Corsi organizzati per l'anno accademico 2022-2023

Diffraction methods in materials science (8h)

Prof. Marco Taddei
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The discovery that crystals can diffract X-rays, made by Max von Laue in 1912, sparked a revolution in the study of solid-state materials, giving scientists a precious tool to "see" the atomic structure of matter. This course aims at providing an exhaustive overview of diffraction-based methods for the characterization of solid-state materials and will cover the following topics:

I) Basic concepts of crystallography: crystals, unit cell, symmetry operations, Bravais lattices, Miller indices, reciprocal lattice. Diffraction of X-rays by crystalline solids.
II) Generation and detection of X-rays. Single crystal X-ray diffraction: structural analysis. Powder X-ray diffraction: indexing, whole powder pattern fitting, structure solution, Rietveld method.
III) Powder X-ray diffraction: quantitative phase analysis, microstructural analysis, thin films analysis, textural analysis. In situ X-ray diffraction.
IV) Diffraction by nanocrystalline/amorphous materials: total scattering techniques. Neutron diffraction. Electron diffraction.

Calendar:
23.11.2022 - Room 24 – 14:30|16:30
28.11.2022 - Room 33 – 14:30|16:30
30.11.2022 - Room 24 – 14:30|16:30
05.12.2022 - Room 33 – 14:30|16:30
The lectures will be held in presence @DCCI. If you need any further info or have any request, please contact marco.taddei@unipi.it

Applications of ultrafast spectroscopy (8h)

Dott. Mariangela Di Donato, Istituto di Chimica dei Composti OrganoMetallici, CNR-ICCOM, LENS Firenze
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The course aims at introducing the principal methodologies of ultrafast time resolved spectroscopies, giving an overview of the technical and experimental aspects connected with the use of ultrafast lasers. Examples of applications will be given concerning the study of photo-induced energy and electron transfer processes in complex molecular systems. Data analysis methods will be also presented. The specific content of the lectures will deal with:

- Introduction about ultrafast lasers and time resolved spectroscopic techniques
- Pump-probe spectroscopy to study energy and charge transfer in multi-chromophore systems and proteins
- Infrared and Raman time resolved spectroscopies
- Two-dimensional infrared and visible spectroscopies

Calendar:
16.01.2023 - Aula Magna – 14:30|16:30
23.01.2023 - Aula Magna – 11:00|13:00
30.01.2023 - Room 021 – 11:00|13:00
06.02.2023 - Room 021 – 11:00|13:00

Translational Chemistry in Personalized Medicine: Prescriptomics using High Resolution MS Spectrometry (6h)

Prof. Jose Luis Capelo, Università Nova di Lisbona

MS-based proteomics has become a valuable approach to identify, quantify, and characterize large numbers of proteins in solid and liquid biopsies. The application of MS techniques in determining the presence of amyloid fibril protein in amyloidotic tissues was demonstrated by Gilbertson et al. in a blinded comparison with IHC. Overall, there was significant concordance between the two techniques, but the MS-based approach achieved 94% accuracy, while the diagnostic accuracy of the IHC-based approach was lower at 76%. In MS-based proteomics, label-free approaches are proving advantageous because when labels are not used, there is (i) no limitation to the number of experiments that can be compared, (ii) higher dynamic range of quantification, and (iii) fewer time-consuming steps are needed. Indeed, significant changes can be rapidly measured across an entire proteome and compared in a large cohort of samples. The total protein approach (TPA) is a label-free method that does not require the inclusion of standards either, which measures the absolute amounts of proteins in the sample to deliver large-scale proteomic datasets . TPA has been applied previously to study human colorectal cancer, hepatocyte proteome, and the effects of high-fat diet in mice small intestine mucosa, demonstrating the accuracy and utility of the method .

Specific subject of the lessons:
- The use of Ultrasounds in Sample Preparation.
- MS / Protein Quantification, In the way of Personalise Medicine: Prescriptomics
- MS spectrometry applied in Proteomics.

Calendar:
13.02.2023 - Room 024, 10:00 -12:00
14.02.2023 - Room 024, 10:00 - 12:00
15.02.2023 - Room 024, 9:30 - 11:30

Translational Chemistry: From Molecular to Nano systems development. Synthesis, applications and Case studies (8h)

