NEW STRATEGIES FOR THE DESIGN AND SYNTHESIS OF METAL DRUGS

The research activity is in the field of bioinorganic chemistry, and deals particularly with inorganic and organometallic drugs.

GOALS

(a) Design, synthesis and characterization of new inorganic synthons for a low-impact production of anticancer Platinum complexes bearing anionic O-donors and S-donors.
(b) Study of the chemical and biological properties of PTA (1,3,5 triaza-7-phosphaadamantane) derivatives to be used as ligands for anticancer metal ions (platinum, ruthenium, rhenium etc.), supported on lipidic nanoparticles.
(c) Use of the water-soluble phosphine PTA (1,3,5 triaza-7-phosphaadamantane) as hydrogen bond acceptor in solution and in the solid state; study of co-crystals of pharmaceutical interest.
(d) Coordination of the cancer cell pro-apoptotic dichloroacetic acid and its synthetic derivatives to anticancer metal ions (platinum, ruthenium, rhenium etc.) aimed at obtaining polifunctional drugs.

INSTRUMENTS AND METHODS

Synthetic techniques under controller atmosphere and by microwaves, spectroscopic techniques (such as FTIR, multinuclear NMR, mass spectrometry), elemental analysis, X-ray diffraction, atomic absorption spectroscopy.

MAIN SUBJECTS

Organic synthesis, inorganic synthesis, spectroscopy, pharmaceutical chemistry.

RESEARCH GROUP

Dr. P. Bergamini, Dr. L. Marvelli

COLLABORATIONS

- Prof. M. Fogagnolo, A. Pagnoni (Department of Chemical and Pharmaceutical Sciences, UniFe)
- Prof. V. Bertolasi, Dr. V. Ferretti (Department of Chemical and Pharmaceutical Sciences, UniFe)
- Prof. R. Gambari, Prof. R. Gavioli, Prof. R. Cortesi (Department of Life Sciences and Biotechnologies, UniFe)

CHEMISTRY OF RADIOMETALS FOR MEDICINE

Nuclear medicine is an intrinsically molecular imaging technology, which allows monitoring non-invasively metabolic processes occurring in living tissues by using radiolabeled single-molecule probes. Metallic radionuclides play a key role in the production of diagnostic and therapeutic agents for a variety of diseases. The research in this field is focused on the production of exotic metallic radionuclides and of the corresponding radiopharmaceuticals employed either as simple inorganic ions or comprising a bioactive ligand.

GOALS

To synthesize highly sensitive biological probes, radiolabeled with metallic radionuclides, for exploring biological processes at the molecular level. To exploit this information for developing diagnostic and therapeutic (theranostics) agents for the treatment of major diseases.

INSTRUMENTS AND METHODS

70-MeV high-current, high-energy cyclotron (Best Theratronic, Canada), proton beam lines and targets, fully equipped radiochemical laboratories, clean rooms, PET/SPECT/CT small-animal scanner, gamma spectroscopy laboratory.

MAIN SUBJECTS

Inorganic chemistry, nuclear physics, radiochemistry, medicinal chemistry, radiopharmaceutical chemistry, molecular biology, molecular imaging, positron emission tomography (PET), single photon emission tomography (SPECT), theranostics.

RESEARCH GROUP

Prof. A. Duatti

COLLABORATIONS

- National Institut of Nuclear Physics at the National Laboratories in Legnaro (LNL-INFN, Italy)
- Arronax GIP, Nantes (France)
- International Atomic Energy Agency (IAEA, Vienna, Austria)
- Institut of Bioimaging and Molecular Physiology (Bicocca University, Milan, Italy)

STRUCTURES OF ORGANOMETALLIC CATALYSTS

Many important homogeneous catalysis processes involve coordination complexes or organometallic compounds. An improvement in the homogeneous catalysis field is represented by the development of specific catalysts such as the Grubbs' Catalysts, a series of transition metal carbene complexes used in organic chemistry for olefin metathesis reactions.

GOALS

X-ray structural determination of a) new Grubbs' second generation catalysts employed in reactions of olefin metathesis, b) new organometallic compounds active for polymerization of olefins and for polar monomers, c) new organometallic complexes of Pd and Pt.
These studies allow the elucidation of the electronic and steric factors affecting the reactivity of the complexes examined along with the regio- and stereoselectivity of processes for the formation of novel carbon-carbon and carbon-nitrogen bonds.

INSTRUMENTS AND METHODS

Structural determination by single-crystal X-ray diffraction technique at both room and cryogenic temperature.

