Macromolecular engineering

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European credits ECTS: 6

Teaching Language: English

Supporting files: English

	Number of course slots (1h20)	Number of course slots (4h)
Magisterial	30	
Tutorials	9	
Practical		

Description

- Acquiring the concepts and methodologies for controlling polymerization reactions, i.e. functionality, molecular weights, dispersity, tacticity and architecture of polymer chains.
- Achieving shape-persistent structures at various length scale using self-assembly principles.

Outline

Part 1: Controlled radical and ionic polymerizations

Introduction to controlled and living polymerizations

- Experimental criteria
- General strategies
- Application in macromolecular engineering

Control in anionic polymerization

- Monomers and initiating systems
- Polymerization of styrene
- Polymerization of dienes (stereo-control)
- Polymerization of (meth)acrylates
- Polymerization of heterocycles (ethylene oxide, propylene oxide, cyclic esters, etc.)
- Recent developments

Control in cationic polymerization

- Monomers and initiating systems

- Polymerization of isobutene
- Polymerization of styrene
- Polymerization of vinyl ethers
- Polymerization of oxazolines
- Polymerization of THF

Control in radical polymerizations

- Principle
- Controlled polymerization by stable counter-radicals
- Atom transfer radical polymerization
- Degenerative transfer radical polymerization
- Applications to dispersed medias

Part 2: Applications to the design of macromolecular architecture

Introduction to macromolecular engineering

Block copolymers design

- General interest of block copolymers
- Synthesis via non-living polymerization techniques
- Synthesis via controlled/living polymerization techniques
- Examples of synthesis via combination of various techniques
- Graft copolymers

Hybrid nanocomposites

- Sol gel chemistry: a general introduction
- Polymer/inorganic hybrid materials from sol-gel chemistry
- Hybrid nano/micro-particles
- Core-corona particles
- Core-shell particles via heterogeneous polymerization

Part 3: Polymer self-assembly:

Introduction to self-assembly phenomena in Soft Matter

Theoretical background:

- Flory-Huggins Theory
- Application to polymer blends
- Phase separation by “nucleation and growth” or “spinodal decomposition”
- Relationships between free-energy diagram and phase diagram

Block copolymer self-assembly

- Parameters describing block copolymer self-assembly and phase diagram
- Weak and strong segregation limits

Determination of block copolymer phase diagram

- Order/disorder& order/order transitions

- Scattering and microscopy techniques applied to block copolymer structures

Complex block copolymer systems
- Effect of chain architecture
- Rod-coil copolymers
- Copolymers and homopolymers blends

Block copolymer self-assembly in solution
- Packing parameter and analogy to surfactant microstructures
- Micellization phenomena and concentration regimes
- Thermodynamics of micellization

Phase diagram in solution: solvent selectivity
- Micellar structures from block copolymer self-assembly in solution
- Influence of macromolecular parameters on the phase diagram
- Influence of extrinsic parameters (concentration, temperature, solvent quality) on the phase diagram
- Formation of micellar structures: out-of-equilibrium structures and dependent pathways
- Macromolecular engineering towards more complex micellar structures
- Scattering and microscopy techniques applied to block copolymer self-assembly in solution

Applications of block copolymers in nanotechnologies