High-throughput Experimentation in Electrochemistry for Alkaline Water Electrolysis

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Introduction

High-throughput experimentation [1], a well-established and powerful tool in the field of heterogeneous catalysis screening is extended to the field of electrochemistry. Parallel testing accelerates catalyst screening compared to classical approaches. Besides that, this testing procedure comprises also the standardization of workflows, hardware, and software tools.

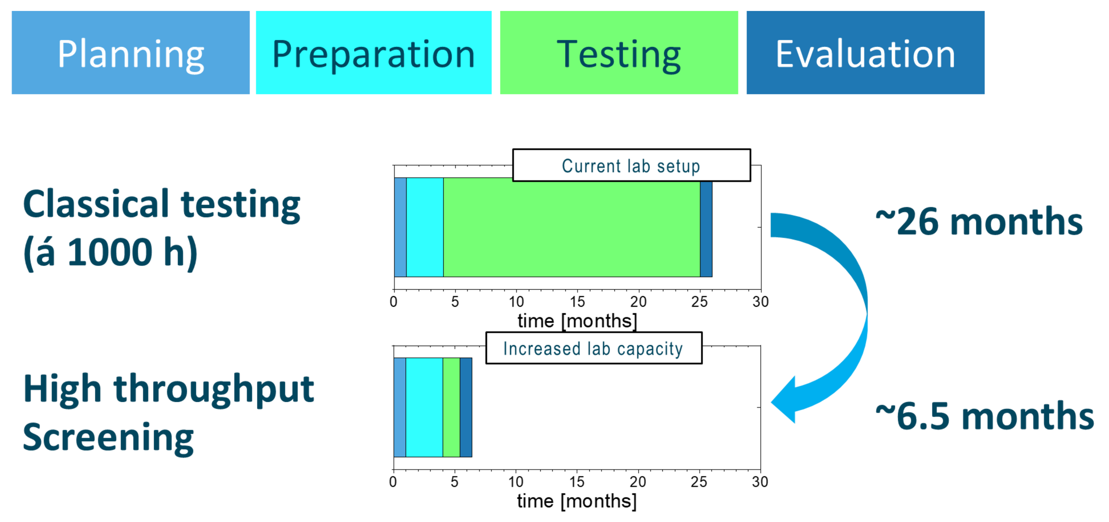

Figure 1: Estimated time savings for 16 electrochemical long-term experiments (1000 h). Classical testing vs. high-throughput experimentation

Together with our partners we present a new modular platform in the field of electrochemistry.

New Modular Flow Cells for Electrochemistry

The Fraunhofer Institute for Microengineering and Microsystems IMM developed a new modularized flow cell construction kit in cooperation with hte GmbH and IEK-9 / FZ Jülich GmbH for elevated pressure operation. The flow cell construction kit consists of standardized configurations which cover roughly 13 different experimental setups in electrolysis research. Further, even fuel cell and redox flow applications can be realized.

Figure 2: Open flow cell without electrodes or separators

Figure 3: Mechanical press with four flow cells

The electrode area is easily adjustable. A mechanical press with adjustable seal force is used for screwless sealing. For alkaline water electrolysis, initial parallelized tests have been carried out with promising results for characterizing the flow cells.

