

Nanotechnology in membrane environments

The research carried out in the laboratory of Dr. R. Jelinek aims at studying varied membrane processes and biotechnological application utilising an innovative chromatic lipid/polymer molecular assembly mimicking cellular membranes. Extensive experimental work carried out during the past few years has demonstrated that dramatic colour transitions can be induced within the polymer (polydiacetylene, abbreviated PDA) by diverse bio-molecular interactions at the membrane interface. The lipid/PDA assemblies were shown to exhibit wide-ranging scientific and biotechnological applications based upon the interconnection between the bio-mimetic platform [the lipid assembly] and the colorimetric reporter [the PDA domains]. Additional research efforts aim for studying effect of lipids upon fibrillation processes. Selected research projects:

Biomimetic chromatic nanoparticle-based sensors

We have developed unique assemblies comprising lipids and polydiacetylene – a chromatic polymer which undergoes dramatic blue-red and fluorescence transformations induced by external biological stimuli. The produced assemblies generally mimic the cellular membrane environment and adopt a variety of configurations (Figure 1), including small and giant vesicles, agar-embedded aggregates, and others. We have shown that the lipid/PDA systems constitute a useful vehicle for detection and analysis of varied membrane-associated biological processes.

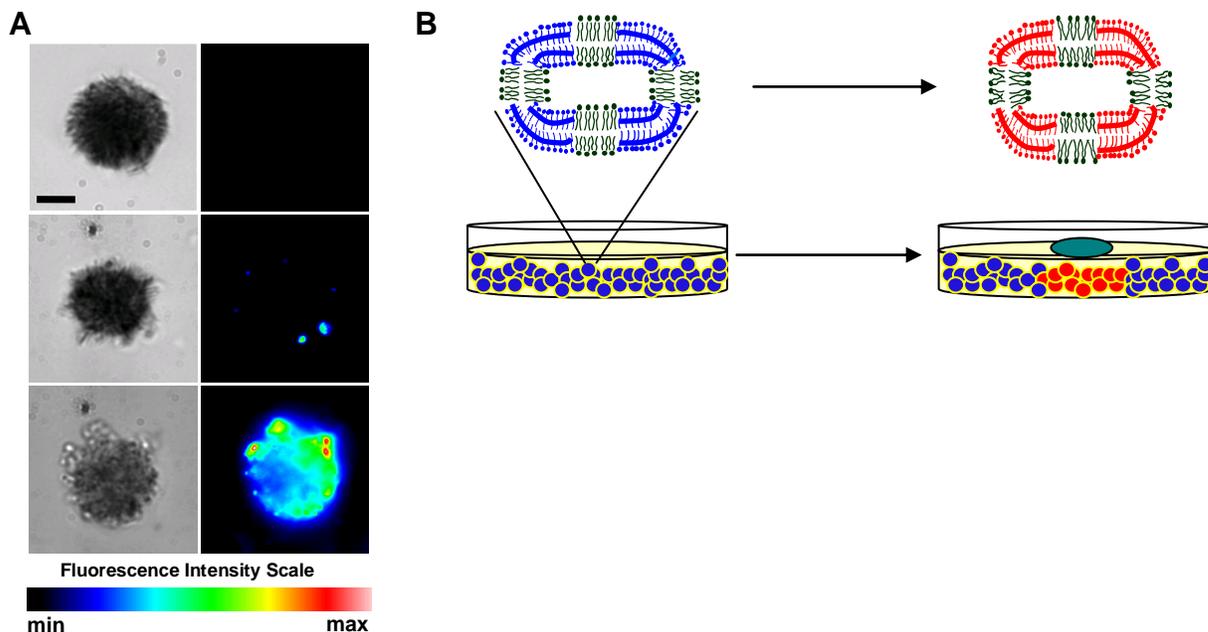


Figure 1: A. Interactions of a membrane-active compound with giant DMPC/PDA vesicles. On the left are the optical microscopy images, on the left fluorescence microscopy images. As the concentration of the membrane-active molecule is increased more fluorescence is induced. The bar corresponds to 2 μm . **B.** Agar-embedded lipid/PDA vesicles used for bacterial

detection. Left: agar scaffold containing vesicular nanoparticles composed of phospholipids (black) and PDA (blue). Right: Bacterial proliferation (green oval) on the agar surface causes blue-red transformation of embedded vesicles due to bacterially-secreted compounds that diffuse through the agar.

