

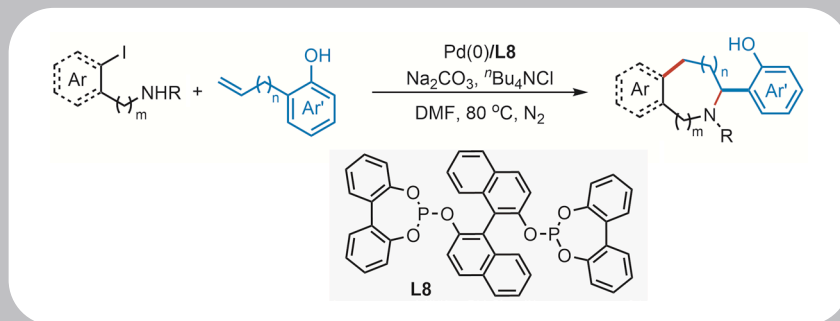
Synform

People, Trends and Views in Chemical Synthesis

2023/01

Construction of Azaheterocycles via Pd-Catalyzed Migratory Cycloannulation Reaction of Unactivated Alkenes

Highlighted article by J.-P. Wang, S. Song, Y. Wu, P. Wang



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Thieme

Dear Readers,

Happy New Year! Please, allow me to start this new year of SYNFORM with a personal note: from January 2023 my career has taken a new direction, with a move to Brussels (Belgium) at the headquarters of the European Research Council Executive Agency (ERCEA), where I have been seconded as a National Expert from my Italian employer, the National Research Council. My new job will focus on supporting the ERC in its invaluable activity of selecting and funding excellent frontier research in Europe. As you can imagine, I am very excited by this professional opportunity and by the new life in Brussels, a fantastic city I have always loved, since my very first visit over 25 years ago. So, new year and new job for me! But some continuity is guaranteed by my role in SYNFORM, which remains the same. As does our motivation at Thieme Chemistry to cover the best research in organic chemistry with SYNFORM's unique style and perspective.

The first article of 2023 comes from Japan, and specifically from the group of M. Akiyama, with a fascinating and elegant study published in *Science* on how to trap an electron in a cube. A molecular cube, of course, namely perfluorocubane, which was synthesised and shown to be an electron acceptor. The second article covers an original method developed by the group of Q. Song (P. R. of China) to achieve the stereo- and chemoselective diborylation of 1-chloro-1-trifluoromethyl-2-alkenes by exploiting the potential of copper-catalysis. The next article reports on a novel Pd-catalyzed approach to azaheterocycles having different ring sizes, developed by the group of P. Wang (P. R. of China) and recently published in *Nat. Commun.* A Young Career Focus interview with Thieme Chemistry Journals Award 2022 recipient Oliver Dumele (Germany) completes the issue.

Enjoy your reading!



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Contact

If you have any questions or wish to send feedback, please write to Matteo Zanda at: synform@outlook.com

Electron in a Cube: Synthesis and Characterization of Perfluorocubane as an Electron Acceptor

Science **2022**, 377, 756–759

The beautiful, highly symmetric structures of polyhedral molecules have long fascinated scientists. In a study recently published in *Science*, the group of Professor Midori Akiyama from The University of Tokyo (Japan) have succeeded for the first time in synthesizing a polyhedral molecule with all carbons fluorinated. Professor Akiyama explained: “Introduction of fluorine – one of the most peculiar and distinctive elements – into a molecule dramatically changes the properties of the compound itself. On the other hand, perfluorinated polyhedral molecules had been expected to capture an electron inside,¹ which was proven in this study by exploiting some of the unique features of fluorine atoms.”

Professor Akiyama acknowledged that her laboratory was founded at The University of Tokyo in 2017 with funding from AGC Inc., one of the world leading fluorine chemical companies. “What is quite special about our lab are the available facilities and techniques for the safe handling of elemental fluorine, a hazardous gas,” said Professor Akiyama. She continued: “Our mission has been the creation of novel and valuable fluorine chemistry via collaboration between the available and special combination of industrial and academic knowledge. During the survey of interesting structures

to be fluorinated, we found an extremely intriguing theoretical prediction about perfluorocubane as an electron acceptor by Dr. Irikura.¹ Then, we started to make it in the real world (Figure 1).”

Surprisingly, the group found that ‘radical’ fluorination of highly strained cubane derivatives could be achieved via the ‘PERFECT’ fluorination method,² and six or seven fluorine atoms could be introduced. The remaining one or two fluorine atom(s) were introduced using an electrophilic fluorinating reagent. “In the beginning, perfluorocubane was synthesized from hexafluorocubane, which can be obtained in higher yield and shorter steps,” explained Professor Akiyama. She continued: “Although perfluorocubane could be isolated via this route, the yield was actually rather miserable due to its high volatility. Then we changed the synthetic scheme to one starting from heptafluorocubane (Figure 2), which requires more preparative steps than hexafluorocubane to reach the target. This decision produced good fruit and the isolated yield of perfluorocubane increased nearly 20 times. We learned that ‘Haste makes waste’ from this experience.”

