

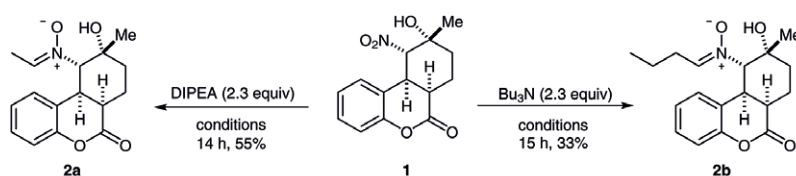
# Synform

People, Trends and Views in Chemical Synthesis

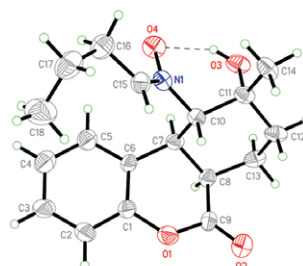
2015/09

## A New Approach to Nitrones through Cascade Reaction of Nitro Compounds Enabled by Visible Light Photoredox Catalysis

Highlighted article by C.-W. Lin, B.-C. Hong, W.-C. Chang, G.-H. Lee



conditions = Ru(bpy)<sub>3</sub>Cl<sub>2</sub>·6H<sub>2</sub>O (2.5 mol%), Hantzsch ester (1.2 equiv), MeCN (0.1 M), 24 W CFL, 35 °C



X-ray crystal structure of **2b**

### Contact

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## Dear Readers,

This is an unusually brief editorial – and I apologize for that – but annual leave, backlog and family commitments are hoovering up most of my time, so I will go straight to the heart of our new SYNFORM issue, whose quality has definitely not been affected by the holiday period. The first article is from the group of L. Gooßen (Germany) with his new highly effective method for incorporating the  $SCF_3$  function into organic molecules. The second contribution comes from S. Canesi (Canada) whose group has developed a new approach to the synthesis of the alkaloid strychnine mediated by hypervalent iodine reagents. The third article is a Young Career Focus with M. von Delius (Germany) who answers the usual set of questions about his views on organic chemistry, his career so far and professional ambitions. The issue is closed by the new photoredox approach to nitrones from nitro compounds developed by B.-C. Hong (Taiwan).

Enjoy your reading!



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

# Metal-Free Trifluoromethylthiolation of Alkyl Electrophiles via a Cascade of Thiocyanation and Nucleophilic Cyanide- $\text{CF}_3$ Substitution

*Synlett* 2015, 26, 1628–1632

Fluorine atoms can have profound effects on bioactive molecules. Trifluoromethylthio groups can impart many desirable properties, such as higher metabolic stability and increased lipophilicity. Professor Lukas Gooßen at the Kaiserslautern University of Technology (Germany) has been fascinated by these effects since his time at Bayer central research. He commented: “At Bayer, a dedicated team of experts including my later wife provided customized fluorinated building blocks to other synthetic chemists to give them a head start against competitors. The methods they routinely employed required special equipment and substantial experience. In recent years,” he continued, “the chemical community has become aware of the importance of fluorinated compounds, and the development of convenient trifluoromethylation reactions that can be employed by synthetic organic chemists without special training is currently one of the most topical fields in method development.”

Professor Gooßen said: “Our paradigm has always been to base new methods on simple, inexpensive and sustainable raw materials. We are less interested in methods whose use will remain restricted to drug discovery where the cost of reagents does not matter, preferring to provide scalable protocols for use throughout academia and industry. Thus, we deliberately steered away from high-tech catalysts and elaborate reagents and, instead, based our early fluoroalkylation methods on basic Sandmeyer chemistry.”

In recent years, the focus of medicinal and agrochemistry has expanded to include fluoroalkylthio groups whose properties often surpass those of the corresponding fluoroalkyl moieties. “Contemporary reports in top journals underline that the introduction of trifluoromethylthio groups is viewed as an unsolved problem that justifies the use of even the most elaborate reagents,” said Professor Gooßen, adding: “This attracted our interest, and we set out to search for a straightforward synthetic approach for the introduction of fluoroalkylthio groups into functionalized molecules.”

When analyzing existing synthetic approaches, Professor Gooßen and co-workers came to the conclusion that their complexity and cost arises from the underlying strategy that consists of transferring the  $\text{SCF}_3$  group as a whole from a preformed reagent. “However, Langlois et al. had demonstrated already in 1997 that  $\text{SCF}_3$  groups can be generated from thio-

cyanates via nucleophilic displacement of CN by  $\text{CF}_3$ . We immediately realized that this somewhat underappreciated concept might open up straightforward synthetic entries to fluoroalkylthiolated molecules that would not require preformed  $\text{SCF}_3$  reagents but could be based on the comparably inexpensive Ruppert–Prakash reagent,” remarked Professor Gooßen.

He continued: “Our reasoning was that if it was possible to introduce thiocyanate groups in the presence of nucleophilic fluoroalkylating reagents, the resulting organothiocyanates could be directly converted into the desired fluoroalkylthio groups.” According to Professor Gooßen, the key challenge of this approach was to direct the reactivity of the fluoroalkylating reagent exclusively towards the thiocyanate moiety and avoid side reactions between the reagents present in the mixture. With a small team composed of the PhD students Bilguun Bayarmagnai, Matthias Grünberg and Christian Matheis and the postdoctoral researchers Dr. Grégory Danoun and Dr. Kévin Jouvin, they set out to probe the viability of this approach. After many setbacks, the Kaiserslautern based research team finally managed to combine Sandmeyer thiocyanations with Langlois-type trifluoromethylations and novel difluoromethylations and, thus, developed efficient synthetic entries to aryl fluoroalkyl thioethers from readily available arene-diazonium salts and inexpensive TMS-fluoroalkanes (*Angew. Chem. Int. Ed.* 2015, 54, 5753, *Chem. Sci.* 2014, 5, 1312).

