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SEMINAR

Tuesday, 15th January, 12.00 pm, Seminar Room

Host: Prof. Luis Liz-Marzán

Graphene Plasmonics

Prof. Javier García de Abajo
IQFR-CSIC, Serrano 119, 28006 Madrid, Spain

After an extensive and tutorial discussion of plasmonics during the first part of the seminar, we will discuss the extraordinary optical properties of highly doped graphene, along with new classical and quantum phenomena involving plasmons in this material. A summary of recent experimental observations will be presented, including spatial mapping of confined graphene plasmons and spectroscopic evidence of plasmon-mediated resonant absorption. Classical devices for infrared spectroscopy, sensing, and light modulation will be also discussed, while prospects for extending these phenomena to the visible and near-infrared regimes will be examined as well.

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SEMINAR

Thursday, 24th January, 12.00 pm, Seminar Room

Host: Dr. Juan C. Mareque-Rivas

Nanoparticle based analysis of biomolecules, cells and tissue

Duncan Graham
Centre for Molecular Nanometrology, WestCHEM, Department of Pure and Applied Chemistry, University of Strathclyde, 295 Cathedral Street, Glasgow, G1 1XL

Metallic nanoparticles offer many opportunities in terms of detection including light scattering, surface plasmon resonance and surface enhanced resonance scattering (SERS). We are interested in the optical properties of metal nanoparticles and their potential application in a range of different biological studies. We can make use of the optical properties of nanoparticles in two ways.

1. The nanoparticle can act as an extrinsic label for a specific biomolecular target in the same way as a fluorescent label is used. The advantage of using the nanoparticle is its optical brightness (typically several orders of magnitude more than fluorophores) and the lack of background vibrational signals. Functionalisation of the nanoparticle with a specific targeting species such as an antibody or peptide aptamer allows this approach to be used in a wide range of studies including cell, tissue and *in vivo* analysis.

2. Nanoparticles can be designed to contain a specific recognition probe designed to cause a change in the aggregation status of the nanoparticles resulting in a discernible optical change when it interacts with its biomolecular target. This allows separation free analysis of specific biomolecular interactions and can be applied to a range of different probe/target interactions such as DNA-DNA, peptide-protein and sugar-protein.

We have been making use of nanoparticles in both of these approaches in conjunction with SERS which is an advanced vibrational spectroscopy. To demonstrate the applicability of the two different approaches examples will be given on the use of nanoparticles for cell imaging in two and three-dimensions, imaging of nanoparticles at centimetre depths through tissue and also their ability to report on biological molecules *in vitro* and *in vivo*.

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SEMINAR

Tuesday, 29th January, 12.00 pm, Seminar Room

Host: Dr. Ilya Reviakine

Combining quantitative XPS and QCM techniques: elaboration of surface mechanisms in corrosion and protein adsorption

Anouk Galtayries
Laboratoire de Physico-Chimie des Surfaces (UMR CNRS 7045),
Ecole Nationale Supérieure de Chimie de Paris (Chimie ParisTech)
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Surface chemical analysis techniques such as X-ray Photoelectron Spectroscopy (XPS) and Time-of-Flight Secondary Ion Mass Spectrometry (ToF-SIMS) are very useful tools to characterize surface modifications of passive metals in interaction with reactive aqueous liquids: it is applied in fields such as corrosion in liquid phase or biomaterials in biological solutions.

In order to complete the investigation of the surface mechanisms in the early stages of metals modifications, we combined UHV surface characterization techniques and (Electrochemical)-Quartz Crystal Microbalance (EQCM) to get new quantitative and kinetic information for different systems such as:

- corrosion kinetics and chemical modifications of Ag thin films in alkaline Na2S solutions,
- adsorption of albumin on passivated Cr surfaces as a function of potential and pH,
- kinetics of fibronectin (Fn) adsorption on passivated Ti and Cr surfaces,
- cleaning of protein-contaminated metallic surfaces.

From this set of illustrations, the adsorption modes, as determined from the combination of gravimetric and spectroscopic data, will be presented and discussed as regards further applications as cell adhesion (in the case of biological systems).

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SEMINAR

Monday, 4th February, 12.00 pm, Seminar Room

Host: Prof. Luis Liz Marzán

NMR and molecular recognition of carbohydrates

Jesús Jiménez-Barbero
Chemical and Physical Biology, Centro de Investigaciones Biológicas, C.S.I.C., 28040 Madrid, Spain

Molecular recognition by specific targets is at the heart of the life processes. In recent years, it has been shown that the interactions between proteins (lectins, enzymes, antibodies) and carbohydrates mediate a broad range of biological activities, from fertilization, embryogenesis, and tissue maturation, to pathological processes. The elucidation of the mechanisms that govern how sugars are accommodated in the binding sites of these receptors is currently a topic of interest. Thus, the determination of the structural and conformational factors and the physicochemical features which govern the molecular recognition of these molecules is of paramount importance. This presentation is focused on the application of NMR methods both from the ligand and receptor's perspective (especially chemical shift perturbation analysis, Saturation Transfer Difference, and trNOESY experiments) to the study of molecular recognition processes between a variety of polypeptides of biomedical interest and carbohydrate-based molecules, drugs and inhibitors. Lectins and enzymes, both wild type and mutants, have been used as receptors with the final aim to know and to evaluate the relative importance of polar (hydrogen bonding, electrostatic interactions) and non polar (van der Waals, CH-π) forces in the molecular recognition process. As examples, structural and conformational details of chitooligosaccharide recognition by hevein domains will be shown. Additional examples will be presented that include the binding of heparin analogues to the acidic fibroblast growth factor and its receptor.

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SEMINAR

Thursday, 7th February, 12.00 pm, Seminar Room

Host: Dr. Ilya Reviakine

Unraveling the mechanism of molecular motors by using micromanipulation methods

Dr. Maria Manosas
Small Biosystems Lab
Departament de Fisica Fonamental
Facultat de Fisica, Universitat de Barcelona

Single-molecule micromanipulation methods have shed new light on DNA protein interactions. In particular these methods have provided novel insights on the mechanisms of molecular motors that convert chemical energy (e.g. the energy released in the hydrolysis of ATP) into mechanical work. In this talk I will describe the use of magnetic traps for the investigation of DNA based motors involved in DNA replication and DNA repair. In these assays magnetic traps are used to mechanically manipulate a DNA molecule and follow in real time the activity of different DNA molecular motors. The applied mechanical force allows either to assist or to hinder motor activities revealing the mechanisms of individual motors as well as their coordinated action when processing DNA (such as during DNA replication). Mechanical switch in molecular motor activity offers interesting applications for single-molecule DNA sequencing.

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SEMINAR

Wednesday, 13th February, 12.00 pm, Seminar Room

Host: Dr. Ralf P. Richter

Nanomaterials to probe the structure and functions of the cell microenvironment.

David G Fernig
Department of Structural and Chemical Biology, Institute of Integrative Biology, Biosciences Building, University of Liverpool, Liverpool L69 7ZB
E: dgfernig@liv.ac.uk
Blog: http://ferniglab.wordpress.com/

The evolution of metazoans resulted in a transformation of the unit of natural selection, from the individual cell to the organism. This profound change required a deep integration of cellular function within the organism, which was achieved through a number of molecular innovations. Two of these stand out, because they are restricted to metazoans: tyrosine phosphorylation and extracellular matrix. Unsurprisingly, virtually all cell communication involves one or both of these.

Transport of effectors between cells is one means whereby metazoans integrate cellular function. For example, gradients of morphogens and of epithelial-mesenchymal signal relays are common currency in developmental biology. Moreover, organism homeostasis depends on similar transport of effector proteins, such as growth factors, cytokines and chemokines from source to target cell; these effectors and their receptors are major targets for cancer therapeutics. Such transport occurs in the extracellular and pericellular matrices that lie between cells where the glycosaminoglycan heparan sulfate (HS) chains of proteoglycans (PG) are a dominant molecular species, due to their size (~40 nm to 160 nm long), amount and the number of proteins they bind to.

To understand if matrices have a higher order (so supramolecular) structure, above and beyond that of the individual components, and whether such structure impacts on molecular and cellular function we are:

- Determining the origins of matrices.
- Quantifying the interactome of matrix constituents in health and disease.
- Quantifying the interactions of effector proteins in matrices at the single molecule level.

Choanoflagellates are the sister clade of metazoans and descendants of the last common unicellular ancestor of metazoans. As well as tyrosine phosphorylation, bioinformatic and biochemical analyses demonstrate that choanoflagellates produce both heparan sulfate and chondroitin sulfate, This indicates that these key matrix polysaccharides were likely to be instrumental in enabling multicellularity.

On a genome-wide basis we have identified 435 HS binding proteins ((HS interactome) in matrices. Network maps of their protein-protein interactions demonstrate their central role in cell regulation. An analysis focussed on the pancreas shows that this is also true in an organ and, importantly in diseases of that organ that are of high socio-economic impact. A practical consequence of this work is that HS interacting proteins are an easily accessible extracellular interactome that can be mined for biomarkers and novel drug targets.

To probe whether there is structure in the matrices of living cells, the dynamics of individual FGF2 molecules associated with the pericellular matrix has been measured. To understand what actually occurs to soluble ligands when they interact with cell surface proteoglycans and receptors, novel nanoparticle probes have been developed, which enable the quantitative imaging of the dynamics of individual molecules in living cells >10 min. These probes consist of:

(i) Small gold nanoparticles (ø 5 nm to 10 nm), protected by a self-assembled monolayer of small ligands. This ligand shell provides a non-stick surface (no non-specific binding is detectable) and the means to specifically functionalise the nanoparticles monovalently, e.g., 1 FGF:1 nanoparticle. Imaging of individual nanoparticles is possible by the application of photothermal microscopy (pointing accuracy of ~10 nm, frame rate of 42 ms).

(ii) Quantum dots with a similar self-assembled ligand shell to the gold nanoparticles and which possess the same remarkable resistance to non-specific binding.

Imaging of individual FGF-2 ligands labelled with the nanoparticle probes in the pericellular matrix using optical microscopy and electron microscopy leads to a radical new model of this inter cellular compartment.

Taken together, these new insights provoke a re-think of strategies for the design of scaffolds for tissue engineering, for polymers for regenerative medicine and for therapies that aim to re-programme tissues, for example in inflammation and cancer.

