

Photoexciting Molecules: Abstract Booklet

Invited Speakers

Dynamic Molecular Systems, from switches to motors

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The fascinating molecular motors and machines that sustain life offer a great source of inspiration to the molecular explorer at the nanoscale. Among the major challenges ahead in the design of artificial molecular systems that induce controlled motion. Chiral compounds play a crucial role in the design of our responsive molecules ranging from photochemical switches to molecular motors. Chemical systems and adaptive materials ultimately require integration of structure, organization and function of multi-component dynamic molecular assemblies at different hierarchical levels. A major goal is to achieve and exploit translational and rotary motion.

In this presentation the focus is on the synthesis, photochemistry and dynamics of functional molecular systems as well as triggering and assembly processes. The properties of distinct classes of molecular switches and rotary motors will be discussed with a focus on overcrowded alkenes.

The modulation of chirality using molecular switches offers unique opportunities to regulation properties including supramolecular self-assembly and control of liquid crystalline materials. Furthermore, photochemically active responsive materials is discussed with an emphasis on cooperative action, amplification along multiple length scales and 2D and 3D organized systems. Our recent advances in the design and functioning of rotary molecular motors and multistage photo-redox switches will also be presented with a prospect toward future dynamic molecular systems.

Molecular Machines: Nature, September 2015

Molecular Switches: Chemistry World, June 2016

Vision statement "Materials in Motion": Adv. Mater. 2020

R. Costil, M. Holzheimer, S. Crespi, N.A. Simeth, B.L. Feringa, Chem. Rev. 2021, 121, 13213-13237.

Photoswitches at the Crossroads

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Photoswitchable molecules that reversibly interconvert between two (meta)stable isomers with distinct properties are key to applications ranging from photopharmacology and smart materials, to optical devices and energy storage. Unlocking their full potential requires not only understanding their primary photochemical reactions, but also predicting any competing process that can take place, such as thermal relaxation, fluorescence, or other undesired photochemical reaction. In this talk, I will present several intriguing cases where photoswitchable molecules find themselves at a crossroads of competing pathways. Examples include azopyrazoles designed for photopharmacology, stilbenes adsorbed in amorphous silica, and bimetallic fulvalene complexes for solar thermal energy storage. The first case concerns the identification of the thermal Z/E isomerization mechanism in heteroaromatic azo-based photoswitches (1). The second explores the competition between fluorescence and isomerization in a push–pull stilbene switch adsorbed in amorphous silica (2). Finally, I will discuss the contrasting mechanisms of photoswitching versus photodecarboxylation in bimetallic fulvalene complexes in the context of Marcus-theory (3).

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On “life-like” light-driven soft actuators and moving polymer films

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Molecular photoswitches have multiple faces as building blocks for photonic soft matter. On the one hand, their reversible photoisomerization powers life-like soft actuators, particularly in liquid crystal networks and hydrogels, where light acts as a remote trigger for adaptive, responsive, and bioinspired motions. Importantly, these photochemical processes often also generate significant photothermal heating, further boosting actuation. On the other hand, molecular photoswitches, azobenzenes in particular, can drive photoinduced mass migration in thin polymer films, producing well-defined surface relief patterns in response to laser interference irradiation, with applications ranging from cell-instructive substrates to diffractive optical elements in AR/VR technologies. This presentation will address these two manifestations of photomechanics, life-like actuation and surface patterning, pointing the way toward light-driven multifunctional soft systems across scales.

Illuminating Biology – Photoexciting molecules as triggers of cellular function

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Light offers unmatched opportunities to control biological processes with high spatial and temporal precision. In my group, we work on optochemical tools that exploit the unique chemical power of photosensitive molecules, including fluorophores, photosensitizers, and photoswitches, to address complex biological questions. By doing so, we aim to unravel cellular functions and understand how their misregulation contributes to the development of diseases. In this lecture, I will present an overview highlighting some of our recent advances using photoswitches. Those include: i) the reversible control of RNA splicing in the context of spinal muscular atrophy (SMA) using photoswitchable small molecules demonstrating control at both mRNA and protein levels;¹ ii) a photoswitchable cyclic peptide that acts as a genuine *on-off* functional switch, capable of modulating the activity of an epigenetic enzyme and, thus, gene expression. Remarkably, our molecule enables non-invasive *in vivo* control of hematopoiesis;² iii) photoswitchable stapled peptides that conditionally stabilize the transcription factor HIF1 α , providing light-controlled cellular responses that mimic those in hypoxia under normoxia conditions.³

Beyond photoswitches, our research also addresses the limitations of photosensitisers, such as dark toxicity, selectivity and light penetration. For this purpose, we introduced the concept of bioorthogonally photoactivatable photosensitizers⁴ and, more recently, self-illuminating luciferase–photosensitizer conjugates that generate intracellular light to drive photodynamic phenomena autonomously of external irradiation.⁵

Our results illustrate how photoexciting molecules can be used to interrogate and manipulate biology across multiple levels—from gene expression to therapeutic phototoxicity. Optochemical tools do not open new possibilities for fundamental discovery but also pave the way for the next generation of therapeutics within the emerging field of photopharmacology.

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Stereocontrol in Photochemical Reactions

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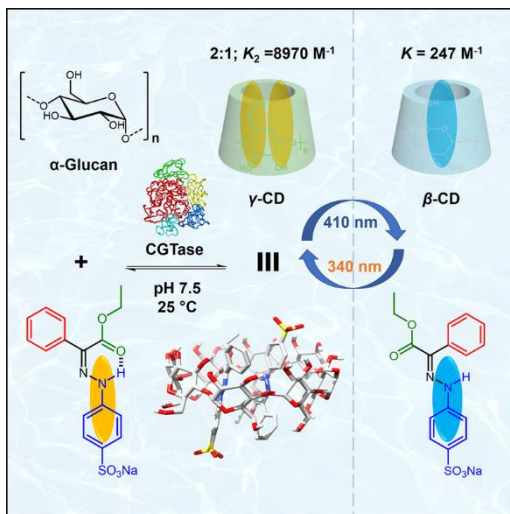
Photochemistry is intriguing as a synthetic tool because the absorption of light by an organic molecule results in the formation of exceptionally energetic reactive intermediates that can react in ways that are inaccessible to ground-state molecules. However, this high reactivity is also a challenge for stereoselective synthesis: control over the stereochemistry of photochemical reactions, particularly using enantioselective catalysts, has been a long-standing challenging synthetic problem with few general solutions. We are developing “designer” chiral photocatalysts that mediate a range of highly enantioselective photoreactions with exceptional efficiency. Detailed investigations of the mechanisms of these reactions reveal a surprising diversity of binding modes and catalytic activation modes.

Hydrazone-Based Adaptive Functional Materials

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For the past few years we have been developing structurally simple, easy to make, modular, and tunable hydrazone-based functional materials.¹ This presentation will deal with our recent advances with these systems, with an emphasis on photochromic hydrazones² and their use in the templated synthesis of γ -cyclodextrin,³ reversible multi-color liquid crystal applications,⁴ hand-held 3D volumetric displays,⁵ and anion pumping.⁶



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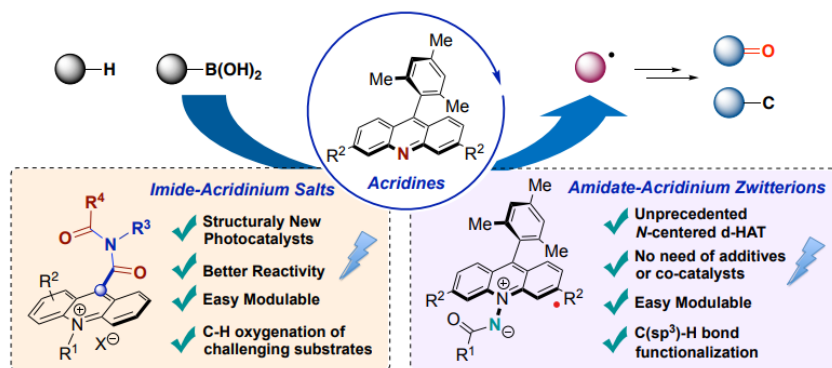
Acridinium Dyes as Versatile Organophotocatalysts

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In recent years, visible-light organic dyes were found as a valid and potent alternative photocatalysts, which give access to reactivities that were previously limited to transition-metal photocatalysts.¹ In this regard, the acridinium-based photoredox catalysts have attracted a vast interest, especially due to their great structural variety combined with the easy fine-tuning of their electronic properties, allowing for unlocking new possibilities for the generation of reactive intermediates.² In this lecture, our recent advancements in the design of acridinium-based organic photocatalysts and their use in organic synthesis will be covered. In particular, besides targeting the late-stage functionalization of biorelevant molecules,³ we have recently designed a new class of easily tunable imide-acridine-based structures with enhanced catalytic activity respect to the well-established C9-mesityl acridinium salt as potent photoredox-catalysts for the oxygenation of challenging substrates.^{4,5} Furthermore, we have achieved the development of a direct hydrogen atom transfer (d-HAT) catalysts based on unprecedented N-centered amidyl radicals from zwitterionic amidate-acridinium species capable of C-H bond functionalization of alkanes without the need of external additives or co-catalysts.⁶ Lastly, the in situ generation of the photoactive acridinium species for the activation of boronic acids will be presented.⁷



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7. *Unpublished results*

**Nucleophilic Substitution Reactions:
A Radical Alternative to S_N1 and S_N2 Reactions**

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Classical methods for achieving nucleophilic substitution reactions of alkyl electrophiles (S_N1 and S_N2) have limited scope and are not generally amenable to enantioconvergent variants that employ readily available racemic electrophiles. In this presentation, I will describe how a combination of radical chemistry and transition-metal catalysis has opened the door to addressing this dual challenge of reactivity and enantioselectivity.

Adaptive Metal-Organic Materials

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The development of the next generation of functional materials, including optoelectronic devices and on-demand drug delivery platforms with tailorable properties, relies on rapid switching between two or more distinct forms in bulk solids.^[1,2] The current benchmark in the field of stimuli-responsive materials has previously been achieving solution-like photoisomerization kinetics in the solid state. However, we present a fundamentally novel approach by far surpassing solution-like photoisomerization kinetics in the solid state through strategic engineering of the molecular environment. Integration of sterically demanding spiropyran derivatives in solvent-free confined space resulted in a breakthrough in the preconceived “speed limit” for photochromic molecules. The presented studies rely specifically on the design of a precise switch environment through integration within solvent-free metal-organic frameworks (MOFs). We showed that the constructed solvent-free pore environment led to a ~1,000-fold enhancement of the photoisomerization rate in the solid state even compared to the same spiropyran derivatives in solution, setting a record in the field. We employed this concept for the development of field-effect transistors, photochromic catalysts as well as “smart” absorbents. These practical aspects will be discussed in the presented work.

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Negative photochromism of biaryl-bridged imidazole dimers

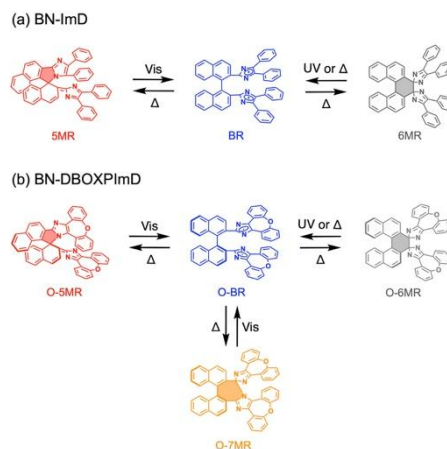
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As a representative class of T-type photochromic molecules with fast thermal reverse reactions, binaphthyl-bridged imidazole dimer (BN-ImD) derivatives have been extensively developed by our group^[1-5]. BN-ImD exhibits a unique negative photochromic reaction in which the thermally stable colored isomer, 5MR, converts to the metastable colorless isomer, 6MR, via the short-lived biradical, BR, upon visible light irradiation. We have previously developed a series of BN-ImD derivatives, including those responsive to near-infrared light^[2], those functioning as turn-on type fluorescence switches^[3], those enabling fully bidirectional photoisomerization^[4], and those exhibiting two-photon photochromism^[5].

Here, we present BN-DBOXPImD, featuring dibenzoxepine units integrated into a BN-ImD framework. BN-DBOXPImD exhibits a markedly accelerated thermal reversion from the metastable colorless isomer to the stable colored isomer. Although BN-ImD derivatives are known to undergo multi-state photoisomerization via a short-lived biradical intermediate, a quantitative assessment of each individual step has yet to be accomplished. Global analysis of the transient absorption spectra of the colored and colorless isomers enabled the determination of the rate constants and quantum yields for the individual photoisomerization processes. The photoconversion efficiency from the colored to the colorless isomer of BN-DBOXPImD was determined to be 0.082, corresponding to an approximate 19% enhancement over the previously reported value of 0.069 for BN-ImD. These findings highlight the critical role of structural flexibility in governing the photochromic behavior of BN-ImD and



offer a guiding framework for the rational design of next-generation molecular photoswitches exhibiting negative photochromism.

