



RESEARCH PROJECT
“From Bulk to Value”

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International Doctorate Program “Photo Electro Catlysis”
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Building Molecular Complexity from Simple Chemicals with Light and Electricity

Organic chemistry plays a central role in our daily lives: from life-saving pharmaceuticals to agrochemicals that secure our food supply, from polymers that make up modern materials to countless everyday products. A major challenge, however, is how to build complex molecules from very simple, abundant, and inexpensive raw materials. These so-called “feedstock chemicals”, such as alkanes or oxygen from air, are extremely stable and unreactive. Traditionally, their conversion requires harsh conditions or toxic reagents.

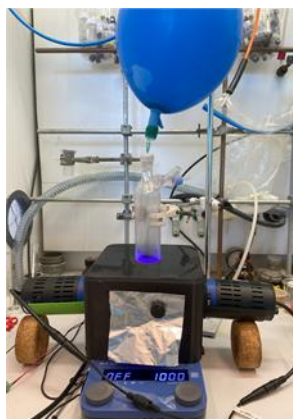
Photochemistry and electrochemistry are opening up compelling alternatives. Photochemistry harnesses light to excite molecules and trigger reactions. When a photon is absorbed, it can promote an electron to a higher energy level, creating reactive excited states that behave very differently from their stable ground-state counterparts. This allows bonds that are normally inert to be selectively activated. This is often achieved through photocatalysis, where a catalyst captures light and transfers its energy or electrons to other molecules, unlocking reactions that would otherwise be impossible. Electrochemistry instead uses electricity to push reactions forward. By carefully applying a voltage (potentiostatic conditions) or a current (galvanostatic conditions), chemists can add or remove electrons from molecules in a highly controlled way. Both approaches replace toxic reagents with clean “fuels”: light and electric current, so called “traceless reactants”. When light and electricity are combined in photoelectrochemistry, their powers reinforce one another. Reactions can then be carried out under mild, environmentally friendly conditions. These methods generate radicals, short-lived but powerful intermediates capable of activating even the most inert feedstocks. This opens new doors to turning cheap, simple molecules into useful chemical building blocks in a sustainable way.

I am a Ph.D. student at the University of Regensburg in the group of Prof. Joshua P. Barham, within the IDK-PEC consortium funded by the Elitenetzwerk Bayern. From November 2024 to August 2025, I spent ten months at the University of Amsterdam in the group of Prof. Timothy Noël, a world leader in flow chemistry. In flow chemistry, reactions are carried out in continuously flowing streams rather than traditional flasks. This makes processes safer, easier to scale, and more energy-efficient, key features for bringing promising lab discoveries closer to industrial application.

During my stay in Netherlands, I contributed to three projects:

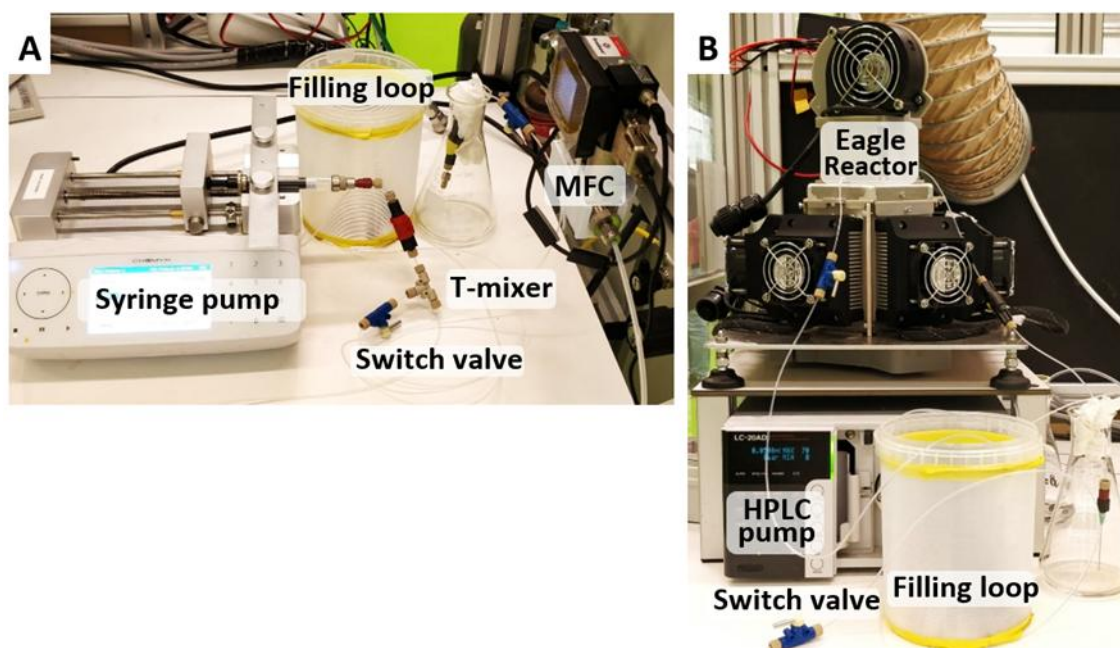
- Project A: Direct conversion of simple alkanes into more complex alkenes harvesting light and electricity. This is important because alkanes are cheap and plentiful but difficult to functionalize. We are adapting the method to flow reactors for safer and scalable production.
- Project B: Development of a one-pot method combining amides, olefins, and oxygen into oxygenated amide products. The reaction proceeds under mild conditions is easily scaled up, offering a sustainable path to pharmaceutically relevant molecules.
- Project C: Development of a new class of powerful photocatalysts to activate even gaseous alkanes such as ethane or propane, among the most challenging substrates in chemistry.

Overall, this research demonstrates how light and electricity can transform abundant, low-value feedstocks into complex and valuable molecules.



Caption: **5 mmol batch set up**

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Caption: **continuous flow reactor using gaseous reagents**

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