymerization, photo polymerization, Electro chemical polymerization, Metathesis polymerization, Group transfer polymerization, ATRP, Reversible addition-fragmentation chain transfer polymerization, dendrimer.

Unit 3: Specialty polymers- Functional polymers, LCPs, Conducting polymers, degradable polymers, Engineering Polymers: Unsaturated polyester resin, Epoxy resins, phenolic resins, Amino resins, Alkyds. Properties and applications of engineering polymers: Nylons, polyesters, PAN, PC, PU, ABS, Polyacrylates and allied polymers, Fluoropolymers, modification of industrial polymers.

Unit 4: Concept of polymer molecular weight: Importance of molecular weight control. Arthemitic mean-molecular weight, Weight average molecular weight, Mw, number –average molecular weight, Mn and viscosity average molecular weight Mv. Molecular weight distribution and its importance from the point of applications.
Determination of molecular weight- End group analysis, cryoscopic method, ebulliometric methods, membrane osmometry, vapour phase osmometry, light scattering, ultra centrifugation & viscometry.

Unit 5: Polymer processing
Processing of polymers: Moulding-compression moulding, injection moulding, blow moulding, rotational moulding, thermoforming, Extrusion-coextrusion, film extrusion, pultrusion, calendering, casting, coating. Reaction injection moulding (RIM) - principle and Moulding of DMC and SMC and other thermoset processing operations.

Unit 6: Polymer Testing
Mechanical properties: Tensile properties, compression properties, flexural properties, shear properties, impact resistance, toughness, tear resistance, abrasion resistance and hardness, creep, stress relaxation, fatigue properties, flexing and resilience.
Flammability properties: Oxygen index, critical temperature index, smoke density, flammability test, ignition properties, and surface burning characteristics.

Electrical properties: insulation resistance, volume resistivity, surface resistivity, breakdown voltage, dielectric strength, arc resistance, dielectric constant, power factor.
Optical properties: gloss, haze, refractive index and degree of yellowness, transmittance, photoelectric properties, and color.
Miscellaneous properties: MFI, MVI, specific gravity, bulk density, ESCR, weathering properties, toxicity, resistance to chemicals, abrasion, tearing, coefficient of friction, VST, HDT, Nondestructive testing methods.

Unit 7: Spectroscopic Methods: UV-visible spectroscopy- principle & theory Applications- qualitative and quantitative analysis, purity, cis-trans-conformation, molecular weight determination. Polymer degradation analysis.
Fourier transform infrared spectroscopy: principle and theory. Applications- Establishment of chemical structure of polymers, reaction kinetics, polymer linkages, hydrogen bond formation, purity, copolymerization, qualitative and quantitative results.
Nuclear magnetic resonance spectroscopy: (^{1}H and ^{13}C NMR) principle, theory, applications- structure (chemical), purity, tacticity, etc.

Unit 8: Thermal methods:
DSC: theory, principle& interpretations of DSC thermogram, Applications- heat of fusion and degree of crystallinity or isotacticity. Random copolymer structure, Block copolymer structure, polymer mixture melting point depression by diluents, crystallization, melt crystallization, cold crystallization, Tg, Tm, determination of blend composition, purity, identification of unknown, degree of crystallization, degree of cure, rate of cure studies(kinetics of curing) plasticizer effect, (Broido method, Kissinger method, Ozawa method, R& D method).
Thermogravimetric analysis: Principle, theory, Applications-purity, fiber content composition of compounded rubber, identification of polymers and rubbers, thermal stability, thermal degradation, kinetics of thermal degradation, IPDT, etc, Principles of DMA and TMA-applications.

Unit 9: Chromatographic Technique: Gel permeation chromatography-theory, principles, Applications-qualitative and quantitative analysis, molecular weight determination and molecular weight distribution, purity, composition, polymerization kinetics, depolymerization, identification of unknown, etc.

X-ray diffraction: SAXS, WAXS, theory, principle, Application- chain conformation, chain packing, disorder in crystals, degree of crystallinity, microstructural parameters, degree of orientations. Principles of optical microscopy, SEM, TEM, AFM. Applications- Methodology of polymers, crystallization behavior, phase separation.

Unit10: Structure -property relationship
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 interchain 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, calorimetric properties- heat capacity, enthalpy, and entropy, transition temperature - Tg, Tm and relationship between Tg and Tm of polymers, solubility- the solubility parameters, solubility limits.

References:

1. V.M Parikh: Application, spectroscopy of organic molecules(Mehata)
2. D.W. Williams and Flemmings: Spectroscopic methods of organic compounds.
3. Silertein and Basallar: Spectroscopic identification of organic compounds.
4. V.M.Parikh :Absorption spectroscopy of organic compounds (John Wiley)
5. P.S.Kalsi: Spectroscope of organic compounds (New Age)
6. J.R.Dyer: Applications of absorption spectroscopy of organic compounds.
7. Jackman and Stermineil: Application of NMR spectroscopy
8. J.D Roberts: Nuclear magnetic resonance(J.Willey)
9. Jafee and Orchin: Theory and application of U.V.
10. Introduction to Instrumentation Analysis by RD Braun Pharma Med Press
11. Introduction to Instrumental Analysis -RD, Braun, pharmamed press, Indian Reprint(2006)
12. Principles of Instrumental analysis,5th edition, D.A.Skoog, F.J.Holler,T.A.Nieman, Philadelphia Saunders College Publishing (1988)
13. Plastic Materials-Brydson
14. Rubbery materials and their compounds-Brydson.
15. Rubber Technology and manufacture-C.M. Blow
16. Polymer Chemistry- Seymour& Carreher, Marcel Dekkar, NY.
17. Principles of Polymerization-Odian G, wiley Inter Science, New Delhi
18. Polymer Science -Gowarikar, Wiley Estern Ltd. New Delhi
19. Fundamentals of Polymer Science and Engineering- anilkumar & S.K. Gupta, Tata McGraw Hill, New Delhi
20. Textbook of Polymer Science - F.W. Billmeyer.

Syllabus for Ph.D Course Work to be implemented from Academic year 2010-2011

Research Methodology

Unit I: Fundamental Laboratory Techniques: Basic principles, Health and safety, working with liquids. Basic laboratory procedures, pH and buffer solutions.
The investigative approach: making and recording measurements, SI units and their use, scientific method and design of experiments, Project work.
Research problem: meaning of research problems, sources of research problems, criteria/ characteristics of a good research problem, errors in selecting a research problem.
Developing a research plan: Research objective, information's required for solving the problem.
Hypothesis: Meaning, types of hypothesis.
Developing a research proposal: Format of research proposal, individual research proposal and institutional proposal.

Unit II: Research Report: Format of the research report, style of writing the report, references and bibliography. Analytical Techniques.
Analysis and presentation data: Using graphs, presenting data in tables, Hints for solving numerical problems, descriptive statistics, choosing and using statistical tests, drawing chemical structures, chemo metrics, computational chemistry.
Information Technology and Library Resources: The internet and world wide web, internet resources for polymer science, using spreadsheets, word processors, databases and other packages, finding and citing information.
Communicating information: General aspects of scientific writing, writing essays, reporting practical and project work, writing literature survey and reviews, organizing a poster display, giving an oral presentation examination.

Unit III: Scope of research in polymer science, types of research-basic and applied, frontier areas of research in polymer science, interdisciplinary research, outstanding discoveries and noble prizes in polymer field during the last two decades, patents. Research problem- identification, statement of research problem, objectives, design and execution of experiments, collection and interpretation of experimental data, arriving at conclusions, Reporting the results of research- style and format- title, abstract, the text, references, tables, figures, calculations, quotations and footnote, writing of research papers and dissertations.

Unit IV: Chemical safety and disaster Management:
a) Emergency response: chemical spills, radiation spills, biohazard spills, leaking compressed gas cylinders, fires, medical emergency, accident reporting.
b)General safety: General safety and operational rules, safety equipments, personal protective equipments, compressed gas safety, safety practices for disposal of broken glass wares, centrifuge safety, treated biomedical wastes and scientific ethics.

Unit V: Analysis and presentation data: Principle, instrumentation, Applications, Analysis and interpretation of the data for the following techniques: UV-visible spectrometry, IR, GCMS, TG-DTA, Nuclear Analytical Techniques, Fluorimetry, NMR, AAS, XRD. Degradation and stability, Modes of Degradation, Polymer waste disposal techniques, Biodegradable plastics, Pharmaceutical and Medical Applications of polymers.

