Chemistry days – Day #8

Chemistry towards Biology: materials

mercoledì 2 luglio 2014, ore 9, aula D1

9.00-9.15	Introduction *Francesco Trotta, Francesco Turci*
9.15-9.30	Biomolecules-(nano)materials interactions: from in-silico to in-vitro studies. A nightmare or a (reasonable) challenge for chemists? *Gianmario Martra* (10 min discussione)
9.40-9.55	Chemical aspects in (nano)particle toxicology: reducing complexity to understand bio-inorganic interface. *Francesco Turci* (10 min discussione)
10.05-10.20	Materials for hernia treatment *Giuliana Magnacca* (10 min discussione)
10.30-10.40	Comunicazioni dalla Commissione Spokes
10.40-11.00	Pausa caffè
11.00-11.15	Bioceramics that heal: design and preparation of multifunctional systems for bone repair. *Giuseppina Cerrato* (10 min discussione)
11.25-11.40	Polymers for biomaterials: a (partial) overview on the contribution of the Polymer Materials Group. *Pierangiola Bracco* (10 min discussione)
11.50-12.05	Hybrid mesoporous silica nanoparticles as drug delivery systems. *Gloria Berlier* (10 min discussione)
12.15-12.30	Nanosized and nanostructured polymer-based drug delivery systems. *Francesco Trotta* (10 min discussione)

Biomolecules-(nano)materials interactions: from in-silico to in-vitro studies. A nightmare or a (reasonable) challenge for chemists?

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&
Marta Corno, Piero Ugliengo

Independently of the type of response elicited in cells/tissues by exogenous materials, the key role of the surface features of biomaterials has been recognized, leading to the definition, at the beginning of 2000s of the concept of "biological/biomedical" surface science.[1] The unravelling of the ensemble of surface processes and phenomena actually occurring in vivo is still a challenge, but there is a general consensus in setting the causal sequence: (i) biomaterial surface structure, (ii) states of adsorbed water molecules, and (iii) states of adsorbed proteins, as one of the main factors ruling the fate of the interaction of the implant (then actually occurring through a hybrid synthetic/protein interface [2]) with cells. Here we will report on a ten-years research path developed in this respect at the Department, also in a synergic way between theoretical and experimental approaches, focussing not only on targets achieved, but also on open problems, hoping in a stimulating discussion with colleagues.

References

[1] Kasemo, B. Surf. Sci. "Biological Surface Science", 2002, 500, 656-677.
[2] D. Walczyk, F. B. Bombelli, M. P. Monopoli, I. Lynch,K. A. Dawson, "What the cell "sees" in bionanoscience" J.Am. Chem. Soc., 2010, 132, 5761-5768

Chemical aspects in (nano)particle toxicology: reducing complexity to understand bio-inorganic interface

Ingrid Corazzari, Ivana Fenoglio, Bice Fubini, Arianna Marucco, Cristina Pavan, Maura Tomatis, Francesco Turci

The interaction of inorganic particles with living matter (fluid, membrane, tissue) regulates both the beneficial and adverse cells responses, and ultimately determines the particle fate within the body. The toxicity and biocompatibility of materials (TBM) group has a long-standing interdisciplinar research experience on the fundamental chemical aspects of particle toxicology. A strong effort has been recently devoted to: a) clarify the effect of different biological media in determining protein adhesion to the same surface (TiO_2 and SiO_2), b) investigate particle-membrane interaction focusing on red blood cell membranolysis induced by model structures (quartz nanocrystals), and c) evaluate the nanoparticle interaction with skin (TiO_2 polymorphs on ex vivo skin model). We show that an integrated, multi-technique, molecular approach, largely based on the evaluation of particle size, shape, surface chemistry and surface reactivity, may successfully be adopted to explain the complex interplay between biological matter and inorganic surfaces.

Materials for Hernia Treatment

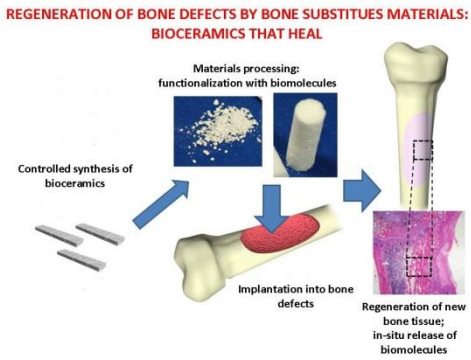
Giuliana Magnacca, Roberto Nisticò, Paola Calza, Debora Fabbri, Paola Avetta e Mery Malandrino

Every year, over 20 million of surgical hernioplasty interventions of various nature (mostly abdominal and inguinal) are performed worldwide. The classical route for treating hernia diseases is the suturing of damaged body tissues by using polymeric nets, mostly made by polypropylene (PP). Notwithstanding the progress of the scientific research, still nowadays the causes of hernioplasty failures are at least two: the surgical infections due to implantation of biomaterials which can bring bacteria in the surgical site, and the shrinking of the prosthesis which can induce the collapse of the anchoring sutures of the prosthesis and the following displacement from the surgical site.
To solve the above cited issues, two types of PP meshes produced by Herniamesh srl (Chivasso) have been studies: the first one surface modified via plasma treatment and coated with an antibacterial layer, the second one surface modified via plasma polymerization with polyacrylic acid in order to induce adhesive properties.

