Lahore University of Management Sciences

CHEM 515 – Polymer Science and Technology

Spring 2024

Instructor	Dr. Basit Yameen
Room No.	9.449A
Office Hours	TBA
Email	basit.yameen@lums.edu.pk
Telephone	8481
Secretary/TA	TBD
TA Office Hours	TBA
Course URL (if any)	NA

Course Teaching Instructions Mode (Please mention following details in plain text)
• Instructions Mode: Depending on the situation, instructions can be either in-person or online.

Course Basics				
Credit Hours	3			
Lecture(s)	Nbr of Lec(s) Per Week	Two	Duration	75 minutes
Recitation/Lab (per week)	Nbr of Lec(s) Per Week	NA	Duration	NA
Tutorial (per week)	Nbr of Lec(s) Per Week	NA	Duration	NA

Course Distribution	
Core	NA
Elective	Yes
Open for Student Category	SBASSE Students
Close for Student Category	Outside SBASSE

COURSE DESCRIPTION

Polymers are at the heart of modern-day science and technology innovations. For over a century, polymeric materials have been key contributors to the global socioeconomic development. Polymers are having revolutionizing impacts on a wide range of academic and industrial endeavors related to healthcare, renewable energy, electronics, textile, packaging, environment, aerospace, automotive, and construction. The total global production of different types of polymers was reported to be 368 million metric tons in the year 2019. Considering the importance of polymers, CHEM 515 is designed to be a comprehensive guide to the essential aspects of polymer science and technology. The contents of this course include an in-depth discussion on the chemistry of different types of polymers including synthetic and natural polymers. An important aspect of this course is a detailed discussion on various types of conventional and emerging polymerization techniques that are enabling the development of a wide variety of chemically and functionally diverse polymeric materials. Properties of synthetic polymers can be controlled by controlling their chemistry as well as molecular architecture. The molecular architecture control can be either in linear homopolymer or in random and block copolymer arrangements. Molecular architecture can be further derivatized via branching (side chain engineering) or crosslinking. The discussion on polymer synthesis will encompass synthetic methods for polymers displaying different molecular architectures and their impact on polymer properties. Kinetic aspects of different polymer synthesis methods will also be discussed. An understanding of polymer chemistry and molecular architecture will help in rationalizing the structure property relationships that are essential for comprehending the expanding applications of polymers. The course will also include understanding of molecular assembly of polymers at different length scales, which is critical to their targeted applications. A substantial amount of discussion will be dedicated to developing the understanding of the principles of various techniques that are being employed for polymer characterization. From application point of view, this course will highlight application of polymers as structural as well as functional elements in a wide range of academic and industrial endeavors addressing health, energy, and environment related opportunities, and this will be accomplished through group presentations. Current challenge of plastic pollution and its emerging solutions will also be discussed. Polymers are building blocks of life and have always been at the forefront of technological advancements. Understanding polymers is, therefore, essential to the training of science and engineering students.

COURSE PREREQUISITE(S)

- CHEM 101 for undergraduate students
- Non for graduate students

Lahore University of Management Sciences

COURSE OBJECTIVES	
•	Introduce synthetic and natural polymers.
•	Introduce methods of polymer synthesis (including kinetics) and polymer characterization
•	Introduce structure-property relationships to rationalize properties of polymers

Learning Outcomes	
•	Learn about natural and synthetic polymers, and polymerization techniques to synthesize polymers with controlled molecular architectures: linear block/random copolymers, graft polymers, and star polymers. Understand the kinetic aspects of polymerization reactions.
•	Learn about the behavior of polymer molecules in solutions and learn to estimate polymer molecular weight.
•	Gain understanding of polymer structure and physiochemical properties and understand the structure-property relationships to rationalize why a polymer behaves as elastomer, plastic, or fiber.
•	Learn designing polymers for applications in the fields of health, energy, and environment.

