UDSMM

Unité de Dynamique et Structure des Matériaux Moléculaires

SANaMPhMET

Seminar on the Advances of Nano-dimensional Materials and Phenomenon for Modern Electro-optical Technologies

December 01, 2023, Calais, France

# Seminar on the Advances of Nano-dimensional Materials and Phenomenon for Modern Electro-optical Technologies (SANaMPhMET)

***Friday, 01 December 2023, Calais, France***

**SANaMPhMET Abstract Booklet**

ulco Université Littoral Côte d'Opale

Pôle MTE – Mutations Technologiques et Environnementales

Coopération France-Québec – Ministère de l'Europe et des Affaires étrangères – Québec

Campus France

# Seminar on the Advances of Nano-dimensional Materials and Phenomenon for Modern Electro-optical Technologies (SANaMPhMET)

**Friday, 01 December 2023, Calais, France**

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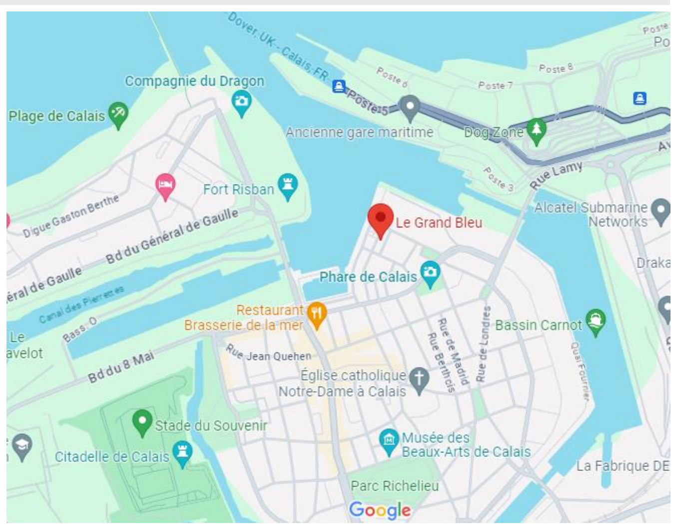
**Venue of Conference:**

**Amphitheater STAPS**
**50 Rue Ferdinand Buisson, 62228 Calais cedex, France**


**Venue of Lunch:**

**Restaurant "Le Grand Bleu"**
**Address: 8 Rue Jean Pierre Avron,**
**62100 Calais**

**** A bus will be available at Entrée 3 at 12h20 for going the restaurant "Le Grand Bleu".**



# Seminar on the Advances of Nano-dimensional Materials and Phenomenon for Modern Electro-optical Technologies (SANaMPhMET)

