Near infrared imaging of cellular signaling

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Cells use molecules to exchange information. A very prominent example is neurotransmitter signaling between neuronal cells or paracrine signaling between blood cells or bacteria. However, it is up to date difficult to visualize signaling processes between cells with high spatial, temporal and chemical resolution. We are interested in developing fluorescent sensors/probes that overcome these limitations and answer novel biological questions by fluorescence microscopy.

For that purpose we use near infrared (NIR) fluorescent single-walled carbon nanotubes (SWCNTs). SWCNTs fluoresce in the nIR tissue transparency window (900 nm -1700 nm) and do not bleach. They are chemically modified to render them selective for biological signaling molecules. In this context, we developed different chemical strategies that include screening for artificial binding motifs, aptamers and nanobodies. Using these strategies we created sensors for the neurotransmitters dopamine/serotonin [1,2], reactive oxygen species [3] and bacterial signaling molecules [4]. These sensors change their fluorescence in the presence of the target molecule and detect down to single molecules. Fast parallel imaging of many of those sensors provides a NIR image (>900 nm) of the neurotransmitter concentration around cells. This technique was used to image hot spots of dopamine release from primary dopaminergic under electrical stimulation and assess the heterogeneity of release sites. Neurotransmitters are not only relevant in the neuronal system but as well in the periphery e.g. in blood cells. In this context, we imaged for the first time how human blood platelets release serotonin after activation and resolved the location and the time scale of release. Finally, such sensors are useful to study signaling between bacteria and even detect them. These results illustrate that tailored SWCNTs are powerful tools for quantitative chemical imaging of biological processes.

[1] M. Dinarvand et al. Nano Letters 2019
[2] S. Kruss et al. PNAS 2017
[3] Wu et al. Nano Letters 2020
[4] Nißler et al. Nature Communications 2020