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Photoswitching for Energy Storage and Release

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Molecular photoswitches provide a powerful platform for storing and releasing photon energy through diverse light-induced transformations. Our work focuses on the design and development of organic systems that undergo reversible photoswitching processes, including E–Z isomerization, [2+2]/[4+4] cycloaddition, and Dewar isomerization. By tailoring these distinct reaction pathways, we demonstrate controllable conversion of photon energy into thermal output, phase transitions, and structural changes in condensed phase environments. This diversity of photochemical mechanisms enables us to tune energy densities, storage lifetimes, and release kinetics, ultimately advancing applications in photon-driven energy storage, emission-free fuels, and adaptive functional materials.

Designing Photoswitches to Restore Human Vision and Alleviate Pain

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Photopharmacology—the use of synthetic, light-switchable molecules to control biological function—has seen remarkable advances over the past two decades. A wide range of molecular targets, including ion channels, G protein–coupled receptors, receptor tyrosine kinases, cytoskeletal components, enzymes, transcription factors, and motor proteins, have been shown to be amenable to optical control. The question now is whether photopharmacological approaches can achieve true clinical relevance. In this talk, I will highlight efforts to restore vision using photoswitchable ligands, including ion channel blockers currently in phase 2 clinical development, and describe emerging strategies to alleviate acute and chronic pain through photoswitchable anesthetics and analgesics. Together, these examples illustrate the translational potential of photopharmacology to address unmet medical needs by enabling precise, reversible, and noninvasive control of biological function with light.

Concepts to control and power chemical reactions with light

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One of the ultimate goals in the material and life sciences is to control *when* and *where* specific physical, chemical, and biological processes take place. As chemists we therefore seek to perform chemistry with high spatial and temporal resolution. In our research group we are developing photoswitchable systems to optically control materials' properties, chemical and biological processes, as well as the function of various devices. In our endeavor light serves as a highly selective, non-invasive external stimulus in combination with photochromic molecules that resemble nanoscale optical remote controls. Our work is therefore devoted to developing and improving photoswitches and exploring them in a variety of applications, most notably in xolography where we harness photoswitches as dual color photoinitiators to enable this high-speed and high-resolution volumetric printing technology. My presentation will focus on the development of photoswitchable systems to control and drive dynamic covalent chemistry thereby allowing us to modulate thermal exchange equilibria by light. Specifically, I will focus on how to control reversible covalent bond formation and cleavage with photoswitches, provide some examples of dynamic covalent photoswitches, and discuss potential impact of such systems.

Radical Catalysis for Selective Molecular Transformations

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We aim to expand the frontiers of radical-based organic synthesis through the development of novel catalysts and reaction platforms. Radical intermediates offer unique reactivity profiles that enable transformations often inaccessible through conventional ionic pathways. In this lecture, we will present our recent efforts to advance radical chemistry by designing catalytic systems that allow precise control over radical species, thereby achieving highly selective and efficient molecular transformations.

Our current research focuses on three main areas. First, we explore light-driven radical catalysis, employing photoredox systems to promote sustainable and selective bond-forming reactions under mild conditions. Second, we develop radical-based methods for the chemical modification of nucleotides, aiming to generate functional nucleic acids for applications in chemical biology and therapeutics. Third, we design photolabile protecting groups for caging strategies that enable spatiotemporal control of bioactive molecules.

Prebiotically Plausible Photosynthesis of Lipids and Photocells

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Across all known evolutionary cell forms, lipid-enclosed compartments have prevailed as a universal hallmark of life. However, the chemical origin of the first lipids on Earth remains an unanswered question for prebiotic chemistry so far.

Here, we propose that early lipids were fatty acids synthesized by the photoconversion of hydrocarbon reservoirs floating on the late Hadean ocean. Our experiments demonstrate that irradiating a thin oil layer on water produces fatty acids—a process sustained by the light-dependent formation of reactive oxidizing species, which occurs even under the oxygen-free conditions that dominated primordial Earth. Notably, our findings suggest that in this molecular landscape, the two-layer geochemical environment promotes the formation of lipids: the oxidation of hydrocarbons at their termini becomes more favorable on water—overcoming statistical, thermodynamic, and kinetic factors. We prove that the oxidizing species originate from water molecules and that organization at the oil-water interface can indeed give rise to an autocatalytic cycle that biases toward the formation of fatty acids by end-chain oxidation.

Our results offer a novel perspective on fundamental photochemical and physical processes at the core of prebiotic lipid synthesis, paving the way toward a more universal and supramolecular-level understanding of the origins of life and its simple building blocks—that is, in stratified and ever more complex media.

Catalytic Photochemical Deracemization Reactions

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Photochemistry enables an access to reaction pathways that are not viable in conventional transformations. The talk will revolve around the conversion of a racemic mixture to a single enantiomer in a catalytic photochemical deracemization reaction.^{1,2} In an ideal scenario, quantitative yields of enantiomerically pure (>90% ee) compounds can be achieved in a single operation.

The entropically disfavored and thermally impossible process is driven by light energy. Product classes which have been successfully deracemized include chiral allenes, olefins, cyclopropanes, and heterocyclic compounds. The reactions are catalyzed by a single photocatalyst which either acts by energy transfer³ or by a reversible hydrogen atom transfer.⁴ Possible applications, the underlying mechanistic considerations, and ongoing work on the topic will be presented.

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Poster Presentations

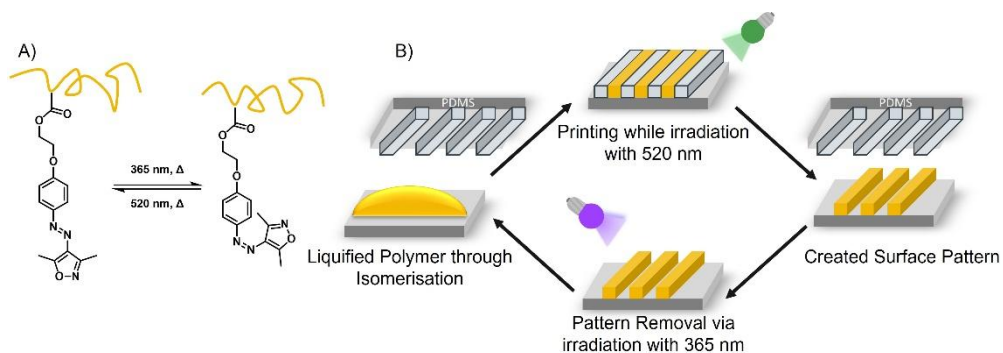
Photoresponsive Polymers for Flexible Surface Patterning (1)

Steffen Lohrmann

University of Münster, Organisch-Chemisches Institut

Over the years surface patterning has found increasing interest in a myriad of fields such as information storage, microelectronics, biomedical applications and many more. Polymers have been regularly utilized in a multitude of these techniques, for example UV-nanoimprint lithography.

Light as a stimulus, besides advantages like high spacial and temporal control, also offers the potential to involve the class of photoswitches. These molecules can reversibly isomerise upon light irradiation to trigger changes in various properties including wettability, adhesion or solubility. In the literature, photoswitches like azobenzene or arylazopyrazole have been utilized often on surfaces or in polymeric materials to change their properties. This work presents a novel photoresponsive polymer integrating arylazosioxazole (AIZ) photoswitches, which has been designed, synthesized and characterised. Furthermore, this photoresponsive polymeric material was tested for reversible surface patterning and expands the known library of materials utilizing AIZs for various applications.



Photoresponsive leaky dielectric fluids (2)

Carlo Rigoni

ISTA

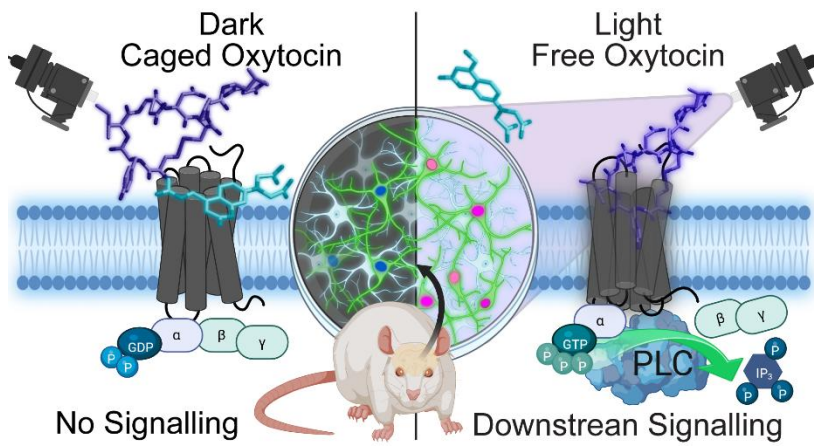
The leaky dielectric properties of mixtures of organic surfactants in nonpolar liquids are fundamental in many electrohydrodynamic phenomena and central for several cutting-edge applications. As of now, the way to tune the electrical properties of these systems is to regulate their composition: surfactant concentration, presence of water and choice of carrier liquid set the properties from the beginning. Here we show how the use of photoresponsive molecules allows to tune the electric properties in nonpolar liquids externally by light irradiation. In particular we focus on the properties of dispersions of azobenzenes as their conductivity can be regulated using two different wavelengths with opposing effects.

Photocaged oxytocin and vasopressin probes to decipher neuropeptide signalling with high spatiotemporal resolution (3)

Konstantin Raabe

University of Vienna, Institute of Biological Chemistry

The oxytocin/vasopressin (OT/VP) neuropeptide signalling system regulates a plethora of important functions in the central nervous system, including complex social behaviour, emotional responses, learning and memory, and its dysregulation is linked to several disorders. Despite decades of research, it remains challenging to accurately decipher the spatiotemporal dynamics of OT/VP signalling in the brain, particularly due to the widespread receptor expression, long half-lives of OT/VP and their distant diffusion. To address these challenges and expand the molecular toolbox for pharmacology and neuroscience, we investigated three classes of photolabile protecting groups for their use in precision brain studies. These photocages encompassed coumarin-, nitrophenylpropyl-, and boron-dipyrromethene-based derivatives, supporting controlled and localised release via light activation at one-photon excitation (365–527 nm) and two-photon excitation (745–800 nm) wavelengths, while avoiding cytotoxic cleavage products. Using these photocages, we developed OT and VP photoprobes and characterised their photochemical and pharmacological properties at their receptors (OTR, V1aR, V1bR). The coumarin- and nitrophenylpropyl-photoprobes worked best with effective masking of bioactivity when caged. Light at the corresponding uncaging wavelengths effectively released native OT and VP, resulting in localised receptor activation in cellular assays and primary rat hippocampal neurons. The photocages, along with their application protocols, are biocompatible, suited for complex cellular and neuronal systems, and, importantly, can be easily installed in a wide range of peptides. This will enable more sophisticated and precise experimental designs that will reveal new mechanistic details in peptide-related signalling in health and disease.

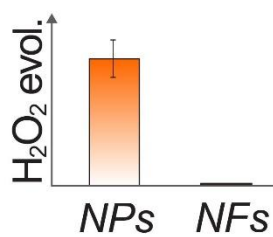
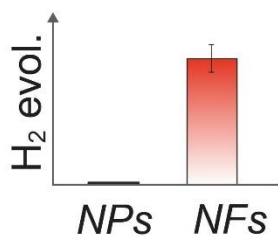
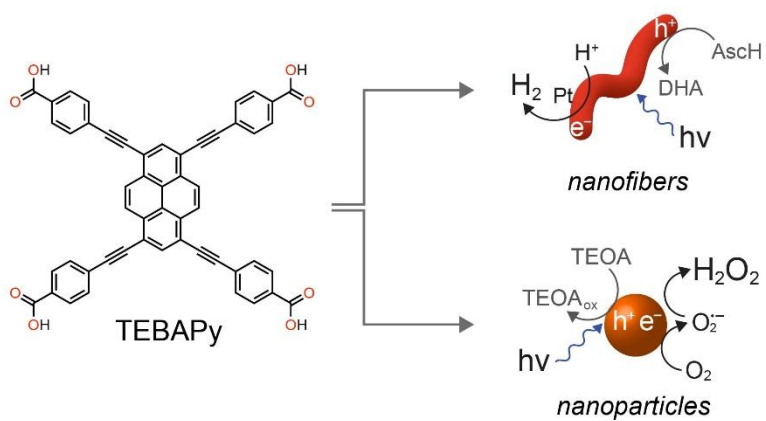


Controlled aggregation of pyrene-based supramolecular nanostructures for light-driven switchable H₂ and H₂O₂ production (4)

Marianna Barbieri

University of Padova

Self-assembled organic chromophores form nanostructures in solutions, with their molecular packing determining the optoelectronic properties and photocatalytic activity. Here we report a dye molecule, 1,3,6,8-tetrakis(4-(carboxylic acid)phenyl-1-ethynyl)pyrene (TEBAPy), that exhibits two aggregate states in aqueous conditions: nanofibers or nanoparticles depending on the charge-screening conditions. The nanofibers promote sacrificial photocatalytic hydrogen production (H₂, 84 mmol g⁻¹ h⁻¹) while the nanoparticles produce hydrogen peroxide (H₂O₂, 85 mmol g⁻¹ h⁻¹). Using a combination of structural and photophysical characterizations, we show that the photocatalytic activity is determined by the nature of the formed self-assembled aggregate, demonstrating the potential of self-assembled nanostructures to tune their activity and switch their reactivity. We show clear correlation between the presence of fibrous nanostructures and photocatalytic H₂ evolution, with spectroscopy showing mixing of excitonic states that is proposed to enable efficient charge separation over multiple chromophore units. In the nanoparticulate aggregates, on the other hand, the excitation is localized and leads to excimer formation that is involved in H₂O₂ production. The results illustrate the potential that molecular packing in self-assembled organic nanostructures has not only for optimizing solar fuels production, but also to achieve multiple and switchable photocatalytic functionalities with a single chromophore.