Theoretically, the radical anion of perfluorocubane had been expected to be stable as an isolated molecule in vacu-

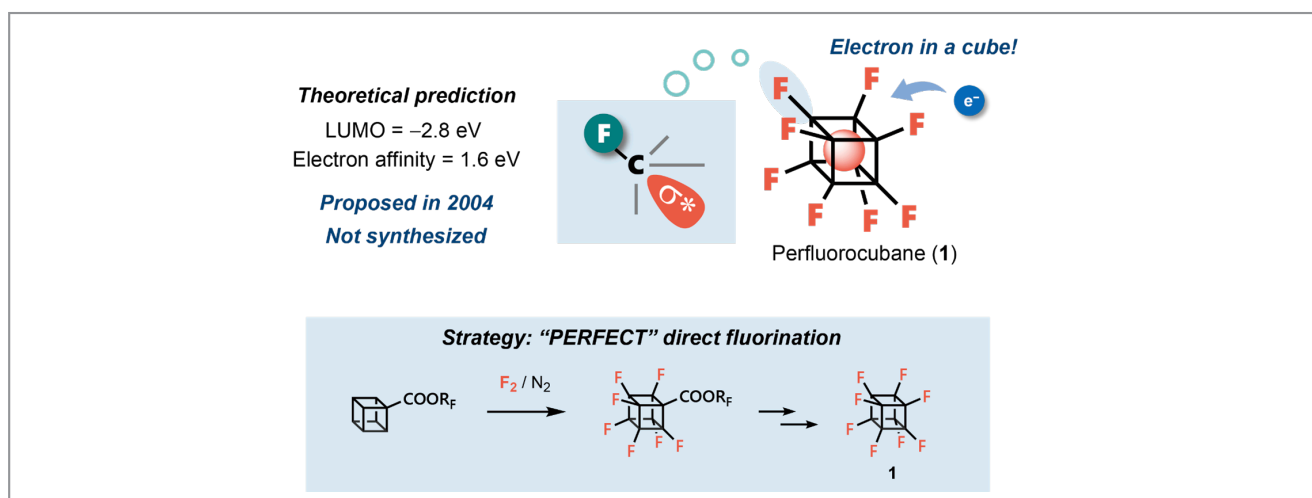


Figure 1 Structure of perfluorocubane (**1**) and its predicted properties, and synthetic strategy of **1** for this study. The energy level of **1** was calculated at the B3LYP/6-311++G(d,p) level of theory, and the predicted electron affinity has been reported previously.¹ From *Science* **2022**, 377, 756–759. Reprinted with permission from AAAS.

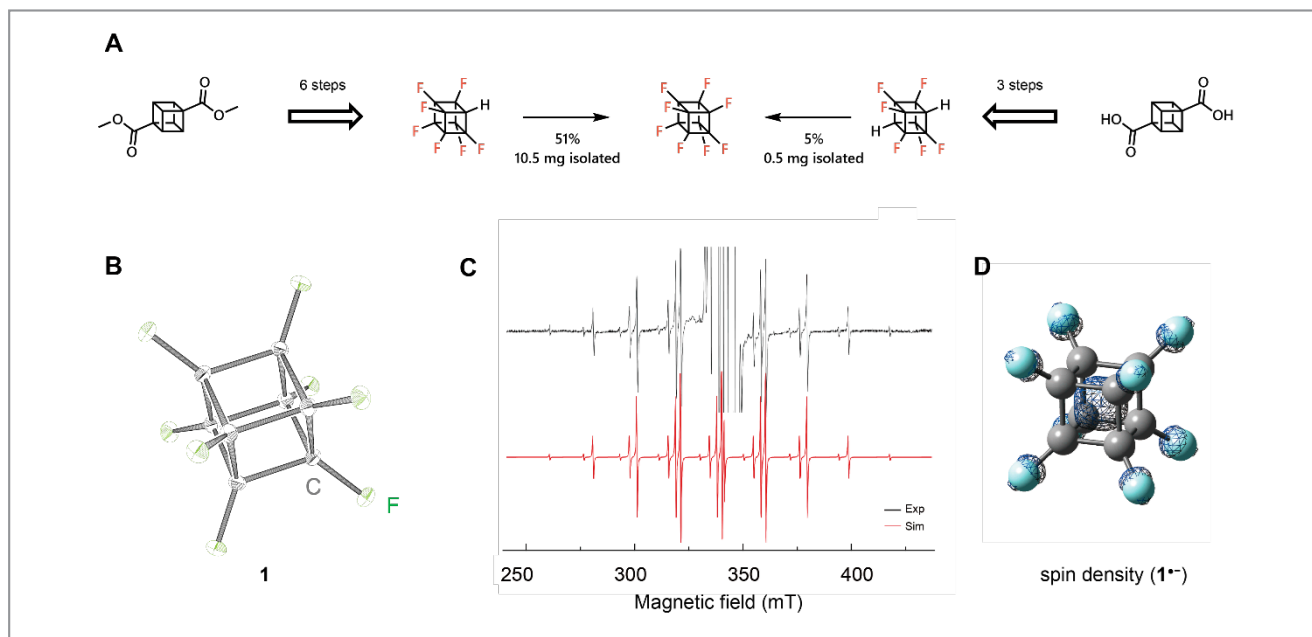


Figure 2 (A) Synthesis of perfluorocubane (**1**) from hepta/hexafluorocubane. (B) Crystal structure of **1** (ellipsoid probability, 50%). (C) ESR spectrum of **1** in a hexamethylethane matrix after γ -ray irradiation at 77 K (black) and simulated ESR spectrum (red) using $g = 1.9985$ and $a(^{19}\text{F}) = 19.62$ mT (8F). (D) Spin density (contour = 0.005) in the radical anion of **1**. From *Science* **2022**, 377, 756–759. Reprinted with permission from AAAS.

um. However, the group's experiments revealed that a cyclic voltammogram in solution showed an irreversible reduction wave, which indicates the unstable nature of the radical anion when it interacts with ambient molecules.