MAIN SUBJECTS

Structural chemistry, General chemistry

RESEARCH GROUP

Prof. Valerio Bertolasi

COLLABORATIONS

- Dr. F. Grisi, Dr. S. Milione (University of Salerno, Italy)
- Prof. L. Canovese, Dr. F. Visentin, (Ca’ Foscari University, Venice, Italy)

NEW ANTIMICROBIAL MATERIALS FOR APPLICATION AD *MEDICAL DEVICES*

The project aims at the preparation of antimicrobial materials for application as Medical Devices acting as barrier against microbial species which may develop into skin lesions and mucous. The active ingredients are based on silica functionalized with silver complexes, both thermally and photochemically stable, and with quaternary ammonium salts or biguanides. The formulations include products for topical, gingival, and dental use.

GOALS

1) Functionalization and characterization of materials based on titanium dioxide with antimicrobial cationic species
2) Functionalization and characterization of materials based on silica with antimicrobial cationic species
3) Functionalization and characterization of materials based on zinc dioxide with antimicrobial cationic species
4) Formulation of products for topical and gingival use

INSTRUMENTS AND METHODS

Preparation of metal and metalloid oxides. Preparation of silver(I) complexes. Characterization with spectroscopic techniques.

MAIN SUBJECTS

Inorganic chemistry, Material Science, Pharmaceutical chemistry.

RESEARCH GROUP

Prof. C. A. Bignozzi

COLLABORATIONS

- Dr. Valeria Dissette (Dipartimento di Scienze della Vita e Biotecnologie, UNIFE)
- Prof. Francesco Carinci (Dipartimento di Morfologia, Chirurgia e Medicina Sperimentale, UNIFE)
- Prof. Roberto Cassino (Centro Vulnologico Italiano, Torino)

SUPRAMOLECULAR PHOTOCHEMISTRY

The research activity is directed towards the design, the synthesis, and the characterization of properly organized supramolecular systems, which contain building blocks such as metal complexes, porphyrins, or organic molecules with specific functional properties upon light absorption. The identification and kinetic characterization of the photoinduced processes by means of time-resolved absorption and emission spectroscopic techniques is at the core of the research.

GOALS

The research activity can be divided into three different lines:
- Photophysical characterization of metal complexes;
- Energy transfer and antenna effect in multi-chromophoric structures where an energy gradient between different components is used to drive an energy flux;
- Charge separation/recombination in supramolecular systems: systematic studies of the kinetics of electron transfer processes as a function of ΔG and the nature and length of chemical bridges.

INSTRUMENTS AND METHODS

Nanosecond laser flash photolysis, pump-probe femtosecond transient absorption spectroscopy, time-correlated single photon counting.

MAIN SUBJECTS

Inorganic chemistry, Photochemistry, Electrochemistry

RESEARCH GROUP

Prof. M. T. Indelli, Prof. F. Scandola, Dr. M. Natali

COLLABORATIONS

- Prof. E. Alessio, Prof. E. Iengo (University of Trieste)
- Prof. S. Campagna (University of Messina)
- Prof. R. Ziessel (Université de Strasbourg, France)
- Prof. F. Würthner (Universität Würzburg, Germany)
- Prof. F. Odobel (CEISAM, Université de Nantes, France)
- Prof. L. De Cola (ISIS, Université de Strasbourg, France)

ARTIFICIAL PHOTOSYNTHESIS

Artificial photosynthesis targets the conversion of solar energy into chemical fuels by means of photoinduced transformations of suitable, abundant substrates. Among several reaction schemes, water splitting into hydrogen and oxygen represents the most challenging transformation. Taking inspiration from the working principles of natural photosynthetic systems, the research aims at the development of functional units for the light-harvesting (antennae), for the photoinduced charge separation (reaction centres), and for the storage and utilization of accumulated charges (multi-electron catalysts). As far as the synthetic aspects is concerned, the project takes advantage from collaborations with different laboratories in Italy and abroad. Of particular relevance within the research group is the optimization of the kinetic aspects, crucial for the resulting efficiency of the investigated molecular systems. Within this framework, several time-resolved spectroscopic techniques are employed in both the fast (nanosecond) and ultrafast (pico/femtosecond) regime.

GOALS

The research activity can be divided into three main lines:
- artificial antennae for light-harvesting
- artificial reaction centers for photoinduced charge separation
- multi-electron catalysts for oxidation and reduction

INSTRUMENTS AND METHODS

Nanosecond laser flash photolysis, pump-probe femtosecond transient absorption spectroscopy, photoelectrochemical techniques, gas-chromatographic techniques.

