BOOK OF ABSTRACTS

Nanobiosciences & Nanomedecine

Tuesday March 18th

3:15 P.M. - 6:30 P.M.

ROOM CD

Program of the session :

Chairs: Andreas REISCH

HOUR	NAME	TITLE
15:15	**Valérie MARCHI** **ISCR - CNRS**	**Luminescent metal nanoclusters for nanosensing in living environment**
15:45	Regina CHIECHIO Dipartimento di Fisica e Astronomia - Università degli Studi di Catania	Gold Nanoclusters for Ultrasensitive and Label-Free DNA Sensing and Biomolecular Detection
16:00	Zied FERJAOUI UTCBS - CNRS	Improved Sensibility in IgG Detection through Signal Amplification of Persistent Luminescence Nanoparticles
16:15	Ester BUTERA MAcSE, UNIVERSITE DE RENNES	Luminescent metal nanoclusters for labelling of biological vesicles
17:00	Marcelina CARDOSO DOS SANTOS I2BC - CEA	Quantum Dot-Based FRET nanosensors to quantify molecular assembly within focal adhesion
17:15	Omar EL-DAHSHAN LCBM/SyMMES - CEA Grenoble	Synthesis and Advanced Characterization of Silver Sulphide Quantum Dots for Bio-Imaging
17:30	Celina MATUSZEWSKA LCMCP - Sorbonne Université	The study of the mechanism of persistent luminescence enhancement in ZnGa2O4: Cr3+ nanoparticles under H2O2
17:45	Guanyu CAI IRCP	ZGSO persistent nanophosphors for bioimaging in NIR
18:00	Baptiste GRIMAUD LuMIn - École Normale Supérieure Paris-Saclay	Measuring axonal transport using neurotropic fluorescent nanodiamonds
18:15	Kariné HEUZÉ ISM - CNRS	Functionalization of Magnetic Nanoparticle Surfaces for Bio-Immobilization, Detection, and Biocatalysis

Valérie MARCHI (CNRS - ISCR, Rennes)

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Short biography

Valérie Marchi, received her engineer diploma and her Master degree in Physical Chemistry from the Ecole Supérieure de Physique et Chimie Industrielles (ESPCI, Paris) in 1994. She acquired an expertise in Supramolecular Chemistry and Organized Soft Matter during her Ph.D with Prof J.-M. Lehn at the Collège de France (Paris) and during a 6 months doctoral staying in the laboratory of Prof T. Kunitake (Fukuoka, Japan,) in 1997. As postdoc, she worked one year in the laboratory of Biophysik with Prof. Erich Sackmann (TUM Munich, Germany). In 1998, she entered to the CNRS at the Chemistry laboratory of Prof Jean-Marie Lehn at the Collège de France in Paris . She moved to the ISCR (University Rennes, UMR 6226) in 2004 where she developed her research in the field of nanoparticles, surface chemistry and nanomaterials synthesis at the interface with the Organized Soft Matter (vesicles, cells) for biological applications (imaging and sensing).

Luminescent metal nanoclusters for nanosensing in living environment

Gold nanoclusters (AuNCs) are attractive candidate as long-lived luminescence sensors. Their ultrasmall
size (< 2 nm) and large window of luminescence lifetime (from nano to microsecond) as well as their good biocompatibility make them an attractive alternative to fluorescent molecular probes or proteins .
We present the synthesis of original ultra-small luminescent peptidic AuNC sensitive to the pH. The versatility of small peptides permits to adjust the emission wavelength and the sensitivity of the emission intensity as well as the luminescent lifetime to the pH. This chemical plateform provides various charged AuNC with potential sensitivity to the environment for biosensing applications.
Due to their ultra-small size, these nanoprobes are shown to be easily internalized into subcellular compartment such as cell nuclei or deliver to synthetic or biological vesicles . Yet their interaction with plants according to different ways of administration has not yet been explored. Here various peptidic luminescent gold nanoclusters with different surface charge were administrated to photosynthetic living organism Thaliana Arabidopsis, used as a model by different ways through a depositived drop on a leaf or by incubation of the roots in the nutrient buffer. Depending of the administration way, their biodistribution in the leave and roots was investigated by optical confocal microscopy.

Keywords

luminescence, nanoclusters, nanosensor, plants, extracellular vesicles

References

1.Chiechio, R. M.; Ducarre, S.; Moulin, G.; Dupont, A.; Marets, C.; Even-Hernandez, P.; Artzner, F.; usumeci ranzo G.; Ravel, C.; LoFaro, M. J.; Marchi, V. Luminescent Gold Nanoclusters Interacting with Synthetic and Biological Vesicles. J. Phys. Chem. Lett. 2022, 13 (30), 6935.
2.Chiechio, R. M., Le Guevél, R., Ducarre, S., Solhi, H., Dutertre, S., Pinson, X., ... & Marchi, V. Active U11 Peptide Luminescent Gold Nanoclusters for Pancreatic Tumor Cell Targeting. ACS Applied Nano Materials 2023, 6(10), 8971-8980.
3.Chiechio, R. M.; Ducarre, S.; Marets, C.; Dupont, A.; Even- Hernandez, P.; Pinson, X.; Dutertre, S.; Artzner, F.; Musumeci, P.; Ravel, C.; Faro, M. J. L.; Marchi, V. Encapsulation of Luminescent Gold Nanoclusters into Synthetic Vesicles. Nanomaterials 2022, 12 (21), 3875.
4.Butera, E., Dupont, A., Aimé, A., Ducarre, S., Chiechio, R. M., Even-Hernandez, P., ... & Marchi, V.In Situ Labeling of the Aqueous Compartment of Extracellular Vesicles with Luminescent Gold Nanoclusters. ACS Applied Materials & Interfaces 2024, 16(17), 21643.

Abstract

Thematic Session: Nanobiosciences & Nanomedecine
Disciplinary fields involved: Chemistry, Physics, Biomedical Science
Keywords: Gold nanoclusters, Fluorescence, DNA detection, Label-free sensors, Early diagnostics

Gold Nanoclusters for Ultrasensitive and Label-Free DNA Sensing and Biomolecular Detection

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Abstract:

Gold nanoclusters (AuNCs) are emerging as promising tools in biomedical and environmental applications due to their unique photoluminescence, biocompatibility, and molecule-like electronic structure[1,2]. However, their application is often hindered by challenges related to sensitivity, specificity, and sustainability. This study presents an innovative AuNC-based sensor platform, characterized by eco-friendly synthesis and label-free functionality, for ultrasensitive biomolecular detection.
AuNCs were synthesized using a green chemistry approach and achieving fluorescence properties with a characteristic absorbance peak at 400nm[3–5]. Functionalization with thiolated single-stranded DNA (ssDNA) enabled rapid and simple detection of target DNA sequences through fluorescence quenching. This label-free mechanism reduces costs and simplifies the system by eliminating the need for complex modifications. The sensor demonstrated excellent performance in both buffer solutions and biological matrices, such as blood. Fluorescence quenching efficiency reached 33% for specific DNA compared to 17% for non-specific sequences, confirming the specificity of the system. An attomolar detection limit

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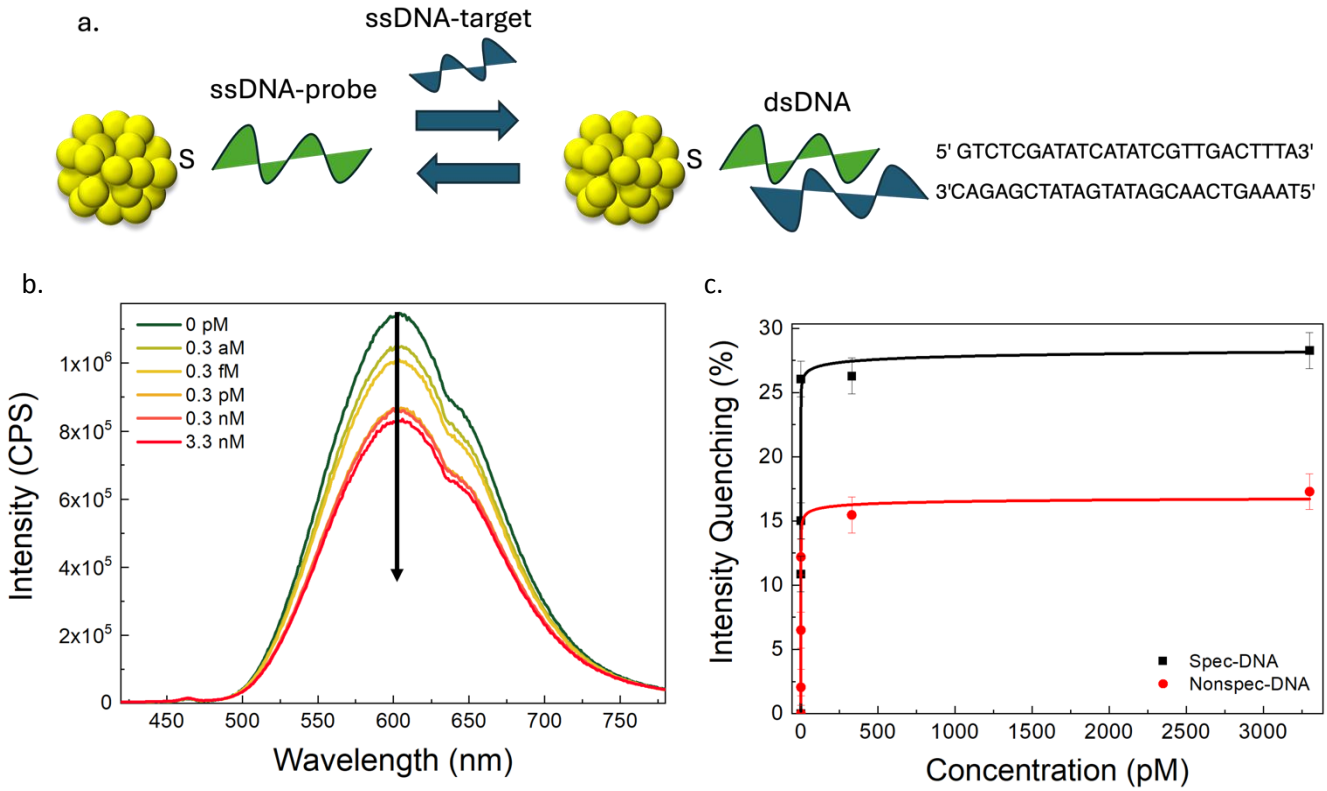
was achieved, making the platform suitable for early detection of low-abundance biomarkers like cancer indicators and pathogenic DNA. The platform's modularity supports the detection of various biomolecules, including peptides and nucleic acids, through aptamer incorporation. These attributes position the AuNC-sensor as a versatile and sustainable tool for medical diagnostics and environmental monitoring.



a) Schematic representation of the NCs-sensor. b) Fluorescence spectrum of the sensor incubated with different target concentrations. c) Percentage of intensity quenching in the presence of increasing target concentrations (λexc=400nm, λem=600nm).

References:

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(5) Chiechio, R. M.; Ducarre, S.; Marets, C.; Dupont, A.; Even-Hernandez, P.; Pinson, X.; Dutertre, S.; Artzner, F.; Musumeci, P.; Ravel, C.; Faro, M. J. L.; Marchi, V. Encapsulation of Luminescent Gold Nanoclusters into Synthetic Vesicles. Nanomaterials 2022, 12 (21), 3875. https://doi.org/10.3390/nano12213875.

Acknowledgement:

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Abstract

Thematic Session (nanobioscience)**:**
Disciplinary fields involved (eg. Chemistry, Physics, Biology …)**:**
Keywords (max. 4-5)**:** Persistent luminescence, Nanoparticles, Functionalization, H_2O_2, Immunoassay

Improved Sensibility in IgG Detection through Signal Amplification of Persistent Luminescence Nanoparticles

Zied Ferjaoui[1], Jianhua Liu[1], Celina Matuszewska[2], Corinne Chanéac[2], Bruno Viana[3], Cédric Bouzigues[4], Daniel Scherman[1], Nathalie Mignet[1] and Cyrille Richard[1]

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Chromium-doped zinc gallate nanoparticles ($ZnGa_2O_4:Cr^{3+}$, ZGO-NPs) provide enhanced sensitivity for enzyme-linked immunosorbent assays (ELISA), particularly in biochemical detection. We have recently shown that these nanoparticles exhibit persistent luminescence that is further amplified in the presence of H_2O_2 [1,2].

This study investigates the impact of varying hydrothermal synthesis durations (6, 12, and 24 hours) on the signal intensity of ZGO-NPs in the presence of H_2O_2. The synthesized ZGO-NPs were integrated into ELISA assays to measure rabbit IgG, and the limit of detection (LOD) was determined. Among the three synthesis durations, ZGO-NPs prepared for 12 hours (ZGO2) showed the lowest LOD of 0.2 pg mL^{-1}, with a detection range from 1 to 1000 pg mL^{-1}. To further improve the LOD, we then functionalized the ZGO-NPs using two strategies: either by conjugating glucose oxidase (GOx) and the detection antibody (AbD) to PEGylated ZGO-NPs (ZGO-GOx-AbD), or simply by linking the detection antibody (ZGO-AbD) and then adding H_2O_2. Functionalization significantly improved the LOD, with ZGO2-GOx-AbD and ZGO2-AbD achieving LODs of approximately 98 fg mL^{-1} and 56 fg mL^{-1}, respectively, with detection ranges from 0.01 to 100 pg mL^{-1}.

These results highlight the importance of synthesis parameters, functionalization and H_2O_2-mediated signal amplification in enhancing detection sensitivity of IgG. Notably, the optimized ZGO2-AbD-based ELISA demonstrated a sensitivity approximately 2000 times better than conventional HRP-based ELISA methods.

This study presents several innovative strategies for improving biomolecule detection, showcasing the potential of ZGO nanoparticles for ultra-sensitive ELISA applications [3].

References (max. 5):

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Acknowledgement:

This research was funded by Agence Nationale de la Recherche (ANR-22-CE09-0029-01 PLEaSe).

Abstract

Thematic Session): Nanobiosciences & Nanomedecine

Disciplinary fields involved: Chemistry

Keywords : luminescence, nanoclusters, nanosensor, plants, extracellular vesicles

Luminescent metal nanoclusters for labelling of biological vesicles

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Among the cellular nanosecretome, extracellular vesicles (EV) are related to epigenetic transgenerational inheritance by binding and internalizing foreign nucleic acids in germ cells (oocyte and spermatozoa). Improving knowledge of this essential process of epigenetic transmission by analyzing EV in human male seminal plasma would allow to identify and isolate the subpopulations of the nanosecretome containing miRNAs of interest and specify their interactions with spermatozoids. In this view, gold nanoclusters (AuNCs) appear as an attractive alternative as nontoxic fluorophore probes because of their luminescence properties, ultrasmall size (<2 nm) and good biocompatibility [1]. Here, we investigated an attractive method that uses fusogenic liposomes[2] to deliver gold nanoclusters into EVs. Luminescent gold nanocluster can be delivered to EV lumen by electrostatic mediated fusion with AuNC preloaded liposomes [3]. This approach guarantees the preservation of the EV membrane without any breakage, thus maintaining compartmental integrity. Different lipid compositions of liposomes preloaded with AuNCs were selected to interact electrostatically with human EV and compared in terms of fusion efficiency. The mixture of liposomes and EVs results in membrane mixing as demonstrated by FRET experiments and fusion revealed by flux cytometry and cryo-TEM. The resulting fused EVs exhibit typical fluorescence of the AuNCs together with an increased size in agreement with fusion. Moreover, the fusion events in mixtures of EVs and AuNCs preloaded liposomes were analyzed by using cryo-electron microscopy. Finally, the ratio of released AuNCs during the fusion between the fusogenic liposomes and the EVs was estimated to be less than 20 mol % by Au titration using ICP spectroscopy.

References :

[1] Chiechio, R. M., Le Guevél, R., Ducarre, S., Solhi, H., Dutertre, S., Pinson, X., ... & Marchi, V. Active U11 Peptide Luminescent Gold Nanoclusters for Pancreatic Tumor Cell Targeting. ACS Applied Nano Materials **2023**, 6(10), 8971-8980.

Abstract

[2] Chiechio, R. M.; Ducarre, S.; Marets, C.; Dupont, A.; Even- Hernandez, P.; Pinson, X.; Dutertre, S.; Artzner, F.; Musumeci, P.; Ravel, C.; Faro, M. J. L.; Marchi, V. Encapsulation of Luminescent Gold Nanoclusters into Synthetic Vesicles. Nanomaterials **2022**, 12 (21), 3875.

[3] Butera, E., Dupont, A., Aimé, A., Ducarre, S., Chiechio, R. M., Even-Hernandez, P., ... & Marchi, V.In Situ Labeling of the Aqueous Compartment of Extracellular Vesicles with Luminescent Gold Nanoclusters. ACS Applied Materials & Interfaces **2024**, 16(17), 21643.

