1. Nanoscience and Nanotechnology
Exploring multiphoton induced luminescence from Spherical gold nanoparticles: Physical insights and biomedical implications

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Gold nanoparticles (AuNPs) demonstrate potential for a wide variety of applications due to their special features and the possibilities of tailor making their optical properties. The particles have previously been introduced as immunolabeling contrast for transmission and scanning electron microscopy. AuNPs are attractive for drug delivery and are explored for the purpose of photothermal cancer treatment.\textsuperscript{1}

Recently, AuNPs have gained interest as a contrast agent in multiphoton laser scanning microscopy (MPM) based on their ability to exhibit multiphoton induced luminescence (MIL). MIL is a process in which nano-particles of noble metals absorb photons through localized surface plasmon resonance.\textsuperscript{2} When exposed to high photon densities, multiple photons can be absorbed. To better be able to use the particles as contrast agents, it is important to understand the process by which they exhibit luminescence.

The study was carried in two steps. Firstly we explored AuNPs deposited on a glass surface in a gradient pattern (Error! Reference source not found.), which were managed using a MPM setup with settings applicable to life sciences. It was concluded that 10 nm AuNPs need to be clustered to be visible using a multi-photon microscope. For the second set of experiments 20 nm AuNPs functionalized with zinc-responsive polypeptides were used.\textsuperscript{3} The peptides fold and dimerize in the presence of zinc ions, which causes the particles to aggregate. A clear correlation between aggregation and MIL could be seen when viewing the particles with a MPM setup, exciting at 800 nm and detecting between 415 and 735 nm. This is due to the aggregates increased absorption in the near infra-red region, which was confirmed using UV-vis spectroscopy.

Calcium effect on directed lipid flow in cell membrane models
Improving knowledge about cell migratory behavior

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Observing the active role of lipids in response to chemical cues in artificial cell membranes could increase our understanding of directed cell transport phenomena in biological cells. Directed cell migration is essential in many biological processes including embryogenesis, wound healing, chronic inflammatory diseases, as well as cancer metastasis. Using biomimetic cell model systems makes it possible to use a minimal set of components for understanding directed cell movement and in-cell transport phenomena in regard to lipid sorting, formation of tubular protrusions and lipid movement. At present, we study directed lipid transport in artificial membranes by local biochemical gradient, calcium. We demonstrate that membrane tubulation and the flow of lipids in the membrane can be triggered and controlled by the chemical gradient applied along the lipid bilayer. This sheds light on interplay between membrane properties and chemical stimulation.
Unfolding of Nanoconfined Circular DNA


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Nanofluidic channels have become a versatile tool to manipulate single DNA molecules. They allow investigation of confined single DNA molecules from a fundamental polymer physics perspective as well as for example in DNA barcoding techniques.

Circular DNA is found in many biologically relevant contexts, such as bacterial plasmids, viruses and eukaryotic mitochondrial DNA. Furthermore, the circular topology forces two strands in close proximity to each other in nanochannel, which changes the polymer physics compared to linear DNA. Circular DNA is difficult to study with traditional single molecule techniques because they generally require the attachment of handles, but is readily accessed using nanofluidics.

Circular DNA in its folded configuration has less entropy and higher conformational free energy than in the unfolded configuration. Therefore, as a double-strand break occurs and circular DNA opens up, it unfolds to its linear configuration inside the nanochannel. This study compares the static properties of confined linear and circular DNA as well as investigates the dynamics of the transition from circular to linear DNA. The difference in extension between the circular and linear configurations depends on the degree of confinement, which we confirm with theoretical predictions. Our data for unfolding of the circular DNA to the linear configuration suggests that hydrodynamic friction between the DNA and the solvent is the main rate-determining factor but that DNA-DNA contacts are also important. Finally, by staining the DNA inhomogeneously, we observe the local dynamics of the DNA as the folding occurs. We are thus able to study the dynamics of confined DNA with unprecedented resolution and obtain completely new information about confined polymers.

References

Implant infection is a devastating complication with major clinical and economic consequences for the patient. Extreme resistance of implant infection to the body defense mechanisms and antibacterial treatments necessitate the development of infection-resistant materials that can function as antibiotic delivery systems. Local release of antibiotic minimizes the subsequent systemic side-effects and maximizes the systemic concentration at the site of implantation. In addition Application of nanotechnology tools to exploit nanorough surfaces to prevent bacterial adhesion opens up new insights into governing current growing global concern about “spreading antibiotics resistance”.

In this study, we present the effectiveness of mesoporous titania films as antimicrobial release coating. Mesoporous titania thin films with pore diameters of 4, 6 and 7 nm were synthesized using the evaporation induces self-assembly method. The surfaces were loaded with antimicrobial agents, Vancomycin and Gentamicin, and S.Aeurous and Pseudomonas aeruginosa were used to evaluate the efficiency towards bacterial colonization. The drug delivery was studied using quartz crystal microbalance with dissipation monitoring (QCM-D), which showed a successful loading and release of the antibiotics. Results from counting the bacterial colony forming units showed a reduced bacterial adhesion for the drug-loaded films. Furthermore, also the presence of the pores showed to have a desired affect on the bacteria, an effect attributed to the nanoroughness.