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SEMINAR

Monday, 18th February, 12.00 pm, Seminar Room

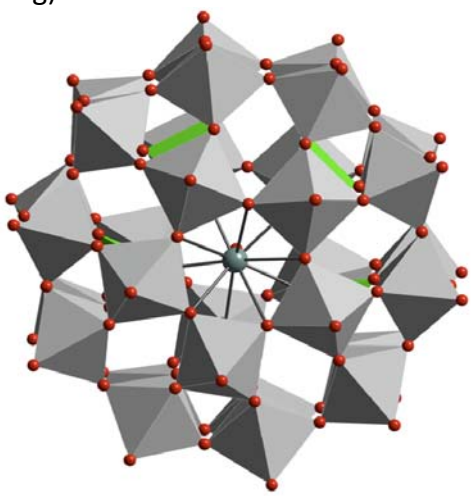
Host: Prof. Luis Liz-Marzán

Molecular nanoscience: A source of new materials

E. Coronado
Instituto de Ciencia Molecular. Universidad de Valencia. (Spain

The molecular region of Nanoscience is still a region that has been scarcely explored in Nanoscience, maybe because the larger structural and electronic complexity of molecules, compared with that found in simpler atom-based nano-objects and nanostructures, make them more difficult to study at the nanoscale with available instrumental techniques. Albeit, it is in this molecular region where molecular chemists, biologists, physicists and engineers working in Nanosciences may find the best opportunities to interact and to converge. Areas like supramolecular chemistry, molecular electronics and molecular magnetism are expected to converge in this region.

In this talk I will present the different aspects covered by the molecular nanoscience in the context of the magnetic systems: 1) The design of functional magnetic molecules; 2) The control of the self-assembling processes to prepare nanostructures of these chemical nano-objects on surfaces, and to prepare new materials based on these molecules (in particular, hybrid magnetic materials exhibiting multifunctional properties); 3) The study of the properties exhibited by these nanomaterials/nanostructures, including the study of properties at the unimolecular level; 4) The development of applications (in molecular spintronics and quantum computing).



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SEMINAR

Tuesday, 26th February, 12.00 pm, Seminar Room

Host: Prof. Luis Liz-Marzán

Small and smart rolled-up tubes for biomaterials in cell biology and nanorobotics.

Samuel Sánchez
Institute for Integrative Nanosciences, IFW Dresden, Helmholtzstrasse 20, D-01069 Dresden, Germany
s.sanchez@ifw-dresden.de

This talk will be focus on the use of rolled-up nanofilms for biomaterials in cell biology and nano-bio-robotics applications. The talk will be divided in two parts, as follows:
The development of an *in vitro* three-dimensional (3D) cell culture scaffold has recently attracted significant research interest, as it mimics the complexity of a tissue more faithfully than a conventional two-dimensional (2D) culture substrate. By the rolled-up nanotechnology, we can design arrays of multifunctional devices on-chip for the observation of *single cell behavior* inside transparent microtubes that can be employed for diverse biological applications. [1] But also, metallic and magnetic materials can be incorporated in the microtubes which can be easily released off-chip and suspended in solution where they navigate as self-propelled micromotors. The downscaling of autonomous devices and nanomachines which could perform advanced tasks is one of the dreams in nanotechnology. In the second part of this talk, I will present our recent advances on the fabrication of *(bio)catalytic micro-motors* based on the rolled-up nanotechnology. The motors can be externally guided for the transport of different micro-objects [2, 3] in microfluidics and biological material such as cells [4]. We performed different methods to wirelessly control the motion and the power of the micromotors such as magnetic guidance [3], temperature [5] and light [6] as external sources. These nanotubular motors can be scaled down to sub-micron size in diameter [7], featuring as the "Smallest man-made jet engine" (awarded with the World Guinness Record), which can be used as nanotools to drill into cells [8] and tissues [9]. Hybrid motors combining tubular structures with bio-functional units such as enzymes [11] and motile cells [12] are also presented.

References:

[1] Stefan M. Harazim et al. *J. Mater. Chem.* **2012**, 22, 2878
[2] Sanchez S. et al, *J. Am. Chem. Soc.*, **2011**, *133*, 701.
[3] Solovev A. A. et al, *Adv. Funct. Mater*. **2010,** *20,* 2430.
[4] S. Sanchez et al, *Chem. Commun*., **2011**, *47*, 698.
[5] S. Sanchez et al, *J. Am. Chem. Soc.* **2011**, *133*, 4860.
[6] Solovev A.A. et al, *Angew. Chem. Int. Ed*., **2011**, *50*, 10875.
[7] Sanchez, S. et al, *Chem. Rec.* **2011**, *11*, 367.
[8] Solovev A. A. et al., *ACS Nano* **2012**, *6*, 1751.
[9] Xi, W., et al., *Nanoscale,* **2012,** DOI10.1039/C2NR32798H
[10] Mei, Y. F. et al., *Chem. Soc. Rev.* **2011**, *40*, 2109.
[11] Sanchez, S. et al., *J. Am. Chem. Soc.,* **2010,** *132,* 13144-13145.
[12] Magdanz, V., et al. submitted.

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SEMINAR

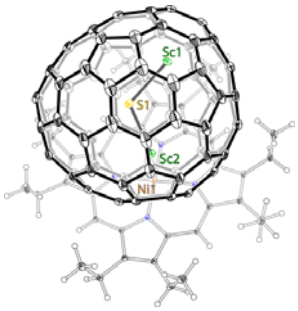
Thursday, 28th February, 12.00 pm, Seminar Room

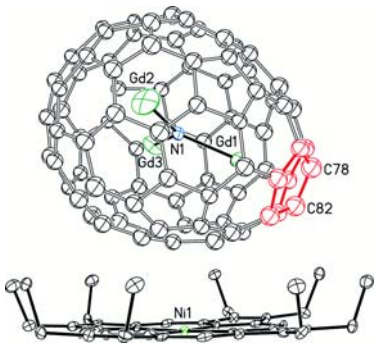
Host: Prof. Luis Liz-Marzán

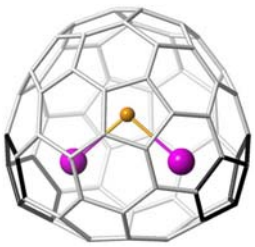
Buckyball maracas: The inside (and outside) story of endohedral fullerenes

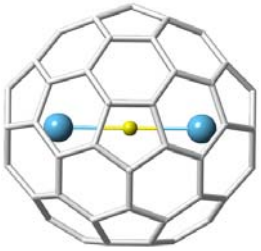
Luis Echegoyen
Department of Chemistry, Univ. of Texas at El Paso, 500 W Univ. Ave., El Paso, TX 79968

A while back we reported a series of trimetallic nitride endohedral fullerenes containing Gd_3N, Pr_3N, Nd_3N, Ce_3N and La_3N inside carbon cages that ranged between C_{78} and C_{96}. The relative abundances of these cages as well as the electrochemical properties are a pronounced function of the size of the encapsulated metal cluster. $M_3N@C_{88}$ compounds predominate for Nd, Pr and Ce and these exhibit surprisingly reversible electrochemical properties and extremely low bandgaps, yet contradictorily low reactivities. In the case of $M_3N@C_{78}$, $M_3N@C_{82}$ and $M_3N@C_{84}$, the observed cages violate the IPR rule and these are independent of the nature of the metal inside. More recently we have discovered a new and very large family of endohedral compounds containing dimetallic sulfide as the encapsulated cluster, $M_2S@C_{2n}$, with cages ranging from C_{70} to C_{100}. The X-Ray single crystal of $Sc_2S@C_{82}$ (C_S) is the first determined for an endohedral compound to possess complete order of the cage as well as of the cluster inside, providing exquisite detail of the interplay between the geometry of the cage and that of the cluster inside, including the Sc-S-Sc angle. The $Sc_2S@C_{82}$ (C_{3V}) crystal structure exhibited an ordered cage but some cluster disorder, and the Sc-S-Sc angle was observed to be very different from that of the C_S isomer. Very recent X-Ray crystallographic results for another member of the scandium sulfide family, $Sc_2S@C_{72}$, indicates the presence of a never reported C_{72} cage with two IPR violations and, as usual, the two pentalene units are adjacent to the two Sc ions. The cage selected is isomer 10,528 out of 11,190 (C_{72} has only one IPR isomer). Very recently we found that $Sc_2S@C_{70}$ possesses a carbon cage that has never been reported before, cage #7,892, with two IPR violations. Within this family we have also identified two new isomers of $Sc_2S@C_{80}$, and from their UV-Vis spectra we know that these are cages that have never been reported before.









A new endohedral compound was recently isolated and characterized, $Ti_2S@C_{78}$, as well as a totally new family of endohedrals, $Sc_2UC@C_{2n}$, where n=33, 35 and 40. This is a totally new metallic carbide family, where the entrapped cluster contains two formally 3+ ions (Sc), one formally 4+ ion (U) and a 4- carbon, forming an unusual carbide cluster

Some derivatives of these endohedral compounds have been prepared using a variety of synthetic techniques, and their properties have been examined, such as charge mobility and their photoresponses. Their properties as acceptors in Organic Solar Cells (OSCs) are being evaluated, since their LUMO levels can be controlled by the nature of the clusters entrapped and the size and isomeric composition of the carbon cages.

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SEMINAR

Thursday, 7th March, 12.00 pm, Seminar Room

Host: Dr. Ilya Reviakine

The physics of blood clotting

Sarah Köster, Institute for X-Ray Physics, University of Göttingen, Göttingen, Germany

Blood platelets are vital for blood clotting and early steps of wound healing. In their resting state, platelets are tiny, disc shaped, anucleate cells. At the site of injury they activate and very quickly change their shape developing dynamic pseudopods and large, flat lamellipodia. These shape changes are accompanied by an increase of surface area and a restructuring of the internal cytoskeleton. Activated, spread platelets together with other blood cells and plasma proteins (e.g. fibrin) form an aggregated blood clot, which then contracts. This contraction is thought to serve the purpose of bringing the wound edges closer together thus facilitating wound closure.

The physiological environment, in which blood clotting occurs, is particular from a physical point of view for several reasons: the blood vessel surface and surrounding tissue is comparably soft (on the order of a few kPa) and it displays distinct micro- and nanostructures defined by the wounded vessel. In addition, blood flow leads to shear forces, which act on the cells. In order to investigate the influence of substrate properties we perform (i) traction force microscopy of individual platelets [1] and (ii) platelet studies on structured substrates. In both cases, we study the cell membrane shape and the internal cytoskeletal (actin-filaments and vinculin as a focal adhesion protein) structure.

Traction force microscopy experiments show that platelet contraction reaches a steady state of total forces per platelet of ~35 nN about half an hour after initiating the activation. These forces are considerably larger than what was previously reported for platelets in aggregates, demonstrating the importance of a single cell approach for studies of platelet contraction. Compared to other contractile cells, we find that platelets are particular, because force fields are nearly isotropic with forces pointing toward the center of the cell area.

When platelets spread on chemical and/or topographic microstructures, we observe that it is rather the topography of the substrates than the degree of coating which influences the contour of the cells. This may be attributed to the additional energy needed for membrane curvature when the cells follow the topography and reach into holes on the substrate.

