Geneva chemistry & biochemistry days 2022

TH 13 January 2022, 09:00–16:45
FR 14 January 2022, 09:00–12:25
LIVE ZOOM VIRTUAL EVENT
https://bit.ly/3GEafmg
No registration required

Dr Guillaume Schull
Université de Strasbourg

Dr Christian Starkenmann
Prix Jaubert 2022 Lecture – Firmenich S.A.

Prof. Michel Steinmetz
Paul Scherrer Institut

Dr John Sutherland
Medical Research Council Cambridge

Prof. Renato Zenobi
Eidgenössische Technische Hochschule Zürich

Junior Speakers:
Lea Assies • Yann Gimbal • Levente Juhasz • Quentin Laurent • Julie Miesch • Mohsen Mirzakhani • Gheorghe Paveliuc • Inga Shybeka • Jihad Sissaoui • Yoshiki Soda • Michal Swierczewski • Pragya Verma • Julian Weninger •

FACULTÉ DES SCIENCES
SECTION DE CHIMIE ET BIOCHIMIE

UNIVERSITÉ DE GENÈVE

FOREWORD

The *Section de chimie et biochimie*, University of Geneva, has the pleasure to announce the 12th edition of its "***Geneva Chemistry & Biochemistry Days***". Due to the sanitary situation, the event will once again be held at distance, via the Zoom interface (flash QR code on the right, or connect to https://unige.zoom.us/j/65067312612 + code GCBD2022 or directly to **https://bit.ly/3GEafmg**; see tips on page iii), but we sincerely hope that the spirit of the event will not be impaired by this mishap.

SCAN ME

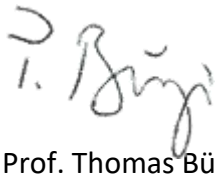
The vocation of the event is to give our students who are close to finishing their PhD studies the opportunity to present their research as attractive speed talks to an audience from academia and industry, and the steering committee is glad to welcome you in this context.

Four distinguished lecturers further enrich the programme. Our four departments have invited them, and they will illustrate the extent and the quality of top-level fundamental research in chemistry and biochemistry today. The 2022 Jaubert Prize Awardee complements this rich choice.

Our BSc and MSc students are welcome to smell the very flavour of the research held in our School and abroad, and to learn a bit more about how to present punchy results to a scientific audience.

We expect that the event will catalyse fruitful discussions between young and advanced researchers, and give our students an opportunity to get ready for their professional career, yet offering our guests an overview of the quality of the fundamental research performed in our School.

Looking forward to welcoming you at this event, we hope that you will enjoy the lectures and interactions!



Prof. Thomas Bürgi
Président de la Section de chimie et biochimie

Steering and organising committee

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Dr Didier Perret	didier.perret@unige.ch *Responsable communication – Section de chimie et biochimie*

PROGRAMME – THURSDAY, 13 JANUARY https:// bit.ly/3GEafmg

Chair: **Prof. Karsten Kruse** (for Senior Speaker)
Dr Piotr Sosnowski (for Junior Speakers)

09:00--09:05	**Prof. Thomas Bürgi**	Welcome message
09:05--09:55	**Prof. Michel Steinmetz** Paul Scherrer Institut	Molecular mechanisms of microtubule tip tracking and centriole formation
09:55--10:15	**Gheorghe Paveliuc**	Computational insights into the physical chemistry of transitional metal complexes
10:15--10:35	**Lea Assies**	Probing membrane tension during endocytosis
10:35--10:55	**Levente Juhasz**	Polydiacetylenes: from mechanochromism to affinochromism
10:55--11:10	Break	1 parallel Virtual Discussion Room available from within the Virtual Conference Room
11:10--11:30	**Jihad Sissaoui**	Dynamics of photoinduced processes at liquid/liquid interfaces
11:30--11:50	**Yoshiki Soda**	Novel materials and analytical methods for optical sensing of ionic species
11:50--13:30	Lunch break	1 parallel Virtual Discussion Room available from within the Virtual Conference Room

Chair: **Prof. Nicolas Winssinger** (for Senior Speaker #1)
Dr Christopher Toret (for Junior Speakers)
Prof. Thomas Bürgi + Prof. Jérôme Lacour (for Senior Speaker #2)

13:30--14:20	**Dr John Sutherland** Medical Research Council Cambridge	Origins of the RNA-protein world – Lost in translation?
14:20--14:40	**Julie Miesch**	Phase separation of +TIPs drives microtubule growth
14:40--15:00	**Yann Gimbal**	Electric Field Gradient calculation within Frozen-Density Embedding Theory
15:00--15:15	Break	1 parallel Virtual Discussion Room available from within the Virtual Conference Room
15:15--15:35	**Quentin Laurent**	Dynamic covalent chemistry for thiol-mediated cellular uptake
15:35--15:55	**Michal Swierczewski**	AFM imaging of Au_{38} nanocluster ultrathin films: from topography to Young's modulus
15:55--16:45	**Dr Christian Starkenmann** **2022 Jaubert Prize** – Firmenich S.A.	Chemistry and biochemistry discoveries in the fragrance and flavor industry
16:45-	Evening break	1 parallel Virtual Discussion Room available from within the Virtual Conference Room

PROGRAMME – FRIDAY, 14 JANUARY https:// bit.ly/3GEafmg

Chair: **Prof. Takuji Adachi** (for Senior Speaker #1)
Dr Jasmine Viger-Gravel (for Junior Speakers)
Prof. Gérard Hopfgartner (for Senior Speaker #2)

09:00--09:50	**Dr Guillaume Schull** Université de Strasbourg	From single-molecule fluorescence to photosynthesis with an STM
09:50--10:10	**Inga Shybeka**	Michael acceptors for thiol - mediated cellular uptake and its inhibition
10:10--10:30	**Mohsen Mirzakhani**	A bottom-up approach to rationalize lanthanide loading of linear oligomers and polymers
10:30--10:45	Break	1 parallel Virtual Discussion Room available from within the Virtual Conference Room
10:45--11:05	**Pragya Verma**	Bimolecular photoinduced electron transfer in non-polar solvents
11:05--11:25	**Julian Weninger**	Identification of active contributions during cellular rearrangement in the basilar papilla of chick
11:25--12:15	**Prof. Renato Zenobi** Eidgenössische Technische Hochschule Zürich	MALDI-MS based detection of ligand-induced binding of G-protein coupled receptors with their interaction partners
12:15--12:20	**Prof. Nicolas Winssinger**	Awards for the best oral Junior presentations
12:20--12:25	**Prof. Thomas Bürgi**	Concluding remark

TIPS FOR A SMOOTH ZOOM EXPERIENCE

The event will be held at distance, via the Zoom interface. During the whole event, the Virtual Conference Room will be **https:// bit.ly/3GEafmg**

From the Virtual Conference Room, one parallel Virtual Discussion Room will be available; this Virtual Discussion Room can be accessed anytime during the event.