Bioceramics that heal: design and preparation of multifunctional systems for bone repair

V. Aina, G. Cerrato, C. Magistris, G. Viscardi

Bone defects can be generated by a variety of diseases or traumatic injuries, such as tumor resection, periodontal resorption and congenital defects. Bioceramics represent a class of materials that, due to their tailorable properties, can be used to treat bone defects.[1]



Recently, the development of intelligent therapeutic systems has transformed the research field of biomaterials, tissue engineering, biosensors and controlled drug delivery.[2]
Micro- and nanoscale intelligent systems can be used to maximize the efficacy of therapeutic treatments because they have the ability to rapidly detect and respond to disease states directly at the local site. The development of devices that will interact with cells on the micro level will potentially target and treat the problem and, at the same time, alleviate extreme damage to entire tissues or even organs reducing the inflammatory response.

[1] Salinas A., Vallet Regì M. Bioactive ceramics: From bone grafts to tissue engineering. RSC Advances 2013, 3, 11116-11131.
[2] Yang L., Zhang L., Webster T.J. Nanobiomaterials: State of the art and future trends. Advanced Engineering Materials 2011, 13, B197-B217.

Polymers for biomaterials: a (partial) overview on the contribution of the Polymer Materials Group

Pierangiola Bracco, Marco Zanetti, Marco Regis, Valentina Brunella

The present contribution will review our recent activities in the field of polymers for biomaterials, focusing in particular on UHMWPE and PEEK for orthopedic applications, but also including a brief overview on applications of the electrospinning technology to the biomaterials field.
UHMWPE has been the material of choice for total joint replacement for more than 40 years. Recent researches aimed to improve the wear resistance and the oxidative stability of the polymer, by means of radiation cross-linking and addition of suitable stabilizers. The biological response to the polymer itself and to its wear debris is still under debate.
PEEK biomaterials are now widely accepted in the field of spine surgery, while fiber-reinforced PEEKs have recently been explored as alternative orthopedic bearings and hip stem materials. However, a deeper understanding of their structure-properties correlation, as well as more extensive wear studies and new prosthesis design criteria must be achieved before further extending the use of these materials in the production of highly durable orthopedic components.
Electrospinning has recently gained a great interest as a simple, extremely powerful technique to produce nanofibers with diameters in the range from few to hundreds nanometers. The electrospinning of biodegradable polymers has shown an enormous potential in the field of drug delivery, wound dressing and tissue engineering.

Hybrid mesoporous silica nanoparticles as drug delivery systems

Gloria Berlier, Ivana Miletto, Giorgia Musso

Mesoporous silica nanoparticles (MSN) are intensively studied as nanocarriers for the vehiculation of bioactive molecules. The success of this material is related to many factors such as the typical features of mesoporous silica (high surface are and regular porosity, allowing in principle the encapsulation and diffusion driven release of durgs), coupled to a relatively easy synthesis and functionalization. The latter aspect is particularly important since functionalization can be employed to tune the MSN surface properties with many aims: i) optimization of drug loading and release kinetics; ii) targeting; iii) imaging; iv) development of stimuli responsive materials answering to pH and temperature changes. Surface functionalization can also affect the nanoparticles fate in biological fluids. An overview of these issues will be given together with results including new hybrid materials prepared by one-pot methods.

Nanosized and nanostructured polymer-based drug delivery systems.

Francesco Trotta, Dominique Scalarone, Valentina Brunella, Fabrizio Caldera

Several polymer-based materials for drug delivery applications are currently being developed in the Polymer Materials Group. Among these, cyclodextrin nanosponges are innovative cross-linked cyclodextrin polymers nanostructured within a three-dimensional network. This type of cyclodextrin polymer can form porous insoluble nanoparticles with a crystalline or amorphous structure and spherical shape or swelling properties. The polarity and dimension of the polymer mesh can be easily tuned by varying the type of cross-linker and degree of cross-linking. Nanosponge functionalisation for site-specific targeting can be achieved by conjugating various ligands on their surface. They are a safe and biodegradable material with negligible toxicity on cell cultures and are well-tolerated after injection in mice. Cyclodextrin-based nanosponges can form complexes with different types of lipophilic or hydrophilic molecules. The release of the entrapped molecules can be varied by modifying the structure to achieve prolonged release kinetics or a faster release. Nanosponges can be used to improve the aqueous solubility of poorly water-soluble molecules, protect degradable substances, obtain sustained delivery systems or design innovative drug carriers for nanomedicine.
In addition to cyclodextrin nanoponges, two mesoporous materials for drug delivery applications will be also presented: 1) mesoporous silica nanoparticles with ordered, highly dense mesopores coated with thermoresponsive copolymers that can open and close the pores depending on the temperature, 2) nanoporous and isoporous polymer membranes of interest for implantable sensor applications and for the fabrication of drug delivery devices providing a controlled drug delivery.