Optical sensors and their applications for probing biological systems - DTU Orbit
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There is a great interest in exploring and developing new optical sensitive methodologies for probing complex biological systems. In this project we developed non-invasive and sensitive biosensor strategies for studying physiologically relevant chemical and physical properties of plant and mammalian cells. First, we performed Surface Enhanced Raman Spectroscopy (SERS) studies on intact plant materials via using silver plasmonic nanostructures. Our studies showed strong Raman signals which resemble to the presence of typical constituents such as carbohydrates, proteins and lipids of different parts of the fresh tissues. The location of the nanoparticles inside some of the tissues was examined via SERS images, collected from Raman signatures of the constituents of the tissues as well as from Raman signatures of a specific pH-sensitive reporter molecule attached to the nanoparticles. The reporter molecule provided pH values of the extracellular space of the in-situ plant material.
The performance of SERS in intact plant tissues included the exploration of different strategies for synthesizing and delivering plasmonic nanostructures into plant tissues via green synthesis of silver nanoparticles with specific plants such as onions and fruit extracts. The formation of spherical and sharp-edged shape silver nanoparticles of around 10 to 300 nm showed the possibility of controlling the morphology of synthesized silver nanoparticles as a function of the plant extract used. Alternatively, the delivery of nanoparticles into the extracellular space of an intact plant tissue was carried out by the incubation of silver salts into the sample. Our results showed the formation of plasmonic nanostructures located at the extracellular space of the sample. This work showed the capability of an intact biological sample to provide a SERS-template where silver nanoparticles can grow, thus providing a new insight into SERS-based sensors for chemically sensing in-situ plant constituents.
Optical manipulation techniques have been used to investigate mechanical properties of soft membrane cells, i.e. mammalian cells, proteins and their interactions within a specific cell environment. Curvature and mechanical forces in the membrane play an important role in the activity of the membrane-bound protein. The overall motivation of the second part of the PhD project was to explore the dependence between the membrane curvature and the activity of membrane proteins. We developed an optical trapping device using a micro-fluidic chip with embedded delivery of laser light. The fluidic system consisted of three inlets joining to form a main channel that led to a single outlet. Cell samples were injected in the central inlet whereas side-inlets were used for hydrodynamic focusing in a stable-laminar flow in the chip. In the middle of the main channel, two optical fibers were placed opposite to one another and perpendicular to the axis of the main channel. Thus when a cell passes through the two opposing optical lasers, it can be trapped and deformed via variations of the light intensity through the optical fibers. Of key importance was the ability to create stable laminar flows at low velocity fields. We therefore optimized the presented device to be able to trap a large number of cells and to exchange the local environment of a trapped cell. The project could provide new insights into the desired biosensor for future membrane-protein cell studies.

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