Prof. Marco Bella
Department of Chemistry
2 buildings «Cannizzaro» and «Caglioti», about 85 people as permanent staff and more than 100 among PhD students, Post-docs, research associates


**Main Research Topics**
- Life-sciences
- Materials
- Green chemistry
- Modelling
- Renewable energy
- Cultural heritage
- Environmental remediation

**Department services for**
Elemental analysis | Mass spectrometry MS | Nuclear magnetic resonance NMR | Raman spectroscopy | Scanning electron microscopy SEM | Energy-dispersive spectroscopy EDS | Photoemission spectroscopy XPS | Single-crystal X-ray diffraction XRD
Two degree courses offered: **Chemistry** and **Industrial Chemistry**.

3-year Bachelor, which includes a 3-month training in the laboratory

2-year Master in: *Industrial Chemistry, Analytical Chemistry, Organic and Biomolecular Chemistry, Physical and inorganic (Materials) Chemistry*. Students are required to attend a final year in a research laboratory and to write a master thesis.

Chemistry Students of Roma Sapienza (about 1000) are an **important resource** because they have a **strong preparation** and already a **solid research training** even before entering a PhD program.
Analytical Chemistry
PROF. ALDO LAGANÀ’s RESEARCH GROUP

Aldo Laganà\textsuperscript{a}, Full Professor
Roberto Samperi\textsuperscript{a}, Full Professor
Alessandro Bacaloni\textsuperscript{a}, Associate Professor
Chiara Cavaliere\textsuperscript{a}, Associate Professor
Giulio Caracciolo\textsuperscript{b}, Associate Professor
Daniela Pozzi\textsuperscript{b}, Assistant Professor
Anna Laura Capriotti\textsuperscript{a}, Assistant Professor

Patrizia Foglia\textsuperscript{a}, Technician
Paolo Scardala\textsuperscript{a}, Technician
Alessia Scardala\textsuperscript{a}, Technician
Giovanna Fago\textsuperscript{a}, Secretary
Susy Piovesana\textsuperscript{a}, Research fellow
Sara Palchetti\textsuperscript{b}, Research fellow
Valentina Colapicchioni\textsuperscript{a}, PhD
Serena Stampachiacchiere\textsuperscript{a}, PhD
Salvatore Ventura\textsuperscript{a}, PhD student
Riccardo Zenezini Chiozzi\textsuperscript{a}, PhD student
Giorgia La Barbera\textsuperscript{a}, PhD student
Francesca Ferraris\textsuperscript{a}, PhD student

\textsuperscript{a} Department of Chemistry, Sapienza University of Rome, Piazzale Aldo Moro 5, Rome, Italy
\textsuperscript{b} Department of Molecular Medicine, Sapienza University of Rome, Viale Regina Elena 261, Rome, Italy
Mass Spectrometry

**Known**
- Standard available?
  - Yes: **Target Screening**
    - MS/MS analysis with reference standard
    - Confirmation with MS/MS spectrum and retention time
  - No: **Suspect Screening**
    - Full MS scan + data dependent MS/MS of predicted ions
    - Exact mass extraction
    - Structure confirmation with MS/MS databases & fragmentation prediction tools
    - Supplementary data analysis (e.g., retention time + ionization plausibility)
    - Tentative identification

**Unknown**
- Predictable?
  - Yes: **Non-target Screening**
    - Full MS scan + data dependent MS/MS
    - Peak picking
    - Molecular formula fit
    - Structure generation & ranking with MS/MS databases & fragmentation prediction tools
  - No: **Target Screening**
    - MS/MS analysis with reference standard
    - Confirmation with MS/MS spectrum and retention time
    - Identification and Quantification
RESEARCH ACTIVITIES

The group research activities are focused on the development and validation of novel analytical methods by means of advanced mass spectrometry instrumentation coupled to separation techniques for the characterization and quantification of natural and anthropogenic substances in environmental, food, plant, and biological matrices.

I- FOOD SAFETY
II- ENVIRONMENTAL ANALYSIS
III- PLANT METABOLOMICS
IV- PLANT PROTEOMICS
V- DIFFERENTIAL PROTEOMICS APPLIED TO NANOMEDICINE
VI- POST-TRANSLATIONAL MODIFICATION ANALYSIS
VII- PEPTIDOMICS AND DISCOVERY OF NEW BIOACTIVE PEPTIDES
Food safety

**MS-based targeted analysis**

- Single compound or multiresidue - multiclass
- Selective extraction or not
- Confirmatory or screening method

SAMPLE
- milk, egg, animal tissue, plant derived food

PRE-TREATMENT/EXTRACTION
- (hydrolysis, deproteinization for milk, defatting for meat, etc.)
- LLE, LSE, SPE, SPME, MAE, SBSE, MSPD, PLE, QuEChERS, MIP

