C'NANO 2018
THE NANOSCIENCE MEETING
TOULON December, 11, 12 and 13
Palais des Congrès Neptune
C'NANO CNRS In partnership with: Club nanoMétrologie LNE RENATECH

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Biography

Dr Fouzia Boulmedais graduated from the University of Strasbourg where she received her Ph.D. in chemistry and physical chemistry in 2003. In 2004, she worked as a Postdoc with Prof. Marcus Textor at ETH Zurich (Switzerland) and with Prof. Gleb Sukhorukhov at Max Planck Institute (Golm, Allemagne) in electrodissolution of multilayers of polyelectrolytes. After a second post-doc with Valérie Marchi on functionalisation of quantum dots, she was appointed CNRS researcher at Institut Charles Sadron (ICS) in Strasbourg in 2006. She obtained the "*Habilitation à Diriger des Recherches*" French Diploma in 2010, providing her accreditation to supervise research. Her research activity deals with the use of an electrical stimulus to induce and control the construction of polymer films as well as with the application of polyelectrolyte films in the field of biomaterials particularly as antibacterial and antifungal coatings. She is co-author of 89 publications and 2 patents. In 2013, she received the Young Researcher prize of the Division of Physical Chemistry, common to the Chemical Society of France and the French Physical Society.

POLYMER NANOCOATINGS: FROM INERT TO FUNCTIONAL BIOMATERIALS

According to the definition agreed upon the Conference of the European Society for Biomaterials in 1986, Biomaterials are non-viable materials used in a medical device for the diagnosis, the cure, the treatment or the prevention of disease. They can be implanted or extracorporeal support systems (artificial respiratory system, dialysis ...). The surface of biomaterials is the privileged location where the interactions with the biological environment take place. The challenge is to control these interactions to enhance their biocompatibility and provide them bioactivity. This can be achieved by tailoring the surface properties of the biomaterial, especially through the application of a coating. Different techniques of surface functionalization forming a thin film on a surface have been developed usually depending on the nature of both the material and the deposited molecules or macromolecules.

In the field of biomaterials, the use of polyelectrolyte multilayers to cover implants offers great potential. These nanofilms, usually about 10 nm to 1 µm thick, are constructed using the Layer-by-Layer (LbL) method based on physisorption (assemblies based on weak, mainly electrostatic interactions) of polyanions and polycations. Simple to implement, these films present tuneable properties depending on the physico-chemical conditions of build-up and allow the immobilisation of several bioactive (macro)molecules or inorganic nanomaterials. In collaboration with UMR 1121 INSERM (Strasbourg) and Halima Kerdjoudj (BIOS EA 4671, Reims), we have been able to develop several types of coatings according to the desired properties such as preventing protein adsorption or cell adhesion, with antimicrobial or anti-inflammatory properties and even inducing stem cells differentiation.

Keywords: multilayers of polyelectrolytes, antifouling, bioactivity, antimicrobial, anti-inflammatory, stem cells differentiation

Session : Nanobiology, Biomaterials

Keywords: DNA, hydrogel, FRET, soft-mechanochemistry, mechanochromic.

Macroscopic mechanofluorescent DNA hydrogels.

Rémi Merindol,[1] Giovanne Delechiave,[2] Luiz Henrique Catalani,[2] Andreas Walther.[3]

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Mechanosensitive materials can sense and respond to mechanical actuation. Such materials are ubiquitous in nature and control many biological processes. Inspired by these systems artificial mechanochromic materials have been designed to respond optically to mechanical actuation. Current approaches generally rely on covalent bond rupture which requires large actuation forces and yield irreversible sensing. Weak and reversible force sensing requires new mechanisms inspired from biological design and based on dynamic supramolecular changes.

Here we present the assembly and characterization of mechanofluorescent hydrogels based on DNA self-assembly. We form macroscopic all-DNA hydrogels using single stranded DNA prepared by enzymatic rolling circle amplification. Rheological characterization shows a thermoplastic behavior allowing easy shaping and recycling. We functionalize these hydrogels with mechanochromic modules that consist in a weak DNA duplex bearing on one side a fluorophore and a quencher on the other side. As long as the duplex holds both in proximity non-radiative Förster Resonance Energy Transfer (FRET) prevents fluorescence. Mechanical stretching triggers the opening of the duplex which induces a decrease of FRET and an increase of fluoresce. We show quantitative strain-fluorescence measurements in homogeneous hydrogels (Figure) and control over the reversibility depending on the sequence and architecture of the module. We also present proof of concept applications for multiscale strain monitoring in composite materials, and visualization of freezing induced stress patterns.