Furthering our understanding of blood platelets is important from a biomedical standpoint. At the same time, however, platelets provide an excellent model system for contractile cells since they are comparably simple and the activation can be triggered in a straightforward way by adding thrombin. We believe that our findings can also be generalized to other cellular systems.

[1] S. Schwarz Henriques, R. Sandmann, A. Strate and S. Köster, *Journal of Cell Science* (*2012)*.

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SEMINAR

Friday, 15th March, 12.00 pm, Seminar Room

Host: Prof. Soledad Penadés

Listeria based vaccines against infectious diseases and cancer

Carmen Alvarez Domínguez. Fundación Marqués de Valdecilla-IFIMAV

Listeria monocytogenes is a human bacterial pathogen harmful for immune-compromised patients, pregnant women and infants. Listeria triggers powerful specific and unspecific immune responses and therefore, it has been used as preventive vaccine vector against infectious diseases as well as therapeutic vaccine vector against tumors. Our group has analyzed different Listeria based vaccine designs to prevent infections of two related bacteria, Listeria and Mycobacterium. We mapped the highest protection abilities against listeriosis within the T cell specific epitopes of Listeria virulence factors with structural similarites, listeriolysin O (LLO) and glyceraldehyde-3-phosphate-dehydrogenase (GAPDH). We also used four different vaccine vectors, biomembranes (i.e., endosomes and phagosomes), macrophages, dendritic cells and nanoparticles, that incorporated these T cell Listeria epitopes. Our results with the different vaccine vectors indicated different ranges of protection as well as toxicity. Dendritic cells showed no toxicity and the highest protection range for all LLO and GAPDH epitopes tested and therefore, we focused our efforts to implement these dendritic vaccine constructs.

We observed that protective vaccines against listeriosis showed features useful for tumor therapy such as specific T cytotoxic cells in immune organs, released Th1 cytokines and recruited dendritic innate immune cells to the vaccination sites. Therefore, we evaluated the anti-tumor therapeutic ability of Listeria based vaccines using dendritic cells.

Melanoma is a melanocytic tumor with high aggressiveness and incidence nowadays among young women. Using a murine inducible melanoma model we observed that only one LLO and one GAPDH epitope incorporated into dendritic cells, and to a lesser extend into glyco-nanoparticles, showed high therapeutic activity and avoided the tumor implant.

In brief, dendritic cells and nanoparticles appear as novel Listeria based vectors to discover the features of successful therapeutic anti-tumor vaccines.

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SEMINAR

Thursday, 21st March, 12.00 pm, Seminar Room

Host: Prof. Luis Liz-Marzán – Dr. Jordi Llop

Catalytic asymmetric fluorocyclization reactions. Radiolabeling of compounds for the detection of Carbonic Anhydrase IX and XII in cancer diagnosis.

Oscar Lozano
Chemistry Research Laboratory, University of Oxford.

The way of introducing fluorine in organic molecules has drawn people's attention since the most electronegative atom was discovered. The uses of electrophilic and nucleophilic reagents are the two main strategies for introducing such a particular atom. In our research group, electrophilic fluorocyclization reactions have attracted much attention, especially the validation of asymmetric variants for the construction of fluorinated natural product analogues. Building on preliminary results, we became interested in developing novel fluorocyclizations to access enantioenriched fluorinated tricyclic heterocycles derived from prochiral functionalized indoles. A detailed account of novel diastereo- and enantioselective fluorocyclizations of indole precursors will be presented inclusive of a catalytic asymmetric variant.

Carbonic Anhydrases IX and XII, are overexpressed in many tumours and are believed to be involved in processes connected with cancer progression and responses to therapy. Carbonic anhydrase IX is confined to a few normal tissues but it is ectopically induced and highly overexpressed in many solid tumour types through transcriptional activation by hypoxia. Novel coumarin and sulfonamide containing compounds will be presented as potential candidates to image hypoxia. Their labelling with either ^{18}F or ^{99m}Tc will also be disclosed for future applications in PET or SPECT diagnostics together with some other properties.

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SEMINAR

Thursday, 11th April, 12.00 pm, Seminar Room

Host: Prof. Luis Liz-Marzán

NanoMedicine: the way for the near future

Prof. Dr. rer. nat. habil. Gyeong-Man Kim
Biomedical Engineering Center and CEIT
University of Navarra

With an increase in life expectancy, the future shows a growing demand for fulfilling and high quality-of-life even in old age. It is to be expected that there will be a strong and sustained increase in the need for modern therapies and highly functional biomaterials.

In the field of materials science, always starting from basic research, new innovative materials or material combinations are being developed for specific applications. Clinically applicable and thus marketable biomaterials must possess a wide range of capabilities, which include biofunctionalities, e.g., tissue and blood compatibility and biodegradation capability. With the help of nanotechnology, we can specifically produce those completely new biomaterials with "custom-tailored" properties, which allow us to realize the ambitious visions formulated within the framework of “Regenerative Medicine (RegMed)”.

RegMed is an interdisciplinary subject area, in which the issues and solutions for clinical medicine are closely interconnected with those of natural and engineering sciences. The subject goes beyond the common focus on organ and tissue substitutes with help of Tissue Engineering and also includes new and additional developments in classical transplantation medicine and cell therapy. Also included are bio-hybrid systems with functional connections between biological and artificial components. RegMed is highly innovative and continually advancing and thus belongs to a particularly promising field of modern biomedical and biological research and development.

It is safe to say, that the start of a new technological era is inseparably associated with nanotechnology. The NanoMedicine is still in its infancy, however, in the near future its promises should be fulfilled to efficiently improve the quality of human life and even to extend it, if we are working closely together.

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SEMINAR

Friday, 19th April, 12.00 pm, Seminar Room

Host: Dr. Abraham Martín

Hybrid Optical Approaches for Preclinical In-vivo Imaging: new methods and validation techniques

Jorge Ripoll
Dept. of Bioengineering and Aerospace Engineering
Universidad Carlos III of Madrid, Madrid, Spain.

The use of optics in preclinical studies is becoming widespread, mainly fueled by the development of novel optical probes and tomographic imaging approaches. However, one intrinsic drawback of optical imaging in small animals is the lack of anatomical information. In this talk an overview of the approaches currently used to complement this lack of anatomical reference will be presented, with emphasis on its use on brain imaging. Finally, the development of new in-toto imaging techniques has also paved the way for new validation approaches which complement the in-vivo information offering information at the cellular level.

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SEMINAR

Monday, 22nd April, 12.00 pm, Seminar Room

Host: Prof. Luis Liz-Marzán

Publishing in Materials Science (and how to maximize your success!)

Dr. Mary Farrell
Managing Editor (Particle), Deputy Editor (Small)

Publishing strategies in materials science will be discussed from the editors' perspective. Journal portraits will be presented for the Wiley-VCH Materials Science publications Advanced Materials, Advanced Functional Materials, Small, and the newer titles Advanced Energy Materials, Advanced Healthcare Materials, and Particle. Publishing in an online age will be discussed, including the role of scientific journals, the editorial process (with a focus on the peer-review process), and a discussion of discoverability. Hints for your publishing strategy will then be presented, including how to choose the right journal and maximize your success. Discussion and questions are encouraged.

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SEMINAR

Friday, 26th April, 12.00 pm, Seminar Room

Host: Dr. Ralf P. Richter

Nanoscale model systems of the permeability barrier of nuclear pore complexes

Nico Eisele
Biosurfaces Unit. CIC biomaGUNE

In eukaryotic cells, macromolecular transport between cytosol and nucleosol is gated by nuclear pore complexes (NPCs) which are embedded in the envelope of the nucleus. The transport channel of an NPC is filled with natively unfolded proteins, so-called FG-repeat domains, which form a permeability barrier. This barrier suppresses the transport of large macromolecules unless they are bound to nuclear transport receptors (NTRs). The mechanism behind selectivity, however, is currently not well understood. To shed light onto this matter, we developed nanoscale model systems of the permeability barrier.

We created planar films of FG-repeat domains as one of our model systems and studied the films with a toolbox of surface-sensitive characterization techniques. The native mode of FG-repeat domain attachment as well as the native FG-repeat domain density could be mimicked with our model system. Furthermore, the films' thickness corresponded to the nanoscopic dimensions of the NPC transport channel. We exploited this system to study the interaction of FG-repeat domains with NTRs and, moreover, characterized the morphology of the films. Furthermore, we derived a connection between morphology and size selectivity of the supramolecular assembly of FG-repeat domains by exploiting basic concepts of polymer theory. These achievements significantly improved the understanding of the mechanism behind size selectivity and the functional role of FG-repeat domains in the permeability barrier.

A long term goal for a better understanding of the selectivity mechanism is the creation of a more elaborated model system that also reproduces the pore-like topology of the NPC's transport channel. We made important key steps towards this goal by developing a setup which allows measuring protein net-flux across a porous substrate. The setup was successfully used to measure protein transport across pores which have not yet been filled with FG-repeat domains. In order to equip the pores with a permeability barrier in the future, we established a surface functionalization strategy that allows end-grafting of FG-repeat domains to the porous substrate. Combining these achievements to reconstitute the permeability barrier in solid state nanopores will be an exciting task for the future.

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SEMINAR

Monday, 29th April, 12.00 pm, Seminar Room

Host: Dr. Valery Pavlov

Natural cancer resistance: From a mouse to a novel human cancer therapy

Prof. Zheng Cui
Department of Pathology , Wake Forest University School of Medicine

It has long been recognized that the healthy humans are protected against cancers by an immunosurveillance system that can eradicate cancer cells after they are established. Although many prior efforts in cancer immunotherapies have been focused on the T and B lymphocytes to target specific surface molecules on cancer cells, the clinical results have been largely unsatisfactory. Our preliminary studies in cancer-resistant mice and humans revealed that a previously unnoticed yet extremely potent cancer-killing activity (CKA) was found at high level predominantly in the granulocyte fraction of the circulating white cells in the cancer-resistant mice and in some healthy humans. Human CKA is a highly dynamic activity sensitive to the influences of aging, genetic background, emotional stress and winter season. We have developed a new CKA assay to monitor CKA levels in human populations. Granulocytes are the most abundant type of circulating white cells that have been previously known only for their antimicrobial activities. Our studies showed that granulocytes in some healthy humans can also directly eradicate established cancer cells with an extremely high efficiency. It appears that granulocytes recognize both bacteria and cancer cells via a similar mechanism. Granulocytes don't recognize any specific molecule on the surfaces of target cells, but rather recognize the cell surfaces with unique electric charges that are different significantly from normal cells and tissues due to very different metabolic patterns of glycolysis. Based on these surprising findings and the fact that granulocyte transplant has been an established clinical practice for over 35 years with excellent safety records, we proposed a new therapeutic concept for human cancer termed Leukocyte Infusion Therapy or LIFT. Preclinical testing of LIFT concept in the mouse models reveals extremely promising results of curing both transplanted and endogenous malignancies that couldn't be cured by other exiting therapies. The major new component of LIFT involves the selection of granulocyte donors from healthy young volunteers based primarily on CKA measured by a newly developed CKA assay against human cancer cell lines and other matching criteria. Additionally, LIFT involves much higher doses of granulocytes since the preclinical studies suggest that the effector-to-target ratio plays a critical role. LIFT is a novel concept and has not been tried in humans for cancer treatment. LIFT is based on a mature technical platform of clinical practices of donor granulocyte transplant. It can be immediately used in cancer treatment setting if clinical trials show some discernable clinical benefits to cancer patients. Early results of clinical trials indicated that LIFT may be an exceptionally effective therapy with minimal adverse side effect for treating human cancers.