CLEAN-UP (if any)
- SPE, dSPE, GPC, RAM, defatting

DETECTION
- (U)HPLC-MS/MS, UHPLC-HRMS

QUANTITATION
- Isotope dilution, matrix matched calibration
Plant metabolomic

Mass chromatogram, full scan MS m/z 150-1000, strawberry extract
Drug and gene delivery

Application to:

- Cancer
- Genetic diseases
- Infective diseases
Protein corona

- The nanoparticle covered with its protein coronal is the real object seen at biological level.
- It affects the **biodistribution**.
- Binding of opsonins (fibrinogen, immunoglobulin, complement system proteins...) facilitates recognition by the immune system, thus the removal of the vector from circulation.
- Strategies to overcome protein corona issues:
  - Antiopsonization strategies (es. PEGilation): reduction of protein adsorption
  - Active targeting of the nanoparticle by means of the protein corona spontaneously covering the delivery system.
Shotgun proteomics allows to determine the composition of the protein corona forming around a nanovector (liposomes) in a biological medium (plasma). In this way the proteins adsorbing on the nanoparticle can be identified and outcome of nanoparticle administration can be predicted.

- Shotgun proteomics was employed also to:
- Assess the effect of PEGylation of liposomes on the formation of the protein corona in plasma.
- Assess the effect of PEG length on multicomponent liposomes.
- Infer the mechanism of internalization of liposomes with target cells by membrane protein analysis before and after interaction with liposomes.
- Elucidate the difference between corona formation in mice model and human plasma, thus understand the differences in biodistribution.
Shotgun proteomics in nanomedicine

- Liposomes

Incubation with plasma

Washing and complex isolation

Tryptic digestion

nanoHPLC-MS/MS Analysis and bioinformatics
Industrial and Engineering Chemistry
The Process Engineering Group at Dept of Chemistry

Today: 1 Full Professor, 1 Associate Professor, 1 Assistant Professor
3 Post-docs, 4 PhD students.

~10 undergraduate students per year (Industrial Chemistry/Biotechnology)

Main research interests:
- Industrial and Environmental Biotechnology
- Bioprocesses for waste and wastewater treatment and conversion into bio-based products
- Biopolymer production
- Soil and groundwater remediation
- Bioelectrochemical processes

Approach:
- Wide range of activities, spanning from “proof of principle” at lab scale to pilot- and demo-scale
- Mostly, collaborative research
- Mostly, EU funded projects,
- but also and one-to-one private committment
- Strong involvement into dissemination actions (e.g Ecomondo fair).
FP7 EC Collaborative Projects

MINOTAURUS (KBBE.2010.3.5-01) Microorganism and enzyme Immobilization: Novel Techniques and Approaches for Upgraded Remediation of Underground, Wastewater and Soil, 3 years, end December 2013.

KILLSPILL (KBBE.2012.3.5-01) “Integrated Biotechnological Solutions for Combating Marine Oil Spills”, 3 years, end 2016.

ROUTES (ENV.2010.3.1.1-2) “Innovative system solutions for municipal sludge treatment and management”, 3 years, end May 2014.

ECOBIOCAP (KBBE.2010.2.3-01) “Ecoefficient Biodegradable Composite Advanced Packaging”, 4 years, end February 2015.

WATER4CROPS (KBBE.2012.3.5-03) “Biotechnological waste water treatments and reuse in agronomical systems”, 4 years, end July 2016.
Innovative Hydrometallurgical Processes to recover Metals from WEEE including lamps and batteries – Demonstration (GA n. 308549)

Acronym: HYDROWEEE DEMO
Funding scheme: Collaborative project

THEME [ENV.2012.6.5-2] Demonstration and exploitation of most promising prototypes and tools derived from European research activities
Duration 48 months (end Sept 2016)

<table>
<thead>
<tr>
<th>Name</th>
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<tbody>
<tr>
<td>Kopacek KEG</td>
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<tr>
<td>RELIGHT SRL</td>
<td>Italy</td>
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<tr>
<td>ECO RECYCLING S.R.L.</td>
<td>Italy</td>
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<tr>
<td>Greentronics</td>
<td>Romania</td>
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<td>COMPANY FOR MANAGEMENT AND ECOLOGICAL RESEARCHES SE TRADE DOO BELGRADE</td>
<td>Serbia</td>
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<tr>
<td>INSTITUT MIHAJLO PUPIN</td>
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<td>UNIVERSITA DEGLI STUDI DELL’AQUILA</td>
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<td>UNIVERSITA DEGLI STUDI DI ROMA LA SAPIENZA</td>
<td>Italy</td>
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<tr>
<td>UNIVERSITA POLITECNICA DELLE MARCHE</td>
<td>Italy</td>
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Spin off Sapienza for technology transfer
Dept. Chemistry for process development
Contact: F. Pagnanelli
- Optimization of hydrometallurgical processes for the treatment of Li-ion Batteries, Cathodic Ray Tubes, Fluorescent lamps, Printed Circuit Boards, Liquid Crystal Displays, Catalysts
- Design and construction of a stationary plant for Cathodic Ray Tube and fluorescent lamp powders
- Design and construction of a mobile plant for hydrometallurgical treatment of all kinds of wastes cited above