Reference:

1. Anderson, Durston and poole, thesis and assignment writing, wiley Estern,1977
2. A.M. Heiss: Challenge to graduate students, Jossey Bass Inc.
3. J. Topping: Errors of observation and their treatment, Champan Hall(1972)
4. I.N. Gibra: Probability and statistical inference for scientist, prentice Hall(1973)
5. Chemical Abstracts, Monographs and Internet Services.
6. Electrochemistry and Electro analytical Techniques.
7. Environmental Chemistry.

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 Science 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 programme 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

1. 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.
2. Take up responsibilities in production, testing, design and marketing in the plastics industries and contribute for the growth of industry.
3. 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
1806	**SC**	Flocculants and dispersants	3	1	0	4
1807	**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	2	2	0	4
18516	**SC**	Engineering plastics	2	2	0	4
	SC	Term Work	2	2		4

(For Non-Polymer Students Only)

Paper Code	HC/SC/E /OE Pr./etc.	Subject	Credits			Total Credits
			L	T	P	
18517	**OE**	Fundamentals of Polymer Chemistry	3	1	0	4
18518	**OE**	Basics of Polymer Chemistry	3	1	0	4
		Credits to be gained from the other Dept Total credits **(16+4) =20**				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**	Polymers Blends & Composites	2	0	2	4
Any One of the below;						
18524	**SC**	Smart Polymers	3	1	0	4
18525	**SC**	Adhesive materials	3	1	0	4
18526	**SC**	Fibre science	3	1	0	4

OPEN-ELECTIVES **20**
(For Non-Polymer Students Only)

Paper Code	HC/SC/E / OE Pr./etc.	Subject	Credits			Total Credits
			L	T	P	
18527	**OE**	Industrial Polymers	3	1	0	4
18528	**OE**	Introduction to polymer composites	3	1	0	4
18529	**OE**	Latex and foam technology	3	1	0	4

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
NULL	**HC**	Project Work	0	2	6	8
Two of the below;						
18552	**HC**	Surface Coatings & Adhesion Technology	3	1	0	4
18553	**HC**	Nano Science	2	2	0	4
18554	**HC**	Polymer Membrane & Drug Delivery	2	2	0	4
18555	**HC**	Rubbery Technology	2	2	0	4
		Credits can be gained from the other Dept				
		(not mandatory)				**20+4=24**

I SEMESTER

HORD CORE

1. Principles of polymer chemistry

2. Polymer compounding

3. Polymeric materials

SOFT CORE

4. Physical chemistry of polymers

5. Inorganic and natural polymers

6. Flocculants and dispersants

7. Advanced spectroscopic methods

PRINCIPLES OF POLYMER CHEMISTRY

Sub.Code:18501
Paper: HC

Duration of the paper: 03h
Max. Marks: 70
Internal Assessment: 30
Total Marks: 100

Objectives:

- To study the fundamental concepts of polymer chemistry.
- To study the structure of monomers, functionality, and classification of polymers based on
- 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 be able to:

- Realize the basic concept of chemical reactions and polymerization reactions involved in the Macro molecules and micro molecular reactions
- Become fully aware of the stereo chemistry 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 monomers,precuations and synthesis of some monomers, 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. **16h**

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, Electro chemical Polymerization, Metathesis polymerization, Group transfer polymerization- synthesis and applications. **16h**

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. **16h**

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). **16h**

Reference:

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.
12. F.W. Billmeyer, Text Book of Polymer Science, 3rd edition, John Wiley and sons, New York,2002.
13. Gorge Odeon – Principles of Polymerization, 4th edition, McGraw Hill Book Company, New York 2004.
14. M.S.Bhatnagar, "A Text Book of Polymers (Chemistry and Technology of Polymers), Vol I, II & III, 1stEdn.,S.Chand and Company, New Delhi, 2007
15. PremamoyGhosh ," Polymer Science and Technology, 2ndedition,McGraw-Hill Publishing
16. R.J. Young, Introduction to Polymers, Chapman and Hall Ltd., London, 1999.

PRINCIPLES OF POLYMER CHEMISTRY PRACTIALS
List of experiments

1. Determination of Molecular Weight by viscosity method.
2. Determination of rate constant for the hydrolysis of an ester.
3. Verification of Beer's law to determine the concentration of a given substance in solution using Photoelectric colorimeter.
4. Determination of molar heat of solution of sparingly soluble organic acid by solubility method.
5. Determination of equivalent conductance of strong electrolytes.
6. Conductometric titration of mixture of HCl, CH_3COOH and $CuSO_4$ against NaOH.
7. Comparison of strengths of acids by studying the kinetics of hydrolysis of an ester.
8. Kinetics of reaction between potassium per sulphate and potassium iodide (I and II orders).
9. Conductometric titration of sodium sulphate against barium chloride.
10. Determination of dissociation constant of a weak acid by conductivity method.
11. Potentiometric titration of a redox reaction involving potassium iodide and Potassium permanganate.
12. Redox polymerization synthesis: preparation of poly (acrylamide) by free Radical polymerization.
13. Precipitation polymerization of acrylonitrile.
14. Suspension polymerization of methyl methacrylate.
15. Emulsion polymerization of methylmethacrylate, polyacrylonitrile.
16. Preparation of polyaniline.
17. Preparation of poly (ethylene terephthalate).
18. Preparation of polystyrene by redox method.
19. Preparation of poly(acryl amide) and poly (acrylic acid) copolymers.
20. Fractional distillation: separation of a mixture of benzene and toluene.
21. Solution polymerization of acrylamide.
22. Hydrolysis of poly (vinyl acetate).
23. Polymerization of Acrylonitrile initiated by the cerium (Iv) – Glutamine Redox System: A Kinetic study.

Reference:

1. Experimental in polymer science -D.G. Hundiwale, V.D. Athawale, U. R. Kapadi, V.V.Gite., New age 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
7. E. M. Mc Caffery, Laboratory Preparation for Macromolecular Chemistry, McGraw Hill,
8. Kogakush 1970.

9. Edward A. Colloid, J. Bares and F.W. Billmeyer Jr., Experiments in Polymer Science, Wiley Interscience, New York 1973.
10. Tim A. Oswald Georg Menges “Material Science of Polymers for Engineers”, Hanser Publications, 2012.
11. Wayne R. Sorenson and T. W. Campbell, Preparative Methods of Polymer Chemistry 3rd edition, Wiley – Interscience, New York, 2001.

POLYMER COMPOUNDING

Sub.Code:18502
Paper: HC

Duration of the paper: 03h
Max. Marks: 70
Internal Assessment: 30
Total Marks: 100

Objectives:

- 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 minimizing 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 able to:

- Realize various methods of **c**ompounding
- 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.
Additives which assist processing – stabilizers, lubricants-properties, mode of action of lubricants and, their application in the processing. The technical and economic significance of lubricants and processing aids. Additives which modify mechanical properties – plasticizers-definition of term, solvency and Gelation properties, effects on hardness, tensile strength, elongation, low temperature resistance and electrical resistance. Reinforcing fillers, toughening agents or impact modifiers-impact modifiers for PVC. **22h**

UNIT-II: Processing additives: Function of processing additives, History of processing additives, Classification of processing additives, processing with plasticizer. Additives which reduced formulation costs – fillers-theory of the action of fillers and reinforcements, properties of filled and reinforced plastic, application criteria for fillers in thermoplastics, extenders .Additives, which

modify surface properties – anti- static agents-chemical structure of anti-static agents, application, measurements of the anti-static 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. Anti-aging additives, antioxidants, autoxidation and mechanisms of anti-oxidation action, testing of antioxidants, mechanisms of U.V stabilization- UV absorbers, quenches, hydroperoxide decomposers, free redical scavengers, Other additives,light stabilizer testing, accelerated weathering, outdoor weathering, influence of pigments on light stabilizer performance, blowing agents, flame retardant, specialty additives.Vulcanizing agents, vulcanization and its effects, vulcanization reaction stages, determination of state of vulcanization, vulcanization systems. **24h**

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 **10h**

UNIT-IV: Compounding machineries and parameters – Mixing technology: principle of mixing, quality control. Different types of mixing role mills, Internal mixers and solution mixers, mixing sequence on a two roll mill, mixing sequence in the internal mixer. Testing and evaluation of compounds, Mould cleaning compounds. **8h**

Reference:

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.
14. R. Gachter and H. Muller, Plastics Additives Hand Book, Hanser Publishers, Munich, 1993.
15. John Murphy, The Additives for Plastics Hand Book, Elsevier Advanced Technology, Oxford, 1996.

16. Jesse Edenbaum, Plastics Additives and Modifiers Hand Book, Chapman & Hall, London,1996.
17. Ica Manas - Zloczower and Zehev Tadmor, Mixing and Compounding of Polymers, Hanser Publications, Munich, 1995.
18. Nicholas P. Cheremisionoff, Polymer Mixing and Extrusion Technology, Marcel Dekker Inc. NewYork, 1995.
17. J.A.Brydson, Plastics Materials, Butter worth Heinemann, Oxford, 1999.