MAIN SUBJECTS

Photochemistry, Photocatalysis, Electrochemistry, Inorganic chemistry

RESEARCH GROUP

Prof. F. Scandola, Prof. M. Teresa Indelli, Dr. Mirco Natali

COLLABORATIONS

- Prof. E. Alessio, Prof. E. Iengo (University of Trieste, Italy)
- Prof. M. Bonchio, Dr. A. Sartorel, Prof. C. Zonta (University of Padua, Italy)
- Prof. S. Campagna (University of Messina, Italy)
- Prof. F. Odobel (CEISAM, Université de Nantes, France)
- Prof. A. G. Coutsolelos (University of Crete, Heraklion, Greece)

NANOSTRUCTURED PHOTOELECTROCHEMICAL SYSTEMS FOR SOLAR ENERGY CONVERSION AND ENVIRONMENTAL PHOTOREMEDIATION

GOALS

The group is involved in the development and dynamic characterization of molecular systems and materials useful for capturing converting and storing solar energy, by mainly exploiting the charge generation and separation at nanostructured semiconductor junctions. Radiant power can be either directly converted in electric power in solar cells sensitized by molecular dyes or by other lower gap semiconductors or stored in the form of chemical energy, by generating solar fuels through photoinduced water splitting/CO_2 reduction reactions. An interesting emerging application of photoelectrochemical reactions in aqueous media is devoted to the oxidative degradation of organic pollutants of recent concern which can be successfully carried out through redox reactions triggered by high energy charge carriers.

INSTRUMENTS AND METHODS

The research activity is focused on the characterization of molecular systems and semiconductor materials and demands the understanding of their dynamic functioning in photoelectrochemical cells. The main methods for the investigations of the charge transfer dynamics are based on the analysis of the current-potential characteristics of the solar devices, on electrochemical impedance spectroscopy, on time resolved optical spectroscopy and on EPR spectroscopy. The structural and morphological characterization of electrodes and materials produced and modified mainly through hydrothermal/wet processing are carried out through scan probe microscopies, X ray diffraction, micro-Raman. Some of these instrumentation is available within the research group (Atomic Force Microscopy) while other techniques are exploited through departmental collaboration (X Ray Diffraction, SEM) or external collaborations (high resolution SEM and TEM, micro Raman, XPS)

MAIN SUBJECTS

Inorganic chemistry, Photochemistry, Photocatalysis, Electrochemistry, Photoelectrochemistry

RESEARCH GROUP

Prof. C. A. Bignozzi, Prof. S. Caramori, Prof. A. Molinari, Dr. R. Boaretto, Dr. R. Argazzi

COLLABORATIONS

The group is involved in various collaboration with other research groups within the department (i.e. Analyitcal Chemistry for chromatography and mass spectrometry) and with other universities and research instituitions at the national levels. Established collaborations are with Università statale di Milano and Milano-Bicocca, Università di Padova, Università di Trento, Università di Roma Tor Vergata/CHOSE, Università di Messina, Università di Trieste, ENI-Istituto Donegani, Università di Torino and Università di Bologna. At the moment various collaborative researches are carried out with the University of North Carolina at Chapel Hill (NC, USA), Universitè de Lorraine (Nancy, France), Queen Mary University (London, UK), EPFL (Lausanne, Switzerland).

INORGANIC PHOTOSENSITIVE MATERIALS FOR HETEROGENEOUS CATALYSIS

Semiconducting oxides such as TiO_2 and WO_3 and polyoxoanions, which are considered as their molecular models, are important materials with potential applications in photocatalysis for degradation of pullutants and emerging contaminants (e.g., drugs).

GOALS

The research activity is focused on the synthesis and characterization of solid inorganic catalysts mainly based on semiconducting oxides. One of the main goals is the understanding of the effects of several parameters, such as the nature of the crystalline phase, on the photocatalytic acticity. Particular attention is also deserved towards the study of the surface energetics. Of particular interest is the study of the mechanism of the photocatalytic reaction by monitoring transient radical species involved in the process.
These photocatalysts under irradiation are equivalent to electrodes under open-circuit conditions. This clearly determines the possibility to move from photocatalysis to photoelectrocatalysis. Targets reactions are both reduction and oxidation processes. Particular attention is devoted to the use of the photocatalytic and photoelectrocatalytic technique as an advance oxidation method for the degradation of pullutants and emerging contaminants which can be potentially coupled to sustainable reactions including hydrogen production or carbon dioxide reduction.

