EUPOC 2025

MacroLight

11-15 May 2025, Bertinoro (FC), Italy

Chairs

Albert Schenning
Eindhoven University of Technology (NL)

Ulrich Steiner
Adolphe Merkle Institute (CH)

Davide Comoretto
Università degli Studi di Genova (I)

Organized by

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

adolphe merkle institute
excellence in pure and applied nanoscience

Università di Genova

Under the auspices of

epf European Polymer Federation

Supported by

AIM Associazione Italiana di Scienza e Tecnologia delle Macromolecole

PRIN 2020 PRIN PETALS

Acknowledgments

ADVANCED OPTICAL MATERIALS

Macromolecular Rapid Communications

attocube WITTENSTEIN group

OPTOPRIM BRILLIANT IN LASER SOLUTIONS

schaefer

GARDINI CIOCCOLATO D'AUTORE

RESPONSIVE MATERIALS Open Access

Book of Abstracts

Index of CONTENTS

Meet the CO-CHAIRS

Albert Schenning

Eindhoven University of Technology
The Netherlands

Ulrich Steiner

Adolphe Merkle Institute
Switzerland

Davide Comoretto

Università di Genova
Italy

The SCIENTIFIC COMMITTEE

Katia Sparnacci

Università del Piemonte Orientale
Italy

Paola Stagnaro

SCITEC-CNR
Italy

Michele Laus

Università del Piemonte Orientale
Italy

Federico Ferrarese Lupi

INRIM
Italy

Daniele Caretti

Università di Bologna
Italy

Angelo Angelini

INRIM
Italy

The ORGANIZATION

Maria Graziella Viola

EUPOC 2025 Administrative Secretariat
eupoc@aim.it

Patrizia Barraco

EUPOC 2025 Administrative Secretariat
patrizia.barraco@scitec.cnr.it

Sabrina Carola Carroccio

AIM Secretariat
segreteria@aim.it

Diego Antonioli

Website Manager
diego.antonioli@uniupo.it

Here are the

INVITED SPEAKERS

in alfabetic order

Christopher Barner-Kowollik

Queensland University of Technology
Australia

Cécile Chazot

Northwestern University
USA

Michael Debije

Eindhoven University of Technology
The Netherlands

Daniel Gryko

Polish Academy of Sciences
Poland

Magnus Jonsson

Linköping University
Sweden

Guglielmo Lanzani

Istituto Italiano di Tecnologia
Italy

Paola Lova

Università di Genova
Italy

Here are the

INVITED SPEAKERS

in alfabetic order

Camilla Parmeggiani

Università di Firenze
Italy

Andrea Pucci

Università di Pisa
Italy

Silvia Vignolini

Max Planck Institute
Germany

Viola Vogler-Neuling

University of Fribourg
Switzerland

Ulrich Wiesner

Cornell University
USA

Younan Xia

Georgia Institute of Technology
USA

INVITED SPEAKERS

Oral Lectures

The Precision Photochemistry Paradigm Enables Multi-Colour 3D Printing

Christopher Barner-Kowollik

Centre for Materials Science, School of Chemistry and Physics, Queensland University of Technology (QUT), 2 George Street, QLD 4000, Brisbane, Australia
Institute of Nanotechnology (INT) and Institute of Functional Interfaces (IFG), Karlsruhe Institute of Technology (KIT), Kaiserstrasse 12, 76131 Karlsruhe, Germany

E-mail address: christopher.barnerkowollik@qut.edu.au

Over the last decade our laboratory has employed monochromatic tuneable laser systems to reveal a strong mismatch between the absorptivity of a reactive chromophore and its photochemical reactivity in the vast majority of covalent bond forming as well as bond cleavage reactions via photochemical action plots. Our data overturns the long-held paradigm that effective photochemical reactions are obtained in situations where there is strong overlap between the absorption spectrum and the emission wavelength under a given set of reaction conditions. However – as we explore herein – the absorption spectrum of a molecule provides only information about singlet excitation and remains largely silent on the accessibility of the critical triplet states and the individual microenvironment of each chromophore, which dictates its individual photochemical reactivity. We propose future avenues of enquiry on how photochemical action plots can be understood and demonstrate how they are of key importance for tailoring photochemical applications in light-driven soft matter materials design – most-notably in advanced light-driven multi-material 3D printing – with never-before-seen precision, exploiting wavelength orthogonal, synergistic, cooperative and antagonistic photochemical reaction modes.

References

1. Michenfelder, R. T.; Pashley-Johnson, F.; Guschin, V.; Delafresnaye, L.; Truong, V. X.; Wagenknecht, H.-A.; Barner-Kowollik, C. *Adv. Sci.* **2024**, 2402011. **2.** Walden, S.L.; Carroll, J.; Unterreiner, A.-N.; Barner-Kowollik, C. *Adv. Sci.* **2024**, 2306014. **3.** Irshadeen, I.M.; Walden, S.L.; Wegener, M.; Truong, V.X.; Frisch, H.; Blinco, J.P.; Barner-Kowollik, C. *J. Am. Chem. Soc.* **2021**, *143*, 21113. **4.** Gauci, S. C.; Du Prez, F. E.; Holloway J. O.; Houck, H. A.; Barner-Kowollik, C. *Angew. Chem. Int. Ed.*, **2023**, e202310274. **5.** Nardi, M.; Blasco, E.; Barner-Kowollik, C. *J. Am. Chem. Soc.* **2022**, *144*, 1094. **6.** Kalayci, K.; Frisch, H.; Truong, V. X.; Barner-Kowollik, C. *Nat. Comm.* **2020**, 11, 4193. **7.** Menzel, J.P.; Noble, B.B.; Blinco, J.P.; Barner-Kowollik, C. *Nat. Comm.* **2021**, 12, 1691. **8.** Rodrigues, L. L; Micallef, A. S.; Pfrunder, M.; Truong, V.X.; McMurtrie, J. C.; Dargaville, T.R.; Goldmann, A. S.; Feist, F.; Barner-Kowollik, C. *J. Am. Chem. Soc.* **2021**, *143*, 7292. **9.** Pashley-Johnson, F.; Munaweera, R.; Houssain, S. I.; Gauci, S. C.; Delafresnaye, L.; Frisch, H.; O'Mara, M. L.; Du Prez, F. E.; Barner-Kowollik, C. *Nat. Commun.*, **2024**, *15*, 6033, 1-9. **10.** Kodura, D.; Houck, H. A.; Bloesser, F. R.; Goldmann, A. S.; Du Prez, F. E.; Frisch, H.; Barner-Kowollik, C. *Chem. Sci.* **2021**, *12*, 1302. **11.** Kodura, D.; Rodrigues, L. L.; Walden, S. L.; Goldmann, A. S.; Frisch, F.; Barner-Kowollik, C. *J. Am. Chem. Soc.* **2022**, *144*, 6343. **12.** Walden, S. L.; Rodrigues, L. L.; Alves, J.; Blinco, J. P.; Truong, V. X.; Barner-Kowollik, C. *Nat. Comm.* **2022**, *13*, 2943. **13.** Thai, D. L.; Guimarães, T. R.; Chambers, L. C.; Kammerer, J. A.; Golberg, D.; Mutlu, H.; Barner-Kowollik, C. *J. Am. Chem. Soc.* **2023**, *145*, 14748. **14**. Hobich, J.; Feist, F.; Werner, P.; Carroll, J. A.; Fuhr, O.; Blasco, E.; Mutlu, H.; Barner-Kowollik, C. *Angew. Chem. Intl. Ed.* **2024**, e202413530. **15**. Nagao, M.; Mundsinger, K.; Barner-Kowollik. C. *Angew. Chem. Intl. Ed.* **2025**, e202419205. **16**. Thai, L. D., Kammerer, J.A., Golberg, D., Mutlu, H., Barner-Kowollik, C. *Chem.* **2024**, 102341. **17**. Ehrmann, K.; Barner-Kowollik, C. *J. Am. Chem. Soc.* **2023**, *145*, 24438- 24446.

Hierarchical Order in Liquid Crystalline Biopolymers

Cécile A. C. Chazot, Simona G. Fine, Eleanor C. Grosvenor, Serafina R. France Tribe, Paloma X. Lee, Emma M. Sellin, Charmaine Guo

Northwestern University, cchazot@northwestern.edu

Biopolymers such as polysaccharides and polypeptides are naturally abundant, sustainable, and versatile alternatives to synthetic macromolecules for functional soft materials with dynamic properties. Key biopolymers, including cellulose, chitosan, collagen, and keratin, have the inherent ability to self-assemble into ordered anisotropic structures across length scales. By controlling the hierarchical ordering of polymeric chains—from repeat unit sequence to secondary structures and long-range liquid crystalline order—the physical properties of these materials can be precisely tailored. Moreover, many biomacromolecules exhibit birefringence and can spontaneously self-assemble into cholesteric liquid crystals (LCs). This long-range helical arrangement consists of stacked nematic pseudo-layers, where the continuous change in refractive index allows selective reflection of part of the electromagnetic spectrum.[1] When the helicoidal pitch matches the wavelength of visible light, dynamic structural colors emerge, driven by the spacing and twisting angles between isoclines (planes of constant orientation). This results in stimuli-responsive optical properties that are sensitive to environmental changes such as mechanical strain, humidity, and temperature. Additionally, controlling the cholesteric pitch and selective reflection bands unlocks other functional properties, including UV protection and radiative thermal regulation. However, significant knowledge gaps remain in understanding the thermodynamic and kinetic forces that drive multiscale order evolution and their effects on material properties across length scales.[2] Here, we elucidate the critical factors influencing order propagation in polysaccharides and polypeptides, from interchain interactions and hydrogen bonding to microscale texture and macroscale geometry. Using wool fibers as a model system, we have established key relationships between protein secondary structure, polymer crystallinity, microscale topology, and their effects on elastic properties and fiber surface energy. We also present our recent advances in elucidating structure-property relationships in cholesteric solutions of cellulose ethers and chitosan, exploring their LC phase behavior and the kinetics of their self-assembly. These insights pave the way for the deterministic design of hierarchical biopolymer structures, pioneering a new class of stimuli-responsive natural soft materials with dynamic optical and mechanical properties.

References

[1] S. G. Fine, C. A. C. Chazot, "Unraveling the Governing Mechanisms Behind the Chiral Nematic Self-Assembly of Cellulose-Based Polymers", *Chemistry of Materials* 2023, 35 (21), https://doi.org/10.1021/acs.chemmater.3c01904

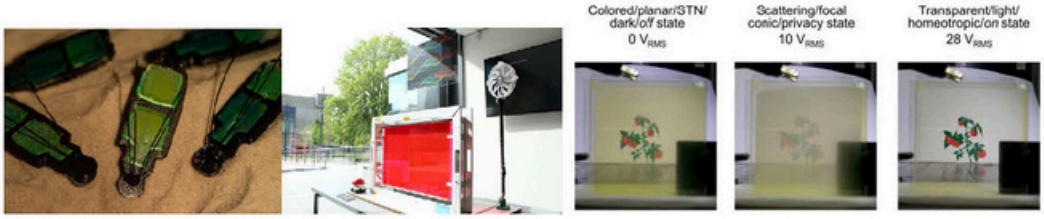
[2] S. G. Fine, S. E. Branovsky, C. A. C. Chazot, "Structural Color Out of the Blue: A Quantitative Framework for the Self-Assembly Kinetics of Cholesteric Cellulosic Mesophases", *Biomacromolecules* 2024, 5 (8), https://doi.org/10.1021/acs.biomac.4c00411

The manipulation and management of light in liquid crystal-based devices

Michael G. Debije

Eindhoven University of Technology, m.g.debije@tue.nl

In this contribution, I describe the use of liquid crystals and liquid crystalline polymers in a survey of the variety of devices we have developed at the TU Eindhoven for manipulating light in the built environment. Calamitic liquid crystals are a state of matter intermediate to liquids and crystals consisting of long, rodlike molecules that generally all point in the same direction in the nematic phase but maintain the ability to flow past each other, a type of 'ordered liquid'. The liquid crystal mesogens, or individual molecules, may be induced into a wide variety of alignments, including planar (lying flat on a surface), homeotropic (standing up from the substrate), 'splay' (rotating from planar to homeotropic through the depth of aa film), and even with a molecular rotation through the film depth. The anisotropic optical and electronic nature of the molecule allow for a variety of optical effects, including the rotation of polarization states and even reflection of narrow bandwidths of light. By synthesizing liquid crystal mesogen with reactive endgroups like acrylates, its possible to trap the liquid crystalline order as a solid film by photopolymerization. These anisotropic films may display the ability to actuate (bending, twisting, curling) in response to a variety of stimuli, including light, heat, magnetic or electric fields, humidity and chemicals, or may display photonic properties that can adapt to changes in their environment. I hope to inspire the audience to consider potential application of these interesting materials by describing a number of applications, including luminescent solar concentrators for generating electricity from sunlight, infrared control layers, 'smart' windows, signage, noise barriers, and actuators. These approaches can be used to produce colorful solar energy converters for use in urban settings, greenhouse roofs that reflect infrared light only in warm weather, stand-alone signs that can light themselves at night without attaching to the grid, mobile chemical factories, and as sensors indicating environmental changes with dramatic variation in their structural colors.

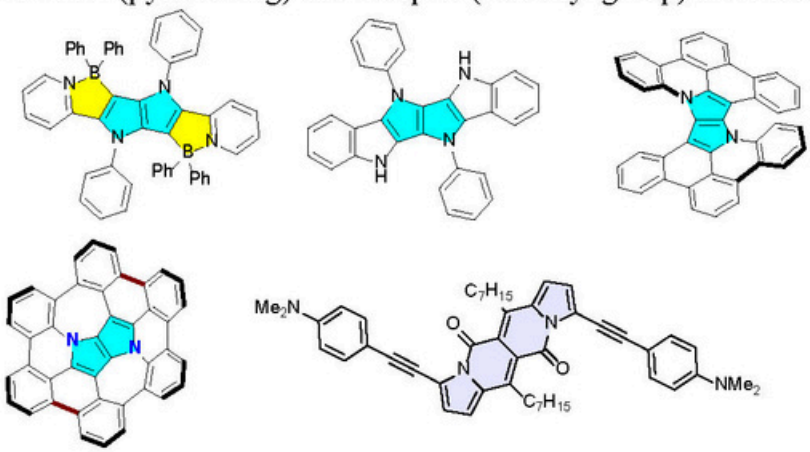


1,4-Dihydropyrrolo[3,2-*b*]pyrrole and Dipyrrolonaphthyridinedione – Novel Building Blocks for Optoelectronics

Daniel T. Gryko

Institute of Organic Chemistry, Polish Academy of Sciences, Kasprzaka 44/52, 01-224 Warsaw, Poland, dtgryko@icho.edu.pl

Recently we have discovered and optimized the first practical synthesis of non-fused pyrrole[3,2-*b*]pyrroles *via* domino reaction of aldehydes, primary amines, and butane-2,3-dione.[1] Six bonds are formed in heretofore unknown tandem process, which gives rise to substituted pyrrole[3,2-*b*]pyrroles – the 'missing link' on the map of aromatic heterocycles. Unparalleled simplicity and versatility of this one-pot reaction, non-chromatographic purification and superb optical properties (including strong violet, blue or green fluorescence both in solution as well as in the solid state), brought these molecules from virtual non-existence to the intensively investigated area functional π-systems. The parent 1,4-dihydro-pyrrolo[3,2-*b*]pyrroles served as building block to construct various π-expanded analogs including nitrogen-embedded buckybowl with inverse Stone–Thrower–Wales topology.[2] These compounds constitute the most electron-rich ladder-type heteroacenes known to date - E_{HOMO} was located at ca. −4.6 eV. Recently, we have proved that the dipyrrolonaphthyridinedione (DPND)[3] core constitutes an excellent scaffold for the design of strongly fluorescent dyes or quadrupolar-type materials with large two-photon absorption (TPA) cross-sections (up to 5,180 GM). These properties result from an unusual arrangement of donor (pyrrole ring) and acceptor (carbonyl group) moieties within the DPND core.



References

[1] M. Krzeszewski, D. Gryko, D. T. Gryko, "'The Tetraarylpyrrolo[3,2-*b*]pyrroles - From Serendipitous Discovery to Promising Heterocyclic Optoelectronic Materials." *Acc. Chem. Res.*, **2017**, *50*, 2334-2345.
[2] S. Mishra, M. Krzeszewski, C. A. Pignedoli, P. Ruffieux, R. Fasel, D. T. Gryko, "On-surface synthesis of a nitrogen-embedded buckybowl with inverse Stone–Thrower–Wales topology."*Nat. Commun.*, **2018**, *9*, 1714.
[3] B. Sadowski, D. T. Gryko "Dipyrrolonaphthyridinedione – (still) a mysterious cross-conjugated chromophore." *Chem. Sci.* **2023**, *14*, 14020-14038.

Dynamic control of light and heat with conducting polymers

Magnus Jonsson

Organic Photonics and Nanooptics group, Laboratory of Organics Electronics, Linköping University, Sweden, magnus.jonsson@liu.se

Conducting polymers offer unique ways to control light and heat, which I will illustrate using recent examples from our research. I will first demonstrate that conducting polymers enable a new type of dynamically tuneable optical nanoantennas.[1-5] Such nanoantennas form the basis for important applications like optical metasurfaces, but they are traditionally static. By contrast, the optical response of conducting polymer nanoantennas can be dynamically tuned by varying the oxidation state of the polymer, opening for redox-tunable metasurfaces and applications like dynamically tunable flat lenses and video holograms.

Next, I will show how the same type of electroactive polymers enables novel means for dynamic structural coloration for reflective displays.[6-7] Such displays form an energy-efficient complement to emissive displays and provide additional benefits such as being suitable for use in bright light.

Finally, I will present some of our work on radiative cooling by which the coldness of outer space enables passive cooling of objects on Earth via thermal radiation. I will focus on the use of conducting polymers to electrically tune the radiative cooling power, offering temperature regulation of objects by tuning their ability to radiate heat.[8-9] The concept is based on modulating the infrared emissivity of our devices, which also offer means for adaptable camouflage and anticounterfeiting.[10]

References

[1] *S. Chen et al.*, "Conductive polymer nanoantennas for dynamic organic plasmonics." *Nat. Nanotechnol.* 2020, 15, 35–40.

[2] *A. Karki et al.*, "Electrical tuning of plasmonic conducting polymer nanoantennas." *Adv. Mater.* 2022, 34, 13, 2107172.

[3] *S. Chen et al.* "Dynamic conducting polymer plasmonics and metasurfaces." *ACS Photonics* 2023, 10, 3, 571–581.

[4] *Y. Duan et al.*, "Tuneable anisotropic plasmonics with shape-symmetric conducting polymer nanoantennas." *Adv. Mater.* 2023, 35, 51, 2303949.

[5] *Y. Duan et al.* "Dynamic narrow nonlocal conducting polymer plasmonics." *submitted* 2025

[6] *S. Rossi et al.*, "Dynamically tuneable reflective structural colouration with electroactive conducting polymer nanocavities." *Adv. Mater.* 2021, 33, 40, 2105004.

[7] *S. Chen et al.*, "Tunable structural color images by UV-patterned conducting polymer nanofilms on metal surfaces." *Adv. Mater.* 2021, 33, 33, 2102451.

[8] *M. Liao et al.*, "Cellulose-based radiative cooling and solar heating powers ionic thermoelectrics." *Adv. Sci.* 2023, 10, 2206510.

[9] *D. Banerjee et al.*, "Electrical tuning of radiative cooling at ambient conditions." *Cell Rep. Phys. Sci.* 2023, 4, 101274.

[10] *C. Kuang et al.*, "Electrically tunable infrared optics enabled by flexible ion-permeable conducting polymer-cellulose paper." *npj Flex. Electron.* 2024, 8, 55.

Light transducers for cell photo stimulation

Guglielmo Lanzani
Center for Nano Science and Technology@PoliMi, Istituto Italiano di Tecnologia Via Pascoli 70/3 20133 Milano – Italy; Dep.of Physics Politecnico di Milano Piazza L. Da Vinci 32 20133 Milano – Italy
guglilemo.lanzani@iit.it

This presentation provides an overview of our current research progress in the field of bio-organic phototransducer. These photo-transducers allow to control cell behavior by light, for application in hybrid robotics and rehabilitation medicine. The photo-transducers are designed to absorb light and convert it into electricity. We deliver photo-transducers to cells, and when we expose these cells to light, the absorbed light is converted into bio-electricity, enabling cell stimulation. Our photo-transducers are primarily composed of carbon based nanoparticles [1] or molecules [2]. Effective interaction with light is ensured by molecular π-conjugation or charge transfer transitions. In certain cells nanoparticles decorate the plasma membrane without being internalized, while molecules partition in the cell membrane due to non-covalent interactions driven by amphiphilicity. Investigating the intricacies of their coupling mechanism is a fundamental aspect of our research objectives. We anticipate various applications in healthcare, life-enhancement, and cyborg technologies. A notable example is the potential restoration of vision in individuals with visual impairments.

References

[1] JF Maya-Vetencourt et al. *Nature Nanotech* **2020**, 15, 698-708
[2] ML Difrancesco et al. *Nature Nanotech* **2020** 15, 296-306

Nanostructured Hybrids for Pollutants and Photons Concentration in Photocatalytic Films

Paola Lova

Department of Chemistry and Industrial Chemistry, University of Genova, Italy

Paola.lova@unige.it

Photocatalysis holds great promise as a tertiary water treatment method for persistent emerging pollutants, such as pharmaceuticals and perfluorinated compounds, which are resistant to conventional treatments due to their low concentrations and chemical stability.[1] However, their implementation in real assets is challenging due to two primary limitations. First, the widespread use of powdered catalysts poses technological and environmental constraints, related to recovery and release of particulate into the environment. Second, strong light scattering severely limits the number of photons reaching the catalyst and complicates process control in large volumes.[2] In this context, thin and thick film photocatalysts offer a viable alternative by overriding light scattering and catalyst recovery, and minimizing environmental release. However, even when nanostructured, these films suffer from a significant reduction in surface area compared to powdered media, which limits their overall performances.

This talk introduces an approach to overcome the limitations of film-based photocatalysts by leveraging highly absorbent hybrid polymer-inorganic nanostructures to enhance both light absorption and pollutant sorption. This is achieved through the strategic alternation of submicron layers composed of composites playing as pollutant collectors and semiconductors. The nanostructuring of these materials serves a dual function. Indeed, it also facilitates the formation of dielectric lattices that increase the local density of photonic states and reduce photon group velocity within specific spectral ranges, thereby enhancing light absorption.[3, 4] By synergistically concentrating pollutants and photons within the structure, this approach significantly improves photocatalytic degradation performances compared to conventional photoactive layers, offering a promising avenue for advanced water treatment technologies.

References

[1] S. Bertucci and P. Lova "Exploring Solar Energy Solutions for Per- and Polyfluoroalkyl Substances Degradation: Advancements and Future Directions in Photocatalytic Processes". *Solar RRL* **2024**, 8, 9, 2400116.

[2] A. Shokri and M. Sanavi Fard "A Critical Review in the Features and Application of Photocatalysts in Wastewater Treatment". *Chem. Pap.* **2022**, 76, 9, 5309-5339.

[3] S. Bertucci, H. Megahd, A. Dodero, S. Fiorito, F. Di Stasio, M. Patrini, D. Comoretto, and P. Lova "Mild Sol–Gel Conditions and High Dielectric Contrast: A Facile Processing toward Large-Scale Hybrid Photonic Crystals for Sensing and Photocatalysis". *ACS Appl. Mater. Interfaces* **2022**, 14, 17, 19806-19817.

[4] H. Megahd, D. Comoretto, and P. Lova "Planar Microcavities: Materials and Processing for Light Control". *Opt. Mater.: X* **2022**, 13, 100130.

From micro to macro: 3D printing of photoresponsive Liquid Crystalline Networks

Camilla Parmeggiani,[a,b] Diederik S. Wiersma,[b,c] Sara Nocentini,[b,d] Daniele Martella,[a,b]

[a] Department of Chemistry, University of Florence, 50019 Sesto Fiorentino, Italy
email: camilla.parmeggiani@unifi.it
[b] European Laboratory for Non-Linear Spectroscopy (LENS), 50019 Sesto Fiorentino, Italy
[c] Department of Physiscs and Astronomy, University of Florence, 50019 Sesto Fiorentino, Italy
[b] Istituto Nazionale di Ricerca Metrologica (INRiM), 50019 Sesto Fiorentino, Italy

The outstanding properties of Liquid Crystalline Networks (LCNs) make them ideal candidates to address challenges in different research areas, from photonics to tissue engineering. In particular, acrylate-based LCNs combine easy processability with the possibility to use 3D printing techniques at different length scales and a demonstrated biocompatibility with different cell lines. Indeed, LCNs offer reversible shape and refractive index variation, which, in combination with 4D micro structuring, achieved by photo-polymerization with two-photon laser writing (TP-DLW), has led to several tunable photonic structures and responsive micro-tags [1]. On the other hand, advanced materials functioning as actuators for the treatment of muscle injuries, could combine rapid and long-lasting intervention, addressing one of the major goals in muscular regenerative medicine [2].

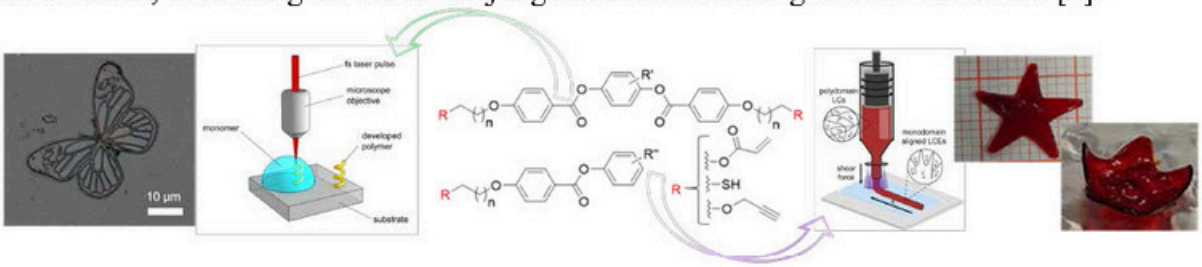


Figure 1: Examples of reactive mesogens for micro- and macro- 3D printing.

Acknowledgment: The research leading to these results has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 952166 (REPAIR).

References

[1] S. Nocentini, D. Martella, C. Parmeggiani, D.S. Wiersma "3D Printed Photoresponsive Materials for photonics" *Adv. Opt. Mater.* **2019**, *7*,1900156.
[2] G. Vitale, B. Grandinetti, S. Querceto, D. Martella, C. Tesi, C. Poggesi, E. Cerbai, D. S. Wiersma, C. Parmeggiani, Cecilia Ferrantini, Leonardo Sacconi (2022) *Photoresponsive polymer-based biomimetic contractile units as building block for artificial muscles*. Macromol. Mater. Eng., 307, 2200187.

Sustainable Polymer-Based Luminescent Solar Concentrators for Light Harvesting Applications

Alberto Picchi, Marco Carlotti, Andrea Pucci

Dipartimento di Chimica e Chimica Industriale, Università di Pisa, Via Giuseppe Moruzzi 13, 56124 Pisa (Italy)
Email: andrea.pucci@unipi.it

The interaction of light with polymeric materials plays a pivotal role in the development of next-generation photovoltaic technologies. Luminescent Solar Concentrators (LSCs) represent a promising approach for efficient sunlight harvesting, particularly in urban environments where conventional solar panels face spatial constraints. However, the sustainability and environmental impact of LSC production remain key challenges. This work introduces a novel strategy for developing high-performance, eco-friendly LSCs through the integration of chemically regenerated polymers and bio-based materials, offering a viable pathway toward greener photovoltaic solutions. We propose a dual approach to optimizing LSC performance and sustainability: (i) employing chemically regenerated poly(methyl methacrylate) (PMMA) obtained via advanced depolymerization techniques, which significantly reduces the carbon footprint associated with traditional PMMA production. While minor impurities in regenerated PMMA may impact long-term stability, targeted purification strategies enhance durability and optical performance, ensuring its viability as a structural component for LSCs. (ii) We develop bio-based LSCs using isomalt and renewable polyesters as sustainable waveguide matrices. Isomalt, doped with naturally derived fluorophores like riboflavin and curcumin, enhances light absorption and emission while ensuring biodegradability. Additionally, renewable polyesters based on diethyl 2,3:4,5-di-O-methylene galactarate (GxMe), particularly GTPn copolymers, exhibit high transparency, fluorophore compatibility, and durability, rivaling traditional PMMA.

Beyond improving LSC performance, this approach aligns with circular economy principles, reducing waste and promoting material recovery in photovoltaic applications. By integrating chemically recycled polymers with bio-based luminophores, we demonstrate a feasible path toward sustainable light-harvesting technologies. This work not only advances the practical implementation of eco-friendly LSCs but also sets a precedent for the broader adoption of renewable materials in the photovoltaic sector, reinforcing the transition toward greener energy solutions.

References

[1] A. Picchi, I. Bettini, M. Ilarioni, M. Carlotti, A. Pucci, Assessing the performance of sustainable luminescent solar concentrators based on chemically recycled poly(methyl methacrylate). *RSC Applied Polymers* **2024,** *2*, 624-633.
[2] A. Picchi, A. Pucci, M. Carlotti, Luminescent Solar Concentrators from Food Substances: A Safe and Simple Experiment to Approach Sunlight Energy Harvesting. *Journal of Chemical Education* **2023,** *100*, 4559-4566.
[3] T. A. Geervliet, I. Gavrila, G. Iasilli, F. Picchioni, A. Pucci, Luminescent Solar Concentrators Based on Renewable Polyester Matrices. *Chem-Asian J* **2019,** *14*, 877-883

Colour Engineering: form nature to applications

Prof Silvia Vignolini

Max Plank for Colloids and Interfaces MPG, Potsdam DE

Department of Chemistry, University of Cambridge Lensfield Road, Cambridge UK

Abstract

The most brilliant colours in nature are obtained by structuring transparent materials on the scale of the wavelength of visible light. By designing the dimensions of such nanostructures, it is possible to achieve extremely intense colourations over the entire visible spectrum without using pigments or colourants. Colour obtained through structure, namely structural colour, is widespread in the animal and plant kingdom. Such natural photonic nanostructures are generally synthesised in ambient conditions using a limited range of biopolymers. Given these limitations, an amazing range of optical structures exists: from very ordered photonic structures, to partially disordered, to completely random ones.