Professor Gooßen said: “In parallel to this work, we probed whether the synthesis of alkyl thiocyanates via nucleophilic substitution of alkyl halides with NaSCN could also be combined with a trifluoromethylation with  $\text{TMSCF}_3$ . Christian systematically varied the reaction conditions of the thiocyanation and the Langlois trifluoromethylation to identify conditions under which both steps would work well and all reagents would remain stable. For many weeks, he was frustrated by the incompatibility of the two steps, which resulted in unsatisfactory yields. After intricate development efforts, he discovered that with acetonitrile as the solvent and  $\text{Cs}_2\text{CO}_3$  as the base, both steps proceeded in high yields when performed individually. Further optimization was required until they could be combined to a one-pot process in which all reagents are added directly at the beginning of the reaction.”

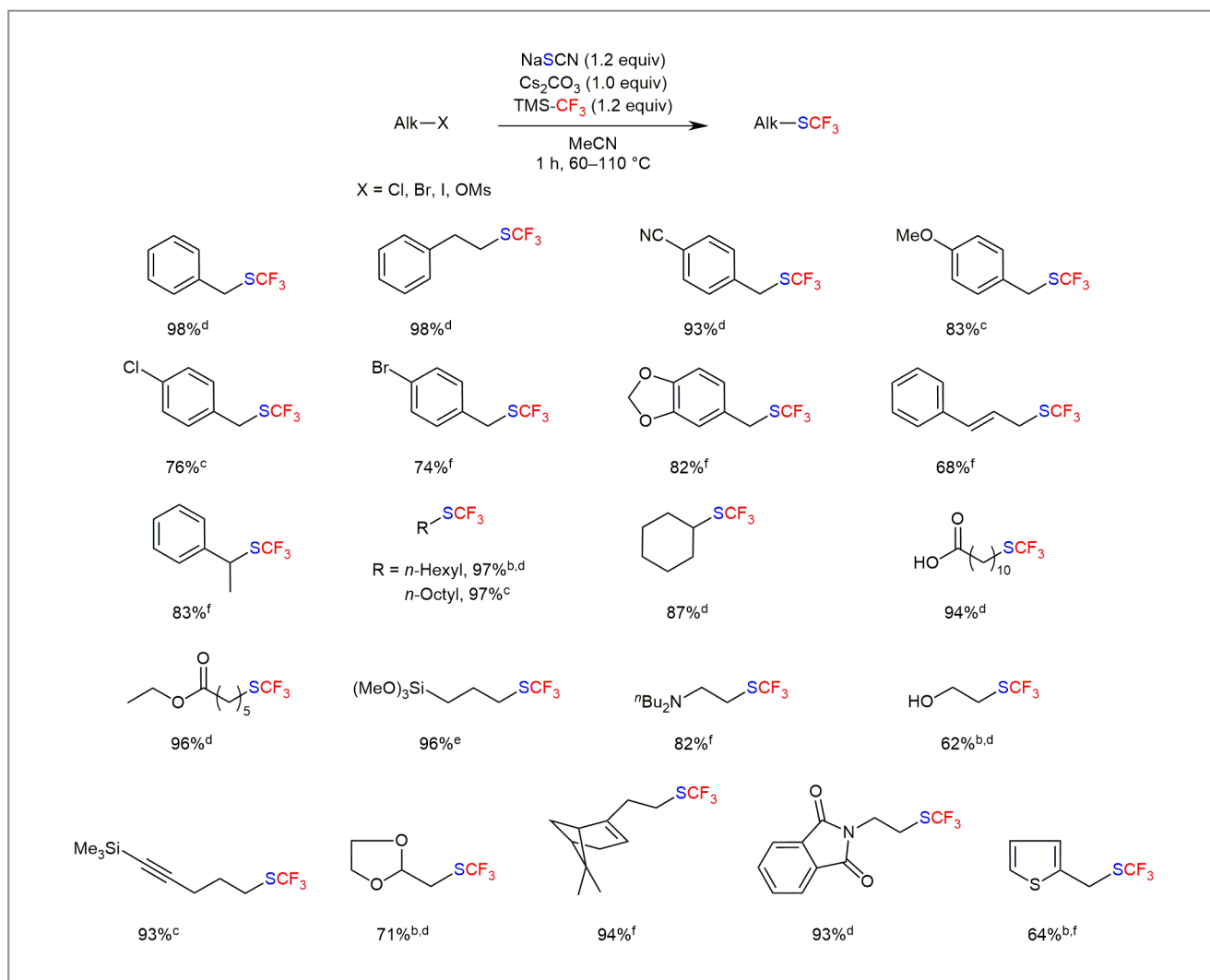
The final protocol is easy to use and widely applicable. It allows access to alkyl trifluoromethyl thioethers from widely

available alkyl halides or mesylates simply by stirring them with sodium thiocyanate, TMS-CF<sub>3</sub> and Cs<sub>2</sub>CO<sub>3</sub> in acetonitrile at 60–110 °C without the need for transition-metal catalysts.

Professor Gooßen revealed that having finally identified an efficient protocol, Christian teamed up with Dr. Minyan Wang and Thilo Krause to investigate its scope. The chromatographic separation of the volatile products from remaining alkyl halide starting materials turned out to be quite tricky. However, they soon found out that the best strategy to overcome their separation problems was to ensure near-quantitative conversions by carefully monitoring the reaction progress. Within a few long working days, they synthesized, isolated

and characterized 22 alkyl trifluoromethyl thioethers bearing various functionalities (Scheme 1).