INSTRUMENTS AND METHODS

Light sources for photolysis experiments, UV-Vis, DR UV-Vis, IR, GC and HPLC, EPR-spin trapping, electrochemical techniques.

MAIN SUBJECTS

Inorganic chemistry, Electrochemistry, Photoelectrochemistry, Catalysis, Material science.

RESEARCH GROUP

Prof. A. Molinari, Prof. C. A. Bignozzi, Prof. S. Caramori

COLLABORATIONS

- Dr. R. Amadelli (ISOF CNR)
- Prof. H. Garcia (University of Valencia, Spagna)
- Prof. P. Hoggard (Santa Clara University, California)
- Dr. G. Magnacca (University of Turin)
- Dr. H. Rezala (University of Blida, Algery)

SYNTHESIS OF MACROCYCLES AND RELATED METAL COMPLEXES OF INTEREST IN PHOTODYNAMIC THERAPY (PDT)

Photodynamic therapy (PDT) is an emerging therapeutic approach for a localized and minimally invasive treatment of a wide variety of medical indications ranging from tumors to microbial infections.
PDT entails a ternary system that combines visible light, oxygen and a light-activated drug (photosensitizer). Each factor is harmless by itself, but, if combined with the others in proper dosage and concentration, it can generate cytotoxic reactive oxygen species (ROS). Currently, PDT is clinically approved for the treatment of several medical conditions including bacterial infections, some skin diseases and cancer.

GOALS

The research is focused on:
- synthesis, characterization and photochemical activity of phthalocyanines, chlorins, bacteriochlorins and related macrocycles of interest in the photodynamic therapy of tumors (PDT) and as antimicrobial agents (APDT)
- immobilization on carriers (i.e., polymeric nanoparticles) for better targeting or scaffolds for wound-healing devices

INSTRUMENTS AND METHODS

Light sources for photochemistry studies, spectroscopic techniques (UV-Vis, multinuclear NMR).

MAIN SUBJECTS

Inorganic chemistry, Organic chemistry, Photochemistry, Material science, Pharmaceutical chemistry

RESEARCH GROUP

Dr. E. Polo

COLLABORATIONS

- Dr. D. Perrone (Department of Chemical and Pharmaceutical Sciences, UniFe)
- Dr. C. Ferroni, Dr. G. Sotgiu, Dr. G. Varchi, Dr. A. Guerrini, Dr. A. Aluigi (ISOF CNR, Bologna)
- Dr. A. Sagnella, MIST E-R Laboratory (Bologna)
- Dr. V. Teresa Orlandi, Dr. E. Marras, Dr. M. Gariboldi, Dr. E. Monti (Department of Biotechnologies and Life Sciences (DBSV), University of Insubria, Varese)

SYNTHESIS AND ACTIVITY IN ASYMMETRIC CATALYSIS OF ORGANOMETALLIC COMPLEXES IMMOBILIZED ON SOLID SUPPORTS

Immobilization using covalent tethering techniques is, at present, the most favored approach to designing stable heterogeneous asymmetric catalysts. The research deals with the synthesis and the study of the activity of organometallic complexes, both in solution and supported, in the preparation of intermediates for the pharmaceutical industry.

GOALS

- Synthesis of titanium organometallic complexes optically active and provided with a tether to enable their covalent graftig onto solid supports, like functionalized silica gel and polymeric matrices or through UV-mediated silylation.
- Immobilization on solid support of the catalysts and their characterization.
- Study of the catalytic systems obtained in the asymmetric hydrosilylation of 2-phenylpyrrolines, as model-compounds of intermediates in pharmaceutical chemistry processes.

INSTRUMENTS AND METHODS

Synthetic techniques under inert atmosphere, spectroscopic techniques (FTIR, multinuclear NMR, GC/MS, ICP-OES), X-ray diffraction

MAIN SUBJECTS

Organometallic chemistry, Organic chemistry, Pharmaceutical chemistry, Catalysis, Material science.

RESEARCH GROUP

Dr. E. Polo

COLLABORATIONS

- Prof. M. Fogagnolo (Department of Chemical and Pharmaceutical Sciences, UniFe)
- Prof. V. Bertolasi (Department of Chemical and Pharmaceutical Sciences, UniFe)
- Prof. J. Khinast, Dr. H. Woefler-Gruber (Pharmaceutical Engineering Institute for Process Engineering, Graz University of Technology, Austria)