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SEMINAR

Tuesday, 30th April, 12.00 pm, Seminar Room

Host: Dr. Ilya Reviakine

Imaging Lipid Domains in the Cellular Plasma Membrane and Label-Free Cell Identification by Secondary Ion Mass Spectrometry

Dr. Mary Kraft, Assistant Professor
Department of Chemical & Biomolecular Engineering
University of Illinois

This talk will focus on the use of secondary ion mass spectrometry (SIMS) for two applications: elucidation of how lipids are organized in the plasma membrane, and identification of the differentiation stages of individual cells. For the first application, we metabolically incorporate distinct stable isotopes into the lipid species of interest, and then use high-resolution SIMS, which is performed with a Cameca NanoSIMS, to map the lipid-specific isotope enrichment on the cell surface with ~90 nm lateral resolution. With this approach, we have imaged the distributions of metabolically incorporated ^{15}N-sphingolipids and ^{18}O-cholesterol on the surfaces of fibroblast cells, and assessed whether domains enriched with cholesterol and sphingolipids were present in their plasma membranes. By visualizing the ^{15}N-sphingolipids and ^{18}Ocholesterol distributions after various drug treatments, we have also tested the hypotheses that cohesive cholesterol-sphingolipid interactions and the cytoskeleton are responsible for lipid organization in the plasma membrane. For the second application, we use time-of-flight SIMS (TOF-SIMS) and multivariate analysis to detect the molecular level changes in cell membrane composition that occur during stem cell differentiation. TOF-SIMS is used to collect spectra that encoded for the surface chemistries of individual hematopoietic cells (HCs) from three distinct phenotypes along the lymphocyte differentiation pathway. Then a multivariate analysis technique, partial least-squares-discriminant analysis (PLS-DA) is used to construct a model that enables identifying the differentiation stages of individual hematopoietic cells from mouse bone marrow according to their mass spectra. This ability to quantitatively identify the differentiation stage of individual HCs with location specificity with facilitate tissue engineering efforts to identify the cues that induce stem cell fate decisions.

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SEMINAR

Monday, 6th May, 12.00 pm, Seminar Room

Host: Dr. Niels C. Reichardt

Bacterial lectins: multivalent proteins interacting with glycosylated surfaces and nanomaterials

Anne Imberty
Centre de Recherches sur les Macromolecules Végétales (CERMAV) – Grenoble – France

A large number of pathogenic microorganisms display receptors for specific recognition and adhesion to the glycoconjugates present on human tissues. Such soluble lectins are involved in infections caused by the bacteria *Pseudomonas aeruginosa* and *Burkholderia cepacia* and by the fungus *Aspergillus fumigatus* that are responsible for hospital-acquired diseases. Accumulated knowledge about the structures of the lectins and the interaction with host glycoconjugates yielded to the design of powerful glyco-derived inhibitors that can serve for antimicrobial therapy as complement or alternative to antibiotics therapy.

These soluble lectins present several binding sites with different architectures that make them perfect tools for studying the effect of multivalency on binding to surfaces or particles. Interaction with glycosylated chips, liposomes, fullerenes and gold nanoparticles provided information about the effect of multivalency on avidity. Such nanomaterials can be used for diagnostic application. Detection of lectins was performed using devices based on glyco-functionalized carbon nanotubes or graphene incorporated in a field effect transistor.

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SEMINAR

Thursday, 9th May, 12.00 pm, Seminar Room

Host: Dr. Ilya Reviakine

Mechanical resonators based on nanotubes and graphene

Adrian Bachtold
ICFO – The Institute of Photonic Sciences, Castelldefels (Barcelona), Spain

Carbon nanotubes and graphene offer unique scientific and technological opportunities as nanoelectromechanical systems (NEMS). Namely, they have allowed the fabrication of mechanical resonators that can be operable at ultra-high frequencies and that can be employed as ultra-sensitive sensors of mass and charge. In addition, nanotubes and graphene have exceptional electron transport properties, including ballistic conduction over long distances. Coupling the mechanical motion to electron transport in these remarkable materials is thus highly appealing. Here, I will review some of our recent results on nanotube and graphene NEMSs, including mass sensing at the proton mass level, and force sensing with a sensitivity of ~10 $zN/Hz^{1/2}$.

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SEMINAR

Thursday, 16th May, 12.00 pm, Seminar Room

Host: Prof. Luis Liz Marzán

Asymmetric catalysis with supported systems: Towards the development of continuous flow processes

Miquel A. Pericàs
Institute of Chemical Research of Catalonia, Tarragona, Spain mapericas@iciq.es, www.iciq.es

The design and preparation of immobilized catalysts that keep intact the characteristics (activity and selectivity) of their homogeneous counterparts represents a major goal in view of more efficient chemical production. When enantioselective processes are considered, the opportunities offered by this approach (recovery and reuse of expensive catalytic species, highly simplified work-up, implementation of continuous flow processing) become even more evident.

In this lecture we will present different strategies followed in our laboratory for the modification of homogeneous ligands and catalysts, in order to make possible its supporting, with special emphasis on the use of the copper-catalyzed alkyne-azide cycloaddition (CuAAC) as a supporting strategy.[1] Examples of the development of highly active catalytic species for enantioselective processes immobilized on either insoluble polymers or magnetic nanoparticles[2] will be presented, and the conversion of batch into continuous flow processes[3] based on these immobilized species will be discussed.

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SEMINAR

Wednesday, 22nd May, 12.00 pm, Seminar Room

Host: Prof. Soledad Penadés

Nanoparticles for in vivo multi-modality molecular imaging of cancer

Prof. Jianghong Rao.
Associate Professor of Radiology and Chemistry (courtesy), member of the Molecular Imaging, Bio-X, Cancer Biology, and Biophysics Programs at Stanford University School of Medicine, California, USA

Advances in nanotechnologies and nanomaterials offer numerous opportunities to develop molecular probes for cancer imaging. In the first part of the talk, I will present our recent effort in developing conjugated polymer nanoparticles for cancer imaging. Conjugated polymer nanoparticles have attractive features such as generally low or no toxicity, bright fluorescence intensity, and excellent photostability and emerged as a new class of fluorescent probes. Similar to quantum dots, conjugated polymer nanoparticles can participate in fluorescence resonance energy transfer (FRET) and bioluminescence resonance energy transfer (BRET) as either a donor or an acceptor. I will discuss the use of conjugated polymer nanoparticles as the nanoplatform for developing cancer imaging probes. In the second part of the talk, I will introduce a different concept of developing nanoparticle probes—in celluo synthesis of nanoparticles for tumor imaging. Instead of synthesizing nanoparticles in vitro and applying them in vivo, this new approach will deliver small molecules to cells as building blocks and then synthesize nanoparticles from them inside cells. Our strategy is based on a biocompatible chemical condensation reaction between two chemical groups -- 1,2-aminothiol and 2-cyanobenzothiazole. Based on this strategy, we have successfully developed probes that can image drug-induced apoptosis in tumor cells in vivo with whole-body fluorescence, positron emission tomography (PET), and magnetic resonance imaging (MRI).

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SEMINAR

Friday, 24th May, 12.00 pm, Seminar Room

Host: Prof. Luis Liz Marzán

Molecular nanomechanics in human health

Raul Perez-Jimenez
Ikerbasque Foundation for Science, CIC nanoGUNE, Tolosa Hiribidea 76, Donostia-San Sebastian, Spain
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Mechanical forces play a crucial role in a myriad of biological processes including numerous diseases and disorders [1]. However, molecular nanobiomechanics are barely considered in modern medicine. Our research line focuses on atomic force microscopy (AFM) to investigate the effect of mechanical forces in proteins and enzymatic reactions that are relevant to human pathologies. In the past years, we have investigated how force affects the chemistry of thioredoxins, a class of enzymes that regulate the redox balance in cells. We showed that force regulates their chemistry, revealing several mechanisms for disulfide bond reduction that were hidden in standard bulk assays [2,3]. Importantly, these enzymes seem to be important during HIV-1 infection by reducing disulfide bonds in human CD4, the primary receptor of the virus. Using AFM techniques we have investigated the mechanics of CD4. We observed that force might trigger mechanical unfolding of CD4 and subsequent disulfide bond reduction in CD4 by Trx enzymes. Further experiments demonstrated, for the first time, that an antibody that blocks HIV-1 infection produces a mechanical effect on CD4 by preventing mechanical unfolding. We suggest that mechanical force might be important during HIV-1 infection which may change our understanding of the mechanism of infection. This observation might offer new avenues to explore novel treatments focused in the mechanics of proteins and enzymes, that is, *mechanopharmacology*.

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SEMINAR

Thursday, 30th May, 12.00 pm, Seminar Room

Host: Dr. Jordi Llop

11C-carbon monoxide chemistry and techniques

Jonas Eriksson
Department of Medicinal Chemistry, Clinical PET Platform, Uppsala University, Sweden

Many endogenous and druglike substances contain carbon (C) in positions within the molecule that are amenable for isotopic labeling with 11C without modifying the chemical structure. This together with suitable decay characteristics has made 11C an important radionuclide for study of interactions of endogenous compounds and other authentic molecules in vivo with PET (Position Emission Tomography). The presentation will focus on chemistry and technology that can be used to manufacture 11C-labelled PET tracers, with special focus on synthesis with [11C]carbon monoxide.

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SEMINAR

Wednesday, 5th June, 12.00 pm, Seminar Room

Host: Dr. Niels C. Reichardt

Glycomics technology development and applications in clinical research

Manfred Wuhrer
Department of Chemistry and Pharmaceutical Sciences, AIMMS Division of Biomolecular Analysis, VU University Amsterdam

The quality, activity, stability and targeting of many secretory and cell-surface proteins is determined by attached carbohydrates (glycans). Protein-linked glycans form a very heterogeneous group of post-translational modifications. Protein glycosylation is involved in many key processes of life such as fertilization, cellular differentiation, immunity and cancer. Hence, protein glycosylation is profoundly regulated but also reflects the physiological and pathological situation of an individual.