“The above examples underline that the metal-free cascade of nucleophilic thiocyanation and nucleophilic CN-CF<sub>3</sub> substitution is a powerful tool for the synthesis of alkyl trifluoromethyl thioethers from broadly available alkyl electrophiles. Its key advantages are its simple operation, broad applicability, and tolerance of various functional groups, despite using one of the cheapest sources of trifluoromethyl groups available,” said Professor Gooßen. He concluded: “We are pleased that our recent fluoroalkylations and fluoroalkylthiations have been so well received by the chemical com-



**Scheme 1** Trifluoromethylthiation of alkyl halides and mesylates.<sup>a</sup>

<sup>a</sup> Isolated yields. <sup>b</sup> Yields were determined by <sup>19</sup>F NMR using trifluoroethanol as an internal standard. <sup>c</sup> Starting from alkyl chloride.

<sup>d</sup> Starting from alkyl bromide. <sup>e</sup> Starting from alkyl iodide. <sup>f</sup> Starting from alkyl mesylate.

munity, and our ‘fluorine guys’ cannot wait to apply the experience gained during this work to address some of the many remaining challenges in fluorine chemistry.”

*Mattheis Fenske*

## About the authors



From left: Dr. M. Wang, T. Krause, Prof. Dr. L. Gooßen with his youngest group member Matilda, C. Matheis

**Christian Matheis** studied Chemistry in Kaiserslautern (Germany) where he received his diploma in 2013 working on new strategies for the formation of C–O bonds. His results were published in *Angewandte Chemie* as a ‘hot paper’ and his thesis was awarded within the Springer BestMasters program. After an industrial internship at BASF (Germany) in the lead optimization of agricultural products, he started his Ph.D. work under the supervision of Prof. Gooßen on the development of straightforward methods for the synthesis of fluorinated compounds. Within his first year, he was able to make great contributions to this research area and published several methods for the introduction of fluoroalkyl(thiol)ated groups.

**Minyan Wang** studied Chemistry at Huazhong University of Science and Technology (P. R. of China). After having received her Bachelor’s degree in 2009, she continued her Ph.D. at Zhejiang University (P. R. of China) under the supervision of Professor Shengming Ma, where she worked on the highly selective electrophilic and nucleophilic addition of functionalized allenes. Both her Bachelor and Ph.D. degrees were graded as

excellent. After completing her thesis in 2014, she moved to the TU Kaiserslautern (Germany) for a postdoctoral stay with Professor Gooßen, where she is presently working on the fluorination of organic compounds.

**Thilo Krause** studied Chemistry at the TU Kaiserslautern (Germany) where he received his diploma in 2013. He is pursuing Ph.D. research under the supervision of Professor Gooßen on the sustainable synthesis of amides from carboxylic acids and amines via in situ generated active esters. In order to gain insights into chemistry in industry, he interrupted his Ph.D. work in April 2014 for a three-month internship in the department of Global Research Agricultural Products at BASF, Ludwigshafen (Germany).

**Lukas Gooßen** studied chemistry at the Universities of Bielefeld (Germany) and Michigan (USA) and carried out graduate studies at UC Berkeley (USA) with Professor K. Peter C. Vollhardt. He was awarded a Ph.D. in 1997 for his research on N-heterocyclic carbene complexes supervised by Professor Wolfgang A. Herrmann, TU Munich (Germany), and pursued postdoctoral research with Professor K. Barry Sharpless, Scripps Research Institute (USA). He began his professional career as an industrial chemist at Bayer AG (Germany) in 1999, but moved back to academia to the group of Professor Manfred T. Reetz, MPI for Coal Research for his habilitation, and further to RWTH Aachen (Germany). He has been a professor at the TU Kaiserslautern (Germany) since 2005. His research is devoted to the development of novel concepts for C–C and C–heteroatom bond formation. He has authored over 120 publications and 25 patents. Recent awards include the Jochen Block Award of the DECHEMA, the Carl Duisberg Award of the GDCh, the Novartis Young Investigator Award, and the AstraZeneca Award in Organic Chemistry (2008).

# Isostrychnine Synthesis Mediated by Hypervalent Iodine Reagent

*Chem. Eur. J.* **2015**, *21*, 7713–7715

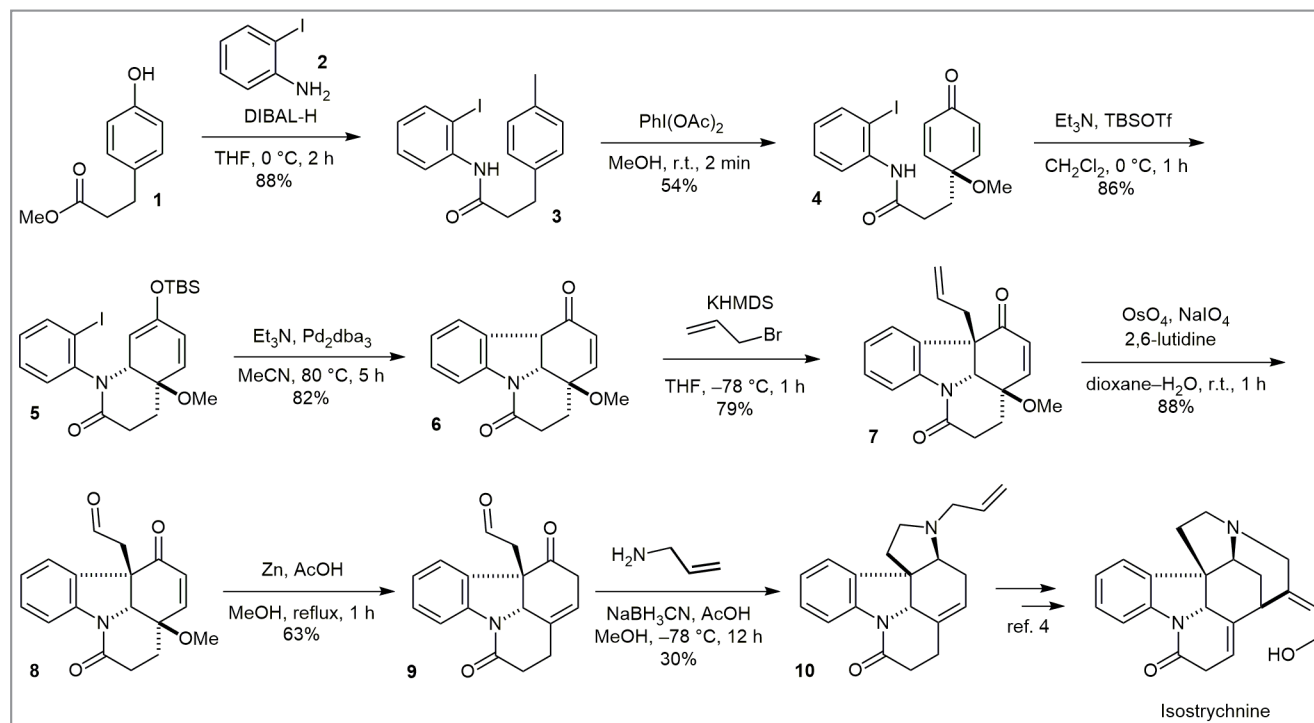
Strychnine is one of the best known compounds in the world, not only by the scientific community but also by the general population, probably due to its remarkable heptacyclic structure and its poisonous effect. Strychnine was isolated in 1818 by Pelletier and Caventou from *Strychnos ignatii* Bergius<sup>1</sup> and its structure was elucidated by Woodward and Brehm in 1948. At this time, *for its molecular size*, strychnine was considered as *the most complex substance known*, as mentioned by Robinson. The first total synthesis of strychnine, reported by Woodward and co-workers in 1954,<sup>2</sup> is considered to be the first complex total synthesis achieved in organic chemistry. A new era in total synthesis had started, in which strychnine has played an important role. Indeed, during the past decades, it has been revealed to be a wonderful source of inspiration for chemists, as illustrated by Overman,<sup>3</sup> and has led to numerous advances in organic chemistry.

When the group of Professor Sylvain Canesi at the Université du Québec à Montréal (Canada) started their project, there were already around twenty syntheses of strychnine

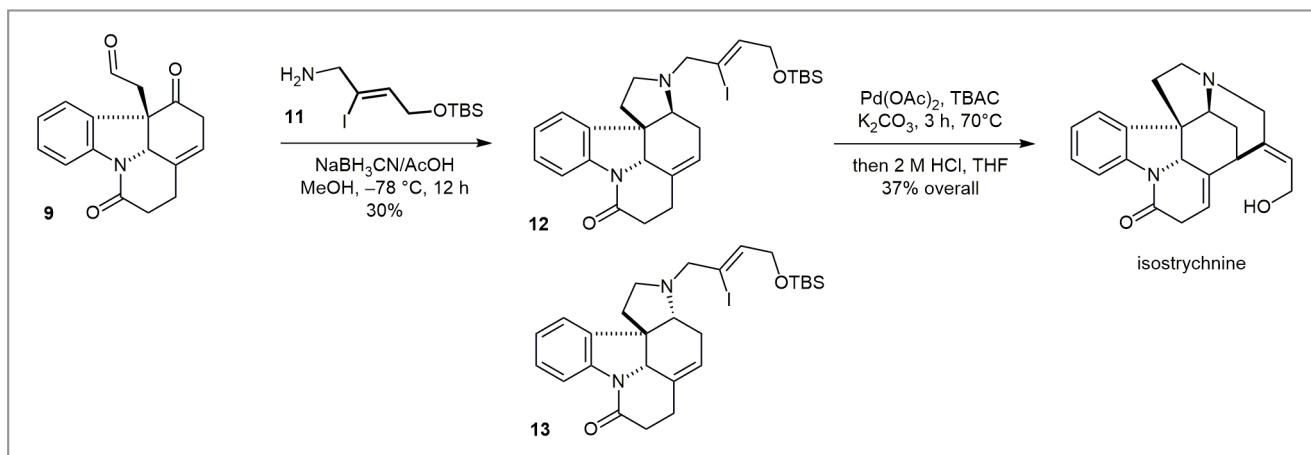
reported in the literature. Professor Canesi said: “However, our interest in developing new and rapid strategies involving hypervalent iodine reagents for the synthesis of complex natural products led us to rise to the challenge. We thus decided to focus on the synthesis of isostrychnine, the natural opened isomer of strychnine. Moreover, in order for it to stand out from the other syntheses, we envisaged basing our strategy on a dearomatization of a phenol mediated by a hypervalent iodine reagent.”

He continued: “We first focused on the racemic synthesis of the tetracyclic core of the molecule. We were pleased to note that our strategy was efficient since we faced no real issues yet. We managed to produce aldehyde **9** in only a few weeks, and after optimization, less than two weeks were necessary to prepare a substantial amount of **10**, a known precursor of strychnine that was described in the synthesis of Bodwell and Li (Scheme 1).<sup>4</sup>”

Professor Canesi and co-workers were interested in using a double amination strategy to produce a more advanced pre-



**Scheme 1**

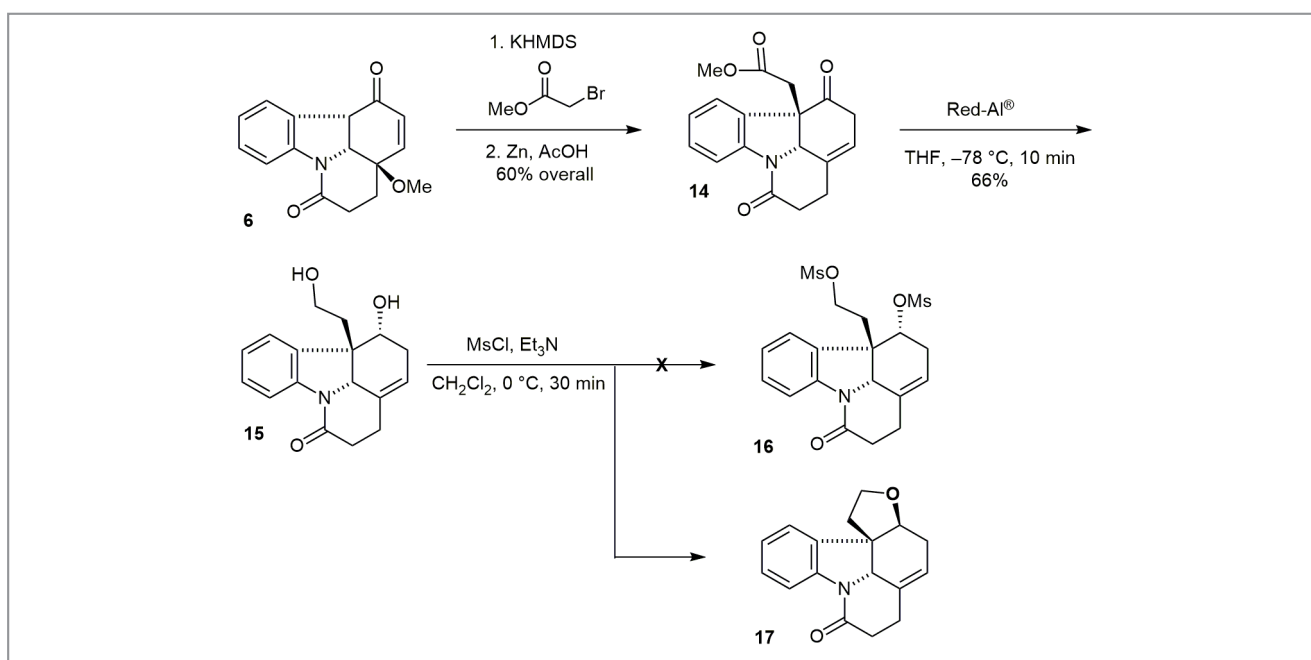


Scheme 2

cursor with an elaborated amine. “However, when we moved to the formation of the new cycloamine **12**, at this point we were very surprised to note that the double reductive amination strategy delivered a considerable amount of the *trans*-diastereoisomer **13**, probably due to the new steric hindrance of our substituted allylamine,” explained Professor Canesi (Scheme 2). He continued: “We thus tried to modify the conditions to improve this selectivity. We first tried to decrease or increase the temperature of the reaction, without any success.

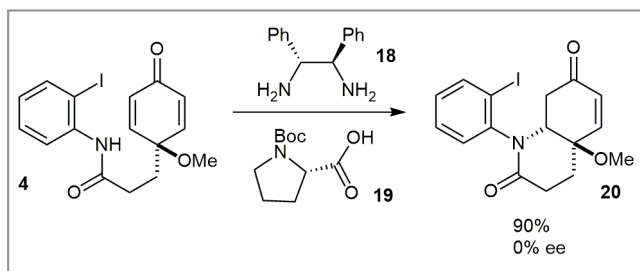
We also tried to perform the reaction in other solvents. We finally tried to use other sources of acids or hydrides, again without real improvement.”

In order to investigate an alternative approach, the group envisaged forming the cycloamine by a double nucleophilic substitution and thus synthesized the diols **15** by alkylation of compound **6** with methyl bromoacetate, followed by a reduction with zinc in acetic acid to produce compound **14**, which was further transformed into diol **15**. Diol **15** was then



Scheme 3





Scheme 4

activated by treatment with MsCl in the presence of Et<sub>3</sub>N. “However, we noticed that only the cycloether **17** was formed,” said Professor Canesi. This result implied that the β-hydroxy compound **15** was obtained instead of the α-hydroxy during the reduction process. Professor Canesi continued: “In order to avoid the presence of oxygen atoms, we tried to convert them into bromine atoms using Appel conditions, but it resulted again in the formation of the cycloether **17** (Scheme 3). We also tried to invert the stereoselectivity of the reduction by using other hydrides, without any success.”

Professor Canesi explained: “Therefore, we considered that even if the formation of compound **12** was accompanied by an important ratio of its undesired diastereoisomer, the rapid elaboration of the polysubstituted main core **9** was a good compromise to conclude a rapid synthesis in only nine steps.” He concluded: “We have also tried to develop an asymmetric pathway from prochiral dienone **4** (Scheme 4). Indeed, if we were able to control the selectivity during the 1,4-addition, the synthesis would become asymmetric. We tried several processes<sup>5</sup> including a treatment with diamine<sup>6</sup> **18** but unfortunately no selectivity was observed for the formation of **20**.”

*Mattias Farnok*

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## About the authors



Dr. G. Jacquemot

**Guillaume Jacquemot** was born in 1986 in Münsingen (Germany). He obtained an engineering diploma in chemistry at ECPM in Strasbourg (France) along with a Master's degree at the University of Strasbourg (France) in 2010. He joined the group of Professor Sylvain Canesi at the Université du Québec à Montréal (Canada) in 2011 and worked on the development of new oxidative methodologies using hypervalent iodine reagents and their application in total synthesis. He obtained his Ph.D. in 2014 and is currently working as a research scientist at Intellisyn R&D (Montreal, Canada).



G. Maertens

**Gaëtan Maertens** (Rouen, France, 1989) obtained an M.Sc. in organic chemistry and an advanced degree in chemistry from the Institut National des Sciences Appliquées de Rouen (France) in 2012. He is currently a Ph.D. candidate under the supervision of Professor Sylvain Canesi at the Université du Québec à Montréal (Canada). His research interests center on the asymmetric total synthesis of natural diterpenes and alkaloids.



Prof. S. Canesi

**Sylvain Canesi** (Ajaccio, Corsica, France, 1977) obtained an advanced degree in chemistry from the Ecole Supérieure de Chimie, Physique et Electronique de Lyon (France), and went on to become a graduate student in the group of Professor Marco A. Ciufolini, obtaining his Ph.D. in 2004. After postdoctoral studies in the group of Professor Pierre Deslongchamps at the University of Sherbrooke (Canada), he accepted a faculty position at the Université du Québec à Montréal (Canada). He is interested in the development of new methodologies and their application to the total synthesis of natural products.



## Young Career Focus: Dr. Max von Delius (Friedrich-Alexander University Erlangen-Nuremberg, FAU, Germany)

**Background and Purpose.** From time to time SYNFORM 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. Max von Delius (FAU Erlangen-Nuremberg, Germany).

### Biographical Sketch



Dr. M. von Delius

**Max von Delius** was born and raised in Nuremberg (Germany). He studied chemistry at FAU in Erlangen (Germany) and at Université Louis Pasteur in Strasbourg (France). In 2007, he moved to Edinburgh (Scotland, UK) where he worked towards his PhD in the lab of Professor David A. Leigh. His doctoral work focused on artificial molecular machines with a special emphasis on 'walking molecules'.

From 2011 to 2012 he was a Leopoldina postdoctoral fellow in the group of Professor Vy M. Dong at the University of Toronto (Canada). During his postdoc, he worked on several projects in the area of homogeneous catalysis, including Ni-catalyzed CO<sub>2</sub> fixation and Rh-catalyzed hydroacylation of olefins. Since 2013, he has been a junior research group leader at FAU Erlangen-Nuremberg. His group is interested in the behavior of complex chemical systems based on interacting organic molecules (systems chemistry), as well as in the synthesis of functional materials, for example, for organic solar cells. He has received numerous awards and fellowships, including most recently a generous funding package provided by the Emmy-Noether Program of the DFG.

### INTERVIEW

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

**Dr. M. von Delius** The research in my group can be summarized under the heading 'organic systems and materials'. The first part of this group motto relates to a trend that has been picking up speed rapidly over the past five years: (organic) chemistry is no longer limited to the synthesis of pure molecules and their uses. Thanks to advanced analytical tools such as HPLC-MS, more and more groups are becoming interested in complex dynamic mixtures and the unexpected behavior that can often be observed in such systems. While this area of research, often called 'systems chemistry', is mainly curiosity-driven, the second area of research, functional materials, usually comes with a specific application in mind. For example, we are currently engaged in a fruitful collaboration on new materials for organic solar cells, but we are also actively pursuing promising avenues in other areas.

**SYNFORM** *When did you get interested in synthesis?*

**Dr. M. von Delius** My interest in organic synthesis really took off in the fourth year of my undergraduate studies, while I was doing research in the lab of Nobel laureate Jean-Marie Lehn in Strasbourg. During those five months, I was allowed to work independently on a rather complex ligand synthesis and I realized how profoundly satisfying it can be to synthesize and characterize compounds that no one else has made (or ever smelled!) before. Even better, once the synthesis was accomplished, I could set out to use these compounds to achieve certain (supramolecular) functions.

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

**Dr. M. von Delius** During my postdoc with Vy Dong, working on frontier research in catalysis, I realized what an abundance of synthetic problems is still out there waiting to be solved. For people like me who have a background in supramolecular chemistry or organic materials, it can sometimes seem as if organic synthesis is essentially a solved problem. But this is far from true for anything that goes beyond 'clicking' building blocks A and B together. I have the impression that vast areas of chemical space are still completely unexplored and that there is still a lot of 'gold' to be found for groups that are willing to engage in ambitious research programs. At the same time, I believe that while we should, wherever possible, look out for potential applications for our methods and materials, we should never narrow our focus too much on applied science. The great risk of such a narrow focus is that sooner or later the very start of the chemical research pipeline would run dry and the consequences of this would be felt by everyone further down the value chain.

**SYNFORM** Your research group is active in the areas of organic synthesis and materials science. Could you tell us more about your research and its aims?

**Dr. M. von Delius** We have already contributed a new chemical tool (orthoester exchange) to the area of systems chemistry, which we are currently applying toward generating various types of interesting dynamic systems. Some major challenges in this area include the design of dissipative systems that consume fuel and operate far from equilibrium and the development of systems and materials in which the sum of the mixture has properties superior to those of the individual components (e.g. in molecular sensing). In the area of functional materials, we were able to prepare solar cells that, thanks to our new azafullerene DPC<sub>59</sub>N, could beat the benchmark fullerene PCBM in certain performance parameters. One of our current goals is to prepare second-generation

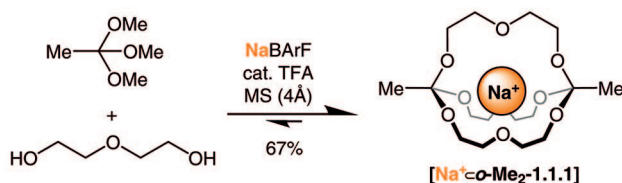
compounds, which we expect will allow further performance enhancements.

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

**Dr. M. von Delius** Just a few weeks ago, we published a paper in Nature Communications [DOI: 10.1038/ncomms8129], in which we describe the first one-pot synthesis of a monometallic cryptate (a small organic cage compound that accommodates a metal ion; see Figure). This finding is very exciting to us, because for the first time in 50 years of research on these smallest cage compounds, it is now possible to make them under thermodynamic control, which also opens up the possibility of subcomponent self-sorting, i.e. allowing metals to select their preferred host. The compounds we have prepared during this project are also the first cryptates that have a 'self-destruct button', which could be a useful property for applications in drug delivery.

*Matthias Janda*

a) Self-assembly of an orthoester cryptate



b) Sculpture based on X-ray data



## A New Approach to Nitrones through Cascade Reaction of Nitro Compounds Enabled by Visible-Light Photoredox Catalysis

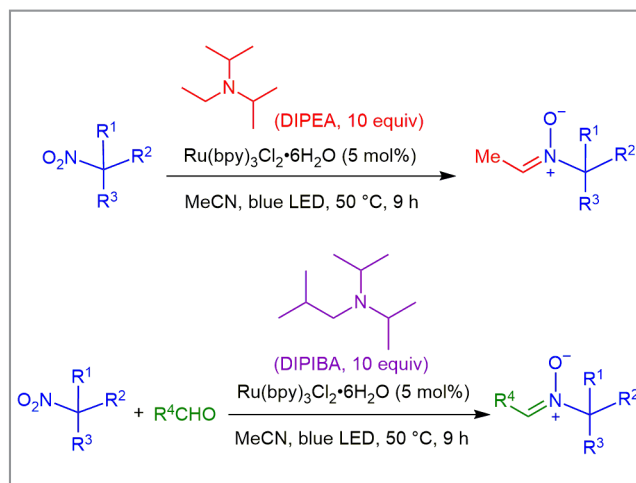
*Org. Lett.* **2015**, *17*, 2314–2317

Visible-light-induced photoredox catalysis has received considerable attention lately and has been used as a key strategy in organic synthesis. Nevertheless, visible light photoredox catalytic reactions of nitroalkanes are particularly scarce, and most examples have been conducted on nitroaromatic compounds. Recently, a new synthesis of oximes through photoredox catalysis of nitro compounds (mainly primary nitroalkanes) by the synergistic actions of visible-light irradiation and Lewis acid promoted dehydration was reported (*Org. Lett.* **2013**, *15*, 2660).

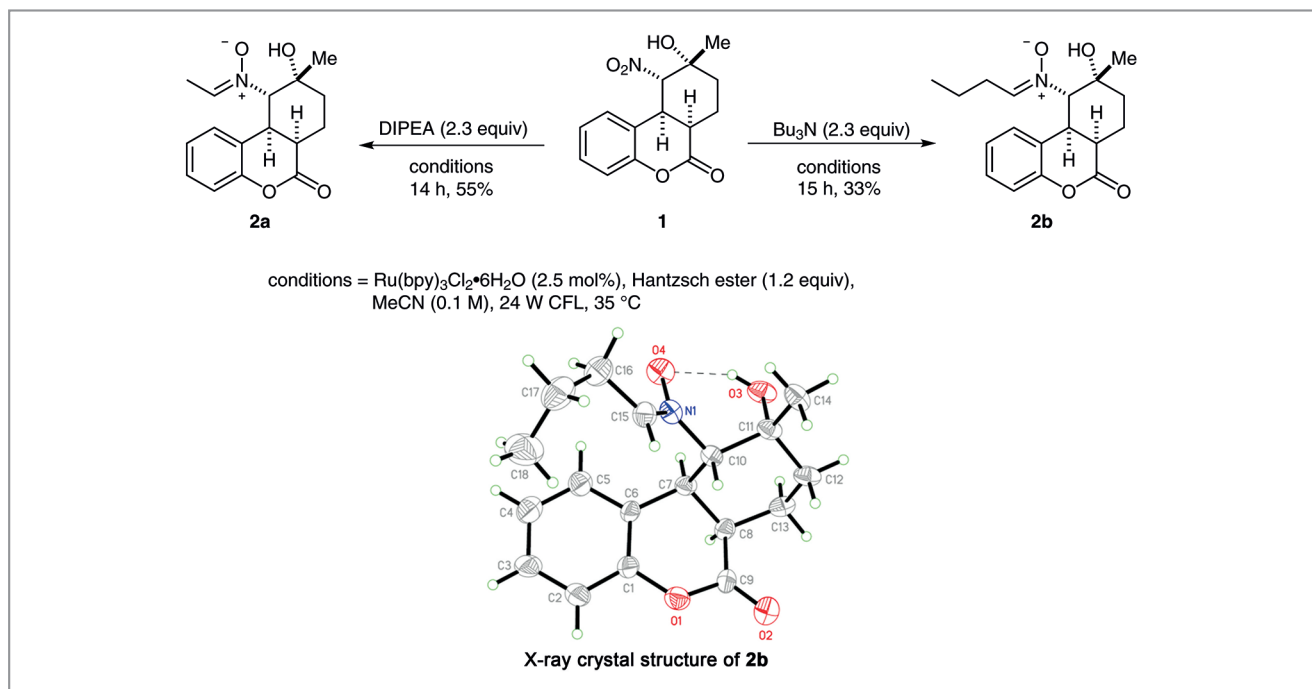
The group of Professor Bor-Cherng Hong at the National Chung Cheng University (Taiwan) has now developed a concise visible-light-induced photocatalytic conversion of nitro compounds carrying various functionalities into nitrone derivatives in high yield. According to the authors, this paper represents the first example of visible-light-induced photocatalytic conversion of nitroalkanes into nitrones. “This one-pot method not only represents a mild and concise process which adds to the repertoire of nitrone formation methodologies but also demonstrates a proof of concept of the synergistic action of photoredox catalytic cycles and condensation processes,” said Professor Hong. “The cross-condensation method had not been possible previously by assistance of Hünig’s base (DIPEA, *N,N*-diisopropylethylamine), but in this case, we achieved this transformation with the addition of DIPIBA (*N,N*-diisopropylisobutylamine) as the sacrificial electron donor. The use of a Hünig’s base surrogate provides a new pathway for photoredox catalysis which was previously not accessible. The structures of the products were unambiguously confirmed by single-crystal X-ray crystallographic analyses.”