In this seminar, I will introduce some striking examples of natural photonic structures and share some insight into their development. Then I will review our recent advances to fabricate bio-mimetic photonic structures using the same material as nature. Developing biomimetic structures with cellulose enables us to fabricate novel photonic materials using low-cost polymers in ambient conditions. Importantly, it also allows us to understand the biological processes at work during the growth of these structures in plants.

From Biomimetic Structural Color to Nonlinear Optics

Rushna Quddus[1], Thomas Kainz[1], Praveen Kumar[1], Meron Debas[2], Stefan Salentinig[2], Ullrich Steiner[1] and Viola V. Vogler-Neuling[1]

[1]Adolphe Merkle Institute, [2]Department of Chemistry and NCCR Bioinspired Materials, University of Fribourg, viola.vogler-neuling@unifr.ch

Photonic crystals are nanostructures with a periodically varying dielectric constant across up to three spatial dimensions.[1] In biology, these photonic structures are often referred to as "structural color" to differentiate their appearance from pigment-based coloration. They are found in various organisms, including arthropods, birds, and plants, serving functions such as camouflage and attraction. While our understanding of the types of photonic structures present in these species and their optical mechanisms has advanced,[2] the developmental processes that give rise to these complex photonic structures in nature remain poorly understood. The molecular composition of biological photonic crystals, particularly during their developmental stages, remains largely unexplored. In this study, we present a comprehensive approach to analyzing the metabolomics and proteomics of structurally colored areas in *Parides* butterflies. By developing effective lipid and protein extraction methods—including cold chloroform, acetonitrile, and various protein solubilization buffers—we have successfully characterized the molecular components of these biological structures. Building on these findings, we investigate the biomimetic fabrication of lipidic lyotropic liquid crystals. Our system incorporates polypeptides, carbohydrates, and lipids, revealing how biopolymers influence structural parameters. Notably, adding chitosan increases vesicle sizes, while controlled aggregation remains a significant challenge. Cholesterol, a key component of natural bilayers that enhances membrane stiffness [3], does not alter the structural sizes or phases of the lyotropic system when incorporated at varying percentages. However, the addition of polylysine affects vesicle morphology and self-assembly. Furthermore, we extend bio-templating techniques to nonlinear photonic crystals. While previously demonstrated for linear optical materials such as titanium dioxide and silica,[4] we now show that *Eupholus schoenherri* structures can be infiltrated with second-order nonlinear materials like barium titanate. This bio-inspired method also applies to artificial photonic crystal assemblies, yielding inverse fcc networks with over 3000-unit cells in the x and y directions and more than 100 in the z-direction, achieving linear reflectance values exceeding 80 %. These findings provide valuable insights into biomimetic photonic materials and their potential applications in optical technologies.

References

[1] J. D. Joannopoulos, S. G. Johnson, J. N. Winn, and R. D. Meade, *Photonic Crystals - Molding the Flow of Light*, 2nd ed. Princeton University Press, 2007.

[2] V. V. Vogler-Neuling *et al.*, "Biopolymer Photonics: From Nature to Nanotechnology," *Adv Funct Mater*, 2023, doi: 10.1002/adfm.202306528.

[3] F. T. Doole, T. Kumarage, R. Ashkar, and M. F. Brown, "Cholesterol Stiffening of Lipid Membranes," Oct. 01, 2022, *Springer*. doi: 10.1007/s00232-022-00263-9.

[4] M. R. Jorgensen and M. H. Bartl, "Biotemplating routes to three-dimensional photonic crystals," *J Mater Chem*, vol. 21, no. 29, pp. 10583–10591, Aug. 2011, doi: 10.1039/c1jm11037c.

Fluorescent core-shell silica nanoparticles to interrogate biology

Ulrich (Uli) Wiesner

Materials Science and Engineering, Cornell University, Ithaca, NY 14853, USA; ubw1@cornell.edu

Optical imaging and detection is a powerful means to interrogate behavior and properties of living and non-living systems. This is particularly true for biological systems where optics in the form of spectroscopy and imaging is the bedrock accounting for the majority of performed detection and characterization work. This contribution will describe work on ultrasmall and fluorescent silica-core and poly(ethylene glycol)-shell core-shell hybrid nanoparticles referred to as Cornell dots or simply C dots for use in bioimaging and nanomedicine. Covalent encapsulation of fluorescent organic dyes into the 30-40 angstrom diameter particle core leads to substantial brightness and stability enhancements of these fluorophores enabling sensitive detection and imaging applications. Furthermore, brightness enhancements also carries over to optical super-resolution microscopy applications, e.g., in the form of stochastic optical reconstruction microscopy (STORM), allowing for near molecular (i.e., ~20 nm) resolution in the far-field of an optical microscope. This talk will describe examples of how the molecular engineering of the silica core can be used to tailor optical and biological properties of these particles. Furthermore, molecular engineering of the polymeric shell will be utilized, e.g., to target specific biological environments for specific detection and imaging applications. Finally, as a result of the ultrasmall size of the particles around 5-6 nm, it will be shown that the particles are renally cleared leading to a "target or clear" paradigm in animal models as well as human clinical trials where the particles either target the site of disease or get efficiently cleared through the kidneys into the urin reducing side effects to patients, e.g., as compared to antibody-drug conjugates. The talk will end with a look into future applications of these particles based on the surprising finding of substantial and diverse anti-tumoral effects in the tumor microenvironment in the absence of any cytotoxic drugs.

References

[1] E. Phillips, O. Penate-Medina, P. B. Zanzonico, R. D. Carvajal, P. Mohan, Y. Ye, J. Humm, M. Gönen, H. Kaliagian, H. Schöder, H. W. Strauss, S. M. Larson, U. Wiesner, M. S. Bradbury, "Clinical translation of an ultrasmall inorganic optical-PET imaging nanoparticle probe", *Sci. Transl. Med.* **2014**, *6*, 260ra149.

[2] S. Eun Kim, L. Zhang, K. Ma, M. Riegman, F. Chen, I. Ingold, M. Conrad, M. Z. Turker, M. Gao, X. Jiang, S. Monette, M. Pauliah, M. Gonen, P. Zanzonico, T. Quinn, U. Wiesner, M. S. Bradbury, M. Overholtzer, *"Ultrasmall Nanoparticles Induce Ferroptosis in Nutrient-Deprived Cancer Cells and Suppress Tumor Growth"*, *Nat. Nanotech.* **2016**, *11*, 977–985.

[3] J. A. Erstling, J. A. Hinckley, N. Bag, J. Hersh, G. B. Feuer, R. Lee, H. F. Malarkey, F. Yu, K. Ma, B. A. Baird, U. B. Wiesner, *"Ultrasmall, Bright, and Photostable Fluorescent Core-Shell Aluminosilicate Nanoparticles for Live-Cell Optical Super-Resolution Microscopy," Adv. Mater.* **2021**, *33*, 2006829.

Photothermal Hybrid Materials for Controlling Phase Transition, Drug Release, and Water Purification

Younan Xia

The Wallace H. Coulter Department of Biomedical Engineering, School of Chemistry and Biochemistry, Georgia Institute of Technology, Atlanta, Georgia 30332, USA, younan.xia@bme.gatech.edu

Becasue of their complementary capabilities, it is advantageous to integrate inorganic with organic/polymeric materials to access the full spectrum of properties offered by diverse materials on different length scales. In this talk, I will discuss how inorganic gold nanocages can be integrated with organic/polymeric materials for an array of applciations. When interacting with light, gold nanocages exhibit an extremely large absorption cross section and a high efficiency for light-to-heat conversion, making them extraodinary photothermal transducers. Their absorption peak can also be easily and precisely tuned through the visible and near-infrared regions to optimize their interaction with the light wavelength(s) of interest. As an inorganic nanomaterial, gold nanocages also have much better photo-stability than conventional organic dyes. I will briefly cover recent progress in controlling the synthesis of gold nanocages, together with their use in applications involving photothermal conversion. I will focus on the photothermal properties of gold nanocages, together with a number of examples to highlight their niche applications in the context of light detection, water evaporation, phase transition, controlled release, and photothermal therapy. At the end, I will offer some perspectives on the challenges with respect to both the fabrication and application of this class of hybrid materials.

Reference

[1] D. Zhang, Y. Chen, M. Hao, Y. Xia "Putting Hybrid Nanomaterials to Work for Biomedical Applications" *Angew. Chem. Int. Ed.* **2024**, *63*, e202319567 (1-38).

Other ORAL CONTRIBUTIONS

Conductive thiophene-based fibres synthesized by living cells as novel bioelectronic materials)

Ludovico Aloisio[1,2], Francesca Di Maria [3], Guglielmo Lanzani [1,2]

1. Dipartimento di Fisica, Politecnico di Milano, Piazza Leonardo da Vinci 32, 20133, Milano, Italy
2. Center for Nano Science and Technology, Istituto Italiano di Tecnologia, Via Pascoli 70, 20133, Milano, Italy
3. Istituto per la Sintesi Organica e Fotoreattività, Consiglio Nazionale delle Ricerche, Via Piero Gobetti, 101, 40129 Bologna, Italy)

In recent years, it has been observed that living cells can be employed as active synthesis platforms for the assembly of intrinsically biocompatible bioelectronics materials. This process, which lies at the interface between living and non-living matter, is of fundamental interest since self-assembly in vivo could allow to circumvent brain-blood barrier and deliver large aggregates or even devices to the brain. Within this context, thiophene-based compounds represent workhorse materials for organic bioelectronics, owing to their biocompatibility and to the possibility to afford both electronic and ionic conduction.
Here, we report about the cell-mediated assembly of semiconductive nanofibers based on dithienothiophene-S,S-dioxide (DTTO) derivatives. Fibers originate inside cells and grow also "through" them, reaching and piercing the plasma membrane in one cell to penetrate the adjacent cell, without killing them. We extensively characterized the photophysics of DTTO molecules during the various steps of fibres production through steady state and time-resolved spectroscopy. We report the presence of DTTO aggregates inside the fibres, which represent the conductive domains of the nanostructured material and describe the interaction between DTTO molecules and the protein scaffold. By complementing the spectroscopic data with XRD characterization and electrical conductivity measurements, we discovered an extended polymorphism of DTTO in solid state. Our results suggest that the aggregation occurring in living cells is somehow unique to the biotic phase, and it involves at least part of the cell machinery. As fibres show electrical conductivity, they represent a way to directly stimulate cells or to induce artificial gap-junctions between cells, possibly affecting signal propagation as occurring in cardio-myocytes or in general to affect cell population behaviour.
Further studies on the fibres' production process are in progress, with the aim to open the way to a wide range of new protein-based materials for bioelectronics and cell photostimulation.

References

[1] Guglielmo Lanzani et al., "Influence of the environment on the excited state deactivation in functionalized quinque-thienyls", J. Chem. Phys. 115, 1623 (2001)
[2] Ilaria Palamà et al., "Live-Cell-Permeant Thiophene Fluorophores and Cell-Mediated Formation of Fluorescent Fibrils" J. Am. Chem. Soc. 133, 44, 17777–17785 (2011)
[3] Ludovico Aloisio et al. "Insight on the Intracellular Supramolecular Assembly of DTTO: A Peculiar Example of Cell-Driven Polymorphism" Adv. Mater. 35, 2302756 (2023)

Neuromorphic functionalities and *in materia* reservoir computing with light-responsive polymers

Mateo Rosero Realpe[1,2], Federico Ferrarese Lupi[1], Antonio Ocarino[2], Francesca Frascella[2], Gianluca Milano[1] and Angelo Angelini[1]

[1] Advanced Materials Metrology and Life Science Division, INRiM (Istituto Nazionale di Ricerca Metrologica), Strada delle Cacce 91, 10135 Torino, Italy.

[2] Department ofApplied Science and Technology (DISAT), Politecnico di Torino, C.so Duca degli Abruzzi 24, Torino 10129, Italy.

E-mail: a.angelini@inrim.it

Materials able to sense and respond to external stimuli by adapting their internal state to process and store information are excellent candidates to emulate neuromorphic functionalities and for the physical implementation of brain-inspired computing paradigms.[1,2] Neuromorphic systems based on light-responsive materials may enable the use of light as an information carrier, allowing to emulate basic functions of the human retina.[3] A well-known class of light-responsive materials are azobenzene-containing molecular compounds, known for their strong light responsivity that may result in light-induced birefringence or light-driven mass migration, phenomena that have been extensively studied in the context of optical memories.

Here, we demonstrate that the optically-induced molecular dynamics in azopolymers can be exploited for neuromorphic-type of data processing and for computing directly at the matter level (i.e., in materia). At first, we characterize the dynamic response of PAZO under polarized illumination and investigate the molecular dynamics that drive light-induced birefringence and enable the implementation of synaptic functionalities including short-term memory, long-term memory and visual memory. Next, we show that the azopolymer film allows spatio-temporal event detection and motion perception, enabling physical implementation of computational schemes requiring real-time analysis of spatio-temporal input stimuli. Furthermore, we experimentally demonstrate that light-induced dynamics can be exploited for the *in materia* implementation of the unconventional computing paradigms denoted as reservoir computing.

We believe that this work underscores the potential of azopolymers as a promising material for developing intelligent, adaptive photo-responsive devices that mimic some of the complex processing abilities of biological systems.

References

[1] D. Marković, A. Mizrahi, D. Querlioz, J. Grollier "Physics for neuromorphic computing" *Nat. Rev. Phys.* **2**, 499–510 (2020).

[2] G. Milano, G. Pedretti, K. Montano, S. Ricci, S. Hashemkhani, L. Boarino, D. Ielmini, C. Ricciardi "*In materia* reservoir computing with a fully memristive architecture based on self-organizing nanowire networks" *Nat. Mater.* **21**, 195–202 (2022).

[3] F. Ferrarese Lupi, G. Milano, A. Angelini, M. Rosero-Realpe, B. Torre, E. Kozma, C. Martella, C. Grazianetti "Synaptic Plasticity and Visual Memory in a Neuromorphic 2D Memitter Based on WS2 Monolayers" *Adv. Funct. Mater.* **34**, 2403158 (2024).

SYNTHESIS AND NANOSTRUCTURATION OF THIN AND CONDUCTIVE PEDOT FILMS BY LIQUID-PHASE POLYMERIZATION

FRANCESCO BISIO, KATIA SPARNACCI

Department of Science and Technological Innovation,
University of Piemonte Orientale, viale T. Michel 11, 15121 Alessandria (Italy)
E-mail: francesco.bisio@uniupo.it

Conductive polymers (CPs) have represented a key research topic in the field of organic electronic devices, as alternatives to silicon-based technologies. Among them, poly(3,4-ethylenedioxythiophene) (PEDOT) is one of the most used and investigated materials because of its good and tailorable electrical properties, transparency to visible light and environmental stability. For all these reasons, PEDOT has found applications in organic solar cells, supercapacitors, organic light-emitting diodes and nanostructured devices.
In this project, we studied the synthesis of this polymer using a liquid-phase polymerization process.[1]
This process involves the sequential deposition of an oxidant solution (vanadium pentoxide) and a monomer solution (EDOT) onto a glass substrate treated with piranha solution. The resulting film is washed with a solvent to eliminate the excess monomer and then subjected to annealing heat treatment.
To enhance the properties of the polymeric film, we varied the deposition time of the oxidizing solution, the rotation speed and the concentration of the oxidizing solution.
The analysis showed that the thickness of the polymeric film is primarily influenced by the deposition time of the oxidant solution.
Additionally, the concentration of the oxidant slightly affects the polymer thickness due to the varying viscosities of more and less concentrated solutions. We determined the morphology and thickness of the samples using optical profilometry and measured the conductivity of the samples with the Van der Pauw method using a 4-point probe in electrical contact with the polymeric film. A direct current is applied between the outer test leads, while a voltage drop is measured between the inner leads, providing the sheet resistance (Rs, measured in Ω/□).
We studied the nanostructuring process of the films using nanosphere lithography. To improve the deposition of nanospheres on the PEDOT layer, a silica one was applied to the film. This layer facilitated the formation of a monolayer of polystyrene particles, which was subsequently reduced using reactive ion etching (RIE).[2]
The resulting mask enabled the precise nanostructuring of the PEDOT films. By optimizing this process, we achieved PEDOT nanostructures with a high degree of order.

References

1. Chen, R.; Xi,J.; et al. Sequential Solution Polymerization of Poly(3,4-ethylenedioxythiophene) Using V2O5 as Oxidant for Flexible Touch Sensors, iScience, 12, 66–75, 2019.
2. Colson P, Cloots R. Nanosphere Lithography: A Powerful Method for the Controlled Manufacturing of Nanomaterials. Jiao T, editor. Journal of Nanomaterials, 2013:948510, 2013.

Quinolinone-Gated Chemistry: A Versatile Platform for Recyclable and Stimuli-Responsive Polymers

Calvino, C*, Stamp C.-H., Charton, L.

Albert Ludwig University of Freiburg – Cluster of Excellence livMatS, Georges-Köhler-Allee 105, D-79110 Freiburg, Germany, E-mail: Celine.calvino@livmats.uni-freiburg.deAffiliations

The ability to precisely control and reverse covalent bond formation is essential for developing recyclable and reprocessable materials. This study identifies quinolinone motifs as highly adaptable building blocks for multi-stimuli-responsive covalent-gated chemistry, employing a reversible [2π+2π] cycloaddition mechanism that can be triggered by light and/or heat. A systematic analysis of photocycloaddition and cycloreversion under different wavelengths and conditions reveals the optimal parameters for achieving highly efficient, orthogonal photoreactions with yields approaching 100%. Notably, these photoprocesses exhibit exceptional reversibility, maintaining consistent performance over eight cycles—an achievement rarely observed in comparable systems.[1] Integrating quinolinones into oligomers enables catalyst-free, fully reversible photopolymerization in solution, yielding polymers with molecular weights of up to 60 kDa. These polymers can depolymerize entirely into their monomeric components through multiple cycles. A significant finding demonstrates that oxygen plays a tunable role in shifting the reversion process from UV-C to UV-B while preserving high conversion efficiency and recyclability, broadening the system's applicability. At the molecular level, further investigations reveal that quinolinone dimers undergo near-quantitative thermal cycloreversion, with over 99% monomer recovery within 10 minutes at 210 °C in the solid state. When incorporated as pendant groups in polymers, these motifs enable light-induced crosslinking and thermal cleavage of solid-state polymer networks, introducing a novel recycling strategy for polymeric materials. Beyond recyclability, this system allows for precise tuning of material properties by modifying processing times, facilitating controlled crosslinking and deconstruction. Such adaptability supports the development of advanced functional materials, including coatings with programmable debonding characteristics. By linking molecular, macromolecular, and material scales, this work positions quinolinones as a versatile platform for designing stimuli-responsive, recyclable, and functional polymers. This new gated system unlocks new possibilities in sustainable materials, advancing polymer design, reuse, and performance.

References

[1] M., Streicher, C-H., Stamp, D. M., Kluth, A., Ripp, C.,Calvino*. "Harnessing the Photoperformance of N-Methyl-Quinolinone for Gated Photo-Driven Cyclability and Reversible Photoligation" Macromol. Rapid Commun., **2024**, 2400474. DOI: 10.1002/marc.202400474 [OA].

High Performance OPV Molecules with ADA Structures and Their Device Performance

Yongsheng Chen

College of Chemistry, Nankai University, Tianjin, 300071, CHINA

Abstract: Among the high demanded green energy technologies, efficient utilization of sunlight energy would probably be the most important one. In this talk, our recent studies for photovoltaic technology using organic solar cell will be presented. These will include material design, synthesis, and device fabrication, and the integrated device applications.

Keywords: Organic Solar Cell, ADA molecules, device, integrated devices

References:

1. "Binary All-polymer Solar Cells with a Perhalogenated-Thiophene- Based Solid Additive Surpass 18% Efficiency" Wanying Feng, Tianqi Chen, Yulu Li, Tainan Duan*, Xue Jiang, Cheng Zhong, Yunxin Zhang, Jifa Yu, Guanghao Lu, Xiangjian Wan, Bin Kan,* **Yongsheng Chen***. ***Angew. Chem. Int. Ed.*** **2024**, e202316698.
2. "Self-sustaining personal all-day thermoregulatoryclothing using only sunlight" Ziyuan Wang, Yiwen Bo, Peijia Bai, Shuchao Zhang, Guanghui Li, Xiangjian Wan,Yongsheng Liu*, Rujun Ma*, **Yongsheng Chen***. ***Science*** 382, 1291–1296 (**2023**).
3. "3D acceptors with multiple A–D–A architectures for highly efficient organic solar cells" Hongbin Chen,Zhe Zhang, Peiran Wang, Yunxin Zhang, Kangqiao Ma, Yi Lin, Tainan Duan, Tengfei He, Zaifei Ma, Guankui Long, Chenxi Li, Bin Kan,* Zhaoyang Yao,* Xiangjian Wan, **Yongsheng Chen***. ***Energy Environ. Sci.,*** **2023**, 16, 1773–1782.
4. "A rare case of brominated small molecule acceptors for high-efficiency organic solar cells". Huazhe Liang, Xingqi Bi, Hongbin Chen, Tengfei He, Yi Lin, Yunxin Zhang, Kangqiao Ma, Wanying Feng, Zaifei Ma, Guankui Long, Chenxi Li, Bin Kan, Hongtao Zhang, Oleg A. Rakitin, Xiangjian Wan, Zhaoyang Yao*, **Yongsheng Chen***. ***Nat Commun*** 14, 4707 (**2023**).
5. "Organic and solution-processed tandem solar cells with 17.3% efficiency", Lingxian Meng, Yamin Zhang, Xiangjian Wan*, Chenxi Li, Xin Zhang, Yanbo Wang, Xin Ke, Zuo Xiao, Liming Ding *, Ruoxi Xia, Hin-Lap Yip, Yong Cao, **Yongsheng Chen***, ***Science***, *2018*, 361, 1094-1098.

Mechanochromic polymer-hybrid coordination polymer composites as smart materials for damage detection

Emma Contini[1], Lorenzo Gatti[1], Chiara Corapi[1], Francesco Mongioì[2], Andrea Bocconcelli[2], Daniele Fazzi[1], Tommaso Maria Brugo[2], Damiano Genovese[1], Lucia Maini[1], Chiara Gualandi[1*]

[1]Department of Chemistry "G. Ciamician", University of Bologna, Via Selmi 2, 40126, Bologna
[2] Department of Industrial Engineering, University of Bologna, Via Terracini 34, 40131, Bologna
E-mail (corresponding author): c.gualandi@unibo.it

Detecting mechanical damage is critical for maintaining the structural integrity and functionality of polymer-based materials and composites. This challenge necessitates adaptive strategies capable of detecting damage and triggering an immediate, irreversible response. Mechanochromic luminescent materials, which exhibit emission changes under mechanical stress, offer a promising approach for real-time damage sensing and self-reporting [1, 2]. However, conventional mechanochromic materials suffer from limitations such as complex synthesis and high stress thresholds required for signal detection.

Here, we introduce a novel class of mechanochromic materials based on inert polymeric matrices incorporating CuI-hybrid coordination polymers (HCP) as mechanochromic fillers [3]. Unlike traditional mechanophores, these chromophores are cost-effective, readily synthesized, and exhibit an instantaneous, irreversible color change upon mechanical damage, attributed to structural modifications in Cu–I and Cu-Cu bond lengths.

In this study, the mechanochromic properties of various polymeric matrices, namely polyvinyl acetate, polycarbonate, polycaprolactone, polyurethane and an epoxy-based coating, embedded with these fillers were evaluated under a wide range of potential scenarios, including compression, tensile, and impact loading. Luminescence changes, easily observable under UV light but not under white light, were quantified using a portable spectrofluorometer, demonstrating a rapid and persistent response directly linked to the material's mechanical history. Moreover, tests performed with different polymeric matrix revealed that the mechanical properties of the host material influence the mechanochromic response of the composite, enabling tunability of the response threshold. These findings establish Polymer-HCP composites as a versatile platform for damage sensing and mechanical stress monitoring, highlighting their potential in a broad range of applications, from structural health monitoring to advanced functional materials.

References

[1] S. Shree et al. Mater. Horiz., 2020, 7, 598
[2] R. Toivola et al. Science and Technology 139 (2017) 74-82
[3] S. Perruchas Dalton Trans. 2021, 50 (35), 12031-12044

Acknowledgement

This work was supported by the NATO Science for Peace and Security Programme, Project COLORaDO – a new Chromogenic technology foR on-field Damage detection.

This work was supported by PRIN-2022-PNRR, Piezochromic smart auto-diagnostic polymeric coatings – STIGMA, CUP: J53D23014670001

Design and characterization of tuneable pigment-polymer antenna complexes using chlorophyll-functionalized polymer brushes

Evelin Csányi[1], Abdullah A. Sari[1], Edwin C. Johnson[1], Jodie West[1], William P. Wardley[2], Demetris Bates[1], Deborah B. Hammond[1], William L. Barnes[2], Nicholas H. Williams[1], Steven P. Armes[1] and Graham J. Leggett[1,*]

[1]Department of Chemistry, University of Sheffield, Brook Hill, Sheffield, S3 7HF, United Kingdom
[2]Department of Physics, University of Exeter, Stocker Road, Exeter, EX4 4QL, United Kingdom

*Correspondence and requests should be addressed to G.J.L. (email: graham.leggett@sheffield.ac.uk)

Recent advances in solar energy capture have shifted focus towards improving photovoltaic technologies beyond silicon-based systems. Organic and hybrid materials present promising alternatives due to their lower production costs, flexibility, and lightweight properties. However, their widespread adoption is hindered by relatively low power conversion efficiencies, mainly caused by short exciton diffusion lengths.

Biological light-harvesting antenna complexes, known for their efficient exciton transfer processes, provide inspiration for alternate solutions. Thus, we developed plexcitonic antenna complexes, where pigment-polymer systems are coupled with localized surface plasmon resonances (LSPRs) to achieve strong light-matter interactions. Poly(cysteine methacrylate) (PCysMA) brushes, grown via surface-initiated atom transfer radical polymerization (ATRP) on gold nanostructures, served as the scaffold for post-modification with chlorophyll (Chl) molecules. Controlling the spatial distribution of pigments within the polymer scaffolds is critical to optimizing these systems. Using X-ray photoelectron spectroscopy (XPS) depth-profiling combined with gas cluster ion sputtering (GCIS), we revealed that the Chl distribution is highly dependent on the brush grafting density, with lower densities yielding higher Chl concentrations. GCIS allowed for precise depth profiling with minimal damage, enabling us to fine-tune the polymerization degree and brush density to achieve exciton coupling energies up to 0.4 eV - double that observed in natural systems. Additionally, the plexcitonic systems achieved a three-fold higher Chl concentration compared to plant light-harvesting complexes. Expanding on this concept, we investigated the non-covalent attachment of Chl to poly(2-(dimethylamino)ethyl methacrylate) (PDMA) brushes, designed to mimic the non-covalent binding of Chl to proteins in light-harvesting systems. Chl concentrations of up to 2 M in PDMA brushes were achieved, leading to strong plasmon-exciton coupling. This approach offers a versatile method for the design of advanced biomimetic light-harvesting materials with tunable optical properties.

References

[1] Evelin Csányi, Deborah B. Hammond, Benjamin Bower, Edwin C. Johnson, Anna Lishchuk, Steven P. Armes, Zhaogang Dong, and Graham J. Leggett, "XPS Depth-Profiling Studies of Chlorophyll Binding to Poly(cysteine methacrylate) Scaffolds in Pigment–Polymer Antenna Complexes Using a Gas Cluster Ion Source" *Langmuir,* **2024,** *40* (28), 14527-14539

Strong-Coupling in all-Polymer Microcavities doped with J-Aggregates

Daniela Di Fonzo[1], Andrea Lanfranchi[1], Paola Lova[1], Davide Comoretto[1]

[1]Department of Chemistry and Industrial Chemistry, University of Genoa, Genoa, Italy.

daniela.difonzo@edu.unige.it

Optical microcavities (MC) offer a versatile platform to manipulate light-matter interactions at the nanoscale. In these systems, the strong confinement of the electromagnetic field enables the possibility to modify the properties of the emission, interesting for applications in photonics and optoelectronics. These structures consist of a periodical stacking of dielectric materials' bilayers with different refractive indices, known as Distributed Bragg Reflectors (DBRs), that give rise to constructive or destructive interference due to refraction and reflection at the layer interfaces at distinct wavelengths. This results in controllable reflectance maxima for wavelengths where light cannot propagate into the structure, named Photonic Bandgaps (PBGs).[1] Introducing an engineered layer disrupts this periodicity, allowing some wavelengths within the PBG spectral region to propagate, forming microcavity modes.[2]

In our work, we focus on the design and characterization of entirely polymer-based microcavities in which the defect layer comprises J-aggregates formed from cyanine dyes (e.g., 1,1'-disulfobutyl-3,3'-diethyl-5,5',6,6'-tetrachloro-benzimidazolylcarbocyanine sodium salt, TDBC). J-aggregates are renowned for their narrow and intense absorption and emission bands, a consequence of the cooperative "head-to-tail" organization of the transitional dipoles. This cooperative behavior not only enhances the overall oscillator strength but also ensures an absorption spectrum bandwidth similar to the width of the cavity mode, both critical factors for achieving a robust strong coupling regime.[3] Our fabrication approach utilizes spin coating to cast uniform thin films, combined with the construction of polymeric DBR made from high dielectric contrast materials (e.g., PVK as the high-index layer and Aquivion® as the low-index layer). The cavity is engineered such that the resonant wavelength of the confined mode matches the absorption peak of the J-aggregates, a prerequisite for reaching resonance. Angle-resolved reflection and transmission measurements reveal an anticrossing behavior. This phenomenon is the fingerprint of a strong-coupling regime between the exciton in J-aggregate and the confined photons at the cavity mode, creating a new hybrid state known as polariton. These results demonstrate polymer microcavities do achieve the strong-coupling regime so far possible for inorganic photonic structures only. This opens new perspectives for the integration of light and flexible polymer photonic structures into devices paving the way for new photonic applications. For example, further optimization of the cavity design and the active medium could lead to the development of ultra-low threshold bendable and stretchable lasers.