Mass spectrometry is a very powerful method for the study of protein glycosylation. We develop high-throughput glycoanalytical workflows for the characterization of protein glycosylation. Sample preparation is performed in 96-well plate format which in conjunction with fast mass spectrometric methods and largely automated data analysis procedures allows the glycosylation analysis of specific proteins such as immunoglobulin G, immunoglobulin A and alpha-1-antitrypsin for large cohorts of thousands of serum or plasma samples. Examples will be given applying these approaches to the study of glycomics changes in cancer and autoimmune diseases such as rheumatoid arthritis and granulomatosis with polyangiitis (Wegener's disease).

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SEMINAR

Thursday, 6th June, 12.00 pm, Seminar Room

Host: Dr. Ilya Reviakine

Investigating lipid and protein organization in cell membrane models

Ling Zhu
Surface Interface Biophysics Laboratory, Biosurfaces Unit, CIC biomaGUNE, Spain
Department of Biochemistry and Molecular Biology, University of the Basque Country, Spain

Cell membrane is based on a lipid bilayer with proteins inserted or bound to it. Both lipids and membrane proteins are organized non-randomly. This organization is necessary for cellular functions such as signal transduction. The first part of this work focuses on the lipid component of cell membrane. Lipids in cell membranes are distributed asymmetrically. 'Reactive' lipids like phosphatidyl serine (PS) are enriched in the cytoplasmic leaflet, while the 'non-reactive' lipids like phosphatidyl choline (PC) are enriched in the extracellular leaflet. In the plane of the membrane, nanoscaled lipid rafts are thought to exist. Model systems that mimic both the transverse and the lateral lipid organization are scarce. Using supported lipid bilayers (SLBs) on titania (TiO_2), a model was developed to mimic the physiological lipid composition and the asymmetric transverse organization characteristic of cell membrane. Lipid diffusion and organization in these SLBs were studied. During the development of this model, the process of SLB formation was investigated using a wide variety of lipid compositions and buffer conditions. Specific focus was on the effects of the osmotic pressure and the electrostatic interactions on the adsorbed liposome behavior, and on the kinetics of the late stages of SLB formation, where the removal of excess lipid from the surface was observed.

The second part of this work is to study membrane protein organization. Many membrane proteins function as oligomers. However, oligomerization of some membrane proteins such as Na^+, K^+-ATPase is still under debate due to the lack of direct evidence. In this study, the supramolecular organization of Na^+, K^+-ATPase in the near-native membrane patches of the outer medulla of rabbit kidney was investigated by AFM. This protein was found to be present as oligomers of various orders, with tetramers $(\alpha\beta)_4$ being the most commonly occurring motif.

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SEMINAR

Thursday, 13th June, 3.00 pm, Seminar Room

Host: Dr. Ilya Reviakine

Mechanistic principles of ion transport in P(II)-type ATPases

Hans-Jürgen Apell
Membrane Biophysics Group, Department of Biology, University of Konstanz
Konstanz, Germany.

An important prerequisite for the existence of living cells is the maintenance of conditions far away from the thermodynamical equilibrium. One component that supports this condition is the existence of electrochemical potential gradients across the membranes of cells, and they are generated in many cells by a class of primary active ion transporters, the so-called P-type ATPases. In contrast to the light-driven proton pump bacteriorhodopsin or the FoF1 ATPases, the molecular mechanism of ion transport in P-type ATPases is still hardly understood. Especially, the comprehension is still lacking of how the free-energy providing ATP hydrolysis is coupled to the vectorial transport of ions through the membrane. The reaction sequence is described by the generally accepted Post-Albers cycle which includes the required three types of partial reactions, which are ion binding/release, enzyme phosphorylation/dephosphorylation and conformation transitions. In recent years sufficient experimental evidence has been collected to compile at least the basic principles of the ion-translocation process. It has been shown that ion-binding sites in the center of the membrane domain of proteins are alternatingly accessible from both sides of the membrane in the respective basic conformations, E1 and P-E2. The exchange of the oppositely translocated ions in the binding sites occurs in a so-called electrogenic fashion through narrow access channels that connect either aqueous phases of the membrane with the ion-binding sites. Ion binding or release is a sequential process in which the accessibility to the ion sites is controlled by a series of minor conformational rearrangements. This finding may serve as starting point for hypotheses to model and identify eventually energy coupling on the one hand and explain tissue specific regulatory mechanisms on the other hand.

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SEMINAR

Thursday, 20th June, 12.00 pm, Seminar Room

Host: Prof. Luis Liz-Marzán

Novel Materials for Electrochemical Biosensing

José M. Pingarrón
Department of Analytical Chemistry, Faculty of Chemistry, Complutense University of Madrid, 28040-Madrid, Spain
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This seminar wants to offer an overview on recent developments for designing and preparing novel electrochemical platforms for biosensing in the group of Electroanalysis and Electrochemical (bio)sensors of the UCM. The seminar will be divided into two main parts.
On the one hand, several strategies implying the design and preparation of electrochemical biosensors (immunosensors and genosensors) for diverse clinical applications will be shown. In particular, approaches for the simultaneous ultrasensitive quantification of hormones, cardiac biomarkers and pathogen microorganisms making use of disposable electrodes will be presented as a previous step for the fabrication of devices able to be used out of the hospitals, allowing in this way a personalized and decentralized attention (point-of care devices) [1-3].
On the other hand, during the last years we have been integrating different hybrid nanomaterials, based on carbon nanotubes, gold nanoparticles, magnetic nanoparticles, graphene nanoparticles and Janus nanoparticles into sensing platforms, most of them electrochemical, to construct nanostructured biosensors. In this seminar some recent examples of these strategies will be commented [4-11].

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SEMINAR

Friday, 21st June, 12.00 pm, Seminar Room

Host: Dr. Ralf P. Richter

Mechanisms behind the assembly and stabilization of hyaluronan-rich extracellular matrices

Natalia S. Baranova
Biosurfaces Unit, CIC biomaGUNE

Many eukaryotic cells surround themselves with a hydrogel-like, polysaccharide-rich matrix. A crucial component of such coats is hyaluronan (HA), a regular, linear polysaccharide of the glycosaminoglycan family of typically several micrometers in contour length. The coats do also contain a number of HA–binding proteins that engage in the self-assembly of HA into relatively thick, soft and highly hydrated coats. An example of such pericellular coats is the cumulus cell-oocyte complex (COC) matrix, an extended viscoelastic coat that grows around oocytes just before ovulation and that is required for fertilization. The secreted product of tumor necrosis factor-stimulated gene-6 (TSG-6), inter-α-inhibitor (IαI) and pentraxin 3 (PTX3) proteins were shown to be crucial for COC matrix stabilization, but how they form a functional and stable HA matrix remains poorly understood.

The aim of this thesis was to gain mechanistic insight into the supramolecular self-assembly processes that lead to the formation of HA-rich matrices, to understand how such matrices are stabilized, and to relate the physico-chemical properties of the matrices to their biological functions. To this end, we used a simplified yet well-defined model system of pericellular coats: films of end-grafted HA.

HA matrices of increasing complexity were reconstituted by external addition of proteins to the HA films which are known to be involved in matrix assembly and stabilization. We found that the inflammation-associated protein TSG-6, when presented alone to the HA film, forms oligomers upon binding to HA. The TSG-6 oligomers cross-link HA and induce a pronounced collapse of the HA matrix. In contrast, when TSG-6 is presented together with IαI, its cross-linking properties are impaired. Instead, TSG-6 acts as an enzyme for the covalent transfer of heavy chain subunits from IαI to HA. The ternary interaction of HA, TSG-6 and IαI results in a matrix containing several different and very stably incorporated proteins and protein complexes. We also found that, in order to incorporate PTX3 into HA matrices, the encounter between IαI, TSG-6 and PTX3 prior to their interaction with HA is required. In the presence of all three proteins, the HA film becomes cross-linked but not collapsed.

Based on these results we propose that the spatio-temporal regulation of HA/protein interactions *in vivo* is responsible for the balance between effective expansion of the COC matrix during ovulation on one hand and matrix stabilization through cross-linking on the other. Our results highlight that a hierarchy of interactions between the molecular players determines the proteins' functions and the properties of the supramolecular assembly. The discovered mechanisms of HA matrix stabilization illustrate the significance of matrix remodeling under inflammatory conditions.

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SEMINAR

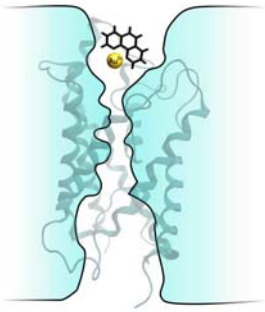
Tuesday, 25th June, 12.00 pm, Seminar Room

Host: Dr. Luca Salassa

Targeting aquaporin function by gold-based compounds: possible therapeutic applications

Angela Casini
Pharmacokinetics, Toxicology and Targeting, Research Institute of Pharmacy, University of Groningen, Antonius Deusinglaan 1, 9713 AV Groningen, The Netherlands.
Email: a.casini@rug.nl

Aquaporins (AQPs) belong to a highly conserved group of membrane proteins present in all type of organisms and involved in the transport of water and small solutes such as glycerol. The 13 human AQP isoforms (AQP0–12) are differentially expressed in many types of cells and tissues in the body and can be divided into two major groups: those strictly selective for water (orthodox aquaporins), and those that are also permeable to other small solutes including glycerol (aquaglyceroporins). Both groups of AQP channels are involved in many pathophysiological conditions. Thus, aquaporin (AQP)-based modulator drugs are predicted to be of broad potential utility in the treatment of several diseases such as kidney diseases, cancer, obesity, glaucoma and brain oedema. However, there are at present very few reported AQP inhibitors that are suitable candidates for clinical trials.
Within this frame, we recently described the AQP inhibitory effects of gold(III) coordination compounds, evaluated on different human and mammalian cell lines. Notably, potent and selective inhibition of human AQP3 and AQP7 (aquaglyceroporin 3 and 7) was observed in various cells.[1] The mechanism of inhibition was explored through molecular modelling and docking approaches. These results were supported by site-directed mutagenesis studies. The peculiar AQP inhibition properties exerted by gold complexes may open the way to the development of new metal-based drugs as innovative scaffolds for targeted therapies or as molecular biological tools to detect AQP activities in cells.