POLYMERIC MATERIALS

Sub.Code:18503
Paper: HC

Duration of the paper: 03h
Max. Marks: 70
Internal Assessment: 30
Total Marks: 100

Objectives:

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 be able to:

- Understand the principles of synthesis and characterization.
- Become fully aware of the structural properties of materials by theory and experimental analysis by XRD, FT-IR, SEM, Molecular weight by viscosity method.
- Realize 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: **16h**

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, Polyvinylacetals. **16h**

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

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

Reference:

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
9. J.A.Brydson, “Plastics Materials”, Butterworth- Heinemann - Oxford, 6th Ed., 1995.
10. Feldman.D and Barbalata.A, “Synthetic Polymers”, Chapman Hall, 1996.

POLYMERIC MATERIALS PRACTICALS

List of Experiment

1. Preparation phenol-formaldehyde resin.
2. Preparation of urea-formaldehyde by polycondensation method.
3. Preparation of polyacrylonitrile.
4. Preparation of glyptal resin.
5. Preparation of polyaniline.
6. Preparation of aniline formaldehyde by polycondensation method.
7. Preparation of polyacrylamide by free radical polymerisatiom.
8. Preparation of polyacrylic acid from acrylic acid monomer.
9. Acetylation of PVA to PVAc.
10. Preparation of glyptal resin.
11. Preparation of polymethyl methacrylate by emulsion polymerisation.
12. Radical copolymerization of styrene and methylmethacrylate.
13. Bulk polymerization of MMA with 2, 2-azo-bis-butyronitrile.
14. Copolymerization of styrene with MMA by free radical solution technique.
15. Preparation of cellulose acetate.
16. Grafting of starch/cellulose with methylmethacrylate by redox initiator.
17. Chlorination/chlorosulphonation of PE.
18. Film casting from polymer solution
    (1) PU (2) cellophane (3) cellulose acetate.
19. Bulk polymerization of styrene with benzoyl peroxide.
20. Preparations of DGEBA epoxy resin using Bisphenol-A and Epichlorohydrin.
21. Preparation of diglycidyl aniline epoxy resin.
22. Preparation of cellulose secondary acetate.
23. Preparation of polyester resin using Ethyleneglycol and maleic acid by polycondensation method.
24. Preparation of melamine- formaldehyde resin.
25. Preparation of resol.

Reference:

1. Experiments in polymer science-E.A.Collis, J.Bares and F.W.Billmeyer.
2. Principles of polymer systems-F.Rodriguez
3. Advanced practical polymer chemistry- Dr. Kuruvilla Joseph, Dr. G. D. Gem Mathew- polymer publication , 2001.
4. Experimental in polymer science -D.G. Hundiwale, V.D.Athawale, U. R. Kapadi, V.V.Gite., Newage International(P) Limited, Pubilishers 2009.

PHYSICAL CHEMISTRY OF POLYMERS

Sub.Code:18504
Paper: SC

Duration of the paper: 03h
Max. Marks: 70
Internal Assessment: 30
Total Marks: 100

Objectives:

- 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 be able to:

- Realize the structure and properties of polymer molecules and micro molecular compounds.
- Understanding the thermodynamic properties of polymers in low concentration solution compared to conventional chemical moieties.
- Become fully aware of the difference between polymers and conventional micro molecular structure, size, molecular weight and thermodynamic behaviors.

COURSE CONTENT:

UNIT-I: Thermodynamics of polymers solutions**:** introduction to thermodynamics, Thermodynamics solubility of the systems,Vant hoff**'**s equation. Change in Volume on dissolution of polymers.Thermodynamics of dissolution of polymers and their structures. Partial molar quantities, methods of calculation. Ideal and non-ideal solutions. Thermodynamic criteria of polymer solubility, solubility parameter. **16h**

UNIT-II: Flory - Huggins theory. Entropy of mixing, enthalpy of mixing, Change in Gibbs free energy of dissolution of polymers. Dilute solution theory based on excluded molar volume. Thermodynamic properties. Perturbation theory and closed expressions. Second virial co-efficients, real polymer chains, Third Virial coefficients, lattices theories. **16h**

UNIT-III: Phase equalibra**:** thermodynamic derivation of phase rule. Theory of binary system. Solid liquid equilibria. Thermal analysis.Crystalizability of polymers, melting temperature of polymers. Three compound systems. Brownian plots. Systems involving two solids and a liquid. Partially miscible three liquid systems. Theory of polymer fractionation. The nature of the crystallinity state in polymers. **16h**

UNIT-IV: Radiation chemistry of polymers, effect of radiation on polymers, structure and Properties, theory of polymer swelling, swelling of non-ionic network system. Swelling of ionic network system, IPN**'**s: networks, sequential, simultaneous, full and semi IPN**'**s, thermoplastic IPN**'**s. **16h**

Reference:

1. Principles of polymer chemistry – P.J. Flory.-Encyclopedias- 672 pages.1995
2. Macromolecules in solution – H.merawetz. interscience. N.Y.1965
3. Principles of polymerization – G. Odian.-John Wiley & sons, Inc 2004.
4. Polymer colloids, A comprehensive Introduction: Rober M. Fitch –Springer 1971 (Academic Press)
5. Physical Chemistry of Polymers – A. Tager

INORGANIC AND NATURAL POLYMERS

Sub.Code:18505
Paper: SC

Duration of the paper: 03h
Exam Marks: 70
Internal Assessment: 30
Total Marks: 100

Objectives:

- To study the Mineralogical type and inorganic polymers structure, properties and applications.
- To study the Natural polymers like cellulose and natural cellulose/fibers, edible oils, gums, etc.
- To study the proteins, nucleic acids, polysaccharides, macromolecular structures, biological functions, biological information, enzymatic activity, bio-polymers-viruses and phages-living macromolecules.

COURSE OUTCOME:

The student will be able to:

- Realize the importance of inorganic and natural polymers and bio-polymers properties and applications.
- Understand the isolation, characterization of natural and bio-polymers.

COURSE CONTENT:

UNIT-I: Introduction. Mineralogical type inorganic polymers. Covalent inorganic polymers. Polymeric sulfur,Silicone polymers,Phosphonate polymers. Polyphosphozenes: History, critical account of preparation, properties, structure and applications, co-ordination polymers (phthalocyanines). **16h**

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

UNIT-III: Natural polymers: Classification, bio-polymers - 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. **16h**

UNIT-IV: Structure of bio-polymers: Proteins, nucleic 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 bio-polymers-viruses and phages–living macromolecules. **16h**

Reference:

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. Principles of Polymer Science-P. Bahadur, N V Sastry- Narosa Publishing House.2002

FLOCCULANTS AND DISPERSANTS

Sub.Code:18506
Paper: SC

Duration of the paper: 03h
Max. Marks: 70
Internal Assessment: 30
Total Marks: 100

Objectives:

- 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 be able to:

- Realize 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, and Economic aspects. **12h**

UNIT-II: Dispersants and Disperse systems Production of disperse systems, Stabilization of disperse systems, Stabilizers, Uses of dispersants. **12h**

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. **20h**

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. **20h**

Reference:

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

ADVANCED SPECTROSCOPIC METHODS

Sub.Code:18507
Paper: SC

Duration of the paper: 03h
Max. Marks: 70
Internal Assessment: 30
Total Marks: 100

Objectives:

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, and XRD) is described. The top method is the IR spectroscopy.

COURSE OUTCOME:

The student will be able to:

- Realize the structure properties and interactions of polymers by FT-IR, and crystallinity and micro-structural properties by XRD techniques.
- Identification polymers by spectroscopic methods.
- Students are aware about UV, DSC, and 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. **20 h**

UnitII: 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; amines; 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. **20 h**

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. **12 h**

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, meta stable peak, Mc Lafferty rearrangement, nitrogen rule. High-resolution mass spectrometry. Examples of mass spectral fragmentation of organic compounds with respect to their structure determination. **12 h**

Reference:

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 Stermineil: 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.