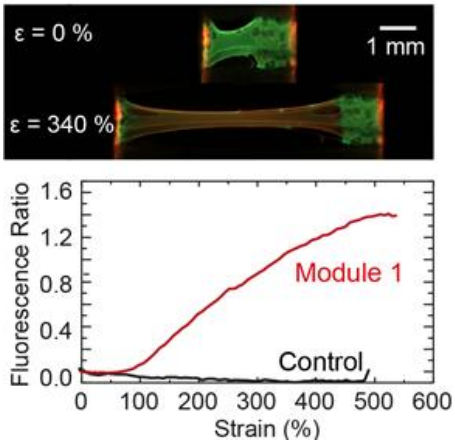

Figure: (Top) Widefield fluorescence imaging of the DNA hydrogel during stretching. (bottom) Quantitative strain-fluorescence curves ($Fluo_{488/510}$)/($Fluo_{530/580}$) for hydrogels with (red) and without (black) force sensing duplex.

Congrès 2018, Toulon

11, 12 & 13 septembre
Session (Nanobiology/biotechnology)
Keywords: “nanoemulsions; surfactants; contrast agents; drug delivery; dry formulations”

Stable perfluorocarbon nanoformulations for theranostic applications

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Our team works for several years on the production of stable perfluorocarbon (PFC) droplets optimized for both early detection of tumor development and controlled therapy.
These "theranostic tools" consist of PFOB droplets stabilized and dispersed in water thanks to a shell resulting from the self-assembling of tailor-made fluorinated surfactants called “F-TAC” and “Dendri-TAC”. Due to the fluorophilic property of perfluorocarbons, it is not possible to encapsulate any drug, even hydrophobic, within the droplet core. To do so, we used a mixture of PFOB/biocompatible oil in different ratios to prepare our nanoemulsions (NEs). Playing on several parameters like the surfactant type, surfactant/[PFOB-oil] ratio, emulsification process we produced nanodroplets with an interesting mean diameter (Do < 100 nm) for medicinal applications. We also succeeded in limiting the nanodroplets growth by a freeze-drying step, affording dry formulations of PFOB easy to store and ready to use after rehydration with almost no change in droplet size and PFOB composition. Once optimized, a fluorescent dye was encapsulated onto the PFC/oil nanodroplets in order to allow their in vivo monitoring and visualization of tumor accumulation after *intravenous* injection in mice. This presentation will cover all the NEs optimization, drug or dye encapsulation and biological validation (*in vitro* and *in vivo* studies) of these new theranostic tools.

Congrès 2018, Toulon

11, 12 & 13 septembre
Session: Nanobiology
Keywords: Nanohydrogels, MRI, Gd-chelates, Polysaccharides

Nanohydrogels-Based Hypersensitive MRI Probes: Synthesis and Functionalization

Malystkyi Volodymyr,[1] Callewaert Maité,[1] Moreau Juliette,[1] Cadiou Cyril,[1] Henoumont Céline,[2] Sébastien Boutry,[3] Laurent Sophie,[2, 3] Chuburu Françoise[1]