References.

3D printing techniques have replaced the traditional subtractive production for a bottom-up approach of multilayer models with nanoscale elements. Advances in this technology will lead to a reduction of waste and a significant price drop. Some 3D printers can already print structures from plastic, metal, nylon, cellulose and several other materials. One of the greatest assets of 3D printed manufacturing is the ability to print with metallic inks, which enables circuit patterning and other high conductivity applications made by metal nanoparticles (e.g., Ag, Cu and Au). However, printing conductive devices with renewable and low cost materials is still unknown. Here we show how a conductive ink made of nanofibrillated cellulose (NFC, green and cheap option) and carbon nanotubes (CNT) can be an excellent choice for 3D printed electronics, see figure 1a. By the addition of successive layers of this ink combined with pure NFC, extremely thin films (only a few micrometres thick) with high resolution can be created, see figure 1b. The combination of the superb electrical properties of the CNT and the excellent mechanical properties of NFC makes this ink a great candidate for circuits and conductive sensors. Besides, it is shown to be a simple 3D printing process based on a drawing file saved into the 3D printer software, printing and drying, since the ink is in form of hydrogel.

**Figure 1.** In (a) the conductivity for different mixtures of NFC/CNT are shown. In (b) 3D printed structures with conductive ink embedded in pure NFC are displayed.

In the past few years, the use of CNT/cellulose composites manufacturing have been approached, but not with 3D printing. We anticipate this inkjet printing to be an opening for a “greener option” in film electronics, such as strain gauges, active matrix displays and high strength cables and substrates. Furthermore, this process can be highly useful in 3D printed electronic devices, including textiles, energy storage and smart paper applications.
The society of today has created a demand for faster and better performing technology. However there are some obstacles that must be overcome in order to be able to reach these new demands. Top-down methods such as photo-lithography are approaching physical limits in creation of continuously smaller electronic components. To enable further miniaturisation, one solution could be to create the electronic components based on molecules and nanoparticles in solutions and then assemble the proto-devices onto a substrate in a second fabrication step.

The aim of our work is to design and synthesise organic molecules which can act as wires, photo-switches, diodes and more. These will then act as linkers between two larger metal particles. This will be assembled from solution onto a substrate to be able to serve in a larger electronic device. The assembly must be parallel and preferable controlled by thermodynamics rather than kinetics.

The nanoparticles are covered with a surfactant in order to keep them suspen ded in solution, this surfactant charges them at the same time. Electrochemical forces are therefore believed to be present when deposition of nanoparticles takes place. This is confirmed after analysing SEM images over 25 nm big palladium nanoparticles on silicon (Figure 1 left), where it is clear that they are uniformly distributed over the surface and that they seem to follow a specific pattern when deposited. Spatial point processes confirms this by showing that the particles will start repelling each other at a distance of 20-50 nm.

Successfully attempts to control the location of the deposition of nanoparticles on silicon surfaces have also been performed (Figure 1 right). This has been done by creating guiding features in a polymer resist covering a silicon surface using electron beam lithography. Results indicate that there is a difference between the densities of particles on the silicon surface depending on if the silicon is positively or negatively doped.

Figure 1: Pd particles on a Si surface (left), scale bar 1μm. Pd particles in a polymer resist feature design using EBL (right), scale bar 200 nm.
Domain orientation of membrane-bound EHD2 involved in membrane reshaping

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The mammalian EH-domain containing protein 2 (EHD2) binds peripherally to lipid membranes and reshapes them. EHD2 is controlling the scission and endocytosis of caveolae from the cell surface in a ATP related fashion. In order to remodel membranes, the EHD2 oligomerises in rings around highly curved lipid templates.

We present the major conformational change involved in the membrane binding of EHD2 established by infrared reflection absorption spectroscopy (IRRAS). We thereby also demonstrate the versatility of IRRAS in determining the orientation of proteins and even of protein domains relative to lipid layers.

EHD2 is not inserted straight into the lipid monolayer in the closed conformation that was previously established in the crystal structure. On the contrary, the helical domains containing the lipid binding motif are highly tilted with respect to the lipid monolayer. Our study thus indicates an open conformation of EHD2 as part of the membrane shaping process and adds valuable information on structural mechanisms involved in caveolar endocytosis.
Optical mapping of single DNA molecules in nanochannels: 
A novel method for identification and characterization of antibiotic resistance

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The use, and overuse, of antibiotics has during the last decade led to a dramatic increase in antibiotic resistance and fast methods for identification of resistance genes are much needed. We here demonstrate how optical mapping based on competitive binding \cite{1} can be used for characterization of plasmid DNA from resistant bacteria, using fluorescence microscopy and nanofluidic channels. We can study the plasmid size, identify sequenced plasmids and create consensus maps for unsequenced plasmids. As an outlook, since our assay requires miniscule amounts of sample, we aim to use optical mapping directly on clinical samples and thereby avoid the time-consuming step of cultivation of bacteria.