SEMESTER- II

HARD-CORE

1. Chemistry of High Polymers

2. Structure Property Relationship in Polymers

3. Polymer Characterization

SOFT-CORE

4. Polymer Identification & Analysis

5. Polymer physics

6. Engineering plastics

Open Elective

(For Non-Polymer Students Only)

7. Fundamentals of Polymer Chemistry

8. Basics of polymer chemistry

CHEMISTRY OF HIGH POLYMERS

Sub.Code:18511
Paper: HC

Duration of the paper: 03h
Max. Marks: 70
Internal Assessment: 30
Total Marks: 100

Objectives:

- 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 students will be able to:

- Realize 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.
- Become fully aware of 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.
- Realize 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**.** **16h**

UNIT-II: Polymerization techniques: Design criteria, polymer reactors, gas phase polymeri

zation, 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. **16h**

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. **16h**

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. **16h**

Reference:

1. Textbook of polymer science – F.W. Bilmeyer.-Wiley- India edition 1957.
2. Polymer science – V.R. Gowarikar, 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
List of Experiment

1. Preparation of cellulose tri-acetate by acetylation of cellulose.
2. Preparation of acrylonitrile grafted starch.
3. Preparation of acrylonitrile grafted HPMC.
4. Determination of acid value.
5. Estimation of Fe(II) using potentiometer.
6. Estimation of mixture of acids by conductometrically.
7. Determination of an acid value the of polymer sample.
8. Prepartion of adipic acid from cyclohexanol.
9. Determination of rate of polymerization.
10. Determination of energy of activation by chemical kinetics.
11. Redox polymerization kinetics.
12. Molecular weight control by chain modifier.
13. Estimation of monomers.(Aniline, Phenol, Urea, Formaldehyde)
14. Suspension polymerization kinetics.
15. Polymerization kinetics of bulk polymerization.
16. Partial molar quantities of a ternary system/ three components system.
17. Retardation inhibition of polymerization reaction.
18. Control of molecular weight.
19. Determination of degree of polymerization.
20. Estimation of Glucose and Albumin by Colorimetric method
21. Estimation of Amino acid and Protien by Colormitric method.
22. Estimation of peptide.
23. Analysis and estimation of phenolic group by bromination method.
24. Analysis and estimation of keto group by iodination method.
25. 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.

STRUCTURE –PROPERTY RELATIONSHIPS IN POLYMERS

Sub.Code:18512
Paper: HC

Duration of the paper: 03h
Max. Marks: 70
Internal Assessment: 30
Total Marks: 100

Objectives:

- 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 be able to:

- Understand the concept of synthesis of homo polymers, co -polymers, ter-polymers, block co-polymers, etc,
- Realize the structural modification by synthesis of various polymerization techniques, co-polymerization, blending, grafting depending on customer specifications.
- Become fully aware of 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, co-polymers, hetero-atomic polymers. Physical structure of polymers– introduction: Melt viscosity, inter-chain and intra-chain 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. **16 h**

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. **16h**

UNIT-III: Mechanical (visco-elastic) 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. **16h**

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. **16h**

Reference:

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
10. Edward Miller, "Plastics Products Design Hand Book", Marcel Dekker,
11. Laszlo Sors and ImreBalazs, "Design of Plastics Moulds and Dies", Elsevier, Amsterdam Oxford - Tokyo - NY, 1989.
12. P.S.CRACKNELL and R.W DYSON, "Hand Book of Thermoplastics - Injection Mould Design", Chapman & Hall, 1993.
13. S.Levy&J.H.Dubois, "Plastic Product Design Engineering Hand Book", Van Nostrand Reinhold Co., New York, 1977.

POLYMER CHARACTERIZATION

Sub.Code:18513
Paper: HC

Duration of the paper: 03h
Max. Marks: 70
Internal Assessment: 30
Total Marks: 100

Objectives:

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 techniques 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 be able to:

- Realize the theory, principle and instrumentation technique of DSC and TGA.
- Understand the Theoretical and instrumentation technique on various types chromatography.
- Become fully aware of both theoretical method of various types of molecular weight
- determination of polymers.
- Cognise 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 co-polymer structure. Polymer mixture melting point depression by diluents, crystallization, melts crystalisation, cold crystalisation. Glass transition- Crystal-crystal transition. Chemical reactions-Curing, polymerisation. Kinetics of Curing (Broido**'**s Method, Kissinger**'**s Method), plasticizer effect. **16h**

UNIT-II. TGA: Determination of degradation kinetic parameters. Method of Freeman and Carrol methods 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- Semi-quatitative and qualitative methods, thermal degradation behavior of some polymers by TG methods. Kinetics of thermal degradation, IPDT, OI, purity, fiber content, composition of compounded rubber. **16h**

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. **16h**

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. **16h**

Reference:

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

POLYMER IDENTIFICATION AND ANALYSIS

Sub.Code:18514
Paper: SC

Duration of the paper: 03h
Exam Marks: 70
Internal Assessment: 30
Total Marks: 100

Objectives:

- 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 be able to:

- Understand to characterize the polymeric materials by the above methods.
- Realize 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)Mysore , other polymer industries and polymer exhibitions.

COURSE CONTENT:

UNIT-I: Chemical methods**:** Qualitative analysis and colour tests, end group analysis, molecular weight, 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. **16h**

UNIT-II: Identification of Polymers: Rubbers, flexible thermoplastics, rigid thermoplastics, thermo-setting plastics. Analysis: Preliminary tests, burning tests, solubility tests, elemental analysis, transition temperatures, chemical Tests.
16h

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, purity, 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. **16h**

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. **16h**

Reference:

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

POLYMER IDENTIFICATION AND ANALYSIS PRACTICALS
List of Experiment

1. Estimation of Iodine value of Castor oil.
2. Acid value of maleic acid
3. Determination of DBP value and sieve analysis of Carbon black.
4. Estimation of acid value of oxalic acid.
5. Acid value of acrylic acid
6. Estimation of hydroxyl value by PVA and Cyclohexanol
7. Determination of epoxy equivalent weight of the epoxy resin.
8. Determination of saponification value of oil.
9. Study of three component system.
10. Determination of percentage of carbon black present in polymer.
11. Preparation of poly (glycerylphthalate) and determination of its acid value.
12. Preparation of polyethylene tetrasulphide and analysis by chemical methods.
13. Kinetics of polymerization of polyesterification reaction between ethylene glycol and phthalic acid.
14. Preparation of nylon 6, 10/6, 6 salt using HMDA- sebasic acid/ adipic acid.
15. Solution and bulk preparation of a polyester/ polyether based polyurethane.
16. Preparation of cross- linked polymers:
17. Poly acrylic acid- co-polyacrylamide
18. Sodiumalginate and poly(vinylalcohol).
19. Preparation of acid catalysed phenol formaldehyde resin.
20. Synthesis of adipic acid from cyclohexanol using Conc. HNO_3.
22. Estimation of carbohydrate by phenol sulphuric acid.
23. Estimation of lactose.
23. Copper (II) sulphate as a new indicator substitute to phenolphthalein in neutralization titrimetry.

Reference:

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

POLYMER PHYSICS

Sub.Code:18515
Paper: SC

Duration of the paper: 03h
Max Marks: 70
Internal Assessment: 30
Total Marks: 100

Objectives:

- 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 be able to:

- Understand the concept of rheological properties of dilute polymeric materials such as viscosity, density, determination of molecular weight, refractive index.
- Realize the nucleation and growth of crystals and their properties by XRD analysis.
- Become fully aware of 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. **16h**

UNIT-II: Nucleation and growth of crystals, cross-linked polymers and theory of rubber elasticity, mechanical behavior of polymers. **16h**

UNIT-III: Basic concepts of rheology: Dependence of shear viscosity on temperature, pressure, molecular weight, flow curve, theory of linear visco-elasticity. Newtonian, Non-Newtonian and visco-elastic fluids. **16h**

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. **16h**

Reference:

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.

ENGINEERING PLASTICS

Sub.Code:18516
Paper: SC

Duration of the paper: 03h
Max Marks: 70
Internal Assessment: 30
Total Marks: 100

Objectives:

- 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 able to:

- Understand that engineering plastics are weight –to- strength ratio, excellent chemical resistance, heat and fire resistance, creep compliances and moderate cost.
- Realise 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. **15 h**

UNIT-II: Genaral purpose Polymers: Chemistry, structure-property relationship of the following polymers: Polyamides, EVA, EPDM, UHMW-HDPE, polycetals. **10 h**

UNIT-III: High performance polymers: Chemistry, structure-property relationship of the following Polymers: Aromatic ethers, aromatic thioethers, polysulfones, polyether sulfones, polyimides, bismeleimides, PEEK, etc. **10 h**

UNIT-IV: Polymers for biomedical applications– Polymers in dentistry, Tissue adhesives , Dialysis Membrane; Blood oxygenators, Bone cement, Prostheses,Biodegradable sutures,Control drug delivery systems. **15 h**

References:

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.

