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Swiss Nanoscience Institute

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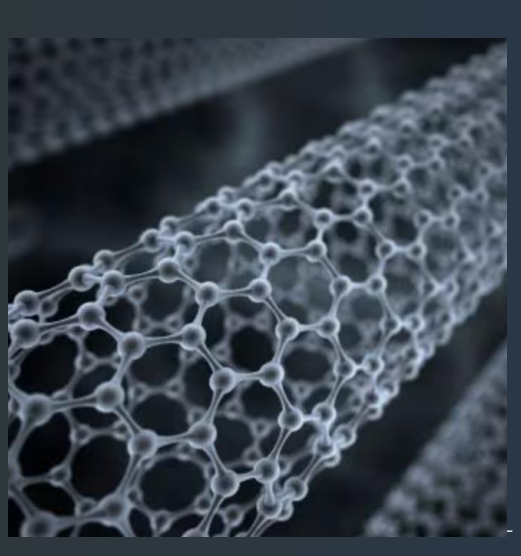
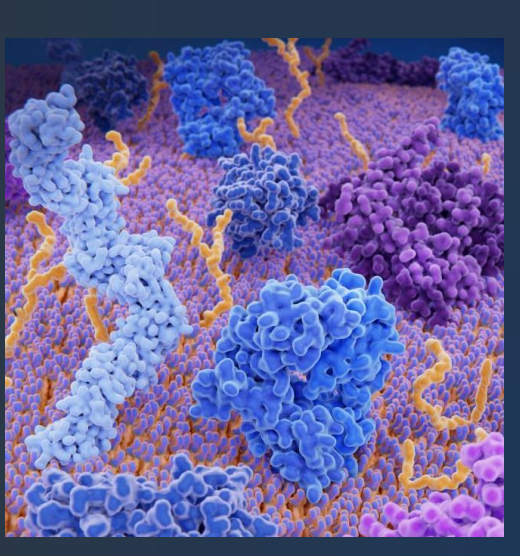
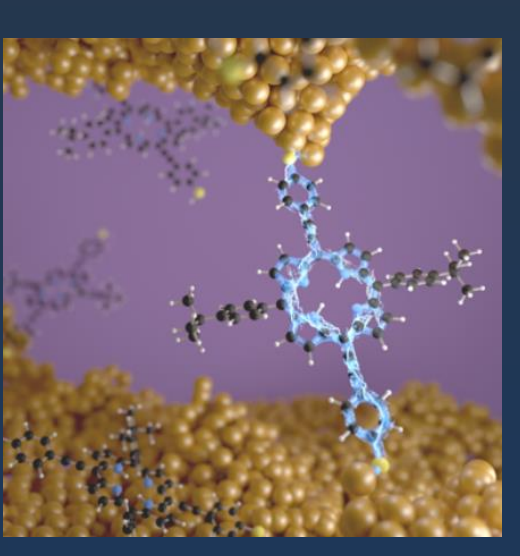
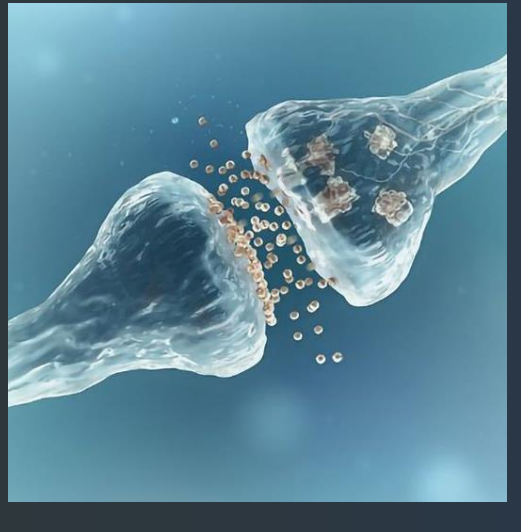
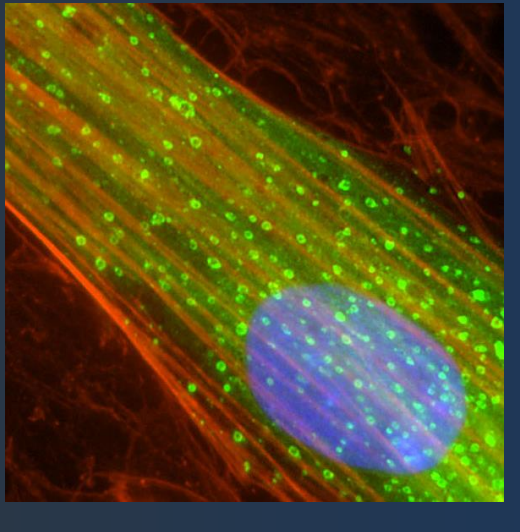
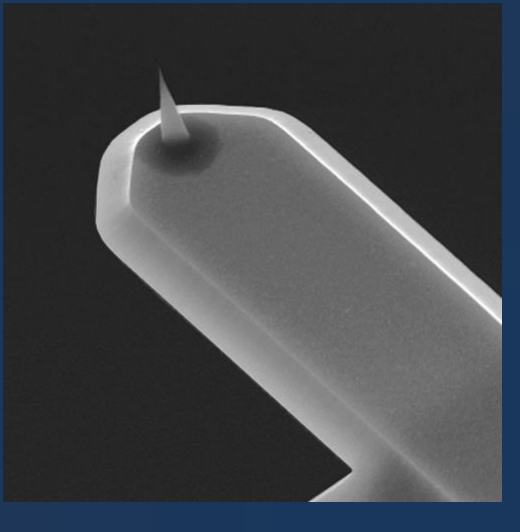
Center of Excellence supported by the University of Basel and the Canton of Aargau