Grading break up: Component Details and weightages
Project/Assignment(s)/Class Participation: 1-2 (10%) Quiz(s): 6-8 (10%) Midterm Examination: 35% Final Examination: 45%

Examination Detail	
Midterm Exam	Yes Combine Separate: One midterm exam Duration: During class timing (75 minutes) Preferred Date: Around mid of the semester Exam Specifications: MCQs, short questions, numerical questions.
Final Exam	Yes Combine Separate: One final exam Duration: 3 hours Exam Specifications: MCQs, short questions, numerical questions.

Lahore University of Management Sciences

COURSE OVERVIEW			
Module	**Topics**	**Recommended Readings**	**Objectives/ Application**
Module-1	Introduction to polymers	**Chapter 1 and 2** - Polymer Chemistry, Seventh Edition, Charles E. Carraher, Jr. **Chapter 1 -** Principles of Polymerization, Fourth Edition by George Odian	Fundamentals of polymers
Module-2	Structure property relationship – Thermal and mechanical (Thermoplastics, thermosets, elastomers, plastics, and fibers)	Chapter 1 and 2 - Polymer Chemistry, Seventh Edition, Charles E. Carraher, Jr. **Chapter 1 -** Principles of Polymerization, Fourth Edition by George Odian	Structure property relationship
Module-3	Polymer chain dimensions/conformation, transition phenomena, solution properties, and molecular weights of polymers	**Chapter 2** - Polymer Chemistry An Introduction, Third Edition by Malcolm P.Stevens **Chapter 2, 3, 4** - Introduction to Polymer Science and Chemistry-A Problem Solving Approach by Manas Chanda	Structure property relationship
Module-4	Principles of techniques used to determine molecular weights of polymers	**Chapter 2** - Polymer Chemistry An Introduction, Third Edition by Malcolm P.Stevens **Chapter 2, 3, 4** - Introduction to Polymer Science and Chemistry-A Problem Solving Approach by Manas Chanda	Polymer Characterization
Module-5	Step growth polymerization, kinetics of step growth polymerization, and examples of polymers	**Chapter 2 -** Principles of Polymerization, Fourth Edition by George Odian	Synthesis of polymers
Module-6	Multi-chain polymerization – branching and crosslinking	**Chapter 2 -** Principles of Polymerization, Fourth Edition by George Odian	Synthesis of polymers and structure-property relationship
Module-7	Step copolymerization – Radom and block polymers	**Chapter 2 -** Principles of Polymerization, Fourth Edition by George Odian	Synthesis of polymers and structure-property relationship
Module-8	Chain growth polymerization, kinetics, and examples of polymers	**Chapter 3 -** Principles of Polymerization, Fourth Edition by George Odian	Synthesis of polymers
Module-9	Thermal, chemical and photochemical initiation of chain growth polymerization	**Chapter 3 -** Principles of Polymerization, Fourth Edition by George Odian	Synthesis of polymers
Module-10	Living Radical Polymerization (ATRP, NMP, RAFT)	**Chapter 3 -** Principles of Polymerization, Fourth Edition by George Odian	Polymers with living character
Module-11	Ionic Chain Polymerization (Cationic and Anionic)	**Chapter 5 -** Principles of Polymerization, Fourth Edition by George Odian	Synthesis of polymers

Module-12	Ring Opening Polymerization	Recommended Books	Synthesis of polymers
Module-13	Biodegradable polymers, Polymers for Health, Energy and Environmental Applications, Socioeconomic impact of polymers	Recommended Books	Polymer Applications, Worldwide development, commercialization, and entrepreneurial activities

Textbook(s)/Supplementary Readings

1) Principles of Polymerization, Fourth Edition by George Odian
2) Seymour/Carraher's Polymer Chemistry, Seventh Edition by Charles E. Carraher, Jr.
3) Polymer Chemistry An Introduction, Third Edition by Malcolm P.Stevens
4) Introduction to Polymer Science and Chemistry-A Problem Solving Approach by Manas Chanda