

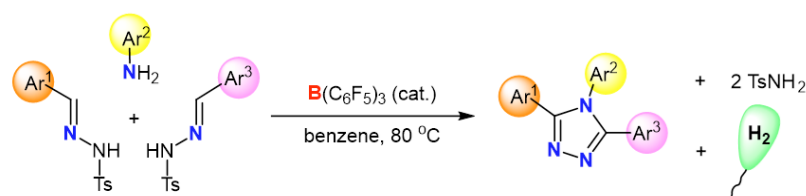
Synform

People, Trends and Views in Chemical Synthesis

2020/01

Acceptorless Dehydrogenative Cyclization of *N*-Tosylhydrazones and Anilines: Dual Role of $B(C_6F_5)_3$

Highlighted article by M. M. Guru, S. De, S. Dutta, D. Koley, B. Maji



Contact

Your opinion about Synform is welcome,
please correspond if you like:
marketing@thieme-chemistry.com

Dear Readers,

Are you ready for the new decade? SYNFORM certainly is! In the era of research visibility and public outreach, SYNFORM – supported by the Thieme Chemistry journals and social media – has become a powerful tool for reaching increasingly larger audiences with your publications and is entering its third decade in sparkling form and more ambitious than ever! In case you had any doubts, just look at the content of this first issue of 2020: I am really pleased that the decade-opening article comes from India, which is taking giant leaps in chemistry, as apparent from the excellent work presented by Koley and Maji on $B(C_6F_5)_3$ -promoted synthesis of triaryl-1,2,4-triazoles. The second article of the decade is Q. Song's (P. R. of China) elegant stereoconvergent synthesis of ketoximes. The third article is from the lab of an absolute heavy-weight of organic chemistry: Prof. K. Barry Sharpless. In this case, supported by J. Dong (P. R. of China), who co-authored a new chapter of the click-chemistry saga recently published in *Nature*. Finally, the first Young Career Focus interview of the decade takes us to the Antipodes, where B. C. Hawkins (New Zealand) tells us about his molecular targets in organic synthesis.

You can tell it's gonna be a good decade!!

Enjoy your reading!!!



In this issue

— Literature Coverage

Acceptorless Dehydrogenative Cyclization of *N*-Tosylhydrazones and Anilines: Dual Role of $B(C_6F_5)_3$ A3

— Literature Coverage

Stereospecific 1,4-Metallate Shift Enables Stereoconvergent Synthesis of Ketoximes..... A8

— Literature Coverage

Modular Click Chemistry Libraries for Functional Screens Using a Diazotizing Reagent..... A11

— Young Career Focus

Young Career Focus: Dr. Bill C. Hawkins (University of Otago, New Zealand)..... A14

Coming soon A16

Contact

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

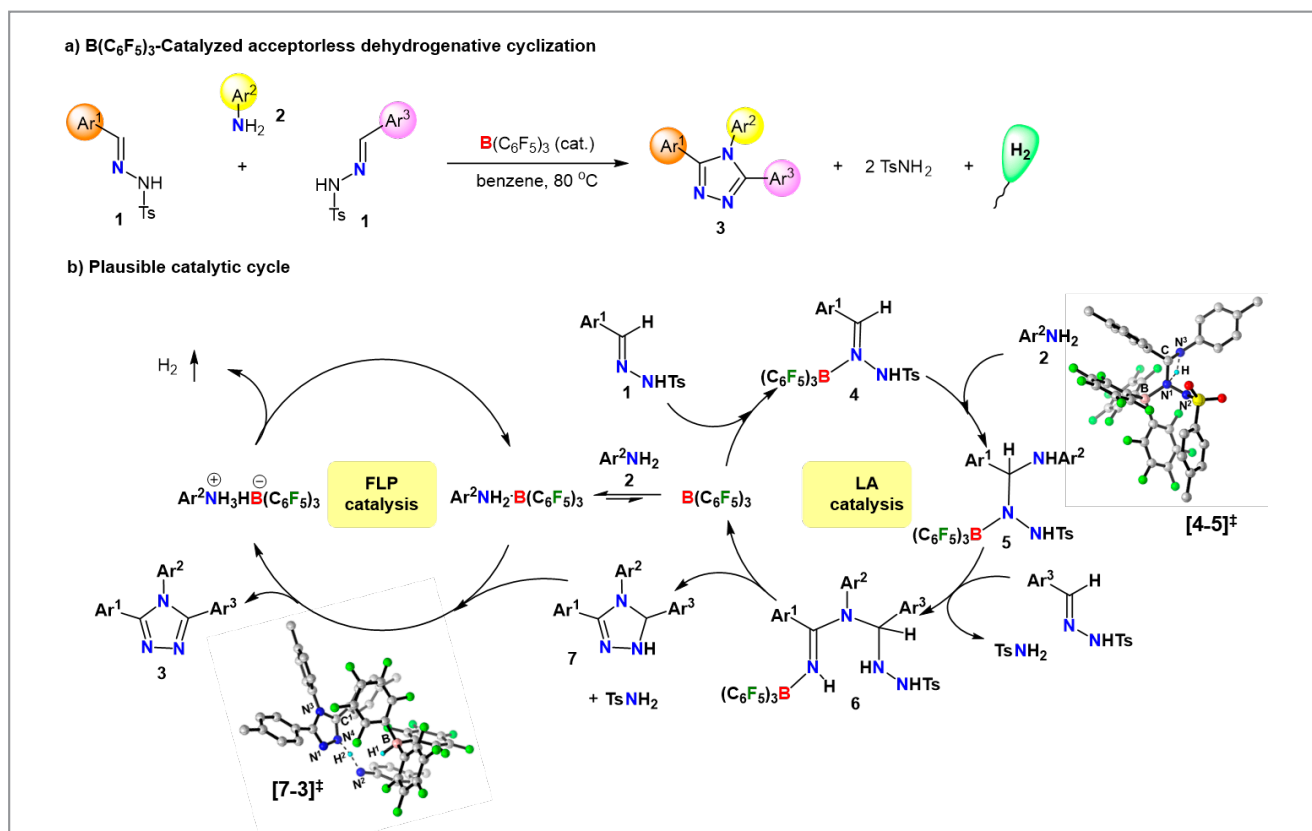
Acceptorless Dehydrogenative Cyclization of *N*-Tosylhydrazones and Anilines: Dual Role of $B(C_6F_5)_3$

Chem. Sci. **2019**, *10*, 7964–7974

Tris(pentafluorophenyl)borane [$B(C_6F_5)_3$] acts as a powerful Lewis acid catalyst for numerous organic transformations. In combination with a sterically demanding Lewis base, it forms Frustrated Lewis-acid Pairs (FLPs), which have recently been applied for small-molecule activations and metal-free hydrogenation as well as dehydrogenation reactions. Recently, the group of Professor Debasis Koley and Professor Biplab Maji at the Indian Institute of Science Education and Research (Kolkata, India) described the $B(C_6F_5)_3$ -catalyzed cyclization of *N*-tosylhydrazones **1** and anilines **2** to form triaryl-1,2,4-triazoles **3** (Scheme 1a), which are essential heterocyclic scaffolds in pharmaceutical, biological, and materials sciences. Professor Maji explained: “The work utilizes a unique dual mode of

activation of $B(C_6F_5)_3$, which initially acts as a Lewis acid to activate **1** thus triggering its cyclization with **2** (Scheme 1b, right).” He continued: “Later, the FLP generated from $B(C_6F_5)_3$ and **2** acts as a dehydrogenation catalyst to liberate hydrogen from the saturated triazole intermediate **7** without the need of an acceptor. The gain in aromaticity drives the dehydrogenation reaction (Scheme 1b, left). The reaction operates at low loading of catalyst, tolerates several functional groups and can be extended to unsymmetrical 1,2,4-triazoles when utilizing two different *N*-tosylhydrazones.”

Professor Maji remarked that it is highly challenging to design acceptorless dehydrogenative transformations, even with transition-metal catalysts, whereas metal-free protocols are



Scheme 1 a) $B(C_6F_5)_3$ -catalyzed dehydrogenative cyclization reaction. b) Probable reaction mechanism for the acceptorless dehydrogenative cyclization reaction.

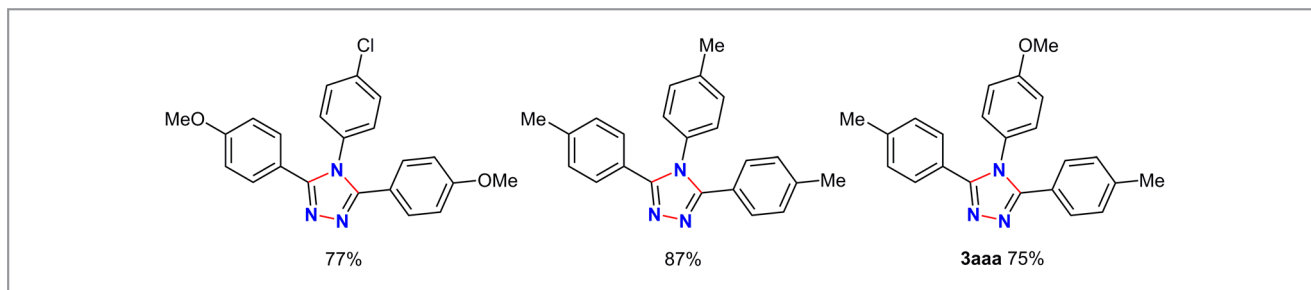


Figure 1 Selected examples for the synthesis of symmetrical 1,2,4-triazoles.

elusive. Using $B(C_6F_5)_3$ as a catalyst, Dr. M. M. Guru – one of the authors – explored the scope of the synthesis of symmetrical triazoles (Figure 1), where *p*-toluene sulfonamide ($TsNH_2$) and hydrogen were obtained as byproducts.

“Expansion of the protocol for the synthesis of unsymmetrical 1,2,4-triazoles using two different *N*-tosylhydrazones was challenging, as the selectivity remained poor after several trials (Scheme 2a),” said Professor Maji. A competitive equilibrium study was performed with two electronically biased *N*-tosylhydrazones (**1a** vs **1c**) with $B(C_6F_5)_3$ which afforded the Lewis acid–base adduct **4a** whereas **1c** remained unreacted (**4a**:**1c** = 1:1) (Scheme 2b). Professor Maji remarked: “Thus, we realized that the electronic difference might be a crucial factor for the selectivity of unsymmetrical 1,2,4-triazole formation. Indeed, we solved the issue by utilizing electronically biased *N*-tosylhydrazones which afforded good to excellent yields of unsymmetrical 1,2,4-triazoles (Scheme 2c).”

He continued: “Moreover, from the Hammett correlation study performed by varying different electronic groups on the aryl ring of **2**, we determined a small $\rho = -1.17$, which plausibly indicates a weak resonance interaction involving a positive charge at the N-center of aniline in the rate-determining step (Scheme 2d).”

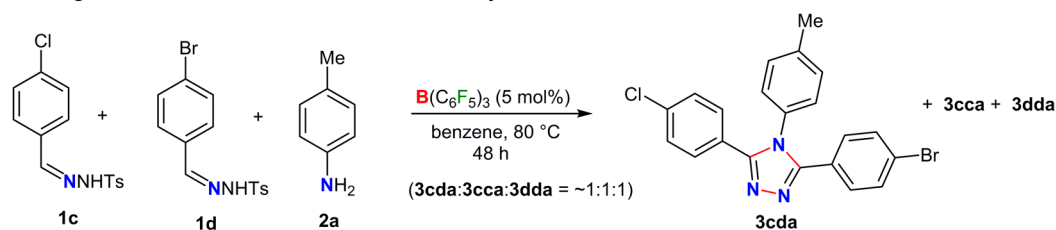
Professor Koley and co-authors Mr. De and Mr. Dutta performed DFT calculations [B3LYP-D3/TZVP(CPCM)//B3LYP/SVP level of theory] to investigate the detailed reaction mechanism, the specific role of $B(C_6F_5)_3$ and the rate-limiting-step in the reaction, and finally the product distribution for the unsymmetrical coupling. Professor Koley said: “As per the experimentally observed equilibrium ratio in Scheme 2b, the formation of **4a** is computed to be more facile than **4c** by ca. 3.0 kcal mol⁻¹ (Figure 2).” He continued: “Eventually, the activation barrier for $B(C_6F_5)_3$ coordination is 3.6 kcal mol⁻¹ more favorable for the OMe substituent ($\Delta\Delta^\ddagger G_L^\ddagger$; Figure 2). What is more interesting is that the overall energy span for the formation of **5** is substantially higher for the Cl than the OMe substituent (42.5 vs. 33.3 kcal mol⁻¹), clearly indicating

the preference for **1a** to undergo $B(C_6F_5)_3$ -assisted intramolecular proton transfer in a facile manner. Therefore, when **5aa** couples with another hydrazone unit, the preferred choice will be the chloro-substituted analogue **1c** as most of **1a** will be available in the adduct form **4a**.”

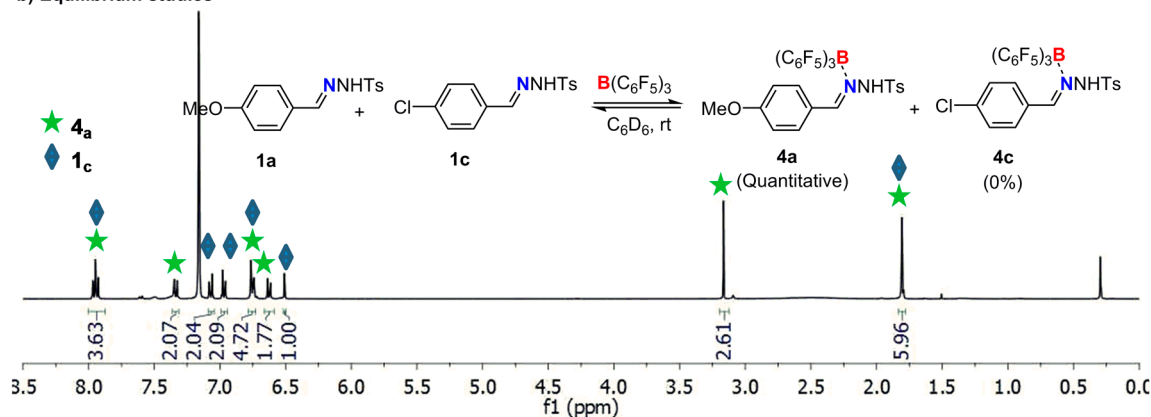
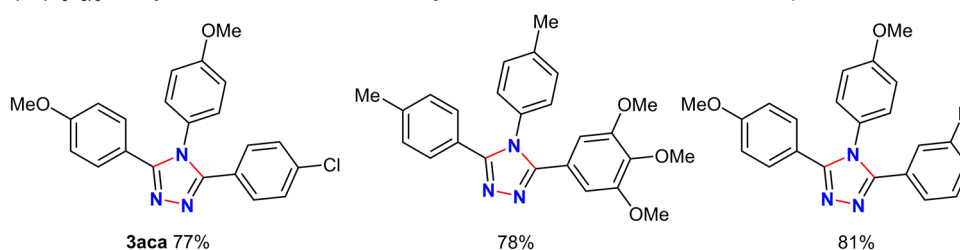
As for the potential applications of the triazole products, the group has recently shown that pyrene-appended triazole-linked dimers could be applied in solution-processable resistive memory devices on a flexible substrate (*Chem. Commun.* **2019**, *55*, 4643).

“In summary, we have developed $B(C_6F_5)_3$ -catalyzed single-pot, acceptorless dehydrogenative cyclization of hydrazones with anilines to access both symmetrical and unsymmetrical 1,2,4-triazoles,” said Professor Maji. He concluded: “Mechanistic experiments and DFT calculations suggest that the boron catalyst plays a dual role, initially acting as a Lewis acid to activate the hydrazone for the nucleophilic attack and later forming an FLP with aniline for acceptorless dehydrogenation. This chemoselective and mild reaction protocol could foster further studies and generate further interest in main-group-catalyzed chemical transformations performed without the use of transition-metal catalysts.”

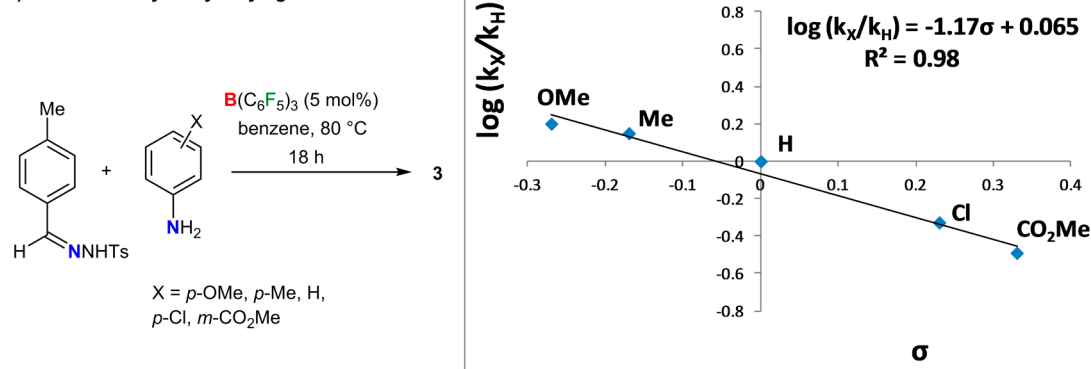
a) Challenges associated with selective formation of unsymmetrical 1,2,4-triazole



b) Equilibrium studies

c) $\text{B}(\text{C}_6\text{F}_5)_3$ -Catalyzed selective formation of unsymmetrical 1,2,4-triazole: selected examples

d) Hammett analysis by varying aniline



Scheme 2 a) Challenges for the synthesis of unsymmetrical 1,2,4-triazoles. b) Equilibrium studies with electronically different *N*-tosylhydrazones. c) Selected examples for the synthesis of unsymmetrical 1,2,4-triazoles. d) Hammett analysis.

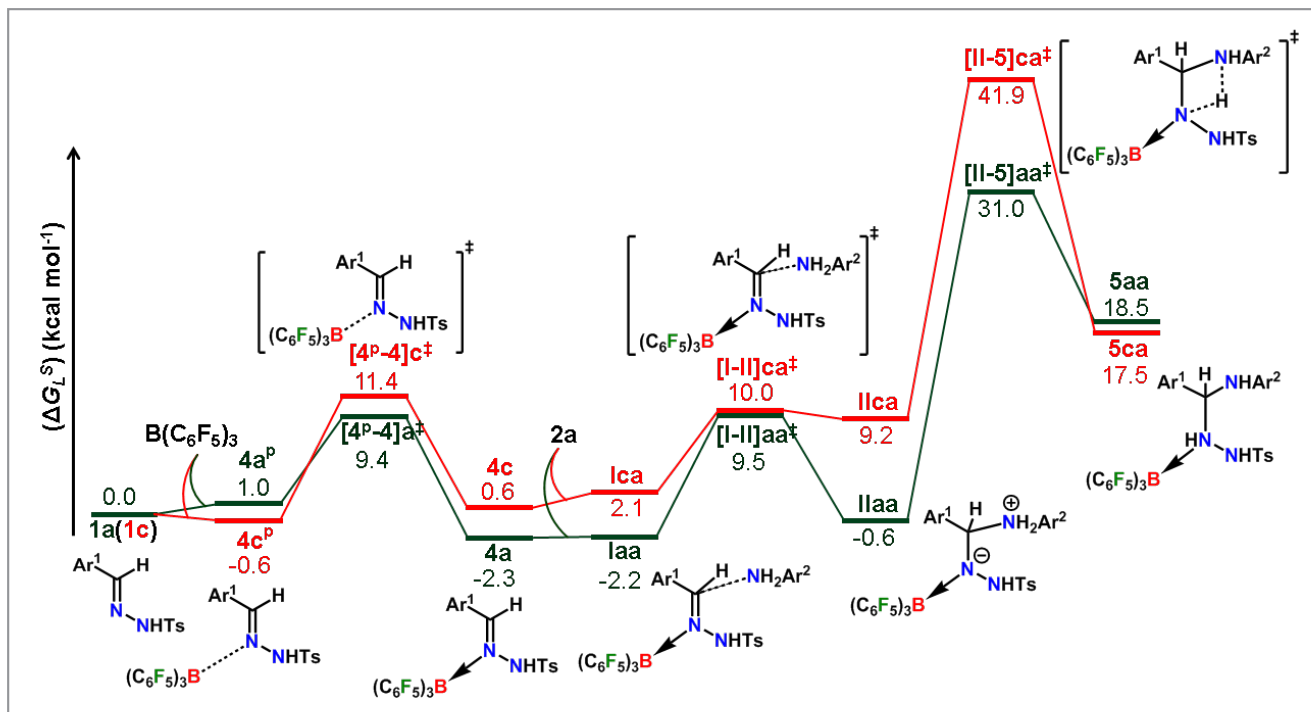


Figure 2 Overlaid energy profiles for the formation of unsymmetrical triazole **3aca** and symmetrical triazole **3aaa** up to the formation of **5**. Energy values are concerning the starting materials [**1a/c** + $B(C_6F_5)_3$]. For green solid line, $Ar^1 = p\text{-MeOC}_6\text{H}_4$ and $Ar^2 = p\text{-MeC}_6\text{H}_4$ where for red solid line, $Ar^1 = p\text{-ClC}_6\text{H}_4$ and $Ar^2 = p\text{-MeC}_6\text{H}_4$. All the energy values (ΔG_L^\ddagger) are in kcal mol^{-1} .

Mattes Fank

About the authors



Dr. M. M. Guru

Murali Mohan Guru received his Ph.D. from Indian Institute of Technology Guwahati (India) in 2013 under the supervision of Prof. T. Punniyamurthy. Subsequently, he moved to RIKEN (Japan) as a postdoctoral researcher in the lab of Prof. Zhaomin Hou, working there from 2013–2016. He returned to India in 2017 and joined the group of Dr. Biplab Maji in IISER Kolkata (India) as a SERB-NPDF. Currently, he is working on novel organic transformations using main-group borane catalysts.



S. De

Sriman De was born in Burdwan, West Bengal, India. He completed his B.Sc. at Burdwan University (India) in 2011. In 2013, he completed his study in chemistry with his M.Sc. degree at Visva-Bharati University (India). In 2014, he started as a Ph.D. student under the supervision of Dr. Debasis Koley at IISER Kolkata (India). His research interests are focused on bimetallic complexes in catalysis using computational methods.



S. Dutta

Sayan Dutta received his B.Sc. from Visva-Bharati University (India) in 2011. He obtained his M.Sc. in chemistry from the same university in 2013 before joining Dr. Debasis Koley's research group at IISER Kolkata (India) in 2014 as a Ph.D. student. His current research focuses on mechanistic investigations of main-group- and transition-metal-mediated chemical transformations and theoretical exploration of the bonding scenario in various donor–acceptor complexes.



Prof. D. Koley

Debasis Koley studied chemistry (honors) at Ramakrishna Mission Vidyamandira (India) from 1996 to 1999. In 2001, he completed his M.Sc. in chemistry at Indian Institute of Technology Delhi (India). In 2005, he received his doctoral degree from Heinrich Heine Universität Düsseldorf (Germany), working under the supervision of Professor Walter Thiel at MPI für Kohlenforschung, Mülheim an der Ruhr (Germany). During 2006 to 2008, he was engaged as a postdoctoral researcher at MPI für Biophysikalische Chemie, Göttingen (Germany). Later he moved to IISER Bangalore (India) as a Centenary postdoctoral fellow in the Inorganic and Physical Chemistry Department under the supervision of Professor S. Ramakrishnan. Since 2011, he has been at the Indian Institute of Science Education and Research (IISER) Kolkata (India), currently a professor in the Department of Chemical Sciences. His Computational Chemistry and Molecular Modelling (CCMM) group focuses on structure, bonding and mechanistic interpretations of various chemical systems using state-of-the-art computational techniques.



Prof. B. Maji

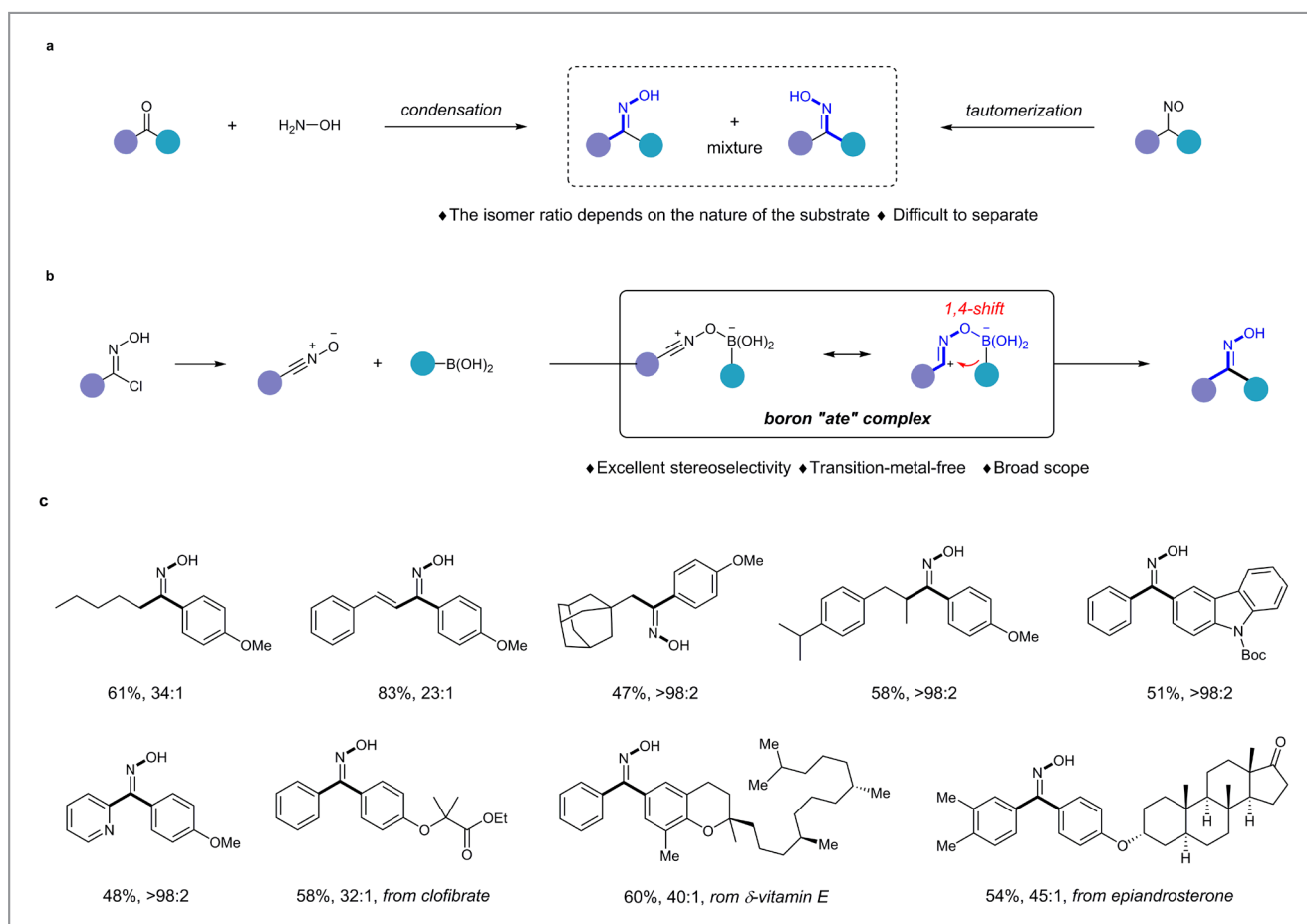
Biplab Maji was born in Howrah (India) in 1987. He obtained his B.Sc. in chemistry (Honors) from University of Calcutta (India) in 2004 and M.Sc. in chemistry from the Indian Institute of Technology Kanpur (India) in 2009. Subsequently, he joined the group of Prof. Herbert Mayr at the Ludwig Maximilian Universität Munich (Germany) for his doctoral studies, which he completed in 2012. In 2013, he joined the group of Prof. Hisashi Yamamoto at the Molecular Catalyst Research Center of Chubu University (Japan) as a postdoctoral fellow. In 2015, he moved to the group of Professor Frank Glorius at Westfälische Wilhelms-Universität Münster (Germany) as an Alexander von Humboldt fellow. Since 2016, he has been working as an assistant professor in the Department of Chemical Sciences, IISER Kolkata (India). His research focuses on organic synthesis, catalysis, and mechanistic studies.

Stereospecific 1,4-Metallate Shift Enables Stereoconvergent Synthesis of Ketoximes

Angew. Chem. Int. Ed. **2019**, *58*, 13421–13426

Stereochemically pure oximes are ubiquitous structural motifs in drugs, bioactive molecules and food additives. They are also very important starting materials for the Beckmann rearrangement, which has been successfully employed for the industrial production of many valuable fine chemicals. The prototypical ketoxime synthesis involves condensation of ketones with hydroxylamine or tautomerization of C-nitroso species, as well as reduction of nitro compounds. However, the ratio of the resulting *E/Z*-isomers is under thermodynamic control and depends on the nature of the substrates, which usually

causes major problems when it comes to isolating a single geometric isomer, unless the two substituents of the ketoximes are structurally very different (Scheme 1a). “This is why the practical and universal direct stereoselective synthesis of stereochemically pure ketoximes, especially of thermodynamically less stable ones, remains an unsolved challenge in modern chemical transformations,” said Professor Qiuling Song, from the Key Laboratory of Molecule Synthesis and Function Discovery, College of Chemistry, Fuzhou University (P. R. of China).



Scheme 1 (a) Typical approaches for ketoxime synthesis. (b) Stereoconvergent synthesis of stereochemically pure ketoximes. (c) Selected examples of the substrate scope.

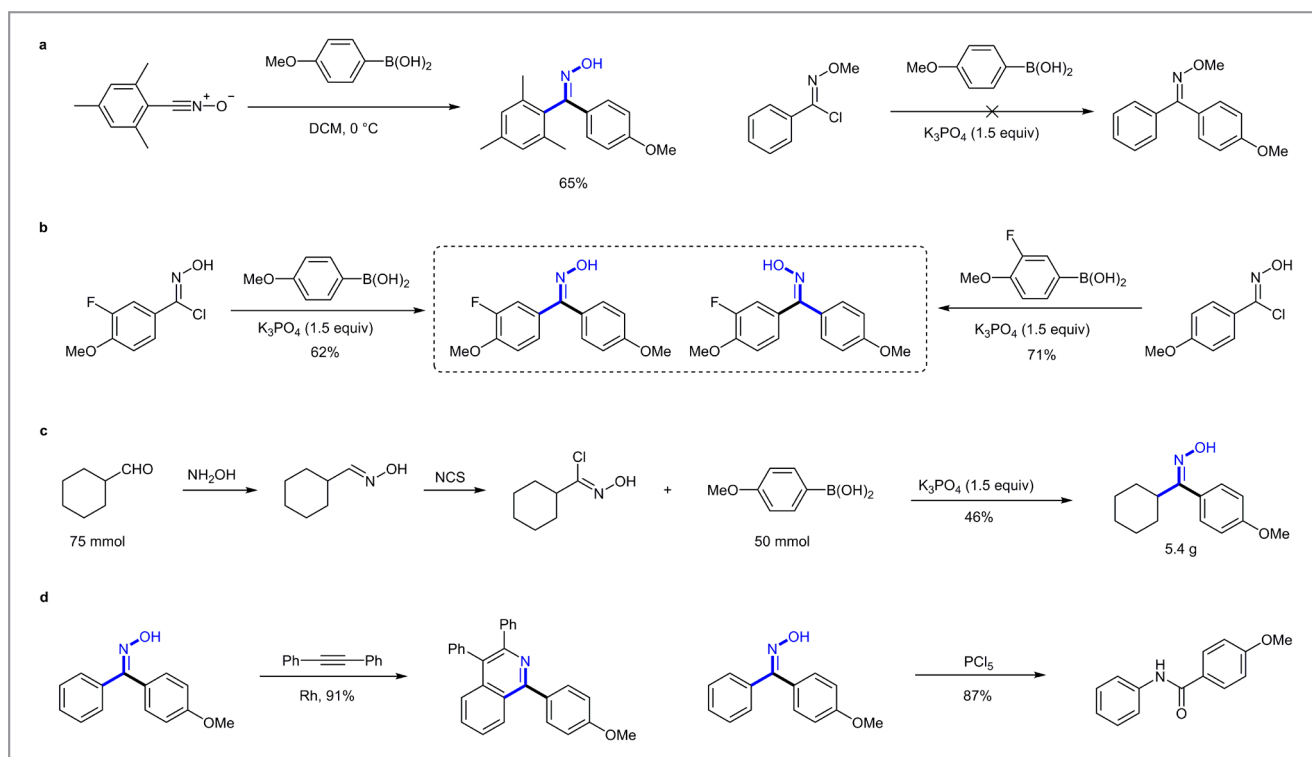
Professor Song continued: “With these issues in mind, we were interested in developing a mechanistically distinct strategy, independent of the configuration of the starting materials and not involving transition metals, which would represent a general method for the synthesis of single-geometry ketoximes.” Nitrile oxides caught the group’s attention, as ketoximes can be obtained from the reaction of organometallic reagents or aromatic nucleophiles and nitrile oxides. Unfortunately, the authors of this study found that the diversity and stereoselectivity of ketoxime products was highly restricted owing to the instability of nitrile oxides and the strong nucleophilicity of these organometallic reagents.

“We then envisioned that nitrile oxides could attack the electrophilic boron atom of arylboronic acids, resulting in a boron ‘ate’-complex that might lead to stereochemically pure ketoximes via a stereospecific 1,4-metallate shift (Scheme 1b),” said co-author Dr. Kai Yang. Considering the instability of nitrile oxides, they selected oxime chlorides as precursors of nitrile oxide. The resulting protocol enabled Professor Song and co-authors to synthesize diverse stereochemically pure ketoximes, including diaryl ketoximes and thermodynamically less stable aryl alkyl ketoximes.

Control experiments were conducted to evaluate the practicality of the protocol (Scheme 2a), and the team performed comparison experiments to synthesize two different stereospecific ketoximes (Scheme 2b). Next, a gram-scale experiment was carried out by postgraduate student Feng Zhang, and demonstrated the preparative utility of this protocol (Scheme 2c). Meanwhile, the team went on to explore the reactivity of ketoximes as directing group in C–H activation reactions and Beckmann rearrangement (Scheme 2d).

“In summary,” said Professor Song, “we have developed a protocol to directly synthesize stereochemically pure ketoximes from oxime chlorides and arylboronic acids via stereospecific 1,4-metallate rearrangement. This approach shows a broad substrate scope and good functional group tolerance. It also provides a good opportunity for the development of oxime chemistry and demonstrates a promising approach to prepare single-geometry ketoximes that could be used by both the chemistry community and pharmaceutical scientists.”

Mattias Fank



Scheme 2 (a) Control experiments. (b) Comparison experiments. (c) Gram-scale synthesis experiment. (d) Selected examples of the synthetic applications.

About the authors



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 PhD at Huaqiao University (P. R. of China) in 2018, directed by Prof. Qiuling Song. Now, he is working as a postdoctoral fellow in the College of Chemistry at Fuzhou University (P. R. of China). He focuses on boron chemistry and green chemistry.



G. Zhang

Guan Zhang was born and grew up in Jining, Shandong province (P. R. of China). She obtained her B.S. degree from Shangqiu Normal University (P. R. of China) in 2017 before joining Professor Song's group to further her studies in organic chemistry. Her research interests are green chemistry and free-radical chemistry.



F. Zhang

Feng Zhang was born and grew up in Jingmen, Hubei Province (P. R. of China). He received his B.S. degree from China Three Gorges University (P. R. of China) in 2018 before moving to Fuzhou University (P. R. of China) to further his studies in organic chemistry, directed by Prof. Qiuling Song. His research interests are boron chemistry and photocatalysis.



Prof. Q. Song

Prof. 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 bonds and C–H bonds, fluorine chemistry, boron chemistry, and radical chemistry.



T. Fang

Tongchang Fang comes from Liaocheng, Shandong Province (P. R. of China). He obtained his B.S. degree from Liaocheng University (P. R. of China) in 2018 before joining Prof. Qiuling Song's group. He focuses on boron chemistry and free-radical chemistry.

Modular Click Chemistry Libraries for Functional Screens Using a Diazotizing Reagent

Nature **2019**, *574*, 86–91

Click chemistry – a term coined by 2001 Chemistry Nobel Prize Laureate Professor Barry Sharpless, at Scripps Research (USA) – aims to be a quick and modular synthesis concept for finding new molecules with desirable properties. Professor Sharpless had the intention of connecting 2 or 3 modules together in solution, in sequence, within a few hours and submitting the mixture directly to screening. “This original hope seemed absurd until his lab discovered the CuAAC triazole annulation reaction in 2002,” said Professor Dong, who remarked: “This one perfect reaction instantly solved nearly all of our needs for intermolecular ligation. Compared with known combinatorial chemistry strategies based on solid-phase synthesis, this ideal click chemistry plan in solution takes advantage of the near-perfect reactivity of CuAAC and does not involve protecting groups. More importantly, and almost uniquely among combinatorial chemistry strategies, it can make any compound of interest pure on a milligram to gram scale in a day or less, very soon after the biologist has revealed the screening results.”

Professor Dong joined Professor Sharpless’ laboratory in 2009 as a research associate and paid tribute to him, saying: “Barry is more than a mentor for me. His visionary lecture about click chemistry at SIOC in 2004 was really inspiring for me as a young chemist there, while others simply thought that he had lost his mind! I have been fortunate to work closely with him in the last ten years, in Scripps and now at SIOC.”

In the first six years, synthesizing and collecting azides or alkynes had become Professor Dong’s daily work. During that time, he noticed at least three aspects having key importance for the aim of generating such a library:

1. The number of commercially accessible azide and alkyne modules is very low.

2. While collecting terminal alkyne molecules, it became evident that usually those molecules hardly tolerated other functional groups or protecting groups, which were generally difficult and laborious to incorporate. Therefore, the alkyne chemical space was limited for this particular application, especially for low-molecular-weight modules.

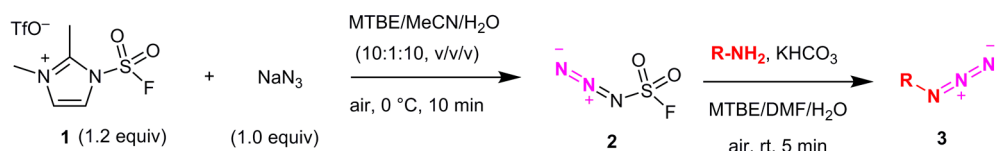
3. Although many procedures are known for the synthesis of azides, the synthesis of low-molecular-weight azides was even more complicated than the synthesis of alkynes.

Firstly, there were significant safety concerns regarding their reactions and purifications; secondly, azides are unstable, especially in solution. The so-called “Diazotransfer process” was already well known at that time. However, the two standard reagents used for this procedure (TfN₃ and imidazole-1-sulfonyl azide hydrochloride) require metal catalysts, excess azide reagent, and sometimes risky purification steps (as mentioned in this *Nature* article). An excess of diazotransfer reagents would affect the CuAAC reaction if both reactions were run in sequence in one-pot.

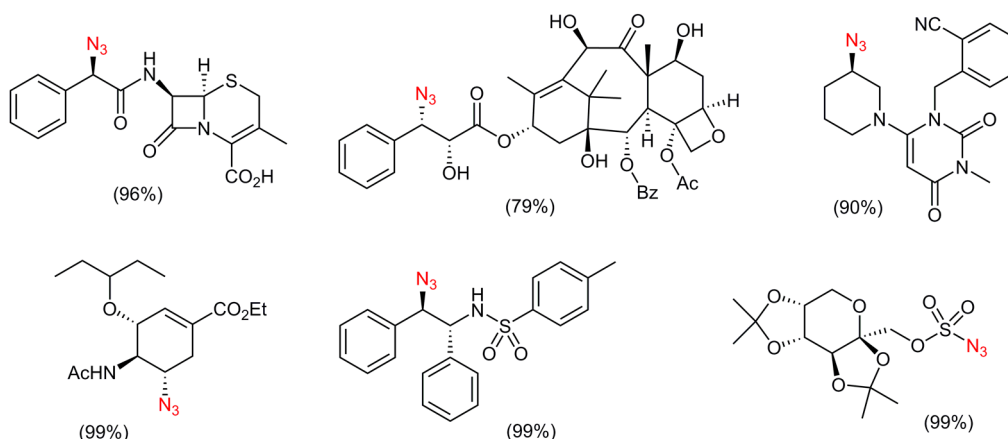
Professor Dong explained: “It has been known for years that the CuAAC reaction is unusually predictable; however, it relies on the power of two highly energetic functional groups nature did not use, which kills the accessibility aspect. The commercial availability of both groups is very low compared to those that medicinal chemists often use. While ready availability of azides/alkynes would be highly desirable, in reality this option is simply too difficult to achieve and too expensive.”

The exciting discovery of this methodology has an interesting origin, partially based on serendipity. In fact, during their experiments, the group wanted to use FSO₂N₃ for the SuFEx reaction and accidentally discovered the abnormal diazotransfer process. Professor Dong said: “Mistakes are the portals of discovery! We were trying to make FSO₂N₃ from our imidazolium fluorosulfonyl triflate salt **1**, but we knew from our previous publication (*Angew. Chem. Int. Ed.* **2018**, *57*, 2605–2610) that the salt would be hydrolyzed very quickly in water. Therefore, three of my students used organic solvents but failed to produce anything. However, our research associate, Genyi Meng, used water and succeeded at the first attempt! So I asked him: “Why did you use water? Didn’t you know the reagent would hydrolyze even without a base?” His answer was, “No, I didn’t know that.” And that is how we found this excellent procedure for making FSO₂N₃.”

Ever since working with Professor Sharpless at Scripps, Professor Dong had wondered how predictable the ligand-



Some of the azides prepared by this method:



Scheme 1

accelerated CuAAC could be and whether it would be possible to find one SOP to fit every substrate in CuAAC and build a modular synthetic platform. “This discovery inspired me, and we suddenly realized we could have thousands of modules to try this idea now,” remarked Professor Dong. He continued: “But it turned out to be surprisingly harder than we thought! PhD student Tiancheng Ma worked hard on it though and we finally figured out a good set of conditions in plates.”

Concerning the future applications of this new methodology, Professor Dong noted that since its discovery, CuAAC has become the most powerful tool to connect two molecular entities chemically. However, its potential as a powerful synthetic tool to produce new compounds has been overlooked. “With this dramatically improved diazotransfer reaction between primary amines and FSO_2N_3 , enormous azide libraries are suddenly a reality,” said Professor Dong. Even more excitingly, Professor Dong considers this reaction to be a powerful leverage of CuAAC or even SuFEx chemistry, not just any new reaction. “It enables a modular synthesis platform based on the most accessible building blocks in medicinal chemistry and on the most predictable connecting method ever known. Just imagine: one could do 1000, even 10000 modifications on a given lead in a predictable fashion without purification,

with just one employee in one day or even less!” said Professor Dong.

“In the last two years, we have collaborated with different groups in China and the U.S.; more than a dozen different 1000-mer triazole libraries have been or are going through phenotypic screens aimed at finding useful activity relevant to human diseases,” said Professor Dong. He concluded: “None of the biology results are included in this manuscript. We hope this reaction can help click chemistry towards its goal of speeding up discoveries of useful new molecules, especially much-needed medicines. We are now working on the next version of this azide library: Taijie Guo – a co-author of this study – scaled up our salt to 5 kg and we purchased more than 5000 primary amines. We hope we can hit 4016 pieces soon (LEGO Death Star 75159 had 4016 pieces) and, eventually, a platform with more than 10000 azides.”

Matthew Fenske

About the authors



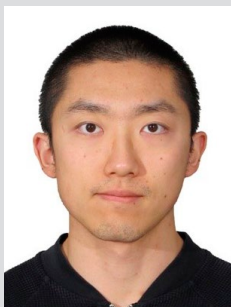
Prof. J. Dong

Jiajia Dong was born in P. R. of China and received his BA from Xiamen University (P. R. of China) in 2000. Prof. Biao Jiang supervised his 2006 PhD in organic chemistry from Shanghai Institute of Organic Chemistry (SIOC, P. R. of China). He was a senior scientific researcher at Egret Pharma, Shanghai (P. R. of China), before becoming a postdoctoral associate in 2009–2015 with Prof. K. Barry Sharpless' group at The Scripps Research Institute (USA). He is currently a research professor at SIOC. His research interests include the main-group fluoride chemistry and click chemistry.



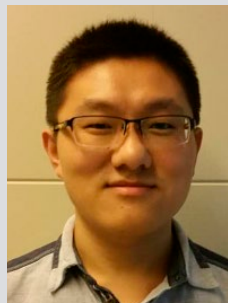
Prof. K. B. Sharpless

Nobel Laureate K. Barry Sharpless became W. M. Keck Professor of Chemistry at The Scripps Research Institute and The Skaggs Institute of Chemical Biology (USA) in 1990. Previously a professor at MIT and Stanford (USA), he was educated at Dartmouth College, USA (BA 1963), Stanford (PhD 1968 with E. E. van Tamelen; postdoc 1969 with J. P. Collman), and Harvard, USA (postdoc 1970, K. E. Bloch). He joined the Key Laboratory of Organofluorine Chemistry, Shanghai Institute of Organic Chemistry, CAS (P. R. of China) as an adjunct professor in 2016.



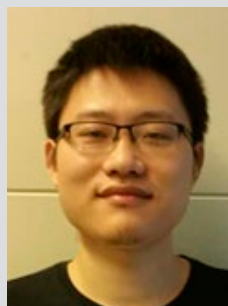
G. Meng

Genyi Meng obtained his BA and MSc in natural sciences from University of Cambridge (UK) in 2016. From 2016 to 2019, he worked under the supervision of Prof. K. Barry Sharpless at Shanghai Institute of Organic Chemistry (P. R. of China) as a research assistant. In 2019, he started his PhD program at the Scripps Research Institute (USA).



T. Guo

Taijie Guo was born in P. R. of China and obtained his B.E. in Chemical Engineering and Technology in 2013 at Jining University (P. R. of China). He received his Master's degree in chemical engineering from Shanghai Normal University (P. R. of China) in 2019. From 2016 to 2019, he studied as a joint student under the supervision of Prof. Jiajia Dong at Shanghai Institute of Organic Chemistry (SIOC), Chinese Academy of Sciences (P. R. of China). He is currently a research assistant at SIOC with Prof. Jiajia Dong.



T. Ma

Tiancheng Ma was born in 1993 in Hefei, P. R. of China. He received his BSc in chemistry in 2015 at Tongji University, Shanghai (P. R. of China). In September 2015, he started his MSc studies at Shanghai Institute of Organic Chemistry (P. R. of China) under the supervision of Prof. Jiajia Dong. In 2017, he transferred to the PhD program.

Young Career Focus: Dr. Bill C. Hawkins (University of Otago, New Zealand)

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. Bill C. Hawkins (University of Otago, New Zealand).

Biographical Sketch



Dr. B. C. Hawkins

Bill C. Hawkins completed his PhD at the University of Wollongong, Australia (Prof. Pyne and Prof. Keller) in 2007, followed by post-doctoral positions at the University of Melbourne, Australia (Prof. Rizzacasa) and Ecole Polytechnique, France (Prof. Zard). After a short stay at the Walter and Eliza Hall Institute of Medical Research (Australia), he joined the Department of Chemistry at the University of Otago (New Zealand) as a lecturer (2012) and was promoted to senior lecturer in 2016. His research interests include the synthesis of bioactive natural products and their use as chemical probes to understand biological processes and inform drug design, as well as the development of new synthetic methodologies. He is the recipient of several awards including the Thieme Chemistry Journals Award (2019) and the Easterfield Medal (RSC/NZIC, 2019).

INTERVIEW

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

Dr. B. C. Hawkins Natural products and synthetic derivatives have and will continue to represent a critical source of pharmaceuticals, accounting for almost 50% of clinically used drugs. Despite the first lab-based synthesis of urea occurring almost 200 years ago, and the incredible advances in synthetic methods since then, we are still far from achieving ideality in synthesis. Our research is focused around developing efficient synthetic methods to access bioactive compounds, with a particular focus on natural products. Specifically, current efforts are aimed at utilizing donor-acceptor cyclopropanes as building blocks for the rapid synthesis of medicinally relevant scaffolds and target oriented synthesis. Current synthetic targets in the lab include spiroaspertrione A and spirocalcaridines A and B (Figure 1).

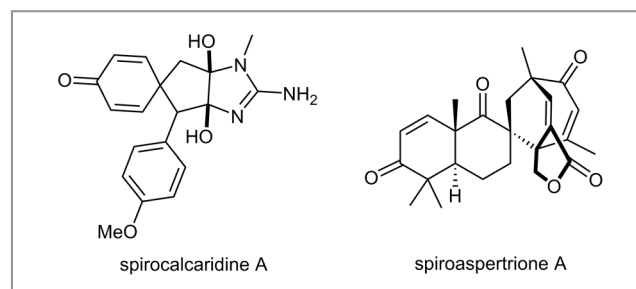


Figure 1 Current synthetic targets in our laboratory

SYNFORM *When did you get interested in synthesis?*

Dr. B. C. Hawkins Science in general has always fascinated me; however, my interest in chemistry came in high school and my love of organic synthesis was sparked during my un-

dergraduate studies. The idea of being the first to synthesize or create a new molecule and elucidate its properties, or develop an elegant synthesis of a known compound, continues to inspire me! The contribution and impact made by early pioneers in the field of total synthesis, such as Woodward and Stork, demonstrated a beauty and creativity that was simply breath-taking. Just from reading the literature it was abundantly clear to me that this was the field I wanted to be a part of.

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

Dr. B. C. Hawkins Organic synthesis will always be a cornerstone in science, a truly enabling discipline that has facilitated the expansion of many disciplines (for example materials, polymers, supramolecular chemistry, and chemical biology). Both fundamental and translational research are important in a modern society. However, the current trend towards overlooking fundamental research in favor of translational research is short-sighted and ultimately slows progress in organic synthesis and science in general. Serendipity and unexpected results are often the source of game-changing discoveries; by focusing solely on applied research, opportunities to uncover truly unique/unexpected processes could be missed.

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

Dr. B. C. Hawkins Our research efforts are relatively broad, encompassing synthetic methodology based around utilizing ring strain to allow entry into medicinally relevant scaffolds, through to target-oriented syntheses. More recently, we have begun a medicinal chemistry program centered around natural products synthesized in our lab. The end goal of our work is to develop fast and efficient entry into medicinally relevant chemical entities. These molecules can then be used as biological tools for collaborators to use to probe cellular processes, and consequently increase our understanding of disease processes and ideally help in the rational design of drugs.

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

Dr. B. C. Hawkins Thanks to the hard work of my research group, we have developed several useful synthetic methods to access important compound classes such as oxazinones,^{1,2} chromones³ and benzannulated spiroketals.⁴ However, my group's synthesis of the marine natural product spiroleucettadine (Fi-

gure 2) is probably the most important achievement of my independent career to date.^{5,6} This synthesis has enabled access to large quantities of spiroleucettadine and the subsequent uncovering of unexpected biological activity, which in turn has led us to pursue a medicinal chemistry program focused on establishing a structure–activity relationship and also, with the help of collaborators, efforts have begun to establish the mechanism of action of spiroleucettadine.

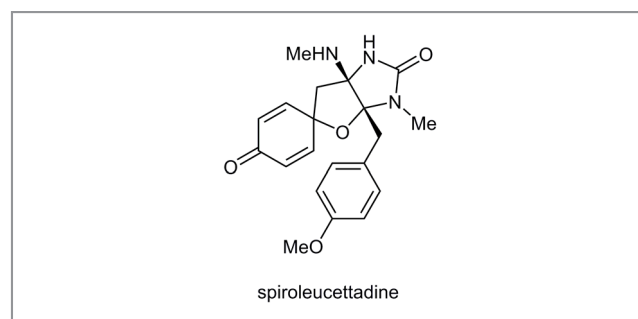


Figure 2 Spiroleucettadine is a member of the Leucetta derived alkaloids

Matthew Farnik

REFERENCES

- (1) A. J. Craig, L. van der Salm, L. Stevens-Cullinane, N. T. Lucas, E. W. Tan, B. C. Hawkins *Org. Lett.* **2015**, *17*, 234–237.
- (2) R. J. Smith, D. A. Mills, D. Nhu, E. W. Tan, N. T. Lucas, B. C. Hawkins *J. Org. Chem.* **2016**, *81*, 2099–2105.
- (3) R. J. Smith, D. Nhu, M. R. Clark, S. Gai, N. T. Lucas, B. C. Hawkins *J. Org. Chem.* **2017**, *82*, 5317–5327.
- (4) S. Gai, N. T. Lucas, B. C. Hawkins *Org. Lett.* **2019**, *21*, 2872–2875.
- (5) R. A. Lamb, N. S. Aberle, N. T. Lucas, G. Lessene, B. C. Hawkins *Angew. Chem. Int. Ed.* **2017**, *56*, 14663–14666.
- (6) R. A. Lamb, N. T. Lucas, G. Lessene, B. C. Hawkins *J. Org. Chem.* **2018**, *83*, 10120–10133.

Coming soon

— Literature Coverage

Photoinduced Skeletal Rearrangements Reveal Radical-Mediated Synthesis of Terpenoids

— Literature Coverage

Unified Prebiotically Plausible Synthesis of Pyrimidine and Purine RNA Ribonucleotides

— Literature Coverage

Late-Stage Trifluoromethylthiolation of Benzylic C–H Bonds

Further highlights

Synthesis **Review: Isothiazoles in the Design and Synthesis of Biologically Active Substances and Ligands for Metal Complexes**

(by A. V. Kletskov and co-workers)

Synlett **Account: Pursuit of C–H Borylation Reactions with Non-Precious Hetero-bimetallic Catalysts: Hypothesis-Driven Variations on a Design Theme**

(by N. P. Mankad and co-workers)

Synfacts **Synfact of the Month in category “Organo- and Biocatalysis”: Excited-State Electron Transfer Enables Organocatalytic Deracemization of Ureas**

For current SYNFORM articles, please visit www.thieme-chemistry.com
 SYNFORM issue 2020/02 is available from January 21, 2020
 at www.thieme-connect.com/ejournals

Editor

Matteo Zanda, Chair in Biomolecular Imaging, Centre for Imaging Science, Department of Chemistry, School of Science, Loughborough University, Leicestershire, LE11 3TU, UK and
 C.N.R. – Istituto di Chimica del Riconoscimento Molecolare
 Via Mancinelli, 7, 20131 Milano, Italy
 Editorial Assistant: Alison M. Sage
synform@outlook.com; fax: +39 02 23993080

Editorial Office

— Managing Editor: Susanne Haak,
susanne.haak@thieme.de, phone: +49 711 8931 786
 — Scientific Editors:
 Stefanie Baumann, stefanie.baumann@thieme.de, phone: +49 711 8931 776
 Selena Boothroyd, selena.boothroyd@thieme.de
 Michael Binanzer, michael.binanzer@thieme.de, phone: +49 711 8931 768
 Giuliana Rubulotta, giuliana.rubulotta@thieme.de, phone: +49 711 8931 183
 Kathrin Ulbrich, kathrin.ulbrich@thieme.de, phone: +49 711 8931 785
 — Senior Production Editors:
 Thomas Loop, thomas.loop@thieme.de, phone: +49 711 8931 778
 Thorsten Schön, thorsten.schoen@thieme.de, phone: +49 711 8931 781
 — Production Manager: Sophia Hengst,
sophia.hengst@thieme.de, phone: +49 711 8931 398
 — Production Assistant: Tobias Brenner,
Tobias.brenner@thieme.de, phone: +49 711 8931 769
 — Editorial Assistant: Sabine Heller,
sabine.heller@thieme.de, phone: +49 711 8931 744
 — Marketing Director: Julia Stötzner,
julia.stoetzner@thieme.de, phone: +49 711 8931 771
 — Postal Address: Chemistry Journals, Editorial Office, Georg Thieme Verlag KG,
 Rüdigerstraße 14, 70469 Stuttgart, Germany,
 — Homepage: www.thieme-chemistry.com

Publication Information

Synform will be published 12 times in 2019 by Georg Thieme Verlag KG, Rüdigerstraße 14, 70469 Stuttgart, Germany, and is an additional online service for Synthesis, Synlett and Synfacts.

Publication Policy

Product names which are in fact registered trademarks may not have been specifically designated as such in every case. Thus, in those cases where a product has been referred to by its registered trademark it cannot be concluded that the name used is public domain. The same applies as regards patents or registered designs.

Ordering Information for Print Subscriptions to Synthesis, Synlett and Synfacts

The Americas: Thieme Publishers New York, Thieme Medical Publishers, Inc., 333 Seventh Avenue, New York, NY 10001, USA.

Via e-mail: customerservice@thieme.com

Via website: www.thieme-chemistry.com

Phone: +1 212 760 0888; Fax: +1 212 947 1112

Order toll-free within the USA: +1 800 782 3488

Europe, Africa, Asia, and Australia: Thieme Publishers Stuttgart, Georg Thieme Verlag KG, Rüdigerstraße 14, 70469 Stuttgart, Germany.

Via e-mail: customerservice@thieme.de

Via website: www.thieme-chemistry.com

Phone: +49 711 8931 421; Fax: +49 711 8931 410

Current list prices are available through www.thieme-chemistry.com.

Online Access

The online versions of Synform as well Synthesis, Synlett, Synfacts and SynOpen are available through www.thiemeconnect.com/products/ejournals/journals where it is also possible to register for a free trial account. For information on multi-site licenses and pricing for corporate customers as well as backfiles, please contact our regional offices:

The Americas: esales@thieme.com, phone: +1 212 584 4695

Europe, Africa, Asia, and Australia: eproducts@thieme.de, phone: +49 711 8931 407

India: eproducts@thieme.in, phone +91 120 45 56 600

Japan: brhosoya@poplar.ocn.ne.jp, phone +81 3 3358 0692

Manuscript Submission to Synthesis, Synlett, and SynOpen

Manuscript submissions will be processed exclusively online via <http://mc.manuscriptcentral.com/synthesis>, <http://mc.manuscriptcentral.com/synlett> and <http://mc.manuscriptcentral.com/synopen>, respectively. Please consult the Instructions for Authors before compiling a new manuscript. The current version and the Word template for manuscript preparation are available for download at www.thieme-chemistry.com.

Copyright

This publication, including all individual contributions and illustrations published therein, is legally protected by copyright for the duration of the copyright period. Any use, exploitation or commercialization outside the narrow limits set by copyright legislation, without the publisher's consent, is illegal and liable to criminal prosecution. This applies to translating, copying and reproduction in printed or electronic media forms (databases, online network systems, Internet, broadcasting, telecasting, CD-ROM, hard disk storage, microcopy edition, photomechanical and other reproduction methods) as well as making the material accessible to users of such media (e.g., as online or offline backfiles).

Copyright Permission for Users in the USA

Authorization to photocopy items for internal or personal use, or the internal or personal use of specific clients, is granted by Georg Thieme Verlag KG Stuttgart · New York for libraries and other users registered with the Copyright Clearance Center (CCC) Transactional Reporting Service, provided that the base fee of US\$ 25.00 per copy of each article is paid directly to CCC, 22 Rosewood Drive, Danvers, MA 01923, USA, 0341-0501/02.