Gold nanoparticle architecture in diacetylene monolayer templates

We have recently developed a new “bottom-up” method for construction of organized nanostructure assemblies through the use of diacetylene templates at the air/water interface. The approach employs condensed diacetylene monolayers compressed upon the water subphase of a Langmuir trough as vehicles for constraining gold nanoparticles (Au NPs). The Au NPs adopt distinct configurations, including nanowires and nanoislets, depending upon the diacetylene headgroup. The Au NP/diacetylene films can be transferred from the air/water interface onto solid substrates and further annealed without altering the surface organization, yielding stable organized gold nanostructures.

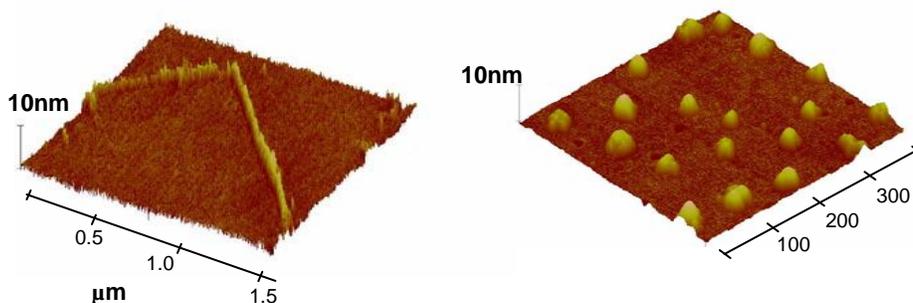


Figure 2: gold nanostructures created via diacetylene monolayers.

Laser-modulated ordering of Au nanoparticles at the air/water interface

Construction of controlled, organized nanostructure assemblies has been among the most challenging aspects of nanotechnology research and development. While “top-down” lithography techniques have been predominant, new “bottom-up” self-assembly methods have garnered increasing interest as viable alternatives. In particular, self-assembled monolayers at the air/water interface (i.e. Langmuir monolayers) have been proposed as promising vehicles for surface patterning of metallic and semiconductor nanostructures. Such “soft lithography” approaches have generally employed condensed monolayers of amphiphilic substances as templates for organization of metal nanoparticles on water. In these systems, the edges of the condensed amphiphilic domains usually constitute the framework for assemblies of two-dimensional monolayer structures. Here we describe unique long-range ordering of Au nanoparticles (Au NPs, diameter approximately 3 nm) occurring when mixed monolayers of the NPs and an unsaturated fatty acid are irradiated with a low-intensity laser light. We demonstrate the formation of a network of elongated Au “wires”, which can be further transferred onto solid substrates. Remarkably, ordering of the Au NPs occurred *only* at zero surface pressures, in which the mixed monolayers exist in highly fluid phases. We show that this unusual and seemingly counter-intuitive

phenomenon is reversible, and is due to local heating of the monolayer surface by the laser irradiation at a very narrow temperature range.

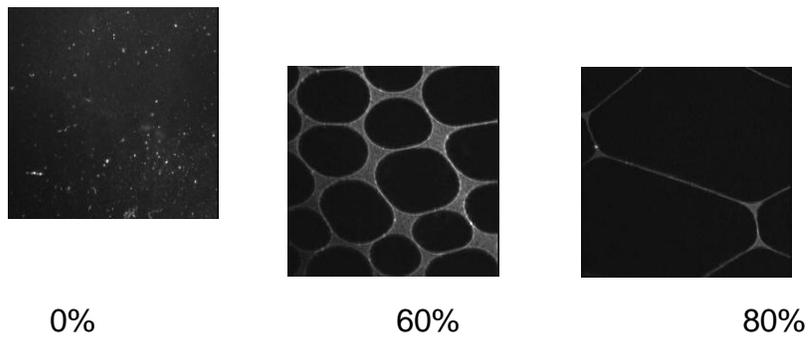


Figure 3: BAM images of Au-NP/elaidic acid Langmuir monolayers at different laser intensities. The percentage values indicate laser power used for monolayer irradiation prior to image acquisition: