Syllabus for 16:160:409/509 Fall 2024
Organic Chemistry of High Polymers

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The field of polymer chemistry has been developing for just over a century since the invention of the first synthetic polymer (Bakelite) in 1907. Despite its relatively short history, polymer chemistry has undoubtedly become a cornerstone of modern society. This course aims to provide a comprehensive understanding of the synthesis and applications of various types of polymers from a chemist's perspective.

We will explore both traditional industrial methods of polymer synthesis (such as step-growth, free-radical chain-growth, copolymerization, Ziegler–Natta catalysis, and network polymers) and more advanced, controlled techniques (including living polymerization, controlled free-radical polymerization, block copolymers, and star/bottlebrush/hyperbranched polymers), which are at the forefront of current academic research and are believed to have huge application potentials in the near future. Additionally, the course will cover the properties and applications of polymers, ranging from everyday industrial products to specialized academic uses. The course is structured around four key aspects of polymer chemistry:

1. **Organic Chemistry**: Understanding the chemical transformations involved in polymerization;
2. **Physical Chemistry**: Analyzing the kinetics and thermodynamics of polymerization reactions;
3. **Statistics**: Assessing the molecular weight distribution of polymerization products;
4. **Process Design**: Understanding how polymers are manufactured in industry.

By the end of the course, students will have the opportunity to present cutting-edge research from the latest literature in polymer chemistry. This course is designed to bridge fundamental chemistry concepts with real-world applications, enriching students' understanding of how chemistry is integrated into our daily life.

Location:	SEC-217
Time:	Monday/Thursday 10:20–11:40 am
Office hours:	Friday 1:00–2:00 pm CCB 3202 (my office) (Additional office hours can be scheduled by appointment)
Textbooks:	*Polymer Chemistry* by Timothy P. Lodge, Paul C. Hiemenz, 3rd Edition (required) *Principles of Polymerization* by George Odian, 4th Edition (required) *Introduction to Polymers* by Robert J. Young, Peter A. Lovell, 3rd Edition (optional)
Lectures:	Lecture notes will be posted on Canvas three days in advance. Lecture attendance is mandatory. If you have a conflict – which should be rare – be sure to notify the instructor to obtain his approval beforehand.
Prerequisites:	One year of sophomore organic chemistry (equivalent to Chem 307/308) is mandatory. You will need an understanding of how to draw and interpret chemical structures, stereochemistry, arrow pushing, reaction mechanisms, chemical nomenclature, pK_a, etc. Understanding of chemical thermodynamics, kinetics, and differential equations at the level of Chem 323/324 is also strongly recommended. Understanding of basic probability concepts is very helpful.
Practice Problems:	There is no graded homework in this course, but practice problems and solutions will be posted periodically during the semester. You are encouraged to work through these practice problems to strengthen your understanding of the course material.

Final Presentation: On October 14th, 20 papers will be posted on Canvas. These papers are selected from recent journals by the instructor and cover a broad range of topics discussed in the course. You will need to choose one paper to give a 20-minute presentation during the final three classes of the semester (December 2nd, December 5th, December 9th).

To facilitate this process, a Google spreadsheet will be provided where you can claim your chosen paper. Please make your claim by October 21st. Check the spreadsheet before making your claim—if multiple students select the same paper, priority will be given to the student who claims it first.

Your presentation should focus on:

1. Elaborating on the fundamental problem the paper aims to address.
2. Introducing the chemical approach developed in the paper.
3. Discussing the potential issues/limitations associated with the work.

Your final presentation will be graded based on:

1. The level of understanding you demonstrate about the paper.
2. The critical thinking you show when introducing the paper.
3. Your ability to handle questions from the audience.
4. Your participation in other students' final presentations.

Midterm Exams: The course has two midterm exams that will be held during the regular lecture time. The first midterm is scheduled for October 14th and will cover material from Lectures 1 through 10. The second midterm is scheduled for November 18th and will cover material from Lectures 11 through 19. You may bring a hand-written, letter-sized cheat sheet and a calculator to the exams. The questions on the midterms will be similar in format to those in the practice problems.

Grading: Your overall grade in the course will be determined as follows:
Lecture Participation: 10%
Midterm Exams 1 & 2: 50% (the higher score will count for 35% and the lower for 15%)
Final Presentation: 40%

Course Policy: You may collaborate freely with your classmates on the practice problems to prepare for the midterm exams. You may also discuss the paper you will present with your classmates, but the presentation itself must be given by you alone. Collaboration is not permitted during midterm exams. Students who do not uphold academic integrity standards consistent with Rutgers' guidelines will automatically fail the course and may face more severe sanctions.

I look forward to your feedback on the course and hope that you find Chem 409/509 both intellectually stimulating and a valuable foundation for applying molecular engineering to your scientific problems. Last, I wish the knowledge you gain in the course will support your future career development and deepen your understanding of the macromolecular aspects of the world around us.