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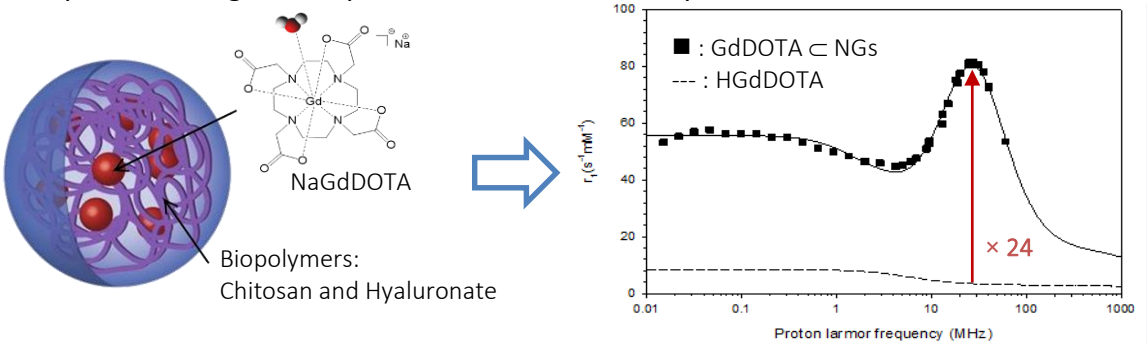
3. Center for Microscopy and Molecular Imaging (CMMI), Gosselies, Belgium

Thanks to its excellent spatial resolution, MRI imaging is one of the most popular medical imaging techniques. However, it lacks from sensitivity and this drawback can be counterbalanced by the use of paramagnetic contrast agents, such as gadolinium polyaminocarboxylate chelates. In order to obtain good contrast between tissues, injected gadolinium doses are actually very high (e.g. for DOTAREM® 0.2 mL per kg of a 0.5 M solution for adults). The development of hypersensitive MRI contrast agents should help to reduce the injected doses. Furthermore, if these agents are targetable, they will find useful applications in molecular imaging.
In the presentation, we will show how the formulation of gadolinium chelates in the form of biocompatible nanogels, can provide an answer to this problem.[1]



We will describe the synthesis of these nanoparticles from biopolymers such as chitosan and hyaluronic acid. We will show that the current process allows to obtain nano-objects whose size is compatible with a parenteral or subcutaneous injection.[2] We will also show how the nature of the polymer matrix influences the nanogel MRI response.[3] Finally, we will discuss of their functionalization for their use in lymphatic system imaging.

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3. M. Callewaert, V.G. Roullin, C. Cadiou, E. Millart, L. Van Gulik, M.C. Andry, C. Portefaix, C. Hoeffel, S. Laurent, L.V. Elst, R. Muller, M. Molinari, F. Chuburu, J. Mater. Chem. B, 2014, 2, 6397.

Congrès 2018, Toulon

11, 12 & 13 septembre
Session: Nanobiology - Biomaterials
Keywords: DNA origami, three-dimentional nanostructures, self-assembly, design

Designing and Programming three-dimensional DNA nanostructures

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The introduction of DNA origami, which uses many staple strands to fold one long scaffold strand into a desired structure with nanometer precision has dramatically improved the complexity and scalability of DNA nanostructures.

Building megadalton-scale 3D nanostructures using hundreds of unique DNA strands for positioning diverse functional moieties becomes then attractive for different applications in biology, chemistry, and physics. Building gigadalton-scale nanostructures is however more challenging mainly because of the practically limited success of manufacturing and manipulating an increasingly long scaffold strand. Recently, in collaboration with Peng Yin's group from Harvard University, we were able to overcome this limitation using the assembly of DNA bricks. This approach does not require a scaffold; instead, it uses short binding of DNA brick strands so that the bricks can specifically interlock to self-assemble into gigadalton-scale nanostructures.

In this presentation, I will discuss the method of DNA bricks for assembling 3D nanostructures. I will also give an overview of how we can engineer DNA origami to build artificial molecular systems and machines by presenting examples of our recent developments in DNA origami design and its applications in structural biology, nanophotonic, and sensing.

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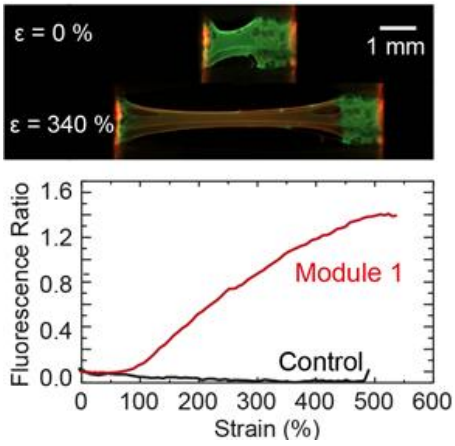

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