

Academic Year	AY20/21	Semester	1
Course Coordinator	Mihaiela Corina Stuparu, Ling Xing Yi		
Course Code	CM4062		
Course Title	Polymer Chemistry		
Pre-requisites	CM2031 or by permission		
Mutually Exclusive	CM9092 ¹		
No of AUs	3 AUs		
Contact Hours	Lectures: 39 hours		
Proposal Date	6 March 2020		

Course Aims

This course aims to develop an understanding of the fundamentals in polymer science covering:

- The synthesis and characterisation of polymers, introducing students to polymers, their synthesis and reaction mechanism.
- The relation between chemical structure, polymer morphology and physico-chemical properties, providing the students with an understanding of polymer behaviour in the solid and solution state, as well as characterisation techniques commonly used in polymer science.

It will prepare you for a job in industries where polymer chemistry knowledge is required – from oils, paints and coatings, to food, cleaning agents and cosmetics, to medical, agricultural and aerospace technologies. This course is also great preparation for a PhD and a career in chemistry research.

Intended Learning Outcomes (ILO)

Upon the successful completion of this course, you (as a student) should be able to:

1. use essential descriptions of define, classify, and depict a polymer.
2. identify the repeat units and structural features of a particular polymers.
3. explain step-growth polymerization, with respect to synthesis mechanisms, choice of monomer and reaction conditions.
4. explain chain-growth polymerization, with respect to synthesis mechanisms, choice of monomer and reaction conditions.
5. suggest the appropriate polymerization method for the synthesis of a desired polymer
6. suggest the appropriate techniques to characterize a polymer
7. determine the relationship between the structure and the properties of a polymer
8. critically review polymer research reports and assess the technical utility and implications of the documented results.
9. communicate challenges, analysis, and conclusions related to polymer chemistry, both orally and textually

Course Content

1. Introductory Concepts and Definitions
2. Classification of Polymers
3. Step-growth polymerization
4. Chain-growth polymerization
5. Characterization of polymer – Molar mass
6. Structure and morphology of bulk polymers
7. Rheology and mechanical properties

¹ Replaced course

Formative feedback

You will be given feedback in three ways:

1. by posting your feedback on the course discussion board.
2. through face-to-face discussion during the collection/during of your mid-term examination.
3. an examiner report will be provided to you after the final exam, as a way to allow you to reflect on the areas for improvement and allow you to achieve intended learning outcomes 1 – 30.

Assessment (includes both continuous and summative assessment)

This is a graded course. There is a checklist of ALL the components of the assessments.

Component	Course ILO Tested	Related Programme LO or Graduate Attributes	Weighting	Team/ Individual	Assessment rubrics
CA1: Assignment Paper Presentation	8, 9	Competence, Communication Civic mindedness Critical thinking	15%	Team	See Appendix 1
CA2: Assignment Oral midterm evaluation	1-9	Communication Competence Creativity	25%	Individual	See Appendix 1
CA3: ResponseWare	1-7	Communication Competence Creativity	10%	Individual	See Appendix 1
Final Examination	1 – 9	Communication Competence Creativity	50%	Individual	See Appendix 1
Total			100%		

Learning and Teaching approach

Approach	How does this approach support students in achieving the learning outcomes?
Lectures	Face to face lectures will be employed for ILO 1 – 9. This is to allow you to interact directly with the instructor.
ResponseWare	Allow instructor to challenge you during lecture and to achieve instant feedback. It also allows you to review the knowledge point right after the delivery and to master the knowledge in-depth.
Oral mid-term	It is designed as discussion with your course instructor on the content delivered during the lectures. It is intended to develop your critical thinking and your communication skills. Additionally, it will allow you to get an instant feed-back and address some of the problems or misconceptions you may have.
Oral presentation	It is anticipated as an opportunity for you to develop your presentation skills and your team-work spirit.