5. C.P.Wong, Polymers for Electronic and Photonic Applications, Academic Press, New York, 1993.
6. H.F. Mark (Ed), Encyclopedia of Polymer Science and Engineering, Wiley – Interscience, New York, 1991
7. L.L. Chapoy (Ed), Recent Advances in Liquid Crystalline Polymers, Chapman and Hall, London, 1985.
8. ManasChanda, Salil K. Roy, Industrial Polymers, Specialty Polymers, and their Applications, CRC Press, 2008.
9. R.W. Dyson, Specialty Polymers, Blackie Academic & Professional, London, (second edition) 1998.
10. Robert William Dyson, Specialty Polymers, 2nd ed., Springer Verlag, 2011.

TERM-WORK

Objectives:

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

COURSE OUTCOME:

The student will be able to:

- 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.

COURSE CONTENTS:

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.

FUNDAMENTALS OF POLYMER CHEMISTRY

Paper code: 18517
Paper: OE

Duration of the paper: 03h
Max. Marks: 70
Internal Assessment: 30
Total Marks: 100

Objectives:

- 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.
- Realize 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. **16 h**

UNIT-II: Techniques of Polymerization: Bulk, solution, suspension, emulsion. Importance of molecular weight in polymers, molecular weight distribution, criteria of polymer solubility, solubility parameter, thermodynamics and phase equilibrium of polymer solution, fractionation of polymers by solubility. **16 h**

UNIT-III: Historical background, types of degradation in polymers: Thermal, oxidative, photo and biodegradation, principles of biodegradation: Introduction, modes of biological degradation, Enzymatic degradation of biopolymers , Microbial degradation of synthetic polymers. **14h**

UNIT-IV: Properties and applications of commodity polymers: LDPE, HDPE, LLDPE, PP, PVC, PS, SAN. Styrene and its copolymers, fluoropolymers, vinyl polymers. Polyesters, poly (vinyl acetate), poly carbonate, PU, PEEK, PEI. **14h**

Reference:

1. Principles of Polymer Engineering, N.G Mccrum, C.P Buckley & C.P Bucknell, Oxford Engineering Press, Oxford, 1988.
2. Biodegradable Polymers & Plastics, M. Vert (Ed.), Royal Society of Chemistry, Cambridge, 1992.
3. Chemistry & Technology of Biodegradable Polymers, G.J.L Griffin (Ed.), Blackie
4. Introduction to Polymer Chemistry-by Charles E.Carroher Jr., CRC Press, Taylor & Francis, Boca Raton, 2010
5. Polymer Science, P.L.Nayak, Kalyani Publishers, New Delhi.2012
6. Textbook of polymer science – F.W. Bilmeyer. Wiley- Indian edition, 1957.
7. Polymer science – V.R. Gowrikar.New age international publishers, 1986

BASICS OF POLYMER CHEMISTRY

Sub.Code:18518
Paper: OE

Duration of the paper: 03h
Max. Marks: 70
Internal Assessment: 30
Total Marks: 100

Objectives:

- To study the basic 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 polymerization reactions, their chemistry, mechanism, structures, properties and applications.

COURSE OUTCOME:

The student will be able to:

- Understand the basic concept of chemical reactions and polymerization reactions involved in the macromolecules and micro molecular reactions
- Realize the stereo chemistry and physical status of polymer molecules, molecular weight, stereo specificity and stability of polymer compounds.
- Become fully aware of 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 monomers,precuations and synthesis of some monomers, 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. **16h**

UNIT-II: Thermoplastics- Polyolefins and allied polymers, Vinyl polymers, Styrene and its co-polymers, Acrylics, Polyamides, Polyesters, PU, Fluoropolymers, Cellulose and its derivatives, Polycarbonates, Polyacetals, PES, PEI, PEEK, Polyacrylic acid, PVA, Polyvinylacetals. **16h**

UNIT-III: Thermosets- PF, MF, UF, Epoxy resins, Unsaturated polyester, Vinyl esters, Cyanate esters, Furan resins and silicone polymers. Elastomers- Natural Rubber, isoprene rubber, butyl rubber, Nitrile rubber, chloroprene Rubber and Styrene-butadiene Rubber, EPDM, Vulcanization, Rubber chemicals. **16h**

UNIT-IV: Introduction. Mineralogical type inorganic polymers. Covalent inorganic polymers. Polymeric sulfur—Silicone polymers—Phosphonate polymers. Polyphosphozenes: History, critical account of preparation, properties, structure and applications, co-ordination polymers

(phthalocyanine). **16h**

Reference:

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. 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 Polymer science- V.
7. Inorganic Polymers – by J.E.Mark, H.R.Alcock and R.West, Prentice Hall Publishers.2005
8. Contemporary Polymer Chemistry- By J.E.Mark, H.R.Alcock and F.W.Lampe, Prentice Hall Publishers, 3rd Edition; 2005.
9. Introduction to Polymer Chemistry-by Charles E.Carroher Jr., CRC Press, Taylor & Francis, Boca Raton, 2010.

SEMESTER – III

HARD - CORE

1. **Testing of Polymers**
2. **Specialty & Functional Polymers**
3. **Polymer Blends & Composites**

SOFT - CORE

4. **Smart Polymers**
5. **Adhesive Materials**
6. **Bio-degradable Polymers**

Open Electives
(For Non-Polymer Students Only)

7. **Industrial Polymers**
8. **Introduction to Polymer Composites**
9. **Latex and Foam Technology**

POLYMER TESTING

Sub.Code:18521
Paper: HC

Duration of the paper: 03h
Max. Marks: 70
Internal Assessment: 30
Total Marks: 100

Objectives:

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

COURSE OUTCOME:

The student will be able to:

- Realize 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 the specimen preparation with condition, shape and size of test specimen.
- Become fully aware of the standard test specimen preparation like moldings for films, specimens for mechanical properties 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. **16h**

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**.** **16h**

UNIT-III: Flammability properties: Oxygen index, critical temperature index, smokes density flammability test, ignition properties, and surface burning characteristics. Electrical properties: Insulation resistance, volume resistivity, surface resistivity, 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. **16h**

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. **16h**

Reference:

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

POLYMER TESTING PRACTICALS
List of Experiments

1. Chemical methods:
a) End group analysis- Molecular weight determination, vinyl content, carboxyl, epoxy, acetyl, amino and hydroxyl.
b) Acid value, iodine number and saponification value.
c) Identification of plastics (qualitative)
2. Physical methods:
a) Solution viscosity
b) Specific gravity/ bulk density.
c) Melt flow index.
d) Refractive index.
e) Sieve analysis/ particle size and its distribution.
3. Analysis and estimation of acrylic monomers by bromometry.
a) Determination of percentage of plasticizer content of a polymer.
b) Determination of ash content and moisture content of a polymer.
c) Determination of softening point by ring and ball method.
4. Isolation of casein from milk.
5. Isolation of caffeine from tea leaves.
6. Estimation of calcium in calcium carbonate.
7. Estimation of amino acid.
8. Deterimation of of plasticer in polyvinyl chloride.
9. End group analysis.
10. Isolation of cystein from hair.
11. Estimation of acetyl value in cellulose acetate.
12. Estimation of Spectrophotometric analysis of potassium permanganate solutions.
13. Estimation the amount of copper present in given $CuSO_4$ solution.
14. Estimation of % Formaline.
15. Estimation of Fe(II) using potentionmeter.
16. Determinationof Pka values of ortho phosphoric acid using PH meter.
17. Estimation of phenol.
18. Determination of melt flow index values of polypropelene.
19. Preparation of p-nitro aniline.
20. Swelling studies.

Reference:

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. G.C. Ives, J.A. Mead and M.M. Riley, Handbook of Plastics Test Methods, Illith Publishers, London, 1982,
7. J. Haslam, H.A. Willis and D. Squirrell, Identification and Analysis of Plastics. 2ndEdn.,Iliffe Book, Butterworth, London, 1983.
8. J.V. Schmitz (Ed) Testing of Polymers, Vol. 1 –3 , Wiley – Interscience, New York,1968.
9. R.P. Brown (Ed), Handbook of Plastics Test Methods, 2nd edition, George Godwin, 1988.
10. W.E. Brown (Ed), Testing of Polymers, Vol. 4, Wiley –Interscience, New York, 1969.

SPECIALTY AND FUNCTIONAL POLYMERS

Sub.Code:18522
Paper: HC

Duration of the paper: 03h
Max. Marks: 70
Internal Assessment: 30
Total Marks: 100

Objectives:

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, electrical and electronics applications, opto-electronics, drug delivery.