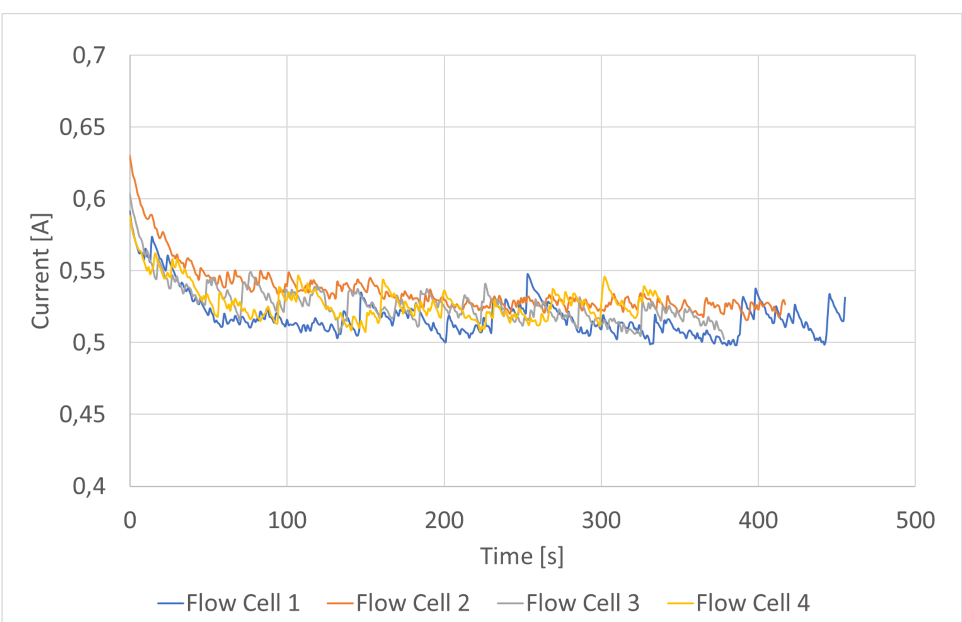

Figure 4: Chronoamperometry (CA) of four parallelized flow cells for alkaline water electrolysis. A simple and robust setup is used for the characterization of the flow cells in parallel operation [2].

Anode/Cathode:

Area 5cm²; Ni foil (0.1mm); Zirfon 220 diaphragm.

Electrolyte:

0.5M KOH; flow 40ml/min.

Process conditions:

CA at 5V; pressure 0.2barg at ambient temperature.

New Modular Screening Platform

The screening platform from hte GmbH is modular in design and can be freely configurated for screening with up to 16 electro cells in parallel. First application will demonstrate the alkaline water electrolysis.