References

[1] P. Lova, G. Manfredi "Advances in Functional Solution Processed Planar One-Dimensional Photonic Crystals." Adv. Opt. Mater. **2018**, 6, 1800730.

[2] H. Megahd, D. Comoretto "Planar microcavities: Materials and processing for light control." Opt. Mater.: X **2022**, 13, 100130.

[3] D. M. Coles, A. J. H. M. Meijer "A Characterization of the Raman Modes in a J-Aggregate-Forming Dye: A Comparison between Theory and Experiment." J. Phys. Chem. A **2010**, 114, 11920–11927.

Large-area and nanopatterned 2D-TMD heterostructures for improved visible-light photoconversion

Authors: S. Di Marco , R. Chennuboina, G. Ferrando, M. Gardella, G. Zambito, M. Barelli, M.C. Giordano, F. Buatier de Mongeot
Affilation: Physics Department, Unige, Via Dodecaneso 33, Genova, 16146 Italy E-mail : buatier@fisica.unige.it

Two-dimensional Transition Metal Dichalcogenides (2D-TMDs) have attracted significant attention for their strong interaction with visible light and tunable bandgap, enabling tailored optoelectronic responses. Their optical absorption in the visible spectrum, two orders of magnitude higher than bulk semiconductors, makes them ideal for photodetection and photoconversion applications, and thanks to their very high refractive index, about 5-6, they are expected to produce excellent scattering effects [1] . Combining TMD layers to form van der Waals heterostructures provides a unique opportunity to engineer the optoelectronic response of 2D devices, with new properties arising from band structure coupling at the junction [2] . To take full advantage of the formation of a van der Walls heterostructure we have developed a homogeneous growth approach of large area 2D-TMDs films by means of a physical deposition process based on Ion Beam Sputtering, followed by high temperature recrystallization in a sulfur enriched atmosphere [3].
The fabrication process has been subsequently optimized for the sequential synthesis of vertically stacked large area MoS_2/WS_2 van der Waals heterostructures [4]. This configuration ensures a type-II staggered band alignment which in turn allows to split excitons across the junction, thus increasing the lifetime of the photogenerated carriers compared to the individual TMD components. Charge separation can be exploited both for energy conversion, since recombination rate is reduced, and for photocatalytic applications, since the separated charges on the surface can boost specific reactions. This is reflected in the superior photodissociation rate of molecular dye probes in solution near the heterostructure sample, and in the photovoltage and photocurrent measured upon illumination of the large area device.
The TMD fabrication approach enables maskless deposition of the 2D material at glancing angles, on periodically nanostructured templates. Light is thus steered parallel to the TMD nanostripe array, boosting optical absorption. MoS_2/WS_2 heterostuctures nanostripe arrays showed remarkable photon harvesting in the flat optics regime, with a 450% enhancement in optical absorption compared to equivalent flat heterostructures, as well as remarkable linear and non-linear scattering effects.
This innovative platform demonstrates the scalable potential of 2D-TMD van der Waals heterostructures for real-world applications in photoconversion, quantum technology, photocatalysis, and energy storage.

References

[1] M. Bhatnagar et al., " Broadbandand Tunable Light Harvestingin Nanorippled MoS_2 Ultrathin Films " ACS Appl. Mater. Interfaces 2021, 13, 13508−13516
[2] M. Gardella et al., "Large area van der Waals MoS2–WS2 heterostructures for visible-light energy conversion RSC Appl. Interfaces", 2024, 1, 1001-1011
[3] M.C. Giordano et al., "Deterministic Thermal Sculpting of Large-Scale 2D Semiconductor Nanocircuits" Adv. Mater. Interfaces 2022, 2201408
[4] M. Gardella et al., " Maskless Synthesis of van der Waals Heterostructure Arrays Engineered for Light Harvesting on Large Area Templates " Nano Micro small 2025

Cholesteric liquid crystal polymer based broadband thermochromic infrared light reflectors for passive indoor temperature regulation

Ramazan Umut Dinc, Johan Lub, Augustinus J. J. Kragt and Albert P. H. J. Schenning

Stimuli-responsive Functional Materials and Devices, Eindhoven University of Technology, The Netherlands
r.u.dinc@tue.nl

In 2021 Eurostat energy balances, it has been reported that 42% of the energy consumed was used in buildings and over 80% of this energy related to heating/cooling or hot water. Besides energy consumption of buildings, every year more than 675 km^2 flat glass is installed in new constructions of buildings or replacement. In this project we aim to develop a smart window foil that can selectively reflect infrared light (IR) when the outside temperature increases. We aim to have visible light transparent smart window foils that can be applied to existing buildings. It has been reported that the use of such a system on top of the windows can decrease the energy consumption of the buildings[1][2]. Our aim is to develop smart window foils by using cholesteric liquid crystal polymers[3][4] that are transparent in the cold state and IR reflective in the warm state.

References

[1] S. Kragt, E. R. van den Ham, H. Sentjens, A. P. H. J. Schenning, and T. Klein, "The Potential of Static and Thermochromic Window Films for Energy Efficient Building Renovations," Journal of Facade Design and Engineering, vol. 10, no. 2, pp. 87–104, Dec. 2022

[2] H. Sentjens, A. J. J. Kragt, A. P. H. J. Schenning, and M. G. Debije, "Recent advances in solar infrared light regulating smart windows based on organic materials," Responsive Materials, vol. 1, no. 1, pp. 1–17, Aug. 2023

[3] H. Sentjens, J. M. A. Bloemers, J. Lub, C. L. Gonzalez, A. J. J. Kragt, and A. P. H. J. Schenning, "On the isomeric purity of endcap molecules in cholesteric liquid crystal oligomers for near-infrared thermochromic coatings," Liq Cryst, 2024

[4] R. U. Dinç, J. Lub, A. J. J. Kragt, and A. Schenning, "L-Isosorbide-based Reactive Chiral Dopant with High Helical Twisting Power for Cholesteric Liquid Crystal Polymers Reflecting Left-handed Circular Polarized Light," Organic Chemistry Frontiers, 2024

Block Copolymer Microparticles: A Versatile Platform for Functional Optical Materials

Simone Bertucci[1], Niklas Schwarz[1,2], Gianluca Mazzotta[2,3], Sawssen Slimani[4], Davide Peddis[4], Paola Lova[4], Davide Comoretto[4], Francesco Di Stasio[5], Christoph Weder[1,2], Ullrich Steiner[1,2], Andrea Dodero[1,2,4]

1 Adolphe Merkle Institute, University of Fribourg, 1700 Fribourg, Switzerland

2 National Center of Competence in Research Bio-Inspired Materials, 1700 Fribourg, Switzerland

3 Department of Chemistry, University of Fribourg, 1700 Fribourg, Switzerland

4 Department of Chemistry and Industrial Chemistry, University of Genoa, 16146 Genoa, Italy

5 Photonic Nanomaterials, Italian Institute of Technology, 16163 Genoa, Italy

E-mail address: andrea.dodero@unifr.ch

The development of functional optical materials with tunable structural colors has gained significant attention for applications in coatings, sensing, and display technologies. In this work, we present a scalable strategy for fabricating photonic microparticles based on the confined self-assembly of block copolymers (BCPs) within emulsion droplets. These microparticles exhibit a well-defined concentric lamellar structure, generating non-iridescent, structurally colored pigments [1], [2]. By tailoring the block copolymer composition and introducing selective swelling agents, the photonic bandgap can be precisely tuned across the visible spectrum, enabling a full range of vibrant colors. Incorporating these photonic microparticles into polymeric matrices allows for the formulation of water-based photonic paints, which exhibit durable, angle-independent coloration with enhanced optical properties. The compatibility of BCP-based microparticles with commercial binders makes them promising candidates for next-generation structural coatings that combine aesthetic appeal with high stability. Furthermore, by co-assembling block copolymers with nanoparticles of different functionalities – such as magnetic cobalt ferrite, plasmonic gold nanoparticles or colloidal quantum dots – we demonstrate the ability to engineer hybrid materials with unique properties [3]. These hybrid architectures break new grounds for applications in tunable photonic devices, responsive coatings, and advanced sensor technologies [4].
Our approach highlights the versatility of block copolymer self-assembly as a platform for multifunctional materials, offering scalable and adaptable solutions for photonic and optoelectronic applications.

References

[1] U. Steiner and A. Dodero, "Block Copolymer-based Photonic Pigments: Towards Structural Non-iridescent Brilliant Coloration," *Chimia*, **2022**, *76* (10).
[2] A. Dodero *et al.*, "Robust Full-Spectral Color Tuning of Photonic Colloids," *Small*, **2023**, *19* (6).
[3] A. Escher *et al.*, "Crafting Nanostructured Hybrid Block Copolymer–Gold Nanoparticles by Confined Self-Assembly in Evaporative Droplets," *ACS Macro Lett*, **2024**, *13* (10).
[4] T. N. Hoheisel, K. Hur, and U. B. Wiesner, "Block copolymer-nanoparticle hybrid self-assembly," *Prog Polym Sci*, **2015**, *40* (1)

Polymeric fluorescent organic nanoparticles for bioimaging and biosensing

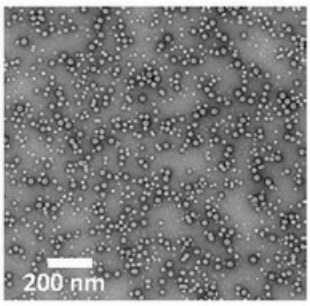
Dalel EL MARROUKI,[1] Clara CATROS,[1] Jyothis DEVASIA,[1,2] Chloé GRAZON[1]

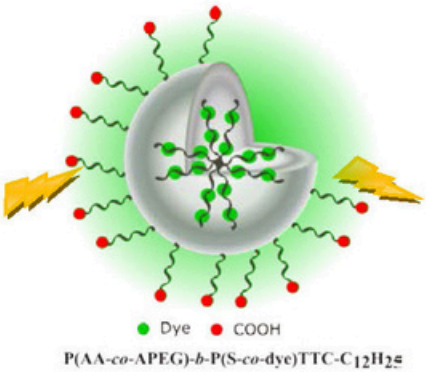
[1] ISM (UMR5255), Univ. Bordeaux, CNRS, Bordeaux INP, 351 Cours de la Libération, 33405 Talence, France.
[2] IINS (UMR 5297), Univ. Bordeaux, CNRS, Campus Carreire, 146 rue Léo-Saignat, 33076 Bordeaux, France.
dalel.el-marrouki@u-bordeaux.fr.

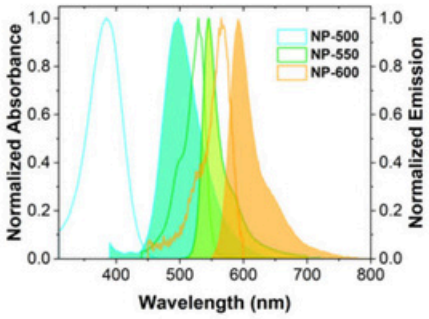
Light-emitting nanoparticles are a unique class of optical nanomaterials combining improved brightness and photoresistance compared to standard dyes[1]. Among the numerous existing luminescent nanoparticles (QDs, UCNPs, ...), the dye-doped fluorescent polymeric organic nanoparticles offer many promises, due to their ease of photophysical properties tunability, surface functionalization and exceptional colloidal stability[2]. All those advantages makes it particularly appealing for applications in sensing, imaging and biomedicine.

We previously described an efficient one-pot method for synthesizing such nanoparticles by copolymerizing dye-acrylates within the hydrophobic core of a polymeric frozen micelle *via* a RAFT polymerization in miniemulsion[3]. This process is particularly efficient and environmentally friendly, as it creates core-shell nanoparticles in a single step, without surfactants or hydrophobic agents, and produces nanoparticles with a high solids content (15%). In more details, a hydrophilic macro-RAFT agent poly[(ethylene oxide acrylate)-*co*-poly(acrylic acid)]-TTC-$C_{12}H_{25}$ is used to control the copolymerization of styrene and a fluorescent monomer in miniemulsion.

In this presentation, I will demonstrate the versatility of this approach, applicable to a variety of dyes (BODIPY, rhodamines, coumarin…), each nanoparticles batch being well controlled in size, emitting at different wavelength with tunable brightness and luminescent lifetimes, making it versatile for use in wide range of biological applications.







References

[1] W.R. Algar "Photoluminescent Nanoparticles for Chemical and Biological Analysis and Imaging." *Chem. Rev* **2021**, *15*, 9243-9358.

[2] A. Reisch, A. S. Klymchenko "Fluorescent Polymer Nanoparticles Based on Dyes: Seeking Brighter Tools for Bioimaging." *small* **2016**, *12*, 1968–1992.

[3] C. Grazon, J. Rieger, R. Méallet-Renault, B. Charleux, G. Clavier "Ultrabright Fluorescent Polymeric Nanoparticles Made from a New Family of BODIPY Monomers."*Macromolecules* **2013**, *46*, 5167-5176.

Fluorescent polymer nanoprobes for dSTORM super-resolution bioimaging

L. Fabre[1], P. Catal[1], C. Rousset[2], A. Fontanier[2], L. Bonnefoy[2], C. Place[3], M.-T. Charreyre[1], P. Bouvet,[4] T. Delair[1], E. Fleury[1], K. Monier[2], A. Favier[1]

1- Université de Lyon, CNRS, UMR 5223, Ingénierie des Matériaux Polymères, Université Claude Bernard Lyon 1, INSA Lyon, F-69622 Villeurbanne Cédex, France. arnaud.favier@univ-lyon1.fr

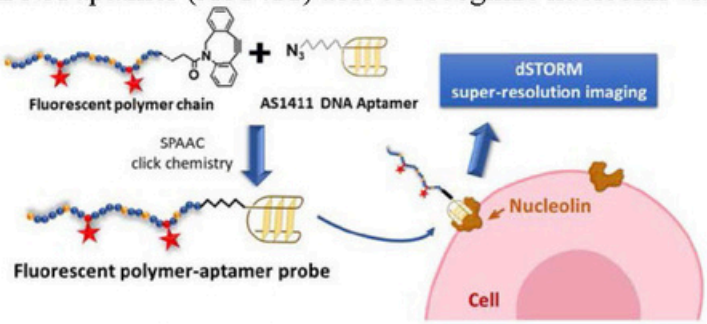
2- Université de Lyon, CNRS UMR 5261 - INSERM U1315, PGNM-Institut NeuroMyoGene-Laboratoire Physiopathologie et Génétique du Neurone et du Muscle, Lyon, F-69008, France

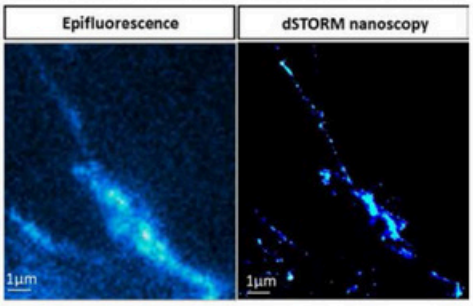
3- CNRS UMR5672, ENS de Lyon, Laboratoire de Physique, F-69364, Lyon, France

4- Université de Lyon, Centre Léon Bérard, UMR INSERM 1052 CNRS 5286, Centre de recherche en cancérologie de Lyon, Lyon, F-69008, France.

Cell biology has greatly benefited from multiscale optical microscopy, though limited to >200 nm-resolution due to the diffraction barrier. Recently, super-resolution methods, such as direct stochastic optical reconstruction microscopy (dSTORM), emerged as techniques providing a 10-fold gain in resolution. However, as dSTORM now provides emitter localization down to 10-30 nm, new labeling approaches are required with fluorescent probes that are both bright and small compared to this localization precision, in addition to provide a selective recognition for their biological target.

We recently developed original fluorescent polymer nanoprobes fulfilling those requirements.[1, 2] One of the objective was to prepare probes for the selective detection of endogenous nucleolin, a protein involved in many biological processes such as cancers.[3] In this case, we synthesized fluorescent polymer chains presenting at one chain-end a small DNA aptamer (AS1411) able to recognize nucleolin via a unique shape-specific interaction.





Polymer chains with both a controlled number of fluorophores and a reactive end-group were prepared via RAFT polymerization. They were then conjugated to AS1411 by bio-orthogonal strained azide-alkyne click chemistry (SPAAC) and the resulting polymer-AS1411 probes were shown to selectively label nucleolin both *in vitro* and *in cellulo*. Interestingly, such small (<10nm) and bright probe provided an attractive alternative to classical immunofluorescence. Moreover, we proved that the probe can be visualized by dSTORM imaging and enabled an unprecedented resolution in the localization of endogenous nucleolin at the cell surface.[2]

References

[1] A. Provost, C. Rousset, L. Bourdon, S. P. Bouvet, E.-I. Pécheur, C. Ladavière, M.-T. Charreyre, A. Favier, C. Place, K. Monier *et al.*, Sci. Rep., **2019**, *9*, 17967.
[2] L. Fabre, C. Rousset, K. Monier, F. Da Cruz-Boisson, P. Bouvet, M.-T. Charreyre, T. Delair, E. Fleury, A. Favier, *Biomacromolecules*, **2022**, *23*, 2302-2314.
[3] F. Mongelard, P. Bouvet, *Curr. Opin. Mol. Ther.*, **2010**, *12*, 107-114.

Block Copolymer-Based Photonic Structures

Federico Ferrarese Lupi [1], Irdi Murataj [1], Eleonora Cara [1], Angelo Angelini [1], Carlo Grazianetti [2]

[1] Advanced Materials Metrology and Life Science Division, INRiM (Istituto Nazionale di Ricerca Metrologica), Strada delle Cacce 91, 10135 Torino, Italy. E-mail: f.ferrareselupi@inrim.it

[2] CNR-IMM, Agrate Brianza Unit, via C. Olivetti 2, 20864 Agrate Brianza, Italy

The development of photonic structures based on polymer materials has gained significant interest due to their potential for large-scale and tunable photonic applications. Among various fabrication strategies, block copolymer (BCP) self-assembly emerges as a powerful bottom-up approach for producing periodic nanostructures with precise control over feature sizes and morphologies. This capability is particularly promising for the scalable realization of photonic structures operating in the visible spectral range.

In this study, we explore the integration of BCP self-assembly with sequential infiltration synthesis (SIS) and liquid phase infiltration (LPI) to fabricate high-resolution nanostructures with tailored photonic properties. The infiltration of metal and metal oxides into the self-assembled BCP templates enables the formation of high-refractive-index nanostructures with well-defined periodicity and composition. The resulting structures exhibit enhanced light-matter interactions, making them suitable for the fabrication of photonic structures such as hyperbolic metasurfaces [1] and 2D memitters.[2]

A key challenge in the design of these photonic architectures is the precise determination of their optical constants at the nanoscale. To address this, we employ a multi-technique characterization approach combining synchrotron-based X-ray scattering, spectroscopic ellipsometry, and atomic force microscopy. This hybrid methodology approach enables the accurate determination of the refractive index and dielectric function of the nanostructured materials, providing critical insights into their optical behavior.[3]

References

[1] I. Murataj, M. Channab, E. Cara, F. Pirri, L. Boarino, A. Angelini, F. Ferrarese Lupi "Hyperbolic Metamaterials via Hierarchical Block Copolymer Nanostructures" *Adv. Opt. Mat.* **2021**, *9*, 7, 2170024.

[2] I. Murataj, A. Angelini, E. Cara, S. Porro, B. Beckhoff, Y. Kayser, P. Hönicke, R. Ciesielski, C. Gollwitzer, V. Soltwisch, F. Perez-Murano, M. Fernandez-Regulez, S. Carignano, L. Boarino, M. Castellino, F. Ferrarese Lupi "Hybrid Metrology for Nanostructured Optical Metasurfaces" *ACS Appl. Mater. Interfaces* **2023**, *15*, 57992–58002.

[3] F. Ferrarese Lupi, G. Milano, A. Angelini, M. Rosero-Realpe, B. Torre, E. Kozma, C. Martella, C. Grazianetti "Synaptic Plasticity and Visual Memory in a Neuromorphic 2D Memitter Based on WS2 Monolayers" *Adv. Func. Mater* **2024**, *34*, 32, 2403158.

Ultrafast Spectroscopy on a Hybrid Plasmonic-Photonic Platform

Andrea Chiappini[1], Diego Florio[2,3], Laura Pasquardini[4,5], Mario Barozzi[6], Monica Bollani[2], Salvatore Stagira[2,3], Tersilla Virgili[2]

1. Istituto di Fotonica e Nanotecnologia, CSMFO Lab. and FBK Photonics Unit, via Sommarive 18, 38123 Povo (Trento), Italy

2. Istituto di Fotonica e Nanotecnologia, CNR, P.zza Leonardo di Vinci 32, 20132 Milano, Italy

3.Politecnico di Milano, P.zza Leonardo di Vinci 32, 20132 Milano, Italy

4.Indivenire srl, via Sommarive 18, 38123 Trento, Italy

5. University of Campania Luigi Vanvitelli, Department of Engineering, via Roma 29, Aversa 81031, Italy

6. Fondazione Bruno Kessler, Sensors and Devices, via Sommarive 18 Trento, Italy

Photonic crystals have attracted interest due to their unique photonic properties, such as enhanced near-field interactions and light confinement, that, along with the low fabrication cost requirements, have made them good candidates for applications in SERS, bio-sensing, and waveguiding. Noble metal nanostructures exhibiting plasmonic functionalities represent another class of noteworthy materials that can be combined with photonic crystals to obtain even more performant hybrid materials. Here, we use femtosecond transient absorption spectroscopy, complemented by a theoretical model, to reveal the hybrid plasmonic-photonic nature of a system consisting of an opal photonic crystal covered with a thin gold layer from a photophysical perspective.

The fabrication process involves the synthesis of a monodisperse colloidal solution of silica nanospheres using Stöber method, followed by self-assembling via vertical deposition on a quartz substrate to create an ordered opal structure. Subsequently, a thin gold layer is evaporated on the opal surface, producing a metal decoration with a peculiar morphology, made by gold nanocrescents connected by a thin film, as observed via high-resolution SEM.

We compare the photophysical response of this sample with that of a flat gold film, obtained by an analogous gold evaporation on a flat quartz substrate. The results of the experiments conducted under different experimental conditions reveal the presence of a bleaching band in the hybrid plasmonic-photonic platform at the opal photonic bandgap (PBG) spectral position (≈620 nm), which is absent in the flat gold film.

We model our system noting that gold nanocrescents, with an aspect ratio consistent with our fabrication parameters (opal's nanospheres diameter and gold thickness deposition), can support spectrally broad localized surface plasmon resonances (LSPRs) in the NIR region. The model accurately predicts the appearance of a bleaching band at the opal PBG spectral position, thus evidencing an interaction between the plasmonic and photonic characters in our hybrid system, manifesting as an LSPR response amplification by the photonic crystal.

Finally, we covered the hybrid plasmonic-photonic platform with dehydrated *Bacillus cereus*, and we found a ≈10 nm red shift of the bleaching band suggesting the possibility to develop a system sensitive to bacteria [1].

References

[1] A. Chiappini et al. submitted.

Light-Driven Modulation of Magnetic Properties via Liquid Crystalline Netoworks

Neri Fuochi, D. Martella, G. Barrera, F. Celegato, D.S. Wiersma, M. Coisson, P. Tiberto, C. Parmeggiani

Department of Chemistry "Ugo Schiff", University of Florence, Via della Lastruccia 3-13, 50019 Sesto F.no, Italy, - Istituto Nazionale di Ricerca Metrologica (INRiM), Strada delle Cacce 91, 10135 Torino, Italy – European laboratory for Non Linear Spectroscopy, via N. Carrara 1, 50019 Sesto F.no, Itlay. e-mail: neri.fuochi@unifi.it

Liquid Crystalline Networks (LCNs) are an advanced class of functional materials that combine the anisotropic responsiveness of liquid crystals with the inherent elasticity of elastomers. Their ability to undergo reversible shape changes in response to external stimuli makes them highly promising for applications in sensors, micro-robotics, and tissue engineering. On the other hand, magnetostrictive materials are widely used in sensors, actuators, and energy storage devices due to their capacity to convert mechanical stress into magnetic property variations and vice versa. Integrating these two material classes presents an intriguing research challenge. In this study, we demonstrated a novel approach to inducing mechanical stress in magnetostrictive devices—thereby altering their magnetic properties—without direct physical contact. This was achieved by incorporating magnetostrictive FeGa thin films into photoresponsive LCNs. [1]
By embedding photo-switchable azobenzene, we enabled the controlled deformation of the LCN by applying mechanical stress also to the FeGa layer. This interaction enables optomechanical, contact-free regulation of the system's magnetic and electrical properties, which can be precisely tuned based on illumination duration and wavelength. The resulting fully reconfigurable magnetic platform holds great potential for next-generation sensor technologies and smart materials.

Acknowledgments: this research was produced with the co-funding of the European Union - Next Generation EU, in the context of The National Recovery and Resilience Plan, Investment 1.5 Ecosystems of Innovation, Project Tuscany Health Ecosystem (THE), ECS00000017. Spoke 3. CUP: B83C22003920001

References

[1] G. Barrera, D. Martella, F. Celegato, N. Fuochi, M. Coïsson, C. Parmeggiani, D. S. Wiersma, and P. Tiberto, "Light-Controlled Magnetic Properties: An Energy-Efficient Opto-Mechanical Control over Magnetic Films by Liquid Crystalline Networks" *Adv. Sci.* **2024**, *11*, 2408273-2408283

Organic Solar Cells: From Low Band-gap Porphyrin Materials to Mechanism Study

Ke Gao

Shandong University, Qingdao, China, kegao@sdu.edu.cn

The talk will start with design and synthesis of a series of low band-gap porphyrin-based donor materials in OPV. Then it will be focused on the verification of multi-length scale morphology, which clarifies the direction of device optimization. Then the deep physical mechanism for energy loss will be presented. Finally, it will be focused on the applications of porphyrin based donor materials in different kinds of organic solar cells, such as, tandem cell, ternary cell, flexible cell, semitransparent cell, some of which achieved some record performance. Furthermore, it validates that such class of porphyrin based materials are the best low band-gap donor materials to date.

References

[1] Yawei Miao, Yanna Sun, Wentao Zou, Xu Zhang, Yuanyuan Kan, Wenqing Zhang, Xinyue Jiang, Xunchang Wang, Renqiang Yang, Xiaotao Hao, Longlong Geng, Huajun Xu, **Ke Gao*** "Isomerization engineering of solid additives enables highly efficient organic solar cells via manipulating molecular stacking and aggregation of active layer. " *Adv. Mater.* **2024**, 36, 2406623.

[2] Yuanyuan Kan[§]; Yanna Sun[§]; Yi Ren; Yixuan Xu; Xinyue Jiang; Haojiang Shen; Longlong Geng; Jianfeng Li; Ping Cai; Huajun Xu; **Ke Gao***, Yuliang Li "Amino - Functionalized Graphdiyne Derivative as a Cathode Interface Layer with High Thickness Tolerance for Highly Efficient Organic Solar Cells. " *Adv. Mater.* **2024**, 36, 2312635.

[3] Xu Zhang[§], Huanhuan Gao[§], Yuanyuan Kan[§], Xunchang Wang, Wenqing Zhang, Kangkang Zhou, Huajun Xu, Long Ye, Renqiang Yang, Yingguo Yang, Xiaotao Hao, Yanna Sun*, **Ke Gao*** "End-extended Conjugation Strategy to Reduce the Efficiency-StabilityMechanical Robustness Gap in Binary All-Polymer Solar Cells." *Angew. Chem. Int. Ed.* **2024**, e202415583.

[4] Yanna Sun§, Li Nian§*, Yuanyuan Kan§, Yi Ren, Zhihao Chen, Lei Zhu, Ming Zhang, Hang Yin, Huajun Xu, Jianfeng Li, Xiaotao Hao, Feng Liu, **Ke Gao***, Yuliang Li "Rational Control of Sequential Morphology Evolution and Vertical Distribution towards 17.18% Efficiency All-Small-Molecule Organic Solar Cells." *Joule*, **2022**, 6, 2835.

[5] Ruijie Ma[§], Kangkang Zhou[§], Yanna Sun[§], Tao Liu*, Yuanyuan Kan, Yiqun Xiao, Top Archie Dela Peña, Yixin Li, Xinhui Zou, Zengshan Xing, Zhenghui Luo, Kam Sing Wong, Xinhui Lu, Long Ye*, He Yan*, **Ke Gao*** "Achieving high efficiency and well-kept ductility in ternary all-polymer organic photovoltaic blends thanks to two well miscible donors." *Matter*, **2022**, 5, 725.

[6] **Ke Gao**,* Yuanyuan Kan, Xuebin Chen, Feng Liu,* Bin Kan, Li Nian,* Xiangjian Wan, Yongsheng Chen, Xiaobin Peng,* Thomas P. Russell,* Yong Cao, and Alex K.-Y. Jen* "Low-Bandgap Porphyrins for Highly Efficient Organic Solar Cells: Materials, Morphology, and Applications." *Adv. Mater.* **2020**, 32, 1906129.

[7] Zaiyu Wang, **Ke Gao***, Yuanyuan Kan, Ming Zhang, Chaoqun Qiu, Lei Zhu, Zhe Zhao, Xiaobin Peng, Wei Feng, Zhiyuan Qian, Xiaodan Gu, Alex K-Y Jen*, Ben Zhong Tang, Yong Cao, Yongming Zhang, Feng Liu* "The coupling and competition of crystallization and phase separation, correlating thermodynamics and kinetics in OPV morphology and performances." *Nat. Commun.*, **2021**, 12, 1, 332.

[8] Le Liu[§], Yuanyuan Kan[§], **Ke Gao***, Jianxiao Wang, Min Zhao, Hao Chen, Chengjie Zhao, Tonggang Jiu*, Alex-K.-Y. Jen, and Yuliang Li* "Graphdiyne Derivative as Multifunctional Solid Additive in Binary Organic Solar Cells with 17.3% Efficiency and High Reproductivity." *Adv. Mater.*, **2020**, 32, 11, 1907604.