Prof. Carlos Lodeiro, Università Nova di Lisbona

Chemistry is the mother of all sciences. The traditional divisions of Organic, Inorganic, Analytical, Physical Chemistry and Chemical Engineering today play the role of spreading all their funding to other complementary research fields. These pure original divisions are nonsense. The current

research world is based more and more on connections between complementary fields, including biology, medicine, biotechnology, pharmacy, cosmetics, genetics, proteomics, forensic, geology, environmental sciences, conservation and restoration, among others. This fact leads to more interdisciplinary research with multifunctional applications and interlaboratory collaborations. Here the suitable molecule and the proper chemical methodology are the keys to success in many applications. In two simple words, we could speak about the new umbrella of Translational Chemistry. In connection with this idea of multifunctional applied research, our research group has been involved in different research projects during the last two decades. Some projects involve new connections based on the synthesis of nanomaterials, the aplication of new dyes as sensors, towards applications in biomedicine, biochemistry, proteomics, genomics, environmental toxicology, and bioanalytics [1-13]. We have invested in detecting targets like metals, molecules and anions, imaging and delivery of drugs, and the OMICS applications, especially in Proteomics, and genomic studies applied in personalized medicine using High resolution mass Spectrometry [14-24]. In this PhD course, We will show you some key results of our research team, and explain selected case studies developed in recent years with applications in nano synthesis, biomedicine, proteomics, and environmental fields.

Specific subject of the lessons:
- Fluorescent ChemoSensors for Polluted Heavy metal detection and quantification
- Green Methodologies applied to the Synthesis and Caracterization of Anisotropic Inorganic Nanomaterials.
- Emissive Inorganic Materials: From Polymers to Liquid Crystals.
- Translational Nanochemistry: Nanoparticles as tools for Bacterials and Proteomics Applications.

Calendar:
13.02.2023 - Room 024, 14:30-16:30
14.02.2023 - Room 024, 14:30-16:30
15.02.2023 - Room 024, 11:30-13:30 and 14:30-16:30

Molecular Electronics from a chemist perspective (8h)

Dr. Marco Carlotti
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In this course, we will explore the realm of Molecular Electronics, a very interdisciplinary field which aims to develop and characterize electronic devices in which the active components are - in at least one of their dimensions - one molecule thick. We will go over the basic principles that define the way molecular junctions work and the experimental platforms that are employed to characterize the electric behavior of a molecule when connected to electrodes. In doing so, while much theoretical investigation and modelling is involved in trying to explain certain phenomena, we will try to focus on the contribution that chemists can give, from designing and synthesizing targeted molecules to the nanofabrication involved in the realization of molecular junctions and experimental setups.

Calendar:
07.03.2023 - Room 032 - 14:30 - 16:30
14.03.2023 - Room 032 - 14:30 - 16:30

21.03.2023 - Room 032 - 14:30 - 16:30
28.03.2023 - Room 032 - 14:30 - 16:30

Gene therapy: a chemical perspective (8h)

Prof. Lorenzo Di Bari
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Gene therapy is at the frontline of current research for the treatment of acute, chronic and genetic diseases and conditions. It is based on synthetic oligonucleotides sequences, that interfere with gene expression. Nucleic acids therapeutics are conceptually very different from standard drugs, because they separate two actions: their target is controlled by the sequence and for this reason it is highly modular, while delivery and potency depend strongly on the chemical modification that one can introduce on the oligonucleotide itself. The course will briefly recall basic concepts of gene expression and of splicing, presenting siRNA, miRNA, shRNA, antisense oligonucleotides. The main classes of modified nucleotides will be presented, covering their chemical design, synthesis and stereochemistry features. The use of carriers to enhance delivery profile in vivo will be discussed. Among the methods to reveal and monitor hybridization with the target sequence and to determine the pairing thermodynamics and kinetics, we shall discuss calorimetry, fluorescence, circular dichroism, surface plasmon resonance. Finally, one can quantify efficacy e.g. by measuring protein expression downregulation (western blotting and other methods) and follow the fate of the nucleic acid therapeutic with imaging techniques, after coupling the synthetic oligonucleotide with suitable reporters.

Colloid Stability, Rheology and Coating Technology (10h)

Prof. Dr. Norbert Willenbacher, The Karlsruhe Institute of Technology, Germany
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The course (10 hours) will be articulated in three parts. The first part (3 hours) will focus on the stability of disperse systems, and will discuss colloidal interactions, Van Der Waals attraction, electrostatic & steric repulsion, depletion attraction, and coagulation kinetics and flow induced aggregation. The second part (5 hours) of the course will deal the rheology of dispersions, describing the difference between hard, repulsive and attractive particles, will analyze the effect of the particle size distribution, and discuss shear thickening and the design of complex, multiphase fluids. The last part of the course (2 hours) will show the application of rheology for printing and coating technology, showing rotary bell atomization in automotive coating, screen printing for printed electronics and metallization of Si-solar cells, robocasting and direct ink writing for printing 3d functional materials, and inkjet printing of colloidal suspensions.

Calendar:
30.05.2023 - Room 024 - 9:00 - 13:00
31.05.2023 - Room 037 - 9:00 - 12:00
01.06.2023 - Room 037 - 9:00 - 12:00