Abstract

Thematic Session : Nanobioscience
Disciplinary fields involved : Biophysics
Keywords : Quantum Dots, nanosensors, FRET, cell adhesion

Quantum Dot-Based FRET nanosensors to quantify molecular assembly within focal adhesion

Audrey Ntadambanya[1], Julien Pernier[2], Violaine David[1], Kimihiro Susumu[3], Igor L. Medintz[3], Mayeul Collot[4], Andrey Klymchenko[4], Niko Hildebrandt[5], Isabelle Le Potier[6], Christophe Le Clainche[1], Marcelina Cardoso Dos Santos[1*]

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Understanding the mechanisms of assembly and disassembly of macromolecular structures in cells relies on solving biomolecular interactions. However, those interactions often remain unclear because tools to track molecular dynamics are not sufficiently resolved in time or space. In this study, we present a straightforward method for resolving inter- and intra-molecular interactions in cell adhesive machinery, using quantum dot (QD) based Förster resonance energy transfer (FRET) nanosensors. Using a mechanosensitive protein, talin, one of the major components of focal adhesions, we are investigating the mechanosensing ability of proteins to sense and respond to mechanical stimuli. First, we quantified the distances separating talin and a giant unilamellar vesicle (GUV) membrane for three talin variants. These variants differ in molecular length. Second, we investigated the mechanosensing capabilities of talin, i.e., its conformational changes due to mechanical stretching initiated by cytoskeleton contraction. Our results suggest that in early focal adhesion, talin undergoes stretching, corresponding to a decrease in the talin-membrane distance of 2.5 nm. We demonstrate that QD-FRET nanosensors can be applied for the sensitive quantification of mechanosensing with a sub-nanometer accuracy.

Abstract

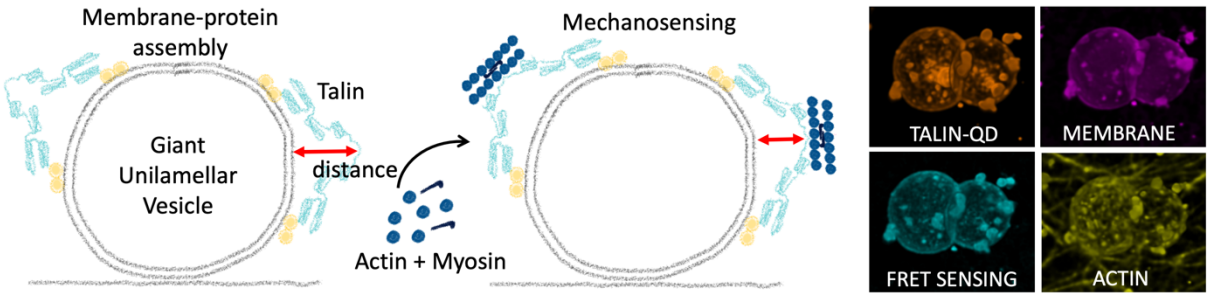

Figure 1. Resolving inter- and intra-molecular interactions in cell adhesive machinery, using quantum dot (QD) based Förster resonance energy transfer (FRET) nanosensors. Using in vitro GUV model, we are investigating mechanosensing ability of talin (left) to sense and respond to mechanical stimuli by mimicking cytoskeleton contraction (actin + myosin, middle). FRET imaging (right) allowed us to quantify distances with sub-nm precision [1].

References :

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Acknowledgement:

This work was partially funded by the Interdisciplinary Object “OI Bioprobe” from Université Paris Saclay.

Abstract

Thematic Session: Nanochemistry and Nanoparticles
Disciplinary fields involved: Chemistry and material science
Keywords: Silver Sulphide, Quantum Dots, Synthesis, NIR-II Imaging, X-Ray Absorption Spectroscopy

Synthesis and Advanced Characterization of Silver Sulphide Quantum Dots for Bio-Imaging

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Abstract

Over the last ten years, silver sulphide quantum dots (Ag_2S QDs) have emerged as a promising non-toxic alternative to traditional binary heavy metal-containing QDs for bio-medical applications due to their ultra-low solubility product constant ($K_{sp} = 6.3 \cdot 10^{-50}$)[1] in aqueous media, low toxicity[2], strong photoluminescence, and tuneable Vis-NIR emission[3]. Typically, research focuses on the organic synthesis of Ag_2S QDs, due to their favourable optical properties, ease of size control, tuneable NIR-II emission, and higher quantum yield[4]. However, recently due to the toxic chemicals and harsh conditions exploited in organic synthesis, there has been a focus on shifting towards greener, aqueous synthetic methods allowing for the synthesis of instantly biocompatible QDs without the need for phase transfer and the associated diminution of their fluorescence intensity[5]. Utilising a novel microwave-based hydrothermal approach, NIR-I and II emitting, L-glutathione capped Ag_2S QDs have been synthesised. Through manipulation of the Ag^+:Ligand feed ratio and reaction time, precise size control and strong emission across the NIR range are visualised through their photophysical properties. XRD studies revealed an intrinsic link between their photoluminescence and their structure, alongside toxicology assays to probe their suitability as *in vivo* imaging probes. Finally, in-depth X-ray Absorption Fine Structure spectroscopy was utilised to divulge the local chemical environment of the QDs and detect their fate *in cellulo*. These results provide an exciting opportunity for the development of new non-toxic bio-probes, with the possibility of conjugation to additional bioactive molecules paving the way for a new generation of multi-modal QD-based bio-probes.

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Abstract

Thematic Session: Nanobiosciences & Nanomedecine

Disciplinary fields involved: Chemistry

Keywords: oxide nanoparticles, nanosensors, persistent luminescence, thermoluminescence

The study of the mechanism of persistent luminescence enhancement in $ZnGa_2O_4$: Cr^{3+} nanoparticles under H_2O_2

Celina Matuszewska[1], Zied Ferjaoui[2], Cyrille Richard[2], Bruno Viana[3], Corinne Chaneac[1]

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Persistent luminescence (PersL) materials exhibit prolonged emission of light lasting from seconds to hours after ceasing the excitation, enabling their use in safety signage, road markings, anticounaterfeiting, and data storage.[1] In recent years, PersL materials have emerged as potential candidates for in vivo imaging, PDT and biosensors.[2] These materials present a significant advantage for sensors applications over conventional luminescent counterparts by achieving a higher signal-to-noise ratio. This is accomplished through the separation of excitation and emission signals, which effectively reduces tissue autofluorescence. In 2023, a novel *in vitro* strategy for biomolecule detection was introduced, exploiting the dose-dependent enhancement of PersL in $ZnGa_2O_4$:Cr^{3+} nanoparticles (ZGO NPs) upon exposure to hydrogen peroxide (H_2O_2). This innovative approach enables both quantitative and qualitative detection of H_2O_2, a product of numerous enzymatic reactions and a crucial biomarker in various diseases, including diabetes, cancer, Alzheimer's, and Parkinson's. Thus, developing sensitive, rapid, and user-friendly H_2O_2 sensors holds significant biomedical importance. This study investigates the mechanism underlying the H_2O_2-induced enhancement of PersL in ZGO NPs. Comprehensive analyses of material structure, surface chemistry, and spectroscopic and electrochemical properties were conducted. The proposed mechanism suggests that redox reactions on the ZGO NPs' surface, triggered by UV-C irradiation in the presence of H_2O_2, generate additional charges that amplify PersL. These findings provide a foundation for advancing the application of PersL materials in biosensing and other innovative fields.

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Abstract

Acknowledgement:
The project was financed by ANR-22-CE09-0029-04 PLEaSe.

Abstract

Thematic Session: Nanochemistry, Nanoparticles, Nanocatalysis
Disciplinary fields involved: Chemistry and Physics of Materials
Keywords: persistent luminescence, NIR, bioimaging, energy transfer

ZGSO persistent nanophosphors for bioimaging in NIR

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Abstract
Persistent luminescence (PersL) nanoparticles (NPs) emit a signal that lasts long after the pre-excitation has ended, enabling highly sensitive bioimaging without background noise [1]. When using UV light as an excitation source before the injection, a strong PersL signal can be detected *in vivo* before disappearing within a few hours. For long-term tracing imaging, PersL NPs produce *in situ* excited signal intensity much lower, compared to the signal obtained after the UV pre-excitation [2-3]. Herein, we report an improvement in the excitation efficiency of visible LED using $Zn_{1.33}Ga_{1.335}Cr_{0.005}Sn_{0.33}O_4$ (ZGSO:Cr^{3+}) PersL NPs. ZGSO:Cr^{3+} NPs were evaluated in terms of structural and optical properties as well as bio-imaging potential. *In vivo* imaging results showed that ZGSO:Cr^{3+} exhibits an approximately 3-fold and 10-fold signal enhancement, respectively, using UV pre-excitation and visible light *in situ* excitation [4]. Based on this finding, a persistent energy transfer strategy is investigated by ZGSO:Cr^{3+} co-dopped with Ni^{2+}, showing an enhancement emission of Ni^{2+} in NIR-II (1000-1400 nm), advantageous for its low photon scattering, deeper tissue penetration, and clearer images [5]. Meanwhile. Cr^{3+} emission in NIR-I (650-950 nm) provides a sensitive depth resolution *in situ.* The proposed "dual-windows PersL imaging method" is validated by ZGSO:Cr^{3+},Ni^{2+} NPs through various excitation condition (e.g. X-rays, UV, visible and NIR light) [5]. Preliminary tests show strong tissue penetration and spatial resolution. *In vivo* results suggest a potential for high-accuracy imaging and the potential of tracing.

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Acknowledgement:
This research was funded by Agence Nationale de la Recherche (ANR-22-CE09-0029-01 PLEaSe).

Abstract

Thematic Session : Nanobioscience
Disciplinary fields involved : Chemistry, Biology
Keywords (max. 4-5)**: fluorescent nanodiamonds, neurotropic peptide, mass spectrometry, axonal transport**

Measuring axonal transport using neurotropic fluorescent nanodiamonds

Baptiste Grimaud[1,2], Brigitte Potier[1], Régis Daniel[4], William Buchmann[4], François Treussart[1]

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2. *CNRS, Université d'Évry Paris-Saclay, Cergy Paris Université, LAMBE, France*

Defects in axonal transport at the molecular level are observed in neurodegenerative diseases, but their roles in the development of the pathology are unknown. We developed a method to measure axonal transport based on the endocytosis of fluorescent nanodiamonds (FNDs) into neurons, followed by recording their movement using fast video-microscopy. We previously demonstrated that this approach is sensitive enough to detect endolysosomal transport deficit in transgenic mouse neuron reproducing change in some molecule concentration found in patients [1]. This approach however suffers from a low FND internalization yield.

In order to enhance their endocytosis, we covalently grafted neurotropic peptides (RVG29) onto pegylated FNDs. We characterized the formation of the FND-PEG-RVG29 conjugate by infrared spectrometry and mass spectrometry (MALDI-TOF), and evaluated its affinity for its target using a surface plasmon resonance biosensor. Preliminary results confirm the formation of a covalent bond.

While continuing to analyze the FND-PEG-RVG29 conjugates, we started to evaluate the gain in internalization efficiency compared to bare FNDs. In both neuron-like cell line (N2a) and primary hippocampal mouse neuron cultures, the functionalized FNDs exhibited a 2- to 3-fold increase in the fraction of particles having a directed motion compare to bare FNDs, suggesting a same fold increase in their uptake. These tests will be extended to progressively more complex models, including *in vitro* stem-cell derived human neurons and *in vivo* zebrafish larva. Altogether, this system could enable precise measurements of axonal transport in relevant models of neurodegenerative diseases.

[1] Haziza, S. *et al*. Fluorescent nanodiamond tracking reveals intraneuronal transport abnormalities induced by brain-disease-related genetic risk factors. *Nat Nanotechnol* **12**, 322–328 (2017).

Acknowledgement:

This work is financially supported by a public grant overseen by the French National Research Agency (ANR) as part of the "Investissements d'Avenir" program (reference: ANR-10-LABX-0035, Labex NanoSaclay); by CNRS MITI interdisciplinary program, and by the interdisciplinary programs BioProbe and 2IM of University Paris-Saclay.

Wednesday March 19th

10:30 A.M. - 12:30 A.M.

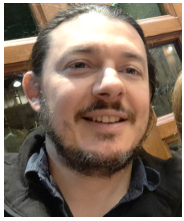
LOUIS ARMAND EST

Program of the session :

Chairs: Nadine MILLOT

HOUR	NAME	TITLE
10:30	**Damien MERTZ** **IPCMS - CNRS**	**Chemical engineering of activable core@shell mesoporous silica nanocomposites for theranostic applications**
11:00	Theo LUCANTE ICPEES - CNRS	Design of surfactant-coated iron oxide nanoparticles for enhancing phosphate removal in the peritoneal dialysis process
11:15	Halima ALEM IJL - Université de Lorraine	Folate-Functionalized Superparamagnetic Core/Shell Nanoparticles for Targeted Drug Delivery and Stealth Behavior Study
11:30	Rafael Gabriel PORRAS GUERRERO ICPEES - UNISTRA	Functionalized Iron Oxide Nanoparticles for targeted imaging of Alzheimer's Disease: Î²-amyloid peptide detection and interaction
11:45	Pierre SARFATI LVTS/INSERM - Université Paris Cité	Hybrid particles for the physical treatment of thrombotic diseases
12:00	Xilling SONG IMAP - ESPCI	MOF-Based Microneedles for Synergistic NO/Â·OH Antibacterial Therapy
12:15	Yang ZHANG LCBPT - Université Paris Cité	Innovative surface functionalization strategy for the design of antioxidant coated-Gold nanoparticles for biomedical applications

Damien MERTZ (CNRS - IPCMS, Strasbourg)



https://www.ipcms.fr/en/equipe/functionalized-nanoparticles/

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Short biography

Damien Mertz is a CNRS researcher in materials chemistry developing his research at the Institut de Physique et Chimie des Matériaux de Strasbourg (IPCMS) since 2013. After a PhD degree in physical chemistry from the University of Strasbourg (2008) focused on the elaboration of mechanotransductive polymer materials, he was a postdoctoral fellow at the University of Melbourne, Australia, working on silica templated protein microparticles for drug delivery applications (2009-2011). At CNRS, he currently works on the chemical engineering of activable mesoporous silica theranostic nanocomposites endowed with treatment functions (drug delivery, magnetic hyperthermia, phototherapy) combined with imaging (MRI or fluorescence imaging).

Chemical engineering of activable core@shell mesoporous silica nanocomposites for theranostic applications.

Designing responsive nanoplatforms for magnetic field- or NIR light-induced hyperthermia coupled with drug delivery still remains a great challenge for nanomedecine applications.[1] Iron oxide nanoparticles (IO NPs) and carbon-based materials are suitable external field-responsive cores respectively for magnetic hyperthermia (MHT) and phototherapy (PTT) while mesoporous silica (MS) shells are well adapted coatings given their biocompatibility, easy surface modification and high drug delivery capability. In our team, we have addressed complementary approaches for the chemical engineering of activable core@shell MS nanocomposites[2], especially tailored with large pore mesoporous silica structures. The first part of this presentation will concern the controlled growth of large pore stellate silica (STMS) shell around IO NPs to afford a range of tuned porous structure denoted IO@STMSx NPs[3]. We investigated in depth the pore structure by nitrogen adsorption, transmission electron microscopy (TEM) and in situ-liquid phase TEM. The influence of this tuned silica shell was evaluated for magnetic resonance imaging (MRI), MHT and NIR-light photothermia applications. In a second part, the chemical engineering of large pore silica around carbon nanotubes will be presented. The large pores are suitable to immobilize a high amount of dephosphorylating enzymes[4] acting as precursors for the self-assembly of peptide fibers providing an in situ architectured hydrogelation from the core@shell nanomaterial (Coll. ICS, Strasbourg[5]). These novel nano-architectured hydrogels were found relevant for drug loading and evaluated for NIR induced-drug release combined with photothermia.

Keywords

nanoplatelets, quantum dots, self-assembly, small angle scattering, twisting

Acknowledgement

These works have been or are currently supported by: IDEX Univ. of Strasbourg, MICA-Carnot Alsace, ANR projects (ANR-19-CE09-0004—CORELMAG and ANR-24-CE18-1966-ISCHeMAG).

References

[1] Coord. Chem. Rev. 2022, 452, 214309 [2] Appl. Mater. Today 2019, 16, 301.; Mater. Today Chem. 2020, 17, 100308. [3] Nanoscale 2024, 16, 15585. [4] Materialia 2022, 22, 101414; ACS Appl. Nano Mater. 2022, 5, 120. [5] Front. Bioeng. Biotechnol. 2020, 8, 938; Langmuir 2019, 35, 33, 10838.

Abstract

Thematic Session (eg. Nanophotonics & nano-optics, nanomaterials, nanobioscience …)**: Nanochemistry & Nanoparticles**
Disciplinary fields involved (eg. Chemistry, Physics, Biology …)**: Chemistry, Physical chemistry**
Keywords (max. 4-5)**: Surfactant-coated iron oxide nanoparticles, phosphate removal, peritoneal dialysis, isothermal titration calorimetry**

Design of surfactant-coated iron oxide nanoparticles for enhancing phosphate removal in the peritoneal dialysis process

Théo Lucante[1,2], Joana Vaz-Ramos[1,2], Manon Kretz[1], Véronique Hubscher-Bruder[3], Jérémy Brandel[3], Philippe Choquet[4], Ariane Zaloszyc[5], Sylvie Bégin-Colin[1,2].