**Friday, 01 December 2023 Venue: Amphitheater STAPS**

**UDSMM, ULCO, 50 Rue Ferdinand Buisson, 62228 Calais cedex, France**

## CONFERENCE PROGRAM

| | | |
|---|---|---|
| 08h30-09h00 | | **Registration and welcome Coffee** |
| 09h00-9h20 | | Welcome address by:<br>**E. ABI-AAD / R. AMARA** (Vice President Research, ULCO)<br>**A. DAOUDI** (Director UDSMM)<br>**D. SCHNEIDER** (Director POLE MTE)<br>**D.P. SINGH** (Organizing Committee) |
| 09h20-10h00 | **Session Chair**<br>A. HADJ SAHRAOUI | **Planary Talk :** *Topological Metadefects in Cholesterics*<br>**Pawel PIERANSKI**, Université Paris-Saclay, Orsay, France |
| 10h00-10h30 | | **Invited Talk:** *Design of Interactive Meta-Holographic Displays via Liquid Crystallinity*<br>**Young-ki KIM**, POSTECH, South Korea (online) |
| 10h30-10h50 | | **Coffee Break** |
| 10h50-11h20 | **Session Chair**<br>D. SCHNEIDER | **Invited Talk:** *Quantum Rods and their Application in Displays and Lighting Devices*<br>**Abhishek K. SRIVASTAVA**, HKUST, Hong Kong (online) |
| 11h20-11h50 | | **Invited Talk:** *Liquid Crystal Plasmonics: From Active Metasurfaces to Pathogen Detection*<br>**Luciano DE SIO**, Sapienza University of Rome, Italy (online) |
| 11h50-12h20 | | **Keynote Talk:** *Active Nematics for Autonomous Microfluidics*<br>**Teresa LOPEZ-LEON**, ESPCI, Paris (online) |
| 12h20-14h20 | | **Lunch Break** |
| 14h20-14h50 | **Session Chair**<br>F. DELATTRE/SINGH | **Keynote Talk:** (*Tribo)-Electret Kinetic Energy Harvesting*<br>**Philippe BASSET**, Université Gustave Eiffel, Paris |
| 14h50-15h20 | | **Invited Talk:** *Highly Efficient Fluorescence based Chemosensor for Ultralow Level detection of Explosive materials*<br>**Atul CHASKAR**, ICT, India |
| 15h20-15h50 | | **Invited Talk:** *Energy Migration, Upconversion in Rare Earth Doped Nanostructures*<br>**John CAPOBIANCO**, Concordia University, Canada (online) |
| 15h50-16h10 | | **Coffee Break** |
| 16h10-16h40 | **Session Chair**<br>M. DEPRIESTER | **Invited talk:** *The Role of Green Quantum Dots in the Development of Sustainable Environmental and Energy Applications*<br>**Rafik NACCACHE**, Concordia University, Canada (online) |
| 16h40-17h10 | | **Introductory Talk** on Franco-Quebéc Scientific Cooperation<br>**Stephanie LEGOUPY**, Consulate General of France in Quebec, Canada (online) |
| 17h10-17h30 | | **Valedictory function** and Vote of Thanks by Abdelhak HADJ SAHRAOUI |

# ABSTRACTS

# Topological Metadefects in Cholesterics

**Pawel PIERANSKI**

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After an introduction to the Frank-Oseen elasticity of the nematic and cholesteric liquid crystals, we will focus on textures of cholesterics confined between two cylindrical orthogonal mica sheets (see Figure 1). We will show that in equilibrium the planar anchoring provided by the mica surfaces drives two effects: 1°- it orients the cholesteric helix in the direction orthogonal to the mica and 2°- it forces the number of the cholesteric pitches to be an integer N that depends on the local thickness h.

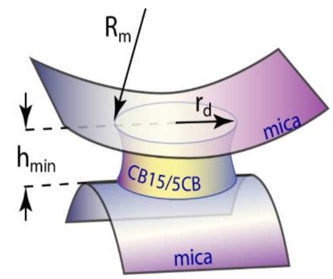


*Figure 1*

Knowing this, we will point out that the adjacent fields with N and N+1 cholesteric pitches must be separated by linear singularities called dislocations. As shown in Figure 2, dislocation must form closed loops because for topological reasons they cannot end in bulk.

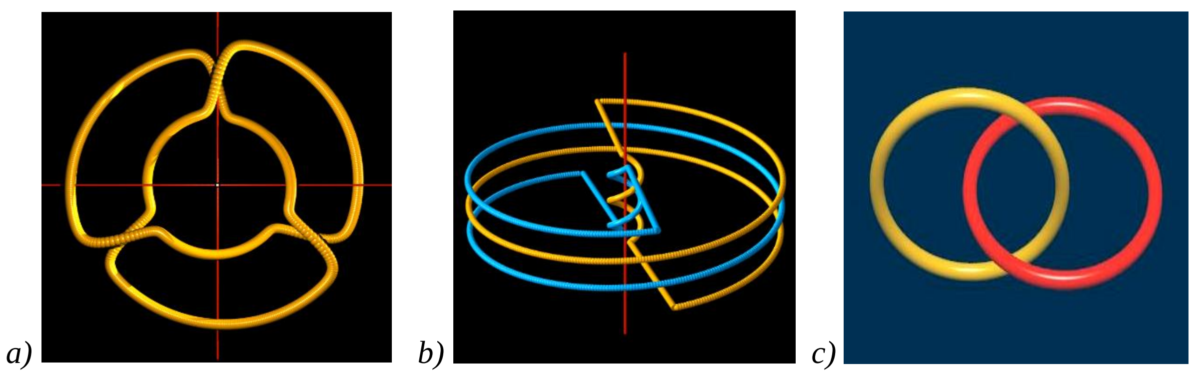


*Figure 2: Topological metadefects made of dislocations in cholesterics : a) trefoil knot, b) double helix tangle, c) Hopf link.*

Finally, we will report on recent experiments in which we have pointed out that dislocation loops can be knotted (Figure 2a), entangled (Figure 2b) [1] or linked (Figure 2c).

