lmapr2019a — Polymer Science and Engineering-Physics

2021

3.00 credits	22.5 h + 7.5 h	Q1

Teacher(s)	Demoustier Sophie ;Jonas Alain (coordinator) ;Van Ruymbeke Evelyne ;
Language :	English
Place of the course	Louvain-la-Neuve
Prerequisites	This course requires to have a knowledge of thermodynamics and statistical physics
Main themes	The first theme deals with the physics of polymer materials, and presents the main properties of these materials while establishing in a formal way the relationship with the physical characteristics of the chains at the molecular scale.
Learning outcomes	**At the end of this learning unit, the student is able to :** 1 **Contribution of the course to the program objectives** With respect to the program of the Master in Chemical and Materials Science Engineering, this course contributes to the development and the acquisition of the following learning outcomes: LO 1.1.Identify and use concepts, laws, and reasoning related to a problem of limited complexity. LO 1.2. Identify and use modelling and computational tools to solve this problem. At the end of this course, students will be able to : Determine the parameters required to model a macromolecular chain by a freely-jointed chain model, a wormlike model, or a model of rotational isomeric states; explain using statistical physics how these parameters vary with molar mass, temperature or chemical nature of the repeat unit; Use statistical physics and a freely-jointed chain model to compute the retraction force resulting from increasing the distance between the chain ends of a polymer chain; explain the main characteristics of this force; derive the stress/strain curve of a rubber band, starting from equations describing the statistical behavior of its chain segments, and from the environmental constraints of the experiment; Describe phenomenologically the glass transition of polymers and the relaxation phenomena associated with it, on the basis of the notion of free volume. Use this approach to explain how the glass transition is sensitive to the temperature and the rate of measurement; Describe the morphology of a semicrystalline polymer at different scales, and draw a scheme of this morphology; state how this morphology controls the properties of the material; enumerate the parameters which control the melting temperature of a polymer; derive the equation relating this melting temperature and the lamellar thickness; list the main experimental facts that must be included in any theory of polymer crystallization, and present briefly some kinetic theories able to explain these facts; Derive the principle of time/temperature equivalence for the elastic modulus of polymers, and describe its practical consequences for the use of such materials; quantify these effects by the Williams-Landel-Ferry equation; Define and explain different concepts related to the molecular structure of polymers (topology, repeating units linking, configurational structures, average molecular weights and dispersity)
Evaluation methods	Written exam at the end of the course, comprising small exercises and questions on the main concepts of the course. Part of the final grade will consist of a continuous evaluation led over the semester for (some parts of) the course. This part of the grade will be used in each exam session; the continuous evaluation cannot be presented again. Final grade: let x1 be the grade on 20 obtained for the continuous evaluation in the part of A. Jonas, let x2 be the grade on 20 for the exam on the part of A. Jonas, and let y be the grade on 20 obtained for the exam on the part of E. Van Ruymbeke, then the final grade on 20 will be 20/13*(max(x2/20*8,(x1/20*4+x2/20*4))+y/20*3+z/20*9), rounded to the closest integer, except if the grade is between 9 and 10 in which case it is rounded to the lowest nearest integer.
Teaching methods	The course mixes formal presentations by the teachers with exercises done by the students. These exercises serve either to raise questions, or to solve issues. The course will be in flipped classroom format for some parts, in the physical presence of teachers and students, with possible parallel online acces for specific parts. The visit of a production plant may be included in the course.
Content	1.1. Main characteristics of macromolecular chains 1.2. Elasticity of macromolecules, and elasticity of elastomer materials 1.3. The glassy state and the glass transition of polymer materials

	1.4. Viscoelasticity and rheology of polymers 1.5. Semicrystalline polymers and polymer crystallization
Inline resources	*Lecture notes and video sequences are available on the Moodle website.*
Bibliography	Des notes de cours et des podcasts vidéos (en Anglais) sont mis à disposition des étudiants sur le site du cours. Des copies des transparents sont disponibles sur le site du cours. Les ouvrages de référence suivants sont intéressants : Paul C. Hiemenz; Timothy P. Lodge, Polymer Chemistry, 2nd edition, CRC Press:Boca Raton, 2007.
Other infos	This course requires to have a knowledge of thermodynamics, statistical physics and organic chemistry.
Faculty or entity in charge	FYKI

Programmes containing this learning unit (UE)

Program title	Acronym	Credits	Prerequisite	Learning outcomes
Master [120] in Physical Engineering	FYAP2M	3		🔍