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SEMINAR

Thursday, 27th June, 12.00 pm, Seminar Room

Host: Dr. Ralf P. Richter

Mechanistic analysis of passive transport and active migration through the mucus barrier

Katharina Ribbeck
Massachusetts Institute of Technology (Boston, USA)

The goal of our research is to elucidate the mechanisms that govern selective filtering by mucus, an important biological gel, which coats all wet epithelia in our body. Mucus has critical, but poorly understood, biological functions in protecting tissues from attack by pathogens, and facilitating transport of particulate material. I will present our strategies to determine the characteristics that distinguish molecules that permeate, versus molecules that are rejected by, a defined mucus barrier. Specifically, I will discuss a suite of methods and conceptual tools to characterize passive transport and active migration of diverse particles and cells, and to elucidate the relationship between a particle's biochemical properties, and its mobility across mucus. Our hope is to provide the foundation for a theoretical framework that captures general principles governing selectivity in mucus, and likely also in other biological hydrogels such as the extracellular matrix, nuclear pores, and bacterial biofilms.

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SEMINAR

Tuesday, 16th July, 12.00 pm, Seminar Room

Host: Prof. Luis Liz-Marzán

Electron Current Effects in Single-Molecule Tunneling Junctions

Jose Ignacio Pascual
CIC nanoGune, Tolosa Hiribidea 78, San Sebastian – Donostia 20018, Spain
Ikerbasque, Basque foundation for Science, Bilbao 48011, Spain.

The paradigm of molecular electronics is to use individual molecules as electronic devices. The way to achieve this necessarily passes through contacting and powering a molecule using macroscopic leads. Beyond future practical applications of individual molecules in electronics, what can be largely debated, molecular tunneling junctions are an ideal workbench for exploring fundamental processes occurring when electrons are injected through a single molecule.

We use a scanning tunneling microscope (STM) at cryogenic conditions as a tool to visualize, contact and investigate the effects of currents and forces on individual molecules. In this talk, I will present recent results on inelastic phenomenology induced by electrons tunneling through an individual molecule, like spin excitations, molecular conformational transformations, or vibrational heating. The main goal is to determine how hot an individual molecule can be when electrons pass through it. An interesting approach is the combination of electron transport measurements with two additional experimental techniques: Force spectroscopy and Light spectroscopy.

- Spin excitations have been observed in paramagnetic molecules on a superconducting substrate. An interesting outcome is that the lifetime of excited states amounts to a few nanoseconds, much larger than on normal metal surfaces. This is interpreted as due to the depletion of electronic states within the superconducting energy gap at the Fermi level, which prohibits pathways of energy relaxation into the substrate.

- Molecular conformational changes are followed during the formation of molecular bridges between the tip of the STM and the surface. Here, we measure forces revealing the intramolecular flexibility and deformations occurring during the formation of the molecular junction. We resolve the strong effect that specific conformations cause in the transmission through the junction.

- Tunneling electrons through molecular junctions also induce light emission mediated by localized plasmon modes at the tunnel junction. The spectroscopic characterization of emitted photons reveals “anti-stokes”-like phenomena, which we interpret as induced by hot molecular modes, excited by inelastic tunneling electrons. This allows us to provide an insight into vibrational temperature induced by inelastic electrons.

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SEMINAR

Thursday, 19th September at 12.00 pm, Seminar Room on the 1st floor

Host: Dr. Valery Pavlov, Biofunctional Nanomaterials Unit

Development of new methods for signal amplification in bioanalytical assays

Natalia Malashikhina
CIC biomaGUNE

Bioanalytical assays are routinely used to detect and quantify analytes of interest in biological matrices. These assays often require highly sensitive detection methods for successful determination of analyte in the sample. Traditionally used bioanalytical tools include high performance liquid chromatography (HPLC), mass-spectrometry (MS), capillary electrophoresis (CE), enzyme linked immunosorbent assay (ELISA), Infrared/Raman spectroscopy, spectrophotometry, fluorimetry and other optical methods. However, some biomolecules are undetectable by these tools. An amplification of the signal in current assays is of great importance.

The aim of this thesis was to develop various approaches of signal amplification in conventional bioanalytical assays and application of these new methods for the sensitive quantification of biomolecules in real samples.

All previously developed strategies of signal enhancement in bioanalysis can be divided into molecular biological (bio-) and nano-approaches. Bio-signal amplification methods are based on employment of different biomolecules, such as enzymes and DNA, while nano-signal amplification methods include nanomaterials such as metal, magnetic and semiconductor nanoparticles (NPs), carbon nanotubes and graphene.

In our work we employed biochemical reactions and surface chemistry of metal and semiconductor nanoparticles to enhance sensitivity in traditionally used methods for bioanalytical signal detection: fluorimetry, Raman spectroscopy, electrochemical impedance spectroscopy and ELISA. We applied developed platforms for the sensitive detection of ascorbic acid (AA), copper (II) ions, MnSOD-2 protein and anti-BSA antibodies.

The reaction conditions of these assays were optimized to provide maximum of the signal enhancement and, consequently, to provide high sensitivity. Finally, the proposed methods were applied to detected mentioned above analytes in real samples.

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SEMINAR

Thursday, 26 September, 12.00 pm, Seminar Room on the 1st Floor

Host:Dr Valery Pavlov

Development of a new optical biosensor for disease diagnosis

Prof. Marc Lamy de la Chapelle

Université Paris 13, France

The development of reliable, sensitive and specific biosensors is a very active research field. Among all the technique, the Surface Enhance Raman Scaterring (SERS) is one of most sensitive way to detect protein [1]. It has been widely used for ultrasensitive chemical analysis down to single molecule detection. Its field of applications now includes chemical-biochemical analysis, nanostructure characterization and biomedical applications. In this work, we present the SERS detection of specific proteins and more especially specific disease biomarkers in serum, using a functionalizion layer.

To investigate the protein detection, the arrays of metallic nanoparticles were made by electron-beam lithography (EBL) to control the Localized Surface Plasmon Resonance (LSPR) position in order to obtain the best enhancement and optimise the SERS signal [2-3]. The nanoparticles were in gold with different shapes: cylinders and rods. The optimization of plasmonic nanostructures to improve their sensing properties such as their sensitivity and their easy manipulation is of first importance in order to develop highly sensitive sensor. The key point is then the optimization of the localized surface plasmon resonance (LSPR) properties especially for surface-enhanced Raman scattering (SERS). Several aspects can be considered in order to optimize the sensing performance: size and shape of the nanoparticles, nanoparticle coupling, molecular adhesion layer between gold nanostructures and glass…[4] By controlling all these aspects, we are able to produce a highly sensitive sensor. To be specific, the surface was functionalized with aptamer or anti-bodies to catch selectively the targeted protein. We have determined the sensor characteristics such as its detection limits and its selectivity. We have determined that such sensor could be highly sensitive by reaching some detection limits lowest than the pico-molar.

In conclusion, we report that we can detect the disease biomarkers using the LSPR and the SERS. Moreover, we demonstrate that the functionalization surface assure the specificity of the biosensor and allow to detect the target protein in the serum.

The authors want to acknowledge the Nanoantenna collaborative European project (HEALTH-F5-2009-241818) for financial support.

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SEMINAR

Wednesday, 2 October, 12.00 pm, Seminar Room on the 1st Floor

Host:Prof Soledad Penadés

Exploring gold glyconanoparticles as multivalent carriers for specific molecules involved in HIV-1 infection

Paolo Di Gianvincenzo

CIC biomaGUNE

The infection of the human immunodeficiency virus (HIV) is the cause of AIDS and is one of the greatest infectious diseases ever seen. HIV infects cells of the human immune system such as helper T cells (specifically $CD4^+$ T cells), macrophages, and dendritic cells. The HIV membrane is decorated with proteins spikes. The envelope glycoprotein (Env) spikes are formed by three transmembrane gp41 non-covalently bound to three gp120, a highly glycosilated protein. The Env spikes initiate infection of host cells and are targets for vaccine development. The molecular mechanism of the entry process, where CD4 receptor, CCR5/CXCR4 co-receptors and the viral envelop glycoprotein gp120 are involved, is still not well understood, however, it was demonstrated that HIV entry is characterized by binding of multiple copies of Env, CD4 and CCR5 or CXCR4. In this thesis we use gold nanoparticles, biofunctionalized with carbohydrates (glyconanoparticles, GNPs) to mutimerize selected molecules that may interfere with concrete steps of HIV infection. Three different families of GNPs were prepared. Sulphated gold glyconanoparticles (SO_4-GNPs), able to bind positive charged amino acids of gp120, were prepared and characterized. We demonstrate that depending on the sulphate ligand density, these nanoparticles can bind gp120 with high affinity as shown in SPR-based experiments and neutralize the *in vitro* HIV infection of T-lymphocytes in the nanomolar range. A miniprotein that mimics the CD4 receptor (miniCD4) and inhibits the HIV entry process was multimerized on GNPs (miniCD4-GNPs). The conformation of miniCD4 did not change once linked to the GNPs as showed by circular dichroism (CD) experiments. However, the multivalent presentation of miniCD4 on GNP did not increase the activity of miniCD4. Indeed, HIV-1 neutralization assays did not show improved IC50 values for the miniCD4-GNPs respect to the free miniCD4, probably because the distance between the miniCD4 on the GNPs do not perfectly match the distance between CD4 binding site on HIV Env. An important peptide of gp120, the V3 variable loop, was also multimerized on GNPs. We found that GNPs bearing only glucose and carboxylic ending linkers are able to modulate the conformation of V3 peptide (random coil) to obtain V3-GNP constructs with well defined conformations (α-helix or β-strand) as showed by CD. Studies by SPR showe that only the V3β-GNP are able to bind mAb the specific anti-V3 antibody 447-52D. HIV neutralization experiments show that V3-GNP were active only at high concentration (100 ug/ml). However, a preliminary immunization study with V3β-GNP on mice shows that mAb contained in mice sera are able to recognize V3β-GNP. A more extensive immunization study will be performed immunizing rabbits with different kind of V3-GNP.

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SEMINAR

Tuesday, 8 October, 12.00 pm, Seminar Room on the 1st Floor

Host: Dr. Valery Pavlov

Enhancing Fluorescence with DNA Origami Nanoantennas

Prof. Philip Tinnefeld

TU Braunschweig, Germany

Scaffolded DNA origami[1] is a simple and efficient technique to design two- and three-dimensional objects of programmed shape. We used DNA origami as a biophysical tool to enhance single-molecule assays. Thereby, the DNA origami serves as molecular breadboard to arrange objects such as dyes and nanoparticles[2,3]. We present examples of how DNA origami can enhance biophysical single-molecule experiments. Applications include the development of nanoscopic rulers for 2D and 3D superresolution microscopy[4], the switching of energy transfer pathways[2], and the enhancement of fluorescence signals[5].

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SEMINAR

Friday 11 October, 12.00 pm, Seminar Room on the 1st Floor

Host: Dr Sergio Moya

Design of functionalized iron oxide nanostructures for energy, spintronic and biomedical applications

Prof. Sylvie Bégin-Colin

Institut de Physique et Chimie des Matériaux de Strasbourg
University of Strasbourg

Functionalized iron oxides nanoparticles are intensively studied for biomedical applications and are also considered as the building blocks of the future nanotechnological devices. Furthermore nanostructured iron oxide based electrodes appear more and more appealing for battery.

