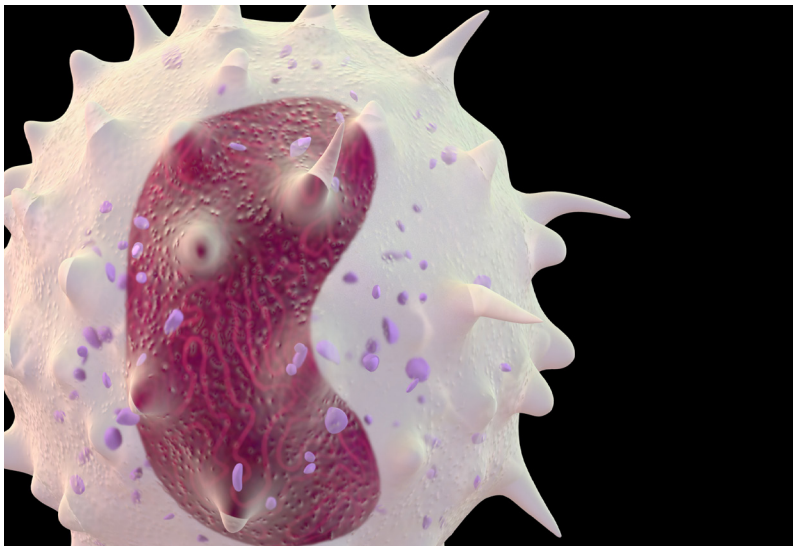

CASE STUDY

At Work in the Lab:

SECM - Scanning Electrochemical Microscopy in Life Science

At Saarland University in the southwest of Germany, the Biophysics Department headed by Prof. Dr. Markus Hoth is dedicated to researching basic mechanisms of the human immune system, often using electrochemical methods. Between 2012 and 2020 Dr. Monika Bozem was the leader of the department's Electrochemical Section. Her team's work focused on studies of the intersections of biophysics, physiology, biochemistry, electrochemistry, and immunology. Due to their specificity and sensitivity in many different contexts, electrochemical techniques proved to be both valuable and versatile for detection of a multitude of analytes in biological systems. The HEKA ElProScan, an electrochemical scanning platform which supports techniques such as scanning electrochemical microscopy (SECM), scanning ion conductance (SICM) and many related methods, was successfully deployed in the lab particularly to study single cells.

The Challenge

The lab had focused its research on the redox regulation of immunological and other physiological and pathological processes. This involved the study of signaling pathways within the metabolism of single primary human and murine living cells and the analysis of the intercellular (paracrine) communications. To accomplish this the team needed a non-destructive way to study specimens selected by visual control of the studied cells to facilitate the choice of a healthy cell for investigation. Additionally, they wanted to combine these microscopy experiments with fluorescence imaging to gain complementary results on extra- and intracellular concentrations of the molecules studied.

The Solution

Scanning electrochemical microscopy experiments on the ElProScan ELP 3 yielded valuable information addressing these challenges on the single cell level. The ELP 3's positioning system was mounted on an inverse microscope equipped with a CCD camera, and control was fully synchronized via software. This made the ELP 3 the ideal setup for studying biological objects.

> "What makes the ElProScan a unique research platform in our lab is its high precision and variability for single cell studies. Adaptations and improvements to our setup have always been realized in close collaboration with HEKA."
>
> *– Dr. Monika Bozem, Senior Scientist, Group Leader of the Electrochemical Section in the Biophysics Department, Saarland University (Germany)*

In SECM experiments, a tiny electrode was positioned at a micrometer distance above the specimen under investigation. Electroactive species within the sensing distance of the electrode were successfully detected by recording the current. Due to the small size of the electrode, local information was obtained, and mapping of single cells or agglomerates was achieved efficiently.

This proved to be of particular interest for spatial and temporal distributions of produced or degraded species in a studied specimen. In this case, there was production of extracellular H_2O_2 at a single cell, which is considered to be the main transmitter of redox signaling.

The Outcome

The advantages of the Saarland University's Electrochemical Section's approach with the ElProScan included the specificity of H_2O_2 detection under physiological conditions, the quantification of dynamic changes in the relevant nanomolar concentration range and stable, long-term monitoring of H_2O_2 production and removal at the plasma membrane of a single cell. The software allowed the team to create protocols enabling high flexibility for specific experiments and sequential measurements of different cells in the same dish. In addition to SECM, the team determined that scanning ion conductance microscopy (SICM) experiments can also be conducted with the same setup using a nanopipette to image the topography of single cells.

In close collaboration with HEKA, the research team's input yielded adaptations of and improvements to the software and hardware, all extremely important to this rapidly-evolving field of study. Dr. Bozem's team benefited from:

- The ELP 3 fine-tuned positioning system allowing reliable and reproducible positioning of the electrode above or directly on the surface of a specimen (e.g., a cell)
- Sequential SECM and SICM measurements of the same specimen
- A built-in microscope perfectly integrated in the setup and software, and therefore an integral part of the device-rather than a separate tool, and therefore streamlining the work with single cells
- Cameras synchronized and controlled by the software allowing fluorescence imaging to also be performed with the same software
- A transparent and versatile method of storing and replaying raw and analyzed data within the software
- Available extensions easily allowing system configuration modifications to best fit changing research needs been using.

"Our studies aimed to examine the production and distribution of H_2O_2 by human monocytes and HEK-293 culture cells. With our ElProScan setup, we could combine SECM measurements with fluorescence measurements to investigate from the same single cell extracellular (SECM) and intracellular processes simultaneously.
This turned out to be of particular advantage to achieve our goals."

– Dr. Monika Bozem, Senior Scientist, Group Leader of the Electrochemical Section in the Biophysics Department, Saarland University (Germany)

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