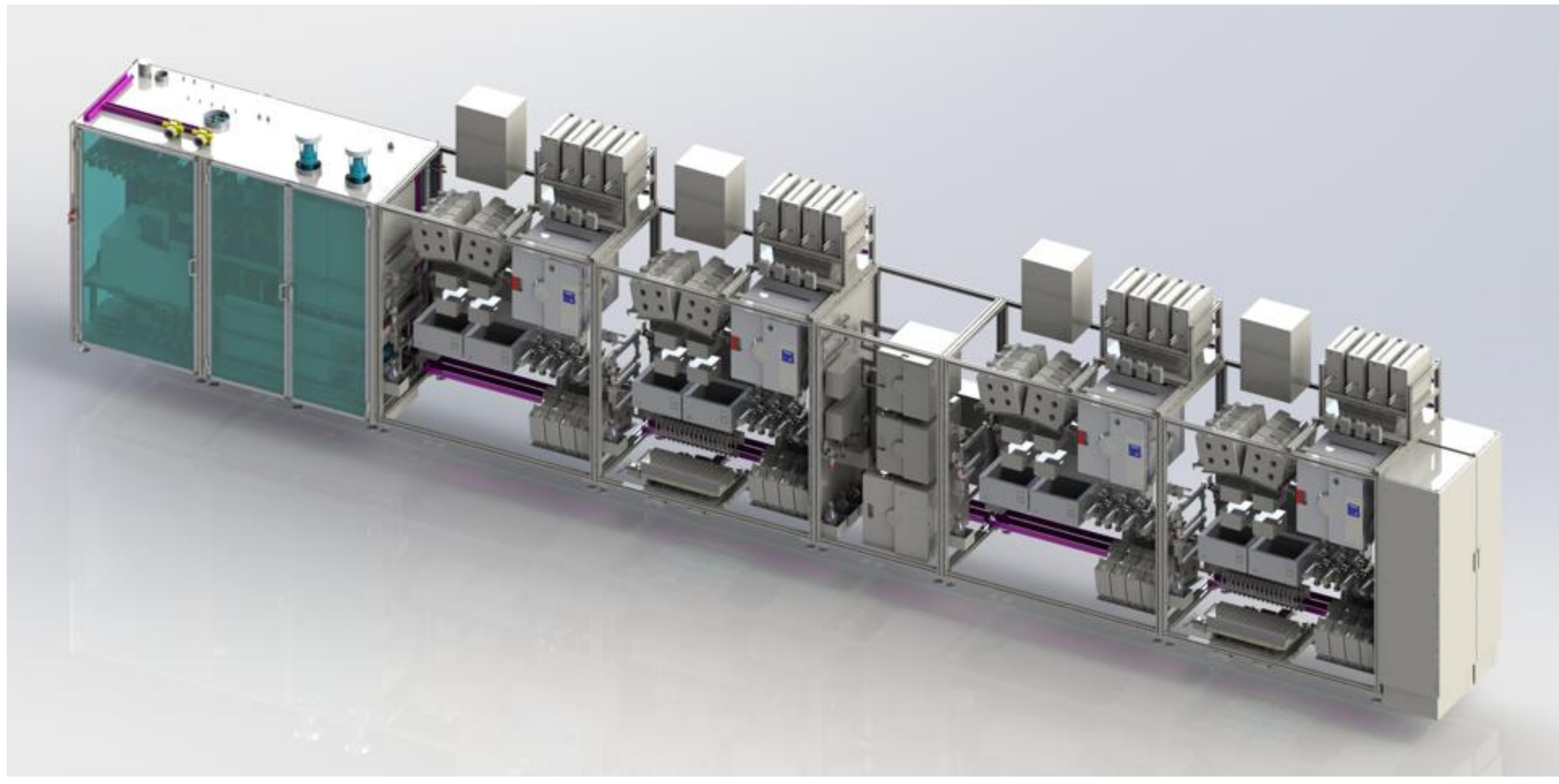

Figure 5: High-throughput screening platform for electrochemistry

Software and Analytics Interfaces

The high-throughput screening platform can control the individual potentiostats of the flow cells. Electrochemical data, trend data as well as analysis data is merged into the myhte4™ proprietary database for data evaluation [3].