Dynamic control over dendritic transitions in soft matter systems (5)

Chanikan Wongkaew

University of Groningen

Cells reversibly change shape to interact with their environments—extending filopodia to migrate, forming dendrites to support synaptic function, or dividing through blebbing. While these processes are typically regulated biochemically, they also rely on fundamental physicochemical principles. Here, we demonstrate that minimal models of artificial cells can undergo reversible shape transformations driven by interfacial tension. A simple reduction in interfacial tension, combined with the insertion of molecular switches in the ordered interfacial layer of the droplet, triggers a transition from a globular shape to twisted dendritic protrusions. These protrusions are characterized by a uniform cross-section, and their number is strictly determined by the initial droplet size. This fully reversible mechanism for globular-to-dendritic transitions enables the controlled formation of complex morphologies, providing a platform to design soft systems and machineries that grow, sense, connect, and exert localized forces—strategies widely employed by living cells in fluid environments.

Light-driven molecular machines and lipid membranes (6)

Ainoa Guinart Planellas

University of Groningen

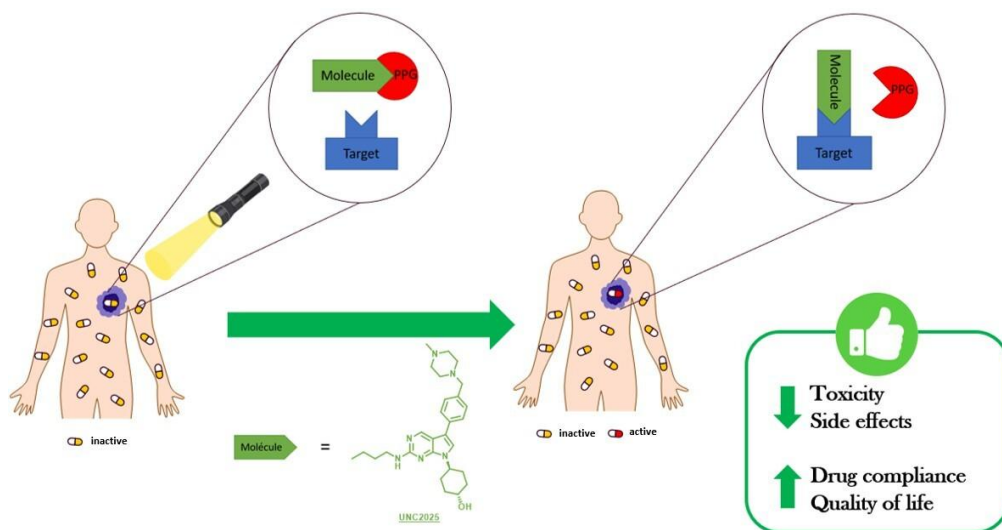
In nature, mechanical forces exerted by the cytoskeleton or proteinaceous coats are responsible for introducing membrane curvature and deformations, of most importance in crucial cellular processes such as differentiation, trafficking, and division. Controlling these deformations is key to regulate many fundamental biological functions. In this study, we present an innovative approach to induce curvature effects by integrating a rotary synthetic Feringa-type molecular motor into phospholipid membranes. We showcase the motor's capacity to incorporate and operate within both supported and free-standing systems. Our findings reveal the interplay between membrane-motor assemblies, elucidating their impact on rotary properties, including speed and quantum yield efficiencies, as well as membrane characteristics such as fluidity and tension. We conduct a systematic study on motor concentration, cholesterol content, membrane composition, local heating effects, and singlet oxygen generation on membrane systems. We demonstrate for the first time, the ability of molecular motors to induce sustained disequilibrium by exposing the system to visible light, thereby enabling on-demand deformations. Notably, our study uncovers a significant increase in the spread of deformations and shape transitions in giant lipid vesicles when they are irradiated, providing valuable insights into the dynamic behavior of this system. Overall, this research contributes to a comprehensive understanding of how molecular motors interact with lipid membranes, elucidating the multifaceted factors that govern membrane responses and shape transitions in the presence of these remarkable molecular machines. Our findings represent a significant advancement in comprehending and harnessing the potential of molecular motors in biological contexts.

Photopharmacological tools with π -extended coumarins based on TAM kinase inhibitor UNC2025 (7)

Sébastien Billotte

Paris Saclay University

Photopharmacology is an emerging therapeutic field that aims to control spatiotemporally drugs activity using light. Various strategies have been developed, including the photoremovable protecting groups (PPGs). This approach entails covalently attaching a photoremovable moiety to an active drug, which inactivates it. During light exposure, the PPG is cleaved, restoring the drug's initial activity. By triggering drug release through external stimuli, such processes enhance selectivity. This study aims to synthesize photocleavable tyrosine kinase inhibitors as a therapeutic tool against cancer. These inhibitors target the TAM kinase family (Tyro3, Axl, and Mer), known to be overexpressed in several types of cancers. They are based on the structure of a well-known inhibitor of this family, UNC2025. To develop effective photocleavable inhibitors suitable for clinical use, the nature of PPG is crucial. Indeed, PPGs should absorb at the highest possible wavelength closest to the therapeutic window to ensure good penetration and low phototoxicity. In this work, we describe the use of π -extended coumarins to afford photocleavable versions of UNC2025, which absorb in the visible light.



Concealed antiaromaticity and excited-state aromaticity in paracyclophanetetraenes (8)

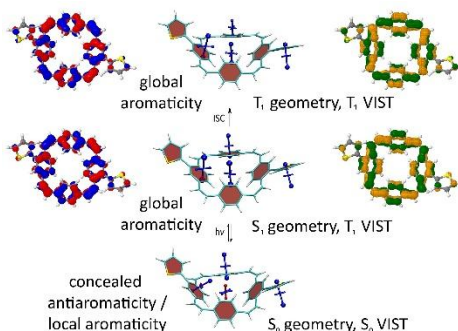
Florian Glöcklhofer

TU Vienna

The literature reports numerous conjugated molecules that are claimed to be antiaromatic because of a formal $4n$ π -electron system. However, this neglects the actual local aromaticity of the molecules, which often feature multiple subunits with $[4n+2]$ π -electrons besides the formal $4n$ π -electron system. This has led to considerable criticism from those who believe that the term antiaromatic should not be used for any molecule with a formal $4n$ π -electron system but should be reserved for truly antiaromatic molecules. To reconcile the different viewpoints, I recently introduced the term and concept of ‘concealed antiaromaticity’.[1] Concealed antiaromaticity acknowledges that many molecules claimed to be antiaromatic are not truly antiaromatic, but they can still exhibit behaviour under certain conditions – including in the excited state – that would normally be expected for antiaromatic molecules.

The concept will be introduced and discussed on the example of paracyclophanetetraene (PCT) and its derivatives (see Figure for a dithienyl-substituted PCT derivative), conjugated macrocycles that we have studied extensively in recent years.[2]

The concept of concealed antiaromaticity enables the conscious, rational design of molecules and materials that exhibit the desirable properties of antiaromatic molecules in redox reactions, upon photoexcitation, and in intermolecular interactions while avoiding or diminishing the undesirable low stability of antiaromatic compounds.



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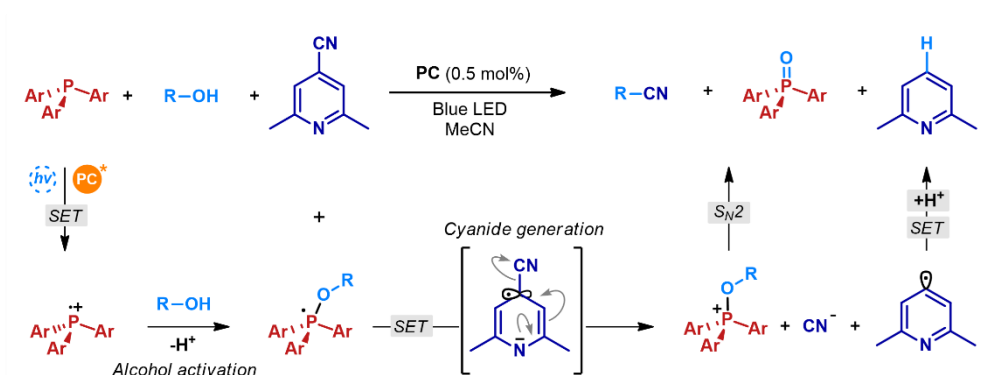
Mechanistic investigation of a fully photogenerated nucleophilic substitution reaction (9)

Igor Dmitriev

University of Barcelona

Photocatalytic methods have recently gained prominence in synthetic chemistry due to their mild conditions, broad functional group tolerance, and use of safer reagents compared to classic transformations. For example, in the Mitsunobu reaction, a cornerstone transformation in pharmaceutical research, toxic and potentially explosive reagents such as diethyl azodicarboxylate (DEAD) are employed. In this work we report the mechanistic details of a photocatalytic reaction that transforms an alcohol into a nitrile, where both the leaving group and the nucleophile are produced by photoinduced pathways, bypassing the need for the hazardous DEAD and streamlining cyanide introduction.

The studied reaction achieves this through reacting a combination of an aromatic phosphine, photocatalyst, and a heteroaromatic cyanoarene (e.g. 4-cyano-2,6-dimethylpyridine), transforming primary alcohols into nitriles upon irradiation with blue light. Our comprehensive mechanistic study employs a combination of transient absorption spectroscopy (TAS), in situ UV-Vis, cyclic voltammetry (CV), kinetic profiling and simulation, intermediate characterization, and computational studies. Altogether, the results suggest that alcohol is activated via formation of a phosphonium intermediate, akin to classical Mitsunobu chemistry. During this process, the cyanoarene functions as a sacrificial electron acceptor, forming a radical anion that undergoes cyanide elimination, yielding this useful nucleophile without employment of toxic precursors. The released cyanide participates in an S_N2 reaction with the Mitsunobu-type intermediate, furnishing the target nitrile in good yields. The precise nature of the aromatic phosphine and the cyanoarene ensures the similarity of the reduction potentials of the cyanoarene and the phosphonium intermediate, highlighting the possible driving force of the reaction.



Base-Assisted Direct Photoactivation of Bipyridine-Ligated Ni(II) Halides

(10)

Tereza Edlová

University of Chemistry and Technology, Prague

Nickel not only provides a cheaper and more abundant alternative to palladium for cross-coupling reactions, but its ability to engage in both single- and double-electron processes may also provide a wider range of applications. To exploit this attractive redox platform, photoredox initiation has emerged as a tool to access Ni(I)/Ni(III)-based catalysis under mild conditions.[1] While bipyridine-ligated Ni(I) halides are accessible through excited-state Ni–C bond homolysis of the corresponding Ni(II) aryl halides,[2] methods employing direct photoexcitation of air- and moisture-stable Ni(II) halide precatalysts have been developed only recently and the mechanism by which the catalytically active Ni(I) species is generated remains unclear.

In this work, we investigate the photochemical activation of bipyridine-ligated Ni(II) dihalides under catalytically relevant settings. Using spectroscopic methods, we show the influence of irradiation wavelength and the effect of basic additives frequently utilized in synthetic applications, which proved to be essential for photoactivation with lower-energy, blue light. Coupled with a computational study, we propose a divergent mechanism for reactive Ni(I) generation, in which near-UV and blue-light irradiation proceed via distinct pathways — the former through homolytic and the latter through heterolytic Ni–Cl bond dissociation. These findings advance the fundamental understanding of Ni(I) formation pathways, providing mechanistic insights to guide the rational development of more efficient Ni(I)-catalyzed transformations.

Acknowledgement: We thank for the financial support from the Czech Science Foundation (Grant No. 25-17760M, DB).