Coloring and wettability control of silk fibroin films by multiple-scale structuring

A. Alegre[1], J. J. Hernández[1], T. A. Ezquerra[1], I. Rodríguez[2], M. C. García-Gutiérrez[1]

[1] Institute for the Structure of Matter (IEM-CSIC), Serrano 121, 28006 Madrid, Spain; [2]Institute for Advanced Studies in Nanoscience (IMDEA Nanociencia), 28049 Madrid, Spain. alejandro.alegre@iem.cfmac.csic.es; jaime.hernández@csic.es; t.ezquerra@csic.es; i.rodriguez@imdea.org; maricruz@iem.cfmac.csic.es

There has been growing interest in the use of natural bionanomaterials and microstructured systems for the development of a more sustainable generation of devices, electronics, photonics and smart textiles [1]. Such materials can confer unique functional properties as well as address concerns pertaining to sustainability in production. Silk fibroin, a protein-based material generally obtained from Bombyx mori cocoons, is a block copolymer consisting of a heavy and a light chain with different amphiphilicity linked together by a single disulphide bond [2]. The present contribution will cover recent research on the micro- and nanopatterning of silk fibroin films by different lithography techniques, like soft lithography and nanoimprint lithography (NIL) [3]. The role of different solvents, master topography, humidity and pressure, among other conditions, will be discussed in order to tune the color and wettability of silk fibroin films.

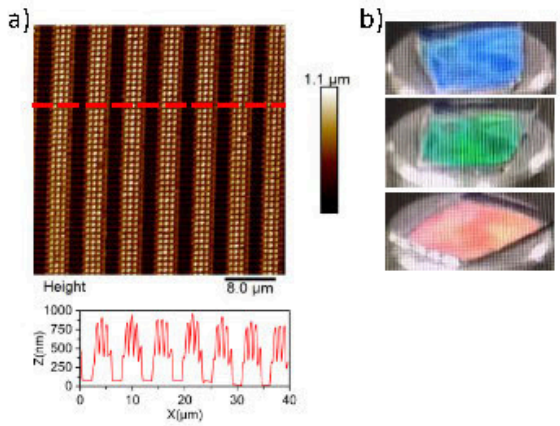


Figure 1. (a) AFM topography image of a bioinspired hierarchical and ordered structure, on a silk fibroin film, composed of micrometer trenches and nanometer pillars on top of them. The height profile along the marked red dashed line is shown below the image. (b) Pictures of the sample showing different colours.

This work has been funded by the Spanish State Research Agency (AEI) and by the European Regional Development Fund (ERDF) "A way of making Europe" MCIN/AEI/10.13039/501100011033 through projects TED2021-129845B-I00 and PID2022-138635NB-I00.

References

[1] C. Wang, K. Xia, Y. Zhang, D. L. Kaplan "Silk-Based Advanced Materials for Soft Electronics". *Acc. Chem. Res.* **2019**, *52*, 2916–2927.
[2] A. Reizabal, C. M. Costa, L. Pérez-Álvarez, et al. "Silk Fibroin as Sustainable Advanced Material: Material Properties and Characteristics, Processing, and Applications". *Adv. Funct. Mater.* **2023**, *33*, 2210764.
[3] I. Rodríguez, J. Hernández "Soft thermal nanoimprint and hybrid processes to produce complex structures", in Nanofabrication: Nanolithography techniques and their applications. **2020** ISBN: 978-0-7503-2606-3.

Tuning the photoacidity of Spiropyran-merocyanine based polymers

Carlo Gericke,[1] Krzysztof Matyjaszeweski,[2] Edmondo Benetti,[1] Cristian Pezzato.[1]

[1] Laboratory for Macromolecular and Organic Chemistry (MOC), Department of Chemical Science, University of Padova, *via* Marzolo 1, 35131 Padova, Italy

[2] Department of Chemistry, Carnegie Mellon University, 4400 Fifth Avenue, Pittsburgh, PA 15213, USA

E-mail: carlo.gericke@phd.unipd.it,

The development of photo-responsive polymers has garnered significant attention due to their versatile applications as switches across various domains of organic, biological,[1] and supramolecular chemistry.[2] Light represents the best option to regulate macromolecular systems due to its non-invasive and selective activation, high energy efficiency, and sustainability. One the most used light-responsive system is based on the spiropyran-merocyanine isomerization, the peculiarity of these molecules is the difference of acidity in dark and upon light irradiation due to reversible structural transitions, defined as *photoacidity*.[3,4] However, the large-scale use of spiropyran-based systems is limited by their low photoacidity, poor stability, and limited solubility in water. The macromolecular approach, particularly polymer-based systems, offers a promising solution to enhance the properties of spiropyrans in aqueous environments. Despite their potential, comprehensive and systematic investigations into the properties of spiropyran-based polymers remain notably scarce. Here, we synthesized a series of random copolymers containing 3-sulfopropyl methacrylate units (SPMA) alternated with spiropyran methacrylate units in their open protonated form (MCH), which can release protons following visible light absorption. We studied the behaviour of these poly(SPMA-*co*-MCH) copolymers in water under dark conditions and upon light irradiation. The macromolecular design significantly enhances the photoacidity and the hydrolytic stability of the MCH moieties, whereas copolymer composition can be used as a tool to rationally control their photoacidic characteristics. The 5% MCH copolymer resulted to be the best performing in terms of both photoacidity and water stability, therefore it has been used to perform pH jumps (**Figure 1**). The results presented here hold promise for the fabrication of materials for photocurrent generation.

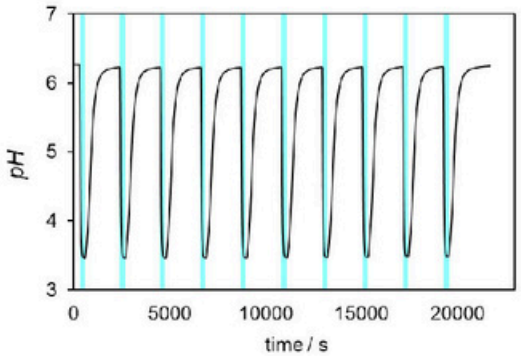


Figure 1. pH jumps of the 5% MCH containing polymer. Experimental conditions: [MCH-*co*-SPMA] = 10 mg/mL, T = 25°C, light intensity: 55.6 mW/cm^2.

References

[1] K. Matsuura *et al.*, *Front. Mol. Biosci.* **2023**, *10*, doi: 10.3389/fmolb.2023.1137885;
[2] H. F. Sleiman *et al.*, *Nat. Chem.* **2021**, *13*, 843-849;
[3] I.-D. Kim *et al.*, *Adv. Mater.* **2022**, *34*, 2201734;
[4] M. L. Lukatskaya *et al.*, *Chem. Mater.* **2024**, *36*, 1308-1317,

Carbon Nitride thin Films for Energy Conversion

Paolo Giusto

Department of Colloid Chemistry, Max Planck Institute of Colloids and Interfaces, Am Mühlenberg 1, 14476 Potsdam-Golm, Germany; E-mail: Paolo.Giusto@mpikg.mpg.de

The interest in metal-free materials has been recently rising, and structures with target properties and chemical features have significantly widened the application spectrum of this class of materials. Among those, carbon nitride materials, a class of 2D polymeric semiconductor with ideal formula C_3N_4, have recently attracted much attention especially in photocatalysis. However, up to now, their application as thin films was hindered due to the low homogeneity of the coatings available. Recently, we developed an innovative method to produce carbon nitride thin films with tunable thickness by means of chemical vapor deposition. The as prepared thin films are highly stable, homogeneous, and flat with a very high refractive index, even in the range of diamond. [1] The high homogeneity and conformal deposition of the carbon nitride thin films prepared enabled to use them to develop innovative batch and microfluidic photoreactors, by coating the reactors' walls, achieving high selectivity and conversion in shorter time. [2] Furthermore, the utilization of carbon nitride thin films further enabled the development of in-operando spectroscopic techniques providing fundamental mechanistic insights and the critical role of surface interactions in key reactions, such as water splitting. [3, 4] Eventually, the use of thin films in energy conversion is still in its infancy, however, it sets the premises for significant improvements in photo-, photoelectro-catalysis, and beyond.

References

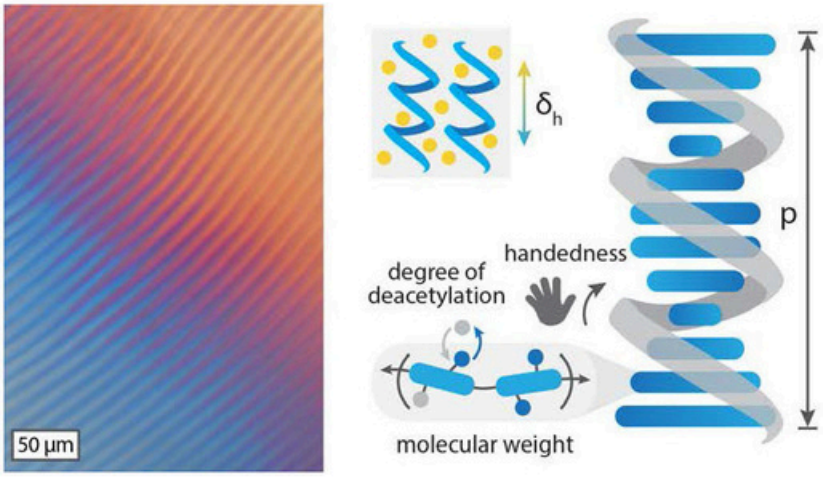
1. Giusto P, Cruz D, Heil T, Arazoe H, Lova P, Aida T, et al. Shine Bright Like a Diamond: New Light on an Old Polymeric Semiconductor. Advanced Materials **2020**, 32(10): 1908140.
2. Mazzanti S, Manfredi G, Barker AJ, Antonietti M, Savateev A, Giusto P. Carbon Nitride Thin Films as All-In-One Technology for Photocatalysis. ACS Catalysis **2021**, 11(17): 11109-11116.
3. Cruz D, Żółtowska S, Savateev O, Antonietti M, Giusto P. Carbon nitride caught in the act of artificial photosynthesis. Nature Communications **2025**, 16(1): 374.
4. Dauth B, Giusto P, König B, Gschwind RM. In situ Monitoring of Photocatalysis on Polymeric Carbon Nitride Thin Films. Angewandte Chemie International Edition **2024**, 63(50): e202412972.

Texture and Pitch Evolution in Cholesteric Chitosan Mesophases

Eleanor C. Grosvenor,* Emma M. Sellin, Sara E. Branovsky, Cécile A. C. Chazot

*Department of Materials Science and Engineering, Northwestern University, 2220 Campus Dr., Evanston, Illinois 60208, United States. Email: eleanorgrosvenor2026@u.northwestern.edu

Chitosan, a polysaccharide derived from the deacetylation of naturally abundant chitin, has been widely implemented as a sustainable natural polymer for applications such as packaging, bioelectronics, and flame retardancy. However, its liquid crystalline self-assembly in solution and associated optical properties remain understudied. When dissolved in an aqueous or organic acid solution at high concentrations, chitosan self-assembles into a chiral nematic liquid crystal with selective reflectivity in the infrared (IR) portion of the electromagnetic spectrum. While this mesophase has been observed in formic acid and other organic acids, the impact of polysaccharide chemistry (i.e., degree of deacetylation - DDA) and molecular weight on phase behavior, lyotropic dependence of the chiral nematic pitch, and chiroptical properties remain to be explored. In this study, we leverage polarized optical microscopy and spectroscopy methods to characterize how chitosan side chain chemistry and molecular weight affect chiral nematic order formation and resulting chiroptical properties. We find that increasing DDA results in a decrease of the lyotropic concentration onset of chiral nematic order formation (c*), while increasing molecular weight drastically reduces chitosan chain mobility in solution and results in a c* with no dependence on interchain interaction. Using circular dichroism spectroscopy and X-ray diffraction, we quantify geometric parameters of the chiral nematic structure, such as handedness and isocline spacing, and their dependence on chitosan side chain chemistry and molecular weight. Lastly, the high viscosity of the concentrated chitosan mesophases allows for straightforward retention of cholesteric order in the dry solid-state after solvent removal, unlike other low-viscosity cholesteric polysaccharides (e.g., cellulose ethers). This unique stability, due to kinetic trapping of the liquid crystalline order and low chain mobility, results in chiroptical solids with selective reflectivity in the IR. This work paves the way for natural materials with enhanced optical functionality, such as radiative passive cooling or optical signature management, highlighting the potential of chitosan-based materials in advanced optical applications.



Optimizing Morphology to Trade Off Charge Transport and Mechanical Properties of Stretchable Conjugated Polymer Films

Hongxiang Li, Sichun Wang, Kefeng Zhao, Yanchun Han

State Key Laboratory of Polymer Physics and Chemistry, Changchun Institute of Applied Chemistry, Chinese Academy of Sciences, 5625 Renmin Street, Changchun 130022, P. R. China
Fax: + 86-431-85262126, Tel: + +86-431-85262175; E-mail:ychan@ciac.ac.cn

The conjugated semiconducting polymers are important materials for flexible and stretchable electronic devices such as field-effect transistors (OFET), organic light-emitting diodes (OLEDs), and organic solar cells (OPVs) because of their tunable electrical and mechanical properties, light weight, and low-cost solution processing [1]. Significant research progress has been achieved in stretchable polymer electronics by synthesizing novel conjugated polymer materials and designing new device geometries. However, the inherent competition between high charge mobility and good mechanical compliance has long existed for conjugated polymer films. The solid-state electrical and mechanical properties of conjugated polymers depend sensitively on their morphologies across all length scales. This multiscale morphology in the solid state is largely affected by molecular weight and its polydispersity, solution-state aggregates and their assembly pathways from solution to thin films [2]. In this talk, we will provide an understanding of how to balance the electrical properties and mechanical properties from the point of view of multiple length scale microstructures of conjugated polymers. We first focus on how to design the percolation morphology with the aggregates, tie chains, and amorphous phase via controlling solution preaggregation and film-formation dynamics. Furthermore, the rational transfer of film morphology from small-area coating to large-area printing is discussed in terms of film uniformity and crystallization control. Finally, we summarize the challenges and opportunities in microstructure control of stretchable conjugated polymer films [3].

References

[1] Zicheng Ding, Dongle Liu, Kui Zhao, and Yanchun Han, *Macromolecules*, 2021, 54, 3907.
[2] Liu, X.; Jin, T.; Li H.*; Wang, S.; Shen, Z.; Li, J.; Chen, R.; Chen, Y.*; Han, Y.* *Macromolecules* 2024, 57 (9), 4141−4157.
[3] Huang, W.; Liu, X.; Ding, Z.; Wang, Z.; Xu, C.; Li, R.; Wang, S.; Wu, Y.; Qin, R.; Han, Y.; Geng, Y.; Liu, S. F.; Han, Y.*; Zhao, K*. *Nano Lett.* 2024, 24 (1), 441−449

Chlorine-mediated organic conjugated materials and quasi-planar heterojunction devices

Feng He*

Department of Chemistry, Southern University of Science and Technology, Shenzhen, 518055 (E-mail: hef@sustech.edu.cn)

ABSTRACT

The properties of organic functional materials are determined by both their chain structure and the intermolecular interactions. Many high-performance organic materials often exhibit synergistic weak interactions between molecules, which plays a crucial role in their good properties. Based on the basic concept of precisely controlling intermolecular interactions, we have developed a series of material systems with specific transport structures by controlling the arrangement and aggregation of organic optoelectronic molecules through the Cl···S and Cl···π interactions. In particular, we discovered a three-dimensional (3D) network structure in the model molecules with specific chlorine-mediated intermolecular interactions. This aggregated state provides more transport junctions and channels for intermolecular electron hopping, which will increase the exciton diffusion distance and effectively improve mobility. We also systematically studied the effects of chlorine substitution position, number, and isomerism on the formation of the 3D network structure, which could provide a better molecular design strategy to achieve improved device performance. With the exciton diffusion distance exceeding 40 nm, those materials open a window for the development of quasi-planar heterojunction (Q-PHJ) devices. Compared with bulk heterojunction (BHJ) devices, Q-PHJ devices have a thermodynamically stable donor-acceptor bilayer structure, which can greatly improve device stability for coming practical applications.

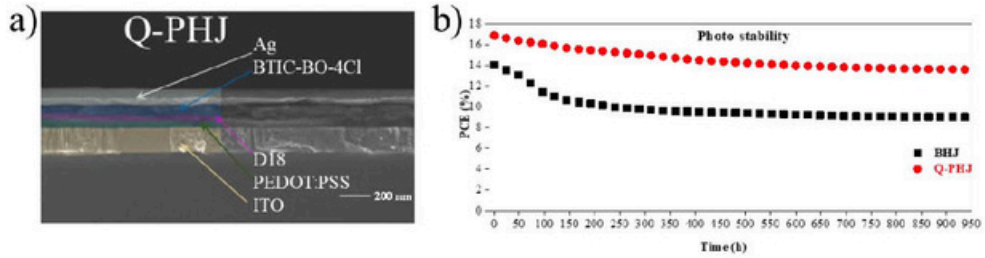


Fig. 1 a) SEM image of Q-PHJ device, b) the photo-stability of BHJ and Q-PHJ devices.

KEYWORDS

chlorine-mediated interactions, three-dimensional network, quasi-planar heterojunction, mobility, stability

Precise and scalable synthesis of conjugated polymers

Hui Huang

University of Chinese Academy of Sciences, huihuang@ucas.ac.cn

Conjugate polymers (CPs), especially the alternating CPs, have attracted much attention since they have applications in many fields, including energy, information, and biology. Currently, the synthesis of alternating CPs mainly depends on the transition metal-catalyzed cross coupling reactions. Due to the homocoupling side reactions, there are intrinsic structural defects in the backbones of the CPs, resulting in detrimental electronic properties, large batch-to-batch variation, and unclear structure-property relationship. Thus, it is important to develop new methods for precise and scalable synthesis of CPs.
In this talk, we will report several novel synthetic methods for precision synthesis of CPs including an original C-S bond activation based polymerization (CASP) method. We will discuss the catalytic systems, the structural defects and the catalytic mechanisms. Also, we will present the challenges and prospects of this field.

References

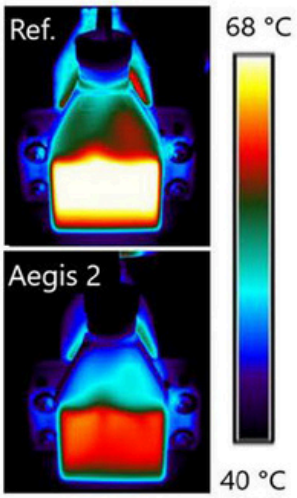
[1] Angew. Chem. Inter. Ed. 2023, 62, e202309922.
[2] Angew. Chem. Inter. Ed. 2023, 62, e202306307.
[3] Nat. Commun. 2022, 13, 144.
[4] Nat. Mater. 2024, 23, 695.

All-Polymer Structures for Thermal Management Applications

Andrea Lanfranchi[1*], Paola Lova[1], Davide Comoretto[1]

[1]University of Genoa, Department of Chemistry and Industrial Chemistry, Via Dodecaneso 31, 16146 Genoa (Italy). *andrea.lanfranchi@edu.unige.it

Global warming, with its consequent increase of extreme natural phenomena has attracted the attention of the scientific community, now focused on central themes such as sustainability and energy efficiency and saving. Air conditioning is a non-negligible problem in these regards.[1,2] Hence, our work explores two alternative solutions – thermal shielding and radiative cooling. For the former, we exploit dielectric mirrors: multilayer structures, made out by stacking thin polymer films (few 100s of nm) one on top of the other. Their periodic arrangement causes interference effects for visible - near infrared radiation (NIR), which make the structure a near perfect mirror for a narrow range of wavelengths. NIR accounts for 45 % of sunlight and causes major heating of irradiated bodies.[3] Thus by reflecting NIR these structures provide passive thermal management of indoors or products exposed to sunlight, as reported in the figure.[4] These selective reflectors can be joined with thermal radiation emitters to achieve radiative cooling. Indeed, part of the thermal emission of objects – depending on the chemical composition – happens in the 8-13 μm spectral range. Since the atmosphere is transparent in this spectral range, radiation emitted this way is dispersed into space. If this offsets the heating due to sunlight, a passive net cooling is achieved.[5] Hence, the idea is to pair dielectric mirrors and/or white polymer reflectors with thermally emissive materials in the atmospheric transparency window. The latter may be even fabricated with recycled materials for improved sustainability. This kind of polymer photonic materials can achieve negligible heating or even cooling under direct sunlight, resulting promising towards the goal of a sustainable human presence on Earth.



References

[1] E. Akpinar-Ferrand, A. Singh "**Sustainability Challenges from Climate Change and Air Conditioning Use in Urban Areas.**" *Environ. Sci. Pol.*, **2010**, *13*, 702-712

[2] E. Akpinar-Ferrand and A. Singh **"Modeling increased demand of energy for air conditioners and consequent CO2 emissions to minimize health risks due to climate change in India."** *Environ. Sci. Pol.*, **2010**, *13*, 8, 702-712

[3] A. Lanfranchi, H. Megahd, P. Lova, D. Comoretto. **"Multilayer Polymer Photonic Aegises Against Near-Infrared Solar Irradiation Heating"** *ACS Appl. Mater. Interfaces*, **2022**, *14*, 14550-14560

[4] A. Lanfranchi, H. Megahd, P. Lova, D. Comoretto **"Engineering all-polymer planar photonic crystals as aegises against sunlight overheating."** *Chem. Eng. Sci.*, **2024**, *283*, 11937

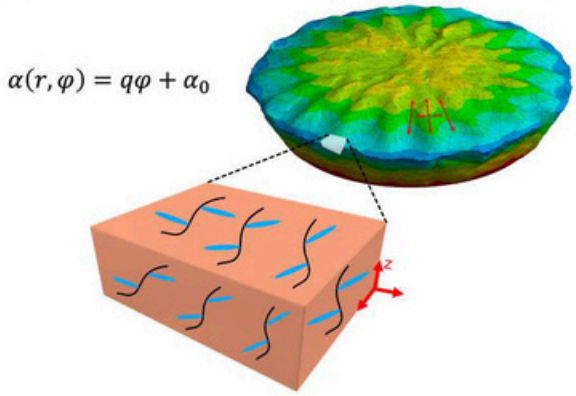
[5] A. P. Raman, M. A. Anoma, L. Zhu, E. Rephaeli, S. Fan **"Passive radiative cooling below ambient air temperature under direct sunlight."** *Nature.*, **2014**, *515*, 510-544

Modeling the viscoplastic deformation of azopolymers under the influence of structured light

Nikolai Liubimtsev[1*], Marina Saphiannikova[1]

[1]Leibniz Institute of Polymer Research Dresden, Germany, e-mail* liubimtsev@ipfdd.de

A distinctive characteristic of side-chain azopolymers is their capacity to convert structured light irradiation into a well-defined stress field [1]. This stress field arises from the alignment and elongation of the polymer backbones along the polarization direction of the light, which serves as a nematic director. Irradiation with linearly or elliptically polarized light results in a uniaxial or biaxial orientation of the azopolymer chains. The stress tensor is directly proportional to the rate of change of the second-order orientation tensor, which can be predicted based on the spatial distribution of the light intensity and polarization [2].



Through the application of viscoplastic photoalignment modeling, we demonstrate that excellent correlation with the experimentally observed reshaping of azopolymer microstructures is achievable. Three-dimensional light fields, such as highly focused Gaussian beams or various q-plate patterns [3], are employed to induce directional photodeformations. The light field is implemented in the finite element software ANSYS either analytically or through the direct mapping of its intensity, polarization, and ellipticity at each material point. This direct mapping technique proves particularly useful for arbitrary light fields, which can be generated by spatial light modulators on the surface of the sample.

The financial support of the DFG grant GR 3725/10-1 is gratefully acknowledged.

References

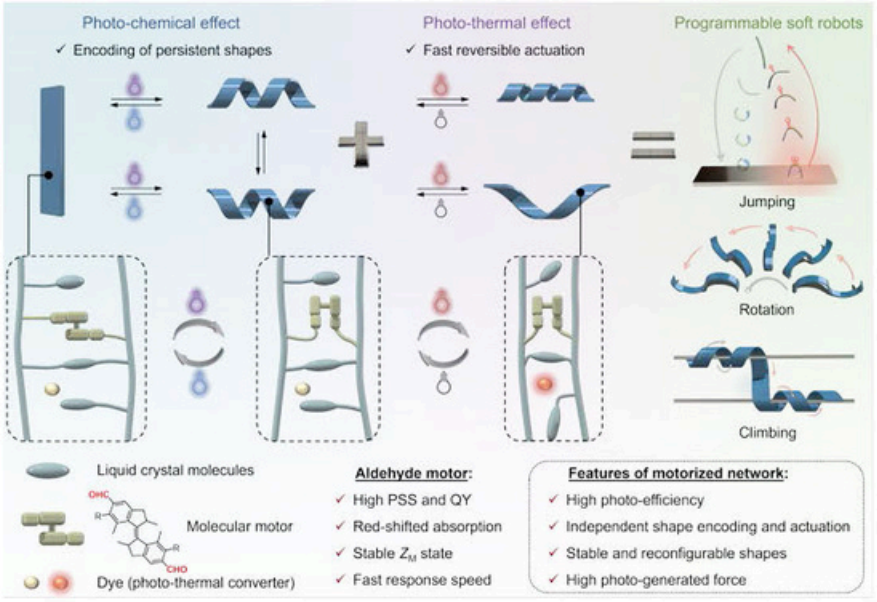
[1] M. Saphiannikova, V. Toshchevikov, N. Tverdokhleb. "Optical deformations of azobenzene polymers: orientation approach vs. other concepts." *Soft Matter* **2024**, *20*, 2688-2710.
[2] N. Tverdokhleb, B. Audia, P. Pagliusi, M. Saphiannikova. "Viscoplastic photoalignment modeling of asymmetric surface restructuring in azopolymer films by elliptically polarized light." *J. Mater. Chem. C* **2025**, *13*, 1263-1271.
[3] W. Ji, CH. Lee, P. Chen, et al. "Meta-q-plate for complex beam shaping." *Sci Rep* **2016**, *6*, 25528.

Boosted molecular motors in polymer networks: unlocking complex deformations through decoupled photochemical and photothermal effects

Guiying Long, Alexander Ryabchun*, Ben L. Feringa*

Stratingh Institute for Chemistry, University of Groningen, Nijenborgh 3, 9747 AG Groningen, The Netherlands.

In recent years, the field of soft robotics has made significant advances, particularly in achieving precise motion control in complex environments through the integration of stimuli-responsive materials. However, developing highly efficient actuators capable of reconfigurable deformation with independent control over shape encoding and rapid actuation remains a major challenge. Here, we present an efficient photo-responsive soft robotic system based on a liquid crystal polymer network (LCPN) that leverages both photochemical and photothermal effects to enable highly programmable and complex motion behaviors. In this system, rotation of high performance bisaldehyde molecular motor[1] under UV light (photochemical effect) enables encoding of persistent shape in polymer films. While the photothermal agent (dye) rapidly heats the material under red light irradiation, disrupting the liquid crystal order of the LCPN and inducing fast, reversible deformations of the system. By preprogramming macroscopic shapes and utilizing rapid actuation, our system demonstrates diverse modes of complex motion, including jumping, rotating and climbing. This photo-responsive LCPN system also exhibits the ability to generate high mechanical forces under light stimulation. This approach provides new design strategies and technological advancements for developing next-generation intelligent materials and multifunctional soft robots.



References

[1] Sheng, J., et al. Formylation boosts the performance of light-driven overcrowded alkene-derived rotary molecular motors. *Nat. Chem.* **2024**, *16*, 1330-1338.

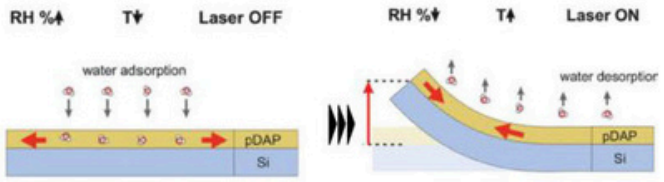
Ultrafast light-driven actuation of plasma-polymerized polydiamine membranes and MEMS cantilevers

Pawel W. Majewski[1], Adam Krysztofik[2], Przemyslaw Pula[1], Mikolaj Pochylski[2], Karol Zaleski[2], Jacek Gapinski[2], Bartlomiej Graczykowski[2]

[1]Department of Chemistry, University of Warsaw, Zwirki i Wigury 101, 02089 Warsaw, Poland, Email: pmajewski@chem.uw.edu.pl; [2] Faculty of Physics, Adam Mickiewicz University, Poznan, 61614, Poland

In advanced miniaturized soft actuators, the demand for fast response and long-term reliability is a pressing need for robust stimuli-responsive polymeric materials. While thin polymeric films show great potential in this regard, solution-processible polymers often lack sufficient mechanical strength and durability. We report on the fabrication and characterization of poly(1,3-diaminopropane) (pDAP) thin films, free-standing membranes, and composite pDAP-silicon cantilevers produced by plasma-assisted deposition.

Our approach enables rapid and scalable coating of diverse surfaces, circumventing the conventional multi-step polymer processing while yielding films with excellent adhesion, high elasticity (Young's modulus of 6.5–8 GPa) assessed by micro-Brillouin light scattering spectroscopy (μ-BLS), and exceptional durability up to 400 °C. We have fabricated ultra-thin (20 nm) pDAP membranes freely suspended over millimeter-scale openings, achieving an extraordinary lateral size-to-thickness ratio of ≈ 40,000. pDAP exhibits responsiveness to temperature and humidity, driven by reversible water sorption that leads to one-dimensional swelling and shrinking, resulting in wrinkling and flattening of the free-standing membranes. This capability enables sensor-like and actuator functionality of pDAP layers in response to changes in temperature, ambient humidity, or laser irradiation. In particular, we demonstrated rapid laser-light-driven photothermal actuation of free-standing pDAP membranes with relaxation times under 10 milliseconds governed primarily by swift water desorption upon illumination and subsequent absorption in darkness. Furthermore, by exploiting differential thermal expansion between the pDAP and silicon, we achieved high-frequency photoactuation of pDAP-silicon cantilever MEMS devices, with measured relaxation times as low as 40 microseconds and micrometer-scale deflection amplitudes with stability exceeding 106 actuation cycles. This performance illustrates the potential to extend the operational bandwidth beyond 10 kHz for the studied materials' dimensions and even higher frequencies with continued miniaturization.