# Small Talk

## 15. Mai 2024

Klingelbergstrasse 82, 4056 Basel
Physik Mensa; 8:00-15:00

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| | |
|---|---|
| 8:00 – 8:25 | Registration |
| 8:25 – 8:30 | Introduction<br>Anja Car |
| 8:30 – 8:45 | Copper Indium Sulfide Quantum Dots (CIS QDs) as a Light-Harvesting system<br>Yannik Schnider |
| 8:45 – 9:00 | Surface modifications of titanium implants<br>Nina Bonderer |
| 9:00 – 9:15 | A self-assembling peptide nanoparticle for the entrapment of rifampicin<br>Salome Brunner |
| 9:15 – 9:30 | Investigation of Ca2+ sweet-spot concentration to improve the mechanical properties of the adhesin-gellan hydrogel.<br>Senhong Cao |

Coffee Break

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| 10:15 – 10:30 | Investigation of the insertion of synthetic molecular switches and encapsulation of Atto647 in polymersomes<br>Karthekan Sivasubramaniam |
| 10:30 – 10:45 | Towards scalable spin qubits: Probing stability diagrams and g-factors of a fin field-effect transistor hole spin qubit<br>Timon Eya |
| 10:45 – 11:00 | Mechanical Testing and Self-Healing of Thermoplastic Polyurethane<br>Abisika Sutharsan |
| 11:00 – 11:15 | Formation of 2D molecular networks on Cu(111) by adsorption of DPDI<br>Leon Pfeifer |

## Lunch Break & Poster Session

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| 13:15 – 13:30 | Assessing whether the murine place cell network can distinguish between highly similar environments<br>Alain Bubendorf |
| 13:30 – 13:45 | Synthesis of Gold Nanoparticles for Rapid Pathogen Detection<br>Sofia Marcucci |
| 13:45 – 14:00 | Investigation of D7H and DT7H on Au(111) surface by nc-UHV AFM<br>Gabriel Eisler |