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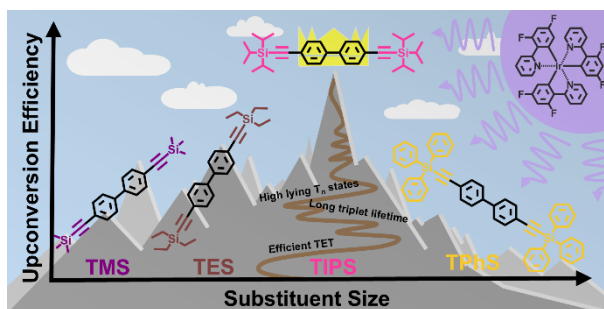
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At the “peak” of TTA upconversion: Clear advantages of TIPS substituents (11)

Julian Amir Moghtader

University of Mainz

With the increasing importance of triplet-triplet annihilation upconversion in applications such as light-driven catalysis, bio-imaging and 3D-printing, the need for highly efficient annihilators has increased significantly.[1] The attachment of the triisopropylsilyl ethynyl group (TIPS) to an aromatic core unit has led to the development of many annihilators with high annihilation quantum yields.[2,3] One major aspect of the TIPS substitution is to prevent excimer formation and therefore reduce unproductive competitive quenching pathways.[4,5] In our study, we synthesized a series of biphenyls with silyl substituents of varying size and employed them in blue-to-UV upconversion systems to explore the respective influence on the triplet energy transfer (TET) and the following triplet-triplet annihilation. We demonstrate that, in comparison to trimethylsilyl- (TMS), tritethylsilyl- (TES) or triphenylsilyl (TPhS)-derivatives, the TIPS-substituted biphenyl shows the longest triplet lifetime as well as high-lying, inaccessible T₂ and T₃ states, thereby reducing energy-wasting processes. Exploiting our findings, we developed a highly efficient UC system with the doubly TIPS-substituted biphenyl (bTIPS-BP) as annihilator. We employed this best-performing system for initiating the release of fluorescein from a photocage by blue-to-UV upconversion.



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Straightforward Access to New N,N-Bidentate Ligands for Visible Light-Driven Catalysis (12)

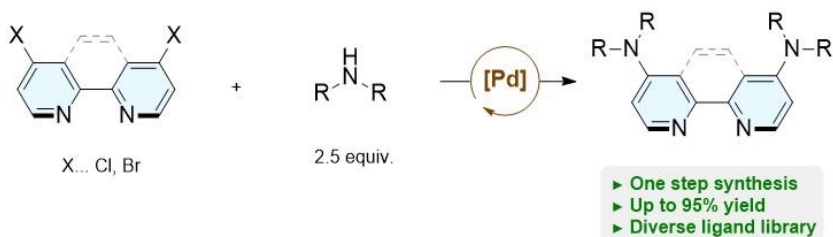
Adam Petrik

ISTA

Nickel-catalyzed cross-coupling reactions, such as C(sp²)–heteroatom formations, and C(sp²)–C(sp³) couplings that operate through NiI/NiIII cycles rely on redox-active N,N-bidentate ligands that are capable of delocalizing the metal's unpaired electron in the ligand's π^* -orbital. The vast majority of catalytic protocols apply a handful of commercially available 2,2'-bipyridines, such as 4,4'-di-tert-butyl-2,2'-bipyridine (dtbbpy), as ligands. As a result, the impact of structural ligand modifications on catalysis is underexplored.

We and others recently provided strong evidence that 2,2'-bipyridine ligands decorated with N-based substituents offer benefits compared to commercially available ligands in Ni-catalyzed coupling processes.⁽¹⁻³⁾ However, comprehensive studies that correlate the effects of changes in ligand structures with their impact on elementary steps of NiI/NiIII catalytic cycles are necessary to explore and understand the factors responsible for the unique reactivity observed. This is hampered by the lack of a general approach for preparing diverse ligand libraries.

To address this limitation, we developed a robust Buchwald–Hartwig amination protocol that serves as a general platform for the synthesis of 2,2'-bipyridine and 1,10-phenanthroline ligands decorated with N-based substituents. The method allowed us to prepare a structurally diverse ligand library in a single step from commercially available starting materials in good to excellent yields. This library has already led to the identification of a new ligand that enables a general approach to light-induced Ni-catalyzed C(sp²)-heteroatom cross-coupling.



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Investigating the Impact of Mechanical Resistance on the Full Operation of a Molecular Motor (13)

Mira Müller

Humboldt University Berlin

Molecular motors are capable of converting external stimuli into directional motion and, under mechanical load, can perform work on properly coupled systems. However, the application of such resistance also alters their efficiency and overall behavior. In this study, we systematically examine how mechanical load affects the complete operational cycle of a rotary molecular motor by constraining its motion with tethers of varying lengths. Upon sequential light irradiation and heating, the motor winds the tether, which functions as a mechanical resistance, limiting the number of 180° rotations. Short tethers impose greater resistance and allow only a single 180° rotation, while longer tethers impose less resistance and enable up to three successive 180° rotations. Our results reveal that both thermal and photochemical equilibria across the full cycle are influenced by the accumulating restoring force. These findings provide deeper insight into the fundamental operation of molecular machines and offer guiding principles for the design of systems capable of performing mechanical work efficiently.

Novel photoactuators for bacterial modulation: New strategies to tune antibiotic resistance (14)

Marta Ghidoli

Polytechnic University Milan

Light offers unique advantages for cellular stimulation, providing high spatiotemporal precision with minimal invasiveness. When combined with photoswitches, it enables remote and reversible modulation of biological functions. While widely explored in eukaryotic systems, this approach remains underutilized in bacteria, where processes such as ATP generation, signaling, and antibiotic adaptation are tightly linked to the membrane potential.

Here, we introduce a light-controlled strategy to influence antibiotic persistence using membrane-targeted azobenzenes, which have previously shown to modulate bacterial membrane potential upon photoactivation. Using *Bacillus subtilis* as a model, we tested two antibiotics with distinct mechanisms: Kanamycin, requiring cytosolic uptake to inhibit protein synthesis, and Ampicillin, which disrupts cell wall synthesis extracellularly.

Illumination with blue light (470 nm) in the presence of Ziapin2 strongly reduced the lethal effects of Kanamycin, indicating that membrane potential modulation affects drug uptake or accumulation. By contrast, Ampicillin activity was largely unchanged, consistent with its external target.

These findings demonstrate that light-driven control of membrane potential can selectively influence antibiotic action, offering a non-genetic, reversible tool to study bacterial physiology and suggesting novel strategies to tackle antibiotic resistance [1],[2],[3].

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Why do Coordination Cages Accelerate Anthracene Dimerization Reactions? (15)

Cyprien Muller

ISTA

We have shown in recent years that a Pd₆L₄ water-soluble coordination cage can encapsulate a myriad of water-insoluble guests and enable or accelerate their reactivity, including photochemical reactivity. For instance, anthracenes, which form a 2:1 complex with this host, tend to be dimerized much more efficiently upon UV-light irradiation compared to the same reaction in an organic solvent. The most obvious rationale for this improved reactivity is that nanoconfinement brings the reaction partners together, facilitating their encounter. With that hypothesis in mind, other hosts of similar size and structure should perform equally well. In this work, we aimed to test that hypothesis by studying the dimerization kinetics of three haloanthracenes inside our typical Pd host as well as a newly developed Pt host by UV-vis and NMR spectroscopies. Owing to the lanthanide contraction, Pd and Pt have similar radii and both cages should thus be of comparable sizes, as evidenced by X-ray diffraction. Yet, we show that, when switching the host from Pd to Pt, the rate of dimerization increases by a factor of 2 and 5 for Br-Anthracene and Cl-Anthracene, respectively, whereas the rate of dimerization of I-Anthracene is not impacted. These results hint at the fact that the confinement effect mentioned above cannot be the only one at play in this process. Cage dynamics (i.e., Pd/Pt–N bond on/off rates), which are much slower for the Pt host and its complexes, might play an important role. The study of that well-known photochemical process thus shows that the way coordination cages impact reactivity might be more complex than once thought.

Photoacidic polyelectrolytes (16)

Carlo Gericke

University of Padova

The development of photo-responsive systems has garnered significant attention due to their versatile applications as switches across various domains of organic, biological,¹ and supramolecular chemistry.² Among different stimuli 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 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. 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 multiple (Figure 1a), and modulated (Figure 1b) pH jumps. The results presented here hold promise for the fabrication of materials for photocurrent generation.

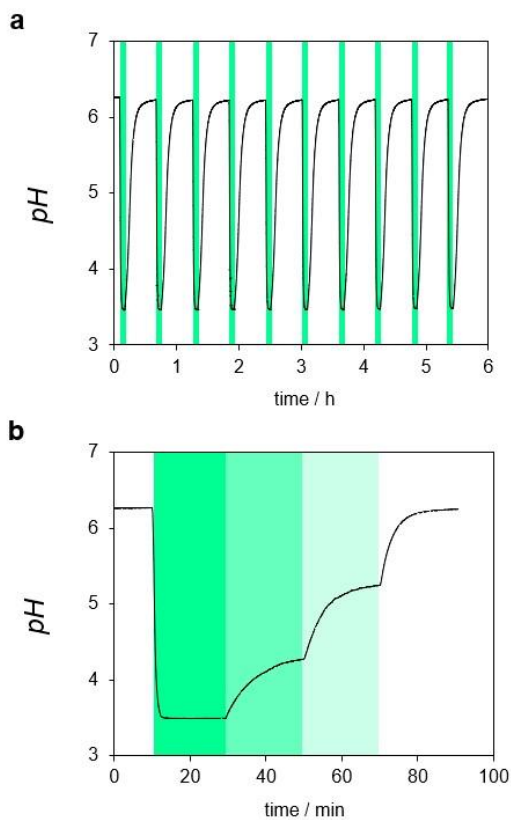


Figure 1. Multiple (a) and modulated (b) pH jumps of the 5% MCH containing polymer. *Exp. cond.*: [MCH-co-SPMA] = 25 mg/mL, $T = 25^{\circ}\text{C}$, light intensity: (a) 5 minutes 55.6 mW/cm^2 , 45 minutes dark; (b) 5 minutes consecutively of 55.6, 5.01, and 1.12 mW/cm^2 .

References:

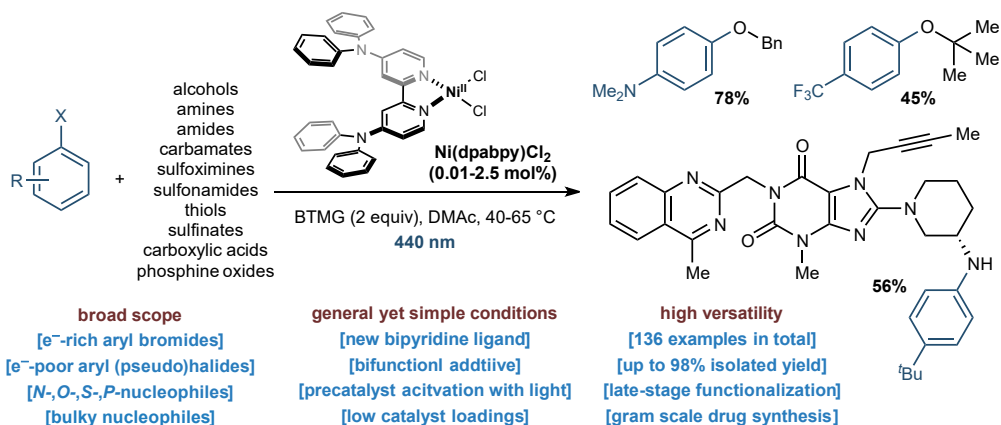
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A general strategy for light-mediated nickel-catalyzed C(sp²)-heteroatom cross-couplings (17)

Aleksander Bena

ISTA

C(sp²)-heteroatom cross-couplings are central to the synthesis of pharmaceuticals, agrochemicals, and materials, yet current methods often rely on elaborate ligands, expensive catalysts, or narrow substrate scopes. We report a broadly applicable strategy for light-mediated nickel-catalyzed C(sp²)-heteroatom cross-couplings enabled by the combination of a new electron-rich bipyridine ligand (4,4'-diphenylamino-2,2'-bipyridine, dpabpy) and Barton's base (BTMG) as a key additive. This platform exploits direct activation of a Ni(II) pre-catalysts using visible light to access a Ni(I)/Ni(III) catalytic cycle that allows for efficient couplings of both electron-rich and electron-poor aryl halides with a wide array of nucleophiles, such as alcohols, amines, thiols, or carboxylic acids. The method tolerates a variety of functional groups, enables late-stage modification of bioactive molecules, and unlocks cross-couplings using low Ni catalyst loadings (down to 100 ppm). We anticipate that this practical and versatile methodology will be valuable for research in both academic and industrial laboratories, offering a powerful new tool for the construction of C(sp²)-heteroatom bonds.



The Development of Opto-ABPP (18)

Niccolo Azzini

Imperial College London

Photopharmacology is an attractive area of research where light is used as an external stimulus for improved spatial and temporal control. Photopharmacology has been applied to a wide range of biological machinery and processes. However, this approach has often been limited by the drug designer process, which requires careful target selection. ABPP is a chemical proteomics technology developed by Cravatt and colleagues by which synthetically simple “scout-fragments” are submitted to the proteome of the cell. These electrophilic scout fragments function as a bait to catch broad ranges of proteins by binding to nucleophilic amino acids residues.

By combining these two technologies, we set out to develop a library of photoswitchable stereoprobes to investigate light-dependent ligation across the cancer proteome, adding another dimension to high-throughput proteomics. We started by developing a library of photoswitchable molecules based on the tryptoline stereoscaffold. The photoswitchable fragments varied from the classical azobenzene design used in photopharmacology, to newer version such as the arylazopyrazoles.

