McMaster University | ENGINEERING Chemical Engineering

CHEMICAL ENG 4B03/6B03: Polymer Reaction Engineering

September – December 2025

INSTRUCTOR: Dr. Boyang Zhang
JHE A416
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LECTURE HOURS: Tuesday 8:30-11:30pm
LOCATION: ABB166

COURSE OBJECTIVE:

In this course you will learn about the fundamentals of polymerization reaction (condensation, free radical, controlled radical, anionic, cationic, Ziegler-Natta, and metallocene) followed by a series of case studies that highlight how advances in polymerization and polymer design can be applied in research and industrial applications.

COMMUNICATION:

- This is an in-person course, and attendance is expected. Should you have to be absent from the lecture for any unexpected circumstances, you may ask the instructor to provide you with the recorded lecture content from previous years. However, the lecture might not match the current term exactly. All tests require in-person attendance. Absences from tests require the use of an MSAF. It's your responsibility to coordinate with your teammate on group assignments should you be absent from class.
- All course slides and materials will be made available on Avenue. No textbook required.
- 6B03 students must use 4B03 course shell on Avenue2Learn, NOT 6B03.
- In-class group assignment will be in-class to facilitate group work. The instructor will provide the assignment problem in class as well as on avenue. The instructor will guide the student through the assignment in class as needed.

TOPICAL OUTLINE:

Unit 1. Introduction to Polymer Reaction Engineering –Review and introduce the topic of polymer reaction engineering and discuss what is polymer and macromolecule; how to classify polymer and polymer properties as well as polymer molecular weight calculation.

Unit 2. Polymerization Mechanisms and Kinetics – Discuss condensation polymerization, free radical polymerization, Ziegler-Natta polymerization, etc.; Polymerization rate and polymer

molecular weight distribution; Copolymerization and Copolymer composition; Penultimate model; Branching and crosslinking; Flory's theory of gelation.

Unit 3. Polymer Reaction in Research and Industrial Applications – Discuss how polymer reaction can be applied in 3D printing, microfluidic reactors, and the development of biodegradable materials. This unit is designed to provide students with real life examples of how polymer reaction engineering can be integrated with other technologies and applied in research and industrial applications.

Unit 4. In-class student presentation on selected topics – Train the students on performing independent literature review and communicate newly learned materials in a concise manner. Students will work in groups to independently learn a specific topic on polymer reaction and then teach the class about the topic in a short in-class presentation.

COURSE SCHEDULE: Please note that this schedule is subject to change based on weather cancellations, class interest in a particular topic, and changes in the availability of guest lecturers. Any changes to this schedule affecting evaluations will be announced at least one week in advance via the Announcements page on the Avenue to Learn site for this course and announced in-class.

Date	3-hour session	
Week 1 (September 2)	Course outline and Lecture 1.1, (Introduction and MW Calculation)	In-class assignment 1
Week 2 (September 9)	Lecture 2.1 (Step polymerization)	In-class assignment 2
Week 3 (September 16)	Lecture 2.2 (Free radical polymerization)	In-class assignment 3
Week 4 (September 23)	Lecture 2.3 (Anionic polymerization)	In-class assignment 4
Week 5 (September 30)	Lecture 2.4 (Ziegler-Natta polymerization)	In-class assignment 5
Week 6 (October 7)	Lecture 2.5 (Co-polymerization)	In-class assignment 6
Week 7 (October 14)	No Class (Midterm recess)	
Week 8 (October 21)	**Midterm exam (in-class)**	
Week 9 (October 28)	Lecture 2.6 (Polymerization methods)	
Week 10 (November 4)	Lecture 3.1 (3D printing and polymerization)	In-class assignment 7
Week 11 (November 11)	Lecture 3.2 (Polymerization in microfluidic reactors)	In-class assignment 8
Week 12 (November 18)	Lecture 3.3 (Development and polymerization of degradation biopolymers)	In-class assignment 9
Week 13 (November 25)	In-class student presentation on selected topics	
Week 14 (December 2)	In-class student presentation on selected topics	
Final exam weeks	**Final Exam**	

ASSESSMENT:

In-class weekly assignments (9 group assignments, 5% each)	45%
In-class presentation	15%
Midterm test (15%) and Final examination (25%)	40%

NOTES ON ASSESSMENTS:

- **In-class weekly group assignments** are intended to give practical experience in applying concepts introduced in the lectures to solve specific problems. Students will work individually or as a group of two to solve these problems. You have to sign up for your group here for our record. Only one submission per group is needed. Most of the problem are calculation-based while others are design-based. These workshop are highly relevant as the midterm and final exam questions will reflect the style of the workshop problems. The instructor will join each group periodically to answer any specific questions in class. Each assignment will be due on Avenue2Learn at midnight on the Tuesday of the following week. One excused missed assignment will be considered for accommodation via an MSAF except in exceptional circumstances; further missed workshops will result in a mark of zero being applied to that workshop.

