UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Chimica per le Nanotecnologie Biomediche

2526-2-F5401Q073

Aims

Lo studente acquisirà le basi teoriche, concettuali e metodologiche per la sintesi, la caratterizzazione e le applicazioni di biomateriali avanzati su scala nanometrica. Il corso comprende una parte più orientata alle applicazioni di materiali avanzati per applicazioni diagnostiche e terapeutiche, e una parte più orientata a formulazioni innovative di materiali 3D avanzati per applicazioni di ingegneria tissutale e protesica. Inoltre lo studente acquisirà le basi teoriche relativa agli strumenti di ultima generazione basati su Intelligenza Artificiale, Machine Learning e Deep Learning, applicati alla sintesi predittiva di biomateriali e all'automazione di laboratori dedicati.

Contents

The course will cover the chemical methodologies for the development of nanostructured materials for biomedical applications. In particular, chemical approaches to synthesize nanomaterials that employ synthetic, natural and hybrid polymers will be presented. A particular focus will be dedicated to the translational potential of bio- and nano-materials in the development of nanostructured diagnostic and therapeutic tools, implantable medical devices and systems based on 3D printed and 3D bioprintable materials.
At the end of the course the student is able to:

- Determine the characteristics of synthetic and natural nanostructured materials for biomedical applications.
- Detect the different performances of biomaterials based on chemical, structural and biological properties.
- Evaluate the applicability of polymers of various nature for different biomedical purposes; choose the appropriate synthetic methodologies useful for the development of nanosystems (nanoparticles or biomaterials) for diagnostic and/or therapeutic purposes.
- Identify the most suitable formulation methodologies based on the target biological system, the pathologies of interest and the use of the "medical device" / nanoformulation (including 3D printing and bioprinting)
- Identify the applications, useful data and applicability of predictive synthesis systems and robotic automation (AI, ML, DL) in the field of bio and nanomaterials.

Detailed program

The application of conjugation, synthesis and characterization of materials/biomaterials and the use of innovative systems based on Artificial Intelligence for predictive synthesis, synthesis assisted by collaborative robotics and characterization strategies based on machine learning. In detail, the following objectives will be highlighted:

- methods for nanoparticles, nanostructures, nanofilms, nanopolymers, biopolymers syntehsis
- methods for nanosized systems characterization
- biological and medical aims/questions and rational design of nanomaterials for therapeutic and diagnostic use. In detail, the fundamental principles of the immune system, biological barriers and corona proteins, target organs and tissues. Strategies for the controlled release of drugs, and targeting to organ and tissues. Molecular recognition and interactions of nanomaterials and biological targes. Methods for nanomaterials fucntionalization with drugs, diagnostics systems and biomolecules responsible for molecular recognition. Chemoselective conjugation methods. Applications of nanostructured biomaterials to mimic and regenerate tissues and organs. Chemcial and physical features of nanomaterials for regeneration and tissue replacement. Implantation and application sites for permanent (non-biodegradable) and non-permanent (biodegradable) medical devices. Methods for design adn sysnthesis of nanostructured materials in the prosthetic sector and in regenerative medicine. Methods for characterizing the chemical-physical properties of advanced materials for tissue engineering applications. Chemoselective functionalization methods for obtaining tissue- and organ-specific bio-responsive materials. Crosslinking methods for the covalent stabilization and physical control of 3D structures. Methods and strategies for bioactivation of polymeric materials with advanced biological properties. Development and synthesis strategies for materials in the form of injectable hydrogels, scaffolds, bulks and implantable networks. Formulation strategies and methodologies by solvent casting, freeze dry, moulding and layer-by-layer etc. New formulation methodologies and associated chemical strategies will also be described: 3D printing and bioprinting, characteristics and classification of printable polymers 3D printing and bioprinting. Synthetic and characterization methodologies for the development of printable and bioprintable polymers. 3D printing and bioprinting: design of 3D prosthetic and tissue models. New methods and platforms based on artificial intelligence (AI) machine learning (ML) and deep learning (DL) employed in the automated prediction, synthesis and formulation of bio- and nanomaterials for biomedical applications.

Prerequisites

Organic Chemistry I

Teaching form

44 h in person, Delivered Didactics, 22 lessons 2 h in person, in person, Delivered Didactics 20 h Hybrid Didactic Activities 2 seminars/h in 2 hours modules in person, Hybrid Didactic activities.

Textbook and teaching resource

Recording of Lectures Slides (PPT). Videos and Scientific Articles (Reviews and Original Articles). Software for

planning and design, biomaterial synthesis prediction, databanks

Semester

I semester

Assessment method

The exam (in Italian or English) consists in a power point presentation and subsequent questions on the general program. The exam will be organized as followed defined:

- The test consists of an oral presentation supported by ppt on the topics covered by the course, with critical analysis and personal research contribution related to a specific research topic selected by the student.
- The individual oral presentations will deal with a scientific article selected by the student and are the subject of open discussion, with questions and cross-examination by those present, and allow to verify the level of knowledge acquired, the autonomy of analysis and judgment, the student's presentation skills, the ability to identify particularly promising advances in a given nanotechnology sector.
- Following the presentation, the knowledge on other topics covered during the course will be assessed.
  The final grade is expressed in thirtieths with possible honors. The presentation of the article and the knowledge of the arguments presented during the course will be evaluated.

Office hours

appointment

Sustainable Development Goals

GOOD HEALTH AND WELL-BEING