Overall, the combination of plasma polymerization, extreme thinness, robustness, and multi-stimuli actuation underlines the substantial promise of pDAP-based systems. These attributes open new avenues for integrating environmentally friendly and low-cost polymeric actuators in energy harvesters, high-resolution sensors, and micro-robotic components.

[1] A. Krysztofik, P. Pula, M. Pochylski, K. Zaleski, J. Gapinski, P. Majewski, B. Graczykowski, "Fast Photoactuation and Environmental Response of Humidity-Sensitive pDAP-Silicon Nanocantilevers." *Adv. Mater.* **2024**, 36, 2403114.

Hydrophilic π-Conjugated Foams: Synthesis and Photocatalytic Activity

Aleksander Saša Markovič, [a,b] Sebastijan Kovačič [a,b,*]

[a] *National Institute of Chemistry, Department of Inorganic Chemistry and Technology, Hajdrihova 19, 1000 Ljubljana, Slovenia*
[b] *Faculty of Chemistry and Chemical Engineering, University of Maribor, Smetanova ulica 17, 2000 Maribor, Slovenia; email: sebastijan.kovacic@um.si*

Conjugated polymers (CPs) are well-known organic semiconductors, with a variety of applications. A subset of these materials is known as conjugated porous polymers (CPPs). When pendant backbone ionic groups are added to CPPs, these materials are referred as conjugated porous electrolytes (CPEs). The addition of ionic groups gives these materials a range of specific properties that combine the semiconducting properties of CP with hydrophilicity. For this reasons, these materials are used in a variety of fields as promising photocatalysts for the degradation or/and adsorption of pigments [1] and small molecules, such as per- and polyfluoroalkyl substances (PFAS) [2] or bisphenols [3], which are an increasing problem for our society. For this reasons, we have developed a family of visible light active CPE foams by high internal phase emulsion (HIPE) templating, to perform the degradation of a model compound Bisphenol A (BPA), a common additive in plastics.
This presentation will duscuss the development of three different CPE foams were using Sonogashira-Hagihara cross-coupling reaction as the polymerization chemistry. The emulsion templating technique is used to structure the porosity in the CPE network. The obtained CPE foams contain a semiconductive π-conjugated backbone with pendant anionic, cationic and zwitterionic sidechains. These polymer foams were then tested to remove BPA from water through adsorption and/or photooxidation. We have further developed our materials by producing translucent monoliths that have shown greater photocatalytic activity and ability to remove our model polutant, which will also be covered in the presentation.

References

[1] S. Ghasimi, S. Prescher, Z.J. Wang, K. Landfester, J. Yuan, K.A.I. Zhang, Heterophase Photocatalysts from Water-Soluble Conjugated Polyelectrolytes: An Example of Self-Initiation under Visible Light, Angew. Chem. Int. Ed. 54 (2015) 14549–14553. https://doi.org/10.1002/anie.201505325.

[2] X. Chen, S. Hussain, Y. Tang, X. Chen, S. Zhang, Y. Wang, P. Zhang, R. Gao, S. Wang, Y. Hao, Two-in-one platform based on conjugated polymer for ultrasensitive ratiometric detection and efficient removal of perfluoroalk
yl substances from environmental water, Sci. Total Environ. 860 (2023) 160467. https://doi.org/10.1016/j.scitotenv.2022.160467.

[3] D. Šorm, J. Brus, A. Pintar, J. Sedláček, S. Kovačič, Hierarchically Porous Polyacetylene Networks: Adsorptive Photocatalysts for Efficient Bisphenol A Removal from Water, ACS Polym. Au (2024) acspolymersau.4c00032. https://doi.org/10.1021/acspolymersau.4c00032.

Microstructured liquid crystalline polymers for tunable optics and sensors

Daniele Martella,[a,b] Diederik S. Wiersma,[a] Camilla Parmeggiani,[a,b] Sara Nocentini[a]

[a] European Laboratory for Non-Linear Spectroscopy (LENS), 50019 Sesto Fiorentino, Italy; email: martella@lens.unifi.it

[b] Department of Chemistry, University of Florence, 50019 Sesto Fiorentino, Italy

Materials responding to the surrounding environment by a shape or colour variation are of great benefit for the development of portable sensors, e.g. to monitor temperature or to detect hazardous chemicals, and photonic devices, e.g. dynamic optical filters. For both applications, Liquid Crystalline Networks are emerging as great candidates thanks to their reversible shape-change and refractive index variation under stimuli, including temperature, light and organic solvents or vapours.

In this communication, we will present the fabrication of micro-structured Liquid Crystalline Networks harnessing the potential of photopolymerization of reactive mesogens. This reaction is compatible with many photolithographic techniques (e.g. Direct Laser Writing, and Digital Light Projection lithography) allowing for 3D patterning at different length scales. [1] By exposing the micro-patterns to temperature variations and solvent vapours, we demonstrated a colour-base real-time temperature and organic chemicals detection (Figure 1). Sensitivity can be enhanced by coupling the responsive polymers with nanometric metal layers to build up Fabri-Pérot micro-cavities. Such optical cavities demonstrate large, reversible and linear spectral tuning under temperature variation, working both as tuneable optical filters and temperature sensors. [2]

Acknowledgment: this project is supported by the Italian Ministry of University and Research (MUR) under the PRIN2022 WATERONIC grant.

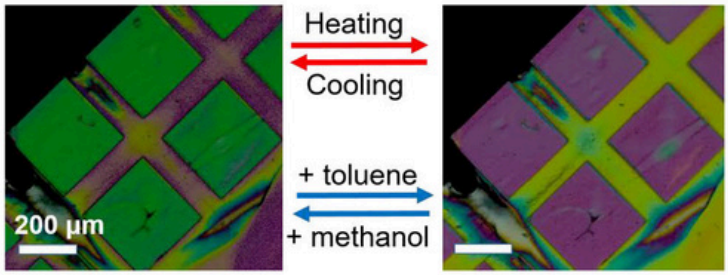


Figure 1. Examples of responsive micropatterned polymers

References

[1] Donato, S; et al. "Liquid Crystalline Network Microstructures for Stimuli Responsive Labels with Multi-Level Encryption." *Small 2024*, 20, 2306802.

[2] Zubritskaya, I; et al. "Dynamically Tunable Optical Cavities with Embedded Nematic Liquid Crystalline Networks." *Adv. Mater.* **2023**, 2209152.

Chameleon-Inspired 1D Photonic Crystals: Stretchable Photonic Sensors for Real-Time Strain Detection

Martina Martusciello, Andrea Lanfranchi, Paola Lova, Davide Comoretto

Università degli Studi di Genova, Dipartimento di Chimica e Chimica Industriale, Via Dodecaneso, 31, 16146, Genova (IT), martina.martusciello@edu.unige.it

Mechanochromic materials represent a groundbreaking paradigm in the visual quantification of strain, with profound implications for biomedical diagnostics, electronic skin, soft robotics, and structural health monitoring.[1] Traditional strain sensors, which transduce mechanical deformation into electrical signals, are inherently constrained by their reliance on external power sources and wiring.[2] Drawing inspiration from the sophisticated coloration mechanisms of biological systems, such as the camouflage of chameleons [3], this study explores the potential of photonic crystals (PCs) as autonomous optical strain sensors.[4] Photonic crystals are periodic nanostructures composed of alternating materials with different refractive indices, forming a dielectric lattice that extends in one, two, or three dimensions. This structural order effects photon propagation in an analogous manner to how crystalline lattices influence electron behavior, giving rise to photonic band gaps (PBGs) that manifest as distinct reflectance peaks.[5] Here, we focus on one-dimensional photonic crystals known as distributed Bragg reflectors (DBRs), engineered via solution-based deposition technique employing elastomeric block copolymers, materials renowned for their exceptional mechanical resilience relative to conventional thermoplastics. Under mechanical stress, the DBR lattice undergoes nanoscale deformation, inducing shifts in the spectral position of the PBG, thereby altering perceived color. By fabricating DBRs with varied compositions and integrating them onto diverse substrates, we conduct a comprehensive optomechanical characterization, quantifying the strain-induced optical response through mechanochromic sensitivity (MS) metrics. Furthermore, we probe the structural reversibility of the nanostructure, shedding light on the durability and adaptability of these self-powered, mechanochromic systems.[4] Our findings pave the way for next-generation strain sensors that combine precision, durability, and energy efficiency.

References

[1] J. M. Clough "Mechanochromism in Structurally Colored Polymeric Materials" *Macromol. Rapid Commun.* **2021**, *42*, 2000528.
[2] R. K. Langat "In-situ piezoelectric sensors for structural health monitoring with machine learning integration" *Mechatronics* **2025**, *106,* 103297.
[3] J. Teyssier "Photonic crystals cause active colour change in chameleons" *Nat. Commun.* **2015**, 6, 6368
[4] M. Martusciello "Stretchable Distributed Bragg Reflectors as Strain-Responsive Mechanochromic Sensors" *ACS Appl. Mater. Interfaces.* **2024,** *16,* 51384-51396.
[5] P. Lova "Advances in Functional Solution Processed Planar 1D Photonic Crystals" *Adv. Opt. Mater.* **2018**, *6*, 1800730.

Acridone Derivatives for Near-UV Radical Polymerization: One-Component Type II vs. Multicomponent Behaviors

Adel Noon [1,2], Francesco Calogero [3,4], Andrea Gualandi [3,4], Fabrice Morlet-Savary [1,2], Michael Schmitt [1,2], Pier Giorgio Cozzi [3,4,*] and Jacques Lalevée[1,2,*]

[1] Université de Haute-Alsace, CNRS, IS2M UMR 7361, F-68100 Mulhouse, France ; adel.noon@uha.fr
[2] Université de Strasbourg, Strasbourg, France.
[3] Department of Chemistry Giacomo Ciamician, University of Bologna, Via Selmi 2, 40126 Bologna, Italy.
[4] Center for Chemical Catalysis-C3, Alma Mater Studiorum-Università di Bologna, Via Selmi 2, 40126 Bologna, Italy.
*Correspondence: piergiorgio.cozzi@unibo.it (P.G.C.); jacques.lalevee@uha.fr (J.L.).

In this work, two novel acridone-based photoinitiators (Bn-Acr and DPM-Acr) were designed and synthesized for the free radical polymerization of acrylates with a light-emitting diode emitting at 405 nm.[1] These acridone derivatives were employed as mono-component Type II photoinitiators and as multicomponent photoinitiating systems in the presence of an iodonium salt or an amine synergist (EDB) in which they achieved excellent polymerization initiating abilities and high final conversions of the acrylate group (Figure 1). Photoinitiation mechanisms through which reactive species are produced were investigat-ed employing different complementary techniques including steady-state photolysis, steady-state fluorescence, cyclic voltammetry, UV–visible absorption spectroscopy, and electron spin reso-nance spectroscopy. Finally, these molecules were also used in the direct laser writing process for the fabrication of 3D objects.

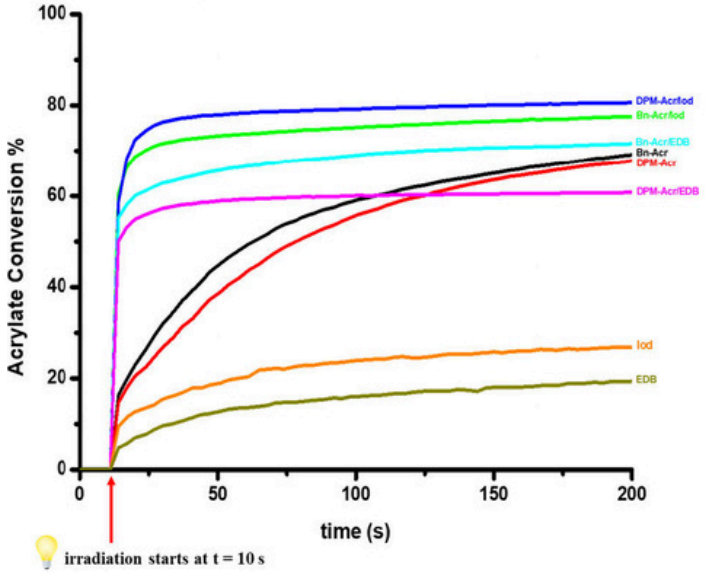


Figure 1. Photopolymerization profiles of TA (acrylate function conversion vs. irradiation time) upon exposure to an LED (λ = 405 nm) in the presence of PIs (1%w/w), PIs/Iod (1%/1% w/w), PIs/EDB (1%/1% w/w), Iod alone (1% w/w), and EDB alone (1% w/w). The irradiation starts at t = 10 s.

References

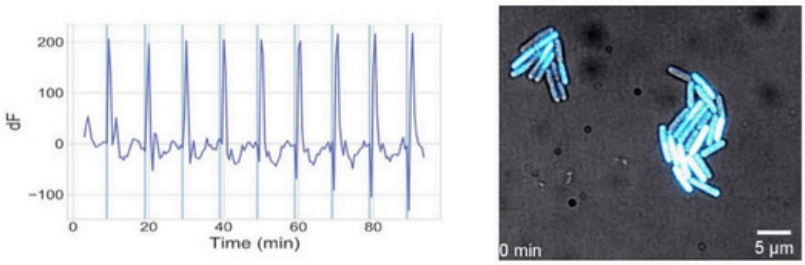
[1] A. Noon, F. Calogero, A. Gualandi, F. Morlet-Savary, M. Schmitt, P.G. Cozzi, and J. Lalevée, Acridone derivatives for near-UV radical polymerization: one-component Type II vs. multicomponent behaviors, *Molecules*, 2024, 29(19), 4715.

Materials-Driven Phototaming of Bacterial Bioelectricity

Giuseppe Maria Paternò

Department of Physics, Politecnico di Milano, piazza L. Da Vinci 32, 20133 Milano, Italy
Center for Nanoscience and Technology, Istituto Italiano di Tecnologia, via Rubattino 81, 20134 Milano
giuseppemaria.paterno@polimi.it

The goal of engineering living matter is to modify biological attributes to leverage the unique capabilities of living organisms. One prevalent method involves rendering living matter responsive to specific stimuli through either synthetic biology techniques or functional materials, aiming to modulate the electrophysiology and activity of cells and organisms. This method applies to bacteria as well, even though the connections between their electrophysiology, bioelectricity, bioenergetics, and behavior have only recently started to be elucidated. Recent studies have revealed that bacterial membrane potential is a dynamic, rather than static, parameter and plays a significant bioelectric signaling role. Such a communication paradigm governs their metabolism, behavior, and functions within microbial communities. Given that membrane potential dynamics mediate this language, manipulating this parameter represents a promising and intriguing strategy for bacterial engineering.
Here, I show that precise optical modulation of bacterial membrane potential can be achieved through a materials-based approach.[1] Specifically, we found that the isomerization reaction at the membrane location induces either hyperpolarisation or depolarisation of the potential depending on the excited state deactivation pathways, within a bio-mimetic mechanism reproducing the initial fate of retinal. This can trigger neuron-like bioelectric signalling and can highlight the role of previously uncharacterized ion channels in bacteria electrophysiology. Finally, I also show perspectives on the light-modulation of antibiotic uptake, as well as on the photocontrol of bacterial motion and assembly behavior in consortia and multispecies ecosystems.



Periodic photo-induced hyperpolarization of a B. subtilis microcolony cultured with azobenzene and stimulated by 470 nm light for 10 s every 10 min. Reference: Adv. Sci. 2023, 10, 2205007

References

[1] T. C. de Souza-Guerreiro, G. Bondelli, I. Grobas, S. Donini, V. Sesti, C. Bertarelli, G. Lanzani, M. Asally, G. M. Paternò, *Adv. Sci.* **2023**, *10*, 1.

Block copolymer based self-assembled metamaterials and metasurfaces

Alberto Alvarez-Fernandez[1,2], Cian Cummins[1,2], Guillaume Fleury[2], Xuan Wang[1], Morten Kildemo[3], Alexandre Baron[1], and Virginie Ponsinet[1]

[1]Univ. Bordeaux, CNRS, Centre de Recherche Paul Pascal (CRPP), UMR 5031, Pessac, France
[2]Laboratoire de Chimie des Polymères Organiques (LCPO), CNRS UMR 5629, Univ. Bordeaux, Pessac, France
[3]Physics Department, NTNU, Høgskoleringen 1, Trondheim 7491, Norway
virginie.ponsinet@crpp.cnrs.fr

Since the emergence of the metamaterial field in the 2000s', nano-optics has relied on assembled artificial optical resonators, which interact strongly with light. This presentation will present two examples of nanoresonator assemblies where the optical responses were tailored using self-assembling block copolymers.

In a first example, we produced multilayered uniaxial films of alternate pure polystyrene (PS) layers, and composite layers of gold nanoparticles and poly(2-vinylpyridine) (P2VP) of variable gold volume fraction. We determine by spectroscopic ellipsometry that the dielectric functions $\varepsilon_{//}$ and ε_z both present a resonance at wavelength ~ 600 nm, close to the plasmon resonance of the gold nanoparticles. The amplitude of the $\varepsilon_{//}$ resonance significantly increases with the gold loading, reaching a regime of negative values for high gold fractions. The results demonstrate the capacity of the stack to respond as a hyperbolic effective medium [1] in a given spectral region. In the hyperbolic region, the dispersion relation allows propagative modes for large values of $|k_x|$, potentially providing super-resolution.

In a second example, we produced ultra-thin light-absorber layers, using bottom-up technologies. Au nanoresonators possessing heights from 5 - 15 nm with sub-50 nm diameters were engineered by block copolymer templating. The Au nanoresonators were fabricated on an alumina spacer layer and a reflecting Au mirror, in a film-coupled nanoparticle design [2]. The BCP nanopatterning strategy allows to achieve near-perfect absorption at wavelength ~ 600 nm. These experimental approaches allow for the large scale production of resonant materials and thin films of controlled optical properties.

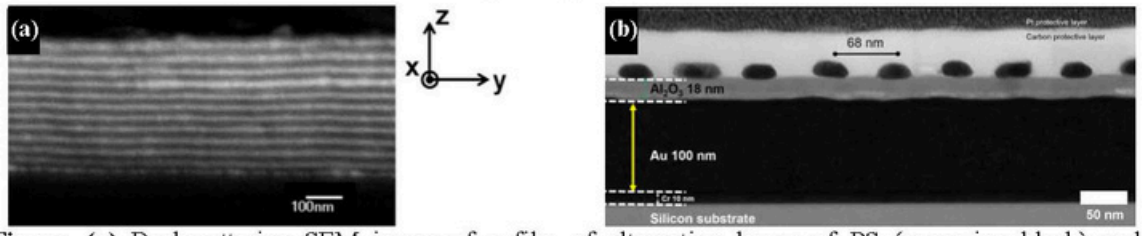


Figure. (a) Backscattering SEM image of a film of alternating layers of PS (appearing black) and Au nanoparticles+P2VP nanocomposite (appearing white). The trihedral indicates the ordinary ((x,y) or //) and extraordinary (z) directions. **(b)** STEM image of the Au metasurface revealing the cross-sectional profile of the fabricated bilayer absorber comprised of an Au reflector layer (100 nm), Al_2O_3 spacer layer (18 nm) and the rounded Au dots, with center-to-center distance 68 nm, diameter 42 nm, and Au height 15 nm.

References

[1] X. Wang, *et al.* "Hyperbolic-by-design self-assembled metamaterial based on block copolymers lamellar phases." *Opt. Laser Technol.* **2017**, *88*, 85-95.
[2] C. Cummins, *et al.* "An Ultra-Thin Near-Perfect Absorber via Block Copolymer Engineered Metasurface." *J.C.I.S.* **2020**, *609*, 375-383.

Covalently Integrated Benzothioxanthene Emitters for Sustainable Luminescent Solar Concentrators

H.Pryshchepa[a], A.Picchi[a], M.Carlotti[a,b], A.Pucci[a,c]

[a]Department of Chemistry and Industrial Chemistry, University of Pisa, Pisa, Italy
[b]Center for Materials Interfaces, Istituto Italiano di Tecnologia, Pontedera, Italy
[c]INSTM UdR di Pisa, University of Pisa, Pisa, Italy

E-mail: hanna.pryshchepa@dcci.unipi.it

The incorporation of fluorophores into Luminescent Solar Concentrators (LSCs) is key to enhancing efficiency by optimizing light absorption and emission while minimizing energy losses from aggregation-caused quenching (ACQ). This work explores two strategies for integrating fluorophores into the poly(methyl methacrylate) (PMMA) matrix: the use of (i) **EH-BTX**, with an aliphatic chain for physical dispersion, and (ii) **MA-BTX**, featuring a methacrylic group for co-polymerization with methyl methacrylate (MMA). To promote sustainability, all devices were fabricated via cell casting using PMMA from the free-radical polymerization of chemically recycled methyl methacrylate (r-MMA). LSCs with 100–1000 ppm fluorophore concentrations were evaluated for photon efficiencies (η_{int}, η_{ext}), quantum yield (QY%), and device efficiency (η_{dev})[1]. Both blending (**EH-BTX**) and covalent bonding (**p(MABTX-*co*-rMMA)**) approaches showed similar performance, likely due to the good compatibility of BTXs with the methacrylic matrix and limited ACQ. While η_{dev} and η_{ext} did not exceed those of the state-of-the-art Lumogen Red 305 (LR305)[2], the BTX systems exhibited excellent photostability and higher QY%, with minimal quenching and reduced self-absorption losses.

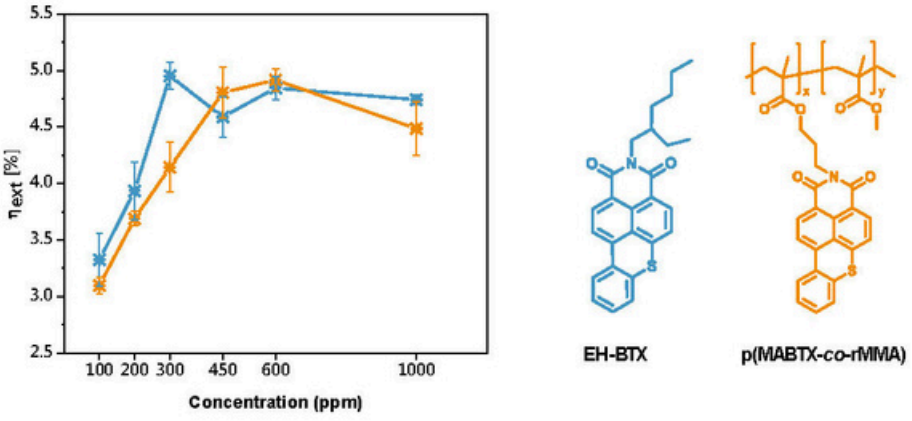


Figure 1: η_{ext} (%) and chemical structures of EH-BTX and p(MABTX-*co*-rMMA)

References

[1] M.G. Debije, R.C. Evans, G. Griffini "Laboratory protocols for measuring and reporting the performance of luminescent solar concentrators." *Energy & Environmental Science* **2021**, *14*, 293–301.
[2] A. Picchi, I. Bettini, M. Ilarioni, M. Carlotti, A. Pucci "Assessing the performance of sustainable luminescent solar concentrators based on chemically recycled poly (methyl methacrylate)." *RSC.ApplPolym* **2024**, *2*, 624–633.

Polymerizations with Elemental Sulfur and Commodity Sulfur Chemicals for Next Generation Plastic Optics

Jeffrey Pyun

†Department of Chemistry & Biochemistry, ‡Wyant College of Optical Sciences, University of Arizona, Tucson, AZ 85721

The development of new optical polymeric materials possessing controllable refractive index, high transparency and low chromatic dispersion while retaining excellent thermomechanical properties is an essential area of science & engineering. Plastic optics have been widely deployed for commercial applications that require large volume and low cost lenses, such as consumer eyeware and smartphones. Plastic optics have numerous advantages in comparison to inorganic optical materials, which include low cost, light weight, and improved processability into optical elements. However, the poor transparency and low RI values of plastic optics ($n \sim 1.35$ to 1.75) in the 2-14 μm SWIR-MWIR-LWIR region has prevented deployment of these materials for IR optics. The poor IR transparency of plastic optics arises from bond vibrations of C-H, C-C and C-X atoms present in the structural framework of organic polymers. Hence, there remains a tremendous technological opportunity to both increase the RI of polymers ($n > 2.0$) and enhance optical transmittance in the IR spectrum from 2-14 μm by designing and synthesizing advanced polymeric materials. In this talk, we will discuss our recent progress with several new classes of optical polymers for potential use in consumer plastics optics, IR optics and polymer waveguide photonics. These include our work with optical materials based on, chalcogenide hybrid inorganic/organic polymers (CHIPs) for IR optics (Pyun et al. *Adv. Mater.* **2014**, *Angew. Chem. Int. Ed.* **2019**), refractive index contrast (RIC) polymers for photonic devices (*ACS Macro Lett.* **2020**, J. Light. Tech. **2022,** *OMEx* **2022**) and new unpublished work on low cost, thiol-free optical polymers for high RI, high Abbe number optical products. Recent major breakthroughs will be discussed on the invention of a new class of commodity optical polymers, termed, Disulfide Glass, which possesses high refractive index, remarkable optical transparency and outstanding manufacturabilty for plastic optics (Pyun et al. *Adv. Funct Mater.* **2025**, 2422569). New polymers from this process are anticipated to afford a new class of commodity optical plastics that distinct optical figures of merit over state of the art commodity optical polymers, such as PMMA, or polycarbonate.

Polymer-based non-iridescent photonic pigments

Niklas Rocca Schwarz[1,2], Ullrich Steiner[1,2], Andrea Dodero[1,2,3]

[1] Adolphe Merkle Institute, University of Fribourg, 1700 Fribourg, Switzerland

[2] National Center of Competence in Research (NCCR) Bio-Inspired Materials, 1700 Fribourg, Switzerland

[3] Department of Chemistry and Industrial Chemistry, University of Genoa, 16146 Genoa, Italy

Email address: niklas.schwarz@unifr.ch

Structural pigments offer a promising alternative to conventional pigments by achieving coloration through constructive interference rather than selective absorption. Unlike traditional ones, which often degrade over time due to photochemical reactions and oxidation, structural pigments exhibit superior lightfastness, making them highly durable and attractive for applications in coatings, cosmetics, and sustainable coloration technologies [1].

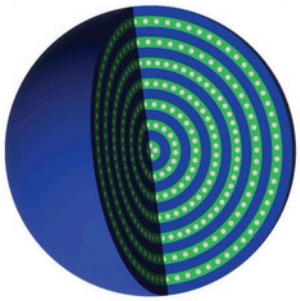


Figure 1. Photonic microparticle showing a concentratic lamellar structure and selective incorporation of titania nanoparticles into one of the block copolymer phases.

In this work, we utilize the self-assembly of linear diblock copolymers within emulsion droplets to fabricate photonic microspheres with a concentric lamellar structure [2]. While this approach easily enables tuneable pigments, a key limitation is the inherently low refractive index contrast between the two block copolymer phases, which limits reflectance and, thus, color luminance. To overcome this challenge, we selectively incorporate high-refractive-index titanium dioxide (TiO_2) nanoparticles into one of the polymer domains, enhancing the refractive index contrast. For the block copolymer polystyrene-*b*-poly(2-vinyl pyridine), we achieve a selective nanoparticle loading of 13% by volume, leading to an estimated increase in the effective refractive index by 0.1. While this is expected to enhance optical performance, experimental validation of the reflectance improvement is ongoing. The resulting photonic pigments exhibit blue hues, which can be red-shifted through the addition of homopolymers and swelling agents or by using block copolymers with higher molecular weight [3]. Additional strategies to further enhance the optical appearance of the fabricated photonic microparticles include incorporating absorbing pigments around the bandgap region [4] and using Mie scattering calculations to optimize absorber type, layer number, sphere size, and refractive index contrast. By leveraging polymer self-assembly and nanoparticle incorporation, this research advances the development of photonic pigments as viable replacements for traditional colorants. The insights gained contribute to designing highly efficient, non-iridescent structural pigments with possible industrial scalability.

References

[1] V. V. Vogler-Neuling, M. Saba, I. Gunkel, J. O. Zoppe, U. Steiner, B. D. Wilts, A. Dodero "Biopolymer Photonics: From Nature to Nanotechnology." *Adv. Funct. Mater.* **2023**, DOI 10.1002/adfm.202306528.

[2] Y. Yang, H. Kim, J. Xu, M.-S. Hwang, D. Tian, K. Wang, L. Zhang, Y. Liao, H. Park, G.-R. Yi, X. Xie, J. Zhu "Responsive Block Copolymer Photonic Microspheres." *Advanced Materials* **2018**, 1707344

[3] A. Dodero, K. Djeghdi, V. Bauernfeind, M. Airoldi, B. D. Wilts, C. Weder, U. Steiner, I. Gunkel "Robust Full-Spectral Color Tuning of Photonic Colloids." *Small* **2023**, 19, 2205438.s

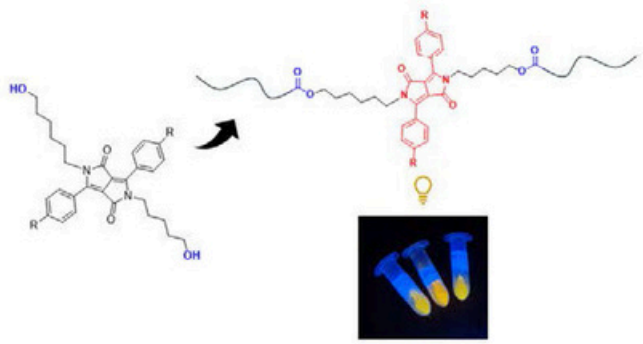
[4] U. Steiner, A. Dodero "Block Copolymer-based Photonic Pigments: Towards Structural Non-iridescent Brilliant Coloration." *Chimia* **2022**, 76, 826.