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4. *ICUBE, UMR 7357, Imagerie Préclinique – Hôpital de Hautepierre, 67412 Illkirch, France*
5. *INSERM, UMR_S 1109, Service pédiatrique – Hôpital de Hautepierre, 67000 Strasbourg, France*

Chronic kidney disease (CKD) results in the progressive loss of the kidney's purification functions, leading notably to accumulation of phosphates in blood. Chronically high phosphate blood concentration is dangerous because it can lead to life-threatening complications. In absence of a transplant, treatment of end-stage CKD involves dialysis techniques: peritoneal dialysis (PD) and hemodialysis. PD has many advantages but its phosphate blood purification efficiency needs to be improved. A promising approach to enhance phosphate removal in PD process is working on the formulation of the dialysate (a specifically-designed solution infused in the patient's peritoneal cavity during a PD process) by incorporating iron oxide nanoparticles (IONs) well-known to have a high affinity for phosphates.
IONs were thus synthesized by coprecipitation and polyol-based synthesis methods and coated with anionic and cationic surfactants (TA, PAA, PDADMAC) by adding them directly during the IONs synthesis or by performing a post-functionalization. The isothermal titration calorimetry (ITC) technique was used to study the contributions of both IO surface and surfactants on phosphate adsorption. ITC experiments evidenced phosphate adsorption on each IONs; no contribution of tested surfactants on phosphate adsorption; and gave information on some surfactant desorption during phosphatation.
IONs were tested in phosphate transport experiments in dialysis laboratory-scale setups with conditions as close as possible to those of the PD process. These setups involved either a dialysis tubing ("tubing-mode") or a dialysis cassette ("cassette mode"): solutions mimicking blood (containing phosphates) and dialysate are thus separated by a semi-permeable membrane. The tubing mode led to a kinetics of phosphate transport close to that reported for clinical PD. The cassette mode evidenced a phosphate electrodiffusion induced by electrolytes in dialysate, as well as a Donnan effect induced by charged IONs. These experiments confirmed the IONs potential to enhance phosphate removal with a maximum efficiency reached in 2h.

Abstract

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Acknowledgement:

This research project was funded by French national agency for research (ANR) under the project PHODIA 2021 (ANR-21-CE09-0037).

Abstract

Thematic Session : Caractérisation à l'échelle nano
Disciplinary fields involved: Physical-Chemitry and Nanomaterials
Keywords: Superparamagnetic nanoparticles, Core/shell nanostructure, Folate targeting, Stealth drug delivery

Folate-Functionalized Superparamagnetic Core/Shell Nanoparticles for Targeted Drug Delivery and Stealth Behavior Study

Zied Ferjaoui[1], Raphaël Schneider[2], Halima Kerdjoudj[3], Damien Mertz[4], Fabienne Quilès[5], Khalid Ferji[6], Eric Gaffet[1] and Halima Alem[1]

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[2]*Université de Lorraine, CNRS, LRGP (UMR 7274), F-54000 Nancy, France*
[3] *Université de Reims Champagne Ardenne, Biomatériaux et Inflammation en Site Osseux (BIOS) EA 4691, F-51100, Reims, France*
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The development of smart nanocarriers for targeted cancer therapy has gained attention due to their potential for precise drug delivery and minimized side effects. This study presents a novel theranostic nanosystem based on superparamagnetic iron oxide nanoparticles functionalized with thermo-responsive polymer brushes and folic acid (FA) as a targeting ligand. The core of the system consists of Fe_3-δO_4 nanoparticles (10 nm) synthesized via coprecipitation, while the shell comprises grafted copolymers of 2-(2-methoxy)ethyl methacrylate and oligo(ethylene glycol) methacrylate. Nanometric-scale characterization was performed using High-Resolution Transmission Electron Microscopy (HR-TEM), X-ray Diffraction (XRD), Dynamic Light Scattering (DLS), and Fourier-transform infrared spectroscopy (FT-IR). TEM confirmed the core/shell structure. The hydrodynamic diameter and colloidal stability were assessed in physiological media, showing aggregation above the Lower Critical Solution Temperature of 41°C. FT-IR confirmed successful polymer grafting and FA conjugation. The interaction with human serum albumin (HSA) and fibrinogen (Fbg) was characterized using a combined FT-IR and DLS approach. Minimal adsorption of HSA was observed, attributed to the protein-repellent nature of the polymer shell. In contrast, partial Fbg diffusion into the polymer layer was noted, suggesting limited protein corona formation. This stealth behavior enhances the circulation time and targeting efficiency of the nanoparticles. These findings demonstrate the potential of this smart nanosystem for cancer therapy, controlled drug release, and hyperthermia-based treatment.

References:

Z. Ferjaoui, et al. *ACS Appl. Mater. Interfaces* **2019**, 11, 34, 30610-30620
Z. Ferjaoui, et al. *Advanced Materials Interfaces* **2023** 10 (12), 2202364

Acknowledgement:

SMI (LCPME), CC3M (IJL), CCXGamma (IJL) platforms of Lorraine University and CNRS.
This work was supported by the French PIA project “Lorraine Université d’Excellence” reference ANR-15-IDEX-04-LUE and University Institute of France (IUF).

Abstract

Thematic Session: Nanobiosciences & Nanomedicine
Disciplinary fields involved: Chemistry
Keywords: IONPs, Amylovis, MRI Contrast agent, βA fibers, Alzheimer's disease

Functionalized Iron Oxide Nanoparticles for targeted imaging of Alzheimer's Disease: β-amyloid peptide detection and interaction

Gabriel Rafael Guerrero Porras[1-3], Marie David[4], Valerie Mazan[5], Gilles Ulrich[1], Marc Schmutz[6], Anais Becker[1], Alberto Bencomo Martínez[2], Chryslaine Rodríguez Tanty[2], Alicia M. Díaz García[3], Marquiza Sablón Carrazana[2], Sylvie Bégin-Colin[1]

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3. *Bioinorganic Laboratory (LBI), Department of General and Inorganic Chemistry, Faculty of Chemistry (FQ), University of Havana (UH), Havana, Cuba*
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The accumulation of β-amyloid peptide (βA) leads to the formation of senile plaques, a hallmark of Alzheimer's disease (AD)[1]. This study explores innovative detection methods using contrast agents (CAs) modified with βA-related target ligands (βA-TL) to enhance sensitivity in Magnetic Resonance Imaging (MRI)[2]. For this purpose, Amylovis compounds as βA-TL, were coupled to two types of functionalized iron oxide nanoparticles (IONPs)[3,4]. The amount of Amylovis conjugated and its influence on the CAs properties of the IONPs were studied by HPLC and relaxometry, respectively. Also, the IONPs were characterized by TEM, XRD, and IR spectroscopy as well as their colloidal stability by DLS. The fibers resulting from the βA assembly were used to test the targeting efficiency of the designed IONPs. The formation of βA fibers in the presence of IONPs coupled with βA-TL was explored by fluorescence and transmission electron microscopy studies. The results corroborate the predictions of *in silico* studies indicating hydrophobic interactions between βA fibers and Amylovis that influence the βA-fibrillation process[4]. The amount of IONPs was also observed to affect the kinetics of the βA fiber formation whereas the introduction of IONPs bearing or not βA-TL to the medium containing already formed fibers showed a stronger interaction of vectorized IONPs with fibers. Overall, the results highlight the dual potential of Amylovis-grafted IONPs as effective CAs and therapeutic agents for AD.

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Abstract

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Acknowledgement:
PHC 49779PH (French Embassy in Cuba); PDI, CDE and ED182 (UNISTRA, Strasbourg, France); PN305LH013-007, PN305LH013-008, PN223LH010-062 and PN211LH008-033 (CITMA, Cuba)

Abstract

Thematic Session: Nanomedicine

Disciplinary fields involved (eg. Chemistry, Physics, Biology …)**: Chemistry, Physics & Biology**

Keywords (max. 4-5)**: hybrid particles ; photo-thermal action ; magneto-mechanical action ; magnetic targeting ; thrombolysis**

HYBRID PARTICLES FOR THE PHYSICAL TREATMENT OF THROMBOTIC DISEASES

Pierre Sarfati[1], Thibault de La Taille[1], Rachida Aid[1,2], Louise Fournier[1], Baptiste Amouroux[1], Claire Wilhelm[3], Yoann Lalatonne[1,4,*], Cédric Chauvierre[1,*]

1. *INSERM U1148 (LVTS), UP Cité, USPN, Paris, France*
2. *UMS34 FRIM, UP Cité, Paris, France*
3. *PCC, CNRS UMR168, Institut Curie, Sorbonne, PSL, Paris, France*
4. *Biophysique et Médecine Nucléaire, AP-HP, Hôpital Avicenne, Bobigny, France*

**contributed equally*

Abstract (**no longer than 250 words** or 18 lines max. incl. figure), Calibri 11, single line spacing, black)

Thrombosis is responsible for most strokes and heart attacks, which are the leading causes of death worldwide [1]. Reperfusion is commonly performed with thrombolytics such as recombinant tissue plasminogen activator (rt-PA) but these present numerous limitations (severe adverse effects, few eligible patients, low recanalization rate). With the objective of designing a safer and efficient treatment, we developed hybrid particles for a combined photo-thermal and magneto-mechanical thrombolysis, through respectively light and magnetic stimulation, with a thrombus-targeting capacity enabled by an external permanent magnet [2], [3].

To achieve this strategy, we embedded iron oxide nanoparticles that have great photothermal and magnetic properties in polysaccharide microbeads (Patent - INSERM - 01/12/2023). We confirmed the hybrid structure by electronic microscopy and FT-IR spectroscopy. Through DLS and ELS, we studied the time stability in size and charge of these new microsystems and characterized them also in saline. Magnetization measurements and particle counting were performed to compute the magnetic moment of these hybrid particles. Also, their response to magnetic stimulation was verified. This was completed with photothermal tests to estimate their ability to increase temperature when irradiated by a near-infrared laser. In an *in vitro* targeting assay, these particles could be retained on platelets by a magnet while flowing through microchannels in venous or arterial conditions, proving their ability to magnetically target the thrombus. Finally, the effect of different levels of hyperthermia as well as the thrombolytic capacity of this photo- and magneto-stimulated treatment are being evaluated on clots *in vitro*.

Abstract

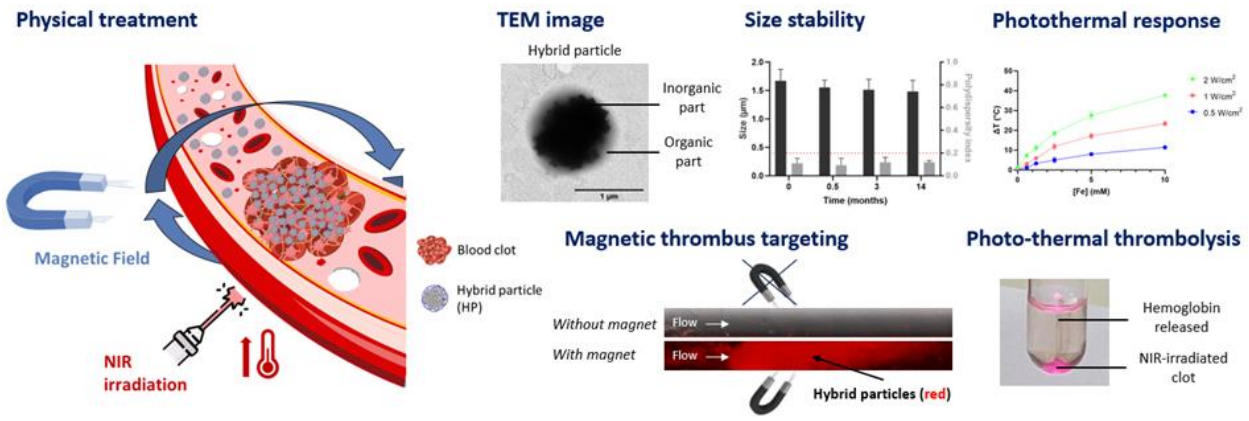

Figure: Graphical abstract

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Acknowledgement:

This work is funded by ANR-20-CE18-0005-01 "FightClot" and we acknowledge Université Paris Cité and the MTCI doctoral school for the PhD grant.

Abstract

Thematic Session: nanomaterials

Disciplinary fields involved: Chemistry

Keywords: Metal-organic frameworks, Nitric Oxide gas therapy, 3D-printing microneedles

MOF-Based Microneedles for Synergistic NO/·OH Antibacterial Therapy

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2. *Institut Necker-Enfants Malades - INEM, Université Paris Cité, Paris, France.*

Abstract

Bacterial infections pose a significant threat to global health, exacerbated by the rise of drug-resistant bacteria due to the misuse of antibiotics.[1] Recently, gaseous nitric oxide (NO) has attracted enormous attention in antibacterial applications.[2] L-arginine (L-arg), a biocompatible amino acid, reacts with excessive hydrogen peroxide (H_2O_2) in wounds to release NO via a non-enzymatic pathway, ensuring high biosafety.[3] However, direct L-arg delivery faces challenges like short half-life and low bioavailability, necessitating efficient delivery systems. Metal-organic frameworks (MOFs) are porous crystalline materials composed of metal ions and organic ligands. The structural diversity and tunable pore sizes of MOFs make them ideal carriers for therapeutic agents. Among them, MIL-100(Fe) (MIL stands for Materials Institute Lavoisier), a benchmark mesoporous iron trimesate MOF nanocarrier, stands out for good biocompatibility, high drug-loading capacity, and biodegradability.[4] Moreover, MIL-100(Fe) is promising for the Fenton reaction to produce hydroxyl radicals (·OH) and induce ferroptosis-like bacteria death.[5] Additionally, MIL-100(Fe) excellent chemical stability allows this nanoMOF to be processed into diverse formats,[4] significantly expanding its utility in medical devices.

In our study, L-arg was encapsulated into MIL-100(Fe) particles through physical adsorption. MIL-100(Fe)@L-arg, along with lactate oxidase (LOx), which catalyzes the conversion of excess lactate in wound area into H_2O_2, was incorporated into a polymer matrix to fabricate microneedle patches using 3D-printed molds. When applied to wounds, the patches dissolved in the wound environment, releasing LOx and MIL-100(Fe)@L-arg particles. In the presence of H_2O_2, the synergistic production of NO and ·OH worked to effectively kill bacteria and promote wound healing.

References:

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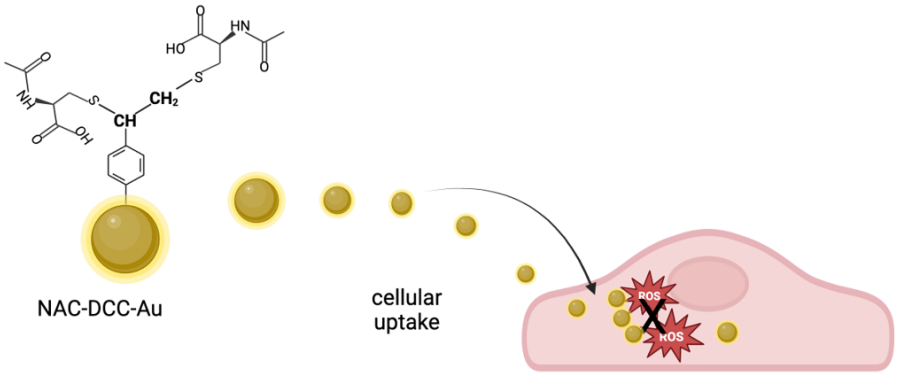
Acknowledgement:

Thanks to Zhihao from IMAP for the design of the microneedles.

Innovative surface functionalization strategy for the design of antioxidant coated-Gold nanoparticles for biomedical applications

Reactive oxygen species (ROS) are oxygen-containing molecules with high reactivity, managed by a combination of enzymatic and non-enzymatic antioxidant systems. Within the heart, ROS are vital for regulating cellular homeostasis, affecting cell proliferation, differentiation, and the excitation-contraction coupling. However, when ROS levels exceed the antioxidant defense capacity, oxidative stress can occur. These excessive ROS can cause cellular and molecular damage, eventually leading to cardiac dysfunction. This study presents a novel approach to address this issue using N-acetylcysteine-functionalized gold nanoparticles. We developed a photo-click chemistry strategy utilizing diazonium salt (DCC) as a coupling agent under UV irradiation to graft NAC onto gold nanoparticles. This method aims to create a stable, high-loading antioxidant nanoformulation. The synthesized NAC-DCC-Au NPs demonstrated high NAC loading capability and long-term stability. Oxygen Radical Absorption Capacity Assay (ORAC) revealed that the nanoparticles exhibited high antioxidant activity, effectively trapping ROS and mitigating oxidative stress. Furthermore, the NAC-DCC-Au NPs showed excellent biocompatibility, as evidenced by high cell viability rates and efficient cellular uptake. These findings suggest NAC-DCC-Au NPs as a promising therapeutic approach for preventing ROS-induced cellular and molecular damage in the heart, potentially improving cardiac function in oxidative stress-related conditions. Given that ROS are implicated in Fe corrosion of stents, future research will explore Fe-based bioresorbable stent surface functionalization with NAC-Au NPs to enhance biocompatibility. This innovative approach could lead to significant advancements in cardiovascular interventions and the management of oxidative stress-related cardiac disorders.



