The light way to polymer brushes

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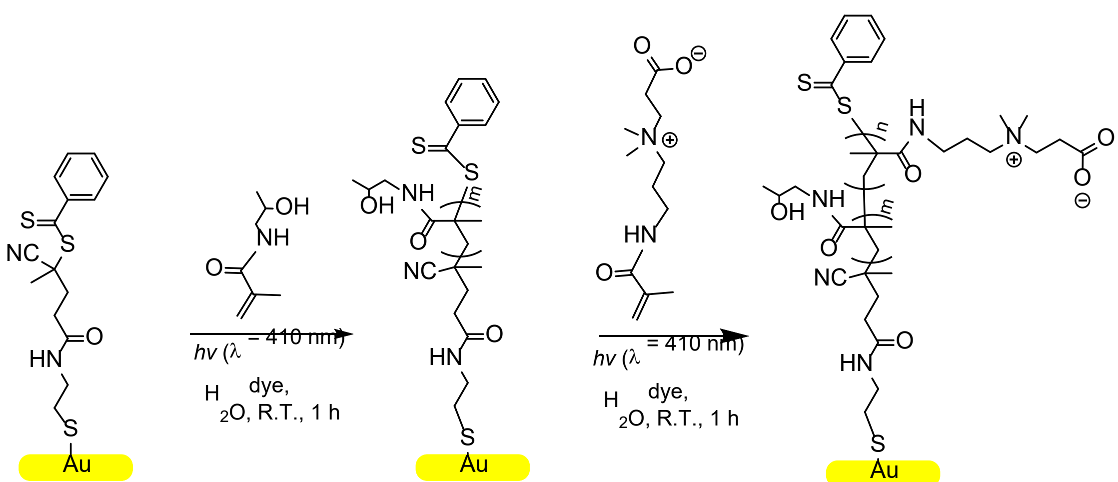
The construction of polymer brushes with increasing complex architectures and the inclusion of specific functionalities has driven many aspects of surface science. Especially the development of a range of controlled radical polymerizations allowed the formation, study and application of a wide range of such densely packed surface-modified surfaces. However, these often came at the price of complicated procedures and the need for a rigorously inert and dry atmosphere. This strongly limited the field, and there was evidently a need for easier and more robust procedures.

Over the last 5 years we have developed a range of visible light-induced methods to obtain high-quality polymer brushes that provide control over a range of properties. Such approaches were shown to work well even in water under ambient atmosphere. The presentation will display this development, and will present a perspective on which ways to go from here.



Mild & visible light-induced formation of diblock polymer brushes

Amphiphilic coatings for marine low-fouling applications

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Manmade materials in contact with ocean water become rapidly colonized by living matter like bacteria, diatoms, barnacles, or mussels. Increased fuel consumption, failure of devices, and substantial maintenance costs are among the penalties associated with marine biofouling. As the historical paradigm to combat fouling by biocide releasing coatings is increasingly challenged by legal restrictions, environmentally benign low-fouling materials for marine applications are intensively explored [1]. While several hydrophilic and hydrophobic materials show promising properties, their combination into amphiphilic coatings unites the best of the two worlds [2]. As hydrophilic compound, zwitterionic materials with different molecular architectures were developed and their structure-function relationship against different fouling organisms have been studied [3]. Amphiphilic coatings based on zwitterionic polymers have been designed and their anti-polyelectrolyte properties have been characterized by several methods including AFM and SPR. Their antifouling properties against a range of marine fouling species and in short term field exposures have been assessed and the results will be discussed under consideration of the interaction of the organic coatings with inorganic particulate matter in the ocean [4,5,6]. Based on the obtained data, design criteria for optimized zwitterionic building blocks for fouling-release technologies will be discussed.

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Biodegradable and environmentally-friendly peptide-based functional coatings

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The lecture will present bio-inspired functional nano-coatings that are spontaneously formed by short peptides. These peptide-based coatings self-assemble on metals, oxides, and polymers under mild conditions without any need for a curing step. The coating can change the surface properties without harming its function or topography. It can serve multiple applications including nanopores modification, antifouling and preventing implant failure. Moreover, it can be integrated into polymeric films by co-extrusion and acquire these films with antibacterial, antifungal and antiviral activity.

AI-Guided Optical Sensors for The Early Detection of Gynecologic Cancers

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Abstract

Gynecologic cancers are particularly difficult to diagnose. Patient prognosis and quality of life are affected substantially by this problem. We are developing new technologies to improve cancer detection using liquid biopsy and *in vivo* sensor approaches. With artificial intelligence algorithms, we harnessed the unique optical properties and sensitivity of single-walled carbon nanotubes to develop intelligent optical sensors. We developed platforms to detect multiple cancer biomarkers in both patient biofluids and within the uterine cavity as implantable devices. Applying machine learning algorithms to analyze the optical response of the sensors enabled the precise detection of multiplexed biomarkers. In addition, when implanted in human uteri, the sensors detected the biomarkers and successfully differentiated between benign and malignant cases. These technologies will significantly improve diagnostics and lead to robust, point-of-care technologies for early-stage diagnosis.

