Elitenetzwerk Bayern

Einblicke in die Forschungsarbeit

FORSCHUNGSPROJEKT

„Elektrizität statt H2-Gas“

ARSLAN RAZA

Elitestudiengang „Advanced Synthesis and Catalysis”

Universität Regensburg, 2025

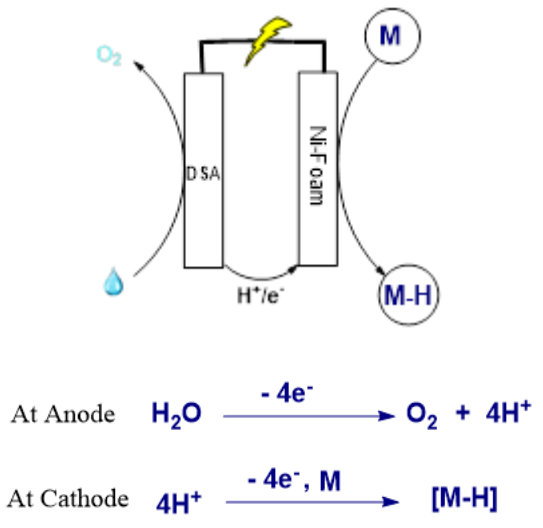
Green Hydrogenation via Electrochemistry

During his external research module, Arslan Raza investigated electrochemical methods as safer alternatives to traditional hydrogenation reactions. Using electricity and nickel foam electrodes, hazardous hydrogen gas was replaced by sustainable electrochemical processes. The work combined fundamental studies, selective molecular transformations, and flow-cell experiments, highlighting how electrochemistry can support greener, safer, and more efficient chemical synthesis.

Ni foam for efficient and sustainable reactions

In the first part of the project, electrochemical hydrogenation reactions were studied using nickel foam as a cathode material. Nickel foam has a sponge-like structure with many pores, providing a large surface area for reactions. Hydrogen can be generated directly at the electrode surface from safe sources such as water or mild acids, eliminating the need for external hydrogen gas.

Using this setup, various nitrogen-containing aromatic compounds were selectively reduced. The experiments showed that some functional groups react faster than others, allowing certain parts of a molecule to be modified while leaving the rest unchanged. This level of control is particularly valuable when working with complex molecules. In addition, the method avoids expensive metals and reduces chemical waste, making it both economically and environmentally attractive.



Schematic representation of the electrochemical reduction of organic compounds at a nickel foam cathode.

Selective reactions for complex molecules

The second project focused on selective reactions between different groups. Many organic molecules contain several reactive groups which compete in . One challenge in chemistry is to modify only the desired part of a molecule without affecting others. In this project, various nitrogen-containing aromatic compounds were studied to understand which functional groups are reduced first under electrochemical conditions.

The results showed that the reaction selectivity depends on the molecular structure and the electrochemical setup. This knowledge helps chemists design more precise reactions and reduce unwanted by-products, which is especially important in pharmaceutical synthesis.

Flow electrochemistry for industrial applications

In the third project, electrochemical reduction was transferred from batch experiments to flow systems, which are particularly relevant for industrial chemistry. Using a flow cell, nitrile compounds were converted into amines, valuable intermediates for polymers and other materials. Flow electrochemistry improves safety, enables continuous operation, and allows better control of reaction conditions.

Overall, the external research module demonstrates how electrochemistry can replace hazardous reagents, reduce waste, and support greener chemical production. The project combines fundamental research with practical relevance and reflects the core goals of the Elite Graduate Program.

Experimental setup used for cyclic voltammetry. This method measures how a substance responds to electrical signals and helps researchers understand its behavior in electrochemical reactions.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Multiple batch electrolysis cells equipped with electrodes and connected to an electrical power supply. This setup allows several electrochemical reactions to be carried out in parallel under controlled conditions.

Mehr zum Elitestudiengang:

Elitenetzwerk: Elitestudiengänge

SynCat - Advanced Synthesis and Catalysis