On Wednesday, 12 January, from 8:30 to 17:30, Junior Speakers and Senior Speakers are invited to **test connexion and screen sharing capabilities** in the Virtual Conference Room with the event administrator; please feel free to join and secure your talk!

On Thursday, 13 January, and Friday, 14 January, the Virtual Conference Room and Discussion Room will be open to the public from 8:30 to 17:30 (Thursday) and from 8:30 to 13:00 (Friday). Participants are invited to create additional parallel Discussion Rooms for their private use.

You can enter the Virtual Conference Room or the Virtual Discussion Room directly via your browser, but the quality of the broadcast may be limited under certain circumstances; for a better experience, it is recommended to download the autonomous Zoom engine via the Zoom Download Centre at **https://zoom.us/download**.

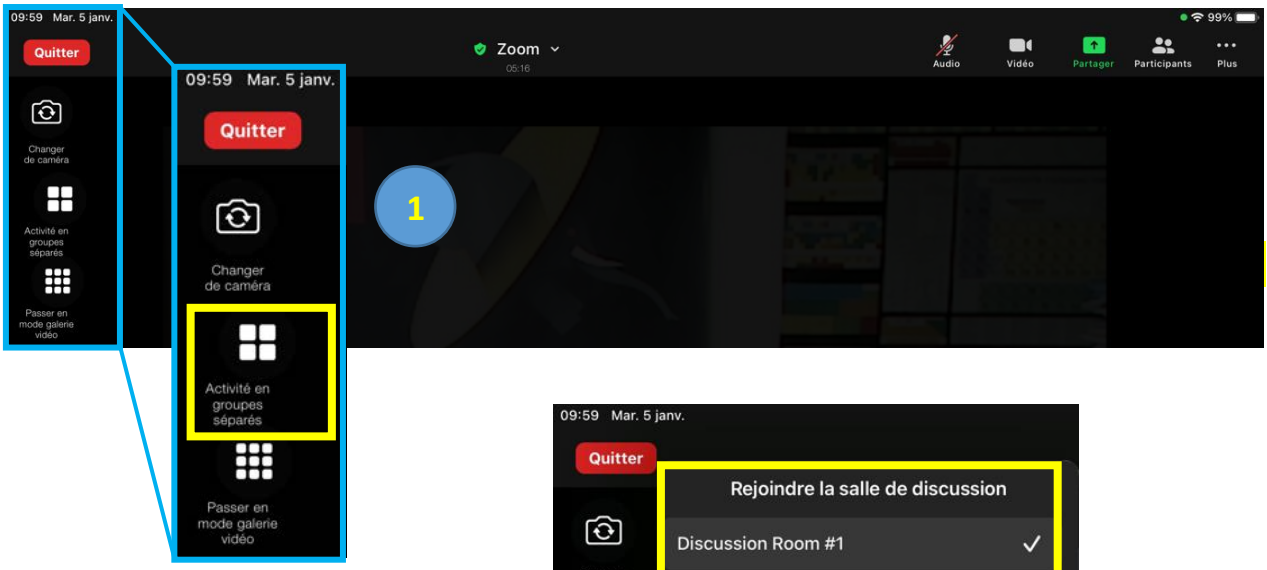
To guarantee a clear voice connexion, it is advised to use an external microphone or headset (*e.g.* USB-connected) instead of the built-in microphone/speaker mounted in your computer.

When reaching the Virtual Conference Room as a participant, please make sure that your microphone is switched to OFF. If you have a slow- or medium-speed connexion, you can increase the bandwidth by switching your camera to OFF.

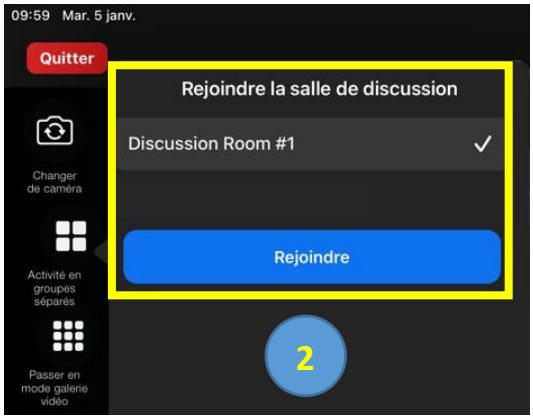
The chairwomen, chairmen, and speakers will be granted administrator rights, to take over the screen-sharing option of Zoom at the beginning of their talk.

To **join a parallel Virtual Discussion Room** and then come back to the main Virtual Conference Room, proceed as follows (example below is on an iPad-based Zoom session, in French; the views may differ depending on the computer used):

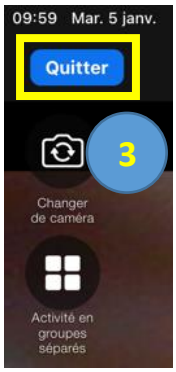
1) Select the bloc of ***Activities in separate groups***:



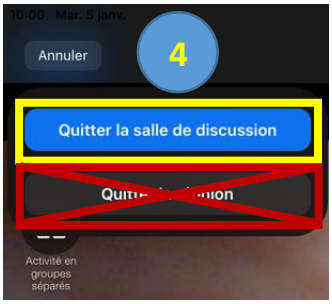
2) Select the ***Discussion Room*** and click on ***Join***:



3) When finished, click on ***Quit*** to join back the main Conference Room:



4) Select ***Quit the Discussion Room*** (and <u>not</u> *Quit the Meeting*, which would kick you out of the main Conference Room!); you will be automatically brought back to the main Conference Room:



DIRECT ZOOM LINK TO THE VIRTUAL CONFERENCE ROOM

https:// bit.ly/3GEafmg (valid for all conferences)

