A Collaboration for Exploring Fundamental Property–Performance Relationships for Electrochemical Energy Storage


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This invited Team Profile was created by Jens Matthies Wrogemann. He and his collaborators at the MEET Battery Research Center, the Helmholtz-Zentrum Berlin für Materialien und Energie GmbH (HZB), and Paderborn University recently published a research article about property–performance relationships of 2D conductive metal–organic frameworks. Flake- and rod-like shaped particles were evaluated to investigate the impact of the particle morphology of MOFs on electrochemical Li^+ ion storage. By optimization of the particle morphology, the diffusion limitation of the Faradaic process can be significantly reduced. "Overcoming Diffusion Limitation of Faradaic Processes: Property–Performance Relationships of 2D Conductive Metal–Organic Framework $Cu_3(HHTP)_2$ for Reversible Lithium-Ion Storage", J. M. Wrogemann, M. J. Lüther, P. Bärmann, M. Lounasvuori, A. Javed, M. Tiemann, R. Golnak, J. Xiao, T. Petit, T. Placke, M. Winter, *Angew. Chem. Int. Ed. Engl.* 2023, *62*, e202303111.

Chemistry is all about interacting elements and systems ...

Research on highly efficient electrochemical energy storage systems is of utmost importance for society to lower its CO_2 footprint. Exploring the fundamental properties of the underlying processes helps us to design and develop future promising materials. Metal–organic frameworks are an interesting material class with tunable characteristics that make it possible to investigate fundamental behaviors of ion storage.

In the group led by Martin Winter, our primary focus was initially analyzing this fascinating material class for lithium ion storage. However, as the project unfolded, we realized that this research requires not only material synthesis and electrochemical investigations but also advanced techniques and expertise for characterization. It became evident that a more comprehensive and nuanced approach is essential to explore fundamental questions and provide accurate answers.

The collaboration of experts from different fields is the best way to address and investigate most of today's complex scientific questions. As our project progressed, more and more questions arose, and we ended up with a team of experts from electrochemistry, solid-state physics, porous materials, and advanced analytics like XAS and FTIR to address all the topics. We were very happy to get support from Tristan Petit, his team, and the colleagues at the beamline; and also to have great support in the area of porous materials from Prof. Tiemann and his team. I think these good relationships helped us to have fruitful discussions in a relaxed but effective atmosphere.

Shared experiences bond us together ...

The core team of Marco, Peer, and myself were eager to learn more about the material and how it behaves: this was the major driving force for all activities. We tried to keep connected through effective communication channels or just even spending time together with a cold drink in the evening. In the face of setbacks, we supported each other and learned from challenges. We questioned our results, adapting our approach to bounce back stronger and achieve success.

Senior researchers, like Tobias and Tristan offered guidance and mentorship, while junior scientists brought fresh ideas. By communicating openly, respecting each other's contributions, and working towards a common purpose, we collaborated harmoniously to make things happen.

Clear communication is super important, especially when it comes to duplicating highly sensitive experiments in other labs, for example to utilize advanced analytics. In the beginning, we faced a lot of challenges in terms of how to prepare the samples at each institute in the same way, e.g., in different states-of-charge without changing material properties. However, after a while, we figured out what could go wrong and learned how important it is that everybody understands the unique properties of the sample.

It takes energy to explore the unknown ...

The overall goal is to get a clearer picture about phenomena in electrochemical energy storage like "pseudocapacitance" and how this is affected by certain material properties. How can we design new materials that undergo Faradaic charge transfer reactions but offer super low kinetic limitations? We are still pondering this question and we will keep it in mind for future research. Furthermore, there are several other interesting topics in electrochemical energy storage, like alternative chemical concepts other than lithium ion batteries. However, all our questions can only be answered by strong collaboration of experts from different fields.

Electrochemical storage techniques like batteries are often based on several components that have to be matched precisely in the final system to address several key performance indicators. Furthermore, materials and battery cells are also highly sensitive towards the testing setup and parameters. It is quite hard to conduct fundamental studies making sure that not too many settings are changed.

At the MEET Battery Research Center we are working on a number of topics, for example more sustainable materials and their processing as well as recycling. Therefore, strong and good collaboration is becoming increasingly important.

Team Profiles highlight how research groups focus their efforts and work together to achieve a common goal. Indeed, it is through the diversity of voices from all parts of the chemistry community that the excellent science published in *Angewandte Chemie* comes about.

International Edition: DOI: 10.1002/anie.202308841
German Edition: DOI: 10.1002/ange.202308841