These compounds were then investigated with the ABPP technology. The biological assays that were performed found a series of light- and stereoselective liganding events across different proteins. We were able to find a combination of many new and previously identified ligandable, nucleophilic cysteines on a proteome-wide scale. The development of this opto-ABPP protocol will streamline the identification of novel photopharmaceutical targets, offering researchers a faster pathway to rational design of photopharmaceutical drugs.

Shining new light on the synthesis of lactams: Photochemical synthesis of oxindole derivatives (19)

Dorottya Mikoczi

TU Vienna

Oxindoles represent a valuable scaffold in medicinal chemistry due to their prevalence in bioactive natural products and pharmaceutical agents. We report a novel photochemical methodology for the efficient synthesis of oxindoles via intramolecular radical cyclization. This approach leverages visible-light irradiation to initiate carbamoyl radical formation by traceless decarboxylation of a carboxylic acid precursor enabling ring closure. The reaction proceeds under mild conditions offering a sustainable method to prepare oxindole compounds. A key advantage of this strategy is its broad functional group tolerance, accommodating diverse modifications on the olefinic moiety as well as varied substitutions on the amine component. This flexibility enhances the potential for structural diversification of the oxindole core. This work expands the synthetic utility of photochemistry in constructing heterocycles and offers new avenues for drug discovery and development.

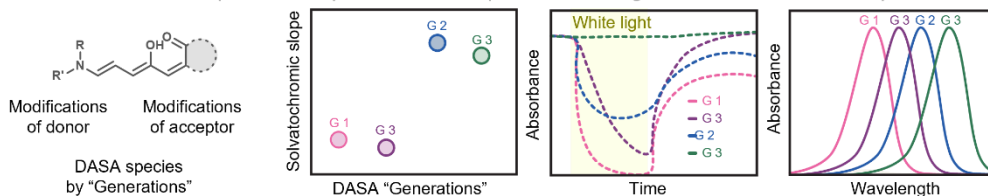
Beyond DASA generations to access highly predictable switching behavior (20)

Jesus Guillen Campos

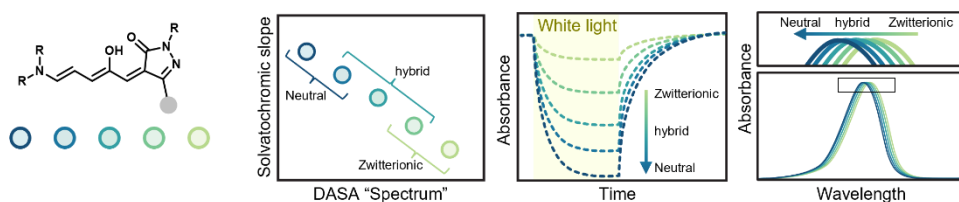
Tampere University

The development of donor-acceptor Stenhouse adducts (DASAs) photoswitches has been tightly linked to their "generational" development. However, this generational labels applied in previous work fail to capture the nuanced and sometimes erratic behavior introduced by substitution patterns, solvent effects, and competing kinetic pathways. Herein, we present a new DASA-design platform that enables highly and easily predictable switching behavior, absorbance profiles and photo-stationary states. These DASAs are introduced in liquid crystal elastomers enabling high correlation of chemical substitution pattern to macroscopic contraction forces.

Previous DASA development: Complex and hard to predict switching kinetics and absorbance profiles



This work: Predictable and fine controlled switching kinetics with similar absorbance profiles

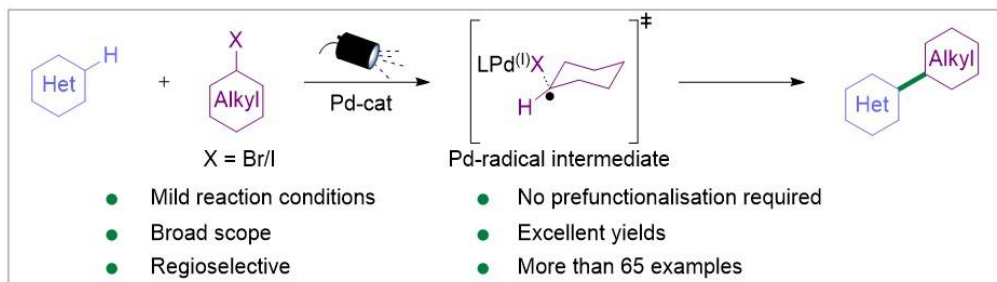


Radical Heterocycle Alkylation via Light-mediated Palladium Catalysis (21)

Sudip Senapati

University of Bayreuth

The direct C–H alkylation of heterocycles represents a powerful strategy for the late-stage functionalization of biologically relevant molecules. However, a broadly applicable strategy leveraging readily available alkyl surrogates has remained elusive. This study presents a mild, light-mediated palladium-catalyzed method that enables efficient C–H alkylation of a wide range of heteroarenes using alkyl halides. Mechanistic investigations, supported by experimental data and computational analysis, suggest a key sequence involving visible light-induced generation of hybrid alkyl Pd radical intermediates, radical addition to the heterocycle, base-assisted deprotonation, and palladium-mediated oxidation. Demonstrating broad utility, this methodology was successfully applied to the late-stage modification of complex natural product and pharmaceutical frameworks.



Reference:

S. Senapati, S. K. Hota, L. Kloene, C. Empel, S. Murarka, R. M. Koenigs, *Angew. Chem. Int. Ed. Engl.* **2024**, 64, e202417107.

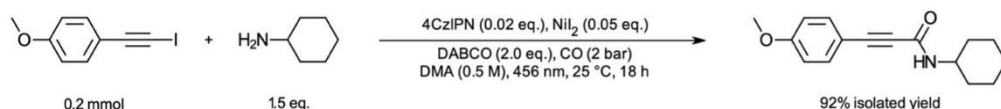
Visible light-induced nickel-catalyzed aminocarbonylative synthesis of 2-ynamides (22)

Michael Weiser

TU Vienna

The structural motif of 2-ynamides plays a pivotal role in the development of pharmaceutically and agriculturally valuable products, as well as versatile building blocks. This significance sparked the development of various synthetic strategies aiming for 2-ynamides and catalytic strategies relying on easily available CO attracted particular interest. However, these approaches inevitably rely on the use of Pd-based catalysts.[1] Light-induced and Ni-catalyzed cross-couplings have emerged as a powerful alternative to the traditional ligand-based Pd-catalyzed systems.[2]

Inspired by these advances, we developed a light-induced and Ni-catalyzed aminocarbonylation process for the synthesis of 2-ynamides. The optimized protocol utilizes readily accessible alkynyl iodides as starting materials and commercially available, bench-stable nickel iodide and 4CzIPN as catalysts. The reactions were performed in a custom-made photo-autoclave at low CO pressure and under visible-light irradiation, affording the desired 2-ynamides in excellent yield.



Acknowledgments: This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program (Grant agreement No. 864991).

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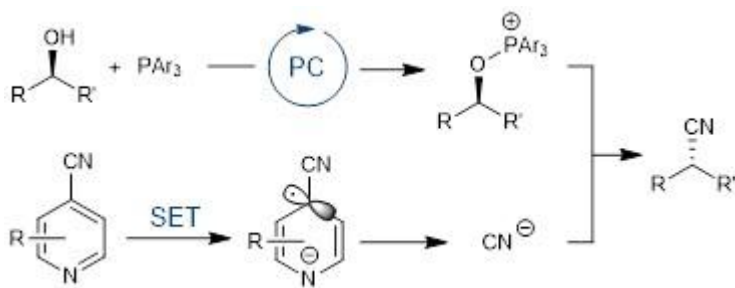
Cyanation of alcohols through photoredox-initiated S_N2 reactions (23)

Trisha Banik

ISTA

Alcohols are abundant, highly attractive starting materials for organic synthesis, but cannot be directly employed to access other valuable functional motifs through nucleophilic substitution reactions because the hydroxide is a poor leaving group. Instead, alcohols are converted to halides or sulfonates prior to the functional group interconversion of interest. Alternatively, Mitsunobu-type reactions that use triphenylphosphine in combination with azodicarboxylates (e.g., DEAD) to generate an oxyphosphonium intermediate—a good leaving group—are used, but azo reagents are toxic and shock-sensitive. Turning an alcohol into a nitrile—a versatile functionality that is widely encountered in the synthesis of materials, pharmaceuticals, and agrochemicals—bears additional safety concerns, because hazardous cyanation reagents, such as highly toxic and volatile HCN and TMSCN, are required.

Here, we show that photoredox catalysis can be leveraged to overcome these long-standing problems. The excited photocatalyst triggers the formation of oxyphosphonium intermediates from alcohols and a triaryl phosphine without the addition of DEAD. Bench-stable and non-toxic cyanopyridine derivatives serve as cyanide surrogates that undergo reductive fragmentation induced by a single electron transfer event, thereby enabling the desired S_N2 reaction to forge alkyl nitrile products in one pot. The mechanistic blueprint merges photoredox catalytic activation of substrates and reagents with ground-state substitution chemistry that can be further expanded to chlorinations, brominations and iodinations.



The QUAD Light-Probe: NMR Integrated Light Excitation (24)

Gaëtan Assemat

QUAD Systems AG

This poster will present the QUAD Light-Probe, an NMR probe with integrated LEDs that allow for seamless integration of light excitation into an NMR spectrometer. No tube inserts, no fibres, no hassle.

The LEDs of different wavelengths are controlled via TTL triggers from the spectrometer. The probe is fully compatible with automatic sample changers and high-throughput screening. Due to a smart electronic design and careful choice of LEDs, there is no compromise in NMR sensitivity, i.e., it is a fully functional NMR probe with competitive sensitivity and lineshapes. The probe can be used with QUAD Systems spectrometers, but it is also compatible with Bruker and Varian spectrometers.

We will show results for different photochemical experiments, such as molecular rearrangements, photo-induced polymerization, and photo-CIDNP.

Heavier Main Group Chemistry and Molecular Photoswitches? (25)

Andreas Orthaber

Uppsala University

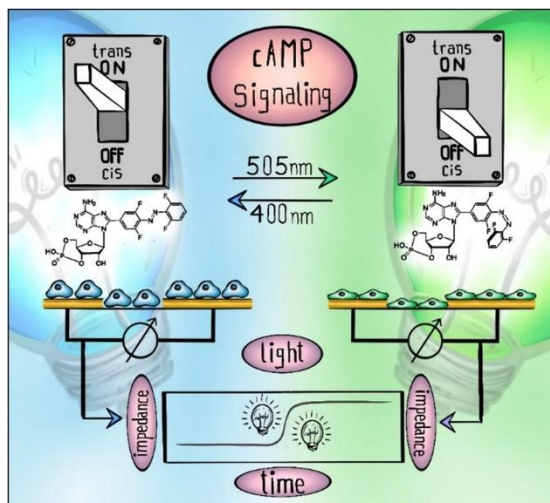
No abstract provided.

Reversible Control of cAMP Activity in Living Cells by Visible Light (26)

Christoph Haag

University of Regensburg

Cyclic adenosine monophosphate (cAMP) is one of the most prominent molecules involved in intracellular signaling. As a second messenger, it regulates a plethora of biochemical processes that are essential to keep a cell alive and orchestrates physiological responses to external stimuli. Ever since its discovery, great efforts have been made to elucidate all the molecular mechanisms involved in cAMP-mediated signaling cascades. However, experimental evidence suggests that cAMP-mediated signal transduction is much more complex than previously assumed. For new insights, it is crucial to study the real-time dynamics and reversibility of the cAMP-related signaling mechanisms, which often remain disguised by classic pharmacological assays or modulators of cAMP signaling. By chemically attaching a photoswitchable moiety to cAMP, we got control over the biological activity of the molecule through visible light of different wavelengths. Combined with label-free electric cell-substrate impedance sensing (ECIS), the dynamic response of living cells treated with photochromic cAMP has been monitored in real time while the cAMP-mediated signaling cascade is reversibly switched on and off by visible light with high temporal resolution.



Carbon nitride materials as heterogeneous photocatalyst in C–H bond functionalization processes (27)

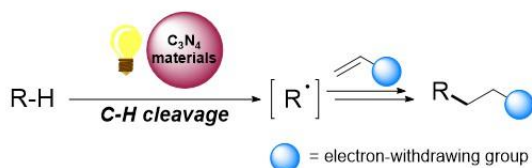
Davide Ravelli

University of Pavia

Graphitic carbon nitride (C₃N₄) semiconductors are inexpensive and reusable photocatalysts, which are actively studied in organic synthesis. [1] Such materials are widely appreciated for their capability to trigger single electron transfer (SET) processes with organic substrates upon irradiation with visible light. Such mechanism, however, limits the number of competent substrates to compounds characterized by modest redox potentials, at any rate matching the redox potentials of the photocatalyst itself. [1]

Much less explored is the possibility to directly functionalize C–H bonds in aliphatic substrates. Along this line, we hereby report an innovative redox-neutral application of carbon nitride materials in a Giese-type reaction between ethers, amides, etc. (R–H) and electron-poor olefins (see Figure 1). The preparative studies have been supplemented by dedicated mechanistic experiments, in particular intermolecular and parallel kinetic isotopic effect (KIE) studies, as well as deuteration studies. Overall, this work points to the involvement of a proton-coupled electron transfer (PCET) mechanism in the key C–H cleavage event in R–H. [2]

General reaction scheme of C-H cleavage



Selected H donors (R-H)

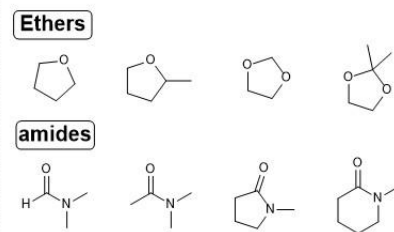


Figure 1. Carbon nitride materials as heterogeneous photocatalyst in C–H bond functionalization. General reaction scheme (left part) and selected C–H substrates (right part).

Acknowledgements: Financial support through the HORIZON-EIC-2021-PATHFINDEROPEN-01 project CATART (GA 101046836) entitled

“Reaction robot with intimate photocatalytic and separation functions in a 3-D network driven by artificial intelligence” is gratefully acknowledged.

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Superziapin: A Non-Specific Azobenzene Photoswitch for Optical Modulation of Membrane Excitability (28)

Paola Moretti

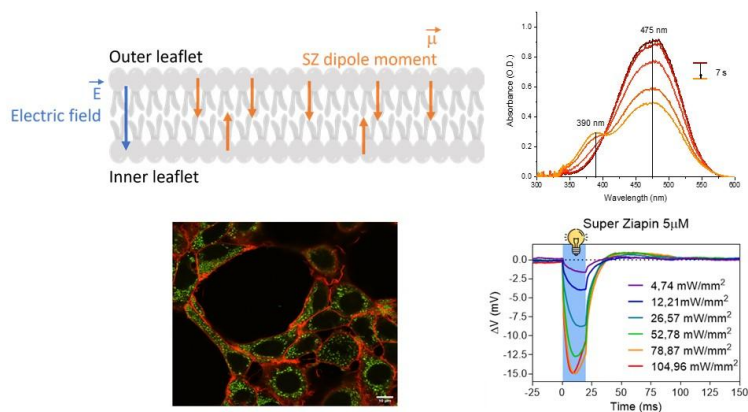
Polytechnic University Milan

Precise modulation of cellular activity is a cornerstone of modern biomedical research and therapeutic innovation. Photopharmacology offers a powerful strategy to achieve this control by using light-responsive molecules to regulate biological functions with high spatiotemporal resolution. This work focuses on Superziapin (SZ) a new non-specific, membrane-targeted azobenzene-based photoswitch designed to overcome limitations of earlier compounds such as poor solubility, and suboptimal photophysical properties.

Superziapin features an unsymmetrical push–pull azobenzene scaffold, with an azepane donor able to generate dimers. The presence of cationic terminations on the azobenzene structure provides an amphiphilic nature to the compound that is thus able to spontaneously partition in the cell membrane. DFT simulations reveal a dipole reorientation of $\sim 90^\circ$, aligning with the membrane electric field in the trans state and disrupting it in the cis state. Upon illumination, SZ undergoes trans–cis isomerization, inducing a conformational change that modulates membrane capacitance and triggers cellular depolarization through a combined mechanical (dimers disruption) and electrical (dipole reorientation) modulation. This mechanism enables reversible, light-driven modulation of membrane potential without direct interaction with ion channels.

Photophysical characterization shows SZ absorbs in the visible range ($\lambda_{\text{max}} \sim 474\text{--}485\text{ nm}$), with fast thermal back-isomerization ($\tau \approx 27\text{ s}$) and good fatigue resistance. In vitro studies confirm membrane localization and biocompatibility, with electrophysiological recordings in HEK293 and hiPSC-derived cardiomyocytes demonstrating light-induced hyperpolarization followed by rebound depolarization. Notably, SZ elicits responses up to three times stronger than previous analogues even at lower concentrations and light doses.

Superziapin thus emerges as a promising tool for non-invasive, reversible control of cellular excitability. Its modular design and robust performance position it as a candidate for future applications in neuromodulation, cardiac pacing, and bioelectronic interfaces.



Top left - Sketch of the membrane lipid bilayer showing the preferential localization of SZ molecules in the outer leaflet, as the molecular dipole moment tends to align to the electric field. Top right – Absorbance of 20 μ M SZ in DMSO over time under illumination with a 470 nm LED. Bottom left – Confocal fluorescence microscopy images showing cellular localization of SZ using CellMask DeepRed. Bottom right - Electrophysiology traces of Superziapin in HEK293 cells.

Singlet and Triplet Contributions to Photoredox Processes in TADF Chromophores (29)

Federica Fina

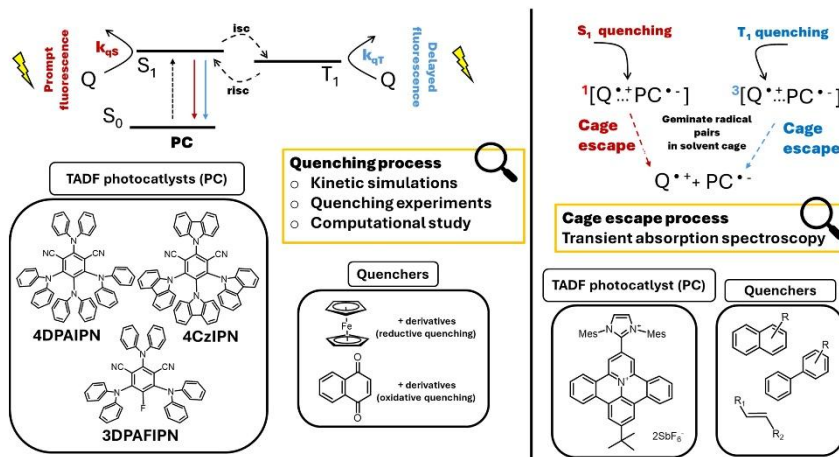
University of Bologna

Chromophores exhibiting thermally activated delayed fluorescence (TADF) are increasingly applied in photoredox catalysis. According to the substrate concentration, photoinduced electron transfer (PeT) can proceed from both singlet (S_1) and triplet (T_1) excited states.[1,2] Understanding the difference in reactivity between these states is essential for optimizing photocatalytic performance and must be carefully studied.

We investigated three representative TADF chromophores (4CzIPN, 4DPAIPN, 3DPAFIPN) in both oxidative and reductive PeT quenching reactions. Kinetic simulations show that Stern–Volmer analysis based on prompt and delayed fluorescence lifetimes—rather than integrated intensities—provides accurate bimolecular quenching constants. Reductive quenching resulted significantly faster from S_1 than from T_1 , while oxidative quenching rates are comparable. Electronic structure calculations suggest that these differences stem from distinct spatial electron–hole distributions in the excited states.

The investigation of singlet and triplet reactivity was further extended in a second project focusing on the inherent quenching efficiency, using a fourth, highly oxidizing TADF chromophore.[4] Our aim was to investigate cage escape quantum yields for the resulting radical cations, hypothesizing that it is more efficient from T_1 than S_1 due to the spin-forbidden in-cage charge recombination in the triplet state, which reduces unproductive back electron transfer.[5,6] Using nanosecond transient absorption spectroscopy with an oxidizable quencher, we monitored and quantified the formation of the radicals as a measure of cage escape efficiency.

These findings provide important insight into the excited-state and post-quenching reactivity of TADF photocatalysts, offering a basis for the rational design of more efficient photoredox systems for synthetic applications.



References:

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Live-Shaping of Hydrogel Thin Films with Light (30)

Matias Paatelainen

Tampere University

Microscopic surface structures in nature serve functions like wetting control, adhesion, and camouflage. Examples include water-repellent surfaces of rose petals and lotus leaves, and photonic crystals on butterfly wings and peacock feathers. Dynamic variants, such as cephalopod skin and chameleon photonic crystals, offer sophisticated control for camouflage and communication. Inspired by these natural structures, artificial dynamic surfaces are being developed for applications in flow control, environmental sensing, active photonic components, and dynamic cell study platforms. Hydrogels, with their tunable chemistry, tissue-like properties, and biocompatibility, are ideal for mimicking living functions. Light-responsive hydrogels are particularly promising for precise, non-invasive control in microactuators and biological devices, and have been demonstrated in remote-triggered drug delivery, soft actuators, and mechano-active cell platforms. However, challenges remain, such as slow actuation times and limited spatial resolution, which constrain applications like body action recreation and photonics. Addressing these limitations, we have developed a method for fast, dynamic, and reconfigurable shaping of hydrogel thin films by controlling a light-responsive supramolecular inclusion complex within the system. The fast dynamics of the hydrogel platform allow expansion-contraction cycles with up to 2 Hz frequency. Fully reconfigurable and dynamically changing surface features can be created within seconds and with sub-micron resolution on top of hydrogel films. Additionally, we show that the fast dynamics can be adapted to free-standing hydrogel films, mimicking chameleon skin color change at respiration frequency.

Electronic Structure Insights Linking Photochemical Ni(I) Generation to Reactivity (31)

Daniel Bím

University of Chemistry and Technology, Prague

Ni(I)/Ni(III) cycles drive many nickel-catalyzed cross-coupling reactions, with the initial generation of Ni(I) often determining reactivity and catalytic efficiency. One of the widely used strategy for accessing Ni(I) in situ employs Ni(II)–bipyridine aryl halide complexes as stable, but directly photochemically activatable precatalysts.[1] Upon visible-light excitation, these complexes undergo Ni–C(aryl) bond homolysis, delivering the reactive Ni(I) intermediates that enter the catalytic cycle. The efficiency of this step depends on the Ni electronic structure, yet the precise ground- and excited-state pathways have been unclear.

We resolve these questions through an integrated computational–synthetic–spectroscopic approach. Time-dependent DFT and multireference (CASSCF/QD-NEVPT2) calculations identify dissociative ligand-to-metal charge-transfer (LMCT) states as the direct drivers of Ni–C bond homolysis. Systematic variation of bipyridine and aryl substituents, quantified through Hammett correlations and charge-transfer energetics, defines how ligand electronics modulate this process.[2]

A geometrically constrained (tethered) Ni(II) complex highlights the effect of ligand rigidity, stabilizing a reversible [Ni(I)...aryl•] contact pair in the excited state. Transient absorption spectroscopy supports the computed excited-state picture and underscores the role of structural constraints in photoreactivity.[3]

Finally, we establish the Ni 3d(z^2) orbital energy as a quantitative predictor of downstream oxidative-addition rates and off-cycle dimerization. These insights provide clear, generalizable design rules for Ni(I) reactivity and enable rational design of next-generation photoactive nickel catalysts.[4],[5]

Funding: Czech Science Foundation, Grant No. 25-17760M (DB)

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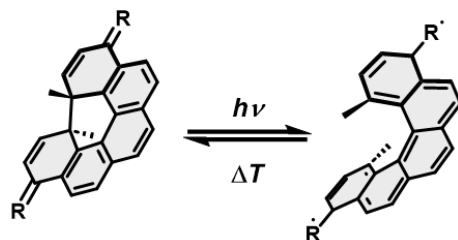
Mechanistic Insights on an Asymmetric All-Organic Photochemical Spin-State Switch (32)

Clara Douglas

University of Cologne

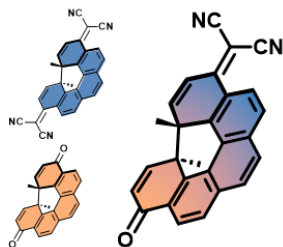
The design of organic spin-state switches is a desirable goal for synthetic chemists, as these molecules promise applications in information technology, data storage and quantum computing. In this work, we report on mechanistic insights into the reversible formation of a paramagnetic triplet state upon irradiation in four all-organic helicene-based photochemical spin-state switches. Two entries are introduced into the series to examine the influence of asymmetrically substitution and the introduction of radical stabilizing groups on the switching behavior. Transient absorption spectroscopy and time-resolved EPR spectroscopy give insights into the mechanism of the formation of the triplet state.