"In the beginning, we were disappointed with this result; however, we could not give up trying to observe the radical anion," said Professor Akiyama. Then the group started collaborative research with Prof. Komaguchi at Hiroshima University (Japan) to carry out low-temperature matrix isolation ESR measurements. "One and a half years passed after the isolation of perfluorocubane; however, the ESR signal indicating generation of the radical anion was finally observed in December 2021!" revealed Professor Akiyama, continuing: "It must have been a Christmas present for us. Although we anticipated that highly symmetrical perfluorocubane would potentially show an isotropic spectrum even in the solid state, it was still fortunate that perfluorocubane actually rotates in the glass matrix and shows clear splitting of the signal (Figure 2)."

Professor Akiyama concluded: "In the future, it may be possible to apply perfluorocubane to electronics and spintronics materials, but for now our interest remains more scientific and fundamental, with questions such as: How does the electron trapped in a perfluorocubane behave? Can electrons be moved in and out? How does perfluorocubane inter-

act with other molecules? And so on. We believe this paper is the first step in opening up a whole new scientific area."

Mattias Farnok

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About the authors



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Masafumi Sugiyama was born in Kanagawa (Japan). He received his B.S. (2019) and M.S. (2021) degrees in chemistry from The University of Tokyo (Japan). He is currently pursuing his Ph.D. at The University of Tokyo (Japan) under the supervision of Prof. Kyoko Nozaki. He works in the fields of synthetic organic chemistry, fluoroorganic chemistry, and physical organic chemistry.



Prof. M. Akiyama

Midori Akiyama is an assistant professor at Kyoto University (Japan). She received her Ph.D. from The University of Tokyo (Japan) under the supervision of Prof. Kyoko Nozaki in 2017. She joined the 'Laboratory for Material and Life Sciences for Fusion of Fluorine and Organic Chemistry' at The University of Tokyo as a project assistant professor in 2017. She moved to Kyoto University as an assistant professor in 2022. She was recognized with a L'Oréal-UNESCO For Women in Science Japan Fellowships Award in 2017. Her research interests include synthetic organic chemistry, physical organic chemistry, photochemistry, organometallic chemistry, and fluoroorganic chemistry.



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Prof. M. Higashi

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Prof. K. Nozaki

Kyoko Nozaki is a professor at The University of Tokyo (Japan). She graduated from Kyoto University (Japan) in 1986 and received her Ph.D. in 1991 from the same university. Since 1991, she was a faculty member at Kyoto University, moved to The University of Tokyo in 2002, and has been in her current position since 2003. Her research interest is focused on the development of homogeneous and heterogeneous catalysts for polymer synthesis and organic synthesis.

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Her achievements have been recognized with The Award of the Society of Polymer Science, Japan (2013), Chemical Society of Japan Award (2020), Distinguished Women in Chemistry or Chemical Engineering (2021), L'Oréal-UNESCO For Women in Science International Awards (2021), and Medal with Purple Ribbon (2022). She has been an International Honorary member of the American Academy of Arts & Sciences since 2021.



Dr. T. Okazoe

Takashi Okazoe is a senior fellow researcher of Materials Integration Laboratories, AGC Inc. (Japan), as well as a part-time lecturer in Department of Chemistry & Biotechnology, School of Engineering, The University of Tokyo (Japan), where he leads collaborative research between AGC Inc. and The University of Tokyo. He graduated from Kyoto University (Japan) with a Master's degree in industrial chemistry in 1987. He joined Asahi Glass

Co., Ltd. (now AGC Inc.) and engaged in the development of fluorinated pharmaceuticals and the creation and development of a new perfluorination method 'PERFECT', and technology planning of AGC Chemicals. During that time, he obtained his Ph.D. from Kyoto University in 2009. As part of his technology planning of the academia-industry collaboration, he launched a social cooperation program 'Laboratory for Material and Life Sciences for Fusion of Fluorine and Organic Chemistry' at The University of Tokyo in 2017. Since then, he has stationed himself there to carry out joint research.

Enantioselective Copper-Catalyzed sp^2/sp^3 Diborylation of 1-Chloro-1-trifluoromethylalkenes

ACS Cent. Sci. 2022, 8, 1134–1144

As one of the most important classes of molecules, organoboron compounds have been widely used in organic synthesis, and the introduction of fluorine-containing groups in these structures can efficiently control their physical, chemical and biological properties. Therefore, fluorine-containing organoboron compounds are widely recognized as a very prominent class of synthons, which find countless applications in organic synthesis, but still have enormous potential for more. Among them, fluorine-containing compounds with chemically different C–B bonds are particularly attractive, because these C–B bonds can undergo chemoselective and diverse transformations to form controllable and multifunctional complex target molecules. Professor Qiuling Song, from the Key Laboratory of Molecule Synthesis and Function Discovery, College of Chemistry, Fuzhou University (P. R. of China), explained: “Despite their remarkable interest, the construction of polyboronated compounds featuring different C–B bonds has been very rarely reported, especially in enantioselective synthesis. There are only two known such asymmetric diborations in the literature, leading to two different C–B bonds with the C_{sp^3} –B bond enantioenriched. Notably, both started from allenes (*J. Am. Chem. Soc.* 2004, 126, 16328–16329; *Chem. Sci.* 2017, 8, 5161–5165; Scheme 1a, left) and neither could lead to fluorine-containing multi-borylated molecules. Therefore, the synthesis of organic fluorine-containing asymmetric diboron compounds remains very interesting and challenging.”

Inspired by previous research work from the same group (*Chem* 2020, 6, 2347–2363) (Scheme 1a, right), in which the authors reported a Cu-catalyzed regio- and stereodivergent chemoselective diborylation of CF_3 -containing 1,3-enynes, rendering three different sp^2/sp^3 diborylated products bearing CF_3 functionality, and as a long-themed interest in the construction of fluorine-containing compounds with diverse C–B bonds, herein the authors reported a Cu-catalyzed construction of enantioselective sp^2/sp^3 diboronation starting from readily accessible starting materials, with final products bearing a geminal difluoroalkenyl moiety, in one step.