\textbf{Figure.} Left: Kymograph of a fluctuating (top) and aligned (bottom) single plasmid of type R100. Right: Comparison of a theoretical (black) and experimental (gray) intensity trace for a single R100 plasmid.

\textbf{References.}

Back electron transfer kinetics in D35-Sensitized TiO₂ in the presence of room temperature ionic liquids probed by nanosecond transient absorption spectroscopy: effect of varying cations and anions.

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Increasing the efficiency of ionic liquid (IL) based dye-sensitized solar cells has been achieved through various approaches such as the use of IL mixtures and the use of additives to control the interfacial chemical and physical properties [1,2]. However, how the ILs presence affects the different electron transfer processes in a DSSCs has not been extensively studied. We explored the possibility of controlling back electron transfer by using ionic liquids in D35-sensitized mesoporous TiO₂. We investigated this using nanosecond transient absorption in the presence of four different room temperature ionic liquids (ILs) by varying the length of the alkyl chain in the cationic counterparts or by varying the anionic counterpart in 1-alkyl-3-methylimidazolium based ILs. The kinetics probed at the absorption wavelength of the oxidized dye varied with the solvent. The back electron transfer was in fact slowed down in the presence of 1-butyl- and 1-hexyl-3-methylimidazolium hexafluorophospate (BMIMPF₆ and HMIMPF₆). The half-life was increased by approximately a factor of two and a factor of three in the presence of BMIMPF₆ and HMIMPF₆ respectively compared to the lifetime in acetonitrile. Contrarily, the presence of 1-butyl-3-methylimidazolium thiocyanate and iodide (BMIMSCN and BMIMI) considerably speed up the rate of the decay. Our spectroelectrochemical data shows direct electron transfer (regeneration of the oxidized dye) from SCN- and I-, which presumably contributes to the observed faster decay.

Figure 1. Fitted kinetic traces of D35-sensitized TiO₂ thin films, probed at 680 nm, in contact with different solvents.

REFERENCES
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Norbornadiene based molecular photoswitch

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The top-down approach in reducing the size of electronic components to fulfill Moore’s law is facing fundamental physical limitations as well as high production cost.\textsuperscript{1} As a result, bottom up approach has been pursued as an alternative to mitigate those challenges. This approach allows systematic design and synthesis of molecules of interest for electronic applications.\textsuperscript{2}

Switches are one example of electronic components. Certain molecules can serve as switches when they allow and disallow the passage of electric current through them in their two different isomeric states. Switches that can be turned ON and OFF using light are termed as photoswitches. One example is Norbornadiene. Norbornadiene forms a metastable isomer called quadricyclane upon shining a UV light. In light of this we have planned to synthesize norbornadiene-based molecular photoswitches with a thioacetate alligator group to allow us attach it with a gold substrate. The key step is the Sonogashira reaction, which is used to couple the two components A and B to get the target product.

Figure: Synthetic procedure for norbornadiene (NBD)-based photoswitch (a) which undergoes light-induced isomerization to quadricyclane (QC) (b); i. PPh\textsubscript{3}, K\textsubscript{2}CO\textsubscript{3} AcCl, MeCN, 60\textdegree C ii, Pd(PPh\textsubscript{3})\textsubscript{2}Cl\textsubscript{2}, Cu(I)I, DIEA, TMSA, THF iii, TBAF, THF, -15\textdegree C iv, \textsuperscript{t}BuOK, \textsuperscript{t}BuLi, TsBr, THF -84 to -40\textdegree C v, Pd(PPh\textsubscript{3})\textsubscript{2}Cl\textsubscript{2}, Cu(I)I, DIEA, Toluene.

References:

**Water treatment – The Natural way: Using Aquaporins, lipids and silica to purify water**

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**WHY?** The growing population in areas where fresh water supplies are scarce is resulting in difficulties satisfying the demands for drinking water. Pollution and environmental changes are increasing the demands further. Improvements in water treatment processes are therefore needed, an achievement we suggest to fulfil by constructing a device that desalinate water using the blueprint of Nature (Fig. 1).

**HOW?** The idea is to desalinate sea water using a membrane that resembles the membrane of living cells, by reconstituting aquaporins in a lipid bilayer. Lipid bilayers are suitable as separation membranes since transmembrane transporter proteins, such as aquaporins, can readily be reconstituted to add selectivity, whereas a general characteristic of lipid bilayers is that they are inert and impermeable to most substances.

The proposed device has to overcome the osmotic pressure that arises, due to for example differences in salt concentration, by applying an external pressure to the membrane. The lipid bilayer is by itself not rigid enough to withstand such pressures, which urges the use of a support that is able to stabilise the bilayer. We are proposing the use of a mesostructured support material that is tailor-made to suit the Aquaporin.

**RESULTS:** There are lots of results on the poster; Go take a look at the droplets!

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**Figure 1:** Illustration of the nanoscale water treatment device. From top to bottom; lipid (POPC) bilayer incorporating a human Aquaporin 4, deposited on mesoporous silica (SiO\textsubscript{2}) substrate. Untreated water enters from the top and pure water exits from the sides of the mesoporous silica.