**References:**

[1] P. Pieranski, M. Zeghal, M.H. Godinho, P. Judeinstein, R. Bouffet-Klein, B. Liagre and N. Rouger: *Topological metadefects: tangles of dislocations*, **Phys. Rev. Lett.,** 131 **(2023)** 128101.

# Design of Interactive Meta-Holographic Displays via Liquid Crystallinity

Jun-Hyung Im, Won-Sik Kim, Jingang Choi, Yena Choi and **Young-ki KIM**

*Pohang University of Science and Technology (POSTECH), Republic of Korea*

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The arrays of nanostructures on a surface, called metasurfaces, have made advances in flat optics because of their potential to display programmable hologram and miniaturize optical components. Because previous metasurface systems are passive, however, their practical applications have been impeded. Accordingly, recent efforts have focused on the realization of active metasurfaces via using, for example, phase-change materials, mechanical actuations, and chemical reactions, but their full potential has yet to be realized. Here, we propose a simple and versatile design approach to enable dynamically tunable metahologram by leveraging unique features of liquid crystals (LCs) [1-4]. We demonstrate the new class of active metahologram, a thin layer of LC integrated with multiplexing metasurface, to autonomously sense a programmed stimulus and dynamically switch the "full-color" holographic images. This attribute provides insight into the rational design of interactive meta-hologram display enabling multifunctional active devices. This work was supported by the Korea National Research Foundation (NRF-2022M3C1A3081312).

**References:**

[1] I. Kim, M. A. Ansari, M. Q. Mehmood, W. -S. Kim, J. Jang, M. Zubair, **Y.-K. Kim*,** and J Rho*, "*Stimuli-responsive dynamic meta-holographic displays with designer liquid crystal modulator*", **Advanced Materials**, 32 (**2020**) 2004664

[2] I. Kim, W. -S. Kim, K. Kim, M. A. Ansari, M. Q. Mehmood, T. Badloe, J. Gwak, H. Lee, Y.-K. Kim*, and J. Rho*, "*Holographic Metasurface Gas Sensors for Instantaneous Visual Alarm*", **Science Advances**, 7 **(2021)** eabe9943

[3] T. Badloe, J. Kim, I. Kim, W.-S. Kim, W. S. Kim, **Y.-K. Kim*,** and J. Rho*, "*Liquid Crystal-Powered Mie Resonators for Electrically Tunable Photorealistic Color Gradients and Dark Blacks*", **Light: Science & Applications,** 11 **(2022)** 118

[4] J. Kim, J.-H. Im, S. So, Y. Choi, H. Kang, B. Lim, M. Lee, **Y.-K. Kim*** and J. Rho&*, "Dynamic Hyperspectral Holography Enabled by Inverse-Designed Metasurfaces with Oblique Helicoidal Cholesterics", Under Review **(2023)**.

# Quantum Rods and Their Application in Displays and Lighting Devices

**Abhishek Kumar SRIVASTAVA**

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The aligned quantum rods emit polarized light that could improve the efficiency of modern displays. Semiconductor quantum rods (QRs), due to their unique shape-dependent emission properties, have been a center of attraction for the last decade [1-8]. These materials not only exhibit the quantum confinement effect due to their size, but also show polarized photoluminescence properties. In this talk, we will discuss the High-quality alignment of the QRs showing a high polarization ratio for the PL. We developed a photoaligned quantum rod enhancement films (QREF) containing red and green QRs, for their application in LCD backlights. A 6-inch QREF was printing using Inkjet printing and later deployed to the LCD [5-8]. The polarization ratio of the emitted light for the printed QREFs is measured to be ~ 7:1 [8]. The intensity of the QREF backlight is measured at ~ 7200 nits, which becomes ~561 nits after the LCD panel shows an optical efficiency of ~7.8%, which is approximately 1.7 times higher than conventional LCDs. Furthermore, we also developed some of the most efficient and bright QRLEDs. The optimization of the hole transporting layers can significantly reduce the EQE roll-off leading to the EQE > 20% even at the operating current density of 1 A/cm$^2$. These results pave a way for brighter and efficient displays that can find application in AR/MR headsets and smart phones. In conclusion, the photoaligned quantum rods can double the efficiency of modern display devices. In this talk, we will explore the detail of photoalignment of QRs and their application in displays and lighting devices.