Thursday March 20th

10:30 A.M. - 12:30 A.M.

LOUIS ARMAND OUEST

Program of the session :

Chairs: Stéphane MORNET

HOUR	NAME	TITLE
10:30	**Ariane BOUDIER** **CITHEFOR - Univ. Lorraine**	**Copper nanoclusters : the 1st treatment for menkes disease**
11:00	Henri COSTE ICMCB - CNRS	Tailoring the surface chemistry of nanoparticles to modulate their Protein Corona
11:15	Udara Bimendra Gunatilake KEKULUPOLAGE ICGM - Université de Montpellier	Peroxidase Mimicking Activity of Polyethyleneimine-mediated Prussian Blue Nanoparticles
11:30	Marine SAGASTUY PHENIX - Sorbonne Université	Fusion of Magnetic Liposomes with Model and Plasma Membranes: Towards Cytoplasmic Delivery
11:45	Mustafa GHARIB LVTS - Université Sorbonne Paris Nord	Replicating Nanoparticles-Based Cytosolic Sensing: Challenges and Key Insights from the 1st Replication Initiative in NanoBioscience
12:00	Naseer Haziq KHAN ITODYS - Université Paris Cite	Functionalization of Tobacco Mosaic Virus with Plasmonic Nanoparticles For In-Solution Sensing Applications
12:15	Min-Hui LI IRCP - CNRS	Heavy-metal-free photocatalysts by polymer micelles/vesicles in photobiocatalysis: under aerobic condition in combination with native enzymes and under anaerobic condition for potential hypoxia cancer therapy

Ariane BOUDIER (Univ. Lorraine - CITHEFOR, Nancy)

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Short biography

Ariane Boudier is Full Professor at the University of Lorraine, teaching Physical and General Chemistry at the Faculty of Pharmacy in nancy. She is a member of the Laboratoire Réactions et Génie des Procédés, LRGP, UMR 7274 CNRS. Since 2009, she has been working on the synthesis and characterisation of metallic nanoparticles for medical applications to develop new drugs or innovative surfaces for medical devices. She is the author/co-author of more than 60 publications and 3 patents. One drug synthesized by her received the Orphan Drug Designation by the European Medicine Agency in 2022 and by the Food and Drug Administration in 2024. She has been a member of the Institut Universitaire de France since 2023 on an innovation project. This project concerns the synthesis and characterisation of copper nanoclusters for application in Menkès disease.

Copper nanoclusters: the 1st treatment for Menkes disease

Menkes' disease is a very rare genetic disorder of copper metabolism with a life expectancy of 3 years [1]. This disease is linked to a deficiency of copper transporter (ATP7A) present in the intestine and in the blood-brain barrier (BBB) inducing a severe copper deficiency with a combined deficiency of essential cuproproteins. This leads to multisystem symptoms and as severe neurodegeneration. The only treatment using copper-histidine complex remains palliative with a poor biodistribution to the brain and unchanged fatal prognosis. Copper nanoclusters (CuNC) were synthetized [2], characterized and tested in Moblo mice (knock down model for ATPase7A transporter). They are characterized by a size of 0.7 nm in diameter, with a metallic core surrounded by biodegradable ligands and can be stored for a long time (>2 years). Subcutaneous injections of CuNC into Moblo mice from 5 days of life saw their life expectancy considerably increased, in correlation with a restoration of the activity of the cuproproteins. Indeed, tyrosinase, a cuproprotein responsible for the production of melanin, showed its activity restored by a darkening of the fur. Images obtained by positron emission tomography after injection of radiolabeled 64CuNC suggested the biodistribution to the brain. The activity of cytochrome C oxidase in the brain showed a restoration of the activity of the brain mitochondrial respiratory chain. Neurobehavioral tests (horizontal scale, open field) showed a drastic improvement in locomotion and coordination of movements in mice, that received CuNC. All of these results allowed the obtention of orphan drug designation from the European Medicine Agency (EMA) and from the Food and Drug Administration (FDA) and the establishment of a pharmaceutical form of the CuNC with the aim of launching clinical trials as soon as possible.

Keywords

Nanoclusters, metabolic disorder, copper, restoration of cuproenzyme activities, neurobehavioral tests

Acknowledgement

IUF for financial support, SATT SAYENS for their support via CuNP2 project, CNRS through the MITI interdisciplinary programs (CopperNiC)

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Abstract

Thematic Session: Nanobiosciences & Nanomedicine

Disciplinary fields involved: Chemistry, Physico-Chemistry, Biology

Keywords: Iron Oxide Nanoflowers, Surface chemistry, Protein Corona

Tailoring the surface chemistry of nanoparticles to modulate their Protein Corona

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It is clearly established that the protein corona (PC) formed by interaction with plasma proteins on injected nanoparticles (NP) determines their biological identity, dictating the NP cell uptake properties and their fate in vivo[1]. The objective of this study is to develop nanoprobes capable of targeting resident foamy macrophages within vulnerable atherosclerotic plaques. Therefore, the PC composition related to the synthetic identity of the NP needs to be adapted for better pharmacokinetic and targeting efficiency. To achieve this objective, chemical moieties will be grafted on the surface of PEGylated NP to promote interactions with the Apolipoprotein-A1 (Apo-A1), a protein involved in the cholesterol efflux at the atherosclerotic plaques.

Covalent chemical surface modifications were applied on maghemite nanoflowers (NFs), known for their remarkable magnetic relaxivities useful for MRI[2], generating a library of synthetic surface identities. The different surfaces were characterized in depth to highlight their potential links with the biological identities established once the PC was formed after incubation in human plasma.

The most promising samples that best interact with the Apo-A1, were selected by SDS-PAGE screening. These results were comforted by the determination of the affinity constants of the protein for each NF measured through fluorescence quenching of the tryptophan residues[3]. Comparative *in vitro* studies of interactions with foamy macrophages are currently in progress by incubation of NFs with the cells observed by confocal microscopy. Further in this project, the objective will be to inject the NFs displaying the best proteomic and Apo-A1 adsorption profiles *in vivo* to atherosclerosis mice model to attempt to image the plaques.

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Acknowledgement:

This project is funded by the ANR (Agence Nationale de la Recherche); *ANR-22-CE09-0001.*

Abstract

Thematic Session: Nanochemistry & Nanoparticles

Disciplinary fields involved: Chemistry

Keywords: Prussian blue nanoparticles, nanozyme, peroxidase mimetic, cyano-bridged coordination polymers.

Peroxidase Mimicking Activity of Polyethyleneimine-mediated Prussian Blue Nanoparticles

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Biosensors often use horseradish peroxidase (HRP) for detecting target molecules by converting biochemical interactions into measurable signals via its catalytic activity. However, natural enzymes face drawbacks such as low stability, environmental sensitivity, non-conductivity, and costly synthesis, prompting the use of nanozymes.[1,2] In this instance, Prussian blue nanoparticles (PBNPs) have been identified as a promising candidate for biomimetic peroxidase-like (POD) activity.[3] The decoration of PBNPs with the desired functional polymers (such as amino- or carboxylate-based) primarily facilitates the subsequent linkage of biomolecules to the nanoparticles for utilisation in biosensor applications. Therefore, the elucidation of the catalytic POD mimicry of these systems represents a significant scientific interest but has not been investigated in depth yet. This study explores the synthesis and characterization of polyethyleneimine (PEI)-mediated PBNPs (PB/PEI NPs) using diverse protocols to produce particles with varying sizes and shapes. Physicochemical analysis was conducted to understand their properties and assess their potential as peroxidase-mimicking nanozymes. The catalytic activity of these PB/PEI NPs was evaluated using a TMB/H_2O_2 system, with the HRP serving as a benchmark for comparison. It is shown that most PB/PEI NPs displayed higher POD-like activity than PBNPs, with higher activity observed in particles of smaller size, higher Fe content, and higher Fe^{2+}/Fe^{3+} ratio. Moreover, the nanoparticles have exhibited augmented chemical stability in comparison to HRP, substantiating the viability of PB/PEI NPs as a prospective nanozyme. This study offers fundamental insights into PB/PEI NPs and their POD-like activities, which provide guidance for the selection of suitable particle types for biosensor applications.

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Acknowledgement: The authors acknowledge the support from EuroNanoMed-JTC2021-110 project, which is funded by the European Union through Instituto de Salud Carlos III and Agence Nationale de la Recherche (ANR).

Abstract

Thematic Session: **Nanobioscience**
Disciplinary fields involved: Chemistry-Biology
Keywords (max. 4-5)**: Magnetic liposomes, fusion, intracellular delivery**

Fusion of Magnetic Liposomes with Model and Plasma Membranes: Towards Cytoplasmic Delivery

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Magnetic nanoparticles (MNPs), like many other nanoparticles, are internalized by cells via endocytosis and become confined within intracellular vesicles known as endosomes.[1] However, for several bio-applications, such as cellular engineering or magnetic hyperthermia treatments, it is necessary that MNPs access the cell cytoplasm. This cytoplasmic delivery would minimize dipolar interactions between the MNPs and enhance their intracellular heating properties[2]. In this study, we propose a novel strategy using **Magnetic Fusogenic Liposomes (MFLs).** Fusogenic liposomes have the unique ability to fuse with the plasma membrane, and consequently deliver their contents directly into the cytosol.

MFLs composed of DOTAP/DOPE/PEGPE/TopfluorPE (45.5/45.5/4.5/4.5 molar ratio, 200 nm) were prepared by reverse phase evaporation method. The protocol was adapted from a previous study to avoid the precipitation of anionic MNPs in contact with cationic lipids (DOTAP)[3]. The fusion of MFLs was first studied on acceptor liposomes with well-defined charge (anionic or zwitterionic), size, and membrane composition. Fluorescence Resonance Energy Transfer (FRET), light scattering experiments, and isothermal titration calorimetry (ITC) demonstrated that fusion is initiated by electrostatic interactions, as already described in the literature[4], and is strongly influenced by the lipid composition. Furthermore, the resulting hybrid liposomes exhibited magnetic properties. We also studied the fusion of MFLs with living cells. Confocal microscopy experiments confirmed the fusion, while cell viability assays performed after magnetic hyperthermia cycles provided insights into the heating capacity of the magnetic nanoparticles.

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Abstract

Thematic Session: Nanobiosciences & Nanomedecine
Disciplinary fields involved: Chemistry, Biology, Nanoscience
Keywords: Replication, Cytosolic sensing, Carbon dots, Endosomal escape, Research integrity

Replicating Nanoparticles-Based Cytosolic Sensing: Challenges and Key Insights from the 1st Replication Initiative in NanoBioscience

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Abstract

Reproducibility is a cornerstone of robust scientific research, yet its challenges remain pervasive, particularly in fields characterized by intricate methodologies and rapid innovation, such as nanobioscience. As part of the NanoBubbles project, we aim to replicate influential studies employing nanoparticles for cytosolic sensing, a critical area for advancements in nanomedicine. From a curated corpus of highly cited articles, we identified eight representative studies for replication.

In our 1st replication attempts, we focused on a study describing a carbon-dot-based dual-emission nanohybrid system designed for the ratiometric fluorescence sensing of Cu^{2+} ions within the cytosolic compartment. Following the original protocols closely, we successfully synthesized the reported nanostructure, implementing modifications and filling in missing experimental details to ensure accurate replication. Our approach was rigorously pre-registered with the Peer Community In-Registered Reports (PCI-RR) platform to invite feedback from experts and the public before lab work commenced, aiming to enhance methodological transparency and rigor.[1-3]

Despite this meticulous replication effort, subsequent testing revealed significant discrepancies, particularly the failure of the reported intracellular Cu^{2+} sensing mechanism. Additional investigation uncovered evidence of data irregularities within key figures of the original publication, which raised concerns about the integrity of the findings as well as the reliability of this widely referenced study.

Here, we will present the full outcomes of our replication effort, including insights into experimental challenges, results, and the broader implications for nanoparticle-based biosensing reliability.

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Abstract

Acknowledgement

This work is part of NanoBubbles, a Synergy grant from the European Research Council (ERC), within the European Union's Horizon 2020 programme, grant agreement no. 951393.

Abstract

Thematic Session : Nanomaterials
Disciplinary fields involved : Chemistry
Keywords: Gold Nanoparticles, SERS , Biomineralization

Functionalization of Tobacco Mosaic Virus with Plasmonic Nanoparticles For In-Solution Sensing Applications.

Haziq Naseer Khan †, Cora Moreira Da Silva †, Nathaly Ortiz-Pena ‡, Stéphanie Lau-Truong† , Tomas Moravec¶, Damien Alloyeau ‡ and Nguyet Thanh Ha Duong † *

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Abstract

The use of biomolecular templates has been instrumental in generating complex hybrid materials. The nanotechnology field has shown a keen interest in plant viruses due to their symmetrical attributes, multivalency, uniformity in size, and self-assembly capabilities. An important advancement is employing plant virus capsids as frameworks to organize three-dimensional nanostructures, which has led to the emergence of novel functional nanomaterials. The demand for these hybrid nanostructures is on the rise because of their prospective applications in medical imaging, drug delivery, chemical detection, and catalysis. The Tobacco mosaic virus (TMV) is particularly recognized for its robustness against heat and chemical degradation. It is also considered safe for human handling and can be modified with a variety of functional materials[1-3].

This study examines the use of TMV modified with surface-attached Cysteine (TMV-Cys) as a base for assembling gold nanoparticles (AuNPs) and "Gold core@gold-silver alloy nanoparticles (Au@Au-Ag NP) in varying proportions to create nanohybrids with exact control over their size and shape. The proximity arrangement and combination of the nanoparticles substantially alter their plasmonic characteristics. We have utilized biomineralization and direct attachment methods to adhere NPs onto TMV-Cys. The attachment of AuNPs on TMV-Cys was monitored through In-situ transmission electron microscopy and confirmed through fluorescence quenching tests. Additionally, we probed the surface modification of TMV-Cys combined with AuNPs and TMV-Cys with Au@Ag-Au NP hybrids employing Raman reporter molecules (BPE & Rhodamine). Our research suggests that the TMV-Cys@NP composite is highly promising as a versatile tool for in-solution Surface-Enhanced Raman Spectroscopy (SERS), especially for detecting biomolecules. Moreover, these hybrids can also exhibit potential as photothermic agents.

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Abstract

Thematic Session: Nanobiosciences & Nanomedecine
Disciplinary fields involved: Chemistry, Biology
Keywords: photoredox catalyst, amphiphilic polymer self-assembly, enzyme cofactor, photobiocatalysis, phototherapy

Heavy-metal-free photocatalysts by polymer micelles/vesicles in photobiocatalysis: under aerobic condition in combination with native enzymes and under anaerobic condition for potential hypoxia cancer therapy

Min-Hui LI[1], Nian ZHANG[1], Hui CHEN[1], Yandong MA[1], Xin JI[2]

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2. *Key Laboratory of Biomaterials of Guangdong Higher Education Institute, Engineering Technology Research Center of Drug Carrier of Guangdong, Department of Biomedical Engineering, Jinan University, Guangzhou 510632, China*

Biocatalytic transformation has attracted increasing attention in the green synthesis of chemicals due to the diversity of enzymes, their high catalytic activities and specificities, and environmentally benign conditions. Most redox enzymes in nature are dependent on nicotinamide cofactors like NAD^+/NADH. The use of solar energy in cofactors' regeneration through the combination of photocatalysis and biocatalysis provides an extraordinary opportunity to make complete green processes. However, this combination has been challenged by the rapid degradation and deactivation of enzymes by photogenerated reactive oxygen species (ROS). Here, we design core-shell structured polymer micelles and vesicles bearing organic luminophores as visible-light-mediated photocatalysts for stable and recyclable photobiocatalysis under aerobic conditions.[1] The NAD^+ can be efficiently regenerated from NADH by the photoactive hydrophobic part of polymer colloids, while the enzyme is screened from the attack of ROS by their hydrophilic surface layer. These polymer colloids have potential application in industrially relevant photobiocatalytic systems.

On the other hand, NADH/NAD^+ cofactors for oxidoreductases play a critical role in numerous intracellular biochemical reactions, like in mitochondrial electron transport chain, mitochondrial tricarboxylic acid cycle, glycolysis and redox balance. Therefore, photocatalysis-induced perturbation of NADH/NAD^+ balance is expected to provoke metabolic dysfunction in cancer cells.[2,3] More interestingly, our AIE polymer colloids can still photocatalyze the NADH-NAD^+ transformation in the absence of O_2 or cytochrome c which is commonly used as electron acceptor to let the triplet excited state return to the ground state. Since hypoxia is a common feature of solid tumors, these polymer colloids are promising for potential cancer phototherapy.