Process and plant for the treatment of run-down batteries (EP 2450991)
Pilot scale platform of Universities of Venice and Verona at the wastewater treatment plant of Treviso (held by Alto Trevigiano Servizi, ATS)

Joint PHA production pilot plant, by Universities of Venice and Rome «Sapienza»
Physical and Material Chemistry
PROF. RUGGERO CAMINITI: a new X-rays Machine

EDXD_3H: The Full Power of X-Rays in a small lab

EDXD_3H, the new frontier of X-Ray laboratory diffractometers
We are proud to present to the scientific community the new prototype of our laboratory
facility: Dispersive Diffractometers. Our new instrument, equipped with three solid state Germanium detectors, is designed to deliver the full
flexibility required by modern-day applications.

While other soft matter systems lack a high sensitivity to slow rates, to only 3 hours.
Such a short overall acquisition time, in combination with the relatively low energy of the beam, results in a global 3D X-ray dose (expression power = 30 kV • 120 • 12000 = 3600 Mdk)
and allows the investigation of biological samples very sensitive to radiation damage. The operating cost is very competitive, if compared to commercial instruments (about 300 euros for a complete measurement), and the data obtained have a very
large Q range, extended up to 2θ = 15°. We encourage our colleagues to send us their
samples for measurement. After the data treatment process, we will provide them with the
detector function of the system (Q(2θ)) and its Fourier transform in real space, an
Differential Distribution Function (DDFQ).

Further details can be found in the brochure distributed at the official presentation of the instrument at “La Sapienza” university, which is attached.

EDXD Group: Ruggero Caminiti, Lorenzo Gennemi, Claudia Sabato, Olga Buscio,
Alessandro Mariani and Eleonora Inversini

Chemistry Department, “La Sapienza” University

http://www.caminiti.universita.it / ruggero.caminiti@universita.it / Lorenzo.gennemi@universita.it

University Department, “La Sapienza” University / Piazzale Aldo Moro, Rome, Italy
Halogen Bonding in 5-Halonucleobases and in their Janus-like co-crystals

Gustavo Portalone

DMXUs, when compared to DMU, are ideal candidates to ascertain the potential role of XB for molecular recognition of DNA/RNA bases. Indeed these compounds, due to the N-methylation in the 1 and 3 positions, lack strong hydrogen bond donors (N-H) but hold C=O groups that do not participate in conventional hydrogen bonds. Since only electrophilic halogens form XB when approaching an atom carrying an available lone pair, hence the halogen atom in DMXUs, which is bonded to an sp² hybridized carbon and becomes polarized due to the adjacent electron-withdrawing carbonyl group, can act in the C-X as XB donor (electron acceptor). The oxygen atom in the C=O of the heterocyclic ring is the counterpart of the intermolecular interaction, and can act as XB acceptor (electron donor).
Prof. R. Zanoni & Dr. A.G. Marrani Group

Surface Science of molecule-surface hybrid interfaces

SURFACES

- Semiconductors
- Metals
- Carbon materials (e.g. graphene)
- Solid/Electrolyte Interfaces (SEI)

MOLECULES & Co.

- Redox centers
- Ligands
- Passivators
- Supramolecular Building Blocks
- Fullerenes
- Nanoparticles
- Dyes, Quantum Dots

APPLICATIONS:

Charge and data storage devices; Molecular electronics; Sensors & Drug Delivery; Corrosion Inhibitors; Antennae systems; Solar Cells; Li batteries

TECHNIQUES & TOOLS: XPS, UPS, AFM, electrochemistry

DANilo DINI: Preparation and characterization of nanostructured semiconducting electrodes for solar energy conversion with dye-sensitized solar cells (DSCs)
Organometallic dyes and squaraines sensitizers
Biomaterials
Nanoparticles for drug delivery prepared by self-assembly of biopolymer-synthetic polymer conjugates

Amphiphilic and stimuli responsive block and graft copolymers

Giancarlo Masci, Anita Scipioni, Serena De Santis, Federica Novelli, Cesare Giordano
Andrea Barbetta: The evolution of cell culture towards the creation of functional in vitro tissue models

Research topic: control over bio-polymeric scaffold morphology

Research topic: bio-activity of biopolymer hydrogels 3D ECM and control over cell disposition (functional structures)

The use of proper artificial extracellular matrix (ECM) analogues can enhance the performances of in vitro cell culture platforms for the study of the physiology, pathology and drug-responsiveness of tissues.
Andrea Barbetta: Biopolymers as ECM for 3D cell culture

Techniques for the engineerization of complex bio-constructs

1. Porous Scaffolds with Controlled Morphology
   - Production of highly customizable foams and emulsion as template systems for fabrication of porous materials.
   - Highly ordered biopolymeric materials with tailored morphologies and enhanced permeability properties.