COURSE OUTCOME:

The student will be able to:

- 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 liquid 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. **16h**

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. **16h**

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

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

Reference:

1. Faiz Mohammad, Specialty Polymers: Materials and Applications, I.K. International Pvt Ltd, 2008
2. H.F.Mark, (Ed)," Encyclopaedia of polymer Science & Engineering". John Wiley & Sons, New York, 1989.
3. Johannes Karl Fink, Hand book of Engineering and Specialty Polymers, John Wiley & Sons, Vol.2, 2011
4. Manas Chanda, Salil K. Roy, Industrial Polymers, Specialty Polymers, and their Applications, CRC Press, 2008
5. ManasChanda, SalilK.Roy," Plastics Technology Hand book ", 2ndedition,Marcel Dekker, New York,1993.
6. Matrin.T. Goosey," Plastics for Electronics", Elsevier, Applied Science, 1985.
7. Norio Ise, IwaoTabushi, An Introduction to Speciality Polymers, Cambridge University Press, 1983 food applications.
8. Robert William Dyson, Speciality Polymers, 2nd ed., Springer verlag, 2011
9. Plastics Technology hand book, Manas chanda and Salil K Roy, (4^{th} edition), CRC press, New York. 1993

POLYMER BLENDS AND COMPOSITES

Sub.Code:18523
Paper: HC

Duration of the paper: 03h
Max. Marks: 70
Internal Assessment: 30
Total Marks: 100

Objectives:

- 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 homo-polymers or Co-polymers 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 be able to:

- Realize 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. **16h**

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

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. **16h**

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. **16h**

Reference:

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
9. A. B. Mathur, I. S. Bharadwaj, Testing and Evaluation of Plastics, Allied Publishers Pvt. Ltd., New Delhi, 2003
10. A. Ya. Malkin, A.A. AskaDsky, V.V. Koverica Experimental methods of polymers, Mir Publishers, Moscow, 1998.
11. B. Sivasankar, Engineering Chemistry, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2012
12. Iver, Mead and Riley, Hand book of Plastic test methods, Illith Publishers, New York, 1982.
13. S. K. Nayak, S. N. Yadav, S. Mohanty, Fundamentals of Plastic Testing, Springer, 2010.
14. Vishu Shah, Hand book of Plastics Testing and Failure Analysis, 3rd Edition, John-Willey & Sons, New York, 2007.

POLYMER BLENDS AND COMPOSITES PRACTICALS

List of Experiments

1. To study the miscibility of the polymer blend using ultrasonic method.
2. To study the miscibility of the polymer blend using viscosity method.
3. To study the miscibility of the polymer blend using refractive index method.
4. Determination of miscibility of polymer blends by density measurement method.
5. To determine the epoxy equivalent of the given resin.
6. To determine the intrinsic viscosity and molecular weight of the given polymer using Ubbelhod viscometer.
7. Elastic properties of polymers.
8. To determine the flexural strength of epoxy/ polyester composite.
9. Determine the refractive indices of polymer blends by using abbe's refractometer.
10. Potentiometric titration acid-base, end group analysis.
11. Conductometric - acid-base titration and end group analysis.
12. Separation of impurities from polymers by soxhlet method.
13. The study of viscosity of oil-in-oil emulsions with different surfactants.
14. Densities and excess volumes of binary liquid mixtures of PEG 200, PEG 400 and PEG 600 with toluene at three temperatures.

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.
7. Asian journal of chemistry vol 12, No.1-Dr. R. K Agarwal- chemic publishing co., Salibabad, India.

SMART POLYMERS

Sub.Code:18524
Paper: SC

Duration of the paper: 03h
Max. Marks: 70
Internal Assessment: 30
Total Marks: 100

Objectives:

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 be able to:

- Realize the polymer hydrogels for temperature and pH responsive hydrogels.
- Understand the hydrogels for biomedical applications like drug delivery
- Become fully aware of 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. **16h**

UNIT-II: Smart adhesives, films, coatings, thermo electric 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 micro tubes and conical carbon nanotube, synthesis and applications. **16h**

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

UNIT-IV: Electrochemistry of conducting Polymers, general synthesis of conducting polymers characterization of conducting polymers, synthesis, processability and applications, organic electrics applications. **16h**

Reference:

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

ADHESIVE MATERIALS

Sub.Code:18525
Paper: SC

Duration of the paper: 03h
Max. Marks: 70
Internal Assessment: 30
Total Marks: 100

Objectives:

- **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 be able to:

- Understand the concept of definition and mechanism of adhesion materials.
- Realize the synthesis 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 – Inter-diffusion theories, adsorption and surface reaction. Surface topography, wetting and setting, thermodynamic work of adhesion, Influence of constitution on adhesion,Inter-facial bonding, Coupling agents. **15 h**

UNIT -II: Characterization of adhesives Principle of fracture mechanics, peel, lap sheen and butt tensile 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. **15 h**

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. **10 h**

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. **10 h**

References:

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.
5. Preparative method in polymer science- Wayne R. Sorenson, Tod W. Campbell.

BIO-DEGRADABLE POLYMERS

Sub.Code:18526
Paper: SC

Duration of the paper: 03h
Max. Marks: 70
Internal Assessment: 30
Total Marks: 100

Objectives:

This paper aims to develop biodegradable polymer /plastics that are degradable by microorganisms in the environment (in soil), thereby reducing the burden on the environment. This will help to harmonize human activities with the natural environment and aid in solving the most serious and urgent global environmental problems as we approach the 21st century.

*Development of biodegradable plastics by utilization of natural polymer materials (Natural polymer derivation).

*Technology will be developed to realize a large –scale synthesis of biodegradable polymer materials by utilizing natural polymer materials.

*Development of technologies for functionalizing and improvement of natural polymers.

*Development of technologies for synthesis and processing.

*To demonstrate that sustainability and efficiency of agricultural practices can be achieved by introducing an innovative, economically viable and fully biodegradable plastic that eliminate waste completely.

*Current existing semi-intensive and intensive farming practices require the use of large qualities of mulching film and fruit protection bags since they help prevent the growth of weeds, protect crops from insects, regulate soil and produce temperature and retain water and nutrients.

* Conventional non-degradable polymer after single-use become plastic waste, creating a serious problem of waste management since it is time –consuming and expensive to recycle. Therefore, governments and farmers demand polymer scientists and technologists cost –efficient, environmentally responsible solutions.

* This waste plastic material to be converted energy source, or construction materials in composite form

COURSE OUTCOME:

The student will be able to:

- Fabricate the biodegradable polymer blend films and composites for high temperature and fire resistant polymers.
- Synthesis of biodegradable polymer films and composite films and edible polymer films for Food packaging and preservating applications, medical, paramedical, pharmaceutical and biomedical applications.
- Preparation of biodegradable polymer composite films for bio-sensors such as pH responsive ,temperature responsive , hydrogels (smart / intelligent materials) for controlled /sustained drug delivery and controlled fertilizer release applications..

COURSE CONTENTS:

UNIT-I: Historical background, types of degradation in polymers: Thermal, oxidative, photo and Bio-degradation, total degradation vs. partial (incomplete) degradation, degradation mechanisms, process technology for biodegradable polymers. 15 h

UNIT-II: Principles of bio-degradation: Introduction– Modes of biological degradation,Enzymatic degradation of bio-polymers, Microbial degradation of synthetic polymers. Starch-based products, additives for bio-degradation, production biodegradable films: Selection of base polymer, active additive, process description. **10 h**

UNIT-III: Synthetic Biodegradable polymers: Biodegradable polymers, Poly(lactides), polyglycosides, poly-caprolactone, Modified poly- caprolactone copolymer.Copolymer of 1,4-butanediol with adipic acid and sebacic acid, Biodegradable polyamides, Copolymers of - amino acid (glycine, serine), aminocaproic acid. Polyester urea, Polyamide urethane, Synthesis and properties of • polyglutamic acid,bacterial polyesters. **15 h**

UNIT-IV: Disposal of polymer waste: Disposal of solid polymer waste by biodegradation Composting (bioreactors), Ideal bioreactors, Stirred tank reactor, Batch and continuous operations, Feed- Batch operation, Plug flow reactor. Market Evolution of Biodegradable polymers. **10 h**

Reference :

1. Laszlo Sors and ImreBalazs, “Design of Plastics Moulds and Dies”, Elsevier, Amsterdam Oxford - Tokyo - NY, 1989.
2. P.S.CRACKNELL and R.W DYSON, “Hand Book of Thermoplastics - Injection Mould Design”, Chapman & Hall, 1993.
3. S.Levy&J.H.Dubois, “Plastic Product Design Engineering Hand Book”, Van Nostrand Reinhold Co., New York, 1977
4. Preparative method in polymer science- Wayne R. Sorenson, Tod W. Campbell.

