UCLouvain

lchm2261

2021

Polymer Chemistry and Physical Chemistry

5.00 credits	45.0 h + 15.0 h	Q1

Teacher(s)	Fustin Charles-André ;Gohy Jean-François ;Jonas Alain ;
Language :	English
Place of the course	Louvain-la-Neuve
Prerequisites	This course requires a previous basic knowledge of the physics and chemistry of polymers, as given in the introductory courses LCHM1361 or LMAPR2019, e.g.
Main themes	This course provides an introduction to advanced methods of polymerization and to the characterization of macromolecules in solution. The course is made of flipped classrooms and projects. All topics are not necessarily covered each year. Part A: After recalling the basics of chain polymerization methods, the different current synthetic strategies will be studied (anionic, cationic, standard radical, controlled radical and coordinative polymerization methods). The scope and limitations of each method will be systematically discussed. Mechanistic and kinetic features will be then studied for each polymerization method. Special emphasis will be finally placed on the control of macromolecular architectures. Part B discusses the notions of ideal and real chains, the size of macromolecules in solution, the notions of excluded volume and second virial coefficient, the thermodynamic properties of polymer solutions, and different techniques of characterization of polymers in solution (osmometry, viscometry, size exclusion chromatography, static light scattering).
Learning outcomes	**At the end of this learning unit, the student is able to :** 1 The course aims at providing a deep knowledge of chain growth polymerization methods, as well as of polymer solutions. The contribution of this Teaching Unit to the development and command of the skills and learning outcomes of the programme(s) can be accessed at the end of this sheet, in the section entitled "Programmes/courses offering this Teaching Unit". At the end of part A, the students will master the state-of-the-art in chain growth polymerization methods, the links between controlled and living polymerization methods and the molecular characteristics of the resulting chains (molar mass, chain dispersity, architecture), and the technological gridlocks facing chain growth polymerization. Additionally, the students will be able to use the above-mentioned concepts in order to propose relevant synthetic methods for specific cases. At the end of part B, the students will be able to analyze results from experimental methods of determination of the molecular characteristics of a polymer (molar mass, distribution of molar mass, radius of gyration), and to predict its behavior in solution (solubility, swelling, second viral coefficient, interaction parameter, phase separation). They will also be capable to solve small problems of practical relevance in the field of polymer engineering using these and complementary notions.
Evaluation methods	The two parts have the same weight in the final grade, which is the arithmetic mean between the grades obtained for each part. **Part A "Chain polymerization methods"** (3 credits) Part (50%) for the work performed during the year (continuous evaluation) and part (50%) for the written exam. The written exam consists of solving cases similar to those studied during the course. The final grade is rounded to the nearest integer. **Part B "Physical chemistry of polymers in solution"** (2 credits) Part of the grade will be given based on the answers to the preparative quizzes of the flipped classrooms. This part will be graded based on effort, not correctness of the answers. Part of the grade will be given by the continuous evaluation of the student progress at the end of each flipped class. This part will be graded based on the correctness of the answers. The last part of the grade will be based on an oral exam on more theoretical questions on the course; the list of possible questions will be given to the students at the beginning of the course. For this part, let x be the grade on 20 obtained for the quizzes, y the grade on 20 obtained for the tests at the end of the classes, and z the grade on 20 obtained at the exam, then the final grade on 20 is max(z,(x+y)/4+z/2), rounded to the nearest integer except if the grade is between 9 and 10 in which case it is rounded to the closest lower integer.

Teaching methods	**Part A "Chain polymerization methods"** The chemistry part is based on a ***self-learning system*** . Scientific reviews, dealing with the main polymerization methods, will be provided and will be analyzed in small groups. Each student will work on three projects (polymerization methods). The self-learning will be conducted for two to three weeks during which the students and teachers will meet to discuss the reviews and prepare a presentation summarizing the reviews (see schedule). The students will then present orally their project before the whole class, followed by questions. This self-learning process will be evaluated by the teachers. **Part B "Physical chemistry of polymers in solution"** The physical chemistry part is made of a small number of classes in ***flipped classroom format**,* in which the students resolve small problems and discuss concepts with the teacher, based on a prior reading of a section of the lecture notes and/or on watching podcasts. Before each class, the students have to answer a few questions on their preparative reading (quizzes); their answers are used by the teacher to identify misconceptions and tune the content of the classes. A small interrogation at the end of each class contributes to the continuous evaluation of the students.
Content	**Part A "Chain polymerization methods"** 1. Introduction: Living and controlled chain polymerizations 2. Atom-transfer radical polymerizations (ATRP) 3. Nitroxide-madiated radical polymerizations (NMP) 4. Reversible addition-fragmentation chain-transfer polymerizations (RAFT) 5. Anionic polymerizations 6. Living ring-opening polymerizations (LROP). 7. Organocatalytic ring-opening polymerizations 8. Control of macromolecular architectures 9. Mechanistic transformations 10. Supramolecular polymerizations At the end of the course, the students will be able to propose a valid synthetic method to prepare a (co)polymer with given molecular characteristics (chemical composition, architecture, chain length,…). **Part B "Physical chemistry of polymers in solution"** 1. Thermodynamics of solutions of small molecules - reminders 2. Osmometry 3. Solvent quality and swelling of macromolecular chains in solution 4. Viscometry and size exclusion chromatography 5. Phase diagrams of polymer solutions 6. Solubility parameters 7. Osmometry of macromolecular solutions 8. Static light scattering by macromolecular solutions At the end of the course, the students will be able to analyze results from experimental methods of determination of the molecular characteristics of a polymer, and to predict its behaviour in dilute solution.
Inline resources	**Part A "Chain polymerization methods"** Review papers and presentations made by the students will be made available on the website of the course. **Part B "Physical chemistry of polymers in solution"** Lecture notes, podcasts and experimental data will be available on the Moodle website of the course.
Bibliography	L'ouvrage de référence suivant couvre *une partie* des concepts du partim B / the following textbook deals with *part* of the concepts of part B: Paul C. Hiemenz & Timothy P. Lodge, Polymer Chemistry, 2nd edition, CRC Press:Boca Raton, 2007. Cet ouvrage n'est pas indispensable pour la participation au cours. This book is not required for the course.
Faculty or entity in charge	CHIM

Programmes containing this learning unit (UE)

Program title	Acronym	Credits	Prerequisite	Learning outcomes
Master [120] in Chemical and Materials Engineering	KIMA2M	5		