From single-molecule fluorescence to photosynthesis with an STM

Guillaume SCHULL

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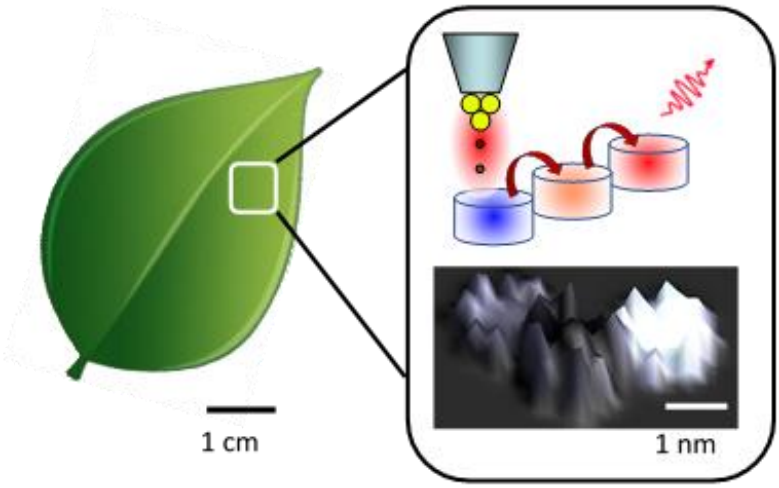
The electric current traversing the junction of a scanning tunneling microscope (STM) may lead to a local emission of light that can be used to generate sub-molecularly resolved fluorescence maps of individual molecules. Combined with spectral selection and time-correlated measurements, this hyper-resolved fluorescence microscopy approach allowed us to scrutinize the vibronic structure of individual molecules[1] in a very similar way than in the recent TERS reports, without requiring an optical excitation.

We used this approach to characterize the photonics properties of charged species[2], to track the motion of hydrogen atoms within free-based phthalocyanine molecules[3], and more recently to follow resonance energy transfers between individual pigments, exploring processes occurring in photosynthetic complexes with sub-molecular spatial resolution[4].

These results constitute an important step towards photonic measurements with atoms-scale resolution[5].



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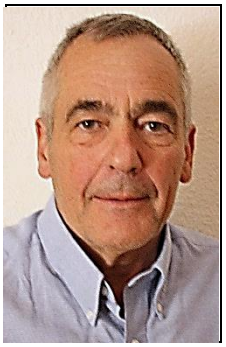
Chemistry and biochemistry discoveries in the fragrance and flavor industry



Christian STARKENMANN

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The mouth is an incredible bioreactor packed with detectors like our olfactory system which allows us to appreciate both the beautiful flavors present in varied dishes and also warns us of the dangers present in spoiled foods. Feedback from our taste buds' "detectors" may or may not encourage us to consume certain foods. Our thermosensory neurons detect thermal stimuli via ion channels receptors (TRP channel family) that can protect us from temperature shocks but are also activated by flavor molecules such as menthol with its pleasant cooling sensation, or capsaicin, with its warm spicy sensation varying from the pleasant to the painful. Food, once inside the mouth is prepared for further digestion by both mechanical means, i.e. chewing, and also by enzymatic metabolism prior to passage to the gut. The primary goal of my research was to discover and develop new compounds with the aim of improving the aroma and flavor of foods.

To illustrate this common theme of my research, I will explain why scallops have such a particular sweet but salty taste. I will then describe our search for molecules displaying trigeminal effects and how we discovered novel natural molecules with interesting properties. One of the major discoveries of my career was to understand the influence of oral microflora on the perception and duration of certain aromas and in particular that of the onion. This discovery helped me to dive into the world of sweating with the final conclusion, that although men are actually different to women, in terms of body odor, it is preferable to have a healthy underarm microbial ecosystem without killing the bacteria present in order to avoid bad body odors, because in fact the bacteria there, are our friends.

Studying onions and then sweat lead me into the world of less desirable smells, and thanks to this gained expertise, I was able to participate in a magnificent project to help improve the quality of life in the developing world through the "Reinvent the toilet challenge" in collaboration with the Bill and Melinda Gates Foundation. I will conclude with an example of a serendipitous discovery that lead from toilet smells to the smell of flint stone and onto the mineral character of chasselas wine from Swiss Romande.

Molecular mechanisms of microtubule tip tracking and centriole formation

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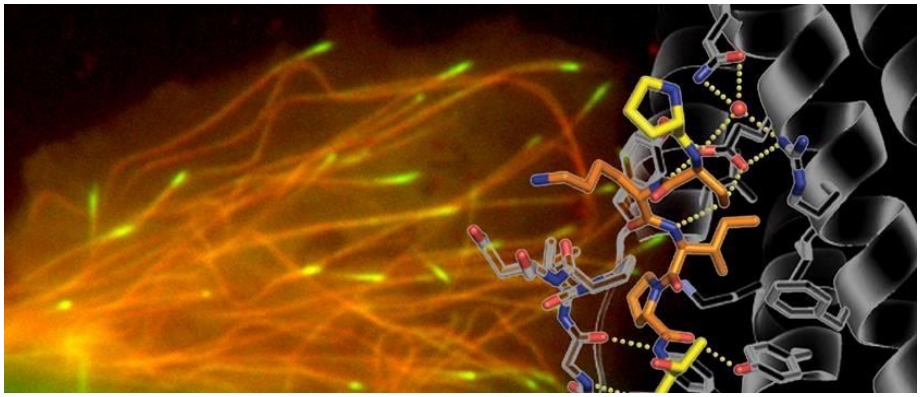
Microtubules (MTs) and their building block tubulin play essential roles in fundamental biological processes, including cell division, motility, and intracellular transport. Because of their importance, MTs and their accessory proteins are attractive drug targets for the treatment of severe human diseases, including cancer, neurological disorders, and infectious diseases. Assessing how regulatory proteins and ligands control the structure, function, and dynamics of MTs at the atomic level is crucial to understand MT function. It is also important to establish a mechanistic basis for the development of strategies against human pathologies.

We use X-ray crystallography and cryo-electron microscopy in combination with biophysical, biochemical, computational, and cell biology approaches to tackle these challenges. To illustrate the approaches that we typically use in our research group, I will present two older stories. In the first story, I will describe key molecular mechanisms used by a large group of microtubule-associated proteins, the so-called microtubule plus-end tracking proteins (+TIPs), to localize to and control the fate of growing microtubule ends. In the second story, I will present our work on the mechanisms involved in the establishment of the universal 9-fold symmetry of centrioles, complex microtubule-based structures that are implicated in microtubule nucleation and in the formation of cilia and flagella.



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Origins of the RNA-protein world – Lost in translation?

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The RNA-protein double act at the heart of biology raises several intriguing origins questions that can be addressed by prebiotic chemistry. Beyond the obvious "which came first?", one can also wonder about the extent to which chemistry shaped the process of translation according to the genetic code.

