UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Nanochemistry, Nanoporous Materials and Nanomedicine

2425-1-FSM01Q040

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.

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.
12 two-hour lectures, in person, Delivered Didactics, dedicated to the first part;
12 two-hour lectures, in person, Delivered Didactics, dedicated to the second part.

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 interview on the topics covered in class, covering both first and second parts, aimed at verifying the level of the
acquired knowledge, the autonomy of analysis and judgment, the student's exhibition skills.

Office hours

Tuesday from 10:30 to 12:30.

Sustainable Development Goals

INDUSTRY, INNOVATION AND INFRASTRUCTURE