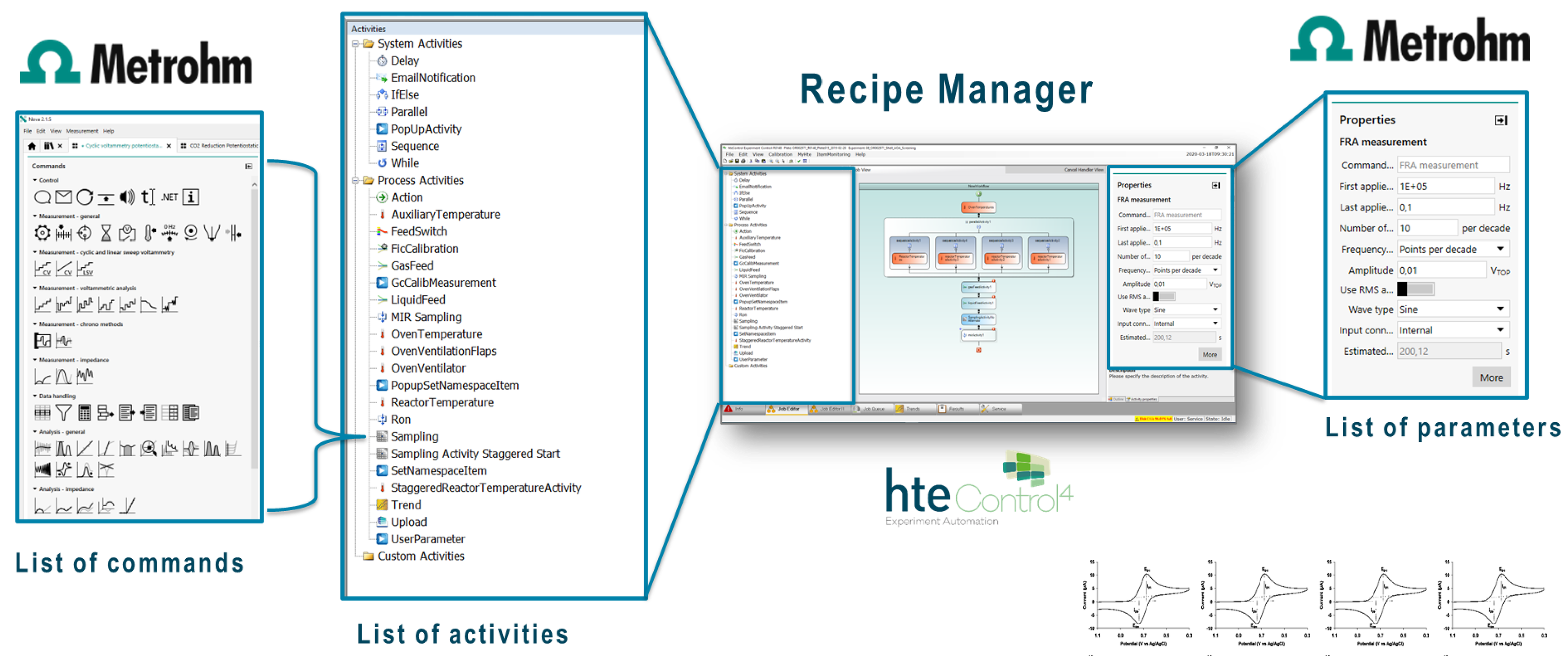

Figure 6: Integration of Metrohm NOVA 2.1.6 software commands to hteControl4™ Recipe Manager to control the individual potentiostats for high-throughput experimentation.

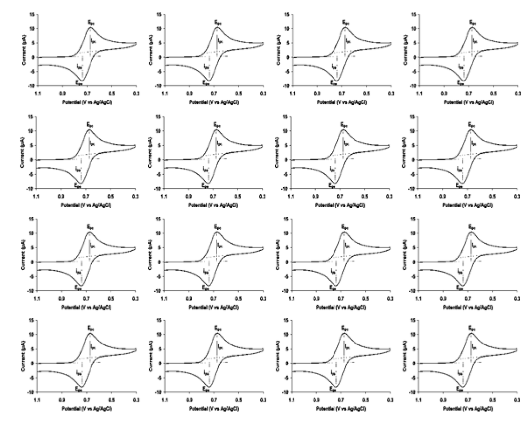

Figure 7: Vision of how electrochemical data could be visualized for high-throughput experimentation [4].

Conclusion

The high-throughput approach will improve data quality and accelerate electrochemical screening primarily for hydrogen applications. Later, this can be used for other applications, for example in the field of electro-organic chemistry (CO_2 reduction). Key features will be standardized electrochemical flow cells, inline electrochemical analyzers, a software prepared for feedback loops, and a harmonized test protocol.

[1] Hagemeyer, Alfred, et al. "High-Throughput Screening in Chemical Catalysis: Technologies, Strategies and Applications, (2006), Wiley-VCH, Weinheim.

[2] Márquez, Raúl A., et al. "Getting the Basics Right: Preparing Alkaline Electrolytes for Electrochemical Applications." ACS Energy Letters 8.2 (2023): 1141-1146.

[3] Müller, Andreas, et al. "High-throughput Technology in Electrochemistry" DGMK Conference Proceedings, 2022-3 (2022): 104-121.

[4] Lifer21 (https://commons.wikimedia.org/wiki/File:Cyclovoltammogram.jpg), „Cyclovoltammogram", Design modified, https://creativecommons.org/publicdomain/zero/1.0/legalcode