In this lecture I will describe some mixed hydrogen cyanide-hydrogen sulfide chemistry that produces nucleotides and amino acids. Some degree of control is necessary for this "cyanosulfidic" chemistry to proceed most efficiently and ways in which environmental factors could exercise this control will be suggested. Synergies in the assembly of nucleotide and amino acid building blocks into higher order structures will then be discussed as will experimental hints of a previously proposed second genetic code. Finally it will be shown how the strength of codon-anticodon binding likely influenced the partial initial assignment of the primary genetic code.

MALDI-MS based detection of ligand-induced binding of G-protein coupled receptors with their interaction partners

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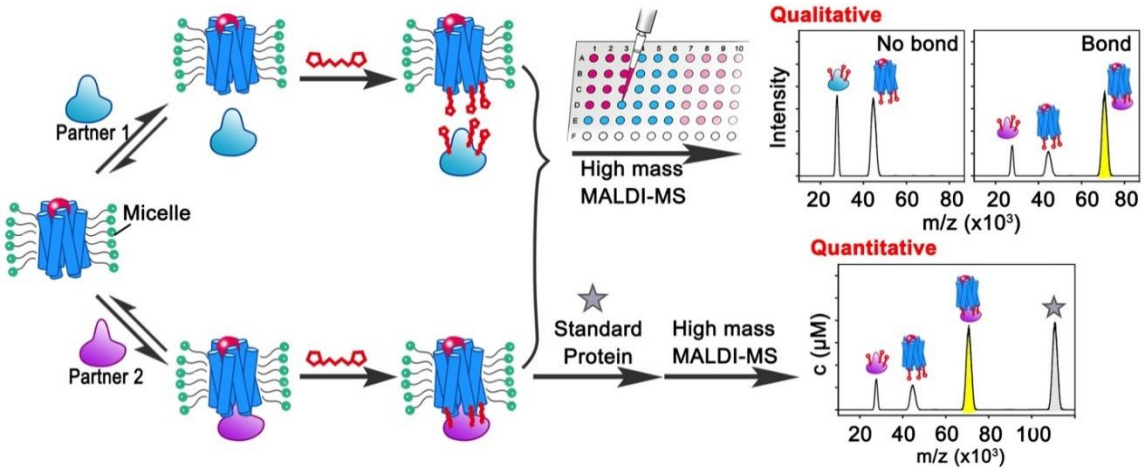
G protein-coupled receptors (GPCRs) are important drug targets and many of the physiological effects are exerted through activating heterotrimeric G proteins via allosteric activation by ligands. Although there are detailed structures of GPCRs in their active conformational state with bound G proteins, the effect of ligand on receptor selectivity for G proteins is still poorly understood.

We present a novel MS based method that combines chemical cross-linking of protein complexes with matrix-assisted laser desorption/ionization mass spectrometry (MALDI-MS) and high-mass detection, which can report the effect of ligand binding by reading out the degree of GPCR●G-protein complex formation. Using an internal standard, we are even able to measure the binding constant of these GPCR●G-protein complexes using this methodology. We assessed three class A GPCRs (rhodopsin, Rho; angiotensin II type I receptor, AT1R; and beta-1 adrenergic receptor, β1AR) and their selectivity to engineered, so-called "mini G" proteins upon ligand binding. We find that all tested apo GPCR can precouple to G_o protein, but that some ligands can bias receptor binding to a specific set of G proteins.

This methodology also paves the way to high-throughput screening of possible GPCR targeting drugs.



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Probing membrane tension during endocytosis

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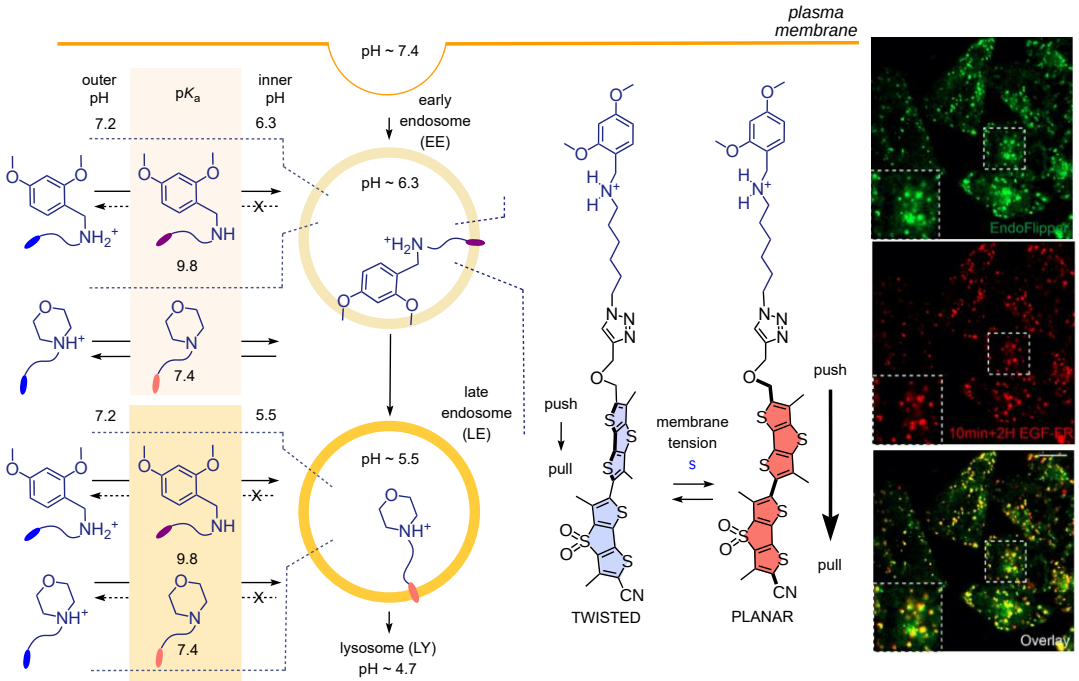
Fluorescent flipper probes have been introduced to image membrane tension in living cells[1], and strategies to target these probes to specific membranes of interest to study biological processes are emerging[2]. The changes in membrane tension during endocytosis are interesting because this parameter has been identified as crucial especially in early stages of endolysosomal trafficking[3,4]. Therefore early endosomes (EE), as first endosomal compartment, are an interesting target and the targeting without the use of protein engineering is particularly appealing[4].

