

Polymer Science and Engineering: Theory and Laboratory

1. GENERAL			
SCHOOL	Faculty of Sciences in collaboration with Faculty of Engineering, Aristotle University of Thessaloniki		
DEPARTMENT	Materials Science and Engineering		
LEVEL OF STUDIES	ISCED level 7 (5-year Integrated Master's programme) ISCED level 6 (4-year BSc programme)		
COURSE CODE	MSEN 405	SEMESTER	4 th Semester
COURSE TITLE	Polymer Science and Engineering: Theory and Laboratory		
TEACHING ACTIVITIES	Lectures, tutorials/problem sessions, laboratory/computer exercises (where applicable), case studies and guided self-study.	TEACHING HOURS PER WEEK	ECTS CREDITS
		4	6
COURSE TYPE	Scientific Area		
PREREQUISITES	No prerequisites		
TEACHING AND EXAMINATION METHODS	English		
COURSE OFFERED TO ERASMUS STUDENTS	Yes		
COURSE URL	https://elearning.auth.gr/course/view.php?id=xxxxx		

2. LEARNING OUTCOMES	
Learning Outcomes	<p>By the end of this course, students will be able to:</p> <ol style="list-style-type: none"> 1. understand the concept of macromolecule and the characteristic properties that macromolecules have in relation to small molecules. 2. recognize the repeating chemical structural unit of several polymers. 3. understand the mechanisms of both chain radical and step polymerization reactions 4. develop equations describing the kinetics of both chain-radical and step polymerization 5. realize the properties of different commercial polymers. 6. understand the characteristics of the copolymerization reactions and the equations describing the copolymer composition. 7. carry out simple laboratory syntheses of polymers 8. determine the basic properties of different polymers 9. know the recycling methods of different polymers <p>solve specific problems related to the kinetics of polymerization reactions.</p>
General Skills	<ul style="list-style-type: none"> • Applying knowledge in practice • Searching, analyzing and synthesizing data and information, using the necessary technologies

	<ul style="list-style-type: none"> • Decision-making • Independent work • Teamwork • Generate new research ideas • Project planning and management emphasizing on the materials science • Promoting free, creative and inductive thinking • Modeling and solving real-world problems • Working in a multidisciplinary environment
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3. COURSE CONTENT

1. Introduction to Polymer Science and Engineering

- The concept of macromolecule.
- Classification and nomenclature of polymers.
- Structure and dimensions of macromolecular chains.

Polymer synthesis

2. Polymerization reactions

- Similarities and differences of various polymerization reactions

3. Free radical chain polymerization

- Mechanism of the reaction.
- Polymerization kinetics.
- Initiators, monomers, retardants, inhibitors.
- Calculation of average molecular weight and molecular weight distribution of a polymer.
- Effect of diffusion phenomena on the polymerization reaction.

4. Controlled radical polymerization

- Chain anionic, cationic and stereoregular polymerization.
- Mechanisms of reactions.
- Atom transfer radical polymerization.
- Nitroxide mediated polymerization.
- RAFT polymerization

5. Step polymerization

- Mechanism of the reaction.
- Kinetics of step polymerization.
- Molecular weight distribution.
- Linear and crosslinked polymers.

6. Typical polymers

- Polyethylenes, polypropylene, polystyrene, polyisoprene, poly(vinyl chloride), polytetrafluoroethylene, poly(methyl methacrylate), poly(vinyl acetate), polyethers, Polyesters (poly(ethylene terephthalate), polyamides (Nylons), polyurethanes, resins.

7. Copolymerization

- Copolymer composition
- Reactivity ratios
- Types of copolymers
- Reaction kinetics

Properties of polymers

8. Molecular Weight distribution and Average molecular weights <ul style="list-style-type: none"> Equations for the estimation of the molecular weight distribution and average molecular weights of polymers. Experimental techniques for determining average molecular weights and the entire Molecular Weight Distribution of polymers
9. Solid state of polymers <ul style="list-style-type: none"> Amorphous and crystalline state. Kinetics of crystallization. Glass transition temperature of polymers.
Polymer Engineering
10. Polymer reaction engineering <ul style="list-style-type: none"> Modeling of chain polymerization. Models for the step polymerization. Statistical methods for the estimation of the average molecular weights (method of moments). Equations for the estimation of the full molecular weight distribution.
11. Polymer process engineering <ul style="list-style-type: none"> Viscoelastic properties. Viscosity models for polymers. Non-Newtonian flow. Introduction to polymer rheology.
12. Polymers and the environment <ul style="list-style-type: none"> Polymer recycling. Chemical/thermo-chemical/physical recycling. Recycling of multilayer polymer films or polymer composites. Microplastics. Hazardous substances in polymeric products
Laboratory exercises <ol style="list-style-type: none"> Synthesis of polymers (e.g. poly(methyl methacrylate), elastomer) Characterization of polymers (e.g. measurement of average molecular weight of polymers, characterization of polymer fibers)

4. LEARNING & TEACHING METHODS - EVALUATION					
Teaching method	Face-to-face.				
Use of ICT	ICT will be used in teaching the course, and in communication with students: <ul style="list-style-type: none"> teaching of the course with modern distance learning (ZOOM) and asynchronous education tools via elearning platform of AUTH, communication with students via email, ZOOM, and elearning platform of AUTH.				
Teaching organization	The supervised and unsupervised workload per activity is indicated below (total workload complies with ECTS standards). <table border="1" data-bbox="523 1960 1337 2031"> <thead> <tr> <th>Activity</th> <th>Workload/semester (hours)</th> </tr> </thead> <tbody> <tr> <td>Lectures</td> <td>27</td> </tr> </tbody> </table>	Activity	Workload/semester (hours)	Lectures	27
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Lectures	27				

	Bibliographic written, research and problem solving	52
	Tutorial	9
	Laboratory exercises	16
	Written assignments	44
	Exams	2
	Total	150
Student evaluation	Assessment Language: English Assessment Methods: <ul style="list-style-type: none"> • Written assignment • Problem Solving • Presentation in audience • Laboratory report 	
5. SUGGESTED BIBLIOGRAPHY		
EUDOXUS		
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Additional bibliography for study		
Billmeyer, F.W. Jr. (1984). Textbook of Polymer Science. 3rd Ed. New York: J. Wiley Davis, T.P., & Matyjaszewski, K. (2002). Handbook of Radical Polymerization. Hoboken: Wiley-Interscience. Fried, J.R. (2003). Polymer Science and Technology. USA: Prentice Hall. Manas, C. (2006). Introduction to Polymer Science and Chemistry. Florida: CRC, Taylor & Francis Group Odian, G. (2004). Principles of Polymerization. 4th Ed. Wiley-Interscience, Hoboken. Saldivar-Guerra, E., & Vivaldo-Lima, E. (2013) Eds. Handbook of polymer synthesis, characterization and processing, J. Wiley & Sons. Hoboken.		