**Acknowledgments**

The financial support from the ITF Grant ITS/370/16, PRP/049/19FX, and ITS/059/22MX from ITC Hong Kong government, The RGC of Hong Kong SAR (Grant No. 26202019), Huawei, Microlite Ltd., CSOT China, TTC HKUST, Transconsultant Ltd, ASTRI HK, and the State Key Laboratory of Advanced Displays and Optoelectronics Technologies, Hong Kong University of Science and Technology are gratefully acknowledged.

**References:**

[1] Maksym F. Prodanov, Valerii V. Vashchenko, A. K. Srivastava, **Nanophotonics**, https://doi.org/10.1515/nanoph-2021-0053, 2021.

[2] C. Kang, M. F. Prodanov, Yiyang Gao, V. V. Vashchenko A. K. Srivastava, **Adv. Mat.,** 2104685, 2021.

[3] A. K. Srivastava, W. Zhang, J. Schneider, J. E. Halpert, and A. L. Rogach, **Adv. Science**, 1901345, 2019.

[4] A. K. Srivastava, W. Zhang, J. Schneider, A. L. Rogach, V. G. Chigrinov, and H. S. Kwok, **Adv. Mat.,** 1701091, 2017.

[5] Y. Gao, M. F. Prodanov, C. Kang, V. V. Vashchenko, S. K. Gupta, C. C. S. Chan, K. S.Wong, A. K. Srivastava, **Nanoscale**, 13, 6400, 2021.

[6] Z. Liao, K. Mallem, M. F. Prodanov, C. Kang, Y. Gao, J. Song, V. V. Vashchenko, A. K. Srivastava, **Adv. Mat.,** 2303950, 2023

[7] K. Mallem, M. Prodanov, C. Dezhang, M. Marus, C. KANG, S. Shivarudraiah, V.Vaschenko, J. Halpert, A. K. Srivastava, **ACS Applied Materials & Interfaces**, 14, 16, 18723, 2022.

[8] M.F. Prodanov, C. Kang, S. K. Gupta, V. V. Vashchenko, and A. K. Srivastava, ***Nano Research***, 1-10, 2022.

# Liquid Crystal Plasmonics: From Active Metasurfaces to Pathogen Detection

**Luciano DE SIO**
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Nanotechnology, with the help of nanomaterials, plays a crucial role in several research fields ranging from photonics to biotechnology. Liquid crystals (LCs) are stimuli-responsive materials that can be controlled using external mechanisms such as optical and electric fields. Bridging nanomaterials and LCs provide exciting opportunities, making next-generation optical and biotechnological applications remotely controllable and more sensitive. With this premise, I report and discuss our latest achievements in LC-based nanotechnology applications. In particular, I overview an innovative class of self-assembled optical metasurfaces, realized using a bottom-up approach combined with a nematic LC layer, showing the realization of a light-controllable optical absorber. [1] Furthermore, I discuss how a new generation of vertical and self-aligned LCs combined with an array of bioactivated gold nanorods are used to realize a multiple biosensor that detects very low and high concentrations of bacteria dispersed in drinkable water. [2] The reported findings open new opportunities in realizing agile and smart photonic and biotech applications.

**References:**

[1] F. Petronella, T. Madeleine, V. De Mei, F. Zaccagnini, M. Striccoli, G. D'Alessandro, M. Rumi, J. Slagle, M. Kaczmarek, L. De Si:. *Thermo-plasmonic controlled optical absorber based on a liquid crystal metasurface*, **ACS Applied Materials & Interfaces**, 15, **(2023)**, 49468–49477.