We developed a class of early endosome targeting flipper probes, using substituted benzylamines with varying pK_a values as head groups. The weakly acidic flipper probes target late endosomes (pH ~ 5.5) and lysosomes (pH ~ 4.7) equally. Yet, flipper probes with higher pK_a values colocalize better in EE, due to the higher inner pH (~6.3) in those. The EE flipper probes are mechanosensitive and can be used to study endocytic processes. We are currently investigating different headgroups with even higher pK_a values aiming for better EE staining.



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Electric Field Gradient calculation within Frozen-Density Embedding Theory

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Frozen-Density Embedding Theory[1,2] (FDET) provides a system-independent formal framework for multi-level computational methods allowing to describe the effect of a frozen electron density of the environment $\rho_B(\vec{r})$ on the chromophore. Within this framework, it is possible to treat either explicitly or implicitly the effect of the embedding species on the electron distribution in the environment in numerical simulations. In the pre-polarization protocol[3], the response of the environment to the electronic structure of the chromophore can be taken into account in the process of generating $\rho_B(\vec{r})$. In practice, due to some approximations made for the FDET potential ranging from the approximate nature of the DFT (bi)functionals to the neglect of Pauli repulsion in the prepolarisation procedure, this treatment is not exact.

The Electric Field Gradient (EFG) being a sensitive parameter, it has been shown that the commonly used Sternheimer approximation does not hold[4,5]. In this work, we used the FDET-based with and without polarization methods to evaluate the EFG of H-bonded systems and coordinated alkaline metals[6]. This study shows that FDET allows for an accurate description of the EFG, demonstrating the importance of the contribution of the Pauli repulsion term in the embedding potential, which is missing in the commonly used point-charge embedding approach.

References:

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Polydiacetylenes: from mechanochromism to affinochromism

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Polydiacetylenes (PDA) are mechanosensitive polymers that change their colour (*e.g.* from blue to red) and turn fluorescent upon external stimuli, such as heat, stress, addition of solvents or chemicals[1]. The overwhelming part of the research hitherto has focused on activation of the colour change of PDA by heat[2] or solvents[3] and little attention has been devoted to the mechanosensitivity of PDA in its true sense, *i.e.* activation of the blue-to-red colour change by forces. Furthermore, these studies were either only qualitative or macroscopic. To fill in the missing piece of the puzzle, we carried out the calibration of the fluorescence response and locally exerted lateral forces at the nanoscale for the first time in PDA history[4].

Another open question in the field of polydiacetylenes is whether the colour change (and fluorescence turn-on) only takes place at activated sites of the polymer film or is applying a stimulus (force, heat, binding of molecules etc.) to a given part of the film does indeed trigger the activation of the complete film, similarly to a domino-effect? To study these two hypotheses, we are going to label α-cyclodextrine, a well-known chemical trigger of the PDA colour change[5], with a fluorescent label, in order to simultaneously follow the binding of the α-cyclodextrine and the fluorescence turn-on of the PDA.

Finally, we have developed a new method to follow the colour change of PDA Langmuir-Blodgett films via confocal microscopy, using the fluorescence signal of both the blue and red states of PDA. The blue state is deemed non-fluorescent in the literature[6], owing to its fairly low fluorescence quantum yield, while the red state fluorescence has been widely used to follow the phase change of PDA. We show that blue state PDA also enables confocal fluorescence imaging, and the simultaneous recording of blue and red fluorescence signals results in an enhanced, more accurate monitoring of the gradual phase change in PDA Langmuir-Blodgett films.

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Dynamic covalent chemistry for thiol-mediated cellular uptake

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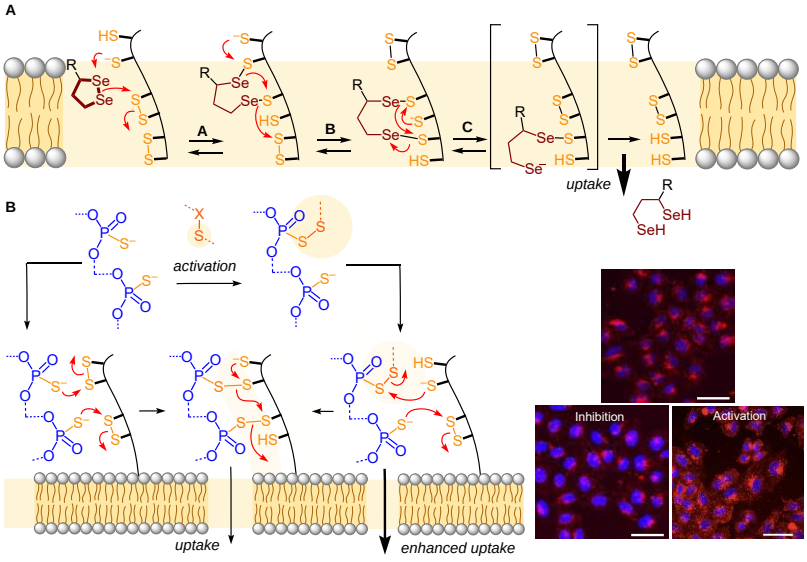
From poly(disulfides) to small cyclic oligochalcogenides, thiol-mediated uptake has emerged as powerful tools for cytosolic delivery[1]. With these tools, our group achieved the delivery of giant substrates such as fluorescent quantum dots, as well as precise cargo release in the cytosol. However, the exact pathways involved in the uptake process remain elusive.

Studying the dynamic covalent chemistry of cyclic disulfides and diselenides, we proposed a molecular walker model to account for their ability to penetrate cells (Figure A)[2,3]. Then, using HPLC-MS and fluorescent microscopy studies, we could show that dynamic covalent chemistry also takes place at the cell surface between oligonucleotide phosphorothioates (OPS) and disulfide-rich proteins (Figure B)[4]. By understanding the processes involved in the uptake of OPS, we could transiently modify their backbone to further increase their cytosolic delivery. This finding is relevant both from a fundamental chemistry and application point of view, OPS being widely used in clinics for their high cellular uptake ability.



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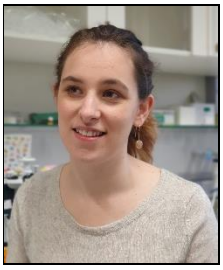
Phase separation of +TIPs drives microtubule growth



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Microtubules are dynamic polymers that form a complex and organized network within the cell. They grow and shrink by the addition and loss of tubulin dimers to their ends. Microtubule growth needs to be spatially and temporally regulated to rearrange network architecture and fulfil a plethora of vital cell functions. Many studies have highlighted how microtubule dynamics are regulated by microtubule-intrinsic mechanisms or by the actions of microtubule binding proteins[1].

