Young Career Focus: Dr. Oliver Dumele (Humboldt Universität zu Berlin, Germany)

Background and Purpose. SYNFORM regularly meets young up-and-coming researchers who are performing exceptionally well in the arena of organic chemistry and related fields of research, in order to introduce them to the readership. This Young Career Focus presents Dr. Oliver Dumele (Humboldt Universität zu Berlin, Germany).

Biographical Sketch

Dr. O. Dumele

Oliver Dumele is a Research Group Leader at the Department of Chemistry at Humboldt University Berlin (Germany). Oliver studied chemistry at the University of Mainz (Germany) and spent 9 months in the group of Jean Fréchet to work on dendrimers for drug delivery. After his return to Mainz, he joined the Max Planck Institute for Polymer Research (Germany) under the guidance of Klaus Müllen and Tanja Weil. After research projects at BASF Ludwigshafen (Germany) and at the National University of Singapore, he moved to Switzerland for his doctoral studies. In 2015, Oliver received his PhD from ETH Zürich (Switzerland) working in the group of François Diederich. He investigated weak supramolecular interactions, such as halogen bonding, and contributed to projects on aromaticity and carbon-rich materials. He pursued his academic career as a postdoc in the group of Samuel I. Stupp at Northwestern University (USA), investigating photocatalytic CO_2 reduction using supramolecular polymers. Since 2019, Oliver has been an independent research group leader at Humboldt University Berlin (Germany), funded by a Liebig scholarship and the German Federal Ministry of Education and Research BMBF.

INTERVIEW

SYNFORM *What is the focus of your current research activity?*

Dr. O. Dumele We work on organic functional materials that span from a wide range of molecular building blocks to entire covalent frameworks. The chemistry behind the materials is driven by concepts of aromaticity that lead us to designing macrocycles, supramolecular scaffolds, and non-planar π-systems. We strive to keep the fraction of carbon atoms at maximum and we typically play with this element in all its facets to gain the desired functions. However, sometimes other light elements are necessary to harvest the best performance. Our materials prove fundamental operation principles in the fields of supramolecular sensors, mimics of protein–ligand interactions, chiral reaction spaces, battery materials, and photomagnetic switches.

SYNFORM *When did you get interested in synthesis?*

Dr. O. Dumele While growing up a few kilometers away from the largest chemical company worldwide, my interaction with chemists and chemistry in general was at a surprisingly low level – if not zero. I sometimes wonder how I was (just statistically) able to circumvent any exposure to chemistry in my early childhood. That changed when I met an outstanding high school teacher at the age of about 16 years. What probably fascinated me the most was the overwhelmingly sudden exploration of an atomistic and molecular world that I had not seen at all until then – but I knew the impact it could have, because I had always seen these massive chemical production sites just in my “backyard”.

After that high school experience, all my career steps were pretty straightforward. It quickly turned out that chemistry is the “science of making materials”. Due to several passionate teachers at university, I was caught by the concept of scaffolding and being a molecular architect using multi-step synthesis – that only existed in the discipline of organic chemistry.

SYNFORM *What do you think about the modern role and prospects of organic synthesis?*

Dr. O. Dumele The complexity of organic compounds is superior to any other field in chemistry with the constant need for new methods to advance the structure space of organic materials. Future commercialized materials will certainly include increasingly complex organic compounds and polymers, as well as framework materials, to tackle the major societal challenges. On the one hand, our task as chemists is to develop feasible methods in order to get this complexity out on the market. On the other hand, academic research and the R&D laboratories of companies must not stop to investigate even the most complex organic compounds. Those are the researchers that demonstrate principles to stimulate future directions and, hence, new fields of applications. In this context, fundamental work on functional materials might appear largely contradictory ("why would a material be regarded as *useful* or *functional* if we can make only several milligrams with significant consumption of resources?"). But the discovery of key principles, even on academic synthetic scales, can turn out as lead concepts in contexts that are in market-realistic products. Thus, we further need to practice organic synthesis at its frontiers to explore new materials and molecules with unprecedented functions.

SYNFORM *Could you tell us more about your group's areas of research and your aims?*

Dr. O. Dumele Our group covers a broad range of topics that all entangle and have common ground in their molecular designs. We scaffold polycyclic π-systems with symmetrical features into 1) covalent organic frameworks (COFs; Figure 1a; see also *ChemRxiv* **2022**, doi: 10.26434/chemrxiv-2022-p0pjr), or 2) strained macrocycles (Figure 1b; see also *Angew. Chem. Int. Ed.* **2021**, *60*, 14909–14914). That approach allows us to use the same synthetic principles when making our building blocks for those two areas. We profit especially from efficient teamwork, and we share and discuss synthetic methods and protocols across the projects.