Mimesis of green fluorescence protein structure by rational design of novel copolyesters containing diketopyrrolopyrroles (DPP) as emissive centers

Stefano Scurti[1], Daniele Caretti[1]

[1] Department of Industrial Chemistry "Toso Montanari", University of Bologna, via Gobetti 85, 40129 Bologna (Italy), stefano.scurti2@unibo.it

Green fluorescent protein (GFP) has become a widely used tool as a genetically encoded, non-invasive fluorescent marker in biological research. The GFP chromophore, formed by the autocatalytic dehydration and oxidation of a Ser-Tyr-Gly tripeptide, undergoes excited-state proton transfer (ESPT). This process involves a proton relay from the phenolic oxygen to the protein matrix, resulting in intense green fluorescence. Upon denaturation, the fluorescence of GFP decreases significantly, by approximately four orders of magnitude. To mimic the photophysics of GFP, several model chromophores have been synthesized using various synthetic approaches. However, these prepared chromophores generally exhibit weak fluorescence ($\Phi < 10^{-2}$) in bulk solutions at room temperature, primarily due to ultrafast internal conversion (IC) caused by free rotational motion.[1-3] Building on these observations, novel emissive monomers based on N-alkylated diketopyrrolopyrroles (DPP) have been developed and properly incorporated into copolyesters. The polymeric chain conformation reduces π–π interactions and the fluorophore geometry limits vibrational and rotational motions of the chromophores, leading to enhanced emissive properties. Furthermore, the photophysical and thermal characteristics of these materials can be tuned through functionalization of the DPP unit and the composition of the copolymers.



References

[1] Kong J, Wang Y, et al "Green fluorescent protein inspired fluorophores." *Adv Colloid Interface Sci.* **2020** 285, 102286.
[2] Deng H., et al. "Multicolor fluorescent polymers inspired from green fluorescent protein." *Macromolecules*, **2015**, 48.16, 5969-5979.
[3] Wei X., Zhang, H., Wang M. "Influence of the Polymer Matrix on the Optical Properties of Bioinspired Fluorescent Polymers Containing Diketopyrrolopyrrole Chromophores". *ACS Applied Polymer Materials*, **2024**, 6.13, 7532-7541.

Novel Sulfur-rich polymers from inverse vulcanization as high-refractive-index materials for all-polymer photonic structures and metamaterials

F. Martorelli,[a] D. Di Fonzo,[b] R. Utzeri,[a] A. Angelini,[c] D. Comoretto,[b] P. Stagnaro[a]

[a] CNR, Institute of Chemical Sciences and Technologies "Giulio Natta", Via De Marini 6, 16149 Genova
[c] National Metrology Institute of Italy INRiM, Str. delle Cacce 91, 10135 Torino
[b] University of Genova, Dep.t of Chemistry and Industrial Chemistry, Via Dodecaneso 31, 16146 Genova
paola.stagnaro@cnr.it

The simple, solvent-free Inverse Vulcanization (IV) process represents an efficient and green method to up-cycle elemental Sulfur, abundant waste by-product of oil and gas refinery, to achieve a new class of amorphous Sulfur-rich macromolecular materials named inverse vulcanized polymers (IVPs).[1] Due to their nature consisting of polysulfide chains cross-linked by organic divinyl moieties, IVPs exhibit unique properties, such as dynamic covalent behaviour and self-healing capability. Furthermore and very interestingly, the high content of easily polarizable S-S bonds endows IVPs with very high refractive index and excellent transparency in the near infrared region (NIR), which makes them appealing building blocks for photonic structures.[2] All-polymer photonic crystals are technologically interesting for materials affordability, fabrication simplicity and scalability. However, their application in the field of light confinement is still limited by the low and similar refractive indices shown by most processable polymers in their transparency range.
In this research, novel IVPs with outstanding refractive index were prepared using purposely designed cross-linking monomers, namely vinyl aromatic derivatives easily synthesized through a single step Suzuky-Miyaura cross-coupling reaction.[2] In the subsequent IV process, comonomer(s) nature and number of their functionalities as well as Sulfur-to-comonomer(s) ratio were varied to address both the optical behaviour and filmability of the ensuing IVPs, that is the technologically relevant properties for their application and industrial scale-up. The achieved IVPs were then employed to fabricate all-polymer distributed Bragg reflectors (DBRs) and imprinted metasurfaces. This paths the way for a variety of applications in the field of light emission control, that span from free-standing DBRs with very high reflectance and microcavities for NIR emitting lasers, to fabrication of metasurfaces and metamaterials for advanced nanophotonics.

Acknowledgements
Project PRIN 2020 "Polymer mETamateriALs for nanophotonicS – PETALS" (prot. 2020TS9LXS) funded by Italian Ministry for Universities and Research (MUR).

References
[1] W. J. Chung, J. J. Griebel, E. T. Kim *et al.*, *Nat. Chem.* **2013**, *5*, 518 – 524.
[2] C. Tavella, G. Luciano, P. Lova, M. Patrini, C. D'Arrigo, D. Comoretto, P. Stagnaro, "2,5-Diisopropenylthiophene by Suzuki–Miyaura cross-coupling reaction and its exploitation in inverse vulcanization: a case study" *RSC Adv.* **2022**, *12*, 8924 – 8935 and references therein.

Azo dye-functionalized polyacrylamides: turning thermo-responsive polymers into photo-responsive for reversible, iso-thermal switching in aqueous systems

René Steinbrecher[1], Peiran Zhang[2], Martin Reifarth[3], Andreas Taubert[1], Peter-Müller-Buschbaum[2], Christine M. Papadakis[2], Jiayin Yuan[4], and André Laschewsky[1]

1 Institute of Chemistry, University of Potsdam, Potsdam-Golm, Germany
2 Physics Department, TUM School of Natural Sciences, Technical University of Munich, Garching, Germany
3 Fraunhofer Institute for Applied Polymer Research IAP, Potsdam-Golm, Germany
4 Dept. of Materials and Environmental Chemistry (MMK), Stockholm University, Stockholm, Sweden
E-mail address of presenting Author: rene.steinbrecher@uni-potsdam.de

By combining thermo-responsive polyacrylamides that feature a lower critical solution temperature (LCST) transition with photo-responsive azo dyes, we synthesized well water-soluble, photo-responsive, and long-time stable polymers for iso-thermal switching in aqueous systems. Such systems have the advantage that both temperature and light are non-invasive triggers that can be controlled independently. Further, light is a fast and easily applied stimulus that also enables high spatial and temporal resolution. This allows for fast and targeted toggling of the hydrophilicity, in contrast to commonly used stimuli, such as changes of the pH or ionic strength. The reversible, *E*-*Z* (*trans*-*cis*) photo-isomerization increases the dipole moment of the azo dye, which decreases its hydrophobicity and hence is expected to increase the phase transition temperature of the polymer. The usually incorporated azobenzene moiety, however, induces typically only quite small shifts of the phase transition temperature of ≤ 5 K. Moreover, the overlap of the main absorption peaks of both isomers leads to a mixed photo stationary state after UV-light irradiation. This problem can be circumvented by replacing azobenzene with aryl azo pyrazoles (AAP) that have emerged recently as enhanced photo switches. They enable nearly quantitative photo-switching with UV- and green light between both isomers, due to their well resolved absorption spectra, and excel also by the long-liveness of their (thermodynamically only metastable) *Z*-state.
We will present on the one hand that by thoughtful design of the polymers, LCST-shifts of up to 15 K can be achieved even when employing simple azobenzene dyes. Furthermore, we shall show that the *E*-*Z* photo-isomerization may not always result in the expected increase of the LCST (as anticipated by theoretical consideration), but can also cause a drastic, counter-intuitive decrease of the LCST. Finally, we will present new azo dye-functionalized polyacrylamides bearing AAP dyes that overcome the shortcomings of classical azobenzene systems, thus enabling changes of the LCST transition by up to 25 K [1], with long lived *Z*-states and no fatigue over multiple cycles of alternating irradiation by UV- and green light.

References

[1] R. Steinbrecher, P Zhang, C. M. Papadakis, P Müller-Buschbaum, A Taubert, A. Laschewsky, "Boosting the photo-switchability of double-responsive water-soluble polymers by incorporating arylazopyrazole dyes", *Chem. Commun.* **2024**, *60 (13)*, 1747-1750

High-Performance All-Polymer Solar Cells

Yanming Sun

School of Chemistry, Beihang University, Beijing 100191, P. R. China

In recent years, with the rapid development of non-fullerene small molecule acceptors, the efficiency of organic solar cells has been continuously improved. However, small molecule acceptors have disadvantages, such as easy crystallization, poor photothermal stability and stretchability. In contrast, polymer acceptors can compensate for these shortcomings of small molecule acceptors. The all-polymer solar cells prepared have excellent stability and mechanical flexibility, showing great potential in wearable and flexible stretchable devices. The all-polymer system, with its high solution viscosity and good leveling performance, is very suitable for the preparation of large-area printed devices. Therefore, all-polymer solar cells have more advantages in commercial applications. Although the all-polymer system has many advantages, the research on all-polymer solar cells is relatively limited and the performance is relatively low. This report will systematically introduce the recent research progress of our research group in the field of all-polymer solar cells, including the design of high-performance polymer receptor materials, morphology control of all-polymer systems, device stability research, and green large-area processing.

References

[1] J. Song, C. Li, H. Ma, B. Han, Q. Wang, X. Wang, D. Wei, Laju Bu, R. Yang, H. Yan, Y. Sun, "Optimizing Double-Fibril Network Morphology via Solid Additive Strategy Enables Binary All-Polymer Solar Cells with 19.50% Efficiency", *Adv. Mater.* **2024**, *36*, 2406922.

[2] H. Ma, J. Song, J. Qiao, B. Han, Q. Wang, M. H. Jee, L. Bu, D. Wei, H. Y. Woo, X. Hao, Y. Sun, "Binary all-polymer solar cells with 19.30% efficiency enabled by bromodibenzothiophene-based solid additive", *Energy Environ. Sci.* **2025**,*18*, 397-405

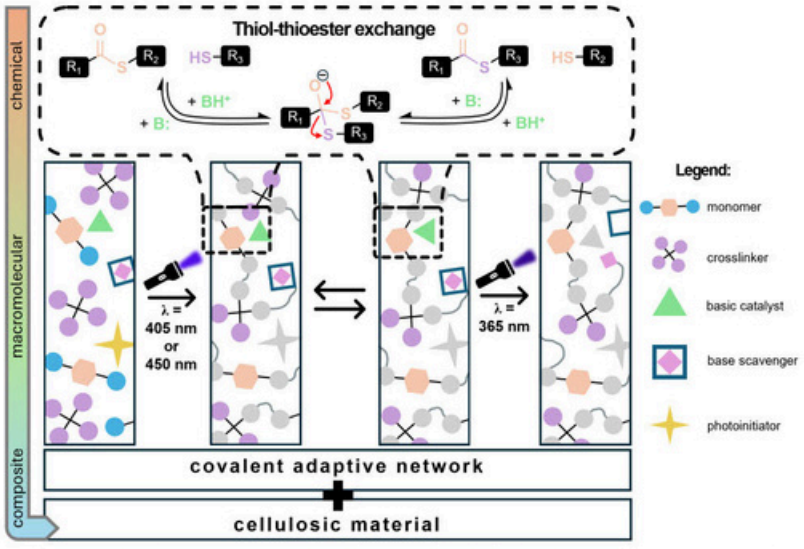
From Proof-of-Concept to Composite Fabrication: Controlling Thiol-Thioester Exchange for Sustainable Polymer Design

J. Tumaneng[1], R. Korotkov[2], E. Rossegger[2], E. Zeno[3], S. Dalle Vacche[1], R. Bongiovanni[1], S. Schlögl[2]

[1]Department of Applied Science and Technology, Politecnico di Torino, 10129 Torino, Italy
[2]Polymer Competence Center Leoben GmbH, Sauraugasse 1, 8700 Leoben, Austria
[3]Centre Technique du Papier, 38000 Grenoble, France

Covalent adaptive networks (CANs) have emerged as a distinct class of polymers, bridging the gap between traditional thermoplastics and thermosets. Their ability to undergo dynamic bond exchange enables properties such as self-healing, stress relaxation, and recyclability, making them promising zcandidates for sustainable materials.

This study explores the design and optimization of a photoresponsive CAN capable of on-demand deactivation of thiol-thioester dynamic bond exchange (DBE) kinetics. Using a multiparametric approach, we identify formulations where macromolecular properties exhibit the greatest contrast between the activated and deactivated states. Our findings reveal the multifaceted role of photoinitiators, extending beyond polymerization to influence exchange dynamics and mechano-chemical behavior. The research also considers other critical factors, including the presence of photoacids[1] and the properties of the catalyst[2], highlighting the need for a holistic approach in understanding and controlling thiol-thioester dynamic bond exchange. The resulting CAN demonstrating shape memory and reprocessability is combined with cellulosic materials to assess its potential for next-generation sustainable composites.



Scheme 1. Diagram illustrating the composite's photocuring, thiol-thioester exchange, and resin deactivation.

References

[1] Alabiso, W.; Sölle, B.; Reisinger, D.; Guedes de la Cruz, G.; Schmallegger, M.; Griesser, T.; Rossegger, E.; Schlögl, S. *Angewandte Chemie*. **2023**. 62. 1-6.
[2] Worrell, B.; Mavila, S.; Wang, C.; Kontour, T.; Lim, C.; McBride, M.; Musgrave, C.; Shoemaker, R.; Bowman, C. *Polym. Chem.* **2018**. 9. 4523-4534.

Programmable mechanochromic time integrators

Ryno van Niekerk, Constantinus M. Martens, Jitte Flapper, A. Catarina C. Esteves, Albert P. H. J. Schenning

R. van Niekerk, A. P. H. J. Schenning, Stimuli-Responsive Functional Materials and Devices (SFD), Department of Chemical Engineering and Chemistry, Eindhoven University of Technology (TU/e), Groene Loper 3, Eindhoven 5612 AE, The Netherlands

R. van Niekerk, C. M. Martens, A. C. C. Esteves, Laboratory of Physical Chemistry (SPC), Department of Chemical Engineering and Chemistry, Eindhoven University of Technology (TU/e), Groene Loper 3, Eindhoven 5612 AE, The Netherlands

J. Flapper, Akzo Nobel Decorative Coatings B.V. Rijksstraatweg 31, Sassenheim 2171 AJ, The Netherlands

Mechanochromic polymers are receiving much attention for monitoring the structural performance of materials. Current mechanochromic polymers however do not offer simultaneous detection of the duration and degree of strain while retaining memory of the strain history. Here a structurally colored polymer coating is reported that can indicate, quantify, and memorize strain over time.[1] The mechanochromic polymers are fabricated by a simple and scalable bar coating process. The mechanochromic coating consists of chemically and optically distinct cholesteric liquid crystal droplets. Upon strain, the droplets deform causing an eye-discernible reflective color change through a diffusion-based compositional ripening process. The response depends on both the degree and duration of strain and can be easily adjusted by the concentration of droplets in the coating. The programmable mechanochromic time integrator offers simultaneous and sensitive detection of strain over a wide range while exhibiting memorability. The user-interactive interface allows people to visually perceive the strain history of materials and introduces a novel mechanochromic material for monitoring the structural performance of materials ultimately enhancing both safety and performance.

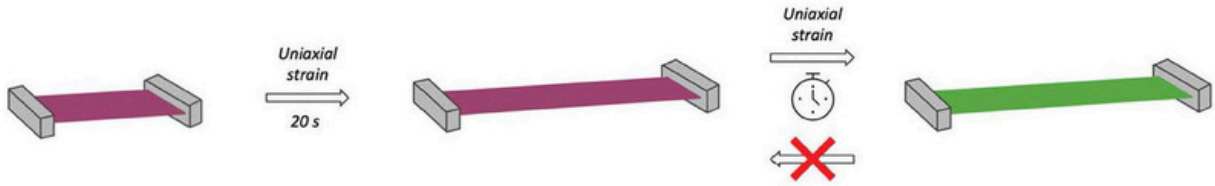


Figure 1: Schematic of a bicolored PDCLC coating showcasing no mechanochromic response upon immediate strain (i.e. 20 s) and a reflective color shift from pink to green with time upon constant uniaxial strain application.

References

[1] R. van Niekerk, C. M. Martens, J. Flapper, A. C. C. Esteves, A. P. H. J. Schenning "Programmable Mechanochromic Time Integrators" *Adv. Funct. Mater.* **2024**, 2418161.

Light-controlled macro surfaces with micro-topographies: pioneering dynamic cell stimulation

R.M.C. Verbroekken, O.K. Savchak. T.F.J. Alofs, A.P.H.J. Schenning, B. Gumuscu

Stimuli-Responsive Functional Materials & Devices, Eindhoven University of Technology, The Netherlands

All biological surfaces possess distinct dynamic surface topographies. Due to their versatility, these topographies play a crucial role in modulating cell behaviour and, when intentionally designed, can precisely guide cellular responses. So far, biomechanical responses have predominantly been studied on static surfaces, overlooking the dynamic environment in the body, where cells constantly interact with shifting biomechanical cues. In this work, we designed and fabricated a light-responsive liquid crystal polymer film to study the effect of micrometre-scale, dynamic surface topographies on cells under physiologically relevant conditions. The light responsive liquid crystal polymers enable on-demand surface topographical changes, reaching pillar heights of 800 nm and grooved topographies with 700 nm height differences at 37°C in water. The light induced surface topographies increased mechano-sensitive cell signalling as well as heterogeneity in distribution of focal adhesions, in a topography-related manner. The pillared topography was seen to cause a lower cellular response, while the grooved topography caused an increased mechanical activation, as well as cell alignment due to a more continuous and aligned physical cue that enhances cell organisation. Excitingly, we observed that subsequent surface topography changes ampliated the cell response. Our work emphasizes the potential of light-responsive liquid crystal polymer films generating dynamic biomechanical cues that allow to modulate and steer cells in-vitro.

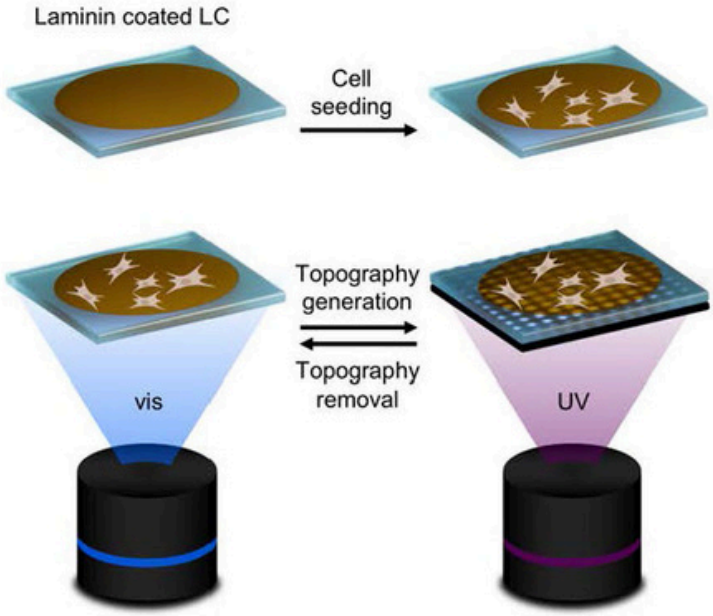


Figure 1. Scheme showing the working principle of LC film functionalization and creation of dynamic topographies using a photomask using bottom mask-exposed UV illumination. Laminin coated LC films allow for cell (fibroblast) attachment and growth. 24 hours post seeding, bottom mask-exposed UV illumination yields surface topographical features, that, upon full visible illumination is removed.

Nanofibrous fluoropolymer coatings for passive radiative cooling by electrospinning

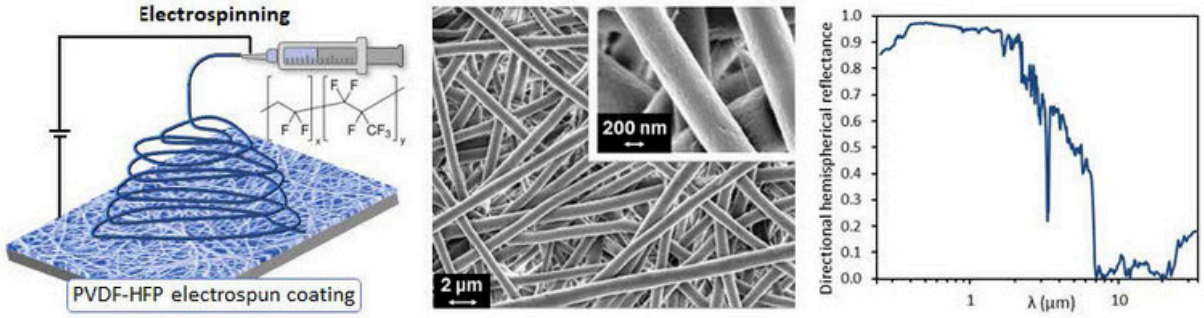
Jessica Alexandra Talamo Ruiz[1], Lorenzo Pattelli[2], Alessandra Vitale[1]

[1]Department of Applied Science and Technology, Politecnico di Torino, 10129 Torino, Italy – alessandra.vitale@polito.it

[2]Istituto Nazionale di Ricerca Metrologica, 10135 Torino, Italy

In recent years, passive daytime radiative cooling (PDRC) has gained significant attention as an advanced cooling technology that maximizes thermal emission while minimizing solar and atmospheric radiation absorption [1]. Its development relies on innovative materials, particularly coatings with high solar reflectance (0.3–2.5 μm) and strong emissivity in the atmospheric transparency window (ATW, 8–13 μm) [2]. Electrospun polymeric coatings are promising for PDRC due to their high porosity, large surface area, and tunable optical properties [1]. Widely studied for PDRC, poly(vinylidene fluoride-co-hexafluoropropylene) (PVDF-HFP) offers negligible solar absorbance and selective emissivity in the ATW [3, 4]. However, its electrospinning process typically requires toxic solvents such as dimethylformamide, acetone, or dimethylacetamide.

This study investigates the feasibility of replacing these traditional solvents with dimethyl sulfoxide (DMSO) to produce electrospun PVDF-HFP nanofibrous coatings for PDRC applications. The findings demonstrate that a simple, one-step electrospinning process can successfully yield nonwoven fluorinated nanofibrous coatings with well-defined, uniform, cylindrical, and continuous fibers, averaging 600–900 nm in diameter, depending on the solvent mixture used. Infrared-optical characterization revealed low UV-Vis-NIR absorptance ($\alpha = 0.03–0.11$) and high thermal emittance ($\varepsilon = 0.86–0.94$). Interestingly, besides being less toxic than traditional solvents, DMSO induces a distinct nanostructured fiber morphology that enhances spectral performance. Further studies are underway to assess the cooling performance of these coatings, particularly the influence of nanofibrous morphology on light interaction and radiative cooling efficiency.



References

[1] D. Zhang et al., "Recent advances in electrospun membranes for radiative cooling", *Materials* **2023**, *16*, 3677
[2] D. Hu et al., "Hollow core-shell particle-containing coating for passive daytime radiative cooling", *Composites A* **2022**, *158*, 106949
[3] J. Mandal et al., "Hierarchically porous polymer coatings for highly efficient passive daytime radiative cooling", *Science* **2018**, *362*, 315
[4] N. Cheng et al., "Nanosphere-structured hierarchically porous PVDF-HFP fabric for passive daytime radiative cooling via one-step water vapor-induced phase separation", *Chem. Eng. J.* **2023**, *460*, 141581

Light-controlled anion binding supramolecular systems

Leonard Wyszynski[1], Leon Hoppmann[2], Pascal Steinforth[1], Lukas Entgelmeier[2], Olga García Mancheño[2], Monika Schönhoff[1]

[1] *University of Münster, Institute of Physical Chemistry, Corrensstraße 28/30, 48149, Münster, Germany*
Email: l.wyszynski@uni-muenster.de, schoenho@uni-muenster.de
[2] *University of Münster, Institute of Organic Chemistry, Corrensstraße 40, 48149, Münster, Germany*

Supramolecular hosts featuring 1,2,3-triazoles are known for their ability to cooperatively bind various anions through hydrogen bonds.[1] There is significant interest in manipulating these host-guest interactions to selectively capture and release anions. One of the most prominent approaches to achieve responsiveness is through conformational changes of photo-switchable units induced by light irradiation.[2] In our previous studies, the binding and folding mechanism of a tetrakis-triazole host was investigated by experimental and theoretical methods, in particular NMR titrations, electrophoretic NMR and DFT computations.[3-4] This revealed effective recognition of anions by the host through multi-dentate binding, with strong dependencies on the temperature and solvent. In this study, we present a systematic modification of the host structure by introducing an azobenzene unit to enable efficient isomerization between its *cis* and *trans* conformations through light irradiation, along with the utilization of different linkers between the triazole units. Employing a self-built in-situ irradiation setup with two LEDs, we determined the binding constants of the host-guest complexes via NMR titrations. Across almost all systems investigated, the *cis* state exhibited a higher affinity for anions compared to the *trans* isomer. Furthermore, we examined the isomerization rates, revealing that the addition of salt stabilized the cis state, resulting in a higher stability of anion binding after blue irradiation. Exploring variations of the photoreversible unit towards arylazopyrazoles led to improved anion binding, characterized by an enhanced contrast between the anion binding constants of the *cis* and *trans* state, as well as enhanced solubility in organic solvents. Our ongoing optimization efforts are focused on enhancing the disparity in binding strength even further, with the aim of refining the light-switchable anion binding behavior.

References

[1] V. Haridas, S. Sahu, P. P. P. Kumara, A. R. Sapalaa "Triazole: a new motif for anion recognition" *RSC Adv.* **2**, *2012*, 12594-12605.
[2] S. Lee, A.-H. Flood "Photoresponsive receptors for binding and releasing anions" *J. Phys. Org. Chem.* **26**, *2013*, 79-86.
[3] D.-G. Piekarski, P. Steinforth, M. Gomez-Martinez, J. Bamberger, F. Ostler, M. Schönhoff, O. García Mancheño "Insight into the folding and cooperative multi-recognition mechanism in supramolecular anion-binding catalysis" *Chem. Eur. J.* **26,** *2020*, 17598-17603.
[4] P. Steinforth, M. Gómez-Martinez, L.-M. Entgelmeier, O. García Mancheño, M. Schönhoff "Relevance of the Cation in Anion Binding of a Triazole Host: An Analysis by Electrophoretic Nuclear Magnetic Resonance" *J. Phys. Chem. B* **126,** *2022*, 10156-10163.

The POSTERS

Thin colorimetric film array for rapid and selective detection of v-type nerve agent mimic in potentially contaminated areas

Ji-hwan Bak, So-young Park, Rini Sharma, Hyung-il Lee

Department of Chemistry, University of Ulsan, Ulsan 680-749, Republic of Korea

sims0904@ulsan.ac.kr

The expeditious detection and quantification of V-series nerve agents (VX) on potentially contaminated surfaces are crucial for the prevention of regional conflict incidents, acts of terrorism, or illicit activities. However, the low volatility and high toxicity of VX make these tasks challenging. Herein, we designed two novel colorimetric thin polymeric films to rapidly and sensitively detect demeton-S, a VX mimic, in contaminated areas. The polymeric films were specifically engineered to include a coordination site for Au (III) ions. Initially, these films were coordinated with Au (III), causing a discernible alteration in color due to enhancement in intramolecular charge transfer process. In the presence of demeton-S, the Au (III) ligands in the films are displaced with demeton-S, resulting in the restoration of the original color of the film, as the enhanced intramolecular charge transfer process is inhibited and thereby serving as an indicator of the presence of demeton-S. The polymeric films exhibit remarkable selectivity toward demeton-S compared to G-type nerve agents and other interference. The reusability of the polymeric films for demeton-S detection was achieved owing to the reversibility of the films during the alternative exposure of Au (III) and demeton-S. The polymeric films demonstrated their applicability for demeton-S detection and quantification in several contaminated areas, including different water, soil, and skin, rendering them highly suitable for on-site measurements.

References

[1] S.-y. Park, R. Sharma, H.-i. Lee. "Thin colorimetric film array for rapid and selective detection of v-type nerve agent mimic in potentially contaminated areas." *Journal of Hazardous Materials*, **465** (2024) 133064.

Disordered Diamond-Like Structures from Colloidal Building Blocks

Nicolas Bruder[1], Andrea Dodero[1, 2, 3], Ullrich Steiner[1, 2]

[1] Adolphe Merkle Institute, University of Fribourg, Chemin des Verdiers 4, 1700 Fribourg, Switzerland

[2] National Center of Competence in Research (NCCR) Bio-Inspired Materials, Chemin des Verdiers 4, 1700 Fribourg, Switzerland

[3] Department of Chemistry and Industrial Chemistry, University of Genoa, 16146 Genoa, Italy

Email address: nicolas.bruder@unifr.ch

Photonic crystals are materials composed of scatterers arranged in a periodic structure that give rise to a photonic response, meaning that photons within a specific range cannot propagate through the material analogous to the behavior of electrons in semiconductors [1]. Among these, the cubic diamond structure is known for exhibiting a complete photonic bandgap and, due to this property, it has been a key focus in the engineering of photonic materials [2]. A promising approach for synthesizing diamond-like photonic crystals is the DNA-mediated self-assembly of patchy tetrameric colloids. While the distinct tetrameric shape prevents the formation of a hexagonal diamond structure, which lacks a photonic bandgap, the four DNA-coated patches enable precise binding to the four nearest neighbors, therefore facilitating the self-assembly of a cubic diamond lattice [3].

Beyond conventional photonic crystals, there is growing interest in introducing disorder into these structures aiming to achieve Anderson localization of light, wherein photons become strongly confided within a disordered medium [4]. While in the past materials with intrinsic disorder but some degree of long-range order were proposed, this project takes the inverse approach starting with a highly ordered cubic diamond lattice and systematically introducing disorder. In this context, the DNA-mediated self-assembly of patchy colloidal particles offers a robust platform for fabricating disordered diamond-like structures while preserving key photonic properties. By controlling the degree of deformation of tetrameric colloids and the extent of the patch protrusion, the rotational freedom of the colloids can be modulated, introducing controlled disorder. Additionally, assembling patchy particles with slight shape variations provides an alternative means to induce disorder while maintaining the overall diamond-like topology. This strategy enables the exploration of novel disordered photonic materials with potential for strong light localization and enhanced optical functionalities.

