ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

University of Bologna

*Semester 3 syllabus**

Course catalog	ECTS
Internship and Transferable Skills	**10**
Spectroscopy of Condensed Phases	**4**
Sustainable Industrial Chemistry and Polymers	**5**
X-Ray Techniques and Operando Spectroscopy	**3**
High Resolution Molecular Spectroscopy	**4**
Organic Chemistry for Nanotechnologies with Laboratory	**4**
Other free choice modules available	**-**

**https://corsi.unibo.it/2cycle/AdvancedSpectroscopyChemistry/course-structure-diagram/piano/2023/5706/000/000/2023*

Mandatory courses Elective courses

Course title	SPECTROSCOPY OF CONDENSED PHASES		
Information	**Number of credits:** 4 ECTS	**Number of taught hours:** 28h lectures ; 8h tutorials	**Number of hours expected of student personal work:** 64h
Synopsis	Classification of the states of matter. The solid crystal state: Crystal structures: Bravais lattices; unit The crystal symmetry; a structural view of crystal symmetry. Bloch functions. The electronic structure of molecular solids in a simplified form. The band structure; model systems; DOS. Excited states of aggregates of molecules; Davydov splitting and Mini-Excitons; linear molecular crystals; Frenkel Excitons; physical dimers; Excimers; Band structure; Charge transfer excitons (CT); Exciton processes; Energy transfer. Vibrations in solids. Vibrations in molecular crystals and quantisation of the vibrational energy: Phonons. Quasi particles. Scattering: phonon-photon scattering and elastic and anelastic processes; X-ray diffraction; phonon-neutron scattering; phonon density of states.		
Learning outcomes / skills and competencies	The course aims to provide the student with a basic description of a number of spectroscopic phenomena associated with such systems, with elementary treatments of fundamental theoretical concepts. Starting from the basics of traditional molecular spectroscopy, optical processes will be treated with emphasis on the condensed phase perspective, to include metals, glasses and molecular crystals. Experimental techniques will be addressed with the goal of understanding spectroscopic data.		
Teaching staff and contact email	Prof. Elisabetta Venuti, email: elisabetta.venuti@unibo.it		
Assessment	Oral Exam, with two questions and the discussion of a research paper chosen by the student and dealing with one of the course topic.		

Course title	SUSTAINABLE INDUSTRIAL CHEMISTRY AND POLYMERS		
Information	**Number of credits:** 5 ECTS	**Number of taught hours:** 32h lectures ; 12h tutorials	**Number of hours expected of student personal work:** 81h
Synopsis	Recall of the main aspects relating to sustainability in the chemical industry, foundations of industrial chemistry. Industrial chemical processes. Processes from conventional raw materials and from renewable raw materials. Catalysis as a tool for greater sustainability of chemical processes: examples. Green Chemistry. Green Engineering. Definition of Sustainable Polymers. Identification of the main parameters affecting the sustainability of macromolecules. ASTM and ISO. Polymers from renewable resources. Case studies. The fate of polymers: recycling and disposal of polymeric materials; biodegradability; compostability.		
Learning outcomes / skills and competencies	The first part of the course is aimed at providing competences for the development and management of catalytic processes for the production of chemicals and fuels, with a particular attention to aspects related to the improvement of sustainability in the chemical industry. The central role of catalysis in the implementation of chemical process will be highlighted. In the second part of the course fundamental aspects of polymer science will be acquired. Particular attention will be focused on polymeric materials obtained using low environmental impact technologies and also to polymers deriving from renewable resources.		
Teaching staff and contact email	Prof. Laura Mazzocchetti, email: laura.mazzocchetti@unibo.it Prof. Fabrizio Cavani, email: fabrizio.cavani@unibo.it		
Assessment	The final exam consists of an oral test, divided into two parts, of the total duration of about 40 minutes duration : The first part consists of an interview on the sustainable industrial chemistry principles and on catalysis in chemical processes. The second part consists of an interview on the topics: sustainability of polymers, correlation of a polymer structure with its application fields and end-of-life fate, industrial applications of polymers, with reference to the concept of sustainability and to regulations in force.		

