UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Nanochemistry, Nanoporous Materials and Nanomedicine

2526-1-FSM02Q040

Aims

The course is divided in two parts:
The first part is focused on fundamental concepts of the design and preparation of nanostructured materials and nanoparticles and andon the effect of dimension size and shape factors on the properties of materials. Self-assembly and templating strategies, and the exploitation of interactions will be used considered for the creation of materials with specific functions, starting from molecular-scale building blocks to complex structures with hierarchical organization over several length scales. Additionally, the program aims atto applying the nanotechnological approaches which have an impact on products and processes to produce materials with improved properties.
The second part is focused on the application of nanostructured materials and nanoparticles in the field of nanomedicine. The course will illustrate the impact that nanomaterials have in the advance of medicine and healthcare including their role in delivery of therapy, tissue engineering and biosensing/diagnosis techniques. Different classes of organic and inorganic nanomaterials will be presented and as well as strategies of surface chemical functionalization to achieve stealth properties and to induce the active and selective targeting of diseased cell. Innovative biomedical applications of nanoparticles (e.g. hyperthermia, photodynamic therapy, use of Cerenkov radiation) will also be discussed.

Knowledge and understanding
At the end of the course the student will have acquired knowledge on:
• main conventional synthesis methods
• latest generation of synthetic strategies for the production of innovative nanomaterials
• property-structure relationships in nanomaterials

Applying knowledge and understanding
At the end of the course the student will be able to describe the main synthetic approaches and the most suitable characterization methods
to modulate the properties of nanomaterials for scientific and applicative uses.

Making judgments

The student will be able to orient himself in the field of nanomaterials both in terms of chemical structure, conventional
and innovative synthesis methods, and in terms of properties of nanomaterials.

Communication skills
The student will be able to express the topics covered during the course with language skills suitable for nanoscience.

Learning skills
The student will be able to apply the knowledge acquired during the course to understand the topics dealt with in the scientific and patent literature in the field of innovative nanomaterials.

Contents

The course highlights the fundamental concepts for fabricating nanostructures and how they are applied to different classes of materials. It includes methods for controlling the size, shape and structure of nanostructured systems, as well as the effect of these parameters on material properties.
The course illustrates the fundamental concepts of nanomedicine and how the properties of nanomaterials can be exploited in biomedical applications. It includes how chemical surface functionalisation can add new functions to the nanodevice and innovative uses of nanomaterials in the biomedical field.

Detailed program

Constructive principles of nanostructured materials, hierarchical assembly, and methods for directing self-assembly
Design and synthesis of building blocks with pre-determined size and form, composition and functionalities for fabricating nanostructured materials and for constructing molecular and hybrid materials
Methods for preparing nanoparticles, nanorods, nanotubes and nanowires
Template synthesis for fabricating nanostructured materials, interface modulation and construction of hybrid materials
Artificial nanomachines and nanoswitches in the solid state and mechanical bond
Specific approaches to characterize nanosized systems
Main applications of nanostructured materials in the field of energy, electronics, automotive, sensing by molecular recognition ect
Nanoporous materials: micro and ultra-micro porosity, high surface area, high capacity, functionalization, selective absorption

- Main families: Molecular Crystals, Metal-organic Frameworks, Covalent Organic Frameworks
- Principles of fabrication
- Molecular confinement and chemical reactions in the nanospaces
- Environmental applications: gas capture, gas purification and sequestration (CO_2), gas storage (H_2 and CH_4)
- Water harvesting and polluttant capture
- Drug carriers
  Nanotechnology in oil and gas industry: sustainable oil and gas separation and recovery.

Second part:
Basic concept of nanomedicine and nanotechnology
Classes of nanostructured materials and nanoparticles (e.g. carbon nanotubes, liposome, inorganic nanoparticles, quantum dots, polymeric NP, etc.)

Coating for biocompatibility and stealth properties
Nanosystems characterization in physiological environment: dynamic light scattering (DLS) and Zeta potential
Nanosystems for drug delivery
Nanosystems for bioimaging
Nanosystems for therapeutics
Stimuli responsive and intelligent nanomaterials
Passive targeting: Enhanced Permeability and Retention (EPR)
Active targeting: ligand/receptor binding
Photodynamic therapy (Cerenkov radiation)
Hyperthermia with gold nanoparticles
Multifunctional nanoparticles
Toxicity of nanomaterials

Prerequisites

• Good knowledge of general chemistry.
• Basic knowledge of thermodynamics, physico-chemical parameters.
• Basic knowledge of spectroscopic and diffraction methods.

Teaching form

The lessons will be delivered in English.
24 two-hour lectures, in person, Delivered Didactics.

Textbook and teaching resource

1. Concepts of Nanochemistry (G. A. Ozin, L. Cademartiri) Wiley
2. Nanoporous Materials (K. Kaneko, F. Rodriguez-Reinoso Eds.) Springer 2019
3. Crystal Engineering A Textbook (Gautam R Desiraju, J. J. Vittal, A. Ramanan)
4. Nanomaterials and Nanotechnology in Medicine (Visakh P.M.) Wiley
5. Fundamentals of Nanomedicine (J. F. Leary) Cambridge University Press
6. Lectue notes (power point presentations to support teaching activities)

Semester

1st year, 2nd semester.

Assessment method

Oral exam for the evaluation of the acquired knowledge during the course.

The oral exam consists of the evaluation of the knowledge acquired by the student in the field of nanoscience with particular attention to the synthesis, structure and properties of nanomaterials. The autonomy of analysis and judgment, and the ability of exposure will be evaluated using the following criteria:
18-20/30: preparation on a small number of topics covered during the course, with limited capacity for discussion and analysis; not always correct presentation skills and vocabulary, with limited capacity for critical processing.
21-23/30: partial preparation on the subjects covered during the course, limited ability to self-analysis; use of correct vocabulary although not entirely accurate and clear; uncertain presentation skills.
24-27/30: preparation on a wide range of topics covered during the course, ability to develop self-argument and critical analysis; Ability to apply general knowledge to the specific context of polymer science and link topics studied to concrete cases; use of correct vocabulary and competence in the use of scientific language.
28-30/30L: complete and comprehensive preparation on all the subjects covered during the course; autonomy of analysis and critical judgment of the topics addressed in class; ability to link the topics studied to concrete cases and different scientific contexts; Full mastery of scientific vocabulary and rigorous presentation skills, clear and articulate; excellent ability to argue and reflect.

Office hours

Tuesday from 10:30 to 12:30.

Sustainable Development Goals

INDUSTRY, INNOVATION AND INFRASTRUCTURE