Reading and References

1. Polymers: Chemistry and Physics of Modern Materials, 3rd ed J.M.G.Cowie and Valeria Arrighi, CRC Press, ISBN-10: 0367092093
2. Polymer Chemistry: An Introduction, 3rd ed Malcolm P. Stevens, Oxford University Press, ISBN-10: 0195124448
3. Polymer Science & Technology, 2nd ed Joel R. Fried, Pearson Education, Inc, ISBN-10: 0137039557
4. Introduction to Physical Polymer Science, 4th ed L.H. Sperling, John Wiley & Son, Inc, ISBN-10: 047170606X
5. Contemporary Polymer Chemistry, 3rd ed, Harry R. Allcock, Frederick W. Lampe, and James, E. Mark, Pearson Education, Inc, ISBN-10: 0130650560

Course Policies and Student Responsibilities

(1) General

You are expected to complete all online activities in good time.

(2) Absenteeism

If you miss a lecture, you are expected to make up for the lost learning activities. If you are sick and unable to attend your class, you have to:

1. send an email to the instructor regarding the absence
2. submit the original Medical Certificate^{ll} to the administrator. (^{ll} the medical certificate mentioned above should be issued in Singapore by a medical practitioner registered with the Singapore Medical Association.)

If you miss the mid-term exam with approval, you will be graded based upon the final.

Academic Integrity

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values.

As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Course Instructor

Instructor	Office Location	Phone	Email
Mihaiela Stuparu	SPMS-CBC-05-01	6592 7765	mstuparu@ntu.edu.sg
Ling Xing Yi	SPMS-CBC-04-05	6513 2740	xyling@ntu.edu.sg

Planned Weekly Schedule

Week	Topic	Course LO	Readings/ Activities
1	Introductory Concepts and Definitions	1, 2	Lecture
2	Classification of Polymers	1, 2	Lecture
3, 4	Step-growth polymerization	1, 2, 3, 5	Lecture
5-7	Chain-growth polymerization	1, 2, 4, 5, 6	Lecture
8, 9	Critically review and present a paper	1 - 9	Oral presentation
9	Midterm	1-5	Online interactive content, LAMS
10	Characterization of polymer – Molar mass	1, 2, 6, 7	Lecture, Responseware
11	Structure and morphology of bulk polymers	1, 2, 6, 7	Lecture, Responseware
12	Rheology and Mechanical Properties	1, 2, 6, 7	Lecture, Responseware
13	Review on course contents	1 – 9	Lecture
The above schedule is for illustrative purposes and is subject to the exigencies of the calendar			

Appendix 1:

Rubric for Responseware questions (10%)

For the Responseware questions, you will be expected to show your competency to understand the principle polymer chemistry and polymer characterization. You are expected to apply the knowledge you learn to solve scientific problems. Moreover, the Responseware questions are open for discussion with your course mates. It is designed as an avenue to demonstrate your communication skills, where you can openly discuss your thought and thinking with your peers, and work as a small group to answer the Responseware and LAMS questions. Marks will be scaled to 10% of the course.

0-3 marks	4-7 marks	8-10 marks
Shows little to no understanding of the theoretical and practical principles covered in the lectures	Shows moderate to good understanding of the theoretical and practical principles covered in the lectures	Shows a comprehensive or near comprehensive understanding of the theoretical and practical principles covered in the lectures

Rubric for oral presentation (15%)

For the oral presentation you will be working in a team, to critically review and communicate a scientific report, assess the implications and significance of the reported results. Additionally, it is designed as an opportunity for you to develop your presentation skills and your team-work spirit, as you can discuss and debate ideas together with your team-mates and finally with all your colleagues.

In practice everyone in your team will be getting the same score. Your score may vary if there are evidence that you had not contributed to your team.