FIBRE SCIENCE

Sub.Code:18527
Paper: SC

Duration of the paper: 03h
Max. Marks: 70
Internal Assessment: 30
Total Marks: 100

Objectives:

This course is to understand the textile raw material like fibers, fiber sources, and properties. The conversion of fiber into yarn and yarn spinning process as well as the conversion of yarn into various fabric developments like woven, knit, and other forms of fabrics. It includes both natural and synthetic fibers. Natural fibers further classified as plant fibers and animal fibers. United Nation General Assembly declares 2009 the International Year of Natural Fibres.15 of the world's major most important fibers are – 8 from plant fibers and 7 from animal fibers.

•Impart knowledge related to the structure and morphology of textile fibres.
•Understand the different characteristics of each fibre.
•Impart knowledge about process of producing bulk and textured yarn
.•Impart knowledge about high performance fibres.

COURSE OUTCOME:

The student will be able to:

•Gain knowledge on the physical, chemical and morphological structures of natural and man-made fibers .
•Know and Measure important fibre properties such as fibre length, fineness, strength, moisture regain and content % etc.
•Correlate the physical properties of fibre to its microstructure and its influence to other characteristics.
•Have knowledge on formation of texturised yarn.
•Have knowledge on different high performance fibres.

COURSE CONTENTS:

UNIT-I: Introduction: classification, sources of fibres, essential properties of textile fibres, sources of cellulose, sources of cellulosic fibres, sources of synthetic fibres, Fibres formation: synthesis of monomer, polymerization and formation of polymer, characteristics of fibres formation polymers, drawing. Fibres structure: unit cell, arrangement of chain molecules in the crystallites, formation and arrangement of crystallites in fibres, chemical methods. Vegetable fibres: cellulose, jute, flax, hemp, ramie, sisal, pinapple, coir. **10h**

UNIT-II: cellulose: molecular structure of cellulose, crystal structure of cellulose, swelling, reactions of cellulose, oxycellulose, types of oxycellulose. Cotton: cultivation, development of cotton fibres in seed, commercial classification of cotton, morphological structure, chemical composition of cotton, physical and chemical properties of cotton. Protein: structure, chemical constitution of proteins, configuration of polypeptide chain. Silk: morphological structure, production of raw silk, chemical

composition, chemical processing of silk, physical and chemical properties. Wool: structure, chemical composition, wool production. **15h**

UNIT-III: Regenerated Protein Fibres: Principle of manufacture, casein fibres, general properties of regenerated man-made fibres. Regenerated cellulosic fibres: sources of cellulose, fibres formed by esterification: cellulose acetate; manufacture, physical and chemical properties, uses, cellulose triacetate-chemical and physical properties. **10h**

UNIT-IV: Polyamide fibres: general methods of preparation, classification of nylons, general structure, properties, fibres formation, newly developed nylons-nylon 4, 7, 12; 4.6, 11;6,6; and 6,10, aromatic polyamides- Nomex and Kevlar. Vinyl fibres: poly acrylonitrile fibres, preparation, formation of polymer, structure of acrylic fibres, poly vinyl acetate, poly vinyl alcohol fibres, poly vinyl chloride fibre. High performance fibres. Processing of fibres. Identification and application of fibres. **15h**

Reference:

1. A textbook fibre science and technology- S. P. MISHRA- New age international publishers 2000
2. Fibre science and technology, ed. by V I Kostikov, Kluwer Academic Publishers, 1995
3. Man made fibers; Science and Technology, Edt. H.F.Mark, S.M.Atlas & Cerina., Inter Science publishers, New York. 1967
4. A text book of Fiber Science & Technology, S.P Mishra, New age international publishers, New Delhi. 2000

INDUSTRIAL POLYMERS

Sub.Code:18527
Paper: OE

Duration of the paper: 03h
Max. Marks: 70
Internal Assessment: 30
Total Marks: 100

Objectives:

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 be able to:

- Realize 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.
- Become fully aware of the Industrial polymer resins and their applications.
- Realize the properties and applications of engineering polymers.

COURSE CONTENTS:

UNIT-I: Raw materials for industrial polymers, production technology of polymer ; PEEK, PPO, PPS, PAN, PC, PU, Epoxy. **16h**

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

UNIT-III: Properties and Applications of Unsaturated polyester epoxy resins, phenolics, amino resins, alkyds. **16h**

UNIT-IV: Properties and applications of engineering polymers: Nylons, polyesters, ABS, Polyacrylates and allied polymers, fluoropolymers, modification of industrial polymers. **16h**

Reference:

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

INTRODUCTION TO POLYMER COMPOSITES

Sub.Code:18528
Paper: OE

Duration of the paper: 03h
Max. Marks: 70
Internal Assessment: 30
Total Marks: 100

Objectives:

The main objective of the current Topic/title is on Processing of Polymers and Polymer Composites course is to impart an understanding of the manufacturing science and engineering of polymers and polymer composites which is usually not covered at the UG level.

Course outcome:

The student will be able to:

- Understand the basic concept of polymer composites, classification of composites, classifications of polymer composites and their applications.
- Become fully aware of the concept of adhesion, fabrication techniques of composites.
- Realize the analysis and testing of composites, and applications.

COURSE CONTENTS

UNIT-I: Basic concept of polymer composites, classification of composites, matrix resins, Reinforcing agents: geometry and applications e.g., particulate, fibrous-short and continuous and sheet types. **15h**

UNIT-II: Surface treatment and modification, principles of adhesion, classification of adhesives, structural adhesive, pressure sensitive adhesive, high temperature adhesive, adhesion mechanism. **15h**

UNIT-III: Fabrication techniques of composites: hand lay-up spray coating, prepeg formation, Lamination, filament winding, vacuum bag molding. **10 h**

UNIT-IV: SMC, BMC and DMC, RRIM, RTM, polymer nanocomposites, analysis and testing of composites, applications. 1**0 h**

Reference:

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.

LATEX AND FOAM TECHNOLOGY

Sub.Code:18529
Paper: OE

Duration of the paper: 03h
Max. Marks: 70
Internal Assessment: 30
Total Marks: 100

Objectives:

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

COURSE OUTCOME:

The student will be able to:

- Understand the synthesis of latex foam, laminated paper, latex coated with natural fibers.
- Realize 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. **10 h**

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**. 15 h**

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**. 10 h**

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. **15 h**

References:

1. Latex Foam Rubber- E.W. Madge, , MacLaren and Sons Ltd., London, 1962.
2. Polymeric Foams and Foam Technology, 2 nd 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.2001

SEMESTER - IV

HARD-CORE

1. **Principles of Polymer Processing**
2. **Project Work**

SOFT-CORE

3. **Surface Coatings & Adhesion Technology**
4. **Nano science**
5. **Polymer Membranes and Drug Delivery**
6. **Rubber Technology**

Open Electives
(For Non-Polymer Students Only)

5. **Basics of polymer processing**

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PRINCIPLE OF POLYMER PROCESSING

Sub.Code:18551
Paper: HC

Duration of the paper: 03h
Max. Marks: 70
Internal Assessment: 30
Total Marks: 100

Objectives:

- 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 be able to:

- Realize the basic concept of polymer rheology, viscoelastic properties of polymers and need for processing.
- Understanding the role additives and their properties in raw material to process and get desire end product.
- Become fully aware of 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. **14h**

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**.** **16h**

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. **14h**

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 of textile terms, types of fibres, deneier, tenacity, moisture content & moisture regain, crimp, fabric property terms, properties of textile fabrics: Electrical properties, mechanical properties, dyeability, chemical stability, crease resistance, crease retention, fabric stability, wear resistance, aesthetic factors, comfort, fiber after-treatments: Scouring, lubrication, sizing, dying, finishing, textured yarn, woven & non-woven fabrics. **20h**

Reference:
Principles of Polymer Processing:

1. Plastic technology – Manas Chanda and Salil K Roy, 4th edition, CRC Press NY, 1993.
2. Polymer plastics technology and engineering vol. II – Naturman, L.M.dekkar, Louis Naturman, Marcel Dekker. (1975).
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.,1980
5. Synthetic rubber – G.S. Witby, wiley online library, 1955.
6. Essential fiber chemistry – Mery E. Carter, Marcel Decker. wiley online library, 1971.
7. Fibre science and technology, ed. by V I Kostikov, Kluwer Academic Publishers, 1995
8. Man made fibers; Science and Technology, Edt. H.F.Mark, S.M.Atlas & Cerina., Inter Science publishers, New York. 1967
9. A text book of Fiber Science & Technology, S.P Mishra, New age international publishers, New Delhi. 2000
10. Rubber Processing on a two-roll milln- B. R. Gupta Allied Publishers LTD.1998

PROJECT WORK

Duration of the paper: 03h
Max. Marks: 70
Internal Assessment: 30
Total Marks: 100

COURSE CONTENTS:

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.

