PhD course “Hierarchically organized polymeric materials: synthesis by living/controlled polymerization and applications”

**SYLLABUS**

# Lecturer information

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# Title of the course

**Hierarchically organized polymeric materials: synthesis by living/controlled polymerization and applications**

# Course program

(150-200 words)

The course aims at covering recent advances in polymer synthesis, notably controlled radical polymerization, a powerful new approach that provides access to advanced materials with precise composition, structure, architecture and morphology. To this end, the basic principles of polymers and polymerization methods will first be recalled, or introduced for students with no previous theoretical training in polymer chemistry. The course will then introduce physico-chemical concepts such as compatibility and self-assembly, to appreciate the need of precise hierarchical structures, accessible only by living polymerization techniques, for certain applications. The impact of a reduced degree of “livingness” on the materials properties will be assessed. The course will then introduce the various living polymerization methods, focusing on the more powerful radical approaches. Finally, examples of advanced applications of the resulting materials in different technological areas will be presented.

# Course content detailed per lesson of two hours (possibly with dates and room real and virtual)

Lesson 1 – 1. Introduction: polymers and polymerizations (types of reactions, polymerization mechanisms, monomer valence, polymer topology and dimensionality, mass- and weight-average molecular weights, molecular weight distributions).

Lesson 2 – 2. Polymer solutions and blends (polymer compatibility, self-organization, packing parameters, micelles and vesicles). 3. Living chain growth polymerizations (characteristics of living polymerizations, controlled radical polymerization, immortal polymerization).

Lesson 3 – 4. Deviations from living behavior (effects of terminations, chain transfers and slow initiation). 5. Types of controlled radical polymerization (reversible termination strategies: nitroxide-mediated polymerization, atom transfer radical polymerization, organometallic-mediated radical polymerization)

Lesson 4 – 5. Types of controlled radical polymerization (continued) (degenerative transfer strategies: iodine transfer polymerization, tellurium- and antimony-mediated polymerizations, reversible addition-fragmentation chain-transfer (RAFT) polymerization. 6. A few examples of applications (thermoplastic elastomers, electronic materials, nanolithography, hydrogels, sealants, catalytic nanoreactors, etc.).

# Suggested reading

[N.V. Tsarevsky](https://www.amazon.com/s/ref=dp_byline_sr_book_1?ie=UTF8&field-author=Nicolay+V+Tsarevsky&text=Nicolay+V+Tsarevsky&sort=relevancerank&search-alias=books) and [B.S. Sumerlin](https://www.amazon.com/s/ref=dp_byline_sr_book_2?ie=UTF8&field-author=Brent+S+Sumerlin&text=Brent+S+Sumerlin&sort=relevancerank&search-alias=books) (Editors), Fundamentals of Controlled/Living Radical Polymerization (Polymer Chemistry Series, Volume 4), 1st Edition, Royal Society of Chemistry, 2013. DOI: [10.1039/9781849737425](https://doi.org/10.1039/9781849737425).

A. H. E. Müller and K. Matyjaszewski (Editors), Controlled and Living Polymerizations: From Mechanisms to Applications, Wiley-VCH, 2019. DOI: [10.1002/9783527629091](http://dx.doi.org/10.1002/9783527629091).

K. Solc (Editor), Polymer Compatibility and Incompatibility: Principles and Practice, MMI Press Symposium Series, 1982. ISBN: 3718600463.

M. Destarac, Industrial development of reversible-deactivation radical polymerization: is the induction period over? *Polym. Chem.* **2018**, *9*, 4947-4967. DOI: [10.1039/c8py00970h](http://dx.doi.org/10.1039/c8py00970h).

# Learning Objectives

Principles of living polymerization. Principles of controlled radical polymerization.

# Knowledge and Skills to be acquired

Knowledge of the available strategies to synthesize hierarchically organized polymers. Appreciation of the structure/function relationships for hierarchically organized polymers.

# Prerequisites

Organic chemistry; basic knowledge of polymers and polymerization (these will be recalled).

# Teaching Methods

MODE 1 - Pre-recorded lessons uploaded on the moodle platform (a meeting must be organized with PhD students in order to clarify eventual doubts)

◼ MODE 2 (preferred) - Lessons delivered in-person and in remote with simultaneous recording by the WEBEX platform

(The lessons must be recorded and available to all the students that cannot take part to the lessons in streaming. The Webex platform must be used. All course content should be uploaded to the Moodle platform on the Chemical Sciences PhD page “Courses and Seminars of the PhD in Chemical Sciences 2022-2023”)

# Further information

# Type of Assessment

The final evaluations will have to be validated maximum 1 month after the end of the course

# Period

2-3-9 December 2024.