Since microtubule growth is mainly determined by tubulin concentration, we focused on a new way for microtubules to regulate their dynamics: local tubulin condensation[2]. We show that the microtubule plus end binding proteins (+TIPs) CLIP and EB3 undergo liquid-liquid phase separation (LLPS) and have the capacity to co-condense tubulin, increasing the tubulin effective concentration. The "+TIP-droplet" formed by CLIP/EB3/tubulin increases growth speeds and strongly reduces depolymerization events, suggesting LLPS plays a robust role in microtubule network regulation.

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A bottom up approach to rationalize lanthanide loading of linear oligomers and polymers

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Complexation of multisite polymeric ligands with transition metals produces a class of hybrid materials that combines the electronic and optical properties of transition metals with the versatility of organic polymers. Despite their favourable properties, the absence of rational control over metal loading in multisite polymers severely limits the design and reproducibility of the target metallopolymers[1]. To reap the greatest rewards from these hybrid materials, we should identify the thermodynamic parameters that govern both the organization and the final structure of the metallopolymers. The complexation of a linear multi-site polymer with labile lanthanides results in a complex thermodynamic system composed of numerous successive and concurrent thermodynamic equilibria. These complicated equilibria can be summarized in terms of two independent and quantifiable parameters by using the site binding model. The first parameter is the free energy for connection of a lanthanide (Ln) ion to a binding site $\Delta G^{\mathrm{Ln},\mathbf{P}^N} = -RT\ln(f^{\mathrm{Ln},\mathbf{P}^N})$ and the second parameter is the free energy of interaction occurring when two adjacent sites are occupied $(\Delta E_{i,j}^{\mathrm{Ln,Ln}})$. The intrinsic metal-receptor affinity for the coordination units within the polymer traditionally derived from that measured for the analogous monomeric ligand. However, this oversimplified approach is misleading and causes a significant discrepancy between the intrinsic affinity for the same binding unit taken either separately or within the polymeric backbone. Taking this into consideration, we study complexation reactions in the series of oligomers (**L1**-**L5**) to investigate the exact origin of the unusual changes in thermodynamic affinities. We indeed discover that the modulation of the affinity between the terminal and central binding units in the linear multi-tridentate receptor is responsible for the global decrease of metal−ligand binding strengths with an increase in the length of the receptors (monomer → dimer → trimer → polymer)[2].

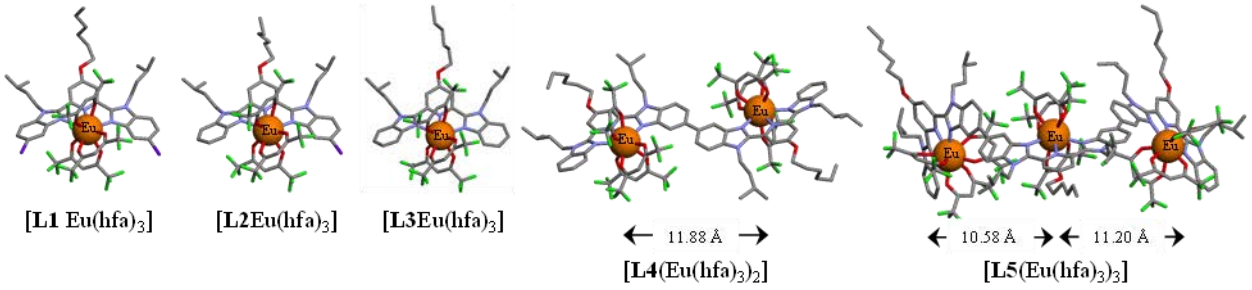

Figure.Views of the molecular structures of the complexes [**L*k***Eu(hfa)$_3$] (k = 1−5), as found in their crystal structures. Color code: C, gray; N, blue; O, red; F, light green; Br, magenta; Eu, orange. Hydrogen atoms are omitted for clarity.

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Computational insights into the physical chemistry of transitional metal complexes

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Transition metal complexes (TMCs) exhibit a rich variety of physicochemical properties which make them the subjects of studies in diverse areas of fundamental and applied research. Thus, their photophysical relaxation processes are investigated using ultrafast spectroscopies to gain insights into photophysical properties with applications in fields like dye-sensitised solar cells, OLEDs, or phototherapy[1]. TMCs can exhibit spin crossover (SCO). SCO compounds are archetypes of photoswitchable molecular materials for designing optoelectronic and spintronic devices; they are the subject of numerous multidisciplinary studies[2].

The study of SCO complexes is hampered by difficulties tied to the accurate prediction of the high-spin/low-spin energy difference which rules the phenomenon. We show how this issue can be circumvented and accurate spin-state energetics obtained using density-functional or wavefunction-based methods. We also report the characterization of substituted Nickel(II) porphyrins in their ground and excited-state manifolds in connection with their photophysics as recently probed by X-ray emission spectroscopy.

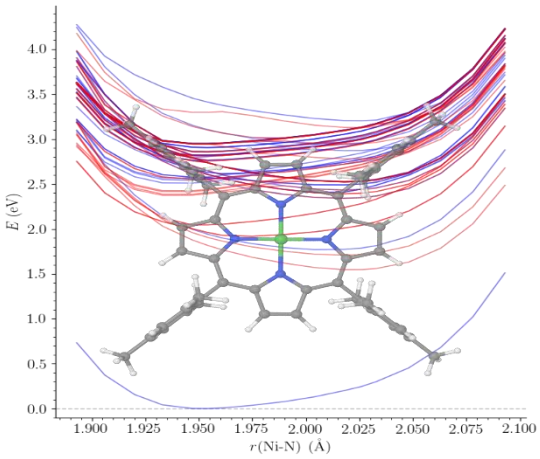

Figure. TD-PBE/TZP calculated potential energy curves for NiTMP (blue and red curves are for singlet and triplet states, respectively).

Acknowledgements. The computations were performed at the University of Geneva on the "Baobab" and "Yggdrasil" HPC clusters. The authors thank Thomas Bürgi for the financial support given during the projects.

