GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering
Level: PG
Branch: Rubber Technology
Subject Code: ME02088111
Subject Name : Biopolymers and compostable Polymers

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

Prerequisite:	Basic knowledge of rubber technology and polymer technology, its chemistry, synthesis, processing, applications, and environmental impact of biopolymers.
Rationale:	The study of biopolymers is crucial in advancing sustainable material science and addressing global environmental challenges. Biopolymers, derived from natural and synthetic biodegradable sources, are gaining importance due to their versatility, eco-friendliness, and potential to replace traditional non-biodegradable polymers. Real-world applications in packaging, automotive, medical, and agriculture sectors demonstrate the versatility of biopolymers. Case studies provide tangible evidence of their successful integration, while future trends highlight innovative research directions, ensuring relevance in evolving markets. This comprehensive approach ensures a holistic understanding of biopolymers, equipping researchers and industry professionals with the knowledge to innovate and implement sustainable material solutions effectively.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes
C01	Describe the fundamental properties and synthesis of biopolymers.
C02	Evaluate the environmental impact and biodegradability of various compostable polymers.
C03	Analyze the application of biopolymers in rubber technology.
C04	Design and assess sustainable polymeric materials for industrial applications.

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
03	00	02	04	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Introduction to Biopolymers:** Definition and Classification: Biopolymers, synthetic biodegradable polymers, and compostable polymers, Sources: Natural sources (plants, microorganisms, algae), Importance and Applications: Food packaging, medical devices, rubber blends, etc. Global Perspective: Market trends and challenges.	8	15
2.	**Chemistry and Synthesis of Biopolymers:** Natural Biopolymers: Polysaccharides (starch, cellulose, chitosan), proteins (gelatin, casein), Microbial Biopolymers: Polyhydroxyalkanoates (PHA), polylactic acid (PLA), Synthetic Biodegradable Polymers: Polycaprolactone (PCL), poly(butylene succinate) (PBS), Chemical Modification: Grafting, crosslinking, and blending for enhanced properties.	8	20
3.	**Biodegradability and Environmental Impact:** Biodegradation Mechanisms: Hydrolysis, enzymatic degradation, microbial degradation, Standards and Certifications: ISO, ASTM, EN standards for compostability, Life Cycle Analysis (LCA): Environmental impact assessment.	8	20
4.	**Processing and Properties of Compostable Polymers:** Processing Techniques: Extrusion, injection molding, film blowing, 3D printing, Mechanical, Thermal, and Barrier Properties: Testing and analysis, Additives and Fillers: Natural fibers, plasticizers, compatibilizers.	7	15
5.	**Biopolymers in Rubber Technology:** Rubber Blends and Composites: Blending biopolymers with natural and synthetic rubbers, Applications: Eco-friendly tires, seals, and medical rubber products, Challenges: Compatibility, processability, and cost-effectiveness.	7	15
6.	**Applications and Case Studies:** Industrial Applications: Packaging, automotive, medical, and agriculture. Case Studies: Biopolymer integration in products, Future Trends: Innovations and potential research areas.	7	15
	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	10	20	10	10	10

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. Biodegradable Polymers for Industrial Applications by Ray Smith and Gerald Scott.
2. Biopolymers: New Materials for Sustainable Films and Coatings by David Plackett.
3. Introduction to Bioplastics Engineering by Syed Ali Ashter.
4. Handbook of Biodegradable Polymers by Andreas Lendlein and Adam Sisson.

(b) List of Open Source Software/learning website:
- **https://next-gen.materialsproject.org/**
- **https://libretexts.org/**
- **https://www.nist.gov/mgi**
- **https://ntrs.nasa.gov/**

Suggested Course Practical List: If any
Practical based on above topics.

Suggested Project List:

1. Develop a database of biopolymers and their classifications, highlighting their natural sources and key properties.
2. Analyze global market trends and challenges for biopolymers with a focus on regulations and commercialization strategies.
3. Investigate the chemical modification of starch to enhance its compatibility with synthetic rubbers.
4. Perform a Life Cycle Assessment (LCA) of a biopolymer-based product (e.g., a biodegradable bag) to evaluate its carbon footprint.
5. Evaluate the effect of natural fiber additives (e.g., jute, hemp) on the thermal and barrier properties of biopolymer composites.
6. Develop and test 3D-printed components using compostable polymer filaments.
7. Study the mechanical and thermal properties of rubber blends with chitosan as a natural **biopolymer**

filler.

8. Develop and evaluate eco-friendly tires using blends of natural rubber and biopolymer-based additives.
9. Investigate the cost-effectiveness and processability of biopolymer-integrated rubber seals for automotive applications.
10. Conduct a case study on the use of biopolymers in the agriculture industry (e.g., mulch films or slow-release fertilizers).
11. Develop a prototype packaging material using a biopolymer blend and analyze its shelf-life properties for food applications.
12. Research future trends and emerging biopolymer technologies for sustainable solutions in the automotive sector.
13. Design a hybrid composite using PLA and graphene oxide for advanced medical device applications.
14. Develop a smart biopolymer-based material with embedded sensors for monitoring biodegradation in real time.
15. Explore the scalability of biopolymer production using waste feedstock (e.g., agricultural residues).

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