[2] F. Petronella, D. De Biase, F. Zaccagnini, V. Verrina, S.-In Lim, K.-Un Jeong, S. Miglietta, V. Petrozza, V. Scognamiglio, N. P. Godman, D. R. Evans, M. McConney and L. De Sio: *Label-free and reusable antibody-functionalized gold nanorod arrays for the rapid detection of Escherichia coli cells in a water dispersion*, **Environ. Sci.: Nano**, 9, **(2022)**, 3343-3360.

# Active Nematics for Autonomous Microfluidics

**Teresa LOPEZ-LEON**

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Active nematics refers to a variety of systems ranging from bacterial suspensions to biological tissues in which self-propelling elongated units self-organize to produce local orientational order and collective flow [1]. This "self-flow" of active nematics has markedly different phenomenological properties compared to passive fluids. The past decade has witnessed important experimental and theoretical advances in understanding how active nematics flow in simple geometries [2-5]. Yet very little is known about how these active fluids flow in networks of interconnected channels, despite the prevalence of these architectures in Nature. Understanding the principles governing active flow networks would enable the development of a new generation of bioinspired microfluidic micromachines, which would operate out of equilibrium and could perform complex functions, from convoluted transport to logical operations [6,7].

In this work, we experimentally address these questions using a two-dimensional microtubule-kinesin active nematic formed by spontaneous self-assembly at an oil-water interface. Our microfluidic devices are 3D-printed polymeric platforms, placed at the oil-water interface, in which the channels are empty spaces enclosed by solid walls [4]. We investigate how the local geometry of the channels and the global topology of the network impact the spatial distribution of the flow. We find that the amplitude and direction of the flow velocity in each individual channel is controlled by the channel geometry, while the coupling between connected channels strongly depends on the node geometry. We show that AND/OR logical circuits can be implemented by combining elementary channels and bifurcations, in which bits of information are encoded via the presence (1) or absence (0) of net flow at the network inlets and outlets. These experiments shed light on the principles controlling active flows in channel networks, providing design principles for the conception of functional autonomous microfluidic devices.

**References:**

[1] A. Doostmohammadi et al, **Nat. Commun**. 9 **(2018)** 3246.
[2] J. Hardoüin et al., **Nat. Comm**. 13 **(2022)** 6675.
[3] J. Hardoüin et al, **Soft Matter** 16 **(2020)** 9230.
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[5] A. Opathalage et al., **PNAS** 116 **(2019)** 4788.
[6] F. G. Woodhouse and J. Dunkel, **Nat. Comm.** 8 **(2017)** 15169.
[7] R. Zhang et al., **Sci. Adv.** 8 **(2022)** eabg9060.

# (Tribo)-Electret Kinetic Energy Harvesting

**Philippe BASSET**

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Triboelectric contact is a simple way to charge the electret of an electrostatic kinetic energy harvester. Unlike traditional techniques such as the corona effect or soft x-rays, triboelectric charging does not need to be performed during the fabrication of the device. On the contrary, it allows a regular renewal of the charges trapped in the tribo-electret layer "at work", which can compensate for the tendency of the electret charges to release over time.

As for any electrostatic transducers, triboelectric (nano)generators (TENGs) need to maximize their DC bias voltage for a good kinetic-to-electrical energy conversion. TENGs have the great advantage to self-generate high AC open-circuit voltage of several hundred volts peak, but with relatively low short-circuit current. However, most applications require DC voltages around only a few volts, with DC currents of at least a few tens of µA in order to generate a minimum average power of 100 µW. In addition, if a very high DC voltage can be obtained directly with a diode bridge for some state-of-art TENGs, a recent class of unstable charge-pump conditioning circuits can also be used to reach such high values with more basic TENGs.

This presentation will introduce the modeling and conditioning of triboelectric generators, and how to deal with the generated high voltage to maximize the electromechanical conversion efficiency.

**References:**

[1] L. Q. Machado, H. Zhao, M. Amjadi, H. Ouyang, P. Basset, D. Yurchenko: *Optimisation-driven design of sliding mode triboelectric energy harvesters*, **Nano Energy** 115 **(2023)** 108735.

