CASE STUDY

Battery Research at KIT Driving a Sustainable Electric Future

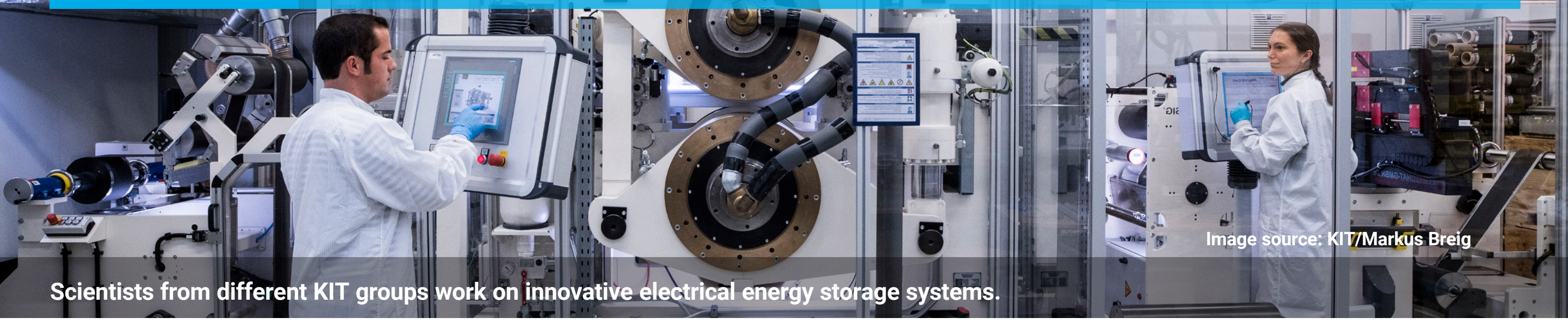

Image source: KIT/Markus Breig

Scientists from different KIT groups work on innovative electrical energy storage systems.

How to generate, store, and use electrical energy in a sustainable and cost-efficient way is one of the biggest global challenges. Right now, even though we can generate clean energy from wind, solar, or hydropower, most of that energy needs to be used immediately and only a small portion can be stored for later use. This is because creating a battery that is large enough to store energy reserves while also being cost-efficient and stable is extremely difficult.

Karlsruhe Institute of Technology (KIT), The Research University in the Helmholtz Association, is a hub for this kind of much needed energy research. KIT houses the Institute for Applied Materials—Materials Science and Engineering (IAM-WK), where scientist Andreas Hofmann works on developing the best electrolyte mixture for batteries.

Although building high-capacity, rechargeable batteries for clean energy sources could change a lot about how the world consumes energy, the process itself can also be environmentally damaging. The other challenges associated with these batteries include maximizing energy density, minimizing flammability, and avoiding costly materials in favor of new, cheaper ones. In addition, Sodium-based cells have been widely identified as a possible cheaper replacement for Li in the future. Working in-collaboration with the POLIS research cluster of which he is a part, Hofmann investigates decomposition products in Na-ion cells as well as Li-ion cells.

> *Hofmann explains, "Sodium is much more abundant in the environment, plus it exhibits similar potential when compared to lithium, and this makes it a fascinating subject for ongoing research"*

Batteries rely on the chemical processes electrolytes undergo as the source of power—their reactions are the flow of power. Each piece of the battery and how those materials interact with each other is vital to the health, longevity, and safety of the end product. Hofmann's research is centered around understanding how various electrolytes behave and characterizing their properties so the best battery can be made.

> *"A battery is an interplay," says Hofmann. "You can have great materials for the housing unit and electrodes, but if the electrolyte is the wrong one, then it simply decomposes, and then that decomposition can catalyze another reaction. To have a good battery, we need to coordinate everything and that makes the electrolyte work more of a challenge than in previous battery development."*

To answer these research topics, Hofmann's research is closely connected with other KIT institutes and integrated into a comprehensive research context to which several KIT institutes belong to, including the Battery Technology Center at KIT. The focus here is on the development and production of new materials and cells as well as the development of batteries and the integration to an overall system. Simultaneously, new manufacturing processes for the cost-efficient production of those batteries are being developed and demonstrated.

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With Hofmann's focus on the electrolyte portion, his work is about capturing all of the reactions and processes that happen over a battery's lifetime. Most rechargeable batteries last for years, but there is a point when they begin to lose the capacity to hold the same amount of charge they did before, or they simply cannot hold any charge anymore. Those things happen because the electrolyte within the battery is degrading, which can happen through aging or abuse. During the battery creation process, usually the solid electrolyte interface (SEI) is formed around the graphite in the anode in one of the last steps—a vital process as without it, the SEI would continually degrade. During the process, molecules and organic solvents heavily decompose and gases form. The composition of the gases depends, among other things, on the materials and the electrolytes used. Certain gases can help to build a better SEI, but they can also cause safety issues or have an impact on the battery performance and lifetime. Understanding this process known as off-gassing is also helpful to get a better understanding of the mechanism in batteries and how to influence them during the formation.

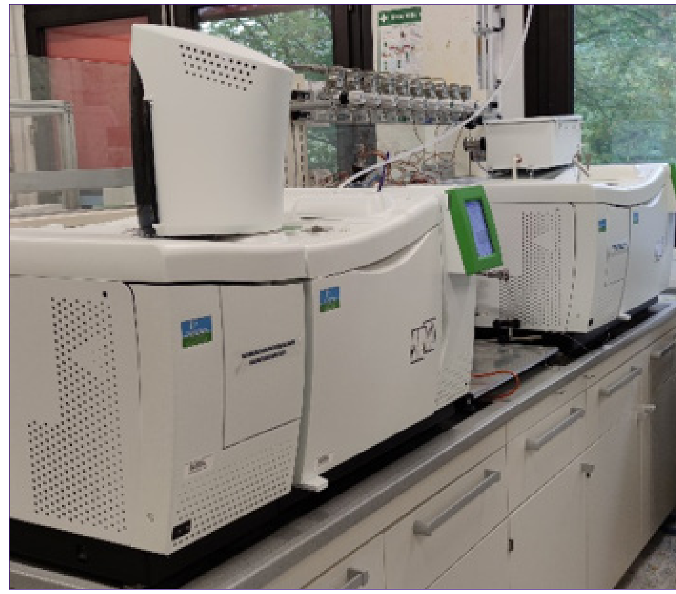

Figure 1: Hofmann can study these reactions by using his PerkinElmer gas chromatography (GC) instruments—a Clarus® 690, a Clarus 690/SQ8 GCMS with HS, and an ARNEL Gas Analyzer system.

Another research area is solid electrolytes, which are a class of materials that are considered promising for Li-ion batteries. Currently, however, there are still difficulties in the solid electrolyte-electrode material interface. Hofmann and his colleagues are investigating this challenge with novel techniques such as printing batteries. Since decomposition products are also formed, gas chromatography is necessary for analyzing reaction products, such as gas extraction.

The PerkinElmer systems Hofmann uses are very flexible, and with them the team at KIT's IAM-WK can study both the gases and liquids, addressing most of their research questions.

Karlsruhe Institute of Technology

About KIT Institute for Applied Materials (IAM): The interdisciplinary materials research at the IAM covers a diversity of material science issues. With national and international partners, they research materials from their atomic structure to their function in the product, bridging the gap from material development to process technology to system integration. www.iam.kit.edu/english/Research.php

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