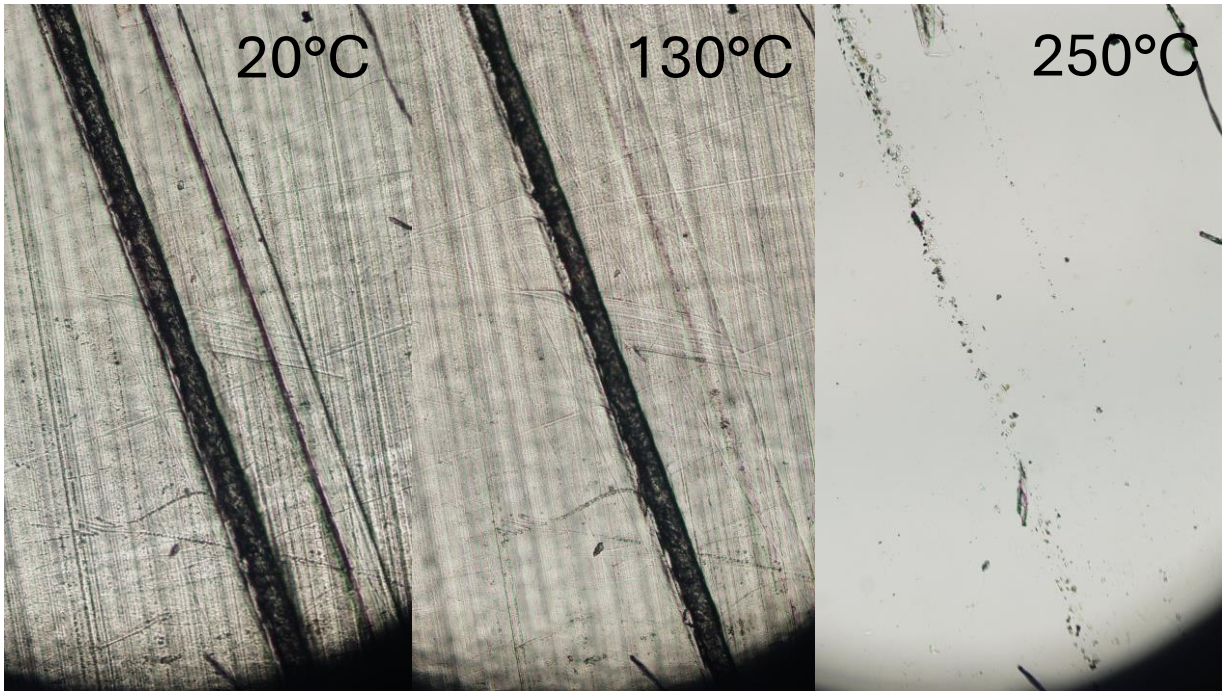
# Closing Remarks, Awards & Apero

Prof. Martino Poggio

# Mechanical Testing and Self-Healing of Thermoplastic Polyurethane

*Abisika Sutharsan*

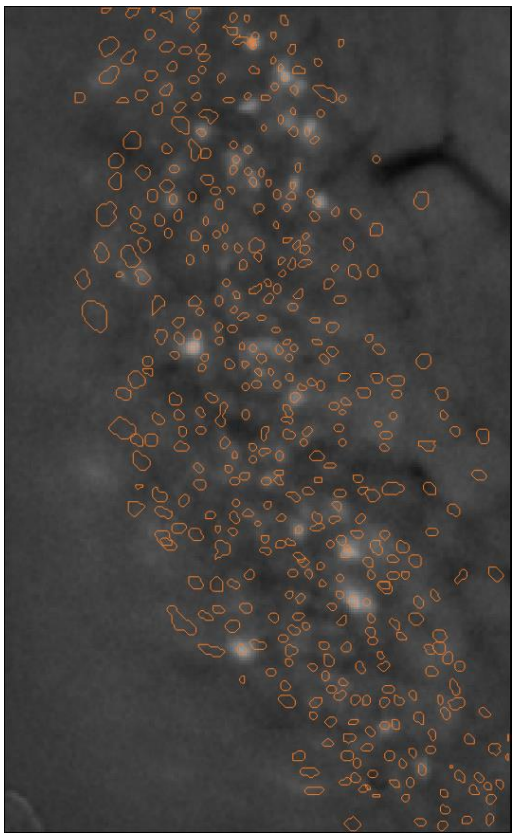
Thermoplastic polyurethane (TPU) is a versatile polymer known for its durability, flexibility, and thermoplastic behavior. Because of these properties, functional TPU is suitable for diverse applications such as in medical devices, aerospace engineering, and sports equipment.
The aim of this study is to compare the mechanical strength and the self-healing properties of TPU with and without the additives dioxane and di-n-butyltin dilaurate. For mechanical analysis, dynamic mechanical analysis (DMA) and tensile tests were performed. For the analysis of the self-healing ability, cuts were made into the polymer samples, which were examined under an optical microscope with a heating pad.
Results indicated that the presence of the catalyst influenced the mechanical strength of the polymer, with samples without the catalyst performing better in the tensile test. In terms of self-healing capabilities, samples containing the catalyst exhibited degradation over time with a lack of self-healing. The samples with only TPU demonstrated partial self-healing, suggesting the potential for self-repair mechanisms.



# Assessing whether the murine place cell network can distinguish between highly similar environments

*Alain Bubendorf*

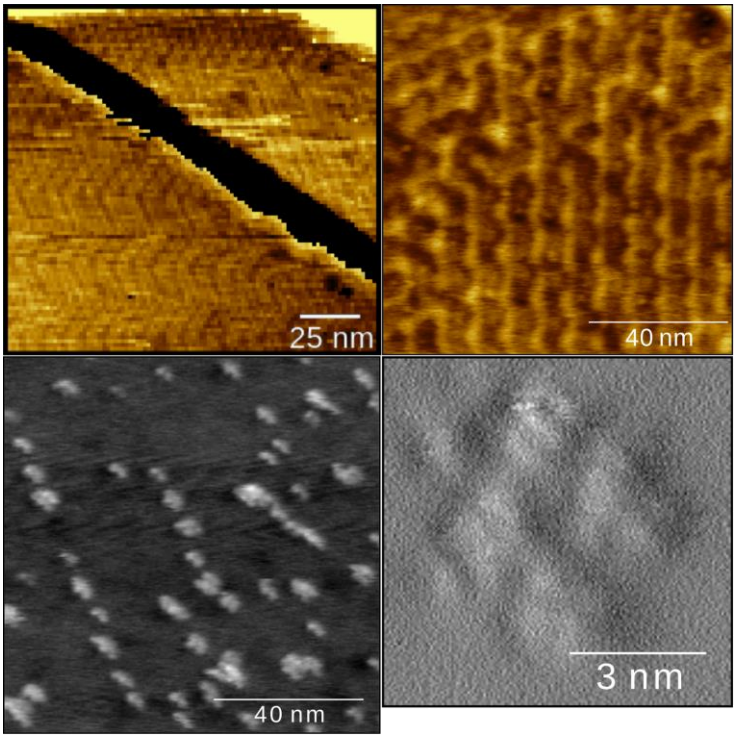
The hippocampal place cells show a spatially modulated firing pattern (place field) which encodes spatial information and is thought to be of critical importance for spatial memory and spatial recognition. These place fields are plastic and change through various processes. Recently it has been shown that sedentary animals show different dynamics in stability and remapping of place fields. Now do we want to assert whether physical factors other than a lack of movement, in this case fear conditioning, influence the place field dynamics as well. While we did find place cells during the experiment, the obtained data did not yield a reliable result.