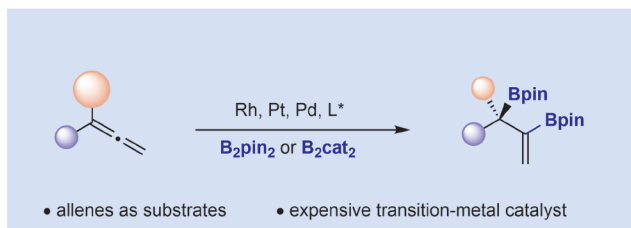
In this work, the authors first evaluated the reaction generality under the optimal conditions (see Scheme 1c, with some selected examples). Next, they selectively transformed C_{sp^2} –B bonds and C_{sp^3} –B bonds (Scheme 2a). Professor Song commented: “We are interested in the mechanism of the re-

action, in particular: between the two different C–B bonds, which one is generated first?” In order to understand the reaction mechanism, control experiments were carried out by postgraduate student Zhenwei Fan (Schemes 2b–d). “When we lowered the reaction temperature to 0 °C, compound **113** with only one boron moiety was obtained in 41% isolated yield, along with 25% yield of target product **3** (Scheme 2b),” added Professor Song, who continued: “When monoboron **113** was exposed to asymmetric conditions, the corresponding desired chiral product **60** was obtained in 91% yield with 97:3 e.r. value (Scheme 2c). Based on the above experiments, we have sufficient reason to believe that compound **113** is the key intermediate of the reaction. To further validate our hypothesis, we monitored the yield changes of intermediate **113** and product **3** over time, and found that the yield of **3** gradually increased as the time went on during the reaction. Meanwhile, the yield of compound **113** initially increased during the first two hours and then decreased gradually (Scheme 2d).” These results further confirmed the role of compound **113** as the key intermediate in the novel transformation.

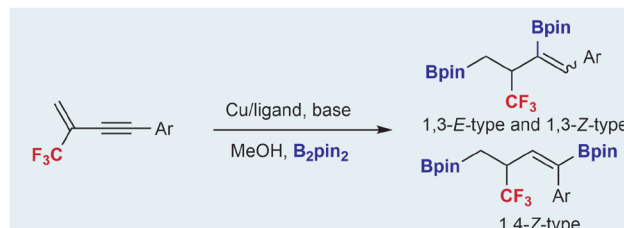
“In summary,” said Professor Song, “we developed a facile enantioselective copper-catalyzed diborylation reaction from readily accessible 1-chloro-1-trifluoromethylalkenes, a commercially available diboron reagent, and inexpensive Cu catalyst to produce a diverse array of enantioenriched *gem*-difluoroalkyl diboronates.” She concluded: “We anticipate that this strategy based on the diversity of boron chemistry will simplify the synthesis and enhance structural elaborations of *gem*-difluoroalkene targets for chemistry, biology, and pharmaceutical and medicinal chemistries.”

Mattia Fanale

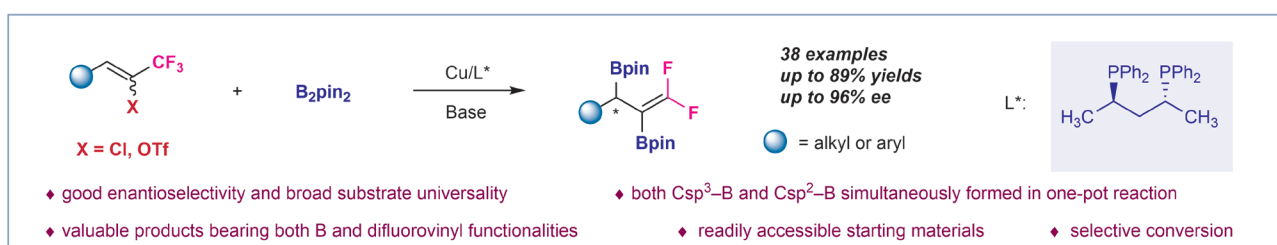
a: Known strategies for stereoselective synthesis of bis-organoborons with two different types of C–B bonds