Nitroalkanes, which are known as synthetic chameleons, are able to undergo transformation to a variety of functionalities and have received much attention in organic chemistry. Professor Hong said: “The visible-light-induced photocatalysis of nitroalkanes we described provides a mild and direct protocol for the synthesis of nitrones. Given the importance of the nitrone functionality in synthetic and medicinal chemistry, this mild and efficient reaction method could constitute a useful protocol with broad applications in chemical synthesis.”

The discovery of this novel reaction occurred serendipitously, revealed Professor Hong. In fact, during the course of a study combining organocatalysis with photoredox catalysis,



Ms. Chang observed that a visible-light-induced photoredox-catalyzed reaction of nitroalkane **1** afforded an unexpected product (**2a**) bearing a CHCH<sub>3</sub> substituent. Professor Hong remarked: “However, with only the NMR spectra in hand, the exact structure of the product and the mechanism remained elusive. At least two questions arose from this noteworthy observation: (1) where does the CHCH<sub>3</sub> group come from? and: (2) how did the transformation occur and how can it be controlled for a better yield?” To answer the first question, the same reaction was conducted with the replacement of DIPEA by Bu<sub>3</sub>N, followed by a 15-hour irradiation to give the corresponding photoadduct carrying a CH(CH<sub>2</sub>)<sub>2</sub>CH<sub>3</sub> group, although in lower yield (33%) and with recovery of a certain amount of starting compound **1**. “These results implied that the alkyl fragment on the photoadduct came from the alkylamine additive,” explained Professor Hong, continuing: “Nevertheless, the exact structure of the photoadduct remained unknown. For a period of time, we thought it might be an alkylimine, especially because the original mass spectra gave the daughter ion M-16 as the false molecular ion peak. However, we remained skeptical about this structural assignment since imines should not have such a high polarity as the photoadduct we obtained. In addition, in contrast with the instability of imines, the photoadducts we obtained were quite stable. Later, we found out that these compounds were not oximes either.”



In short, the bona fide structure of the photoadducts remained unknown at that time, and many structure-elucidation efforts, including re-crystallization in order to produce a single crystal for X-ray analysis, were in vain. The two unexpected products were eventually left in the refrigerator for a long time. Professor Hong said: “In the meantime, Mr. Lin expanded the exploration of this chemistry and undertook extensive experimental endeavors in order to optimize the reaction conditions and explore the reaction scope as well as provide more analogues for structure elucidation.” A few months after Ms. Chang’s graduation in 2013, Professor Hong took the photoadducts which Ms. Chang prepared and managed to carry out the crystallization process successfully. Professor Hong concluded: “Fortunately, the single crystals of compound **2b**, prepared from the Bu<sub>3</sub>N additive, were obtained; the structure of photoadduct **2b** could therefore be unambiguously assigned by X-ray crystal structure analysis. The project was then advanced by refocusing on the photocatalysis of nitroalkanes to nitrones. This clearly demonstrates once again that research progress benefits from the power and synergy of team work.”

With regard to future prospects and developments, the one-pot and cascade asymmetric organocatalysis/photocatalysis/dipolar cycloaddition, as well as the exploration of its application in natural products synthesis, are currently under active investigation.

*Mattias Farnik*

## About the authors



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**Cheng-Wei Lin** was born in Changhua (Taiwan) in 1982. He received his BSc in chemistry from National Tsing Hua University (Taiwan) in 2004 and his MSc in organic chemistry from National Changhua University of Education (Taiwan) in 2009. He is currently a PhD student in the Department of Chemistry and Biochemistry, NCCU, under the guidance of Professor Hong. His research interests are the development of new methodologies for catalysis and their application to natural product synthesis.



Prof. B.-C. Hong

**Bor-Cherng Hong** was born in Changhua (Taiwan) in 1962. He graduated with a BSc from Tunghai University (Taiwan) in 1984 and received his MSc from National Taiwan University in 1986 (working with Professor Jim-Min Fang). After the two-year mandatory military service, he went to The University of Chicago (USA) for graduate studies where he obtained his PhD degree under the guidance of Professor J. D. Winkler in 1992.

Immediately after graduating, he joined the group of Professor E. J. Corey as a postdoctoral fellow at Harvard University (USA) from January 1993 to July 1994. He was appointed as an Associate Professor at National Chung Cheng University in August

1994, established his research group, and was promoted to Full Professor in 1999. His current research interests are focused on the development of novel annulation methodologies, especially with organocatalysts or photocatalysts, and natural products synthesis.



W.-C. Chang

**Wan-Chen Chang** was born in Taipei (Taiwan) in 1988. After receiving her BSc in chemistry from Chung Yuan Christian University (Taiwan) in 2011, she joined Professor Hong's research group as a graduate student at NCCU and received her MSc in 2013. Currently, she is a research scientist in a pharmaceutical company.



Dr. G.-H. Lee

**Gene-Hsiang Lee** graduated with a BSc in chemistry from Chinese Culture University (Taiwan) and received his MSc from the same university in applied chemistry and his PhD in organic and polymeric materials from National Taipei University of Technology (Taiwan). He is currently a senior crystallographic specialist in the X-ray Diffraction Laboratory at Instrumentation Center, National Taiwan University.



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