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Thursday March 20th

2:00 P.M. - 4:30 P.M.

ROOM CD

Program of the session :

Chairs: Gaetan BELLOT

HOUR	NAME	TITLE
14:00	**Nesrine AISSAOUI** **Univ. Paris-Cité - CiTCoM**	**DNA Origami-based protein manipulation systems : From structural biology to mechanical regulation**
14:30	Marine LE GOAS Institut Galien Paris-Saclay - CNRS	Demonstration of the impact of flow on protein adsorption on nanoparticles via in situ flow-DDM
14:45	François HENN L2C - Université de Montpellier	Confinement of a Biological Ionic Chanel in a SWCNT
15:00	Julie FINKEL Centre de Biologie Structurale - CNRS	DNA origami self-assembly with complex curved surfaces defined in 3D space
15:15	Manon ROCHEDY ISCR - CNRS	Internal structure evolution of lipoplexes in the presence of surfactants and biological media for nucleic acids delivery
15:30	Olivier SANDRE LCPO - CNRS	Magnetic Polymersome Deformation by a Static Magnetic Field
15:45	Adrien NICOLAÏ ICB - Université Bourgogne	MoS2 Solid-State Nanopores as Single-BioMolecule Sensors
16:00	Marc ZELSMANN LTM - CNRS	On-chip photonic crystal tweezers for bacteria and bacteriophage viruses trapping and susceptibility testing
16:15	Silvia PERAZA KU ISCR - CONACYT	Understanding the spontaneous formation of toroids and other handle topologies in polypeptides self-assembly

Nesrine AISSAOUI (Univ. Paris-Cité - CiTCoM, Paris)

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Short biography

I am a physico-chemist by training, with a great interest in biology. In my research projects, I use « top-down » – « bottom-up » engineering approaches to create highly ordered materials with tailored properties and functions suitable for applications in biology, medicine, and beyond. In this context, the supramolecular assembly of biomolecules was a very interesting approach to create organized bio-synthetic systems, at the nanometer scale. I also use the self-assembly method of DNA, called DNA-origami, to design and construct three-dimensional geometries with nanometer precision. In 2020, I joined the University Paris Cité for an assistant professor position to work in the team « signaling and membrane transport » in developing bio-inspired systems based on DNA origami method which can provide practical advantages to help to better understand fundamental biological questions with potential uses in medicine.

DNA Origami-based protein manipulation systems : From structural biology to mechanical regulation

In this presentation, I will illustrate the bottom-up DNA origami nanotechnology as a tool to build artificial molecular systems and machines sufficiently sophisticated to decipher fundamental aspects of biology. First, as a method we are exploring as a molecular imaging scaffold for single-particle electron microscopy (EM). I will present examples of DNA nanostructures designed (i) to provide a simple, versatile, and straightforward method to enable accurate molecular scale positioning as a fiducial marker for EM [1], (ii) and to improve the cryo-EM sample preparation step which is still the primary limiting factor to guarantee the success of the data processing step [2]. In the second part, I will present our latest progress in constructing a nano-machine that can be programmed to actuate autonomously as a “robot” for the mechanical activation of membrane proteins [3]. This customizable origami provides an instrument-free approach that can be applied to control and explore a diversity of mechanotransduction circuits on living cells.

Keywords

DNA origami nanotechnology; structural biology; physical-chemistry of interfaces; supramolecular assembly

Acknowledgement

We thank financial supports: IDEX UPC of University Paris Cité, ANR JCJC (ANR23CE09-0012-01_REDIRECT).

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Abstract

Thematic Session: Nanobiosciences & Nanomedecine
Disciplinary fields involved: Biology, Physical chemistry
Keywords: nanomedicine, protein corona, microfluidics, in situ characterization

Demonstration of the impact of flow on protein adsorption on nanoparticles via *in situ* flow-DDM

Marine Le Goas[1,2], Dikran Mekhjian[1], Pierre-Luc Latreille[1], Sara González Bolivar[1], Justine Saber[1], James A. Richards[3], Vincent A. Martinez[3], Jochen Arlt[3], Xavier Banquy[1]

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In nanomedicine and nanotoxicology, understanding the interaction of nanoparticles (NPs) with biological systems is key. One main challenge for these studies remains the characterization of NPs *in situ*, i.e., in a real biological environment. The complexity and dynamic aspects of biological environments are indeed not compatible with most current characterization techniques.

We show here how differential dynamic microscopy (DDM) can provide valuable *in situ* information regarding NP behavior under realistic biological conditions. DDM is a technique that extracts the dynamics of NPs from movies recorded under an optical microscope, without the need to resolve the NPs. This powerful technique enables NP sizing, even under flow, and quantifying protein adsorption onto NPs.[1,2]

Our study aimed to model an intravenous injection of NPs, i.e. to study protein adsorption on NPs in dynamic conditions and compare it to the static conditions generally used in the lab after pipette mixing. We developed a microfluidic system to mix NPs and fluorescent proteins under flowing conditions and characterize the resulting assemblies in situ via DDM. Both the number of proteins adsorbed per NP and the size of the NP/protein assemblies were determined for different flow rates and protein concentrations. The flow rate was found to have no effect on protein adsorption in the explored range. However, large differences were observed with the “static” conditions, highlighting the long-term impact of the mixing conditions (turbulent vs laminar flow).

This work demonstrates the impact of flow on protein adsorption onto NPs. Our results emphasize the need to study these phenomena under conditions better mimicking the biological environments.

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Abstract

Thematic Session: Nanobiosciences & Nanomedecine
Disciplinary fields involved: Physics & Chemistry
Keywords (max. 4-5)**:** Carbon Nanotubes, Confinement, Ionic Channel

Confinement of a Biological Ionic Chanel in a SWCNT

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Ion transport in nanoscale channels is an elementary process underlying life and numerous industrial applications. Despite significant progress, advances are still required in fundamental understanding and developing more efficient applications, especially in the case of nanofiltration for water desalination, single-molecule recognition, or “blue” energy production [1, 2]. It is also relevant for the development of novel ionotronic µ-device which holds promise for innovative sensors, actuators, and artificial neurons. Single-Wall Carbon Nanotubes (SWCNTs) with diameters below 2 nm offer promising potential due to their ability to transport electrolytes rapidly. However, enhancing ion selectivity remains a critical challenge. Inspired by nature, we aim to improve SWCNT ion transport properties by incorporating gramicidin, a small, highly selective biological ion channel. While gramicidin has been successfully confined in large (i.e. 10 nm) nanochannels in thin film polymer [3] and while its confinement in SWCNT has been predicted by Molecular Simulation [4], there is not yet experimental evidence that it can be confined into SWCNT. Our objective is to explore this feasibility. Various techniques were used, including TEM, Neutron and X-Ray Diffraction, µ-Raman spectroscopy, and water adsorption isotherms. These methods consistently indicate that gramicidin strongly interacts with SWCNT and can be encapsulated inside. Moreover, the results from water adsorption isotherms show that gramicidin might have adopted a helical conformation within at least some SWCNTs, hence mimicking its biological state. This important breakthrough suggests that the SWCNT/gramicidin bioinspired hybrid system may exhibit remarkable permeability and ionic selectivity properties.

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Abstract

Thematic Session: nanobioscience
Disciplinary fields involved: biology
Keywords (max. 4-5)**:** DNA origami, self-assembly, nanotechnology

DNA origami self-assembly with complex curved surfaces defined in 3D space

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Curved structures found in both artificial constructions and natural biomolecular assemblies enable the gain of sophisticated properties and adaptability. They provide a source of inspiration for the DNA de novo design of innovative biomimetic architectures, materials, and devices with enhanced functionalities. However, the DNA nanotechnology field encounters challenges in achieving complex curved structures in 3D space. While already existing methodologies enable the design and production of DNA origami with curvatures1,2,3,4, the inherent constraints imposed by the DNA geometry pose significant limitations in achieving high yields of well-defined structures with precise curvatures and complexities.

In response to these challenges, we present a general method to fold arbitrary 3D curved structures using a routing algorithm that traces scaffold strands along curved surfaces. Crossover positioning is made by the user using the 3D view panel, directly from the intended geometry of the desired shape. This new method has been implemented in a design software developed by the team of Nicolas Schabannel, CNRS, France, named ENSnano. This software offers a highly automated workflow for designing complex curved DNA nanostructures. We apply our procedure to design ten origami structures with unprecedentedly complex curvatures defined in 3D space. The accuracy of the programmed and folded objects has been validated through cryo electron microscopy.

We believe that the sleek and user-friendly geometric interface of ENSnano will catalyze the design of biomimetic nanostructures with the potential to expand the range of achievable shapes in DNA nanotechnology.

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Abstract

Thematic Session: Nanobiosciences & Nanomedecine
Disciplinary fields involved: Physical chemistry
Keywords: Lipoplexes, internal structure, stability, disassembly, gene delivery

Internal structure evolution of lipoplexes in the presence of surfactants and biological media for nucleic acids delivery

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Abstract:
Nucleic acid-based therapies are at the forefront of emerging therapies as shown by new mRNA vaccines. Lipoplexes are lipid-based synthetic carriers of nucleic acids (NAs) used for these applications. Their molecular structure, characteristics and formulation methodologies have been thoroughly studied [1]. However, their intracellular stability and dissociation mechanisms remain poorly explained in the literature [2]. In this work, the evolution of lipoplexes' internal structure, size, and NAs release ability in presence of surfactants (Triton X-114) and biological media (Phosphate Buffer Saline, DMEM culture media, fetal bovine serum), was studied through Small Angle X-ray Scattering (SAXS) [3], Dynamic Light Scattering and gel electrophoresis, respectively. For this purpose, two formulation methodologies (bulk complexation of NAs with cationic liposomes and rapid mixing microfluidic systems) were used to prepare lipoplexes at different charge ratios, using a plasmid and two model cationic lipophosphoramidates.
For all lipoplexes, after dilution with water or addition of Triton X-114, changes in their multilamellar organization were observed by SAXS measurements, leading to the formation of new vesicle structures, while releasing NAs when specific concentrations of surfactant determined by gel electrophoresis are added. The changes of the internal structure of lipoplexes can be explained by a dilution-induced reorganization of lipids – with or without Triton X-114 – to form new type of particles still able to somehow complex plasmid DNA if the surfactant concentration is not too high. Hence, it is

Abstract

demonstrated the importance of studying lipoplexes' stability prior to transfection assays, the lipoplexes' morphology possibly changing even before reaching the cells.

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Acknowledgement:

ANR DIMECO and AIS Région Bretagne are acknowledged for the funding of the project. The Synanovect platform is thanked for the access to equipments and for the help and the guidance. Finally, Javier Perez (Synchrotron SOLEIL, F-91192, Gif-sur-Yvette) and the BAG 20231446 (SLAMM) are warmly thanked for the opportunity to perform SAXS experiments on the SWING beamline of SOLEIL facilities, and for all the help and fruitful discussions.

Abstract

Thematic Session: Nanochemistry & Nanoparticles / Nanobiosciences & Nanomedecine / ANR
Disciplinary fields involved: Polymer Chemistry, Physical Chemistry, Biological Applications
Keywords (max. 4-5)**: Polymers, Anisotropic Nanoparticles, Irradiation, Magnetism, Cell Death**

Magnetic Polymersome Deformation by a Static Magnetic Field

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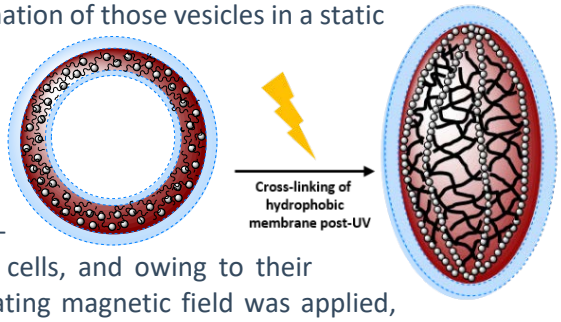
Incorporation of superparamagnetic iron oxide nanoparticles (SPION) in polymer vesicles has been mostly studied as means to cancer cell death induction *via* drug encapsulation and delivery at the tumor site [1]. Nonspherical polymeric nanostructures prevail over spherical ones in terms of circulation time, cell uptake amount and kinetics [2]. Our study aims at preparing such anisotropic magnetic polymersomes and use them as mechanical actuators to destroy cells by mechanical torques under rotating magnetic fields. Such "nano-blenders" were prepared by co-assembly of hydrophobically SPIONs with amphiphilic block copolymers (BCPs) constituting the membranes. Two topologies of BCPs were designed: triblock BCPs with either linear or comb-like topology. While the hydrophilic block was always poly(ethylene oxide) (PEO), the hydrophobic part was composed of two polymers chosen for their soft rubbery state (*i.e.* low Tg), polyisoprene (PI) which double-bonds were epoxidized and further cross-linked, and poly(trimethylene carbonate) (PTMC), both ones being reported to self-assemble into polymersomes when designed as diblock copolymer with PEO. Then we studied the deformation of those vesicles in a static magnetic field and the shift of their morphology from spherical to (slightly) elongated. During this elongation process, the hydrophobic membranes were crosslinked by irradiation with either UV or Γ rays. For this aim, a fraction of double bonds in the PI block was epoxidized followed by cationic ring opening *via* a cationic photo-initiator. These vesicles were incorporated into cancer cells, and owing to their anisotropy used to exert mechanical torques when rotating magnetic field was applied, forcing the vesicles to rotate, thereby damaging internal cell compartments, and leading to apoptosis.



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Acknowledgement:

This work received funding from the French National Research Agency, project "Magnetic VEsicle Rotation Induced Cell Killing" (MAVERICK, ANR-19-CE09-0024) and from the French Ministry of Foreign Affairs (PHC Pavlic Savić 2023 "Preservation of magnetic polymersomes' anisotropic morphology *via* gamma irradiation induced crosslinking")

Abstract

Thematic Session: Nanobiosciences & Nanomedecine (Nano-biodétection)
Disciplinary fields involved: Biophysics
Keywords: Nanopores, 2D Materials, Proteins, Molecular Dynamics, Machine Learning.

MoS_2 Solid-State Nanopores as Single-BioMolecule Sensors

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Laboratoire Interdisciplinaire Carnot de Bourgogne, UMR 6303 CNRS, Université de Bourgogne, Dijon, France.

Solid-state nanopores (SSNs) made of 2-D materials such as molybdenum disulfide have emerged as one of the most versatile sensors for single-molecule detection. One of the most promising application of SSNs is protein sequencing, at a low cost and faster than the current standard methods. However, protein sequencing using SSN remains highly challenging since the protein ensemble is very complex and the fast translocation speed provides a short observation time per single molecule [1].

In this work, we performed Molecular Dynamics simulations to investigate the performances of SSNs for protein sequencing. Particularly, we studied the detection of the twenty proteinogenic amino acids through single-layer MoS_2 nanopores [2]. Using unsupervised learning, we demonstrate that positively and negatively charged amino acids present singular fingerprints. In addition, we demonstrated that this information would be sufficient to identify proteins using the concept of coarse-grained sequencing depending on their charge. Then, we sequenced peptides made of 12 distinct sequences through SSNs. Peptide sequences were comprised of 1 positively, 1 negatively charged, and 4 neutral amino acids, with the position of amino acids in the sequence being shuffled to generate all possible configurations. Using supervised learning, we classified these sequences to determine the most relevant information such as the position of amino acids or the spacing between charged amino acids in the sequences to encode binary information based on ionic current traces monitored during translocation [3]. These very promising results emphasized the best approaches to design peptide sequences as building blocks for molecular information storage.

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Acknowledgement:
The simulations were performed using HPC resources from DSI-CCuB (Université de Bourgogne). The work is part of the project SEPIA supported by the EIPHI Graduate School (contract ANR-17-EURE-0002), the Conseil Régional de Bourgogne-Franche-Comté and the European Union through the PO FEDER-FSE Bourgogne 2021/2027 program.

Abstract

Thematic Session: Nanobiosciences & Nanomedecine
Disciplinary fields involved: Photonics, Microbiology
Keywords: Optical tweezer, Photonic crystal resonators, Bacteria, Bacteriophages

On-chip photonic crystal tweezers for bacteria and bacteriophage viruses trapping and susceptibility testing

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Antimicrobial resistance is a major threat to public health. This resistance is due to multiple factors such as natural bacterial mutations, but above all to the overuse of antibiotics in agronomic and medical practices. Traditional antimicrobial susceptibility testing relies on time-consuming bacterial growth processes. In this context, we are developing a new interdisciplinary methodology for antibiotic or phage susceptibility testing based on bio-photonic microsystems. Silicon-on-insulator (SOI) photonic crystal micro-cavities are integrated in a microfluidic system for transporting nano-objects. Thanks to the use of highly localized resonances, single bacteria and phages can be trapped by the electric field gradient in the near field of the resonator. The very high sensitivity of the resonance frequency to the environment allows monitoring the presence, nature (selectivity) [1], residual motion or viability [2] of the trapped object in real time in the transmitted optical signal. This makes it possible to finely track the phage-bacteria interactions at the single-cell level, providing much richer information than classical antimicrobial susceptibility test methods with fewer resources. Furthermore, it is by essence perfectly suited to personalized medicine where one need to rapidly find the best treatment from the least biomass available. Therefore, we believe our approach to be a disruptive technology that has the potential to significantly accelerate the screening of bacteriophages and perform fast antimicrobial susceptibility tests.