Laser-induced Graphene Capacitive Killing of Bacteria

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Laser-induced graphene (LIG) is a method of generating a foam-like conformal carbon layer of porous graphene on many types of carbon-based surfaces. This electrically conductive material is useful in many applications including environmental technology and its antimicrobial surfaces can help address persistent environmental challenges spawned by bacterial and viral contaminates like antibiotic resistant bacteria. In this work we show that a single film of LIG stores charge under an applied voltage and subsequently dissipates this charge in the presence of an electrolyte solution to produce an electricidal antibacterial surface effect. Accumulated/dissipated surface charge was quantified with an electrometer. Approx. 65 pC of charge can be stored on an LIG surface in a standard capacitor configuration with a gap distance of 94 **μ**m (areal capacitance of 1.63 pF/cm^2). We corroborate stored charge decay with bacteria death via direct electrical contact. Antimicrobial rates decrease with the same monotonic pattern as LIG surface charge decay (i.e., AR ~ 97% 0s after voltage source disconnection vs. AR ~ 21% 90s after disconnection). Ultimately, bacterial death was proven to be a function of delayed LIG exposure time after applied voltage disconnection. In terms of energy efficiency, bacteria potency increased ~170% for equivalent energy costs as that previously estimated for configurations of continuously applied voltage. Given our results, a mechanistic explanation for the capacitive behavior and the electricidal effects for a single plate of LIG are postulated.

Reference: Powell, C. D., Pisharody, L., Thamaraiselvan, C., Jopp, J., Sharon-Gojman, R., Tesfahunegn, B. A., Sharma, C. P., Kleinberg, M. N., Burch, R., & Arnusch, C. J. Laser-induced Graphene Capacitive Killing of Bacteria. *ACS applied bio materials* (**2023**).

Laser-processed Direct Coating of Graphene-Based Films on Plastic Substrates with Anti-Bacterial Properties Substrates with Anti-Bacterial Properties

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Abstract

Enormous efforts are devoted to the search for cost-effective, easy, and single-step synthesis techniques for micron-thick coatings. Recently, laser processing emerged as a novel method to form micron-thick films of highly graphitic carbon. Laser processing offers significant advancements including (1) fast, single-step, and waste-free synthesis, (2) allowing direct printing of graphene over any substrate, including thermal-sensitive materials (i.e., polymers), and (c) micron-resolution patterning of the coated materials. In this work, we use an intense laser beam to fabricate graphene-metal-oxide nanoparticles composites films. The metal-oxide nanoparticle films (Cobalt and Copper) are tested for antibacterial activity. Due to the combined formation, the metal-oxide nanoparticles are highly dispersed and strongly adhered to the graphene matrix. Importantly, chemical and physical properties such as the graphitization level can be controlled by tuning the laser parameters. Moreover, the composite coatings demonstrate anti-bacterial activity. Studying substrates coated with different compositions of metal found that 4.5-5% of metal contents have antibacterial activity (% inhibition), by 89%. Moreover, leaching studies demonstrate the fabricated substrates are stable in different pH solutions.

Near-infrared fluorescent single-walled carbon nanotubes for *In vivo* imaging within *C. elegans* nematodes

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Caenorhabditis elegans (*C. elegans)* nematodes serve as a model organism for eukaryotes, especially due to their genetic similarity. Although they have many advantages like their small size and transparency, their autofluorescence in the entire visible range poses a challenge for imaging and tracking fluorescent proteins or dyes using standard fluorescence microscopy. We use near-infrared (NIR) fluorescent single-walled carbon nanotubes (SWCNTs) for *in vivo* imaging within the gastrointestinal tract of *C. elegans*1. The SWCNTs are biocompatible, and do not affect the worms' viability nor their reproduction ability. The worms do not show any autofluorescence in the NIR range, thus enabling the spectral separation between the SWCNT NIR fluorescence and the strong autofluorescence of the worm gut granules. The worms are fed with ssDNA-SWCNT, which are visualized mainly in the intestine lumen. The NIR fluorescence is used to track the contraction and relaxation *in vivo,* in the area of the pharyngeal valve at the anterior of the terminal bulb. These biocompatible, non-photobleaching, NIR fluorescent nanoparticles can advance *in vivo* imaging and tracking within *C. elegans* and other small model organisms by overcoming the signal-to-noise challenge stemming from the wide-range visible autofluorescence.

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