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Michael acceptors for thiol - mediated cellular uptake and its inhibition

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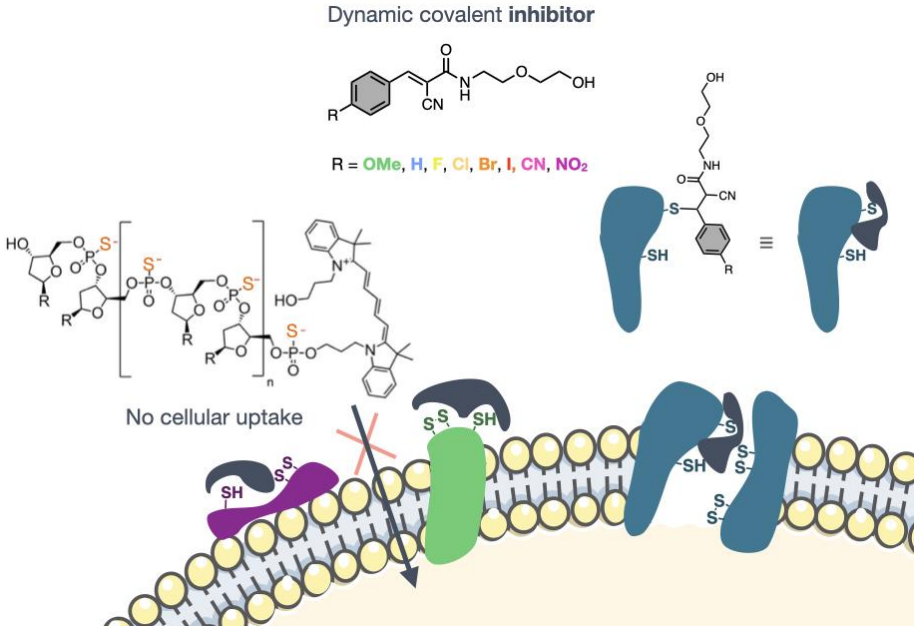
Thiol - mediated uptake (TMU), operating through dynamic covalent exchange reactions with cellular thiols, has been shown to be a potent way to deliver various cargos to the cytosol, from a fluorophore molecules to nanoparticles[1]. To expand the collection of previously known transporters and inhibitors, Michel acceptors (MAs) for TMU were introduced. The MA, carrying fluoresceine, enters the living cells with high efficacy. The efficiency of MAs, as reversible inhibitors of TMU, was studied with oligonucleotide phosphorothioates (OPS)[2] as a reporter.

The versatility of the scaffold of MAs, allows the modifications, which impacts their biological activity for TMU. Based on benzalcyanoacetamide, MAs with EWG on the phenyl ring, as well as halogen, have been shown to increase the inhibition activity. Highlighting the importance not only the reactivity of MAs, but also halogen bonding[3] with components of the cell membrane. This presents MAs as interesting tools regarding the control over the cytosolic delivery and its inhibition.



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Dynamics of photoinduced processes at liquid/liquid interfaces

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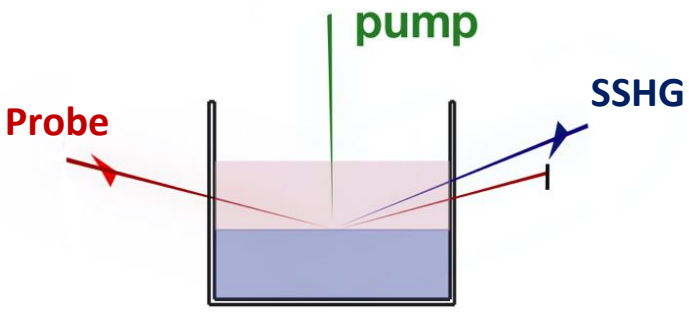
Interfaces between two isotropic media play a key role in various areas of science. A major experimental difficulty when investigating interfaces using conventional spectroscopic methods is that the signal originating from the interfacial region is completely hidden by that from the bulk. We are investigating liquid/liquid interfaces using surface second harmonic generation (SSHG) technique[1]. Due to the cancellation of the SHG process in centrosymmetric media like bulk liquids, the signal originates only from the interface region where the symmetry is broken, making SSHG a surface specific technique.

In this presentation, we will focus on two systems investigated using SSHG with two different approaches. The first approach consists of using a molecular probe to report on various interfacial properties such as the overall interfacial charge, friction, and aggregation. For example, the influence of room-temperature ionic liquids (RTIL) on the excited-state properties of an organic dye, Malachite Green (MG), at water/dodecane interface was investigated[2]. In the second example, we are interested in understanding how the interfacial properties affect chemical reactivity. We are investigating electron-transfer dynamics of a donor-acceptor dyad[3] at water/dodecane interface. Particularly, pump-probe experiments were conducted to probe the interfacial electron-transfer dynamics.



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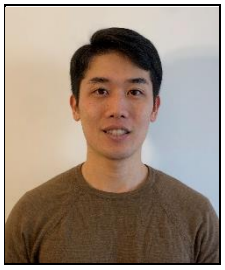
Novel materials and analytical methods for optical sensing of ionic species



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Ionic species such as atomic ions and polyions play a crucial role in living organisms. Examples include maintaining homeostasis, growth and evolution. There is therefore a high demand for quantitatively measuring ionic species in various media (biofluids, seawater, food, etc). Among various quantification method developed to date, ion-selective optodes (ISOs)[1] enable versatile, selective and sensitive optical sensing both in the bulk and at the nanoscale.

The reliable readout method of colorimetric signals has always been spectrophotometry, but it is cumbersome and does not take full advantage of ISO miniaturization. Various readout methods to overcome these shortcomings will be presented. The first approach is to translate ion concentration into "distance" with the assistance of capillary-based ISO membrane and filter paper, thereby realizing an equipment-free detection of K^+. Another approach is to conduct pixel-level quantification by imaging devices. With a newly designed computational method, the dye quantity corresponding to an image pixel may be obtained independently of ambient light intensity and type of camera, allow for quantification in heterogeneous systems. Using this technique, K^+ diffusion into agarose gel was quantitatively visualized as a false-coloured video which showed good correspondence to Fick's diffusion law.

Although sensing mechanisms of ISOs have relied on ion exchange between target ion and an optical reporter ever since the very first ISO was developed, emulsion-based ion exchange type ISOs were found not to be ideal for polyion detection owing to their inadequate selectivity[2]. A new mechanism for polyion sensing based on a "hyper-polarizing organic phase" will be presented where solvatochromic dyes are strongly polarized in the organic phase. This mechanism improves the selectivity of ISOs and allows for the polycation/polyanion quantification in plasma and serum for the first time with optical nanoscale sensors.

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AFM imaging of Au_{38} nanocluster ultrathin films: from topography to Young's modulus

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Thiolate-protected gold nanoclusters are a family of atomically precise nanoparticles below 2 nm in diameter that are distinguished by their unusual molecule-like optical properties. The high stability of certain gold nanoclusters, such as $Au_{38}(SC_2H_4Ph)_{24}$, permits the attainment of exceptional monodispersity, which is pertinent for layer formation using Langmuir-Blodgett (LB) technique.