Superparamagnetic iron oxide NPs with appropriate surface coating are widely used in numerous *in vivo* applications such as MRI contrast enhancement, hyperthermia treatment, cell sorting, drug delivery, immunoassay, and tissue repair. In all these applications, it is mandatory to engineer the surface of NPs not only to improve biocompatibility, solubility and stability in physiological media but also to ensure a small particle size distribution (below 100 nm) after decoration and to preserve good magnetic properties. In that context, we propose a concept combining a dendritic coating of magnetic oxide nanoparticles with phosphonate anchors. Dendronized iron oxide nanoparticles were demonstrated to induce any cytotoxicity, to display contrast enhancement properties higher than those of commercial polymer-coated NPs and to be eliminated by urinary and hepatobiliary pathways without unspecific uptake especially in the RES organs and in the lungs. The design of dendronized NPs was further improved to obtain theranostic nano-objects.

In the field of spintronic and for magnetic applications, the controlled elaboration of ordered arrays of nanoparticles (NPs) have attracted great interest in the last decades because they allow fundamental studies on collective magnetic and transport properties and also because it represents a very exciting and important challenge with regards to their high potential in the development of new spintronic nanodevices. Among the different assembling techniques, the Langmuir-Blodgett and the Layer by Layer techniques and the deposition on well-addressed substrates have been investigated. The parameters leading to uniform arrays with a high density and degree of order have been determined for all methods. Then the dipolar interactions in such 2D and 3D arrays have been studied by comparing DC and AC SQUID measurements on powdered NPs, 2D and 3D organized NPs and on diluted NPs. The magneto-transport properties of these NPs have been studied on LB multilayer deposited between two electrodes : enhanced MR values (45% at 110K) have been obtained on arrays of 16 nm NPs.

In the development of new materials for electrodes in Li ions batteries, the current research aimed at tuning the nanostructuration of iron oxide to improve performance and stability of electrodes. The synthesis of iron oxide nanostructures displaying high porosity and high specific surface area has been optimized and their electrochemical properties

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SEMINAR

Tuesday 15 October, 12.00 pm, Seminar Room on the 1st Floor

Host: Dr Ralf Richter

Stimuli-Responsive and DNA-Aptamer Gating Membranes

Prof. Thomas Shäfer

POLYMAT, University of the Basque Country
Donostia, Spain

Artificial membranes, mostly consisting of polymers or inorganic materials, are widely employed in a multitude of industrial or biomedical separation tasks. Dialysis would not be possible without membranes, neither would potable water be available in the many arid regions on Earth; petroleum industry relies on membranes for gas separation as much as the diary industry. Yet, while there is a quest to develop artificial membranes that perform as perfectly as the cell membranes that prevent our body from being an amorphous blob, there is a distinct difference between the function and operation of artificial and biological membranes. This talk will shortly introduce the concept of artificial membranes and then discuss recent advances and concepts in the quest for the holy grail: the attempt of mimicking cell membranes - with an engineering approach.

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SEMINAR

Thursday 17 October, 12.00 pm, Seminar Room on the 1st Floor

Host: Prof Luis Liz Marzán

Genesis of gels and crystals: The evasive nucleus in organic molecular matter

Prof. David Amabilino

Institut de Ciència de Materials de Barcelona, Spain

The formation of gel-like materials and crystals of organic molecules from solution is a stochastic process that can be tamed in certain cases but whose true nature is intangible even today. The importance of the process, in biological matter as well as in synthetic systems, is utmost because of its involvement in the development of certain maladies and the processing of manmade compounds. The talk will trace the importance and state of the art of the area, and will present results from the Amabilino group on the homogeneous nucleation of materials made for the preparation of organic conductors of electricity and the heterogeneous nucleation of chiral molecules on micropatterned surfaces. The results suggest new tools for the study of the emergence of nuclei in molecular (bio)materials.

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OPEN GROUP SEMINAR

Thursday 24 October, 12.00 pm, Seminar Room on the 1st Floor

Host: Prof. Luis Liz Marzán

Functionalized silica-based supports: applications in sensing and delivery

Prof. Ramón Martínez Máñez

Department of Chemistry
Universitat Polytècnica de València

Silica-based materials are suitable supports for the preparation of hybrid materials due to their unique properties such as large stability and easy functionalization. Application using these supports in the design of chromo-fluorogenic probes and in the development of smart controlled delivery systems will be detailed.

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SEMINAR

Thursday 31 October, 12.00 pm, Seminar Room on the 1st Floor

Host: Prof. Luis Liz Marzán

Bio-enabled and Synthetic Microresonators for Plasmonics and Photonics

Prof. Joseph Perry

School of Chemistry and Biochemistry
Center for Organic Photonics and Electronics
Georgia Institute of Technology, USA

Micro- and nanostructured metallic and dielectric materials can be used to obtain tailored optical responses for applications in telecommunication, signal processing, displays, sensing, and remote detection, among others. In this talk, I will present recent work in the fabrication and characterization of resonant plasmonic and photonic microstructures for extraordinary transmission, stop-band engineering in photonic crystals and organic microlasers. Biological microstructures with quasiperiodic hole arrays from the "shells" of single-celled algae (diatoms) have been converted into shape-preserving replicas that exhibit extraordinary transmission. Multiphoton 3D lithography (MPL) has been used to form high fidelity photonic crystals with strong stop bands that can be tailored via structure variations or coating with titania or silver, via chemical amplification methods. We have also investigated simple polyhedral microstructures as optical resonators, which were fabricated from dye-doped photopolymer resins via MPL, including rectangular and cubic structures. We show that it is possible to decouple the microresonators from the substrate to realize significant reductions in "lasing" thresholds.

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SEMINAR

Tuesday 5 November, 12.00 pm, Seminar Room on the 1st Floor

Host: Dr. Ralf Richter

Reconstruction of minimal bacterial divisomes in the test tube: from physical to cytomimetic biochemistry

Dr. Germán Rivas

Centro de Investigaciones Biológicas (CIB-CSIC), Madrid, Spain

Research in our group aims at reconstructing a minimal protein set that reproduces the initial steps of bacterial division in cell-like compartments. Individual elements of the first molecular assembly of the divisome (the proto-ring), their functional interactions and organization (in time and space) are studied by biochemical, biophysical and imaging technologies. In *Eschericia coli*, the cell division protein FtsZ is anchored to the cytoplasmic membrane by the action of the membrane protein ZipA and the amphitropic protein FtsA, forming the initial assembly of the division machinery which drives cytokinesis at mid-cell, where FtsZ polymers form a dynamic Z-ring active in division. We study the activities, interactions and assembly properties of FtsZ in minimal reconstructions of the proto-ring structured in membrane-like systems, such as nanodiscs, microbeads, bilayers, vesicles and microdroplets. We investigate the action of Min proteins and nucleoid-like structures (to reproduce Z-ring positioning mechanisms) on the properties of minimal divisomes. This integrative strategy, combining quantitative and synthetic approaches, will help to gain new mechanisic insights on how bacterial division works, leading to applications in antimicrobial drug discovery.

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- Martos A, Jiménez M, Rivas G*, Schwille P* (2012). Towards a bottom-up reconstitution of bacterial cell division. *Trends Cell Biol.* 22:634-643
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Germán Rivas - CV

CSIC predoctoral fellow (IQFR “Rocasolano”-CSIC, Madrid; 1984-1989). PhD in Chemistry – Biochemistry (UAM, Madrid; 1989). Fogarty Fellow (NIH, Bethesda, USA; 1990-1992). EMBO Fellow (Biozentrum, Univ. Basilea; 1993). CSIC postdoctoral investigator (CIB-CSIC; 1994-1995). CSIC scientist (1996-2005). CSIC senior investigator (since 2006).

Fields of expertise

Quantitative biochemistry; physical biochemistry; biophysics; protein-protein interactions; protein-membrane interactions; macromolecular assembly; bacterial cell division; analytical ultracentrifugation; light scattering; optical biosensing

Research areas

Synthetic biochemistry of bacterial cell division: Reconstitution of minimal bacterial divisomes in artificial membrane systems - nanodiscs, coated-microbeads, supported bilayers, giant vesicles, and microdroplets.

Cytomimetic) biochemistry: Investigation of the effect of excluded volume in crowded solutions and of surface adsorption (biomembranes) on the functional energetics of macromolecular associations and assembly.

Physical biochemistry: quantitative characterization of macromolecular interactions by means of techniques of analytical ultracentrifugation, light scattering, fluorescence spectroscopy and optical biosensing.

Recent scientific achievements

- Introduction in Spain of **advanced methods of analytical ultracentrifugation** (1994) and **static light scattering** (2006, 2009) to measure macromolecular interactions in solution. Sedimentation velocity (2005) and static light scattering (2012) analysis of functional associations and assembly of the essential bacterial division FtsZ protein.
- Development of **equilibrium sedimentation methods** to study the **behavior of proteins in highly crowded solutions** that reproduce biological environments (1999, 2004, 2010). Description of the effects of macromolecular crowding on FtsZ self-association and assembly (2001, 2003).
- **Reconstitution of bacterial division proto-ring elements in biomimetic membrane systems**: phospholipid bilayer nanodiscs (2012), coated beads (2012), giant vesicles (2011,2013) and confined droplets (2013).

Bibliometric summary

118 articles in international peer-reviewed journals
h index: 34; citations: 4410

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SEMINAR

Monday 11 November, 12.00 pm, Seminar Room on the 1st Floor

Host: Prof Luis Liz Marzán

Amphibious polymer carriers for nanoparticle phase transfer

Prof. Dayang Wang

Ian Wark Research Institute
University of South Australia, Australia

This talk will present how one can take the advantage of most hydrophilic polymers being soluble in both water and organic solvents to harness them to direct nanoparticles (NPs) into different media. The first part of the talk will discuss bidirectional transfer of NPs coated with stimuli-responsive polymer brushes between aqueous and organic phases across the interfaces by deliberate engineering the interactions of the stimuli-polymer coating with the sorrounding media.[1,2] We have experimentally and theoretically demonstrated that the reulsing NPs can readily transfer from oil to salty water aross the planar interfaces when the environmental temperature is reduced below 5 ºC, while they transfer from salty water to oil when the environmental temperature returns to room temperature. The second part of the talk will present a fairly simple and versatile way to use hydrogel as a generic carrier to directly and freely transfer various particulate materials such as inorganic NPs and enzymes into different media and thus encapsulate them without need of chemical modification of the loading guests and the hydrogel network and any size matching or chemical affinity of the loading guests for the hydrogel host.[3,4] The key of the present methodology is to use water-miscible organic solvents such as tetrahydrofuran and isopropanol intermediates to reversibly exchange the aqueous milieu initially absorbed in the hydrogel with water-immiscible organic solvents such as chloroform or hexane, thanks to the fact that the hydrogels themselves can be dispersed in a wide range of solvents of different polarity. This new development may not only provoke a number of experimental and theoretical interest in temperature effect on the structural stability, hydration, denaturing, and re-activation of biological molecules but also lead to new formulation design for delivery of marker and drugs for diagnosis and therapy especially for crossing biological barriers.

