



UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Nanochemistry and Nanoporous Materials

2324-1-FSM01Q014

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 on 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 at 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 (CO₂), gas storage (H₂ and CH₄)
 - Water harvesting and pollutant 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

Lessons.

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. Lecture 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.

Office hours

Tuesday from 10:30 to 12:30.

Sustainable Development Goals

INDUSTRY, INNOVATION AND INFRASTRUCTURE