# Investigation of D7H and DT7H on Au(111) surface by nc-UHV AFM

*Gabriel Eisler*

Non-contact ultrahigh vacuum atomic force microscopy (nc-UHV AFM) provides sub-nanometer resolution which matters most for investigating the adsorption of (in)organic molecules on metal, semiconductor or insulator surfaces.
Non-contact describes that the cantilever which oscillates by exciting a connected Piezo crystal with its resonance frequency does not touch the surface of the probe. However, the frequency shift as the cantilever oscillates near the surface is measured which provides information about the topography.
Here, double[7]helicenes, one with (DT7H) and one without (D7H) four sulphur substitutions were adsorbed on an atomically clean gold surface Au(111). Resolution was further improved using multipass where the sample is scanned twice.
After varying adsorption parameters, it could be seen that D7H only forms a monolayer or does not adsorb entirely. This is proven as the gold's herringbone structure could either be seen everywhere or nowhere. However, DT7H forms clusters of four molecules. The clusters elongate and increase size after further annealing at 150°C.

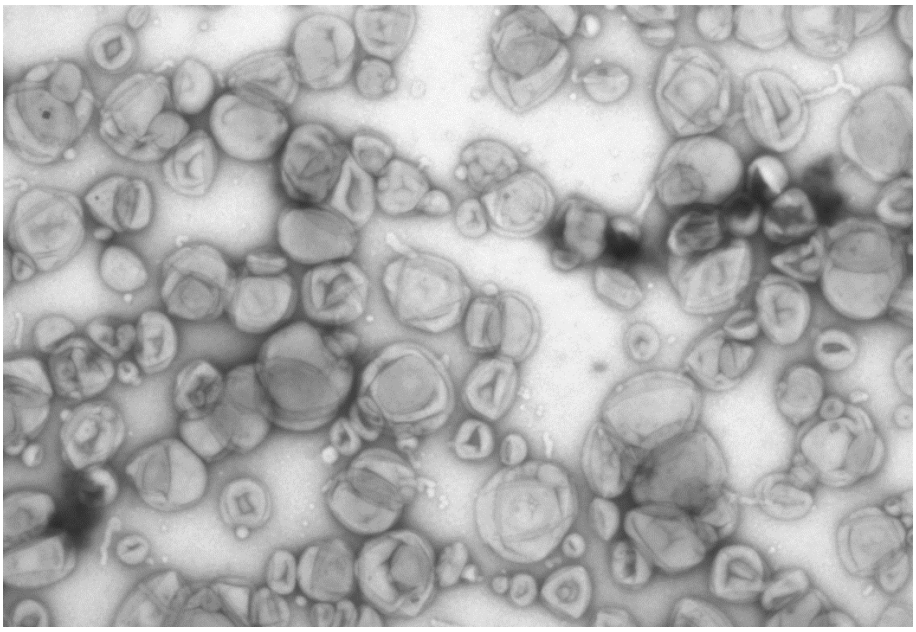


# Investigation of insertion of light-responsive molecular switches into PDMS25-*b*-PMOXA10 polymersomes

*Karthekan Sivasubramaniam*

Diseases ranging from the common cold to life-threatening cancer are a major challenge. Traditional medicine lacks precision and often causes side effects. Targeted drug delivery systems offer a solution by selectively transporting drugs to diseased cells. Amphiphilic polymer based nanoparticles, in particular light-responsive polymersomes, show great potential for targeted drug delivery with enhanced release control.

This project focuses on the integration of light-driven molecular switches into polymersomes to enhance drug release control. Successful incorporation of molecular switches is achieved without altering the morphology of the polymersome. Encapsulation of the fluorescent dye Atto647 has been demonstrated, but release requires further investigation.