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Acknowledgement:

This work was supported the French RENATECH network, by the French National Research Agency (ANR) through the SUPPLY project (grant no. ANR-22-CE93-0011-01), by the Swiss National Science Foundation (SNSF) through grants no. 310030L_212772 and no. 200020_188649.

Abstract

Thematic Session: Nanochemistry & Nanoparticles
Disciplinary fields involved: Chemistry, Physics.
Keywords (max. 4-5)**: Nanoprecipitation, polypeptide, toroids, secondary structure.**

Understanding the spontaneous formation of toroids and other handle topologies in polypeptides self-assembly.

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Poly (γ-benzyl-L-glutamate), also known as PBLG, is a hydrophobic polypeptide capable of adopting different secondary structures depending on the molar mass, temperature and the solvent(1). This includes α-helix, leading to rod-like configurations; and the β-sheet, in which extended polypeptide strands are connected by a network of hydrogen bonds. PBLG is also capable of forming nanoparticles with a variety of morphologies when transferred to water. Among these structures, toroids and other multi-handle topologies are observed. Until now, the emergence of these non-conventional shapes and the relationship between PBLG conformations and the resultant nanoprecipitations has yet to be fully understood. Comprehending the construction of these complex nanostructures is important due to their potential in different fields such as template chemistry, biomedical research and nanomaterial(2).
In this work, we studied the nanoprecipitation of PBLG in tetrahydrofuran/water mixtures at different conditions such as polymer concentration, temperature and mixing speed. Experiments achieved in our group include (a) building a reproductible "phase" diagram of the different topologies obtained in various conditions (PBLG concentration, ratio water/solvent, temperature). The resulting particles are characterized by MEB and the secondary structure are determined by RAMAN and circular dichroism. (b) CryoTEM and preliminary SAXS analyses showing that the toroids exist in the solvent/water mixtures, and (c) Stopped-flow experiments (detection of scattered light). This formation of objects with complex and non-isotropic morphology is a unique example of symmetry breaking at the nanoscale that occurs spontaneously during self-assembly.

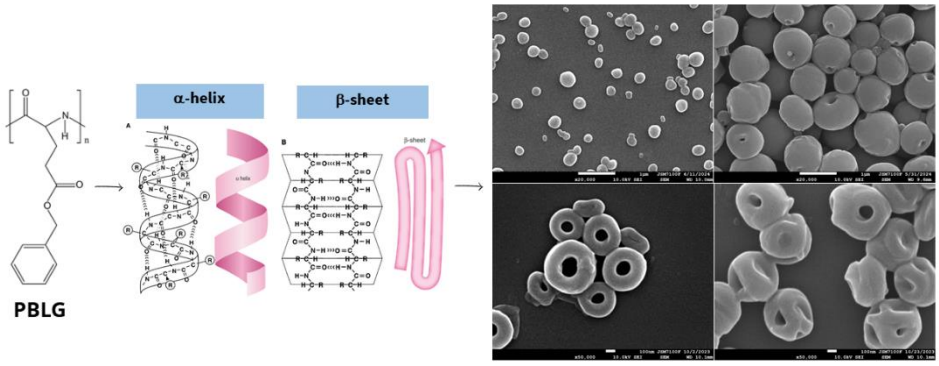

Figure 1. PBLG polypeptide can adopt different secondary structures depending on its environment. To the right, different morphologies of PBLG nanoparticles obtained by nanoprecipitation.

Abstract

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Acknowledgement:

The authors would like to thank Loïc Joanny for his assistance in the MEB analyses and Soizic Chevance for the access to the CD apparatus. This project wouldn't be possible without the financial support of the National Council of Humanities, Sciences, and Technologies (CONAHCYT, Mexico).

Friday March 21th

10:30 A.M. - 12:30 A.M.

LOUIS ARMAND OUEST

Program of the session :

Chairs: Thomas PONS

HOUR	NAME	TITLE
10:30	**Chloé GRAZON** **ISM - CNRS**	**From Quantum Dots to Fluorescent Organic Nanoparticles: bright nanotools for biosensing**
11:00	Eleonore KUREK ISM - Université de Bordeaux	3D Real-Time Single Particle Tracking using two-photon fluorescence from bright dye-based organic nanoparticles
11:15	Riccardo OSSANNA ISMO - CNRS	Control of the optical absorption properties of nanovectors for photoacoustic imaging (CAP-PHOTOAC)
11:30	Mariah HARRIS ISMO - Université Paris-Saclay	Optical Biosensors for the Detection of Bacteria
11:45	Limeng RUAN LP2N - China Scholarship Council	Polarization sensitive single nanoparticle tracking in the near-infrared
12:00	Qilin ZOU LPMC - Ecole Polytechnique	CsxWO3-Î´@NaYF4:Yb,Er heterogeneous nanocrystals for local temperature monitoring during photothermal heating
12:15	Tristan PELLUAU i-CLeHS - ChimieParisTech	Design and Synthesis of Iron-Doped Carbon Dots for Enhanced MRI Imaging Applications

Chloé GRAZON (CNRS - ISM, Bordeaux)

https://www.ism.u-bordeaux.fr/annuaire/mme-grazon-chloe

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Short biography

Chloé Grazon is a former student of the University of Rennes I and ESPCI Paris-PSL, graduating in 2009. She completed her PhD at ENS Cachan under the supervision of R. Méallet and G. Clavier, in collaboration with J. Rieger and B. Charleux. Her thesis focused on the synthesis of fluorescent polymer nanoparticles that are perfectly stable in water and extremely bright.
She then worked for nine months at L'Oréal, followed by four years at the startup Nexdot, where she developed ligands for quantum dots used in bioimaging and display technologies. In 2019, she was awarded a Marie Curie fellowship between Boston University with M. W. Grinstaff and the University of Bordeaux with S. Lecommandoux. During this period, she developed progesterone biosensors and designed a new method for synthesizing polypeptide nanoparticles in water (ROPISA).
Building on this experience, she joined CNRS in 2020 at ISM-Bordeaux with M. Blanchard-Desce. Her research focuses on the development of fluorescent organic nanoparticles for use as biosensors. In 2022, she was awarded an ERC Starting Grant for this work.

From Quantum Dots to Fluorescent Organic Nanoparticles: bright nanotools for biosensing

The in situ and real-time detection of analytes in complex biological media demands robust, sensitive, and stable biosensors capable of signal amplification. Luminescent nanoparticles (LNPs) are promising candidates, offering exceptional brightness and photostability compared to traditional dyes.1 These LNPs fall into two main categories: intrinsically luminescent, such as Quantum Dots (QDs), or doped NPs, where dyes are encapsulated within a matrix. For imaging and sensing applications, LNPs aim to achieve excellent brightness, enhanced photostability, and strong colloidal stability in water, outperforming conventional organic dyes. Classical FRET nanosensors typically involve a donor LNP conjugated with bioreceptors that bind to a ligand labeled with an acceptor dye. While bioreceptors optimization has advanced detection limits and dynamic ranges, the roles of dye type and spatial configuration in these systems remained underexplored. In this talk, we will compare organic fluorophores (e.g., Cy5, Texas Red) and QDs as FRET donors or acceptors, identifying key molecular parameters that enhance sensor performance to provide guidelines for FRET-based assays and diagnostics.2-3 Additionally, Fluorescent Organic Nanoparticles (dFONs) will be introduced as metal-free alternatives to QDs, with comparable brightness per volume. Obtained via nanoprecipitation of hydrophobic dyes, dFONs remain underutilized as biosensors due to limited functionalization strategies.4 We demonstrate an innovative maleimide-thiol surface functionalization approach, enabling applications such as intracellular thiol sensing in the µM range5 and biotinylation for biomarker development. These advancements position dFONs as versatile, ultra-bright, and metal-free tools for next-generation diagnostics.

Keywords

fluorescence, biosensors, biomarkers, bioimaging, FRET

Acknowledgement

CG deeply acknowledges her main collaborators who permitted to develop those studies, especially M.W. Grinstaff, J. Gallagan, A. M. Dennis, S. Lecommandoux, M. Chern, O. Dal Pra, J. Daniel and M. Blanchard-Desce. This work received support from the EU under the H2020 program (Marie-Curie Grant 749973) and under the Horizon Europe program (ERC St 101077364).

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Abstract

Thematic Session: Nanophotonics & nano-optics, Nanoparticles, Nanoscale characterization
Disciplinary fields involved: Physics, Chemistry
Keywords : 3D real-time Single Particle Tracking, two-photon fluorescence, dye-based organic nanoparticles

3D Real-Time Single Particle Tracking using two-photon fluorescence from bright dye-based organic nanoparticles

Eleonore Kurek†[1], Marie-Charlotte Emperauger†[2], Florian Semmer[2#], Karen Perronet[2], Jonathan Daniel[1], François Marquier*[2], Mireille Blanchard-Desce*[1]

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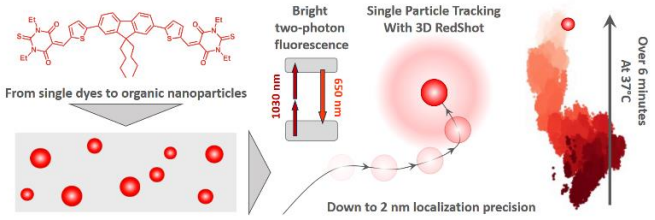
Single Particle Tracking (SPT) is a powerful tool to explore biological dynamics at the molecular or cellular level[1]. Nanoparticles can be tracked by SPT various techniques[2] using their optical signal. 2-photon excited fluorescence is of particular interest for biological applications as the red to near-infrared excitation and emission wavelengths allow tracking deep into tissues, due to minimal absorption and scattering[3]. Here we report the use of ultrabright dye-based fluorescent organic nanoparticles (*d*FONs)[4], prepared by nanoprecipitation of dedicated polar and polarizable dyes, in 3D-Red Shot[5], a real-time 3D single-particle tracking two-photon microscopy setup. The nanoparticles consist of an assembly of quadrupolar dyes, presenting a large two-photon absorption cross-section. They exhibit low photobleaching, crucial for long-term tracking, and their high brightness allows nanometer localization precision (down to 2 nm). Their small size compared to previously used nonlinear inorganic nanocrystals, stable structure at physiological temperature, and adjustable optical properties make them promising tools for further biological research. This study highlights the potential to use these fluorescent organic nanoparticles to track dynamic processes with precision and stability, paving the way for exploring cellular processes at the nanoscale.



Two-photon single particle tracking with unique precision using dye-based organic nanoparticles

Abstract

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Acknowledgement:

This work has received financial support from the French National Research Agency ANR (ANR-18-CE09-0027), and from a public grant overseen by the ANR as part of the "Investissements d'Avenir" Program (reference: ANR-10-LABX-0035, Labex NanoSaclay). The research was supported by two Ph.D. scholarships, from ENS Paris-Saclay (MCE) and the University of Bordeaux (EK). The authors also acknowledge the support from the LIGHT S&T Graduate Program of Bordeaux (PIA3 Investment for the Future Program, ANR-17-EURE-0027). This work was partially supported by the European Commission.

Abstract

Thematic Session: Nanobiosciences & Nanomedicine
Disciplinary fields involved: Chemistry, Physics, Biology
Keywords: bodipy, imaging, nanoparticles, photoacoustic

Control of the optical absorption properties of nanovectors for photoacoustic imaging (CAP-PHOTOAC)

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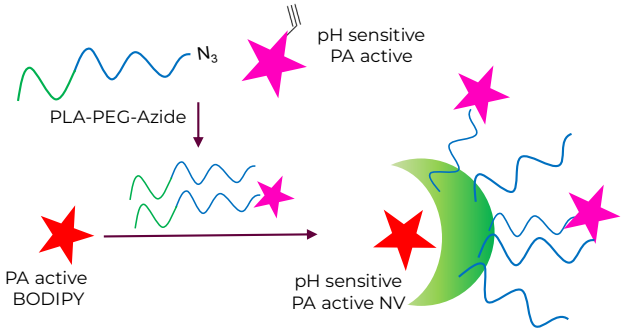
Optically absorbing structures can generate sound waves via the photoacoustic (PA) effect, which enables high-resolution imaging of molecules or nanoparticles in biological tissues. BODIPY dyes are commonly used as molecular PA agents due to their high absorption coefficient, tunable absorption maxima, and photostability. Past work from our research group[1] has produced a novel BODIPY-based chromophore that, when conjugated to a *lactide* chain and grafted onto a *PEGylated* nanoparticle (NP), shows remarkable absorption properties and biocompatibility, making it an excellent platform for *PA imaging* and *drug delivery*. In this study, we aim to develop a *stimulus-responsive PA agent* by synthetizing and characterizing a pH-sensitive molecule using the BODIPY scaffold. So far our work has produced two BODIPY molecules of novel synthesis, equipped with a clickable handle and a *3-nitro-4-phenol* group, whose *phenol-phenolate interconversion* provides the capacity of responding to pH changes in the cellular environment[2]. The pH-sensitive BODIPYs are conjugated to PLA-PEG and formulated into pH sensitive *PLA-PEG* NPs. The NPs are characterized and their performances evaluated with the goal of selecting the most promising dye and adding it to a previously developed design for BODIPY-labeled PLA-PEG NPs to create multifunctional nanovectors that provide control over the optical absorption without adding toxicity.



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Acknowledgement: This project has received funding by the French National Research Agency under the program ANR-21-CE09-0024-01

Abstract

Thematic Session: Nanobiosciences & Nanomedicine
Disciplinary fields involved: Chemistry & Biology
Keywords: Fluorescence, Bacteria Detection, Nanoparticles, pH

Optical Biosensors for the Detection of Bacteria

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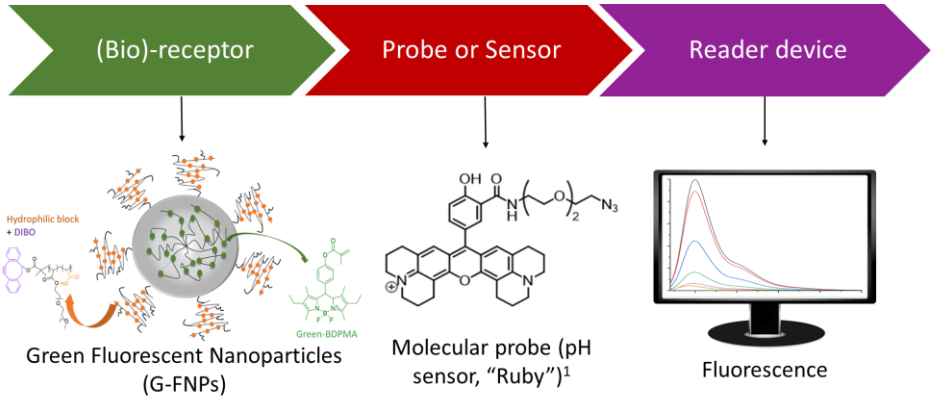
Abstract (**no longer than 250 words** or 18 lines max. incl. figure), Calibri 11, single line spacing, black)



Throughout human history, bacterial infections have posed significant challenges to public health.[1] With the discovery of antimicrobial agents and antibiotics to combat bacterial infections came the ability of bacteria to become resistant to these drugs due to genetic mutations and overuse.[1,2] As the current antimicrobial medicines are becoming ineffective, there is an urgent need for new medicines and an urgent push to improve early detection of bacterial infections. Currently, effective bacterial detection methods require the ability to identify pathogenic bacteria with sensitivity and specificity but such methods can be expensive and time consuming.[3,4] To overcome the current limitations of existing detection techniques, biosensors utilizing nanoparticles (NPs) and fluorescence have emerged as alternatives by offering detection in faster and more efficient ways. In the present work, we created two optical biosensors by utilizing fluorescent organic NPs as the sensing element, a pH sensor, and fluorescence as the reader device. Fluorescent organic NPs allow for great photostability, easy cellular uptake, and can be turned within the visible range making them valuable for biosensing applications.[5] We found that the photophysical properties of the individual compounds in varying pH buffers remained consistent when they become bound together in solution by SPAAC click chemistry, with the NPs not responsive to the pH change while the sensor displayed increased fluorescence intensity in acidic media with a pKa of 5.3 ± 0.2. With toxicity tests, the grafted particles (NPs + pH sensor) display no toxicity to the growth of bacteria, displaying potential for future bacteria tests. When immobilized onto a glass surface, the photophysical properties and

Abstract

pH sensing capabilities were retained. By plotting the intensity ratio of the pH sensor over the intensity of the NPs, a pKa of the luminescent surface was determined to be 6.0 ± 0.2, which is within the physiological range for bacteria detection. In conclusion, there is potential in our optical biosensors for detecting bacteria by sensing pH change. Next steps include further bacteria detection tests to improve the detection of these optical biosensors.