Besides designing symmetrical units, we aim at rather exotic molecular building blocks that may not be an obvious choice for materials scientists in the field of frameworks or macrocycles. The side projects that naturally result from tedious syntheses for reaching long-term goals rewarded us with spectacular surprises – and this was somehow a planned strategy. Along the synthetic route on the monomer level, we discovered several functional molecules that were initially planned to be implemented into COFs or macrocycles but they turned into independent projects. As such, we discovered a new molecular species that we developed into a photomagnetic switch. These molecules can be irradiated with light to switch their magnetic behavior from diamagnetic to paramagnetic (Figure 1c; see also *J. Am. Chem. Soc.* **2022**, *144*, 8707–8716).

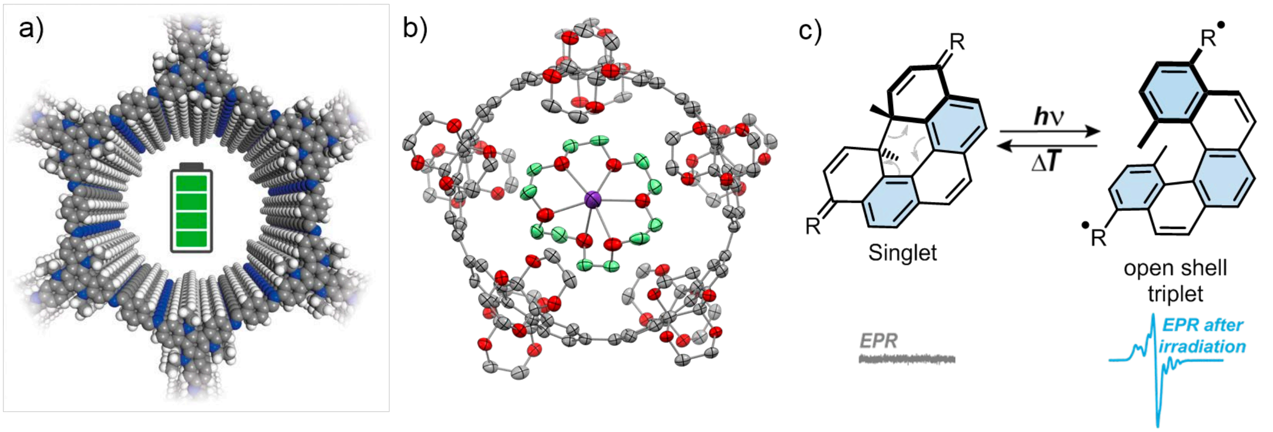

Figure 1 a) Covalent organic frameworks with applications in energy storage; b) strained polyaromatic macrocycles with confined inner spaces to host unusual substrates; c) photomagnetic switches based on [5]helicenes.

Our general aims are in the three areas of:

- Energy conversion and energy storage with framework materials (COFs). We are convinced that the crystallinity and porosity of these materials will teach us fundamentally new functions.
- Supramolecular materials for binding exotic substrates and study non-covalent interactions as model systems for biological processes.
- Interactive magnetic materials for future spintronics and data storage concepts.

One additional aspect that we are just about to establish is the interplay of chirality and unpaired electrons with distinct spin states for advancing information technology.

Overall, while having a synthetic focus, we work on very interdisciplinary topics that require all group members to learn multiple methods and become experts in areas beyond synthesis.

SYNFORM *What is your most important scientific achievement to date and why?*

Dr. O. Dumele The most important achievement was to have found a critical number of people who were curious to work on joint ideas. These are people who took a risk at an early career stage and explored fields from scratch without much prior expertise present in the group. I am very grateful to those individuals. Likewise, I was able to grow my independent group in a very open and supportive environment at Humboldt University, where I profited in many ways from hands-off mentorship and support from the scientific staff.

In a more scientific aspect, the isolation of an unexpected side product and the subsequent identification of its impact had the greatest influence on our research program so far. When we stumbled upon an oxidized [5]helicene scaffold, we initially would not have guessed that it opened a new branch in our group. Very quickly, it became clear that this molecule had all the structural features that were necessary to be a potential photomagnetic switch. Without much optimization, it did exactly what we had expected (although at a much lower temperature), and we were able to switch the magnetism of this helicene from diamagnetic to paramagnetic back and forth with light or heat, respectively.

Matteo Zanda