# Highly Efficient Fluorescence based Chemosensor for Ultralow Level detection of Explosive materials

**Atul CHASKAR***[1], Aniket Parab[2] and Aniket Karpe[2]

[1]*Department of Chemistry, Institute of Chemical Technology Mumbai, N.P.Marg, Matunga, Mumbai-400019*

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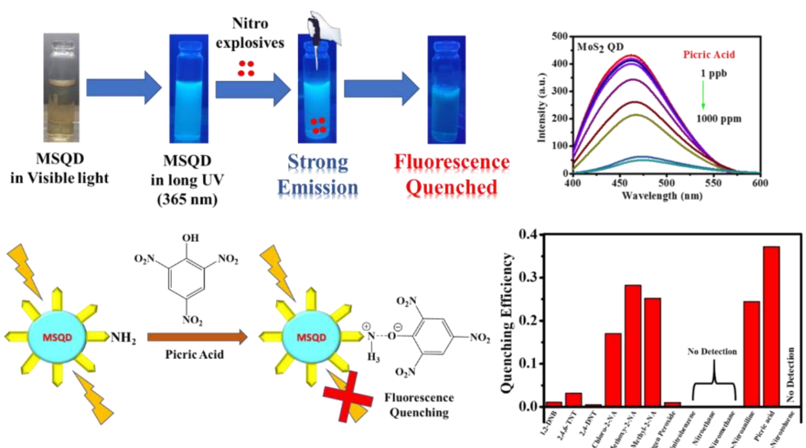
The rapid detection of buried landmines has become a crucial concern of global security owing to the advancement in terrorist attacks. Indeed, the development of smart materials for the rapid detection of explosives especially nitro-explosives is the need of time. However, the sensitivity and selectivity of materials for the detection of nitro-explosives are major hurdles due to their low vapour pressure at room temperature. Albeit, it could be resolved by the use of advanced functional nanomaterials bearing high surface area and excellent optoelectronic properties. In this context, the water-soluble $MoS_2$ quantum dots (QDs) and $WS_2$ nanosheets are synthesized by an ultrafast eco-friendly hot injection method and potentially used for the detection of nitro-explosives. The detection of picric acid (PA), 2,4,6- Trinitrotoluene (TNT) and various other nitroaromatic compounds is performed by fluorescent probe technique. Notably, $MoS_2$ QDs have effectively detected picric acid and TNT exhibiting detection limits of 5.13 ppm and 43.93 ppm respectively in water via a photoinduced electron transfer mechanism. However, $WS_2$ nanosheets efficiently detect picric acid and 2,4,6-TNT in aqueous media with lower detection limits of 2.21 ppm and 63.60 ppm, respectively. Real-time analysis of picric acid employing a paper strip of $MoS_2$ QD and $WS_2$ nanosheets as a fluorescent probe clearly demonstrates their potential for practical usage in explosive detection.




## References:

[1] Aniket A. Parab, Aniket S. Karpe, Anjali Tiwari, Amitansu Pattanaik, Yogesh Jadhav, Pravin Walke, and Atul C. Chaskar *Eco-friendly and Efficient Synthesis of Water-soluble MoS2 Quantum Dot Probe for Smart Explosive Senso*r **Chemistry Select** 8 (29),**2023**, e202300142.

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Seminar on the Advances of Nano-dimensional Materials and Phenomenon for Modern Electro-optical Technologies (SANaMPhMET)

01 December 2023, UDSMM, Université du Littoral Côte d'Opale, 62228 Calais cedex, France

# Energy Migration, Upconversion in Rare Earth Doped Nanostructures

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Since the turn of the millennium, the study of lanthanide upconversion in nanoparticles has grown exponentially, contributing to over four thousand publications in 2022 alone, according to Google Scholar. Due to the electronic configuration of the trivalent lanthanide ions, which possess energy levels with relatively long-lived intermediate excited states, upconversion luminescence in the ultraviolet and visible spectral regions can be achieved through a sequential absorption of two or more near-infrared photons. While their emissions are particularly useful for many applications, one infrequently used property of lanthanide upconversion is the luminescence lifetimes, which can persist for several milliseconds after the excitation source has ceased. Examining the dynamics and the energy transfer mechanisms we demonstrate the potential of upconversion in anti-counterfeiting, microfluidic devices to measure particle velocity, and understanding the upconversion mechanism in co-crystals and MOF (metal organic frameworks).

