GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering
Level: Under Graduate
Branch: Rubber Technology
Subject Code : BE05026131
Subject Name : Biodegradable Polymers

w. e. f. Academic Year:	2024-25
Semester:	5
Category of the Course:	Professional Elective Course - 2

Prerequisite:	None
Rationale:	This course provides fundamental understanding of biodegradable polymers and elastomers with emphasis on sustainability and environmental responsibility in polymer and rubber industries. It covers concepts of biodegradability, degradation mechanisms, testing methods, polymer blends, and microbial degradation of natural and synthetic polymers. The course also focuses on environmental impact assessment and emerging applications of biodegradable materials in medical and advanced engineering fields. It enables students to understand eco-friendly material design, waste reduction strategies, and development of sustainable polymer systems aligned with modern environmental and circular economy requirements.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	Marks % weightage
C01	Explain classification and structural characteristics of biodegradable polymers.	20
C02	Describe mechanisms and factors influencing polymer biodegradation	20
C03	Analyze the different methods for measurement of Biodegradation in Elastomers and polymers.	20
C04	Analyze microbial degradation behavior of natural rubber and synthetic biodegradable elastomers.	20
C05	Develop the various biodegradable applications in field of rubber technology.	20

Teaching and Examination Scheme:

Teaching/Learning Scheme in hrs/semester					Total Credits	Assessment Pattern and Marks					Total Marks
						Theory		Practical			
L	T	P	PBL*	TH	TH/30	ESE (E)	PA (M)	PA (I)	PBL(I)	ESE (V)	
45	0	30	15	90	3	70	30	20	30	50	200

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, ESE = End-Semester Examination, PA = Progressive Assessment

*** Problem Based Learning (PBL) aims to accommodate learning beyond syllabus as per clause 9.4 of NBA manual.**

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	The Basics of Biodegradable Polymers: General considerations, Concept of sustainability in polymer and rubber industries, Concept of biodegradable, compostable and bio-based polymers, Biodegradability, Classification of biodegradable materials, Properties of Biodegradable Polymers, Environmental issues of rubber waste, Standards for biodegradability (ASTM, ISO).	05	10
2.	Polymer Biodegradation Mechanisms: Polymer Molecular Size, Structure and Chemical Composition, Influence of crystallinity and crosslinking, Hydrolytic, oxidative and enzymatic degradation mechanisms, Biodegradable Polymer Classes, Natural Biodegradable Polymers, Synthetic Biodegradable Polymers, Modified Biodegradable Polymers.	05	10
3.	Measurement of polymer biodegradation: Principles, Applications and drawbacks : Enzyme Assays, Plate Tests, Respiration Tests, Gas Evolution tests, Radioactively Labeled Polymers, Laboratory-scale Simulated Accelerating Environments, Applications and limitations of test methods. Evaluation of biodegradability, environmental impact, and material properties of biodegradable polymers as per relevant BIS standards such as **IS/ISO 14855, IS/ISO 14852, and IS 13360 series**.	05	10
4.	Biodegradable polymer blends:Basic structure of biodegradable medical polymers, new concepts of biodegradable polymer blends, Biodegradable polymer hybrids, Property modification through blending.	05	10
5.	Microbial degradation of Natural Rubber (Isoprene):production, biosynthetic pathways, biological functions, and biotechnological potential, Microbial cycling of Isoprene, Anaerobic Biodegradation of cis-1,4-Polyisoprene, Biodegradation of trans-1,4-Polyisoprene, Factors affecting natural rubber biodegradation.	05	15
6.	Microbial degradation of Synthetic polymers: Enzymatic activities for Poly (polyol sebacate) (PPS), Poly (glycerol sebacate) (PGS), Poly (xylitol sebacate) (PXS) and other PPS Elastomers, Photo polymerised poly (glycerol sebacate-co-acrylate) (PGSA), PGS-based elastomeric composites, Citric acid-based Elastomers, Other biodegradable soft Elastomers.	05	15
7.	Environmental Fate and Ecotoxicity Assessment of Biodegradable Polymers: Introduction, End of Life Scenarios of Biodegradable Polymers, Investigation into Polymer Biodegradation, Environmental Fate of Biodegradation Intermediates, Ecotoxicological Assessment of Biodegradation Intermediates.	05	10

8.	Applications of Biodegradable Elastomers & Polymers: Emerging biomaterials for various medical applications, drug delivery and tissue engineering, Preparation strategies, Design considerations, Degradation rate, Influence on properties during degradation.	05	10
9.	Biodegradable polymers from monomers based on vegetable oils: Introduction, Monomers from vegetable oils, vegetable oil based polyesters, vegetable oil based polyanhydrides, vegetable oil based polyesteramides, Biodegradation, Application	05	10
	Total	45	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
10	15	10	10	10	15

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Handbook of Biodegradable Polymers, Editor: Catia Bastioli, Smithers Rapra Technology Ltd.
2. Science and Principles of Biodegradable and Bioresorbable Medical Polymers , Materials and Properties by Xiang Zhang.
3. Biodegradation of Natural and Synthetic Rubbers by Alexandros Linos1, Alexander Steinbüchel.
4. Biodegradable Polymers: Recent Developments and new Perspectives by Geraldine Rohman
5. Biomaterials in Rubber & Polymer Industries: Sustainable Innovations and Application by Prof. Sunilkumar Padhiyar, Dr. Haresh K Dave, Dr. Nareshkumar R Vaghela, Mr. Dhiraj Nimje- Cosmas Scientific Publications

(b) List of Open Source Software/learning website:

- **http://nopr.niscair.res.in/bitstream/**
- **https://www.mdpi.com/2073-4360/11/6/1066/htm**
- **https://www.ijpsonline.com/articles/biodegradable-polymers**
- **https://doi.org/10.1038/s41396-018-0072-6**
- **https://biomedres.us/pdfs/BJSTR.MS.ID.002056.pdf**

List of Experiments:
Tutorials/Presentation/Practical based on above topics.

Overall SDG Mapping

The course primarily supports **SDG 12** through development and application of biodegradable polymers for sustainable material management. It contributes to **SDG 13** by reducing environmental pollution from conventional polymers and promotes **SDG 9** through innovation in green polymer technologies. The

course also aligns with **SDG 3, SDG 14**, and **SDG 15** by encouraging environmentally safe and bio-compatible material development.

Activities suggested under problem based learning:

Sr No.	Name of the activity	No. of hours	Evaluation Criteria
1.	Online Course	Minimum duration of the course should be 20 h.	Based on assignment submitted and certificate produced.
2.	Virtual /Industry Trip	Duration of hours-5h Report preparation- 5h Total -10 h	Based on report submitted. Report should contain manufacturing process, flow chart.
3.	Assignments	Completion of five independent tasks, each designed for a 3-hour engagement. Total = 15h	Based on assignment submitted.
4.	Case Study Analysis related to subject	Duration of data collection -6 h Report preparation – 4h Total- 10 h	Based on Problem identification, depth of analysis, technical insight, application relevance
5.	Technical Article/Video Reviews related to subject	Duration of Review -6h Report preparation -4h Total-10h	Relevance of content, clarity of summary, insights drawn, conceptual understanding
6.	DIY Experiments	5 hours including report preparation	Based on report submitted. Report should contain experiments performed which have Creativity, relevance to rubber properties, observation documentation, safety awareness.
7.	Course Seminar	Duration -10h	Based on technical Content & Understanding, Analysis, literature review, Quality of report and presentation.
8.	Mini/ Micro Project	Duration -10h	Based on Technical Analysis, literature review, methodology, innovation/sustainability aspect, Quality of report and presentation.
9.	Complex Problem solving	Duration -5h	Evaluation is based on problem complexity & clarity, analytical approach, design/experimental methodology, use of modern tools, sustainability considerations,

			innovation, result validation, and feasibility of solution.
10.	Videos focusing on industrial safety topics relevant to the subject	Duration of video = 5h Report preparation = 5h Total = 10h	Based report submitted. Report should contain all safety aspects explaining its importance.
11.	Visual presentation of technical content through posters, charts, or PowerPoint slides	Duration = 10 h	Based on quality of poster/chart preparation, creativity, accuracy and effectiveness of presentation skills.

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