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This research project is thanks to the 2MIB doctoral school at Université Paris-Saclay as well as CNRS. I also wish to thank my supervisors for their help.

Abstract

Thematic Session: Nanobioscience
Disciplinary fields involved: Physics
Keywords: single-molecule, tracking, super-resolution microscope, carbon nanotube

Polarization sensitive single nanoparticle tracking in the near-infrared

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Abstract

Single-walled carbon nanotubes (SWCNTs) are highly efficient emitters in the near-infrared (NIR) domain, making them highly valuable for bioimaging and quantum light sources. In particular, many applications rely on the ability to control or detect SWCNT emission at the single-molecule level. While the study of SWCNT translational diffusion has been well established, their rotational diffusion characteristics remain underexplored. Understanding these characteristics is crucial for advancing our knowledge of the nanoscale diffusion of physiological and pathological molecules. To this aim, we developed a radially and azimuthally polarized (raPol) microscope working in the NIR inspired by single-molecule orientation-localization microscopy (SMOLM)[1]. Our system is based on the optical property that the fluorescence polarization emitted by SWCNTs is always along their backbone. By engineering the dipole-spread function, two different polarization images are obtained, which exhibit different shapes and intensities depending on the 3D orientation of the SWCNT. This allows us to get both 2D localization and 3D orientational information. Our analysis is based on vectorial phase retrieval[2] and deep learning algorithms[3] to achieve high-precision measurements. Our work provides a new approach for studying the rotational diffusion of SWCNTs and holds promising potential for applications in nanoscale brain imaging and material characterization.

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Acknowledgement:

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Abstract

Nanobiosciences & Nanomedecine

Chemistry

Keywords: heterogenous nanocrystal, plasmonic heating, nanothermometry, upconversion

$Cs_xWO_{3-\delta}$@$NaYF_4$:Yb,Er heterogeneous nanocrystals for local temperature monitoring during photothermal heating

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Monitoring local temperature evolution during photothermal therapies is key to accurately control the thermal treatment for preventing side effects on surrounding tissue.[1, 2] We developed a synthetic protocol to produce heterogeneous nanocrystals that combine efficient photothermal effect and in-situ luminescent nanothermometry under NIR laser irradiation. These nanoprobes are composed of a plasmonic $Cs_xWO_{3-\delta}$ nanorod or nanoplatelet as a nanoheater core, which is surrounded by an upconverting luminescent $NaYF_4$:Yb,Er as a nanothermometer shell. By virtue of crystal structure and element analyses, the epitaxial growth of the shell on the core is demonstrated. This robust connection of the two components enables largely improved colloidal stability of the nanoprobes compared to the natively unstable $Cs_xWO_{3-\delta}$ nanocrystals. Under 980 nm laser excitation, the local temperature can be measured by a ratiometric analysis of the Er^{3+} emission spectrum. A remarkable local heating effect (ΔT >100 °C) was observed due to the exceptionally high NIR absorption cross section of the plasmonic $Cs_xWO_{3-\delta}$ nanocrystal core. For the therapeutic application, the cell viability was estimated by using surface-functionalized nanoprobes. We present our latest investigation on the *in-situ* local thermometry during the *in-vitro* photothermal therapy. This study paves a way of using these nanoprobes in various therapies applications.

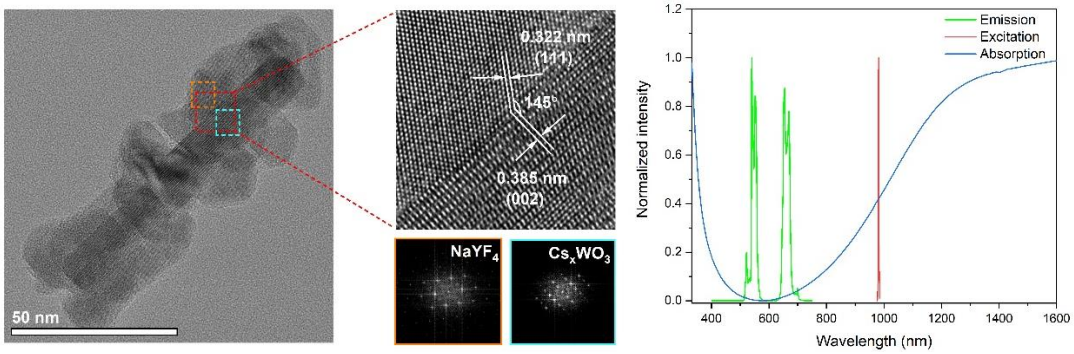

Figure 1. Characterizations of Cs_xWO_3@$NaYF_4$:Yb,Er hybrid nanocrystals. HR-TEM and FFT images (left and middle), optical spectra (right).

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Acknowledgement:

We are grateful to Dr. Kassiogé Dembélé for the help of advanced TEM characterizations.

Abstract

Thematic Session: Nanochimie & Nanoparticules
Disciplinary fields involved: Chemistry, Physical characterization
Keywords: Carbon dots, MRI, Iron doping

Design and Synthesis of Iron-Doped Carbon Dots for Enhanced MRI Imaging Applications

Tristan Pelluau[1*], Romina Adel[1], Anne Varenne[1], Laura Trapiella-Alfonso[1]

1. *Institute of Chemistry for Life and Health Sciences (i-CLeHS), SEISAD team, ChimieParisTech, PSL University, Paris France*

Early diagnosis remains a crucial factor in improving outcomes for numerous diseases, including cancer, neurodegenerative disorders, and cardiovascular conditions. Magnetic Resonance Imaging (MRI) plays a central role in non-invasive diagnostics, yet conventional contrast agents, particularly gadolinium-based complexes, raise significant safety concerns due to their inherent toxicity.[1] In this context, carbon dots (C-dots) have emerged as promising candidates for alternative imaging agents.[2,3] These zero-dimensional nanomaterials exhibit highly desirable properties, including excellent water solubility, expected biocompatibility, and a versatile surface that allows for targeted functionalization. Moreover, C-dots possess unique photophysical characteristics that can be further enhanced through doping.[4]
This study investigates the synthesis of iron-functionalized C-dots to combine the optical advantages of C-dots with magnetic properties suitable for MRI applications. This work presents the developed methodologies aiming to optimize the MRI performance of these nanostructures while preserving their intrinsic photoluminescence.
By exploring these synthesis pathways, the project seeks to establish a structure-property relationship for these functionalized C-dots, which will guide their future application in safe and efficient imaging technologies. This strategy aligns with the growing need for innovative, biocompatible, versatile diagnostic agents, potentially extending the applicability of MRI and broadening its impact on early disease detection.

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Poster Session

NANOCHEMISTRY & NANOPARTICLES/NANOBIOSCIENCES & NANOMEDECINE /NANOMATERIALS FOR ENERGY/ SUSTAINABILITY AND ECO DESIGN OF NANOMATERIALS

N° POSTER	TITLE	NOM	Prénom
31	Plasmon-induced thermo-polymerization of PETA in presence of various thermal initiators	BASTIDE	Mathieu
32	Green synthesis of curcumin based nanoparticle	BASU	Surita
33	Synthesis of Polyvinylpyrrolidone nanocomposite with palygorskite for application in water-based drilling fluids	DALMONEKI	Anna Clara
34	Carbon supported metal oxides nanoparticles and their applications in biomass valorization	DJELLALI	Ali
35	Synthesis of Polyacrylamide/Palygorskite Nanocomposites for Application in Water-Based Drilling Fluids	GOMES	Ana Beatriz
36	Re(CO)-based silica-nanoparticles as multimodal probes for bio-imaging	KAUFFELD	Willem
37	Chiral CdSe/CdS Nanonails	KUZNETSOVA	Vera
38	Towards large-scale production of Cobalt nanorods	LISOIR	Emma
39	Synthesis and Evaluation of PAMAM G0.5 Dendrimer as a Swelling Inhibitor Additive for Clays in Water-Based Drilling Fluids	LOPES/SPINELLI	Grazielle/Luciana
40	Plasmonic nanoclusters synthesized by a multi-step colloidal approach	ROMANUS	Martin
41	Influence of CuInS2 crystalline structure on the synthesis of CuIn1-xFexS2 quantum dot by cation exchange	ROUX-BYL	Céline
42	Chirality in Zinc Oxide nanoparticle synthesis	SARTOR	Valerie
43	Application and evaluation of core-shell nanocomposite using silica nanoparticles and AM/AMPS/DMDAAC/AAC tetrapolymer	SPINELLI	Luciana
44	Design of efficient nanocatalysts for H2 release from boranes and silanes	THIBAULT	Maxime
45	Influence of crystalline structure on the acoustic vibrations of elongated nano-objects	VERNIER	Charles
46	Chemistry and biological effects of germanium oxide nanoparticles	VIKRAMAN	Haribaskar
47	From laser-synthesized nanoparticles to innovative medical devices	AL KATTAN	Ahmed
48	Ultra-small Superparamagnetic Iron Oxide Coated Phosphonate-based Ligand for MRI Application	CHE DJI	Lyns Verel
49	Magnetic hyperthermia tumor ablation and tumor microenvironment modulation monitored by optical imaging	COSTE	Henri
50	Synthesis of iron oxide nanoparticles and magnetic properties tuning by temperature cycling: towards fine control of crystal phase and size distribution	HUEZ	Cecile
51	Hybrid plasmon-semiconductor nanoparticles for charge or resonant energy transfer based dynamic phototherapy	JEFFRIES	Beatrice
52	Re(CO)-based silica-nanoparticles as multimodal probes for bio-imaging	KAUFELD	Willem
53	Force nanosensor development for measuring mechanical stress exerted by living cells	LACROIX	Noemie
54	Combination therapy using nanoheaters and CAR-T immunotherapy on 3D tumor models	LEINEBO	Charlotte Amalie
55	Red-blood-cell-membrane-coated polymer micelles/vesicles as biomimetic nanoassemblies for potential photocatalytic cancer therapy under hypoxia	MA	Yandong
56	Vivoptic, a preclinical optical imaging platform for the evaluation of diagnostic and therapeutic strategies	MORNET	Stéphane
57	On the Roles of Polymer Chemistry, Kinetics, and Mixing in the Assembly of Loaded Polymer Nanoparticles	REISCH	Andreas
58	Digital colorimetric biosensing on gold-DNA origami nanostructures	ZHANG	Zixiao
59	Cu Isotopic Fractionation Following Foliar uptake	CALAS	Aude
60	New process "Multi-Dip Coating" applied for biological statistical analysis of Antimicrobial Surfaces	CHARLIAC	Jérôme
61	One step synthesis using laser pyrolysis of nanostructured carbides molybdenum catalysts for hydrogen production	RIO	Simon
62	Study of the reactivity of Fe(0) nanoparticles towards ammonia	ZAMBLE	Christian Irie
63	Chemical Passivation of GaN Nanowires for the Development of Innovative Photocatalysts	ZORAI	Amel

Nanobiosciences & Nanomedecine

Romain Scarabelli[1,2], Magali Gary-Bobo[3], Christophe Drouet[2], Ahmed Al-Kattan[1]

Abstract (**no longer than 250 words** or 18 lines max. incl. figure), Calibri 11, single line spacing, black)

From laser-synthesized nanoparticles to innovative medical devices

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Driven by surface cleanness, unique physical and chemical properties, bare (ligand-free) laser- synthesized nanoparticles (NPs) are in the focus of intensive research in our group for biomedical and tissue engineering applications [1]. Indeed, based on the interaction of ultrafast laser beam in liquid ambiance (e.g., aqueous solution) with a solid target material, this process leads naturally to the formation of spherical NPs with modulate physicochemical properties including diameter and size dispersion, surface chemistry and oxidation rate [1]. Recently in our group we have thus demonstrated the possibility to elaborate ultraclean and very stable colloidal suspensions with unique physicochemical properties for biomedical applications [2,3]. We have also evidenced the complete safety properties using *in vivo* nude mice animal model [4] and their possibility to be employed as efficient nanotherapeutic tools [5].
More recently, we have also started to explore such materials as functional additives for wound healing and tissue engineering applications, able to emphasize proliferation, differentiation, and motility of cells [6]. For instance, their combination with electrospun-nanofibers platforms make them potentially inescapable nanoparticles to design innovative medical for emergency and restorative medicine.

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Abstract

Thematic Session: nanobiosciences and nanomedecine
Disciplinary fields involved: Chemistry, Physics
Keywords: Superparamagnetic iron oxide nanoparticles, Magnetic resonance imaging contrast agent, methylene phosphonic acid, Nuclear magnetic resonance dispersion profile

Ultra-small Superparamagnetic Iron Oxide Coated Phosphonate-based Ligand for MRI Application

Lyns Verel Che Dji[1,2], Amel Cherraj[2], Solenne Fleutot[2], Sabine Bouguet-Bonnet[1]

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2. *IJL (Institut Jean Lamour), CNRS, Université de Lorraine, F-54000 Nancy, France*

Abstract

Magnetic particles at the nanoscale exhibiting superparamagnetic properties are used as contrast enhancers in Magnetic Resonance Imaging (MRI). The application of these particles in the human body is mediated by the surface coating, which improves biocompatibility, colloidal stability, targeting ability, and size distribution control. To achieve these desirable properties, a microwave-assisted coprecipitation synthesis method was developed, using a commercially available phosphonate-based ligand, methylene phosphonic acid (DTPMP), as the coating agent. Subsequent to the synthesis, thorough physicochemical and magnetic characterizations were conducted. The measure of the efficacy of these nanoparticles in enhancing image intensities in MRI is referred to as relaxivity. They demonstrated high relaxivity values, allowing reduced dosage to obtain high-quality images, especially at medically relevant magnetic field strengths. The field-dependent nature of relaxivity was evaluated over a broad range of magnetic field strengths, from 0.24 mT to 14.1 T encompassing all medical MRI equipment, and a Nuclear Magnetic Resonance Dispersion or NMRD profile was unveiled. A numerical aspect of this study involved modeling the NMRD profile using a pre-existing quantum mechanical formulation to provide a unique alternating characterization method.

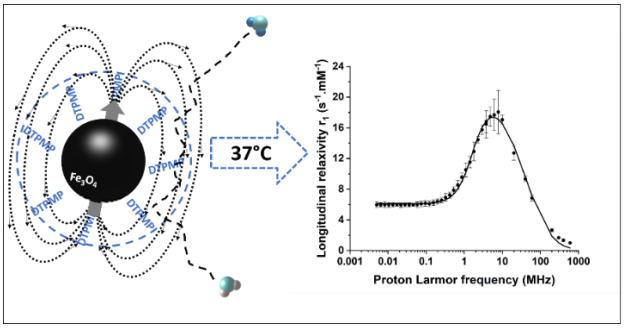

Fig. 1. Longitudinal r_1 NMRD profile of ultra-small superparamagnetic iron oxide coated methylene phosphonic acid (DTPMP) at 37°C

Magnetic hyperthermia tumor ablation and tumor microenvironment modulation monitored by optical imaging

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Magnetic hyperthermia (MHT) represents a promising tool for cancer therapies but requires fine control of the thermal power dissipated by magnetic nanoparticles (MNPs) to achieve the complete tumor ablation while preserving surrounding healthy organs. A better control would also make it possible to sensitize its microenvironment by mild hyperthermia in order to potentiate the efficiency of therapeutic agents. The present work achieved at VivOptic platform reports the real-time monitoring by optical imaging of local MHT at different thermal power used to induce cancer cell death and microenvironment sensitization *in vivo*.

Multifunctional hybrid nanoparticles composed of iron oxide nanoflower surrounded by a near-IR fluorescent silica shell were used as heat mediator. These MNPs are functionalized with quaternary ammoniums enabling them to expose permanent positive charges in order to improve residence time in extracellular matrix of tumors and promote endocytosis. Mouse prostate cancer (RM1) cells were modified for luciferase firefly (Fluc) or nanoluciferase (Nluc) constitutive expression. RM1-Fluc were implanted into WT mice and RM1-Nluc into transgenic thermo-sensitive mice by subcutaneous injection. Thermo-sensitive mice express Fluc under a thermo-sensitive promoter Hsp70. Magnetic hyperthermia monitored by optical imaging was performed *in vivo*, after intratumoral injection of MNPs.

RM1-Fluc tumors injected with MNPs were submitted to magnetic induction and the viability was followed by bioluminescence imaging (BLI). The results showed a significant decrease of BLI signal attesting of a partial or total tumor thermo-ablation correlated to a measured dissipated thermal power. RM1-Nluc tumors were implanted into transgenice mice expressing Fluc under thermo-sensitive promoter. Tumors were injected with MNPs and submitted to magnetic hyperthermia. Viability of tumor and tumor microenvironment activation were followed by BLI. Results showed a decrease of BLI signal into the tumor attesting a thermos-ablation. In contrast, we observed apparition of BLI signal from the transgenic mice attesting of a microenvironment activation. Results obtain *in vivo* show that, by injecting a dose of iron oxide ten times lower than that used for clinical trials, core tumor thermoablation can occur while inducing thermo-sensitive gene expression in the peripheral microenvironment.