Good luck with the course!

Yuwei Gu

Schedule: Please note that, except for the fixed mid-term exam dates, the chapter-by-chapter schedule is subject to adjustment and change without further notification.

Chemistry 409/509 Fall 2024 Course Schedule			
09/05 (Thu.)	Lecture 1	Introduction of Polymers I: History, Structural Isomerism	Lodge 1.1-1.6 Odian 1.1-1.3
09/09 (Mon.)	Lecture 2	Introduction of Polymers II: Properties, Molecular Weight Distribution, GPC	Lodge 1.7-1.10 Odian 1.4-1.6
09/12 (Thu.)	Lecture 3	Step-Growth Polymerization I: Introduction, MWD, Kinetics	Lodge 2.1-2.4, 2.8 Odian 2.1-2.7
09/16 (Mon.)	Lecture 4	Step-Growth Polymerization II: Process Conditions	Lodge 2.5-2.7 Odian 2.8, 2.14
09/19 (Thu.)	Lecture 5	Chain-Growth Radical Polymerization I: Introduction, Kinetics	Lodge 3.1-3.6 Odian 3.1-3.5
09/23 (Mon.)	Lecture 6	Chain-Growth Radical Polymerization II: MWD, Thermodynamics, Chain Transfer	Lodge 3.7-3.9, 4.7 Odian 3.6-3.12
09/26 (Thu.)	Lecture 7	Chain-Growth Radical Polymerization III: Process Conditions, Copolymerization	Lodge 5.1-5.3 Odian 3.13-3.14, 4.1-4.3
09/30 (Mon.)	Lecture 8	Chain-Growth Radical Polymerization IV: Copolymerization	Lodge 5.4-5.6 Odian 6.1-6.3
10/03 (Thu.)	Lecture 9	Controlled Polymerization I: Introduction, Poisson Distribution, Anionic Polymerization	Lodge 4.1-4.3 Odian 5.1, 5.3
10/07 (Mon.)	Lecture 10	Controlled Polymerization II: Anionic Polymerization, Cationic Polymerization	Lodge 4.3, 4.5 Odian 5.2, 5.3, 5.6
10/10 (Thu.)	Lecture 11	Controlled Polymerization III: Reversible Deactivation Radical Polymerization	Lodge 4.6 Odian 3.15
10/14 (Mon.)	Midterm Exam I (Lecture 1 through Lecture 10) (Paper choice for the final presentation will be posted after the lecture)		
10/17 (Thu.)	Lecture 12	Controlled Polymerization IV: Block Copolymer Synthesis	Lodge 4.4 Odian 5.4
10/21 (Mon.)	Lecture 13	Ring-Opening Polymerization I: Cyclic Ethers/Acetals, Lactams, NCA, Lactones (Choice of paper for the final presentation is due)	Lodge 4.8 Odian 7.1-7.3, 7.5
10/24 (Thu.)	Lecture 14	Ring-Opening Polymerization II: ROMP, Radical ROP, Inorganic Polymers	Lodge 4.8 Odian 7.4, 7.8-7.11
10/28 (Mon.)	Lecture 15	Stereochemistry of Polymerization I: Stereoregularity, Stereoregulation in Polymerization	Lodge 5.7-5.9 Odian 8.1-8.3
10/31 (Thu.)	Lecture 16	Stereochemistry of Polymerization II: Ziegler–Natta Polymerization, Metallocene Polymerization	Lodge 5.11-5.12 Odian 8.4-8.12
11/04 (Mon.)	Lecture 17	Polymer Topology I: Cyclic/Star/Bottlebrush Polymers, Surface Brushes	Lodge 4.4 Odian 9.9
11/07 (Thu.)	Lecture 18	Polymer Topology II: Crosslinked Polymer Networks	Lodge 10.1-10.2 Odian 9.2, 2.10-2.12
11/11 (Mon.)	Lecture 19	Polymer Topology III: Hyperbranched Polymers, Dendrimers	Lodge 4.9 Odian 2.16
11/14 (Thu.)	Lecture 20	Special Topic I: Semiconducting Polymers	
11/18 (Mon.)	Midterm Exam II (Lecture 11 through Lecture 19)		
11/21 (Thu.)	Lecture 21	Special Topic II: Synthesis of Biopolymers	
11/25 (Mon.)	Lecture 22	Special Topic III: Polymeric Biomaterials	
11/26 (Tue.) (Thu. Classes)	Lecture 23	Special Topic IV: Polymer Sustainability	
12/02 (Mon.)	Final Presentation of Literature by Students		
12/05 (Thu.)	Final Presentation of Literature by Students		
12/09 (Mon.)	Final Presentation of Literature by Students		