0-4 marks	4-7 marks	8-10 marks
<ul style="list-style-type: none"> • Talk difficult to follow • Unclear language • Does not understand the research • Does not understand the experimental approach • Hesitation and uncertainty are very apparent • Presentation poorly timed • No logical placement of information • Mostly text and very few images • Labeling is not clear and size is too small to see • Figures are not explained • Presentation has numerous misspellings and/or grammatical errors • Either makes no effort to respond to questions or does so poorly 	<ul style="list-style-type: none"> • Talk easy to follow • Uses proper language • Identifies the research • Has basic understanding of the experimental approach and significance • Speaks well, but often repeats comments • Presentation well timed • Logical progression • Very little text • Figures and images described well • Most figures and images explained and described well • Presentation has an occasional misspelling or grammatical error • Understands audience questions • Can address some questions 	<ul style="list-style-type: none"> • Well thought out with logical progression • Uses proper language • Identifies the research question/research field • Has good understanding of the experimental approach and significance • Speaks with good pacing and enthusiasm • Uses time wisely • Very little text • Figures and images explained and described well • Presentation has no misspellings or grammatical errors • Understands audience questions • Thoroughly responds to all questions

Rubric for oral mid-term test (25%)

The mid-term test will be conducted as oral examination where you will be expected to show your competency to understand the principle polymer chemistry and polymer characterization. You are expected to apply the knowledge you learn to solve scientific problems. The oral examination is intended to allow you develop your oral communication skills.

0-6 marks	4-15 marks	15-20 marks
<ul style="list-style-type: none">- Shows little to no understanding of the theoretical and practical principles covered in the lectures.- Make no effort and often responds poorly to questions.- Does not use the appropriate scientific language.	<ul style="list-style-type: none">- Shows moderate to good understanding of the theoretical and practical principles covered in the lectures.- Understands and can address some of the questions.- Use the appropriate scientific language	<ul style="list-style-type: none">- Shows a comprehensive or near comprehensive understanding of the theoretical and practical principles covered in the lectures.- Understands and can well address all the questions.- Use the appropriate scientific language.

Grading criteria for the Course

The following guideline describes the criteria expected of the different levels of performance in this course.

Standards	Criteria
A+ (Exceptional) A (Excellent)	Actively participate and answer Responseware questions correctly in and out of class. Complete assignment punctually and correctly. Able to apply the knowledge learned very well with referenced to the learning outcomes (LO) 1 to 9 in order to answer the questions in written exams.
A- (Very good) B+ (Good)	Actively participate in Responseware questions in and out of class. Complete assignment punctually and be correct on majority of the questions. Able to apply the knowledge learned with referenced to the LO 1 to 9 to answer most of the questions in written exams.
B (Average) B- (Satisfactory) C+ (Marginally satisfactory)	Participate in Responseware questions in and out of class. Complete assignments with average marks. Partially able to apply the knowledge learned with referenced to the LO 1 to 9 to answer some of the questions in written exams.
C (Bordering unsatisfactory) C- (Unsatisfactory)	Seldom participate in Responseware questions in and out of class. Not able to complete the assignments on time or achieve average marks. Not able to apply the knowledge learned with referenced to the LO 1 to 9 to answer some of the questions in written exams.
D, F (Deeply unsatisfactory)	Does not participate in Responseware questions in and out of class. Not able to complete assignments. Not able to apply the knowledge learned with referenced to the LO 1 to 9 to answer most of the questions in written exams.

CBC Programme Learning Outcome

The Division of Chemistry and Biological Chemistry (CBC) offers an undergraduate degree major in Chemistry that satisfies the American Chemical Society (ACS) curricular guidelines and equips students with knowledge relevant to the industry. Graduates of the Division of Chemistry and Biological Chemistry should have the following key attributes:

1. Competence

Graduates should be well-versed in the foundational and advanced concepts of chemical science, be able to evaluate chemistry-related information critically and independently, and be able to use complex reasoning to solve emergent chemical problems.

2. Creativity

Graduates should be able to synthesize and integrate multiple ideas across the curriculum, and propose innovative solutions to emergent chemistry-related problems based on their training in chemistry.

3. Communication

Graduates should be able to demonstrate clarity of thought, independent thinking, and sound scientific analysis and reasoning through written and oral reports to audiences with varying technical backgrounds. They should also be able to effectively engage other professional chemists in collaborative endeavours.

4. Character

Graduates should be able to act in responsible ways and uphold the high ethical standards that the society expects of professional chemists.

5. Civic-mindedness

Graduates should be aware of the impact of chemistry on society, and how chemistry can be applied to benefit mankind. They should also be aware of and uphold the best chemical safety practices.