- Both the **midterm and final exams** will be open book (i.e. you may bring notes and any other reference material you wish to bring). You can use your laptop and calculator. The midterm test will be during class time. The midterm and final exam will be instructor-invigilated.

- For the **in-class student presentation,** you will work individually or in a group of two (same group as your weekly assignment). Together you will research the synthesis or production process (either lab based or industrial based) of a specific commodity polymer (e.g., polystyrene, polypropylene, polyurethane) or a novel biopolymer (e.g., Polyethylene Glycol, etc.). Your team will sign up for a polymer of choice from the list provided here on a first-come-first-serve basis. You may also propose your own suggestions. To avoid duplication, your choice has to be different from others. In the in-class presentation, you will (1) present the importance and application of the selected polymer in the introduction, (2) describe the specific reaction process and relate that back to concepts introduced in the course, and finally (3) discuss with current challenges in the production or synthesis process and propose areas for future research. The presentation should be 15 min long with 5 min for Q&A from the class. You are encouraged to check your topic with Dr. Zhang prior to starting this assignment to ensure it fits within the scope of the course. A marking scheme will be provided and you will be graded on the content and the effectiveness of your communication. If you require accommodation for this assignment, please don't hesitate to reach out to me. I am also willing to explore alternative method of assessment.

ASSESSMENT POLICIES:

- Late evaluations will be assessed a penalty of 10% per school day late. If deadlines cannot be met due to sickness or other valid reasons, you *must* complete the McMaster Student Absence Form and forward it to the instructor to receive consideration for waived late penalties and/or arrange alternate due dates. Please note that the requirement for an MSAF also pertains to requests for consideration for missed mandatory workshops, as per the guidelines outlined earlier.

- The final percentage grades will be converted to letter grades using the Registrar's recommended procedure. Adjustments to the final grades may be done at the discretion of the instructor.

RESOURCES:
There is no textbook for this course. You are not required to read anything other than what is provided by the course instructor on Avenue-to-Learn. However, you might find it useful to expand your learning by referencing the following textbooks and references:

Suggested reading:

1. Chem Eng 4B03/6B03 Course Notes (provided by the instructor on Avenue to Learn website).
2. S. Zhu, A.E. Hamielec "Polymerization Kinetic Modeling and Macromolecular Reaction Engineering" In: Matyjaszewski K and Möller M (eds.) Polymer Science: A Comprehensive Reference, Vol 4, pp. 779–831. Amsterdam: Elsevier BV (provided by the instructor on Avenue to Learn website).
3. Paul Hiemenz, Timothy Lodge, "Polymer Chemistry, The Basic Concepts", 2nd edition, Marcel Dekker, 2007
4. George Odian, "Principles of Polymerization", 4th edition, Wiley-Interscience, 2004
5. J.A. Biesenberger, D.H. Sebastian, "Principles of Polymerization Engineering", John Wiley & Sons, 1983
6. A. Rudin, "The Elements of Polymer Science and Engineering", 2nd edition,
7. Academic Press, 1998
8. H.R. Allcock, F.W. Lampe, J.E. Mark, "Contemporary Polymer Chemistry", 3rd edition, Prentice Hall, 2003
9. P.J. Flory, "Principles of Polymer Chemistry", Cornell University Press, 1953
10. J.M.G. Cowie, "Polymers: Chemistry and Physics of Modern Materials" 2nd Edition, Blackie A&P, 1994
11. R.J. Young, P.A. Lovel "Introduction to Polymers" 2nd edition, CRC, 2000
12. T.L. Richardson, "Industrial Plastics: Theory and Application", 2nd ed., Delmar Publishers, 1989

The following Faculty of Engineering and University Senate policies will be followed in this course:

ACADEMIC INTEGRITY

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity. **It is your responsibility to understand what constitutes academic dishonesty.**

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university. For information on the various types of academic dishonesty please refer to the Academic Integrity Policy, located at https://secretariat.mcmaster.ca/university-policies-procedures-guidelines/

The following illustrates only three forms of academic dishonesty:
•plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.
•improper collaboration in group work.
•copying or using unauthorized aids in tests and examinations.

AUTHENTICITY/PLAGIARISM DETECTION

Some courses may use a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work. For courses using such software, students will be expected to submit their work electronically either directly to Turnitin.com or via an online learning platform (e.g. A2L, etc.) using plagiarism detection (a service supported by Turnitin.com) so it can be checked for academic dishonesty.

Students who do not wish their work to be submitted through the plagiarism detection software must inform the Instructor before the assignment is due. No penalty will be assigned to a student who does not submit work to the plagiarism detection software. **All submitted work is subject to normal verification that standards of academic integrity have been upheld** (e.g., on-line search, other software, etc.). For more details about McMaster's use of Turnitin.com please go to www.mcmaster.ca/academicintegrity.

COURSES WITH AN ON-LINE ELEMENT

Some courses may use on-line elements (e.g. e-mail, Avenue to Learn (A2L), LearnLink, web pages, capa, Moodle, ThinkingCap, etc.). Students should be aware that, when they access the electronic components of a course using these elements, private information such as first and last names, user names for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in a course that uses on-line elements will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure please discuss this with the course instructor.

ONLINE PROCTORING

Some courses may use online proctoring software for tests and exams. This software may require students to turn on their video camera, present identification, monitor and record their computer activities, and/or lock/restrict their browser or other applications/ software during tests or exams. This software may be required to be installed before the test/exam begins.

CONDUCT EXPECTATIONS

As a McMaster student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the Code of Student Rights & Responsibilities (the "Code"). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, **whether in person or online**.

It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g. use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students' access to these platforms.

ACADEMIC ACCOMMODATION OF STUDENTS WITH DISABILITIES

Students with disabilities who require academic accommodation must contact Student Accessibility Services (SAS)at 905-525-9140 ext. 28652 or sas@mcmaster.ca to make arrangements with a Program Coordinator. For further information, consult McMaster University's Academic Accommodation of Students with Disabilities policy.

REQUESTS FOR RELIEF FOR MISSED ACADEMIC TERM WORK

MSAF policy regarding student absences: Students may request relief for missed work in two ways using the McMaster Student Absence Form (MSAF), Type A and Type B. In both cases, an email notification is sent to the instructor (or designate), students must follow-up with the instructor promptly after the absence (by email, Avenue to Learn, or other communication pathway indicated by the instructor for the course) for the relief to be provided, and while instructors are expected to provide relief, instructors determine the relief that is appropriate for the work and the course.

Type A MSAF is used directly by students through the Mosaic reporting tool for assignments worth <25% and for absences lasting 3 days or fewer. The Type A pathway can only be used once, whether for a first request or subsequent to another Type B request. No documentation is required.

Type B MSAF requires that the student meet with an academic advisor to complete the MSAF request through the Mosaic reporting tool. Type B is used for assignments worth 25% or more and for absences lasting more than three days. Type B will also be used if this is the second or

subsequent reported absence. This pathway provides for students missing a significant amount of work to benefit from advising as students are required to seek advice before a Type B MSAF is submitted. No documentation is required for the fall 2022 term and the role of the academic advisor is not to approve the request, but to advise the student on the potential impact on their academic success.

ACADEMIC ACCOMMODATION FOR RELIGIOUS, INDIGENOUS OR SPIRITUAL OBSERVANCES (RISO)

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the RISO policy. Students should submit their request to their Faculty Office ***normally within 10 working days*** of the beginning of term in which they anticipate a need for accommodation or to the Registrar's Office prior to their examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

COPYRIGHT AND RECORDING

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, **including lectures** by University instructors. The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

EXTREME CIRCUMSTANCES

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email

The P.R.O.C.E.S.S.

As some of you may already be aware, the department of Chemical Engineering has a storied history of education. In addition to teaching and learning, the department is proud of our graduates not only for their academic success, but their more intrinsic traits that make them respected members of the engineering community.

Recently, several high-ranking graduates from the McMaster Chemical Engineering Program employed in various industries (oil/gas, financials, *etc*.) were interviewed to ask what traits they look for when hiring for engineering positions. Using this information, the department would like to present to you the **PROCESS**: a code of conduct that we hope will guide our students throughout this program and their careers to come.

- **P**rofessionalism
- **R**esponsibility
- **O**wnership

- **C**uriosity
- **E**mpathy
- **S**elflessness
- **S**ervice

It is up to YOU to interpret these traits and apply them to your time at McMaster and your career as you see fit. These traits will not be assessed for grades but will be strongly encouraged throughout your time at McMaster. We hope that you identify with these character traits and what they mean to you, and that you **trust the process**.