INSTITUTO POLITÉCNICO DE BRAGANÇA

Course Unit	Polymer Science and Product Engineering			Field of study	Polymers		
Master in	Chemical Engineering			School	School of Technology and Management		
Academic Year	2023/2024	Year of study	1	Level	2-1	ECTS credits	6.0
Type	Semestral	Semester	1	Code	6362-756-1101-00-23		

Workload (hours)	162	Contact hours	T	TP	PL	TC	S	E	OT	O
			30	30	-	-	-	-	-	-

T - Lectures; TP - Lectures and problem-solving; PL - Problem-solving, project or laboratory; TC - Fieldwork; S - Seminar; E - Placement; OT - Tutorial; O - Other

Name(s) of lecturer(s): Maria Filomena Filipe Barreiro, Arantzazu Santamaria Echart

Learning outcomes and competences

At the end of the course unit the learner is expected to be able to:
1. Know some historical and industrial perspectives on polymer science;
2. Identify the most relevant synthetic polymers, associated chemistry and used polymerization processes;
3. Recognize the most relevant, natural or natural-based polymers, having in view industrial applications;
4. Understand average molecular weight and polydispersity concepts, and know the major experimental determination techniques;
5. Understand polymer morphology, and know some experimental techniques to access structural, morphological and thermal characterization;
6. Know polymer processing techniques;
7. Learn about specialty polymers and recent developments in polymer science;
8. Know product engineering topics aimed at designing new polymer-based products oriented towards new developments, sustainability, and functional products.

Prerequisites

Before the course unit the learner is expected to be able to:
Demonstrate background knowledge of Mathematics, Physics and Organic Chemistry.

Course contents

Identify synthetic polymers, associated chemistry and polymerization processes; Know natural or natural-based polymers; Understand the concept of molecular weight, polydispersity and techniques for its determination; Learn morphological concepts and techniques for structural, morphological and thermal characterization; Know polymer processing techniques; Know specialty polymers and new developments; Know and apply concepts of product engineering.

Course contents (extended version)

1. Introduction
   - Macromolecules, historical perspectives, technological and economic importance;
   - Monomer, polymer, repeating unit and polymerization degree;
   - Momopolymers and copolymers;
   - Tacticity;
   - Linear, branched and crosslinking polymers;
   - Amorphous and crystalline polymers;
   - Thermoplastic and thermoset polymers.
2. Synthetic polymers
   - Polyurethanes, polyamides, polyesters, polyethers, phenolic resins and epoxides;
   - Applications;
   - Polymers produced by polycondensation and polyaddition;
   - Polymerization techniques (bulk, solution, emulsion and suspension).
3. Natural and natural derived polymers
   - Natural rubber; polysaccharides, polyamides and polyesters;
   - Importance as biomaterials.
4. Degree of polymerization and molecular weight
   - Molecular weight distribution and average molecular weight;
   - Degree of polymerization and average molecular weight in number, weight;
   - Experimental determination of molecular weight: absolute and relative methods;
   - End-group analysis, membrane and vapour pressure osmometry, light scattering;
   - Intrinsic viscosity measurements and size exclusion chromatography.
5. Morphology concepts
   - Morphological changes: linear amorphous polymers, crystalline polymers and crosslinking polymers;
   - Glass transition temperature (Tg);
   - Melting temperature (Tm);
   - Crystalization kinetics;
   - Experimental techniques for determining crystalinity: density measures and X-ray diffraction;
   - Structure-properties relationship;
   - Effect of molecular weight and composition on Tg;
   - Experimental techniques for Tg and Tm evaluation: dilatometry and differential scanning calorimetry.
6. Technological aspects
   - Extrusion and molding techniques, composites, polymer blends, compounding;
   - Extrusion, injection and thermoforming processing. Composites, nanocomposites and polymeric blends.
7. Novel polymers and applications
   - Water-based, conducting polymers, polymers derived from renewable resources, microencapsulation;
   - Hydrogels, biocompatible and biodegradable polymers, adhesives devoted for biomedical applications.
   - Polymeric nanofibers and their applications.
8. Product engineering concepts
   - Steps to reach the production phase: identify and classify consumer needs;
   - Develop product ideas, apply criteria of ideas selection, and outline manufacturing processes.
9. Product development project.

Recommended reading

1. Fried, Polymer Science and Technology, 2nd Edition, Prentice Hall, 2009;
2. Campbell, Introduction to Synthetic Polymers, 3th Edition, Oxford University Press, 2011;
3. 3. Al-Maadeed, Ponnamma, Carignano Eds. , Polymer Science and Innovative Applications: Materials, Techniques, and Future Developments, 1st Edition, Elsevier Science Publishing, 2020;
4. N. D. Polychronopoulos, J. Vlachopoulos, Polymer Processing and Rheology, Functional Polymers, 1st Edition, Springer International Publishing, 2019.
5. Cussler and Moggridge; Chemical Product Design, 2nd Edition, Cambridge University Press, 2011

Teaching and learning methods

The teaching methodologies involve theoretical and theoretical-practical classes for the exposition of concepts and problem solving. Additionally, a project for the development of an innovative product of polymeric origin will be carried out under a tutorial regime, where students, organized into groups, will combine the knowledge acquired in polymer science with that of product engineering.

Assessment methods

1. Alternative 1 - (Regular, Student Worker) (Final, Supplementary, Special)
   - Development Topics - 50% (Product development project.)
   - Final Written Exam - 50%
2. Alternative 2 - (Regular, Student Worker) (Special)
   - Final Written Exam - 100%
3. Alternative 3 - (Student Worker) (Final, Supplementary)
   - Final Written Exam - 100%

Language of instruction

English

Electronic validation

Maria Filomena Filipe Barreiro	Hélder Teixeira Gomes	Simão Pedro de Almeida Pinho	José Carlos Rufino Amaro
13-10-2023	25-10-2023	25-10-2023	31-10-2023