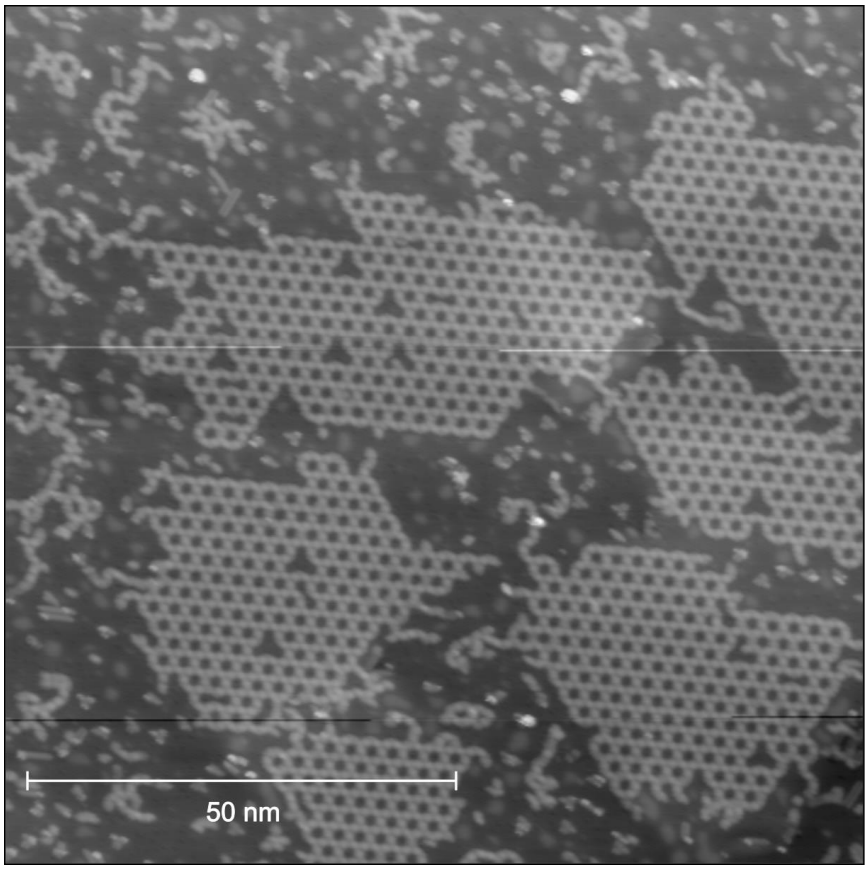


# Formation of 2D molecular networks on Cu(111) by adsorption of DPDI

*Leon Pfeifer*

The behavior of quantum systems depends on their dimensionality. For example, 2D electron gases will behave different from 1D nanowires and these two will show properties fundamentally different from 0D quantum systems. These are often described as quantum dots and they can be created using different approaches.

One example of quantum dots are on-surface nano sized quantum wells, made by a 2D structure of 4,9-diaminoperylene quinone-3,10-diimine (DPDI) on a Cu(111) single crystal surface. These molecules form extensive, periodic 2D arrays of networks on the surface. The structure of the networks depends on the surface itself. On Cu(111), this network is hexagonal, while it is quadratic on Cu(100). This system acts as a host on the surface, while small molecules or even atoms can act as a guest by entering the pores of the 2D structure. Using benzene as example, the goal is to qualitatively investigate this host-guest system by imaging it using STM at a temperature of 4K.