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2. Stocco, A.; Chanana, M.; Su, G.; Cernoch, P.; Binks B. P.; Wang, D.; *Angew. Chem. Int. Ed*. **2012**, *51*, 9647-9651.
3. Bai, S.; Nguyen, T.-L.; Mulvaney, P.; Wang, D.; *Adv. Mater.* **2010**, *22*, 3247-3250
4. Bai, S.; Wu, C.; Gawlitza, K.; v. Klitzing, R.; Ansorge-Schumacher, M.; Wang, D.; *Langmuir* **2010,** 26, 12980 12987

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Biography

Dayang Wang was born in Liaoning, China, in 1972. He studied chemistry at Jilin University, Changchun, China, where he obtained a B. Eng. in 1993 and a PhD in 1998 under co-supervision of Profs. Xinyi Tang, Tiejin Li, and Yubai Bai. In 1999 he worked as a postdoctoral fellow in the group of Prof. D. Lam in Dept. Mech. Eng. at Hong Kong University of Science and Technology, Hong Kong. Later in 1999 he joined the research group of Prof. F. Caruso, as a postdoctoral fellow, at the Dept. Interfaces, headed by Prof. H. Möhwald, at the Max Planck Institute of Colloids and Interfaces (MPIKG), Potsdam, Germany. In 2000 he received an Alexander von Humboldt Research Fellowship. Since July 2003 he became a group leader at the Dept. Interfaces, MPIKG. In July 2010 he took up a tenured professor position at the Ian Wark Research Institute, University of South Australia, Adelaide, Australia. His current research interests include surfaces, interfaces (adsorption, adhesion, translocation, and phase transfer), gas and ion adsorption and transportation, crystallization, self-assembly, hydrogel, drug delivery, and nanomedicine.

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SEMINAR

Wednesday 13 November, 12.00 pm, Seminar Room on the 1st Floor

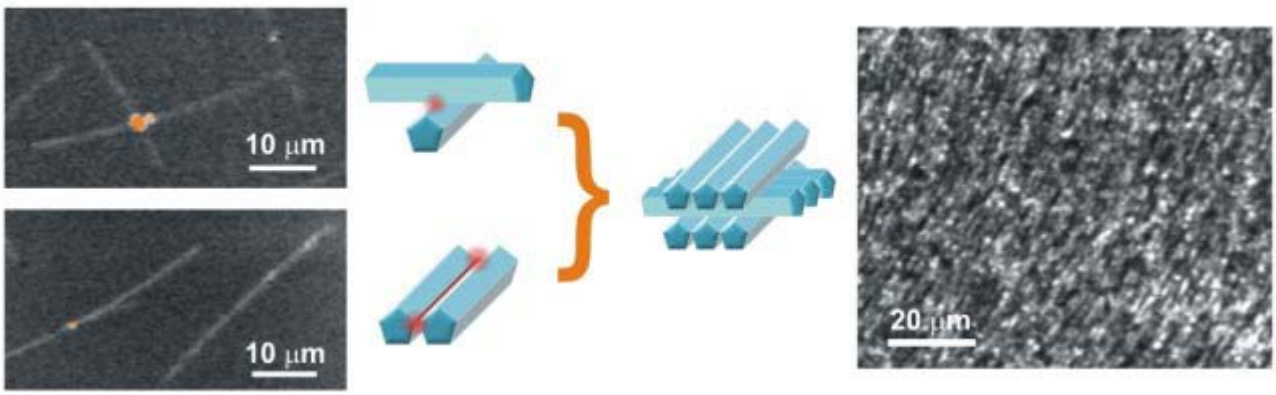
Host: Prof. Luis Liz Marzán

Chemical etching and self-assembly of Ag nanowires to increase hot spots for Surface-Enhanced Raman Spectroscopy application

Asst. Prof. Xing Yi Ling

Nanyang Technological University, Singapore

The surface-enhanced Raman spectroscopy (SERS) “hot spots” are highly localized regions of enhanced electromagnetic field within a SERS substrate that dominate the overall SERS intensity. This results in inhomogeneous distribution of SERS intensity in a SERS substrate, thus limiting their application as reproducible and ultrasensitive sensing platforms. In this seminar, I will address this challenge by using two strategies. The first strategy uses chemical etching method to increase the surface roughness of Ag nanowires to increase the number of SERS hot spots along the longitudinal axis of Ag nanowires. Undulating sharp ridges are created along the entire lengths of nanowires. Single-nanowire SERS measurements show that these ridges act as antennas of the etched Ag nanowires for efficient light coupling, with increased SERS signals are measured over the entire length of etched Ag nanowires. In second section, we self-assemble Ag nanowires into 3D woodpile structures in a layer-by-layer manner to achieve high density of hot spots over a centimeter-scaled surface area. We aim to promote strong electromagnetic coupling between parallel and vertically stacked Ag nanowire pairs within the woodpile structure to create strong plasmonic coupling across the entire 3D SERS substrates. We will demonstrate that, using Raman mapping in x-y plane and x-z plane, all of the 3D Ag nanowire arrays exhibit a homogeneous SERS Raman intensity over a large area with larger SERS depth cross section and angle-independent SERS intensity, making such woodpile 3D SERS substrate more reliable and versatile for future sensing applications.



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Xing Yi Ling obtained her Bachelor Degree of Chemical Engineering, 1st Class Honors from University of Adelaide, Australia in year 2000. She received her Master Degree of Chemical Engineering from the National University of Singapore (NUS) and Institute of Materials Research & Engineering (IMRE) in September 2004. She pursued her Ph.D. research under the supervision of Prof. David Reinhoudt and Prof. Jurriaan Huskens at the University of Twente, Netherlands. In October 2008, she received her Ph.D. degree, with thesis entitled “From Supramolecular Chemistry to Nanotechnology: Assembly of 3D Nanostructures”. She was awarded the 2009 IUPAC Young Chemist award for her Ph.D. research. In May 2009, she joined Prof. Peidong Yang at the University of California, Berkeley for postdoctoral research under the Rubicon fellowship from the Netherlands Organization for Scientific Research (NWO, NL). Xing Yi Ling joined Chemistry and Biological Chemistry division at Nanyang Technological University in July 2011. In January 2012, she was awarded the Singapore National Research Foundation fellowship.

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SEMINAR

Friday 29 November, 12.00 pm, Seminar Room on the 1st Floor

Hosts:Prof. Luis Liz Marzán and Dr. Ralf Richter

Studying bone growth, remodeling and regeneration through multi-scale imaging

Prof. Peter Fratzl
Max Planck Institute of Colloids and Interfaces
Potsdam, Germany

The mechanical properties of bone depend essentially on its complex hierarchical structure which adapts to the need of every part of our skeleton. Collagen fibrils reinforced with mineral nanoparticles are assembled into lamellae at the micron scale. Rotated plywood arrangements of lamellae build osteons in compact bone or trabeculae in cancellous bone. Bone diseases such as osteoprosis or osteogenesis imperfecta, as well as their treatments may affect some or all these levels.

The talk will review the application of multi-scale imaging based on optical and electron imaging combined with scanning synchrotron x-ray scattering to the study of bone structure. Medical applications relating to osteoporosis treatment, bone healing and tissue engineering will be highlighted.

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Peter Fratzl is director at the Max Planck Institute of Colloids and Interfaces in Potsdam, Germany, heading the Department of Biomaterials. He received an engineering degree from Ecole Polytechnique in Paris, France, and a doctorate in Physics from the University of Vienna, Austria. He is honorary professor at Humboldt University Berlin and at Potsdam University. Before moving to Potsdam in 2003, he has been holding professor positions in materials physics at the Universities of Vienna and of Leoben, Austria.

Peter Fratzl's lab studies the relation between (hierarchical) structure and mechanical behaviour of biological and bio-inspired composite materials, and conducts research on osteoporosis and bone regeneration. His research interests include biomaterials systems for mechanosensing and actuation. Peter Fratzl has published more than 400 papers in journals and books.

Peter Fratzl serves on a number of editorial advisory boards, including Science, Nature Communications as well as journals in materials science and in structural biology. He is member of Scientific/Supervisory Boards for a number of institutions in Europe and US. Since 2010, he is also interim director at the Max Planck Institute for microstructure physics in Halle, Germany. Recent awards include the Max Planck Research Award 2008 from the Humboldt Foundation and the Leibniz Prize 2010 from the German Science Foundation. He delivered many keynote lectures at conferences and various named lectures, most recently the 2013 Jerome B. Cohen Distinguished Lecture Series at Northwestern University (Evanston, USA). He received an honorary doctorate from the University of Montpellier in 2010 and was elected corresponding member of the Austrian Academy of Sciences in 2007 and Fellow of the Materials Research Society (USA) in 2012.

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SEMINAR

Thursday, 5 December, 12.00 pm, Seminar Room on the 1st Floor

Host:Prof. Luis Liz Marzán

Langmuir monolayers as physical models in bio- and nanoscience

Prof. Helmuth Moehwald
Max Planck Institute of Colloids and Interfaces, Potsdam Germany

Monolayers of amphiphilic molecules on water surfaces are on one hand excellent models to study ordering processes in 2 dimensions on a flexible and amorphous substrate, on the other hand they may serve as biophysical models to study processes at membrane surfaces. A plethora of techniques has been developed in the past to study the films in detail, the most important ones X-Ray diffraction, reflection and fluorescence and FTIR spectroscopy.

- Inorganic nanoparticles with stimuli responsive coatings are good models to simulate interactions with membranes as well transport through membranes. These can be studied with respect to their interfacial activity and stability.
- Peptides can arrange at interfaces leading to changes of secondary structures. These can be modeled theoretically including their additionally interactions with ions.one can thus contribute to processes that are involved in various diseases like Alzheimer‘s.
- DNA coupling to membranes in direct electrostatic interaction or mediated through divalent cations can be studied showing ordered arrangement at interfaces.
- Sugars are important for recognition processes in biology, and many of these processes occur at membrane surfaces. Thus studies of their arrangement at interfaces are most welcome. It will be shown that they can form a strong crystalline hydrogen bonded network, and if these molecules are coupled to aliphatic chains the competition between chain and sugar ordering can be won by the latter. The resulting structure is again in agreement with molecular dynamics simulations.