

<b>Academic Year</b>	AY22/23	<b>Semester</b>	1
<b>Course Coordinator</b>	Mihaiela Corina Stuparu, Ling Xing Yi		
<b>Course Code</b>	CM4062		
<b>Course Title</b>	Polymer Chemistry		
<b>Pre-requisites</b>	CM2031 or by permission		
<b>Mutually Exclusive</b>	CM9092 <sup>1</sup>		
<b>No of AUs</b>	3 AUs		
<b>Contact Hours</b>	39 hours (18 hours online lectures and 21 hours in-class activities)		
<b>Proposal Date</b>	28 April 2022		

### 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

<sup>1</sup> Replaced course

6. Structure and morphology of bulk polymers
7. Rheology and mechanical properties

### Formative feedback

You will be given feedback in two ways:

1. by posting your feedback on the course discussion board.
2. by interactive discussion between students/course instructor during the class time
3. through face-to-face discussion during the collection of your mid-term paper.

### 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 + Peer Evaluation	8, 9	Competence, Communication Civic mindedness Critical thinking	30%	Team* (20%) / Individual (10%)	See Appendix 1
CA2: Oral Midterm Test	1-9	Communication Competence Creativity	30%	Individual	See Appendix 1
CA3: Written Midterm Test	1,2,6,7	Communication Competence Creativity	30%	Individual	Point-based marking (not rubrics based)
CA4: ResponseWare & assignment	1,2,6,7	Communication Competence Creativity	10%	Individual	See Appendix 1
Total			100%		

\* Please note that by default you would receive the same score as your team. However, your score may vary should there be evidence that you had not contributed to your team.

### Learning and Teaching approach

Approach	How does this approach support students in achieving the learning outcomes?
Blended learning and the flipped classroom	This active learning, student-centred approach aims to increase your engagement in learning the principles of Polymer chemistry and Polymer Characterization. Prior to class, you will be required to view online instructional videos in NTULearn that will introduce you to the course content in a systematic way. In class, you will be able to clarify any doubt and expand your understanding and application of the new content by actively participating in meaningful collaborative learning.
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 midterm test	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<sup>ll</sup> to the administrator. (<sup>ll</sup> the medical certificate mentioned above should be issued in Singapore by a medical practitioner registered with the Singapore Medical Association.)

There will be no make-up test. If you miss the mid-term test with approval, the marks obtained in all other assessments attempted will be re-scaled to a base of 100%.

### 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-04-07	6513 2740	xyling@ntu.edu.sg

#### Planned Weekly Schedule

Week	Topic	Course LO	Readings/ Activities
1	Introductory Concepts and Definitions	1, 2	Reading & writing activities  Interactive discussion between students/course instructor
2	Classification of Polymers	1, 2	Reading & writing activities  Interactive discussion between students/course instructor
3, 4	Step-growth polymerization	1, 2, 3, 5	Reading & writing activities  Interactive discussion between students/course instructor
5-7	Chain-growth polymerization	1, 2, 4, 5, 6	Reading & writing activities  Interactive discussion between students/course instructor
8, 9	Critically review and present a paper	1 - 9	Oral presentation
9	Oral Midterm Test	1-5	Assessment
10	Characterization of polymer – Molar mass	1, 2, 6, 7	Reading & writing activities  Interactive discussion between students/course instructor Responseware
11	Structure and morphology of bulk polymers	1, 2, 6, 7	Reading & writing activities  Interactive discussion between students/course instructor Responseware
12	Rheology and Mechanical Properties	1, 2, 6, 7	Reading & writing activities  Interactive discussion between students/course instructor Responseware
13	Written Midterm Test	1, 2, 6, 7	Assessment

The above schedule is for illustrative purposes and is subject to the exigencies of the calendar

Appendix 1:

**Rubric for oral presentation (20%)**

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.

<b>0-8 marks</b>	<b>9-15 marks</b>	<b>15-20 marks</b>
<ul style="list-style-type: none"> <li>• Talk difficult to follow</li> <li>• Unclear language</li> <li>• Does not understand the research</li> <li>• Does not understand the experimental approach</li> <li>• Hesitation and uncertainty are very apparent</li> <li>• Presentation poorly timed</li> <li>• No logical placement of information</li> <li>• Mostly text and very few images</li> <li>• Labeling is not clear, and size is too small to see</li> <li>• Figures are not explained</li> <li>• Presentation has numerous misspellings and/or grammatical errors</li> <li>• Either makes no effort to respond to questions or does so poorly</li> </ul>	<ul style="list-style-type: none"> <li>• Talk easy to follow</li> <li>• Uses proper language</li> <li>• Identifies the research</li> <li>• Has basic understanding of the experimental approach and significance</li> <li>• Speaks well, but often repeats comments</li> <li>• Presentation well timed</li> <li>• Logical progression</li> <li>• Very little text</li> <li>• Figures and images described well</li> <li>• Most figures and images explained and described well</li> <li>• Presentation has an occasional misspelling or grammatical error</li> <li>• Understands audience questions</li> <li>• Can address some questions</li> </ul>	<ul style="list-style-type: none"> <li>• Well thought out with logical progression</li> <li>• Uses proper language</li> <li>• Identifies the research question/research field</li> <li>• Has good understanding of the experimental approach and significance</li> <li>• Speaks with good pacing and enthusiasm</li> <li>• Uses time wisely</li> <li>• Very little text</li> <li>• Figures and images explained and described well</li> <li>• Presentation has no misspellings or grammatical errors</li> <li>• Understands audience questions</li> <li>• Thoroughly responds to all questions</li> </ul>

**Rubric for peer evaluation (10%)**

<b>9/10</b>	<b>7/8</b>	<b>5/6</b>	<b>2-5</b>	<b>0/1</b>
Contribution to the team's presentation was exceptional, i.e., student put in fair share of work, supported other team members, and contributed significantly to prepare and improve the overall presentation.	Contribution to the team's presentation was significant, i.e., student put in fair share of work and supported other team members.	Contribution to the team's presentation was at least adequate, i.e., student put in fair share of work.	Insufficient contribution to the team's presentation, i.e., student did not do fair share of work.	No contribution to the team's presentation.

### Rubric for oral midterm test (30%)

This mid-term test will be conducted as oral examination where you will be expected to show your competency to understand the principles of 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 to develop your oral communication skills.

0-11 marks	12-20 marks	20-30 marks
<ul style="list-style-type: none"><li>- Shows little to no understanding of the theoretical and practical principles covered in the lectures.</li><li>- Make no effort and often responds poorly to questions.</li><li>- Does not use the appropriate scientific language.</li></ul>	<ul style="list-style-type: none"><li>- Shows moderate to good understanding of the theoretical and practical principles covered in the lectures.</li><li>- Understands and can address some of the questions.</li><li>- Use the appropriate scientific language</li></ul>	<ul style="list-style-type: none"><li>- Shows a comprehensive or near comprehensive understanding of the theoretical and practical principles covered in the lectures.</li><li>- Understands and can well address all the questions.</li><li>- Use the appropriate scientific language.</li></ul>

### Rubric for Responseware questions & assignment (10%)

For the Responseware questions, you will be expected to show your competency to understand the principles of 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 with your peers, and work in a small group to answer the Responseware and LAMS questions. Marks will be scaled to 10% of the course.

0-3 marks	4-6 marks	7-10 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

### 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 reference 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 reference 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 reference 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 reference 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 reference 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.