# Surface modifications of titanium implants

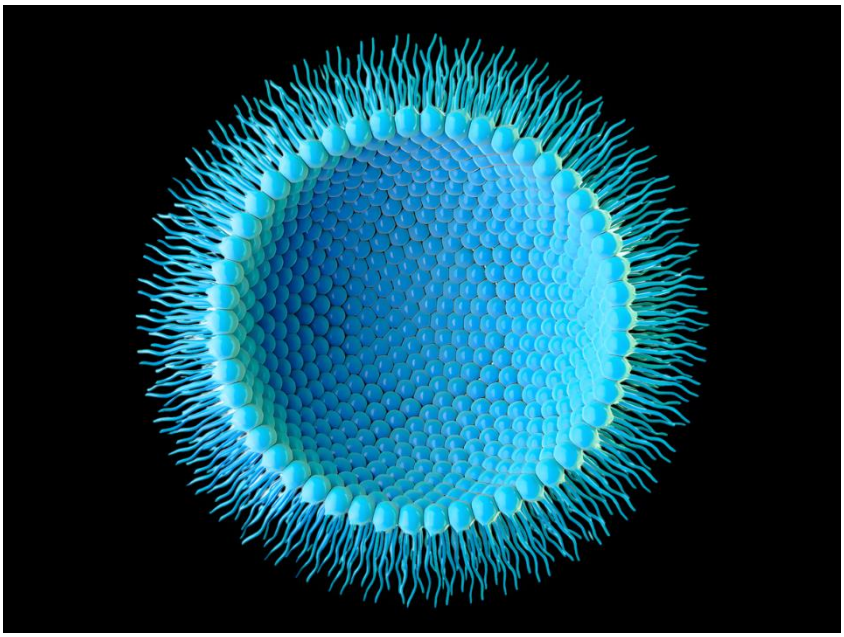
*Nina Bonderer*

Surface modifications are crucial in shaping implant properties, influencing biodegradation rates, corrosion resistance, and tissue integration. This project investigated various surface modifications applied to titanium discs. Through analysis of physico-chemical properties, cytotoxicity testing, and cellular morphology examination, techniques such as polishing, sand-blasting, anodization, and hydroxyapatite (HA) coating were compared. The results revealed differences in surface roughness, homogeneity, and cellular morphology. Notably, the synthesis of HA resulted in a heterogeneous mixture of calcium phosphate (CaP) compounds rather than pure HA. Nonetheless, cytotoxicity assays confirmed the biocompatibility of all modified titanium samples, and eukaryotic cells successfully attached to all surfaces. Moreover, samples coated with a CaP compound displayed distinct morphology suggestive of enhanced integration. Future experiments aim to enhance deposition methods for purer HA layers, assess reproducibility, and determine optimal morphology for specific implant applications, advancing personalized patient care.

# A Self-Assembling Peptide Nanoparticle for the Entrapment of Rifampicin

*Salome Brunner*

The escalating problem of increasing resistance to traditional antibiotics demands innovative strategies in the fight against bacterial infections. This project addresses this issue by focusing on the synthesis and characterization of peptide-multicompartment micellar nanoparticles (MCM-NPs) incorporating the antibiotic rifampicin. The peptide HR3gT, chosen for its ability to self-assemble and its biocompatibility, was employed for this purpose. Throughout the experiment, we examined the effects of rifampicin entrapment on the characteristics of the formed MCM-NPs, as well as the impact of various rifampicin-to-peptide ratios used during synthesis. Systematic analysis of the formed particles revealed that rifampicin entrapment did not significantly alter the favorable physiochemical properties of the particles, regardless of the ratio used. The formulation with a rifampicin-to-peptide ratio of 1:1 exhibited the highest amount of entrapped rifampicin, making it the most promising candidate for further experiments. These findings underscore the potential of MCM-NPs as effective carriers for antimicrobial agents. Entrapping rifampicin within these nanoparticles, followed by immobilization, presents a promising approach to the development of potent antimicrobial coatings.



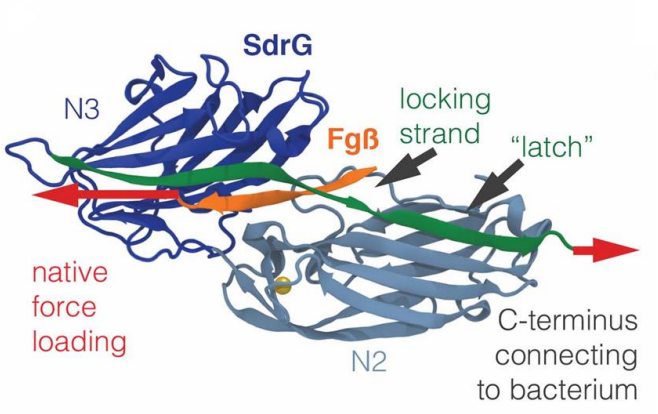
# Investigation of Ca2+ sweet-spot concentration to improve the mechanical properties of the adhesin-gellan hydrogel

*Senhong Cao*

Staphylococcal pathogens adhere to the host cells with adhesin, more specifically, with catch bond forming complex, the strongest protein complex identified to date. One such example is the serine-aspartate repeat protein G - fibrinogen beta strand complex (sdrG-FgB). The mechanostability varies depending on the calcium ion concentration. To observe the macroscopic effect of the catch bonds, the particles functionalized with sdrG and FgB should be embedded into hydrogels so the macroscopic measurements could be performed.

Yet calcium ions also serve as gelling agent for gellan gum. Therefore, the calcium concentration is crucial for such a composite gel, High concentrations of calcium may lead to heterogeneous gelation and excessively stiff gellan gum, while low concentrations may weaken the catch bond complex and gellan network.