Course title	X-RAY TECHNIQUES AND OPERANDO SPECTROSCOPY		
Information	**Number of credits:** 3 ECTS	**Number of taught hours:** 20h lectures ; 4h tutorials ; 4h practicals	**Number of hours expected of student personal work:** 47h
Synopsis	X-rays: origin and generation. X-ray absorption coefficient and mass absorption coefficient. Decay of the core-hole: x-ray Fluorescence and Auger effect. X-ray absorption spectroscopy and the acronyms XANES, EXAFS, SEXAFS, NEXAFS. Theory: The EXAFS equation and the key approximations: one electron, plane wave, and K-threshold. Muffin-Tin and many body effects. Debye-Waller EXAFS factor and disorder. X-Ray Fluorescence spectroscopy. Resonant Inelastic X-ray Scattering. X-Ray Microscopy. Experimental methods for Absorption and Emission. Synchrotron radiation. XAS Spectroelectrochemistry and cells for in-situ measurements. Operando studies. Data Analysis. XANES calculations ad EXAFS fittings. Primary data reduction. Chemometry for spectroscopy. Applications.		
Learning outcomes / skills and competencies	The course provides educational experiences which challenge students to: - be aware of the characteristics of X-ray methods of analysis (X-ray absorption and emission spectroscopy and x-ray microscopy) as a strong structural, electronic and imaging tool: advantages, disadvantages, and applicability in chemistry; to perform a preliminary data reduction; - be aware of the most recent core-level spectroscopy analytical techniques for solid and solutions; to design and comprehend spectroscopic operando / in-situ experiments.		
Teaching staff and contact email	Prof. Marco Giorgetti, email: marco.giorgetti@unibo.it		
Assessment	The exam (single session, about 30 minutes) is composed of two parts: a) Oral presentation on a selected topic learned during the course using 10-15 slides b) Oral exam		

Course title	HIGH RESOLUTION MOLECULAR SPECTROSCOPY		
Information	**Number of credits:** 4 ECTS	**Number of taught hours:** 28h lectures ; 8h tutorials	**Number of hours expected of student personal work:** 64h
Synopsis	Part I (Theory, 18 hours ca.) Interaction radiation-matter. Molecular energy levels. Rotational spectroscopy. Vibrational spectroscopy. Electronic spectroscopy. Raman spectroscopy. Energy levels of simple open shell molecules. Part II (Experimental techniques, 10 hours ca.) Experimental spectroscopic techniques. Fourier transform infrared spectroscopy (FTIR). Introduction to lasers. Einstein coefficients. Part III (Spectrosocpic applications, 8 hours ca.) Applications of spectroscopy: solid state, cultural heritage, atmosphere, astrophysics.		
Learning outcomes / skills and competencies	The course aims to provide the student with a basic description of a number of spectroscopic phenomena associated with such systems, with elementary treatments of fundamental theoretical concepts. Starting from the basics of traditional molecular spectroscopy, optical processes will be treated with emphasis on the condensed phase perspective, to include metals, glasses and molecular crystals. Experimental techniques will be addressed with the goal of understanding spectroscopic data.		
Teaching staff and contact email	Prof. Filippo Tamassia, email: filippo.tamassia@unibo.it		
Assessment	The exam will be only oral and will last about 45 minutes. The contents of all three parts of the course will be tested.		

Course title	ORGANIC CHEMISTRY FOR NANOTECHNOLOGIES WITH LABORATORY		
Information	**Number of credits:** 4 ECTS	**Number of taught hours:** 28h lectures ; 8h tutorials	**Number of hours expected of student personal work:** 64h
Synopsis	1. Introduction to the organic chemistry for nanoscience. 2. Silica Nanoparticles. 3. Gold Nanoparticles. 4. Iron-oxide Nanoparticles. 5. Quantum-Dots. 6. Carbon Nanoparticles. 7. Soft Organic Nanoparticles: Carbohydrates. 8. Soft Organic Nanoparticles: Proteins		
Learning outcomes / skills and competencies	Organic chemistry for nanotechnology represents the next generation of innovation beyond the current applications of organic chemistry. Preliminarily, basic principle of nanotechnology will be introduced, and a quick overview of the metallic nanoparticles' synthetic methods will be presented to the student. Main objective of the course is the understanding the role of the organic functional groups in the Self Assembled Monolayers (SAMs) of several metallic nanoparticles. At the end of the course the student will face the application of the organic chemistry for nanotechnologies to the Nanomedicine with some experimental laboratories. The use of the instruments will be accomplished at the end of the course		
Teaching staff and contact email	Prof. Letizia Sambri, email: letizia.sambri@unibo.it		
Assessment	The assessment consists in oral presentation of the students on a selected research topic learned during the course. The students will make a PowerPoint presentation (maximum of 15 slides according to materials deduced using 1 paper among 2-3 papers proposed to the teacher). Mark will consider how the student will sketch out the "state of the art", and how he/she will describe the results obtained in the selected paper.		