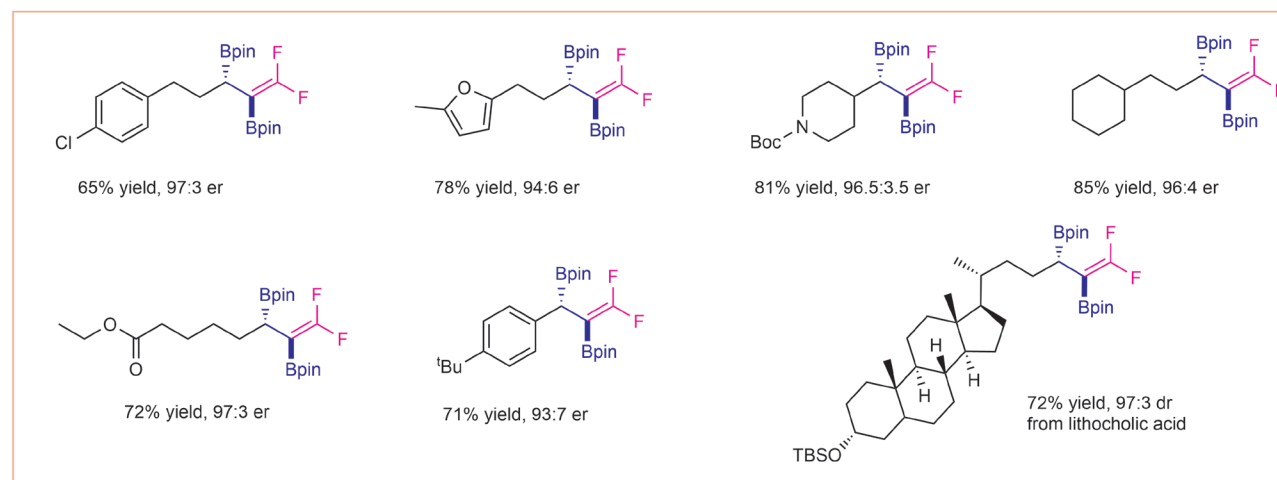
asymmetric diborylation of allenes



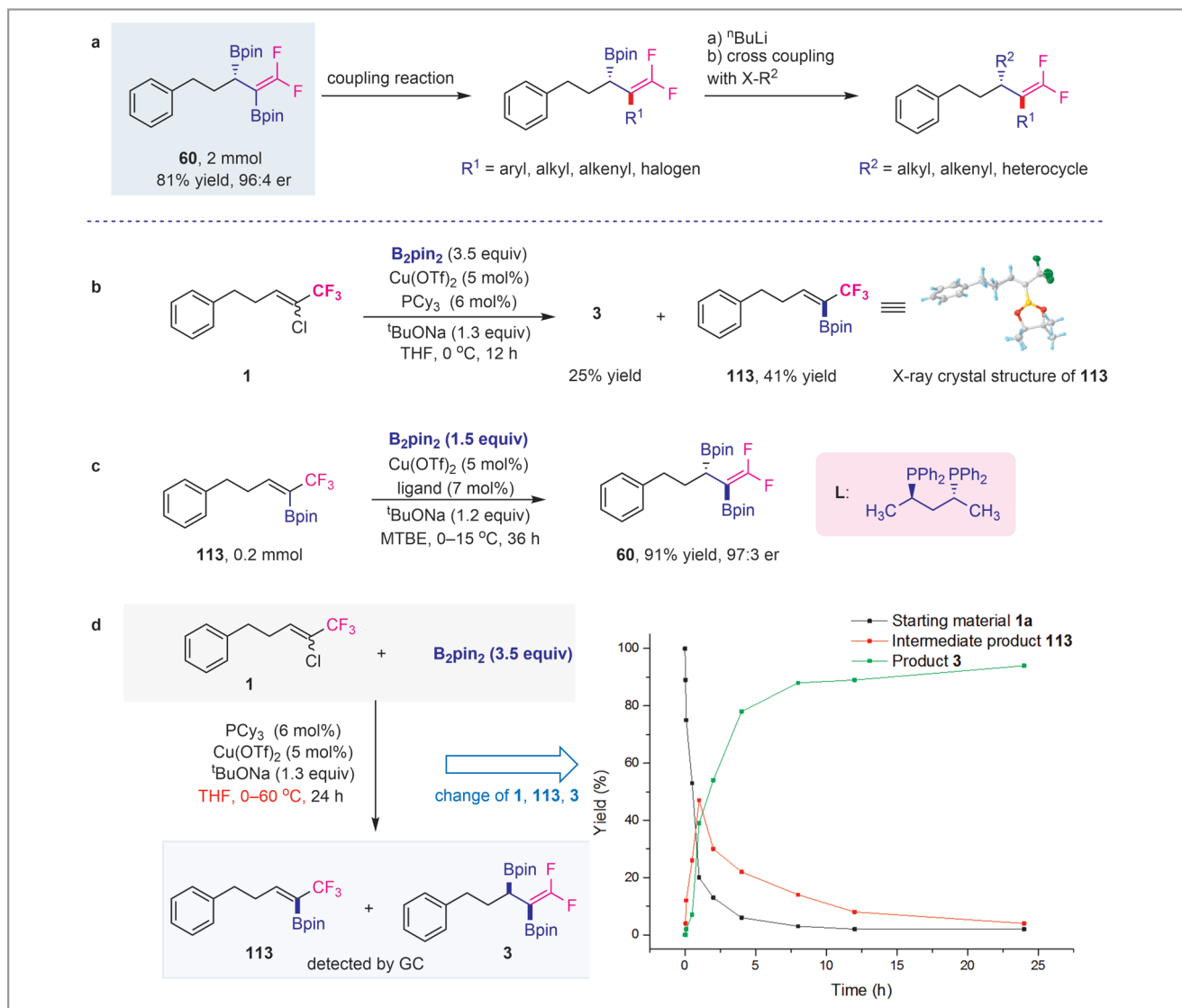
chemo-, regio- and stereoselective diborylation of 1,3-enynes

b: Enantioselective Cu-catalyzed diborylation of 1-chloro-1-trifluoromethyl-2-alkenes (*this work*)

c: Selected examples of the substrate scope



Scheme 1 (a) Known strategies for stereoselective synthesis of bis-organoborons with two different types of C–B bonds. (b) Enantioselective Cu-catalyzed diborylation of 1-chloro-1-trifluoromethyl-2-alkenes (*this work*). (c) Selected examples of the substrate scope.



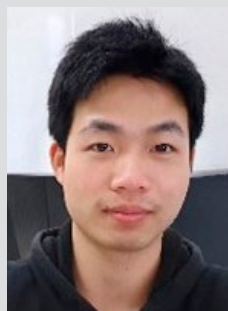
Scheme 2 (a) Selective transformations. (b–d) Control experiments.

About the authors



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Dr. K. Yang

Kai Yang was born in 1990 in Xiangtan (P. R. of China). He graduated from University of South China (P. R. of China) in 2013 and obtained his Ph.D. at Huaqiao University (P. R. of China) in 2018, directed by Prof. Qiuling Song. Then, he worked as a postdoctoral fellow in the College of Chemistry at Fuzhou University (P. R. of China). Now, he has joined Fuzhou University (P. R. of China). He focuses on boron chemistry and green chemistry.



Prof. Q. Song

Currently, her research interests involve the activation and functional transformation of C–C bonds and C–H bonds, fluorine chemistry, boron chemistry, and radical chemistry.

Qiuling Song obtained her B.S. degree from Zhengzhou University (P. R. of China), her M.Sc. in organometallic chemistry from Peking University (P. R. of China) and her Ph.D. in organic chemistry from Princeton University (USA). She joined Huaqiao University (P. R. of China) in 2012 and is now also a professor at Fuzhou University (P. R. of China). Currently, her research interests involve the activation and functional transformation of C–C

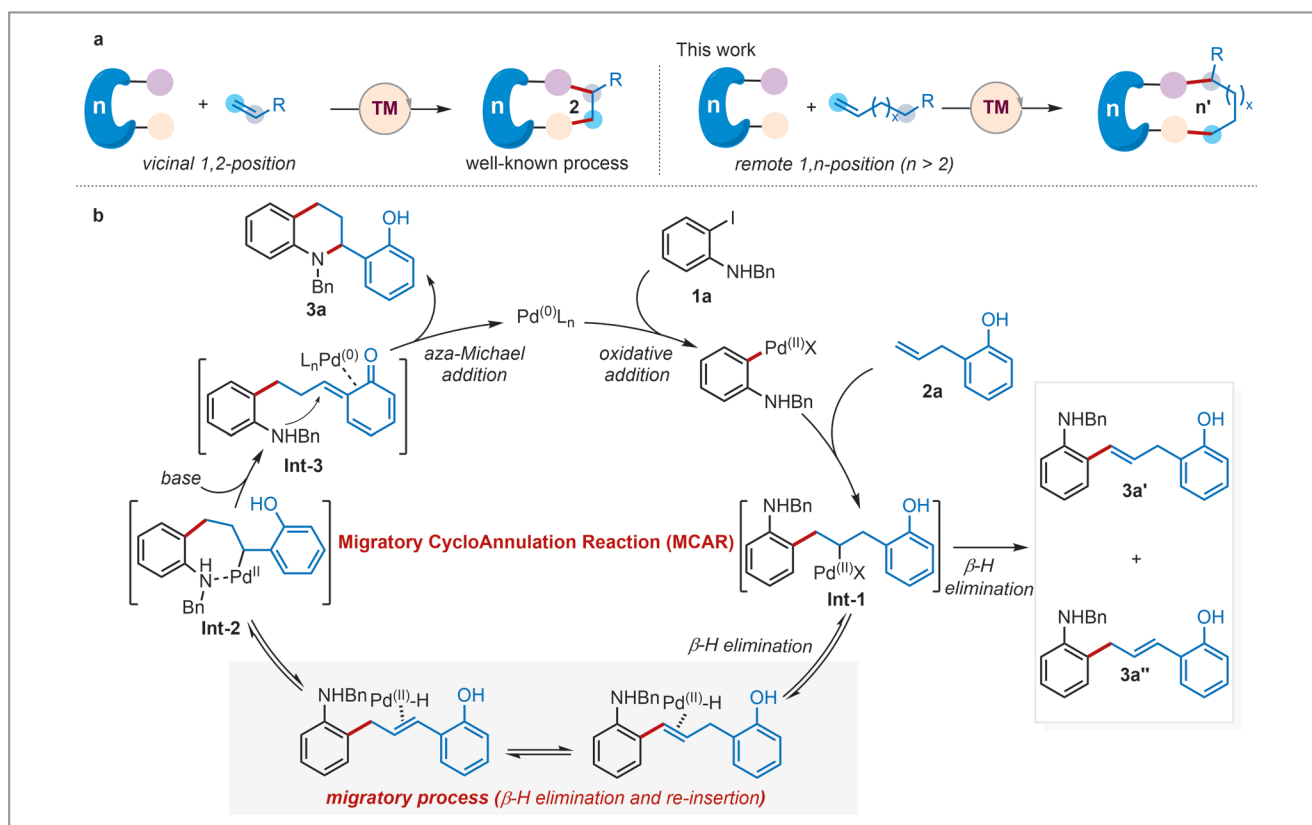
Construction of Azaheterocycles via Pd-Catalyzed Migratory Cycloannulation Reaction of Unactivated Alkenes

Nat. Commun. 2022, 13, 5059

Azaheterocycles, which are among the most prominent structural units in medicinal chemistry, are prevalent in small molecule drugs and bioactive compounds.¹ Therefore, methodologies for the efficient construction of azaheterocycle-containing molecules are in high demand. Among the reported synthetic methods to access these compounds, the Larock annulation – which exploits the cycloannulation of ambiphilic arylhalides with carbon–carbon double bonds – is one of the most widely used and promising strategies. “For now, development of the synthesis of 5- or 6-membered azaheterocycles from highly reactive styrenes, 1,3-dienes, allenes, or strained cyclic alkenes via $[n+2]$ processes, in which the cyclization occurs at the vicinal 1,2-position of those alkenes, dominates the literature,”^{2–4} said Professor Peng Wang, from the Shanghai

Institute of Organic Chemistry (P. R. of China), whose research group has recently introduced the concept of the Pd-catalyzed migratory cycloannulation strategy as a novel approach for building up a range of diverse sizes of azaheterocycles (Scheme 1a). “This protocol breaks through the limitation of the transition-metal-catalyzed $[n+2]$ cyclization, which has normally been achieved with the vicinal 1,2-functionalization of alkenes, leading to the diverse construction of a series of 6-, 7- and 8-membered azaheterocycles,” added Professor Wang.

Professor Wang continued: “One of our group’s research interests is to develop remote difunctionalization of unactivated alkenes by employing transition-metal chain-walking. Recently, we reported a nickel-catalyzed formal hydroarylation of unactivated alkenes.⁵ The mechanistic study revealed



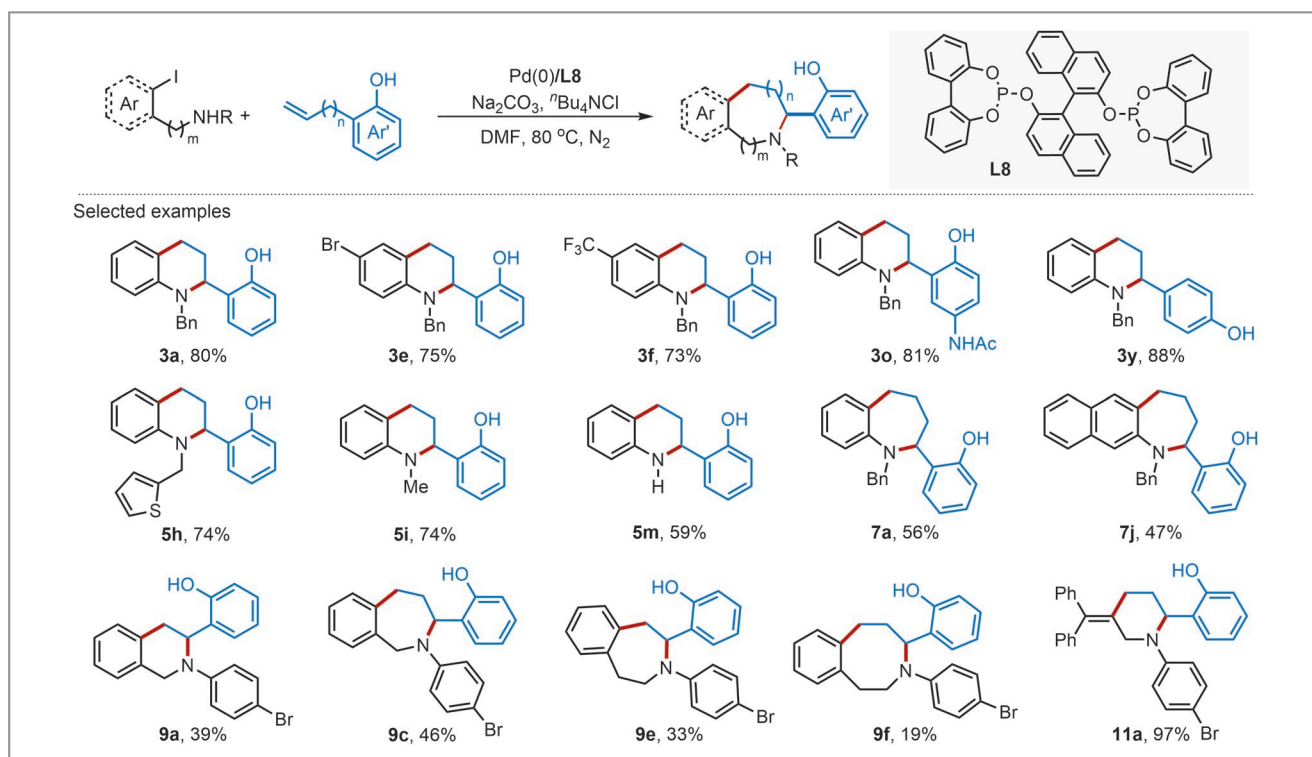
Scheme 1 Pd-Catalyzed migratory cycloannulation reaction

the metal-walking process occurred after the migratory insertion of unactivated alkenes with aryl-metal species. In addition to pursuing the three-component remote difunctionalization of unactivated alkenes, we also came up with a strategy, called transition-metal-catalyzed Migratory Cycloannulation Reaction (MCAR), for the efficient construction of cyclic compounds. This *Nature Communications* paper is a proof-of-concept work on MCAR using a Pd catalyst for the efficient construction of diverse azaheterocycles with unactivated alkenes and the ambiphilic coupling partners."

Jin-Ping Wang, the first author of the title article and a PhD candidate in the Wang laboratory, pointed out: "The key to accessing the target azaheterocycles by this strategy is identifying the suitable unactivated alkenes." After screening various unactivated alkenes in this intermolecular cycloannulation with *N*-benzyl-2-iodoaniline, the target product was observed when a hydroxyl group was introduced. "The use of a hydroxyl group will help to render the reactivity of the unactivated alkenes and to control the ring size. Later, the reaction was proven to go through a quinone methide intermediate after the metal migratory process," Ms. Wang explained, adding: "The mechanistic studies revealed that the reaction might undergo a catalytic cycle involving, sequentially, an oxidative addition

of *N*-benzyl-2-iodoaniline with Pd(0), a migratory insertion to the alkene, the chain-walking process, and an intramolecular aza-Michael addition to the quinone methide intermediate (Scheme 1b)."

"Several challenges were predicted when we started this project, such as the low reactivity of the unactivated nonconjugated alkenes and the difficulty in controlling the cyclization position and in inhibiting any side reactions," recalled Professor Wang, revealing that, in fact, a large amount of byproducts, including isomerized alkenes and oxidative Heck-type products, were detected in the initial study. After systematically evaluating the reaction parameters, the group finally obtained the best efficiency by utilization of BINOL-derived bisphosphate ligand. "Under optimal conditions, differently sized azaheterocycles were constructed, including tetrahydroquinoline, tetrahydroisoquinoline, tetrahydrobenzo[*b*]azepine, tetrahydrobenzo[*c*]azepine, tetrahydrobenzo[*d*]azepine, hexahydrobenzo[*d*]azocine, and piperidine (Scheme 2). Moreover, we developed the efficient synthesis of a potential selective estrogen receptor modulator (SERM) in four steps, compared with seven steps in the known synthetic route," said Professor Wang, who concluded: "This Pd-catalyzed migratory cycloannulation strategy is efficient in constructing a wide



Scheme 2 Selected products of the Pd-catalyzed MCAR

range of azaheterocycles from the corresponding unactivated aliphatic alkenes. The *ortho*-hydroxyl group, introduced as a 'locating group' in this chemistry, favors the formation of quinone methide intermediates, which also controls the ring-size of the azaheterocycles. We are currently applying this design principle to achieve transition-metal-catalyzed MCARs with other coupling partners."

Mattias Fanek

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Prof. Y. Wu

Yichen Wu received her Ph.D. from the Institute of Chemical Research of Catalonia (ICIQ), Spain in 2017 under the supervision of Prof. Alexandr Shafir. From 2018, she joined Prof. Wang's group at the Shanghai Institute of Organic Chemistry (SIOC, P. R. of China) first as a postdoctoral researcher and now as an associate professor. Her current research interest focuses on organosilicon chemistry.



S. Song

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Prof. P. Wang

Peng Wang received his B.S. degree from Tianjin University (P. R. of China) in 2007 and completed his Ph.D. under the supervision of Prof. Yong Tang at Shanghai Institute of Organic Chemistry (SIOC, P. R. of China) in 2013. He joined SIOC as a full professor in early 2018 after carrying out postdoctoral research with Prof. Jin-Quan Yu at the Scripps Research Institute (TRSI, USA). His research group focuses on transition-metal catalysis and main group chemistry.

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 CO₂ 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 scaf-

folding 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).

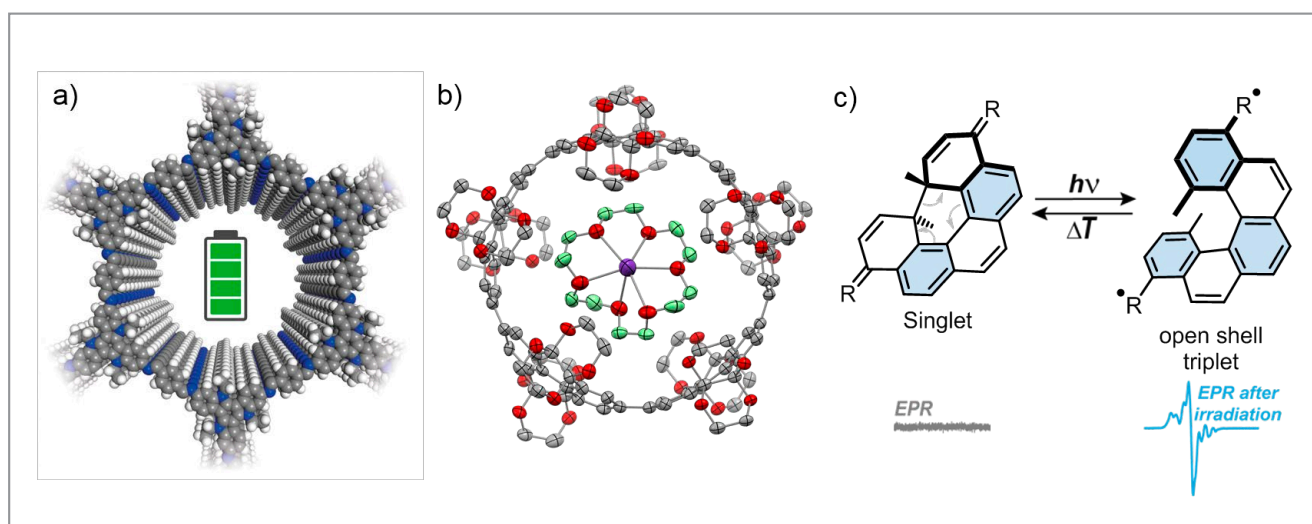


Figure 1 a) Covalent organic frameworks with applications in energy storage; b) strained polyaromatic macrocycles with confined inner spaces to host unusual substrates; c) photomagnetic switches based on [5]helicenes.

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.



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— Literature Coverage

A Concise Synthesis of Tetrodotoxin

— Literature Coverage

Synthesis of *cis*-Thiiranes as Diastereoselective Access to Epoxide Congeners via 4 π -Electrocyclization of Thiocarbonyl Ylides

— Literature Coverage

An Enzyme-Mimic Single Fe-N₃ Atom Catalyst for the Oxidative Synthesis of Nitriles via C–C Bond Cleavage Strategy

Further highlights

Synthesis **Review: The Synthetic Approaches to 1,2-Chlorohydrins**

(by G. Hilt)

Synlett **Account: Recent Progress towards the Transition-Metal-Catalyzed Dearomatizing Spirocyclization Reactions of Indolyl Ynones**

(by W.-B. Shen and co-workers)

Synfacts **Synfact of the Month in category “Innovative Drug Discovery and Development”: Novel Dioxane- and Morpholino Nucleotide Analogues with Improved Off-Target Profiles in siRNAs**

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