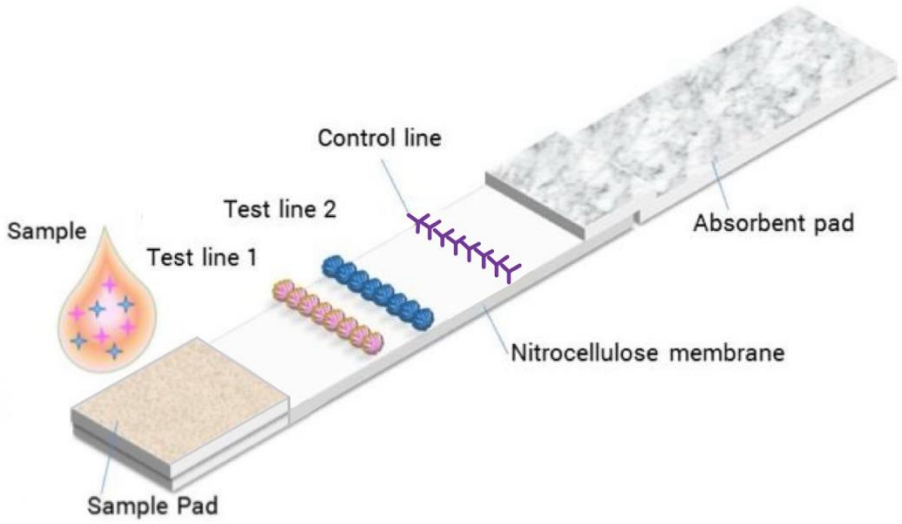
In this block course, sdrG and FgB functionalized PS beads were embedded in gellan gum with different sdrG-FgB ratios and various concentrations of calcium ion. For microscopic scale, the particle distribution was investigated with optical microscopy. For macroscopic scale, the composite gels are loaded into rheometer for rheological measurements.



# Synthesis of Gold Nanoparticles for Rapid Pathogen Detection

*Sofia Marcucci*

Rapid pathogen detection has become an important task for healthcare, especially since the SARS-CoV-2 pandemic of 2019. For this reason, point-of-care (POC) devices have been developed that can be employed in a simple and affordable way near the patient without the need of professional instrumentation or healthcare professionals.
Lateral flow assays (LFAs) are one of the most-established POC platforms, in which a loaded sample flows through capillarity to the nitrocellulose membrane, where specific biological components such as antibodies or antigens are immobilized in test and control lines to detect whether the target analyte is present in the sample. The reaction between the sample and the biological components is made visible by functionalized gold nanoparticles (GNPs) which display a colorimetric signal. For this purpose, GNPs were synthesized, characterised and then functionalised with protein A in order to detect IgG antibodies in a self-assembled LFA.

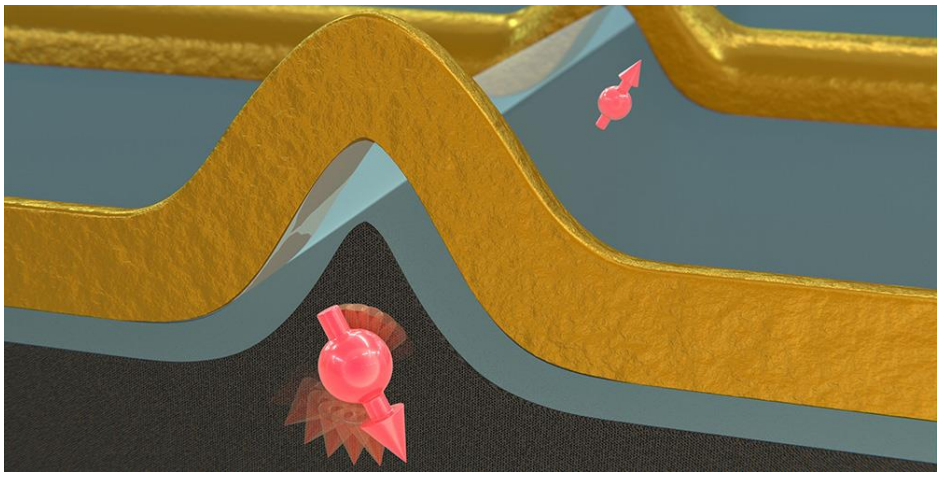


# Towards scalable spin qubits: Probing stability diagrams and g-factors of a fin field-effect transistor hole spin qubit

*Timon Eya*

Currently, the greatest roadblocks for the realization of quantum computing are qubit decoherence, scalability and state manipulation. Fin field-effect transistors (FinFETs) present a compelling platform for the implementation of hole spin qubits that are industry compatible and well suited for scalability and interconnection by harnessing complementary metal-oxide-semiconductor (CMOS) manufacturing processes. They offer long coherence times, fast and high fidelity all-electrical spin manipulation at reported temperatures of up to 4 K, placing them at the higher end of the temperature spectrum compared to other promising qubit designs.

In our work, we investigate the transport properties of a FinFET double quantum dot hole spin qubit operated at 6 K. By analyzing stability diagrams, we demonstrate the formation of bias triangles including observation of Pauli spin blockade, indicating the presence of well-defined spin states. In addition, we employed spin-orbit mediated electric-dipole spin resonance to determine the g-factors of the two dots. These findings further underline the potential of FinFETs for scalable, industry-compatible spin qubit technology.