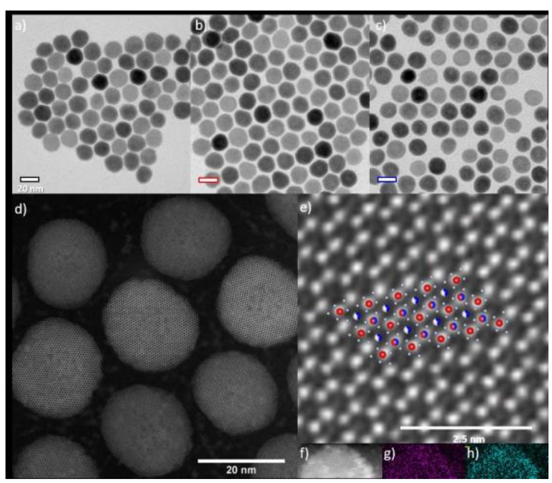


*Figure 1: Microscopic imaging of Rare earth doped nanostructures*

**References:**

[1] Y. Xie, G. Sun, G. A. Mandl, S. L. Maurizio, J. Chen, J. A. Capobianco, L. Sun: *Upconversion Luminescence through Cooperative and Energy-Transfer Mechanisms in Yb3+-Metal-Organic Frameworks*, **Angewandte Chemie International Edition**, 62 **(2023)** e202216269.

# The Role of Green Quantum Dots in the Development of Sustainable Environmental and Energy Applications

Rafik Naccache

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In recent years, nanomaterials (defined as materials < 100 nm in a single dimension) have garnered a significant interest for the development of novel applications in the physical and life sciences. One such class of nanomaterials is organic/inorganic quantum dots,[1,2] which possess versatile optical properties rendering them attractive for imaging, environmental sensing and energy applications. More recently, the scientific community has directed its attention to green quantum dots in an effort to produce these nanomaterials while adhering to the principles of green chemistry. With ultra-compact size, low cytotoxicity, resistance to photo-bleaching/blinking and tunable photoluminescence (Figure. 1), combined with simple, environmentally-friendly and low-cost synthesis, green quantum dots are ideal candidates for study. We synthesize organic and inorganic quantum dots via bottom-up synthesis methods, with simple precursors and study how to tailor their physico-chemical and optical properties via surface passication to achieve high fluorescence quantum yields. Our work focuses on trying to study structure function relationships and how this contributes to the observed optical properties. Finally, we exploit their fluorescence in order to design multifunctional materials for environmental sensing applications and for integration in photovoltaic devices. We also take advantage of their surface chemistry to develop heterogeneous catalysts to produce green fuels.

*Figure 1: The fluorescence of the carbon dots can be tuned from the blue to the far red/near-infrared regions of the spectrum.*

**References:**

[1] T. de Medeiros, J. Manioudakis, F. Noun, J. R. Macairan, F. Victoria and R. Naccache: *Microwave-assisted synthesis of carbon dots and their applications*, **J. Mater Chem. C**, 7 **(2019)** 7175-7195.

[2] W. Yang, X. Li, L. Fei, W. Liu, X. Liu, H. Xu and Y. Liu: *A review on sustainable synthetic approaches toward photoluminescent quantum dots*, **Green Chem.**, 24 **(2022)** 675-700.

# Introductory Talk on Franco-Quebéc Scientific Cooperation

**Stephanie LEGOUPY**

*Attachée de Coopération Scientifique et Universitaire, Service de Coopération et d'Action Culturelle, Consulat Général de France à Québec, 1501, McGill College, Montréal (QC) H3A 3M8*

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Madam Legoupy is responsible of the Scientific and University cooperation actions under the Consulate General of France in Quebec. Under this mission, her principal responsibility is to enhance the French-Quebec scientific cooperation between the French and Quebec research institutes and organization.

During this non-scientific talk, she will explain the possible opportunities for the French-Quebec scientific cooperation under different schemes and programs such as Samuel de Champlain.