SURFACE COATING AND ADHESION TECHNOLOGY

Duration of the paper: 03h
Sub. Code: 18552 **Max. Marks: 70**
Paper: SC **Internal Assessment: 30**
Total Marks: 100

Objectives:

- 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 be able to:

- Realize 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.
- Become fully aware of 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. **16h**

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

UNIT-III: Coating processes –

I. Surface preparation: Mechanical cleaning, solvent cleaning, alkali cleaning and acid pickling. Chemical conversion treatment.

II. Coating application: Mechanism of film formation

a. Applying processes: Brushing, dip coating and flow coating, curtain coating, roller coating and spray coating

b. Fixation

c. Curing: Physical, chemical and oxidative

III. Factors affecting coating properties. **16h**

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. **16h**

Reference:

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.

NANO-SCIENCE

Duration of the paper: 03h
Sub. Code: 18557 **Max. Marks: 70**
Paper: SC **Internal Assessment: 30**
Total Marks: 100

Objectives:

Strengthen the intersections of scientific disciplines by supporting interdisciplinary research to facilitate convergence of knowledge, tools, and domains of nanotechnology with other areas in science and technology.

COURSE OUTCOME:

The student will be able to:

- Realize the introduction to nanotechnology, definition, types, classifications, surface modification and their applications.
- Understand the different techniques of preparation of nano composites.
- Become fully aware of 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 reinforcedComposites. **16h**

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. **16h**

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. **16h**

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- polymer composites. **16h**

Reference:

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

POLYMER MEMBRANES AND DRUG DELIVERY

Sub.Code:18551
Paper: HC

Duration of the paper: 03h
Max. Marks: 70
Internal Assessment: 30
Total Marks: 100

Objectives:

- **Polymers** have played an integral role in the advancement of **polymer membrane**-based **drug delivery** systems technology by providing controlled **release** of therapeutic agents in constant doses over long periods, cyclic dosage, and tunable **release** of both hydrophilic and hydrophobic **drugs**.

COURSE OUTCOME:

The student will be able to:

- Understand the concept of preparation membranes, used for various applications like separation techniques such as separation of toxic gases , bacteria, viruses .
- Realize the different techniques such as controlled drug delivery, muco adhesive polymers,
- Become fully aware of the various applications of membranes such as micro filtrations, ultrafiltrations, nanofiltrations, reverse osmosis , Dialysis- elctrodialysis.

COURSE CONTENTS:

UNIT-I: Fundamentals of Membranes - Introduction to membranes, definition, classification of membranes,. Homogenous dense membranes, Heterogeneous asymmetric membranes, Thin film composite membranes, Liquid membranes-ion exchange membranes, Polymer selection for development of membranes, Polymer selection for development of membranes polymer property, Strength, Viscosity, Chemical resistance, Processing temperature, Factors membrane performance **10 h**

UNIT-II: Development and characterization of membranes- Development of polymer membranes, Modification, Blending, Cross linking,. Grafting- Copolymerization, Characterization of membranes, Solution techniques; Viscosity, Density, Ultrasonic velocity, Thermal methods; TGA, DSC, TMA, Spectroscopy methods; UV, FT-IR, NMR, Optical methods; SEM, TEM and XRD. Application of Membranes, Various applications and uses of membranes; Micro filtration, Ultra filtration, Reverse osmosis-Gas permeation, Pervaporation, Nano filtration, Dialysis, Electro dialysis. **15 h**

UNIT-III: Self-assemblies as promising Vehicles For Drug Delivery, Introduction, Various self assembled aggregates as carriers, Surfactants micelles, Liposomes, polymeric aggregates, Polymeric micelles, Polyion, functional properties of polymeric carriers, Morphological criteria,solubility and stability- Biocompatibility, drug loading and releasing characteristics,

Biological aspects, Pharmacokinetics at the systemic level, Cellular uptake , Release of drugs in the cell.

10 h

UNIT-IV: Role of Polymers in controlled release of drug delivery **-** Introduction, Currently available polymers; Diffusion- Controlled systems- Solvent- Activated systems– Chemically controlled systems, Magnetically controlled systems, Soluble polymers as drug carriers: Pinocytosis, Ideal soluble polymers, Biodegradable or bioerodible polymers: Drug release by matrix solubilization, Erodible diffusional systems, Monolithic systems , Mucoadhesive polymers, Polymer containing pendent bioactive substituents, Matrix systems.
10 h

References:

1. Pervaporation membrane separation processes–RYM.Huang, Elsevier Publications.1991
2. Introduction to Molecular Science, Second Edition – Petrmunk and Tejraj M. Aminabhavi. Wiley Online international,1989
3. Drug delivery systems (second edition)–Vasant V.Ranade, A.Mannfred Hollinger.CRC Press, 2003

RUBBER TECHNOLOGY

Sub.Code:18551
Paper: HC

Duration of the paper: 03h
Max. Marks: 70
Internal Assessment: 30
Total Marks: 100

Objectives:

- To promote and protect the interest, growth and development of the **rubber** industry.
- To foster Co-operation among individuals and units engaged in the manufacture of **rubber** goods with a view to advancing and safeguarding the interest of the industry.
- To provide common fora for exchange of views amongst the members.

COURSE OUTCOME:

The student will be able to:

- Understand the fundamental concept of rubber and its properties and applications.
- Realize the specialty rubbers, high performance rubber.
- Become fully aware of the processing of rubbers

COURSE CONTENTS

UNIT-I: Fundamentals of Rubber - Criteria for a polymer to behave as a rubber, Structure vs Tg, chemical, mechanical and electrical properties, Polymerization types and techniques involved in production of general purpose rubbers , Ozone attack on rubbers, Protection against oxidation, Antioxidants, Network bound antioxidants, Vulcanization, Effect of cross linking density on properties, Role of accelerators, Activators, Non–sulphur vulcanization systems. **10 h**

UNIT-II: Specialty rubbers heat resistant rubbers, Polyisobutylene, butyl and EPDM rubbers, Solvent/oil resistant rubbers, Nitrile, neoprene and chloroprene rubbers, EMA, ACM, EVA, Hypalon and chlorinated PE, High performance, specialty and modified rubbers, Fluorine containing and silicone rubbers, polyurethanes, polyethers, polysulphide, polyalkenomers and thermoplastic elastomers, Reclaim, liquid and powdered rubbers, ebonites. **15 h**

UNIT-III: Processing of rubber rubber processing – Mixing operations – Composition, Concentration, stabilization, coagulation, open mill mixing, internal and continuous mixers, Forming operations ,Calendaring, Extrusion –Spreading and moulding operations. **10 h**

UNIT-IV: Manufacture of tyres and tubes rubber product manufacture, Tyres, Functions, requirements, Basic design reinforcing systems, Construction, Manufacture, Testing, Tube manufacture, Compounding for tyre and tube. Belting, hoses and footwear, belting and hoses, Conveyor, transmission (V and flat) belting. Troughing moulded, braided and hand–built hoses, Compounding, Footwear and ports goods, Hot air vulcanized, Compression moulded, Direct moulded process for shoe bottoming, Injection moulded sole and heel units , Safety and

antistatic foot wear, Micro and macrocellular rubbers, expanding rubber by nitrogen gassing and chemical blowing agents, Tennicoit rings. **15 h**

References:

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.
7. 1. A.K. Bhowmick and H.L.Stephens, Hand Book of Elastomers, Marcel Dekker, New York, 1988.
8. B. Kothandaraman, Rubber Materials, Ane Books Pvt. Ltd., New Delhi, 2008.
9. C.M.Blow and C.Hepburn, "Rubber Technology and Manufacture", 2nd Edn., Butterworths, London, 1982.
10. J. A. Brydson, Plastic Materials, Elsevier Publishers Group, 2014
11. J.M. Martin, W.K.Smith, Handbook of Rubber Technology, Vol. 1 & 2, CBS Publishers & Distributors, 2004
12. M.Morton, Rubber Technology, Van Nostrand Reinhold, 1987.

BASICS OF POLYMER PROCESSING

Sub.Code:18551
Paper: HC

Duration of the paper: 03h
Max. Marks: 70
Internal Assessment: 30
Total Marks: 100

Objectives:

- **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.
- Realize 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. **15 h**

UNIT-II: Extrusion, injection molding, blow molding, compression molding. **15 h**

UNITIII: Transfer molding, calendering, thermoforming, roto-molding, ultra-sonic welding. **10 h**

UNIT-IV: Casting, sintering and compaction, dip coating, powder coating, analysis of defects in molded products. **10 h**

Reference:

1. Plastic technology – Manas Chandra & Salil K Roy, 4 th 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.