established reactivity



For R = O, C(CN)₂

this work



asymmetric switching



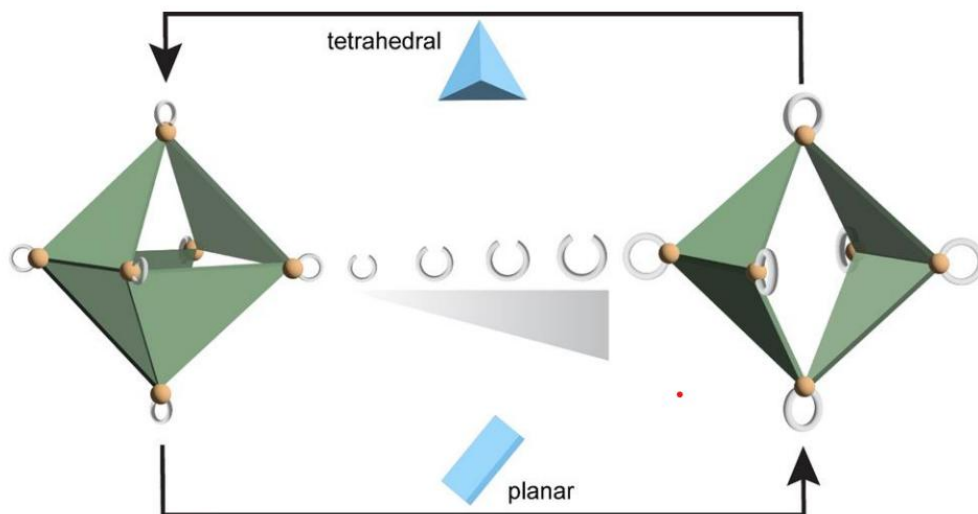
radical stabilization

Orthogonal control of structure and photocatalytic activity of adaptive supramolecular hosts (33)

Promeet Saha

ISTA

The structures of self-assembled supramolecular hosts have a profound impact on the encapsulated guests and hence, the catalytic activity of the host. While most metal–organic cages persist as a single isomer, we previously reported the dynamic nature of a Pd_6L_4 cage, which can transform into a constitutionally different host upon guest encapsulation. Here, we show that the shape of a series of Pd_6L_4 hosts can be toggled between a rigid capsule-shaped (C) and a flexible tube (T) isomer in an orthogonal manner upon (i) systematic increase in the bulkiness of the ancillary ligands; and (ii) encapsulation of tetrahedrally-shaped or planar guests, respectively. We find that, while hosts with T-architectures enable the visible-light-sensitized disequilibrium of encapsulated E-azobenzenes to the metastable Z isomer, the C-architecture facilitates the back-isomerization of Z to the E isomer. The dynamic nature of these supramolecular hosts paves the way for the development of adaptive catalytic systems in aqueous media, which can be switched ‘on’ or ‘off’ upon the action of external stimuli.



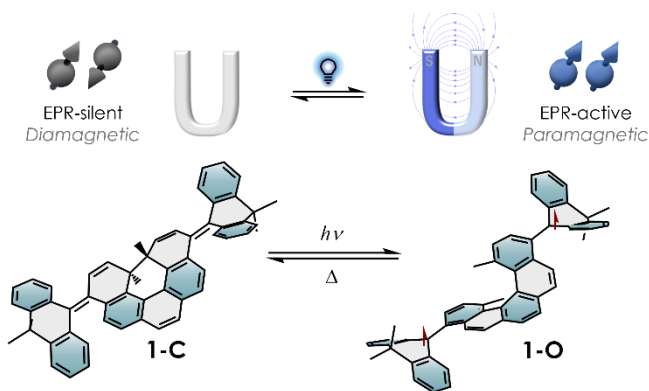
Spin-State Photoswitching in a [5]Helicene-Based Hydrocarbon (34)

Takuma Miyamura

University of Cologne

Precisely controlling the spin state of molecular entities in a reversible manner is one of the longest standing challenges and motivations for scientists. It is especially challenging for stable and purely organic molecules because they are usually locked in a closed-shell electronic configuration.[1,2]

This contribution focuses on the development of helical photochemical spin-state switches.[3] Initially, 1,14-($\pm$)-dimethyl[5]helicene was used in designing a photochemical switch with (meta)stable spin states. By introducing dimethylantranyl substituents at the 4th and 11th positions, the [5]helicene core undergoes photochemical retroelectrocyclization to form a paramagnetic species (1-O, Figure 1).[4] The back reaction to its initial form 1-C can be triggered thermally or by quantum tunnelling at cryogenic temperatures. At high temperatures, a photoisomerisation has been proposed, making this system a unique spin-state photoswitch with dual functionalities.



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- [4] Recent results (unpublished).

A molecular machine directs the synthesis of a catenane (35)

Tommy Wachsmuth

Humboldt University Berlin

Precise mechanical manipulation of molecules is inherently difficult due to random thermal motion. While directed movement on the molecular scale has been achieved, using it to impose specific, especially energetically disfavored, shapes on molecules and construct mechanically interlocked structures remains a fundamental challenge. Here, we report the synthesis of a catenane enabled by a molecular motor that winds molecular strands into discrete entangled structures, each defined by a specific number of mechanical crossings. Light energy drives unidirectional motor rotation, enabling path-dependent control over a sequence of thermodynamically disfavored yet mechanically distinct and kinetically stable winding states, which are covalently captured and subsequently released to yield a catenane. This machine-directed approach offers a general proof-of-concept strategy for the template-free construction of mechanically interlocked molecules.

Controlling the energy landscape of actuators through interdependent stimuli (36)

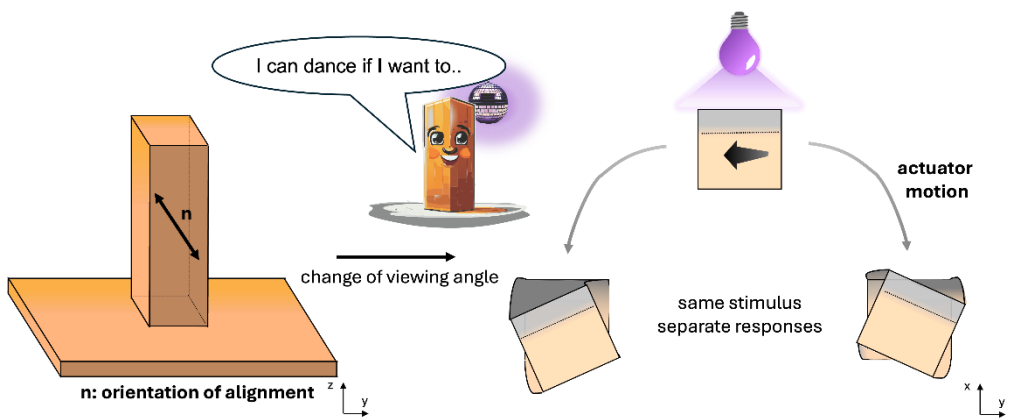
Friedrich Stricker

Harvard University

Over millennia of evolution nature has mastered the ability to control complex energy landscapes enabling cells or proteins to continuously modulate and change their activity based on the input of multiple independent stimuli. Emulating such materials particularly for soft-material actuators promises high degree of functionality while minimizing the number of required inputs.

Synthetically however most materials used – such as liquid crystal elastomers (LCEs) – are based on binary systems where one input results in one specific output with orthogonality providing more complex systems. In LCEs actuation is based on a single-phase transition providing the amplification of a molecular reorientation to a macroscopic shape change. This limits complex motion to be based on careful control of alignment or introduction of patternable input-output systems. Achieving continuous dynamic mechanical response maps to a combination of stimuli within a single material system would vastly widen the synthetic design space.

Here we present a liquid crystal elastomer system with multiple ordered phases. By introducing order to order transitions this system accesses molecular control over position and orientation of molecules. By externally interacting with the phase space, we can travers a three-dimensional energy landscape through two independent stimuli. Using this system in magnetically aligned photoresponsive micropillar actuators we can control both directionality and extent of motion by combining light and heat. This system then can be further adjusted by controlling alignment, mechanical properties and geometry of both material and stimuli. This concept adds another dimension to design actuators promising applications needing multifunctional outputs, environmentally adaptive systems and life-like materials.

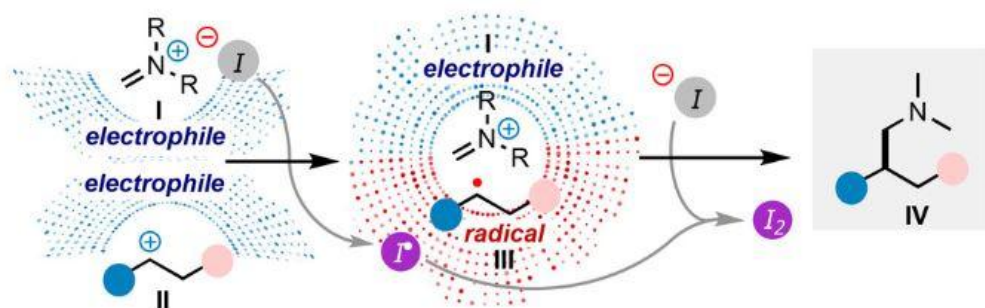


Synthesis of Tertiary Amines via Reductive Cross-Electrophile Coupling (37)

Andreas zur Bonsen

University of Vienna

In this work, we describe the synthesis of branched tertiary amines via the reaction of alkyl halides with iminium iodides—two reactants that may seem unlikely partners at first glance. The coupling of these two intrinsically electrophilic building blocks is enabled by the underexplored reducing power of the iodide counterion which is capable of reducing the alkyl halide, generating a nucleophilic carbon-centered radical in an Umpolung event. This reactive intermediate couples with the iminium carbon. Another single-electron reduction then allows for the formation of the tertiary amines under metal-free electrophile cross-coupling conditions. This method can be employed to access tertiary amines from a broad range of electrophiles and iminium iodides, including the commercially available Eschenmoser salt. The proposed mechanism is strongly supported by both experimental and computational studies.



Surface Tension Manipulation using Photoswitchable Amphiphiles (38)

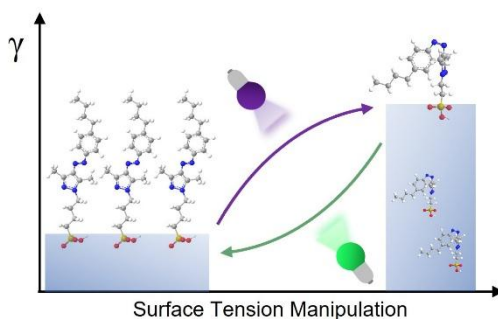
Bastian Stövesand

University of Münster

Interfaces that can change their chemistry on demand have huge potential for applications and are prerequisites for responsive or adaptive materials. We report on the performance of newly designed Arylazopyrazole (AAP) based surfactants that can change their structure at the air–water interface by E/Z photo-isomerization. Large and reversible changes in surface and surface excess demonstrate superior performance of the AAP amphiphile to that of existing azobenzene based surfactants.[1]

While efficient switching between their E and Z isomers predominantly relies on UV light, a recent study by Klajn and co-workers introduced visible light sensitization of E azoarenes and subsequent isomerization as a tool coined disequilibrium by sensitization under confinement (DESC) to obtain high yields of the Z isomer.[2]

This host-guest approach is, however, still constrained to minimally substituted azoarenes with limited applicability in advanced molecular systems. Herein, we expand DESC for the assembly of surfactants at the air-water interface. Leveraging our expertise with photoswitchable amphiphiles, we induce substantial alterations of water's surface tension through reversible arylazopyrazole isomerization.[3] In addition to this new approach of visible light excitation, we also chose the conventional approach to red-shift azoarenes and synthesized surfactants based on known highly substituted red-shifted photoswitches to serve as a comparative system.



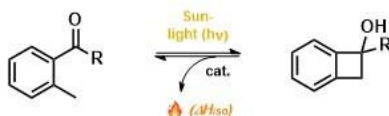
Storing solar energy with benzocyclobutenols (39)

Jérémy Pecourneau

University of Mainz

The ability to store and release energy efficiently is crucial for advancing sustainable energy technologies, and light-driven molecular isomerization presents a promising solution. However, a persistent challenge in this field is achieving both high stability of the energy-storing photoisomer and establishing efficient catalysis for back-isomerization, a critical process for releasing the stored energy as heat. In this work, we introduce a conceptually new molecular system designed for long-term energy storage, which is based on the reversible isomerization of ortho-methylacetophenone $\rightleftharpoons$ benzocyclobutenol. Key to the success of this system is the strategic placement of a trifluoromethyl group, which enhances the overall performance by preventing unwanted side reactions during photochemical cyclization and by increasing the stability of the benzocyclobutenol moiety. Back isomerization is established using simple organic bases as catalysts, taking advantage of significant rate differences between normal and anionic electrocyclic ring-openings. The system displays excellent robustness under variable conditions and operates efficiently under sunlight, achieving up to 87% yield after 4 hours of irradiation. The optimized trifluoroacetophenone derivative exhibits exceptional thermal stability ($t_{1/2} > 10^8$ years at room temperature), high energy density (312 J/g), and reproducible cyclability with >99% material recovery using an immobilized base catalyst. Quantum yields increase with temperature (up to 17%), and photoisomerization proceeds cleanly in aromatic solvents such as benzene. This approach allows for controlled and predictable heat release under ambient conditions, with rate accelerations up to 10^7 -fold compared to the uncatalyzed process, positioning this molecular pair as a promising candidate for practical energy storage solutions.