We demonstrate that *in vivo* optical imaging is a powerful method to monitor MHT in preclinical studies by using both BLI models and fluorescent MNPs. In particular, we found conditions of dissipated thermal power allowing both the core tumor thermo-ablation and microenvironment sensitization. Once controlled, MHT would enable to potentiate conventional therapies by combining of thermos-ablation and mild hyperthermia.

Abstract

Thematic Session : Nanobiosciences

Disciplinary fields involved : chemistry , physics, biology

Keywords : cycling temperature, microwave synthesis, iron oxides, magnetic properties

Synthesis of iron oxide nanoparticles and magnetic properties tuning by temperature cycling: towards fine control of crystal phase and size distribution

B. Amouroux, C. Huez, H. Chamand, S. Belgacem, Y. Lalatonne

LVTS UMRS Inserm 1148, Université Sorbonne Paris Nord and Université Paris Cité, F-75018 Paris, France

Abstract

Applications of inorganic nanomaterials in biology require the preparation of nanocrystals having a precise size with a narrow distribution, in addition to specific crystal phase for optimal physical properties (magnetism, luminescence, …). Increasing the magnetic force of nano-objets can improve their performance in applications such as MRI, hyperthermia therapy or magnetic guidance.[1]

This can be achieved thanks to an accurate control of nanoparticles synthesis by proloting size growth. The latter can be decomposed into two steps: At first, a large amount of nuclei crystallize from “monomers” in solution. Then nuclei grow consuming the remaining monomers. When it reaches a sufficiently low monomers concentration, the smaller particles from the size distribution can be dissolved in solution and deposited on larger ones, which maintains a quasi-stationary monomer concentration. This stage, called Ostwald ripening, leads to an increase in both size and size distribution, and is affected by temperature variations. A first use of (microwave-assisted) cycling temperature for inorganic nanoparticles synthesis has been demonstrated in a niche application: UCNP synthesis by thermal coprecipitation.[3] In the current poster, we will showcase that this methodology can be extended to other systems, such as the sol-gel preparation of iron oxides,[2] one of the most widely used nanomaterials for biomedical application.

Then, we will highlight the potential of this cycling temperature method for obtaining well-controlled larger objects through the successive deposition of iron oxide layers (homoepitaxy). Finally, we will discuss the stunning magnetic properties of those « core@shell » iron oxide, achieving magnetization close to the bulk.

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Abstract

Thematic Session: Nanobiosciences & Nanomedecine

Disciplinary fields involved: Chemistry, Physics, Biology

Keywords (max. 4-5)**:** nanocrystals, surface chemistry, photocatalysis

Hybrid plasmon-semiconductor nanoparticles for charge or resonant energy transfer based dynamic phototherapy

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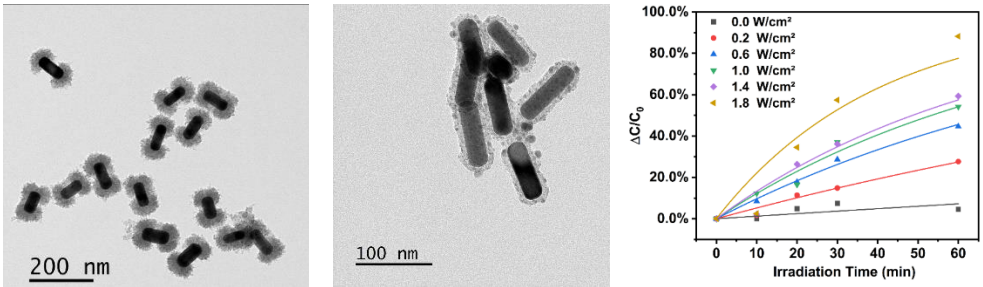
Abstract

Plasmonic nanoparticles, notably gold nanorods, have a particular capacity to absorb a large number of photons at their resonant wavelength and create a strong local electric field. When coupled to semi-conductor nanoparticles, plasmon energy or photo-generated hot charge carriers can be transferred into the semiconductor and used to produce cytotoxic radical oxygen species at the nanoparticle surface. As gold nanorods (AuNR) can be tuned to have their resonant wavelength in the near infrared range, which highly penetrates biological tissue, the coupling of AuNRs and an appropriate semiconductor can lead to an efficient sensitizer, producing hydroxyl radical species for dynamic photothermal therapies in cancer treatment. We have developed the synthesis of various gold-semiconductor nano-hybrid systems, including Au-TiO_2 and Au-Ag_2S and demonstrated their efficient generation of hydroxyl radicals in a physiological medium under near infrared excitation.



Transmission electron microscopy images of Au-TiO_2 and Au-Ag_2S nanohybrids. Degradation of methylene-blue by hydroxy radicals produced by near infrared irradiation of Au-TiO_2.

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Abstract

Thematic Session : Nanobioscience & Nanomedicine
Disciplinary fields involved : Chemistry, Biology
Keywords : Nanoparticles, Re(CO), probes, Cellular studies

Re(CO)-based silica-nanoparticles as multimodal probes for bio-imaging

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Bio-imaging plays a crucial role in elucidating biological processes, offering the capacity to visualize specific biomolecules with high precision. While fluorescence microscopy remains a cornerstone of the field, alternative imaging techniques such as vibrational microspectroscopy and X-ray fluorescence (XRF) microspectroscopy are emerging as powerful modalities. However they suffer from a lack of efficient and specific probes. Metal complexes, such as d^6 low-spin rhenium tricarbonyl compounds, present unique luminescent and vibrational characteristics, positioning them as promising candidates for multimodal imaging applications.[1-2] These complexes demonstrate robust photostability, in contrast of organic fluorophores and exhibit mid-infrared (mid-IR) absorption within the biological transparency window.

This work aims to develop [$ReCl(CO)_3$(pyta)]-based silica nanoparticles (ReSiNPs) to achieve high-density multimodal probes for enhanced sensitivity in mid-IR imaging, fluorescence and synchrotron-based X-fluorescence microscopy. They are also developed as nanothermothers taking advantages of their unique luminescence properties. Utilizing fed-batch co-polymerization methods, the synthesis was optimized to achieve high probe densities within nanoparticles while preserving the desired morphology. Subsequent surface functionalization enhanced nanoparticles dispersion and introduced nano-thermometric properties. ReSiNPs were evaluated for cytotoxicity, mid-IR sensitivity, and imaging efficacy across cellular models, leveraging fluorescence microscopy and synchrotron-based XRF as complementary modalities. Future work of functionalization of ReSiNPs with targeting peptides [3-4] will enable organelle-specific delivery expanding their utility as versatile multimodal probes capable of thermometry as well as IR, XRF, and fluorescence imaging.

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Abstract

Thematic Session: nanobioscience

Disciplinary fields involved : Physics and biophysics

Keywords (max. 4-5)**:** Single molecule imaging, Qdots, FRET, Cell contractility, Cell adhesion

Force nanosensor development for measuring mechanical stress exerted by living cells

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Membrane adhesion receptors and the cytoskeleton are key elements in cell biology mechanotransduction [1]. The molecular machinery of mechanotransduction is a transversal hot topic that gives rise to intense activity in scientific fields mixing physics, chemistry, and biology . Our ability to understand mechanical cues in biology is limited by our capability to measure them in living cells. Therefore, the spatio-temporal dynamics and regulation of active zones involved in mechanosensing, typically at focal adhesion sites, are still poorly understood.
This project proposes to develop a Force NanoSensor (FNS) allowing measurement and mapping of the mechanical strains exerted by living cells at molecular scale [2,3,4]. This probe is composed of an extendible elastic molecule, flanked by two emitters at its ends, including a quantum dot. The force measurement will be achieved when the elastic molecule is stretched, and Förster Resonant Energy Transfer (FRET) will constitute the way to quantify this stretching at the nanoscale. Two different FRET-force calibration experiments are currently being conducted to assess the correspondence between FRET efficiency and the force applied on FNS probes. Two strategies are being explored to tune the force exerted on a single probe: either with optical tweezers or with microfluidic devices. The proposal is to combine a single-molecule imaging technique with a tool allowing for pN force loading on the same setup: typically TIRF imaging with a microfluidic flow chamber and epi-fluorescence microscopy with optical tweezers.

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Abstract

Thematic Session (Nanobioscience)
Disciplinary fields involved (Physics, Biology, Chemistry)**:**
Keywords (Immunotherapy, Nanoparticles, Hyperthermia, Tumor)**:**

Combination therapy using nanoheaters and CAR-T immunotherapy on 3D tumor models

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Abstract (**no longer than 250 words** or 18 lines max. incl. figure), Calibri 11, single line spacing, black)

The tumor microenvironment (TME) of solid tumors consist of physical, chemical and biological barriers which hampers the effect of traditional treatments, such as chemotherapy, but also new and innovative treatments, such as adoptive immunotherapy [1,2]. Despite the promising aspect of adoptive immunotherapy for specific and efficient eradication of tumor cells, the tumor cells remain inaccessible due to the dense and hostile TME [1]. Consequently, local modulation and destructuration of the TME could increase efficacy of immunotherapies. By reducing tumor stiffness and increasing expression of pro-inflammatory agents, the infiltration and activation of CAR-T and native immune cells could be enhanced. Nanoparticle-induced hyperthermia is one possible approach to locally modulate the TME. As nanoparticles are small in size, they can penetrate into and distribute inside the tumor. Moreover, metallic nanoparticles can convert light or magnetic energy into heat, functioning as spatially and temporally activated nanoheaters [3,4]. The efficiency of nanoparticle-induced hyperthermia combined with CAR-T treatment can be evaluated in simple 3D tumor spheroid models, which more accurately mimic *in vivo* conditions compared to 2D cultures [5]. Tumor spheroids are constructed in low attachment well plates in co-cultures with fibroblasts, with or without nanoparticles. Subsequently, spheroids are exposed to laser and/or magnetic field treatment, followed by introduction of CAR-T cells. By monitoring the spheroid periphery and dead cell staining signal, the tumor spheroid killing can be followed kinetically in a live-cell imaging system. This simple yet complex *in vitro* model thus enables combination treatment validation and parameter screening prior to *in vivo* experiments.

Abstract

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Acknowledgement:

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Abstract

Thematic Session: Nanobiosciences & Nanomedecine
Disciplinary fields involved: Chemistry, Biology
Keywords: photoredox catalysis, nanoassemblies, biomimetic, hypoxia, photocatalytic therapy.

Red-blood-cell-membrane-coated polymer micelles/vesicles as biomimetic nanoassemblies for potential photocatalytic cancer therapy under hypoxia

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Recently, photocatalytic therapy has been considered as an important photochemical mechanism of action in addition to photodynamic therapy in anti-tumor treatment.[1] The photocatalytic therapy operates by photoredox catalyzed reaction of enzyme cofactor NADH/NAD+ rather than by photogenerated reactive oxygen species (ROS). In all published photoredox catalytic systems, O_2 or extra molecules like cytochrome c were needed as the terminal electron acceptors to let the triplet excited state of luminophore return to the ground state in the turnover step for continuous conversion of NADH to NAD^+. In this study, we report polymer micelles/vesicles photocatalysts that can function without O_2 or other electron acceptor for recyclable NADH to NAD^+ transformation.[2] This O_2-independent photocatalytic mechanism has inspired a new vision of the mechanism of photoredox reaction. It is proposed that photocatalytic processes use adjacent excited luminophores themselves as the terminal electron acceptor.

We then conducted *in-vitro* and *in-vivo* study of these polymer micelles and vesicles in tumor treatment. For enhancing their bioavailability, polypeptoid-based colloids were coated with folate-modified red blood cell membrane (FA-RBC).[3] Interestingly, photocatalytic efficiency of these biomimetic nanoassemblies under deoxygenated condition was improved by the presence of RBC. Cancer cells with internalized biomimetic nanoassemblies had their NADH/NAD+ balance destroyed upon visible light irradiation and under hypoxia, leading to their mitochondrial dysfunction and cell metabolism inhibition. Further *in-vivo* tests showed that these biomimetic nanoassemblies effectively inhibited tumor growth. This study offers a new nanoplatform of photocatalytic therapy under hypoxia.

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Vivoptic, a preclinical optical imaging platform for the evaluation of diagnostic and therapeutic strategies

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Vivoptic is an approved platform for preclinical experimentation located at the Bordeaux Biomedical Imaging Institute. Labeled France Life Imaging (FLI), it offers not only access to optical imaging equipment for small animals after user training, but also experimental models (genetically modified lines, in vivo tumor models) as well as a set of therapeutic devices. This L1 biological level platform (no pathogens) has fully equipped surgery and animal preparation rooms (anesthesia stations, monitoring (ECG, T°, respiratory rate), micro-injector, stereotaxic frame, etc.). Vivoptic can also help you design the *in vivo* experiment, support you throughout your project and analyze the results.

1 Vivoptic an optical imaging platform

Optical imaging is widely used in cancer research, cardiology and neurology and is a convenient tool for first pharmacological and biodistribution evaluations of nanoparticles labeled with fluorescent dyes, targeting assessment and new therapies. After an initial training, Vivoptic offers you free access to optical imaging devices for bioluminescence and fluorescence imaging:

- Lumina LT (PE) for 2D bioluminescence and fluorescence 2D imaging
- FMT4000 (PE) for fluorescence molecular tomography
- Fluobeam (Fluoptic) a per-operatory probe for free and live monitoring of fluorescence signals including during surgery.
- Probe-based confocal laser endo-microscopy (Cellvizio)
- A clinical/preclinical ultrasound system (Aixplorer) (B mode, Doppler, elastography) including a mouse probe available at the platform, useful for developing therapeutic strategies and image-guided surgery.

2 Vivoptic, a complete offer for in vivo evaluation of your diagnostic and therapeutic agents or your innovative therapeutic strategy.

Vivoptic can provide you a library of optical imaging reporter genes (luciferase, NIR fluorescent proteins), vectors, and modified cell lines. Vivoptic also provide immunocompetent and immunocompromised mouse models of sub-cutaneous, orthotopic and metastasis solid tumors especially dedicated for optical imaging monitoring. Generation of new biological models adapted to your own project is also possible.

3 Vivoptic, a place to share preclinical therapy devices

Therapeutic devices for in vivo gene therapies (electroporation), magnetic hyperthermia, photodynamic therapies (PDT), high intensity focused ultrasound and a clinical and preclinical echograph for imaging and image-guided surgery are also available at Vivoptic.
Vivoptic is a certified place for animal experiment, why not consider Vivoptic to install your own preclinical therapeutic setup?

Abstract

Thematic Session: Nanobiosciences & Nanomedecine
Disciplinary fields involved: Chemistry, Polymerscience, Nanoparticles
Keywords: Nanoprecipitation, Polymer Nanoparticles, Microfluidics, Kinetics

On the Roles of Polymer Chemistry, Kinetics, and Mixing in the Assembly of Loaded Polymer Nanoparticles

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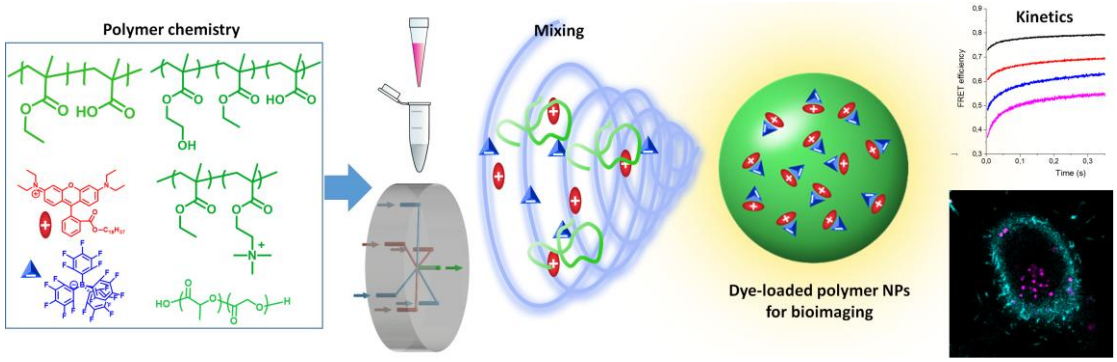
Polymer nanoparticles (NPs) loaded with drugs and/or contrast-agents have become key tools in the advancement of nanomedicine, requiring robust technologies for their synthesis. Nanoprecipitation is a particularly interesting approach for the assembly of loaded polymer NPs, well known to proceed under kinetic control, with a strong influence of assembly conditions. [1] On the other hand, the nature of the used polymer also influences the outcome of nanoprecipitation.[2] Here, we will try to elucidate the relative influences of polymer design, [3] nature of the load and formulation parameters like mixing, [4] on the assembly of dye-loaded polymer NPs for bioimaging applications.[5]



Different polymer chemistry and mixing schemes were used to assemble dye-loaded nanoparticles

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