References

[1] E. Yablonovitch, "Photonic Crystals: Semiconductors of Light," *Sci Am*, **2001**, *285*, 46.
[2] J. D. Joannopoulos, S. G. Johnson, J. N. Winn, and R. D. Meade, *Photonic Crystals*. Princeton University Press **2011**.
[3] M. He *et al.*, "Colloidal diamond," *Nature* **2020**, *585*, 524.
[4] P. W. Anderson, "Absence of Diffusion in Certain Random Lattices," *Physical Review* **1958**, *109*, 1492.

Automated microscale laser heating to shape and control self-assembly of soft materials

Julia M. Chmielewska[1], Daniel C. Redeker[2], Piotr Szustakiewicz[1], Przemyslaw Pula[1], Zohar Arnon[2], Filip Powala[1], Bohdan Paterczyk[1], Oleg Gang[2], Pawel W. Majewski[1]

[1]Department of Chemistry, University of Warsaw, Zwirki i Wigury 101, 02089 Warsaw, Poland, Email: jm.chmielews@student.uw.edu.pl; [2] Department of Chemical Engineering, Columbia University, New York, NY, USA

Illumination with an intense beam of light can be used as a convenient method to locally heat up a material and alter its internal structure by inducing local melting, recrystallization, or grain-growth. In our research, we are focusing on precise spatial control of soft materials, including polymers, liquid crystals, and polymer-colloid hybrids, whose self-assembly can be controlled by laser light. We constructed a dedicated optical processing tool, the Laser Light Microscope (LLM), which projects arbitrary blue-laser (450 nm) patterns with precise spatial and temporal control. This system has been employed to pattern optically active liquid crystal thin films as well as liquid crystal-plasmonic nanoparticle hybrid material films. In these studies, thin films exhibiting chiroptically bipolar patterns are fabricated by re-melting in materials undergoing chirality synchronization.[1]

In a related project, we address a major challenge in DNA-programmed nanoparticle self-assembly: controlling the mesoscale shape and volumetric processing of DNA-AuNP assemblies beyond their lattice-prescribed geometries. Our "light milling" strategy exploits the localized photothermal effect of plasmonic gold nanoparticles embedded in DNA origami superlattices. Upon laser illumination, nanoscale heating selectively melts DNA bonds, allowing the removal of defined regions within the crystal with micrometer precision. By automating this process, we fabricate arbitrarily shaped voids and complex three-dimensional features, as confirmed by confocal fluorescence optical imaging, TEM, FIB-SEM tomography, and supported by thermal simulations. This versatile, on-demand technique opens new avenues for applications in photonics, biosensing, and nano-manufacturing.

Furthermore, the LLM setup has been successfully adapted for high-temperature materials processing. We employed the system to study the self-assembly of block copolymers (BCP) under various thermal conditions, performing up to 64 individual annealing experiments on a single $12 \times 12\,mm^2$ substrate and conducting kinetic studies of grain coarsening in the temperature range of 100–300 °C. Additionally, we demonstrated that the same setup can be used to sinter inorganic Fe_2O_3 and In_2O_3 nanowires derived from BCPs in a controllable manner at temperatures ranging from 200 to 600 °C.

In summary, laser microheating emerges as a versatile and efficient method for shaping and processing a wide range of soft self-assembling systems.

[1] P. Szustakiewicz, F. Powala, D. Szepke, W. Lewandowski, P. W. Majewski, Unrestricted Chiral Patterning by Laser Writing in Liquid Crystalline and Plasmonic Nanocomposite Thin Films. *Adv. Mater.* **2024**, 36, 2310197

Hydrophilic Biocompatible Fluorescent Polymeric Nanoparticles as Nanocarriers for Biosourced Photosensitizers for Photodynamic Therapy

Justine Couvez[1], Rayan Chkair[2], Frédérique Brégier[2], Jonathan Daniel[1], Isabelle Sasaki[1], Vincent Sol[2], Guillaume Chemin[2], Bertrand Liagre[2,*] and Mireille Blanchard-Desce[2,*]

[1] Institut des Sciences Moléculaires (ISM, UMR 5255), Univ. Bordeaux, CNRS, Bordeaux INP, 33400 Talence, France. justine.couvez@u-bordeaux.fr
[2] Laboratoire des Agroressources, Biomolécules et Chimie pour l'Innovation en Santé (LABCiS, UR22722), Univ. Limoges, 87000 Limoges, France.

The number of people diagnosed with cancer is currently increasing, with almost 20 million new cases and 9.7 million deaths in 2022. The World Health Organization (OMS) predicts a 77% increase of in the number of people affected by cancer in 2050. Several treatments have been developed to fight this "21st century disease", including surgery, radiotherapy, immunotherapy and chemotherapy. The later approach often causes numerous side effects for the patient. In this context, photodynamic therapy (PDT) has become a highly attractive medical approach for reducing side effects via local activation by light. However, most photosensitizers of interest for PDT are hydrophobic. For instance, porphyrinoids and chlorines, which are excellent photosensitizers (PSs) generating cytotoxic singlet oxygen under illumination in the presence of O_2, are not soluble in aqueous medium. To render them dispersible in physiological conditions and improve their bioavailability and pharmacokinetics, we chose to use highly water-soluble and biocompatible fluorescent organic nanoparticles (FONPs) [1] as nanocarriers. These polymeric FONPs made from citric acid and diethyltriamine were used as nanoplatforms for hydrophobic photosensitizers (PSs) thanks to ionic and covalent immobilization of a biosourced PS: Purpurin 18 (Pp_{18}) and its Chlorin (Cp_6) derivatives [2]. The functionalized nanoparticles $FONPs^{Pp18/Cp6}$ retain good water solubility, emit both blue fluorescence when excited in the near UV region and deep-red or NIR fluorescence when excited in the visible absorption bands of the PSs (typically at 520 nm, 660 nm or 710 nm) and show high singlet oxygen generation quantum yield in aqueous media (up to 0.72). Moreover, they show high PDT efficiency on colorectal cancer cells (HCT-116 & HT-29) upon excitation in the deep red region (650 nm). Our $FONPs^{Pp18/Cp6}$ induce apoptosis via the intrinsic mitochondrial pathway [3]. Our work demonstrates the photodynamic activity of these nanoparticles, making them promising candidates for the PDT treatment of CRC.

References

[1] J. Daniel, M. Montaleytang & al, "Hydrophilic Fluorescent Nanoprodrug of Paclitaxel for Glioblastoma Chemotherapy", *ACS Omega*, **2019**, 4 *(19)*, 18342–18354.
[2] I. Sasaki, F. Brégier & al, "Hydrophilic Biocompatible Fluorescent Organic Nanoparticles as Nanocarriers for Biosourced Photosensitizers for Photodynamic Therapy", *Nanomaterials*, **2024**, 14 *(2)*, 216.
[3] R. Chkair, J. Couvez & al, "Activity of Hydrophilic, Biocompatible, Fluorescent, Organic Nanoparticles Functionalized with Purpurin-18 in Photodynamic Therapy for Colorectal Cancer", *Nanomaterials*, **2024**, 14, 1557.

Bright White Scatterers Beyond Titania

Victoire de Cauna[1,3], Andrea Dodero[1,3], Viola Voglet-Neuling[1,3], Frank Scheffold[2,3], Ullrich Steiner[1,3]

[1] Soft Matter Physics Group, Adolphe Merkle Institute, University of Fribourg, Switzerland
[2] Sof Matters & Photonics Group, Adolphe Merkle Institute, University of Fribourg, Switzerland
[3] National Center of Competence in Research Bio-inspired Materials, Switzerland

**victoire.decabannesdecauna@unifr.ch*

Titanium dioxide (TiO_2) is widely used in several industrial fields because of its unique properties and low cost. Among others, it scatters light very efficiently due to its high refractive index (n = 2.6)[1], thus being often used to impart a white colour, enhancing the brightness of other colours, and increasing the UV-filtering capabilities of food and drug colorants, coating products, cosmetic products, and sunscreen components [2].

However, despite its remarkable properties, titanium dioxide was banned as a food additive in all European Union countries in 2022 due to health concerns [3]. In this context, there is an urge for a biocompatible white pigment replacement, with guanine appearing to be a promising alternative. In nature, highly refractive guanine crystals are indeed responsible for a diverse array of optical phenomena in animal coloration [4]. These organisms exhibit a vibrant spectrum of colours from blue to white through the organization into stacked structures of these crystals, whose optical properties derive from a high in-plane refractive index (n = 1.83) that endows them with the capability to scatter light, similarly to titanium dioxide. Our objective is to develop a guanine crystal-based pigment that can approximate the optical properties of titanium dioxide, providing a biocompatible alternative.

In this study, we successfully replicated the synthesis of homogeneous guanine crystals using an anti-solvent method and demonstrated the potential for shaping these crystals into spherical forms through confined crystallization. We employed two main techniques: the One-Step Recrystallization method, which yielded highly uniform crystals with an average size of 17 µm, and the Inverse Emulsion method, which produced spherical crystals ranging from 5 to 15 µm in diameter. With these findings, the synthesis of spherical guanine crystals with sizes between 400 and 800 µm is conceivable. Such advancements could lead to the development of a novel white pigment that effectively reflects wavelengths within the visible light spectrum.

[1] T. Radhakrishnan, "THE OPTICAL PROPERTIES OF TITANIUM DIOXIDE."
[2] B. Dréno, A. Alexis, B. Chuberre, and M. Marinovich, "Safety of titanium dioxide nanoparticles in cosmetics," *Journal of the European Academy of Dermatology and Venereology*, vol. 33, no. S7. Blackwell Publishing Ltd, pp. 34–46, Nov. 01, 2019. doi: 10.1111/jdv.15943.
[3] J. Musial, R. Krakowiak, D. T. Mlynarczyk, T. Goslinski, and B. J. Stanisz, "Titanium dioxide nanoparticles in food and personal care products—what do we know about their safety?," *Nanomaterials*, vol. 10, no. 6. MDPI AG, pp. 1–23, Jun. 01, 2020. doi: 10.3390/nano10061110.
[4] F. Chen, D. Guo, J. Gao, and Y. Ma, "Bioinspired Crystallization of Guanine," *Journal of Physical Chemistry Letters*, vol. 12, no. 48, pp. 11695–11702, Dec. 2021, doi: 10.1021/acs.jpclett.1c03010.

Sustainable Adhesives by Photoinduced Frontal Polymerization Of Biobased Acrylates In The Presence Of Natural Fillers

Huseyin Mirac Dizman[1], João T. Cabral[2], Alessandra Vitale[1], Roberta Bongiovanni[1]

[1]Department of Applied Science and Technology, Politecnico di Torino, 10129, Torino, Italy
[2]Department of Chemical Engineering, Imperial College London, London SW7 2AZ, United Kingdom

Frontal polymerization (FP) is a self-sustaining reaction triggered by an external stimulus, such as heat or light, that creates a localized reaction zone called the "polymerization front." The heat released in this exothermic process raises the temperature, enabling further polymerization at the boundary between the formed polymer and the unreacted monomer, often resulting in planar propagation [1]. Compared to traditional polymerization, FP is simpler, faster, and more efficient, requiring no stirring, fewer steps, minimal solvents, and no constant external energy, while ensuring uniform polymer structures and high conversion efficiency [2]. Photoinduced frontal polymerization offers several advantages over traditional thermal FP, primarily due to its ability to provide more precise spatial and temporal control over the reaction.

This study investigates the curing of reactive formulations in dark regions using photoinduced FP of biobased acrylic monomers. The influence of natural fillers, such as wood and cellulose powder, was analyzed. Characterization methods included FT-IR, viscometry, thermal imaging, and FESEM. Additionally, the study examined process optimization concerning thermal effects, frontal velocity, monomer conversion, reaction mechanisms, formulation composition, and environmental and processing conditions. The work demonstrates that the interaction between light and the monomeric system is crucial in tailoring the FP process and thus the material properties, as it allows for the selective activation of polymerization in specific regions. This tunability is particularly beneficial for developing advanced materials, such as high-performance biobased adhesives, where controlled curing, rapid processing, complex geometries, and enhanced mechanical properties are essential.

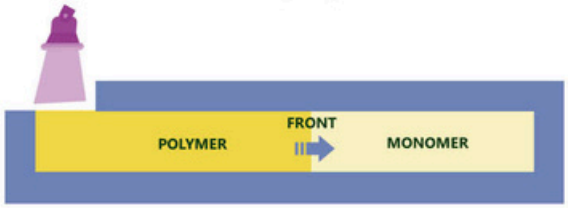


Figure 1. Schematic illustration of frontal polymerization.

References

[1] Benjamin A. Suslick et al, "Frontal Polymerizations: From Chemical Perspectives to Macroscopic Properties and Applications" *Chemical Reviews* Vol 123, 2023, 3237–3298.
[2] Li, Qing et al, "Advances in frontal polymerization strategy: From fundamentals to applications" *Progress in Polymer Science* Vol 127, 2022, 101514.

This project received funding from the HE programme under the MSCA-DN grant agreement No 101073432.

Scalable Manufacturing of Functionalized Fresnel Lens-Based Solar Concentrators using Roll-to-Plate UV Nanoimprint Lithography

Jaime J. Hernández[1,2], Almudena García-Sánchez[3], Guido Vallerotto[3], Paz Cumia[4], José A. Santiago[4], Alejandro García-Cañas[2], Ignacio Antón[3], César Domínguez[3] and Isabel Rodríguez[2]

[1] Instituto de Estructura de la Materia (IEM-CSIC), Serrano 121, 28006 Madrid, Spain
[2] Madrid Institute for Advanced Studies in Nanoscience (IMDEA Nanoscience), 280049 Madrid, Spain
[3] Instituto de Energía Solar, Universidad Politécnica de Madrid, +34 910672568, Madrid, Spain
[4] Nano4Energy

jaime.hernandez@csic.es, almudena.garcia@upm.es, guido.vallerotto@upm.es, paz.cumia@nano4energy.eu, joseantonio.santiago@nano4energy.eu, alejandro.garciacanas@imdea.org, steve.askins@upm.es, i.anton@upm.es, cesar.dominguez@upm.es, i.rodriguez@imdea.org,

Concentrator photovoltaics (CPV) represent an advanced PV technology designed to enhance efficiency of solar cells while lowering the cost and carbon footprint of the solar energy produced. Cost and emissions reduction are achieved by reducing the required area of the semiconductor and by including cheaper optical elements that concentrate light on a smaller region. These are frequently based in Fresnel lens designs that employ micrometric facets to minimize optical thickness. The compact lens size requires the use of high resolution and cost-effective manufacturing techniques like roll-to-roll (R2R) or roll-to-plate (R2P) nanoimprint lithography (NIL).

This work demonstrates the fabrication of linear Fresnel lenses via R2P UV-NIL on rigid glass substrates, incorporating other functional components. This optical system is part of a novel building-integrated (BIPV) module able to generate solar electricity and produce low-glare daylighting at the same time. The additional functional components include antireflective biomimetic moth-eye nanostructures encapsulated with a TiO_2 coating deposited by magnetron sputtering implemented on the exterior-facing side of the CPV lens substrate. Antireflective capability enhances efficiency by maximizing light transmission and reducing reflection losses. Self-cleaning capabilities can minimize dust and debris accumulation. Soiling is known to have a larger impact on optical losses in CPV than in conventional flat-plate systems, so this aspect is critical.

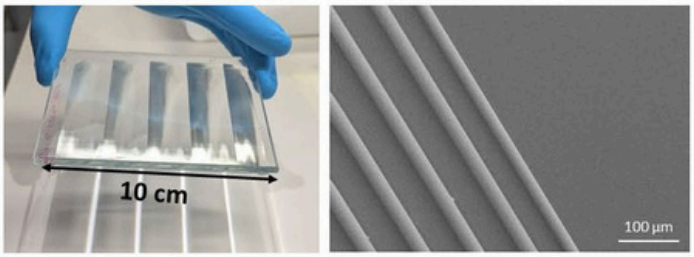


Figure 1. Array of linear Fresnel lenses produced by R2P-UV-NIL (left) and a scanning electron microscopy image showing a detailed view of the lens facets (right).

References

[1] A. Jacobo-Martín et al. "Roll-to-roll nanoimprint lithography of high efficiency Fresnel lenses for micro-concentrator photovoltaics." *Opt. Express* **2021**, *29 21*, 34135.

The Light-activated Effect of Natural Anthraquinone Parietin against Candida auris and Other Fungal Priority Pathogens

Johannes Fiala [1], Thomas Roach [2], Andreas Holzinger [2], Yurii Husiev [3], Lisa Delueg [1], Fabian Hammerle [1], Eva Sanchez Armengol [4], Harald Schöbel [5], Sylvestre Bonnet [3], Flavia Laffleur [4], Ilse Kranner [2], Michaela Lackner [6], Bianka Siewert [1]

1 Department of Pharmacognosy, Institute of Pharmacy, Center for Molecular Biosciences Innsbruck, University of Innsbruck, Austria
2 Department of Botany, University of Innsbruck, Austria
3 Leiden Institute of Chemistry, Leiden University, Netherlands
4 Department of Technology, Institute of Pharmacy, University of Innsbruck, Austria; Flavia.Laffleur@uibk.ac.at
5 Department of Biotechnology, MCI Innsbruck, Austria
6 Institute of Hygiene und Medical Microbiology, Medical University of Innsbruck

Antimicrobial photodynamic therapy (aPDT) is an evolving treatment strategy against human pathogenic microbes such as the Candida species, including the emerging pathogen C. auris. Using a modified EUCAST protocol, the light-enhanced antifungal activity of the natural compound parietin was explored [1]. The photoactivity was evaluated against three separate strains of five yeasts, and its molecular mode of action was analysed via several techniques, i.e., cellular up-take, reactive electrophilic species (RES), and singlet oxygen yield. Under experimental conditions (λ = 428 nm, H = 30 J/cm 2 , PI = 30 min), microbial growth was inhibited by more than 90 % at parietin concentrations as low as c = 0.156 mg/L (0.55 µM) for C. tropicalis and Cryptococcus neoformans, c = 0.313 mg/L (1.10 µM) for C. auris, c = 0.625 mg/L (2.20 µM) for C. glabrata, and c = 1.250 mg/L (4.40 µM) for C.albicans. Mode-of-action analysis demonstrated fungicidal activity. Parietin targets the cell membrane and induces cell death via ROS-mediated lipid peroxidation after light irradiation. In summary, parietin exhibits light-enhanced fungicidal activity against all Candida species tested (including C. auris) and Cryptococcus neoformans, covering three of the four critical threats on the WHO's most recent fungal priority list.

References

[1] M.L. Mugas, G. Calvo, J. Marioni, M. Céspedes, F. Martinez, D. Sáenz, G. Di Venosa, J.L. Cabrera, S.N. Montoya, A.Casas. Photodynamic therapy of tumour cells mediated by the natural anthraquinone parietin and blue light. *J Photochem Photobiol B* **2021**,214, 112089

Development of UV-Curable Pressure Sensitive Adhesives (UV-PSA): towards more sustainable bonding technologies

Qing LI [a], Prof. Jacques LALEVEE [b], Dr. Bruno CHARRIERE [c]

[a] Université de Haute-Alsace, CNRS, IS2M UMR 7361, F-68100 Mulhouse, France. qing.li@uha.fr

[b] Université de Haute-Alsace, CNRS, IS2M UMR 7361, F-68100 Mulhouse, France. jacques.lalevee@uha.fr

[c] Arkema, 92705 Colombes Cedex, France. bruno.charriere@arkema.com

The use of ultraviolet radiation (UV) technology for the crosslinking of acrylic pressure-sensitive adhesives (PSAs) is one of the latest crosslinking methods to replace the conventional crosslinking process of solvent-based acrylic systems. The current industrial standard for UVPSAs involves grafting photoinitiators onto polymer chains to facilitate crosslinking under UV light. With acrylate serving as the backbone, the photoreactive groups attack the C-H bonds present in the neighboring chain, resulting in the crosslink structure typical of PSAs. In this work, we propose an alternative approach by blending acrylic polymers with multifunctional photoinitiators, offering a simplified and efficient method for UV-induced crosslinking. The performance of this technique was systematically evaluated through comparative tests, including peeling adhesion, shear strength, and crosslinking density. The experiments were conducted using both traditional UV mercury lamps and advanced UVC LEDs, highlighting the versatility of the proposed method. Results demonstrate that this blending strategy achieves competitive, if not superior, performance compared to conventional grafting methods, while simplifying the manufacturing process and broadening the applicability of photoinitiated systems. In addition, special attention has also been given to the basic properties of the chosen multifunctional photoinitiators and their kinetic analysis, including reactivity, triplet lifetime, redox potential, and free energy change.

References

[1] Bartkowiak, M.; Czech, Z.; Kim, H.-J.; Shim, G.-S.; Nowak, M.; Antosik, A. K., Photoreactive UV-Crosslinkable Acrylic Pressure-Sensitive Adhesives (PSA) Containing Multifunctional Photoinitiators. Polymers 2021, 13 (24), 4413.

Sculpting Light: Photochromic and Mechanochromic Dyes Embedded in Strain-Sensitive Polymer Nanostructures

Martina Martusciello[1], Paola Lova[1], Christoph Weder[2], Davide Comoretto[1], Jessica Clough[2]

[1]Università degli Studi di Genova, Dipartimento di Chimica e Chimica Industriale, Via Dodecaneso, 31, 16146, Genova (IT), martina.martusciello@edu.unige.it

[2]Adolphe Merkle Institute, University of Fribourg, Chemin des Verdiers 4, 1700 Fribourg, Switzerland

Stimuli-responsive photonic materials are gaining significant attention for applications in sensing, smart coatings, and tunable optoelectronic devices.[1,2] In this context, integrating photochromic and mechanofluorochromic molecular units into stretchable photonic nanostructures [3] promises to enable dynamic control over optical properties and unlock new possibilities for reconfigurable optical components and strain-sensitive fluorescent probes. This study explores two strategies for embedding such responsive molecules into photonic architectures. In the first approach, we designed a flexible photonic structure by incorporating a polyurethane functionalized with a mechanophore composed of two perylene diimide (PDI) dyes linked into a supramolecular loop [4] within a stretchable Distributed Bragg Reflector (DBR).[3] The polyurethane serves as a mechanically adaptive substrate for the DBR, strain-induced unfolding of the supramolecular loop leads to a characteristic modification in the fluorescence spectrum of the mechanophore. We confirmed that these fluorescence changes are preserved when the mechanophore is integrated within the DBR architecture. Additionally, mechanical deformation shifts the spectral position of the DBR's photonic bandgap [3], which further modulates the emission profile. This platform demonstrates how both the mechanofluorochromic properties of the polymer and optical interactions with the photonic structure work together to enable tunable fluorescence. In the second strategy, we incorporated a spiropyran dye within a stretchable planar optical microcavity, exploiting its photochromic properties and investigating its fluorescence response under mechanical strain. Typically, spiropyran dyes do not exhibit mechanofluorochromic behavior unless covalently incorporated in polymer chains.[5] In our system, the microcavity permits mechanical modulation of the dye's optical response. Strain-induced changes in the spectral position of the cavity mode influence the fluorescence response, making the spiropyran responsive to mechanical stress and imparting emergent mechanofluorochromic behavior. By combining these two approaches, we establish a novel platform for dynamically reconfigurable photonic devices.

References

[1] J. M. Clough "Mechanochromism in Structurally Colored Polymeric Materials" Macromol. Rapid Commun. 2021, 42, 2000528.
[2] R. K. Langat "In-situ piezoelectric sensors for structural health monitoring with machine learning integration" Mechatronics 2025, 106, 103297.
[3] M. Martusciello "Stretchable Distributed Bragg Reflectors as Strain-Responsive Mechanochromic Sensors" ACS Appl. Mater. Interfaces. 2024, 16, 51384-51396.
[4] H. Traeger "Folded Perylene Diimide Loops as Mechanoresponsive Motifs" Angew. Chem. 2021, 12, 16327-16335
[5] H. Hu "Polymer Mechanochemistry in Confined Spaces" Angew. Chem. 2024, 64, e202417357

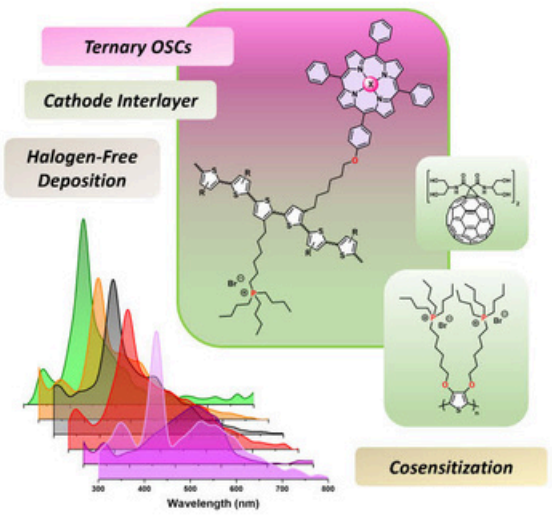
A New Alcohol-Soluble Dye-Tetraphenyl Porphyrin Copolymer: Role as Third Component and Cathode Interlayer in Halogen-Free OSCs

M. Marinelli,[a] R. Medri,[a] E. Salatelli,[a] and M. Lanzi[a]

[a] Dpt. Of Industrial Chemistry "Toso Montanari", University of Bologna, Via P. Gobetti 85, 40129, Bologna (Italy)

E-mail address: riccardo.medri3@unibo.it

Solar energy, particularly through the development of organic solar cells (OSCs), offers promising eco-friendly solutions to address global energy shortages and environmental pollution. OSCs are advantageous due to their use of non-critical raw materials, low-cost production, flexibility, and potential for large-area, semitransparent fabrication. Consequently, significant efforts have been made not only in the design and synthesis of high-performance materials but also in optimizing device architecture to improve their photovoltaic efficiency.
The presented work focuses on the synthesis of novel water- and alcohol-soluble conjugated thiophene-based polymers with ionic phosphonium salts, specifically designed for use in ternary bulk-heterojunction (BHJ) OSCs. The two synthesized materials, poly{3-(6-tributylphosphoniumhexyl)thiophene-co-3-[5-(4-phenoxy)-10,15,20-triphenylporphyrinyl]hexylthiophene bromide} (**P1buP**) and poly[3,4-(6,6'-tributylphosphoniumhexyloxy)thiophene] bromide (**P2buP**), exhibit strong photochemical stability and broad absorption across the visible and near-infrared (NIR) regions.
These polymers were processed entirely using green solvents, such as ethanol, ensuring an environmentally sustainable approach. They were tested both as electron donor components in ternary BHJ OSCs and as cathode interfacial layers in binary devices, exploring the concepts of co-sensitization and device engineering. Notably, the incorporation of the porphyrin-functionalized copolymer as a cathode interlayer improves charge transport and stability. Additionally, metalation with Zn further enhances the device performance, achieving a final power conversion efficiency (PCE) of approximately 6%.[1]



References

[1] M. Marinelli, M. Lanzi, D. Quadretti, Y. Ziai, F. Pierini, A. Zanelli, R. Medri, E. Salatelli, "A new alcohol-soluble dye-tetraphenyl porphyrin functionalized copolymer: Inside the role as a third component/cathode interlayer in halogen-free OSCs." *React. Funct. Polym.* **200**, *2024*, 105928.

A standardized database for data-driven design of nanoscale block copolymer self-assembling

Chiara Magosso[1,2], Irdi Murataj[2], Michele Perego[4], Gabriele Seguini[4], Debra J. Audus[3], Gianluca Milano[2], and Federico Ferrarese Lupi[2]

[1]Department of Electronics and Telecommunications, Politecnico di Torino, Turin, Italy.
[2]INRiM (Istituto Nazionale di Ricerca Metrologica), Turin, Italy.
[3]Materials Science and Engineering Division, National Institute of Standards and Technology, Gaithersburg, Maryland 20899, United States.
[4]CNR-IMM National Laboratory, Agrate Brianza, 20041 Milan, Italy.
i.murataj@inrim.it

Block copolymers (BCPs) are well recognized for their ability to self-organize into distinct morphologies with characteristic nanoscale dimensions and used in various applications, including microelectronics [1] and nanophotonics [2]. Their fabrication relies on many parameters with complex relationships and therefore, challenges remain in fully understanding the effects of synthesis and processing parameters on domain sizes, crucial for optimizing material properties. Approaches such as the Materials Genome Initiative (MGI) [3] can accelerate the use of these unique materials providing the means to reduce the cost and time of materials discovery and optimization. To enable the practical implementation of MGI, a dataset that can then be exploited by computational models of artificial intelligence tools is needed. Existing datasets, however, often suffer from a lack of standardization and metadata, limiting their utility for predictive modeling. Here, we introduce an open-access database containing 1,747 scanning electron microscope micrographs of self-assembled BCPs, designed to support data-driven material design. For each sample image, its fabrication process parameters were inserted into the image metadata and then analyzed with a custom-built automated algorithm to estimate its characteristic morphology parameters. The extracted morphology parameters are then inserted into the corresponding image metadata creating the database. The database is generated using a graphical user interface (GUI) for metadata input and an automated image analysis to eliminate user-dependent bias in image processing and to ensure the database standardization. The database is designed to be dynamically expandable, allowing additional contributions from a broader scientific community. Compliant with FAIR data principles (i.e. Findable, Accessible, Interoperable and Reusable) and integrated with the digital International System of Units (D-SI), the database offers ease of sharing, reusability and resilience against errors. This resource empowers machine learning models to predict BCPs properties, consequently reducing the time and cost of materials innovation.

References

[1] Liu, CC., et al. "Directed self-assembly of block copolymers for 7 nanometre FinFET technology and beyond". *Nat Electron* **1**, 562–569 (2018).
[2] Murataj, I., et al. "Hyperbolic Metamaterials via Hierarchical Block Copolymer Nanostructures" *Adv. Opt. Mater.* **9**(7), 2170024 (2021).
[3] "Materials Genome Initiative Strategic Plan". https://www.mgi.gov/sites/default/files/documents/MGI-2021-Strategic-Plan.pdf.