MOLECULAR PAIR FOR SOLAR ENERGY STORAGE



Metallic Nanoparticles as Antennas for Photoswitches (40)

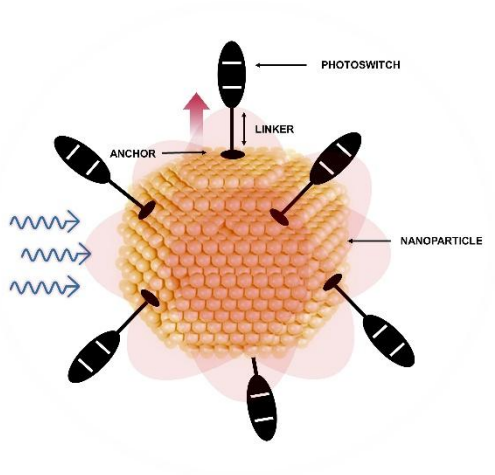
Anna Nožičková

Humboldt University Berlin

UV-activated photochemical systems are often limited by low selectivity of photoreactions resulting in high photodegradation, and the challenges of handling bulky, specialized equipment as the sources. This project investigates the influence of gold nanoparticles on stilbene-based chromophores, which are known for E–Z isomerization and significant thermal activation barriers. By positioning these chromophores near plasmonic nanoparticles, we aim to reveal mechanisms enabling photochemical switching at lower excitation energies.

A unique feature of metal nanoparticles is localized surface plasmon resonance (LSPR), which enhances local electromagnetic fields, generates hot charge carriers, and causes localized heating. These effects can drive chemical and photochemical transformations via multiple pathways. Proposed mechanisms include indirect and direct charge transfer, plasmon-induced resonance energy transfer (PIRET), and nanometal surface energy transfer (NSET). Under certain conditions, strong coupling can result in the formation of hybrid plexciton states that blend plasmonic and molecular excitations.

Experimentally, stilbene derivatives are covalently attached to gold nanoparticles via thiol groups. The linker length is systematically varied to optimize the interaction between the nanoparticles and chromophores. UV–vis spectroscopy is used to monitor isomerization and spectral shifts. The absorption of stilbene, which is distinct from the nanoparticle plasmon resonance, helps to exclude inner filter artifacts. Additionally, since stilbenes function as p-type photoswitches, localized heating does not influence their switching behaviour. The morphology of the nanoparticles is confirmed by scanning transmission electron microscopy (STEM), and electronic structures and energy transfer possibilities are evaluated through theoretical calculations to guide interpretation. This work aims to advance understanding of nanoparticle–chromophore interactions and provide strategies for designing efficient, tunable photosystems that can be operated with lower photon energy.



Driving supramolecular systems with light (41)

Larissa von Krbek

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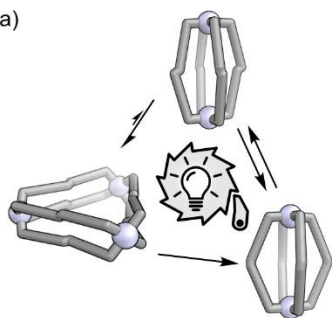
Molecular machines rely on their capacity to exploit non-equilibrium processes to perform work. However, the development of these non-equilibrium processes, such as molecular ratchets, is still in its early stages.

A photoswitchable, azobispyrazole containing ligand assembles into a mixture of a $\text{Pd}^{\text{II}}_2(\text{E-L})_4$ lantern and a thermodynamically more stable $\text{Pd}^{\text{II}}_3(\text{E-L})_6$ double-walled triangle (Figure a). Irradiation on this capsule mixture with UV light causes the reconfiguration into a single $\text{Pd}^{\text{II}}_2(\text{Z-L})_4$ lantern. Back isomerisation to the E-ligand results in selective formation of the out-of-equilibrium $\text{Pd}^{\text{II}}_2(\text{E-L})_4$ lantern, which slowly equilibrates to the lantern-triangle mixture over time. The switching process in this capsule mixture follows as molecular ratchet mechanism, which can be operated autonomously under continuous white light irradiation, selectively enriching the out-of-equilibrium $\text{Pd}^{\text{II}}_2(\text{E-L})_4$ lantern in the mixture.

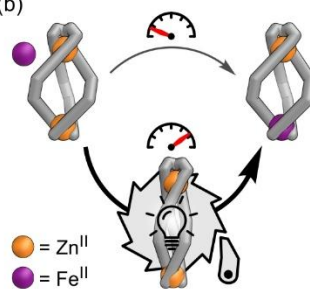
Photoswitchable, homo- and heterobimetallic, helicates form with high diastereo- and regioselectivity via single-step self-assembly or self-sorting from a photoswitchable diazocine-containing ligand and metal(II) cations (Fe, Co, Zn). White-light exposure autonomously operates one helicate as a molecular ratchet, promoting the selective formation of an out-of-equilibrium structure. This ratchet mechanism furthermore accelerates regioselective metal-cation exchange from a homometallic to a heterometallic helicate (Figure b). Thus, the system operates in a manner reminiscent of a “claw machine”, selectively seizing Fe^{II} ions when subjected to a precisely controllable external stimulus.

These findings lay the foundation for creating adaptive and reconfigurable supramolecular structures that use non-equilibrium phenomena on a molecular level.

(a)



(b)



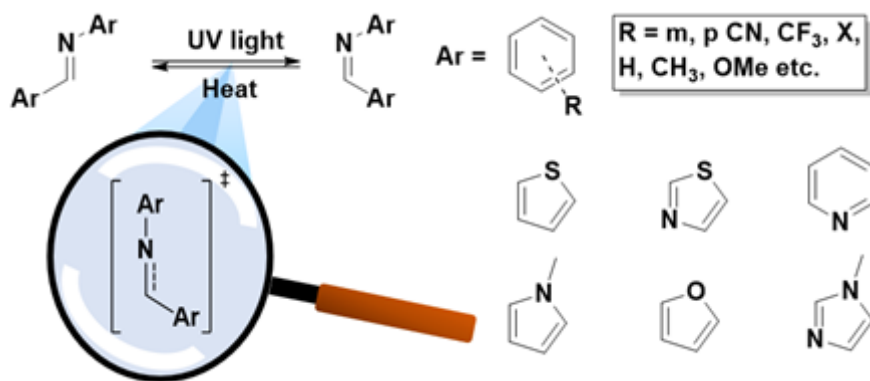
Investigation of the Structure-Property Relationships in Imine Photoswitches (42)

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Despite facile synthesis and a uniquely polar photoswitching system, photochromes are mostly built involving the azobenzene or stilbene motif, rather than using imine photoswitches. Only recently, they were rediscovered, and synthetic advance revealed their potential by extending the half-life of the metastable state from milliseconds to hours, highlighting the critical role of molecular design. Imines have also been utilised as components in molecular machines, where their straightforward synthesis offers a significant advantage over other motifs. However, their typically low isomerisation quantum yields—resulting from competing non-productive pathways—have limited broader adoption.

We believe that a deeper understanding of the imine photoswitches' experimental properties through benchmarking can streamline future design. Focusing on the absorption spectra, the activation barrier of the thermal relaxation, and the effect of electronic substituents on the isomerization quantum yield, we here provide insight into how molecular design can be used to tune their performance.

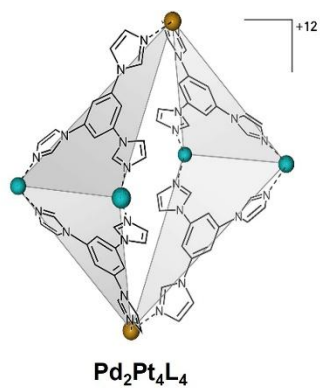
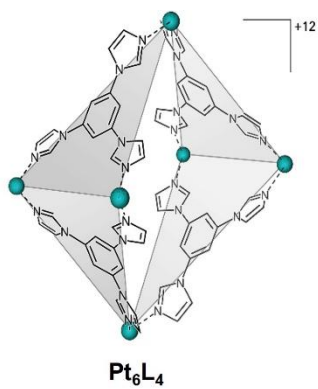
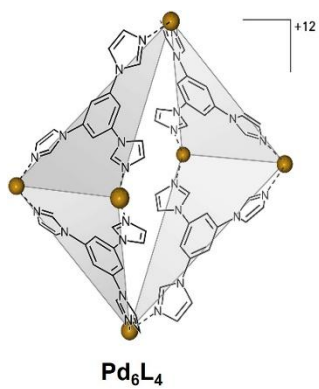


The Role of Host Dynamics in Disequilibrium by Sensitization under Confinement (DESC) (43)

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Photo-switches are the key components of molecular machines and they have found applications in various fields. Previously, we introduced Disequilibrium by Sensitization under Confinement (DESC), a supramolecular strategy for efficiently using visible light to control photo-switches. In DESC, a photosensitizer co-encapsulated with trans-azobenzene inside a Pd_6L_4 (L = ligand) coordination cage is excited by visible light, transferring triplet energy to drive trans-to-cis isomerization. The metastable cis isomer is not able to form a stable heterodimer with the photosensitizer inside the cage and is therefore expelled into solution. In this way, a non-equilibrium photo-stationary state (PSS) rich in the cis state is established without the need for UV irradiation. This study is focused on further elucidating the mechanism of DESC. We first synthesized the platinum analog of the Pd_6L_4 cage (i.e., Pt_6L_4), whose size and shape are nearly identical to Pd_6L_4 (based on the single-crystal structure), but the kinetic stability is much higher (due to the significantly more inert nature of the Pt–N bond). Guest-induced host isomerization experiments confirm the reduced structural dynamics compared to Pd_6L_4 . This difference in host dynamics has a direct impact on DESC: for water-soluble guests, Pt_6L_4 produces a markedly less favorable PSS than Pd_6L_4 , indicating that high structural inertness suppresses the release of cis-azobenzene before it is re-sensitized. To probe this effect, we designed and synthesized a heterometallic $\text{Pd}_2\text{Pt}_4\text{L}_4$ cage with two axial Pd nodes and four equatorial Pt nodes and found that the DESC kinetics and the resulting PSS are similar to those of the Pd-only cage. These results demonstrate the importance of the supramolecular nature of the Pd_6L_4 cage and suggest that the efficient cis-azobenzene release occurs by the transient dissociation of the N–Pdaxial bond. Notably, for water-insoluble guests, Pt_6L_4 cages yield nearly identical reaction kinetics and PSS as Pd_6L_4 , indicating that these guests are capable of retaining the overall architecture of the host–guest inclusion complex despite the lability of the Pd–N bond. In conclusion, this work demonstrates the beneficial role of the supramolecular nature of the Pd_6L_4 host on DESC efficiency.



Radical reactivity of BODIPY-based photocages (44)

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EPFL

Photocages are highly desirable compounds due to their potential applications in drug delivery systems. BODIPY-based photocages are promising candidates as the reactivity of the BODIPY scaffold enables a wide range of its modifications.

It has been previously shown that the photorelease of carboxylate from related BODIPY systems is a photoinduced S_N1 reaction. I have utilized this knowledge to release signaling lipids from BODIPYs. Detailed mechanistic studies on these derivatives revealed possible parallel homolytic payload cleavage.

In the current study, I developed BODIPY-based systems, where a BODIPY-payload bond cleavage is a homolytic process, which enables a photoinduced release of organic radical species. I also present the application of BODIPY-Cl in light-induced polymerization.

Photocatalytic CO₂ Conversion via Homogeneous and Heterogeneous Strategies: From Secondary Coordination Sphere Effects to Porphyrin Immobilization (45)

Florian Ehrtswendtnr

TU Vienna

The photocatalytic reduction of CO₂ to energy-relevant products represents a critical objective in the pursuit of sustainable chemical transformations. In the homogeneous phase, molecular catalysts are investigated in solution, focusing on the influence of secondary coordination sphere interactions on reactivity and product distribution. In the heterogeneous phase, porphyrin complexes are immobilized on graphitic carbon nitride (g-C₃N₄), yielding hybrid photocatalysts that couple efficient light absorption with defined catalytic sites. Comparative analysis of both approaches aims to further the development of high-performance CO₂ reduction catalysts.

Shining New Light on the Synthesis of Lactams: Intramolecular Radical Cyclization and the Design of a Simple Photoreactor – A Do-It-Yourself Approach (46)

Fabian Scharinger

TU Vienna

Lactams, especially oxindoles, are key structural motifs in bioactive molecules, naturally found in mammals and plants. Efficient synthetic access to these frameworks remains a major goal in pharmaceutical research.¹ Traditional methods often require metals or high temperatures to yield the desired product.² In contrast, photoredox catalysis enables lactam formation under mild conditions via photocatalyst-driven substrate oxidation. We developed a photoredox decarboxylative cyclization, where the generated carbamoyl radical selectively attacks an activated double bond, forming lactams in a single step. Using 4CzIPN and derivatives, our metal-free strategy provides a highly selective and sustainable route to these valuable compounds. To successfully apply this concept, we designed a custom photoreactor, easily 3D-printable and equipped with 3W, 457 nm high-power LEDs. The reactor's design ensures efficient airflow, cooling both the reaction and LEDs. 7 mL screw-cap vials fit precisely, maintaining an optimal distance between the light source and reaction mixture for consistent irradiation. With this setup, high-throughput screening of multiple reactions can be conducted under identical conditions, ensuring reproducibility and efficiency, with low cost and easy maintenance.