2. Fibrous Scaffolds with Controlled Morphology
   - 3D printing: Deposition of ~100 μm hydrogel fibers according to arbitrary predetermined patterns.
   - TOP-SEEDED CELLS: hepatocytes (HepaRG)
   - Adhesion, proliferation, increased production of albumin and urea, increased metabolism of drugs.

3. Cell Laden 3D Hydrogels with Spatial Organization
   - 3D bio-printing: Deposition of cell-containing hydrogel fibers
   - Induced cell spreading beneath hydrogel ECM
   - Multicomponent and multicellular deposition (complex tissues and organs)
   - ++80% viability
Cleofe Palocci: Innovative nanofabrication methodologies

Schematic diagram of the continuous flow microfluidic reactor used for the synthesis of polymeric NPs.

SEM micrographs of PLGA NPs formed inside the mixing channel (channel internal diameter = 600µm) scale bar: 100 nm
Plant delivery of biopesticides

Drug delivery in mammalian cells

Gene delivery

Vitis vinifera

Uptake of coumarin 6-loaded PLGA NPs by Vitis vinifera cell suspensions.

Aspergillus niger

Uptake of coumarin 6-loaded PLGA NPs in the fungus A. niger.

PLGA/CS core shell NPs
- Transferrin, lactose, folic acid
- Doxorubicin, dexamethasone, resveratrol

3T6 fibroblasts  C3A hepatocytes

Chitosan/pDNA complex morphology. Chitosan/pDNA complexes assembled with chitosan of 50 kDa at N/P = 10 were analysed by scanning electron microscopy (A) and atomic force microscopy (B, C). c shows magnification of (B), corresponding to the area indicated by the white square.
Synthetic and Supramolecular Chemistry
Marco Bella: Asymmetric Organocatalysis
A Reaction Which Became a Large-scale Industrial Process

Academia (MB)\(^1\)

\[
\text{Catalysts} \rightarrow \text{Product}
\]

Up to 3:1 dr
Up to 66% ee

Industry (Actelion)\(^2\)

\[
\text{Catalysts} + \text{Product} \rightarrow \text{New Product}
\]

reaction: 4.5 L max. volume
717 g product (66%)

<table>
<thead>
<tr>
<th>Overall yield</th>
<th>Old Route</th>
<th>New Route</th>
<th>Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>PMI (Mass of all Materials To Make 1 Kg of Product)</td>
<td>1365 Kg</td>
<td>36 Kg</td>
<td>-38 X</td>
</tr>
<tr>
<td>Solvent</td>
<td>10174 L</td>
<td>207 L</td>
<td>-50 X</td>
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</tbody>
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Marco Bella, Riccardo Salvio: Asymmetric Organocatalytic Synthesis of Biaryls

The formation of this bond is critical.

Research Interests:
**Supramolecular Chemistry**
Use of metal-sal(oph)en complexes for
- Anion recognition
- Ion pair recognition

**Antonella Della Cort**
Associate Professor in Organic Chemistry

a) Sensing of $\text{AMP}^2$, $\text{ADP}^3$, and $\text{ATP}^4$ in the presence of inorganic phosphates

_b) Receptors for $\alpha$-Aminoacids: Chiral Discrimination_

_d) Use of micelles_

The supramolecular system $\text{CTABr/uranyl-salophen}$ binds fluoride in water $10^3 \text{ M}^{-1}$.

\[ \text{ChemPhysChem, 2008, 9, 2168-2171} \]
\[ \text{J. Phys. Chem. B 2013, 117, 11654–11659.} \]
\[ \text{Org. Biomol. Chem., 2015, 13, 2437} \]


\[ \text{Inorg. Chem., 2009, 48, 6229-6235} \]
A convenient molecular fuel for molecular machines

The cyclic motions of the molecular machine are induced solely by the chemical energy supplied by the decarboxylation of the acid (a chemical fuel), without recourse to additional stimuli.

Some of the oligomers present in the polycatenane. It is the first example of main-chain polycatenane.


S. Di Stefano et al. Angew Chem Int Ed, 2016, DOI: 10.1002/anie.201502594
Website: www.chem.uniroma1.it
There is list of staff members with all the research activities in detail.

Contacts:

Marco.Bella@uniroma1.it (Presented)
Aldo.Lagana@uniroma1.it (Director of the Department)