Artificial fingerprints engraved through block-copolymers as nanoscale physical unclonable functions for authentication and identification

Irdi Murataj[1,4], Chiara Magosso[1,2,4], Stefano Carignano[3], Matteo Fretto[1], Federico Ferrarese Lupi[1] & Gianluca Milano[1]

[1]INRiM (Istituto Nazionale di Ricerca Metrologica), Turin, Italy.
[2]Department of Electronics and Telecommunications, Politecnico di Torino, Turin, Italy.
[3]Barcelona Supercomputing Center, Barcelona, Spain.
i.murataj@inrim.it

Counterfeiting represents a growing problem for society that has not only enormous economic implications, from manufacturing of goods to specialized technologies but represents a threat for the entire security and health systems [1]. In this context, hardware encryption systems based on physical unclonable functions (PUFs) have been proposed to overcome limitations of current anti-counterfeiting technologies, enabling the generation of a secret key based on the inherent physical characteristics of a physical system [2]. Here, we report on artificial fingerprints that can be directly engraved on a wide range of target materials (diamond, Si, SiO_2, and quartz) (Fig. 1a) through self-assembled block-copolymer (BCP) templating as PUFs for secure authentication and identification [3]. We show that engraved nanopatterns can be encoded in binary code matrices representing a unique bit stream of information that endow high bit uniformity, high uniqueness, and high entropy (Fig. 1b). Indeed, the encoding relies on morphological properties of the pattern resulting from the self-assembly process, including defects and correlation length that significantly affect the security properties of the PUF. Moreover, we propose a computer vision-based strategy that enables long-term reliable operation and robust authentication/identification against thermal treatment (range −196 °C to 200 °C) in a real-world scenario, as demonstrated by testing 100 PUF devices (Fig. 1c). These results pave the way for the realization of PUF that embraces the inherent stochasticity of self-assembled materials at the nanoscale.

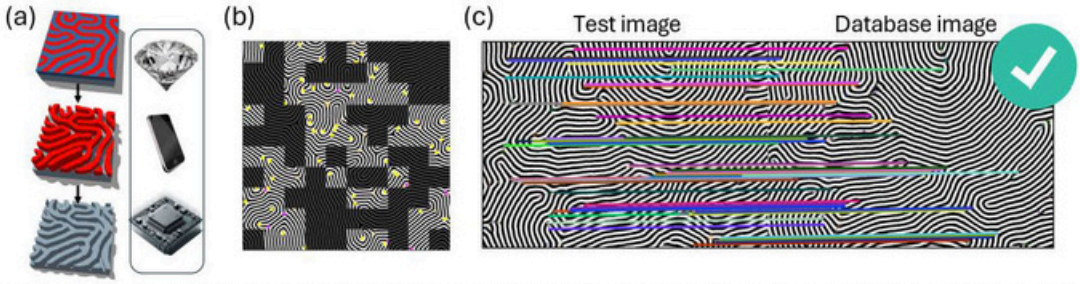


Figure 1: (a) Schematics of fabrication of artificial fingerprints. (b) Exampleof binary code matrix extraction from positive phase defects of the self-assembled binarized nanopatterns. (c) Example of a successful authentication/identification.

References

[1] Fink, C., et al. "The economic effects of counter-feiting and piracy: a review and implications for developing countries." *World Bank Res. Observer* **31**,1–28 (2016).
[2] Gao, Y., et al. "Physical unclonable functions." *Nat. Electron* **3**,81–91 (2020).
[3] Murataj, I., et al. "Artificial fingerprints engraved through block-copolymers as nanoscale physical unclonable functions for authentication and identification." *Nat Commun* **15**, 10576 (2024).

Spectroscopic ellipsometry approach to polymer and hybrid thin films

Maddalena Patrini[a], Paola Lova[b], and Davide Comoretto[b]

[a]Dipartimento di Fisica, Università di Pavia, Via Bassi 6, 27100 Pavia, Italy, maddalena.patrini@unipv.it

[b]Dipartimento di Chimica e Chimica Industriale, Università di Genova, Via Dodecaneso 31, 16132 Genova, Italy

Thin films of polymers and more generally of organic compounds deposited on solid substrates are of high technological importance due to their potential for applications in electronics, photonics, sensing, and multidisciplinary nanotechnology. Their characterization methods must be refined appropriately to obtain information and data useful in the design and analysis of devices. With this aim, Spectroscopic Ellipsometry (SE) has technically improved, becoming the method of choice for determining the optical response of materials, both in dispersion and absorption contributions in the UV-vis-IR spectral range.

In isotropic and layered structures the amount of polarized amplitude and phase available at several oblique angles of incidence allowed to solve the correlation issue between optical functions and thin film thickness, with monolayer sensitivity. For the interpretation, homogeneous phases with smooth and parallel interfaces are usually implemented; nevertheless, surface roughness, porosity, graded composition at interfaces can be introduced and give access to a non-invasive structural characterization for ultrathin films and multilayers, which can complement other experimental evidence.

For non-conjugated polymers, no electronic transitions are usually observed in the vis spectral range and the refractive index dispersion is reproduced using a few parameter Cauchy or Sellmeier model, assuming ideal transparency. Therefore, extension of the spectral range to ultraviolet and infrared regions is desirable because characteristic vibrational, conduction or electronic absorptions are available within these ranges. Corresponding dielectric response is reproduced with physical oscillators, with variable lineshape depending on structural homogeneity; in addition, effective medium approximation models have been adopted to interpret the optical response of polymer blends and hybrid systems with inorganics.[1] Such optical functions can be used for forward analysis and simulation of more complex systems, *e.g.* Distributed Bragg Reflectors in photonics applications, to establish a favorable compromise between growth processing conditions, structure stability and high dielectric contrast between low *vs* high index materials.[2]

Moreover, intrinsic properties, conformational changes and growth procedures should create anisotropy in the dispersion and absorption spectral response. Generalized SE then allows the determination of a complete set of anisotropic optical functions of a polymer film, with uniaxial or biaxial symmetry *w/r* to the sample surface. The anisotropy model can be attributed to preferential molecular/chain orientation; it can be used as input for the interpretation of more sophisticated structures, such as microcavities,[3] and measurements taken by nonlinear optical techniques.

References

[1] C. Tavella, et al. *RSC Advances* **2022**, *12*, 8924.
[2] P. Lova, et al. *Applied Sciences* **2020**, *10*, 4122.
[3] S. Bertucci, et al. *ACS Applied Optical Materials* **2023**, *1*, 1343–1349.
M.P. acknowledges all other co-authors of related publications for preparation of material films and structures.

Tamm Plasmon for the enhancement of Light Matter Interaction

A. Rossini[1,2], F. Marangi[2,3], C. Florindi[2,4], A. Pianetti[1,2], G. Simoncini[1,2], F. Lodola[2,4], F. Scotognella[3], G. Lanzani[1,2] and G. M. Paternò[1,2]

1. Department of Physics, Politecnico di Milano, Milano, Italy
2. Center for Nano Science and Technology, Istituto Italiano di Tecnologia, Milano, Italy
3. Department of Applied Science and Technology, Politecnico di Torino, Torino, Italy
4. Department of Biotechnology and Biosciences, University of Milano -Bicocca, Milano, Italy

andrea.rossini@polimi.it

Tamm Plasmon (TP) modes are a form of Surface Plasmon Resonance (SPR) that can be excited at the interface between a plasmonic layer and a distributed Bragg reflector (DBR). In recent years, interest in TP-based devices has significantly increased due to their unique properties, such as strong confinement of electromagnetic fields and efficient coupling of incident light to localized surface modes. These features make TP devices an ideal platform for the development of novel optoelectronic and photonics applications [1,2].

Previous studies [3] have demonstrated that introducing nanoscale corrugations on the free surface of the plasmonic layer can enable interactions between the confined electromagnetic field and the external interface of the device.

Here, we exploit these capabilities of TP modes to modulate phenomena at the biotic-abiotic interface. So, I discuss the TP-driven enhancement of the phototransduction activity of conjugated polymers at the interface with living cells, enabling photostimulation of biological signaling.

References

1. Kar, C., S. Jena, D.V. Udupa, and K. D. Rao, "Tamm plasmon polaritons in planar structure: A brief overview and applications", Optics & Laser Technology, **2023**, 159, 108928
2. Normani et al., "The impact of Tamm plasmons on photonic crystals technology", Physica B: Condensed Matter, **2022**, 645, 414253
3. Normani et al.,"Tamm Plasmon Resonance as Optical Fingerprint of Silver/Bacteria Interaction" , ACS Appl. Mater. Interfaces, 2023, 15, 27750-27758

Polymer nanofibers for skeletal muscle cells alignment and photostimulation

Giulia Simoncini,[a,b] Ilaria Venturino,[a,b] Fabio Marangi [a,c],Matteo Moschetta[a],Paola Moretti[d],Chiara Bertarelli[d], Giuseppe Maria Paternò[a,b],Guglielmo Lanzani [a,b]

[a] Center for nano science and technlogy,Istituto italiano di tecnologia, Milan,Italy
[b] Dipartimento di Fisica, Politecnico di Milano, Piazza Leonardo da Vinci 32, 20133, Milan, Italy
[c] Dipartimento scienza applicata e tecnologia, Politecnico di Torino,Corso duca degli abruzzi 24, 10129, Turin,Italy
[d] Dipartimento di Chimica, materiali e ingegneria , Politecnico di Milano, Piazza Leonardo da Vinci 32, 20133, Milan, Italy

In tissue engineering, cell-substrate coupling has a crucial role. Its mechanical, chemical, physical and morphological features are decoded by cells as stimuli that strongly affect their behavior. [1] In muscular tissue engineering, in order to efficiently reproduce the natural muscle organization and achieve contraction ability, cell alignment on a suitably stiff substrate is required.[2] Here, electrospinning was used as technique to produce polymer nanofibers, used as scaffold for muscle cells. The polymers employed for these nanofibers must be biocompatible, for this purpose we selected polyvinyl alcohol (PVA). Preliminary study of substrate biocompatibility, cells alignment, cells differentiation and photostimulation were conducted on PVA nanofibers. Combing photochromic molecules and biocompatible polymers is it possible to obtain a blend photoactive material that can guide the cells growth and trigger the contraction of a muscle tissue at the same time. To promote muscle cells contraction electrodes are widely used; however, they may produce side effects like unnatural heating, Reactive Oxigen Spieces production.[3] Alternatively, photostimulation offers advantages such as better spatial and temporal resolution, low toxicity, and invasiveness.[4]
In these experiments we tested first PVA nanofibers with different orientation, suitability in promoting skeletal muscle cells differentiation. The next steps will involeve the synthesis of photoactive nanofibers through the crosslinking of photocromic molecules on the fibers surfaces. Before the fibers functionalization of the fibers, we characterized the optical properties of the molecules in different solvents, studying absorption properties, emission, and isomerization dynamics. Preliminary studies on the electrophysiology and viability of the photoactuator were conducted on HEK cells to better understand the effects of the molecules on the cells membrane.
The next steps will be to optimize the crosslinking process and verify the properties of the functionalized substrates first on HEK cells and then on muscle cells and to trigger a contraction through photostimulation.

References

[1] A Polymer Blend Substrate for Skeletal Muscle Cells Alignment and Photostimulation; Vito Vurro, Alberto Davide Scaccabarozzi, Francesco Lodola, Filippo Storti, Fabio Marangi, Aaron Michael Ross, Giuseppe Maria Paternò, Francesco Scotognella, Luigino Criante, Mario Caironi, and Guglielmo Lanzani*
[2] D. Kai, M. P. Prabhakaran, G. Jin, S. Ramakrishna, J. Biomed. Mater. Res. 2011, 98B, 379.
[3] S. Vasudevan, K. Patel, C. Welle, J. Neural Eng. 2017, 14, 016008.
[4] F. Di Maria, F. Lodola, E. Zucchetti, F. Benfenati, G. Lanzani, Chem. Soc. Rev. 2018, 47, 4757

Use of light and disulfide bonds to control the epoxides polymerization

Alberto Spessa[1], Roberta Bongiovanni[1], Alessandra Vitale[1]

[1]Department of Applied Science and Technology, Politecnico di Torino, Corso Duca degli Abruzzi 24 10129 Torino (Italy) – Email: alberto.spessa@polito.it

Photoinduced cationic ring-opening polymerization (ROP) of epoxy monomers is a well-established polymerization technique, mainly due to its wide range of applications, e.g., coatings, adhesives, microelectronics or 3D printing [1]. In comparison with the free-radical mechanism, epoxide cationic photopolymerization has numerous advantages, chief among them being the absence of oxygen inhibition, but also improved mechanical properties, reduced shrinkage, good adhesion to various substrates, and the ability to proceed even in the absence of light [2]. The integration of this technology into patterning techniques, such as inkjet lithography, which offers scalable, maskless and precise creation of specific patterns, is a promising development for different applications including microfluidic devices and optoelectronic components [3].
Several studies investigated the role of sulfides or thiols in reducing the extent and the rate of cationic ROP, thus inhibiting the epoxide-curing mechanism [4,5]. This study explores the effect of disulfide-containing molecules on the selective inhibition of epoxy cationic ROP, focusing on their impact on both epoxy conversion and insoluble fraction. Two epoxy monomers, characterized by different reactivity and conversion at the gel point, were tested, and a reaction mechanism was proposed. The selective inhibition of epoxide cationic ROP was leveraged as a potential inkjet lithography technique for obtaining patterns without the need of masks.

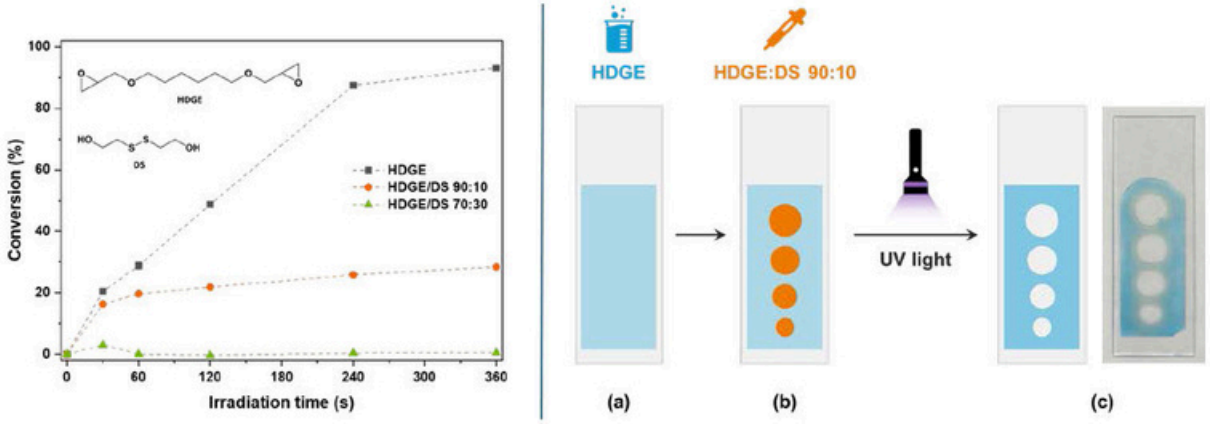


Figure 1. Conversion of epoxy monomer with and without disulfides (left) and schematic representation of its application as patterning technique (right).

References

[1] J.V. Crivello, S. Liu, *J. Polym. Sci. A Polym. Chem.* **2000**, *38*, 389–401.
[2] R. Bongiovanni, S.D. Vacche, A. Vitale, *Polymers* **2021**, 2293.
[3] A. Elkaseer, K.J. Chen, J.C. Janhsen, O. Refle, V. Hagenmeyer, S.G. Scholz, *Add. Man.* **2022**, *60*, 103270.
[4] B. Falk, M.R. Zonca, J.V. Crivello, *J. Polym. Sci. A Polym. Chem.* **2005**, *43*, 2504–2519.
[5] R.A. Ortiz, B.A.P. Urbina, L.V.C. Valdez, L.B. Duarte, R.G. Santos, A.E.G. Valdez, M.D. Soucek, *J. Polym. Sci. A Polym. Chem.* **2007**, *45*, 4829–4843.

Toward voltage-modulated Passive Daytime Radiative Coolers

E. Spotorno[a], E. Peci[a], P. Stagnaro[b], S. Losio[b], L. Conzatti[b], R. Utzeri[b], M. Magnozzi[a], F. Marangi[c], F. Scotognella[d], M. Canepa[a], F. Bisio[e]

[a] DIFI-UNIGE, OptMatLab, via Dodecaneso 33, Genova, IT
[b] CNR-SCITEC, Via De Marini 6, 16149 Genova and Via A. Corti 12, 20133 Milano, IT
[c] CNST-PoliMi, Via Raffaele Rubattino 81, 20134 Milano, IT
[d] DISAT-PoliTO, Corso Duca degli Abruzzi 24, 10129 Torino, IT
[e] CNR-SPIN, Corso Perrone 24, 16152, Genova, IT

Urban areas are experiencing a significant rise in temperature due to the high concentration of buildings, roads, and other infrastructures that absorb and retain heat more efficiently than natural landscapes. Passive Daytime Radiative Coolers (PDRCs) have emerged as an effective solution, enabling sub-ambient cooling without energy consumption, even under direct sunlight [1]. These systems rely on an optical structure featuring near-unity reflectivity in the visible/near-infrared (VIS-NIR) range and selective emissivity in the atmospheric transparency window (8–13 μm). Since their introduction in 2014 [2], PDRCs have been recognized as a disruptive technology with enormous potential for climate mitigation.
Our work focuses on developing a radiative cooler whose photonic response and thermodynamic state can be toggled by means of an externally-applied voltage. We propose a multilayer photonic system composed of a metallic substrate with high absorbance in the short-wavelength visible range, on which an actively-modulated distributed Bragg reflector (DBR) and a polymer-based composite IR-emissive layer are deposited. Modulating the photonic band gap of the DBR will allow to mask/unmask the metallic substrate absorption. The polymeric emissive layer plays a crucial role in maximizing radiative heat dissipation by featuring microstructures that enhance mid-infrared emission. A random distribution of inorganic microparticles, embedded into a suitable polymer matrix, is a promising approach to obtain economical and large-scale radiative coolers. By leveraging material design and nanostructuring techniques, we aim to optimize the emissive properties of the polymeric layer to improve long-term stability and overall cooling performance.

Authors acknowledge financial support under the National Recovery and Resilience Plan (NRRP), Mission 4, Component 2, Investment 1.1, Call for tender no. 104 PRIN 2022 published on 2.2.2022 by the Italian Ministry of University and Research (MUR), funded by the European Union – NextGenerationEU –Project Title ERACLITO – CUP B53D2300904006 and Call for tender no. 1409 PRIN PNRR 2022 published on 14.9.2022 by the Italian Ministry of University and Research (MUR), funded by the European Union – NextGenerationEU – Project Title ARCO –CUP B53D23027690001.

References

[1] S. Fan et al. Photonics and Thermodynamics Concepts in Radiative Cooling. *Nat. Photon.* **2022**, *16*, 182-190.
[2] A.P. Raman et al. Passive Radiative Cooling below Ambient Air Temperature under Direct Sunlight. *Nature* **2014**, *515*, 540–544.

Development of photocurable hybrid adhesives

Axelle STAUDT[1,2], Jacques LALEVÉE[1], Bruno CHARRIÈRE[2], Patxi GARRA[3], Maria CAMPANYA[3]

[1]Institut de Science des Matériaux de Mulhouse, Université de Haute-Alsace, MULHOUSE (FR)
[2]ARKEMA France, 520 rue d'Estienne d'Orves, COLOMBES (FR)
[3]AFINITICA TECHNOLOGIES SL, Edifici Eureka, Campus UAB, BELLATERRA (ES)

Cyanoacrylates are a family of molecules with very high adhesive qualities, better known to the general public by their commercial name "Super Glue". Applied in a thin layer, they react almost instantaneously with ambient humidity on contact with the substrates to be bonded. The main mechanism followed by the curing reaction of cyanoacrylates is an anionic polymerization. The adhesions obtained, although very strong, have a number of major shortcomings: poor mechanical performance[1] (too brittle) and a certain chemical instability[2], among others.
One way to overcome these deficiencies is to add a second type of molecule to the formula. By mixing two components, we obtain hybrid adhesives that perform better, bond more varied substrates and resist impact better. In addition, they only begin to harden when exposed to a light source. This enables the user to reposition the parts to be bonded, clean up any drips, then fix the bond in a matter of seconds (when a low-intensity LED is switched on).
The second type of monomer used in the formula are acrylates. Acrylates polymerize mainly by a radical mechanism, and it's the interaction between anionic and radical polymerization that we are trying to understand. To date, there is no literature describing how these two mechanisms come together in the same reaction. To this end, hybrids have been analyzed using methods that enable the curing of the various components to be tracked independently. This information, coupled with multiple chromatographic, spectroscopic and microscopic techniques, have enabled us to determine the reaction mechanism of hybrids.

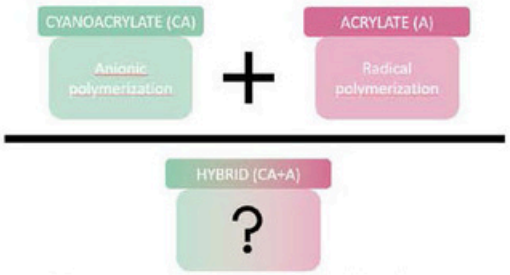


Figure 1 - Interaction of the polymerization mechanisms

References

[1] Millet, G.H. "Cyanoacrylate Adhesives". Hartshorn, S.R. (eds) Structural Adhesives. Topics in Applied Chemistry. Springer, Boston, MA, **1986**.
[2] Raja P.R." Cyanoacrylates Adhesives : A Critical Review". Rev. Adhesion Adhesives, Vol. 4, No. 4, **2016**.

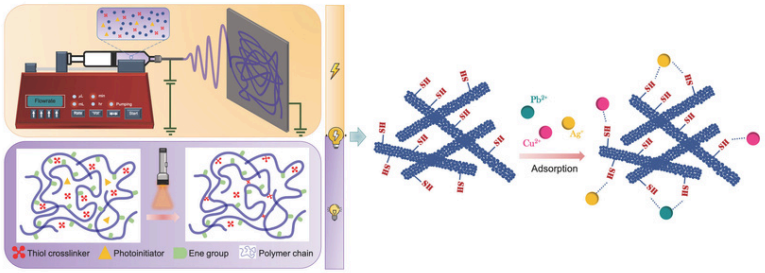
Photo-induced functionalization of electrospun nanofibrous membranes for water treatment applications

Thi Nhung Vu[1], Roberta Bongiovanni[1], Marzia Quaglio[1], Joao T. Cabral[2], Alessandra Vitale[1]

[1]Department of Applied Science and Technology, Politecnico di Torino, 10129, Torino, Italy

[2]Department of Chemical Engineering, Imperial College London, SW7 2AZ, London, UK

Electrospinning is a versatile and prominent technique for generating polymeric fibers and nanofibrous membranes at the nanoscale, with widespread application across various areas [1]. Electrospun nanofibrous membranes have exceptional characteristics, including high surface area, porosity, and tunable structural features. Furthermore, photo-induced crosslinking can be integrated with electrospinning to improve the thermal, chemical, and solvent resistance of the membranes, while enabling precise morphological control and tuning of chemical composition to create (multi)functional materials [2], suitable for water treatment applications.
This study leverages two powerful resources—electricity and light—to fabricate innovative nanofibrous membranes functionalized with thiol groups for heavy metal detection. A styrene-butadiene rubber latex was electrospun (thus using only water as the electrospinning medium to mitigate environmental and human concerns) in the presence of a multifunctional thiol crosslinker. Light irradiation of the membranes was followed to trigger the thiol-ene photo-crosslinking reaction [3]. The photo-crosslinking efficiency was monitored by FT-IR spectroscopy (both in real-time and ATR mode), while the morphology and mechanical properties were investigated by FESEM and tensile testing, respectively. The crosslinker concentration was optimized to ensure the presence of active thiol functional groups on the surface of the membranes after crosslinking, which were quantified by the combination of Ellman's reagent and UV-Vis spectroscopy. Finally, the efficiency of the thiol-functionalized membranes in detecting heavy metal ions (e.g., Cu(II), Hg(II)) was evaluated by diffuse reflectance UV-Vis and EDX spectroscopy.



This project received funding from the HE programme under the MSCA-DN grant agreement No 101073432.

References

[1] Zhu. F et al. "A Critical Review on The Electrospun Nanofibrous Membranes for The Adsorption of Heavy Metal in Water Treatment." *J. Hazard. Mater* **2021**, *401*, 123608.
[2] Vitale A. et al. "Tuning porosity and functionality of electrospun rubber nanofiber Mats by photo-crosslinking." *ACS Appl Mater Interfaces* **2019**, *11(27),* 14544–24551.
[3] Kianfar P. et al. "Suspension Electrospinning of SBR Latex Combined with Photo-Induced Crosslinking: Control of Nanofiber Composition, Morphology, and Properties." *J Mater Sci* **2024**, *59(8),* 3711–3724.

Polymer Functionalized *or* Polymer-Based Smart Nanoporous Membranes with Multifunctional Nanopore Activities

H. Samet Varol,[1,2] Christopher V. Synatschke,[3*] Annette Andrieu-Brunsen,[2*] Tanja Weil,[3*] Damiano Genovese[1*]

[1] Department of Chemistry ''G. Ciamician'', University of Bologna, Via Selmi 2, 40126, Bologna, (Italy) – Email: samet.varol@unibo.it
[2] Department Ernst-Berl Institut für Technische und Makromolekulare Chemie, Technische Universität, Darmstadt, 64287 Darmstadt, (Germany)
[3] Max Planck Institute for Polymer Research, Ackermannweg 10, 55128 Mainz, (Germany)

Bioinspired polymer-functionalized multi- and nanoporous membranes are promising platforms for precisely regulating nanopore transport toward applications in water management, iontronics, catalysis, sensing, drug delivery, or energy conversion.[1] After their pore functionalization, the smart membranes get responsive against various stimuli, such as environmental pH, to control the permselectivity of different cargoes, such as DNA or ions. Despite all these advantages, the nanoporous membrane field still needs new methods to (i) tune gradually and simultaneously the transport of both cations and anions; (ii) provide multi-functionality to the nanopores; and (iii) explain the fundamental role of analyte-nanopore interactions on nanopore transport.

In my contribution, first, I will present how Ca^{2+} ions (act as ligand) interact with polymer functionalized silica nanopores to gradually control the transport of both anions and cations.[2] Second, I will show how we electropolymerized homogeneous polydopamine inside insulating silica nanopores to bring multi-functionality to the nanoporous membranes.[3] Finally, I will explain my current research activities in the Photochemistry Group of Bologna University, where I apply various photophysical methods to understand the ionic nanochannel transport mechanism of different polymeric membranes. In this context, I will present my latest results showing how the cationic luminescent analytes ($Ru(bpy)_3^{2+}$) interact with negatively charged polycarbonate nanochannels during a concentration-driven (ΔC) transport and how this interaction modulates the pH-dependent ionic transport.[4]

References

[1] **H. S. Varol**, D. Kaya, E. Contini, C. Gualandi, D. Genovese, "Fluorescence methods to probe mass transport and sensing in solid-state nanoporous membranes" *Mater Adv* **2024**, 5, 8351.
[2] **H. S. Varol**, C. Förster, A. Andrieu-Brunsen, "Ligand-Binding Mediated Gradual Ionic Transport in Nanopores" *Adv Mater Interfaces* **2023**, 10, 2201902.
[3] **H. S. Varol**, T. Herberger, M. Kirsch, J. Mikolei, L. Veith, V. Kannan-Sampathkumar, R. D. Brand, C. V. Synatschke, T. Weil, A. Andrieu-Brunsen "Electropolymerization of Polydopamine at Electrode-Supported Insulating Mesoporous Films" *Chem Mater* **2023**, 10, 2201902.
[4] **H.S. Varol**, M Cingolani, F Casnati, D Genovese," Modulating Electrostatic Interactions to Control the Analyte Transport in Nanochannels" *ChemRxiv*, **2025**, DOI: 10.26434/chemrxiv-2025-rdq9k.
* only the names of the first and corresponding authors of the to-be presented works are listed in the co-author list.

The European Polymer Federation (EPF) in collaboration with Italian Association of Macromolecular Science and Technology (AIM) is honored and pleased to announce the organization of the EUropean POlymer Conference "MacroLight" (EUPOC 2025) to be held in Bertinoro (Italy), May 11-15, 2025.

The interaction between light and matter drives many systems, e.g. light-emitting diodes and solar cells, biological structures, and future quantum devices.

Photovoltaic action exploiting macromolecules is an important tool for green energy generation, in particular if recyclable and renewable raw materials can be used.

Light-responsive macromolecular architectures are emerging for applications such as untethered soft robots and actuators.

Nature is a great source of inspiration for functional materials and devices by using different architectures that can be mimicked by macromolecules and hybridized with inorganic materials.

The search for efficient, lightweight and sustainable systems for the hyper-connected (both locally and globally) society of the future requires the development of new materials and architectures enabling an efficient management of optical signals with a reduced carbon footprint

In this context, polymers and their architectures - which are often biologically inspired - are gaining strong interest due to their properties that cannot be achieved by inorganic semiconductors and insulators.

In this way, the interaction between light and polymers can be engineered to solve a range of problems such as energy production and conservation, environmental monitoring, bio-medical issues, and more in general sustainability issues.

List of topics to be addressed:

- Bio-inspired architectures;
- Self-assembled photonic structures;
- Stimuli-responsive Functional Materials & Liquid Crystals;
- Soft-actuators & Photochromic Polymers;
- Engineered optoelectronic polymers;
- Polymer photovoltaic systems and light emitting devices
- NLO polymer and organic achitectures;
- Polymers for quantum systems;
- Organic & hybrid photonic crystals and metamaterials;
- Engineered disorder in photonics;
- Polymer photonic sensors;
- Advanced hybrid photocatalytic systems;
- Light induced water splitting;
- Artificial photosynthesis;
- Radiative cooling and thermal shielding;
- Polymer & Bio-Photonics