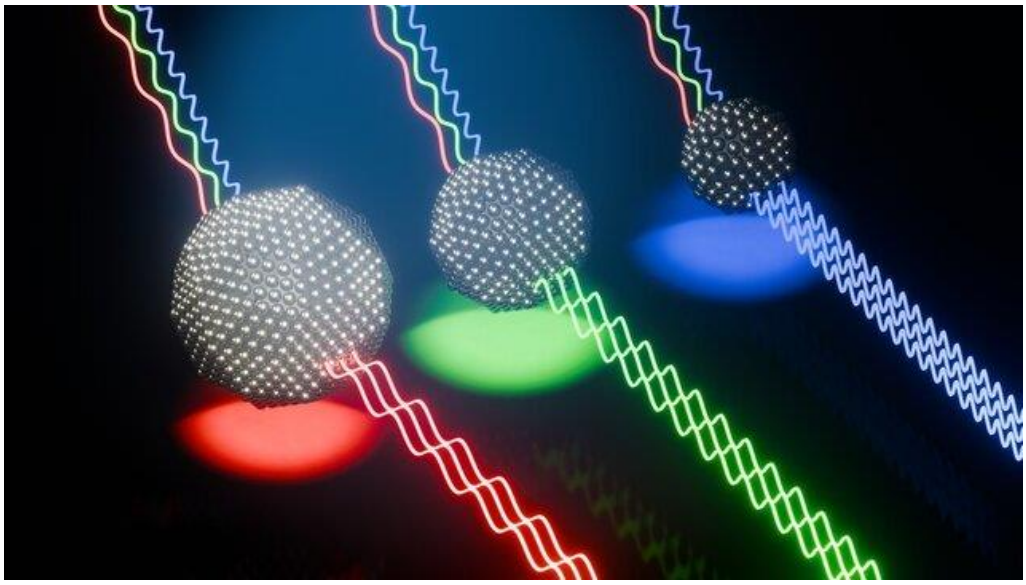
# Copper Indium Sulfide Quantum Dots (CIS QDs) as a Light-Harvesting system

*Yannik Schnider*

Chemical catalysis aims to find new modes of small molecule activation. One such approach is photoredox catalysis using visible light. Generally speaking, this approach harnesses the ability of metal complexes and organic dyes to engage in single-electron-transfer processes with organic substrates upon being excited with visible light. Chromium complexes are known to act as photo-oxidizing agents via an excited doublet state ($^2E$). The transition to this doublet is spin-forbidden from the Cr(III)'s electronic ground state ($^4A_2$). Because of the spin-forbidden nature of this transition, it has a long lifetime and cannot be driven directly by irradiation of visible light; Cr(III) complexes show low absorption in the visible spectrum.

Instead, Copper indium sulfide quantum dots (CIS QDs) may serve as a light-harvesting system, to excite the complex. Quantum dots are highly photoluminescent in the visible range of light, and their molar extinction coefficients can be tuned based on their size. The energy harvested by the QDs can be transferred in an energy cascade. This process is enhanced by an organic moiety that acts as an intermediate and is attached to the QD.

Characterization of the created QDs gave that they are 2.6nm in diameter, have the expected absorption spectrum with a molar extinction coefficient of 28’500 $M^{-1}$ $cm^{-1}$. They show maximal emission at a wavelength of 650nm (red). Their band gap was determined to be around 2.4eV. In a next step the surface of the QDs could be functionalized, then added to a suitable Cr(III) complex and the photocatalytic properties under radiation could be probed.



# Posterliste

**P1** - AFM images of C60 and C60-Pyridine - *Yannik Schnider*

**P2** - Enhancing the cellular uptake of polymersomes by functionalization with mellitin - *Nina Bonderer*

**P3** - Exploring co-translational folding dynamics of proteins using NMR spectroscopy - *Salome Brunner*

**P4** - Polymersomes loaded with photosensitizer as an anti-caner drug delivery appoach - *Senhong Cao*

**P5** - Double quantum dot identification and characterisation in a silicon FinFET device - *Karthekan Sivasubramaniam*

**P6** - PhysNet performance evaluation: Exploration of various training approaches and input configurations - *Timon Eya*

**P7** - Investigating Cell Viability in Response to Surface Modifications of Titanium Samples - *Abisika Sutharsan*

**P8** - Surface functionalization by "layer by layer" formation - *Leon Pfeifer*

**P9** - Automated Behavioral Analysis of Drosophila Melanogaster Using SLEAP for Insights into Homeostasis-Driven Patterns - *Alain Bubendorf*

**P10** - Self-Healing and Mechanical Characterization of Thermoplastic Polyurethane (TPU) containing Exchangable Bonds - *Sofia Marcucci*

**P11** - Using THz techniques to investigate Graphene-COC structures - *Gabriel Eisler*