Atomic Force Microscopy (AFM) is a method widely applied in probing of surface topography. Single mode amplitude modulated (AM) AFM is indispensable for height measurements and analyzing the microscale morphology of LB films. On the other hand, instruments capable of performing fast AFM can eliminate the drift, which allowed imaging of individual Au38 cluster molecules within the LB layer on the nanoscale, evidencing the hexagonal close packing[1].

Moreover, the nanomechanical properties of the cluster films were studied for the first time using bimodal (AM-FM) AFM, whereby the cantilever is excited at two frequencies simultaneously[2]. This allowed a quantified mapping of Young's modulus of the films transferred at a range of surface pressures.

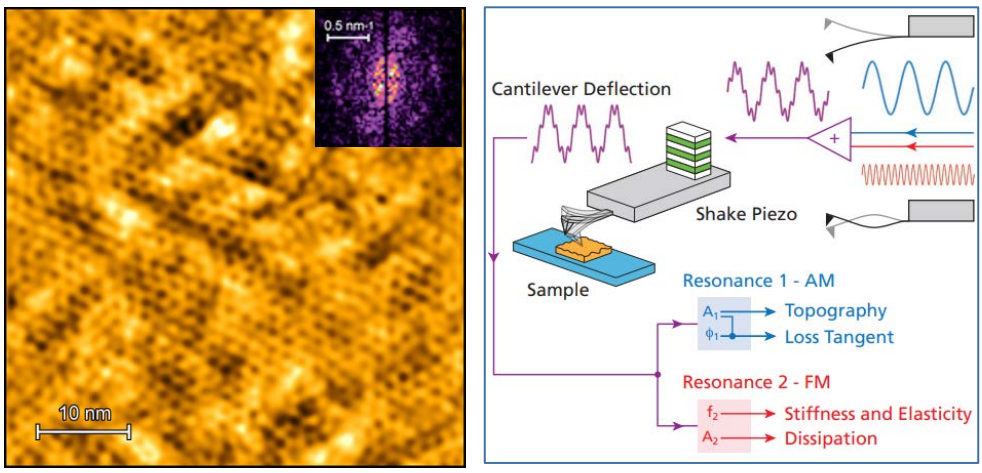

Figure. Left panel: Phase image of $Au_{38}(SC_2H_4Ph)_{24}$ LB film using fast AFM, 2D fast Fourier transform (FFT) image in the inset; Right panel: Scheme of bimodal AFM.

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Bimolecular photoinduced electron transfer in non-polar solvents

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Bimolecular photoinduced electron transfer (ET) in non-polar solvents is still poorly understood. To get a deeper insight into the relevant reaction coordinate, the effect of molecular interactions between donor and acceptor and the nature of the product, we are applying a variety of ultrafast spectroscopic techniques.

In many cases, the electronic absorption spectrum of the chromophore exhibits significant broadening and red shift upon addition of quencher, suggesting the presence of highly coupled reactants pairs[1]. Consequently, different distributions of reactant pairs can be photo-selected by tuning the excitation wavelength (see Figure).

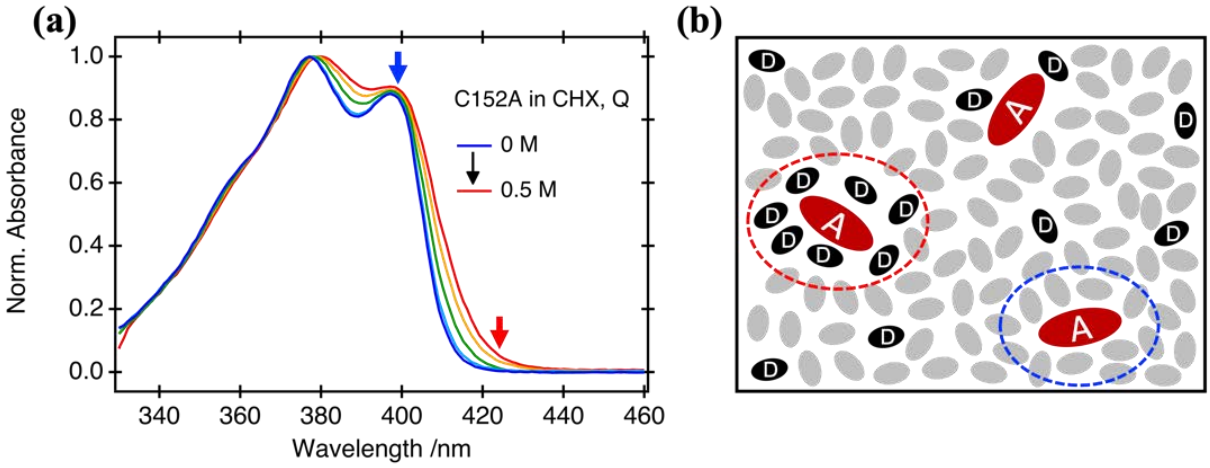

Figure. (**a**) Absorption spectrum of the coumarin C152A in cyclohexane (CHX) with increasing concentration of quencher (Q). (**b**) Pictorial representation for possible distribution of electron donor (D) and acceptor (A) in a non-polar solvent.

We will present our investigation of the effect of the excitation wavelength on the electron transfer quenching dynamics in non-polar solvents using Broadband Fluorescence Up-conversion Spectroscopy (FLUPS)[2] with sub 100 fs resolution and Transient Absorption (TA) techniques

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Identification of active contributions during cellular rearrangement in the basilar papilla of chick

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The auditory organ of chick, called the basilar papilla, comprises of two terminally differentiated cells: sensory hair cells and non-sensory support cells. In prenatal development, these cells arrange into a highly regular pattern where hair cells stand isolated from each other separated by support cells. This patterning of the hair cells becomes even more pronounced as the apical surface area of the hair cells increases 10-fold.

We suggest that non-muscle myosin, found to be located at certain junctions, drives this regular packing by active contraction. Here, we use a mathematical vertex model, that considers mechanical forces at the scale of single cells and cellular junctions, to identify the contributions of forces, that are actively expressed by cells, to the process of cellular rearrangement. Active forces of cell size regulation and myosin contraction stand in contrast to global shear forces, which are known to be involved in similar processes of tissue reorganisation but are experimentally only observed to a limited extend in the basilar papilla.

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