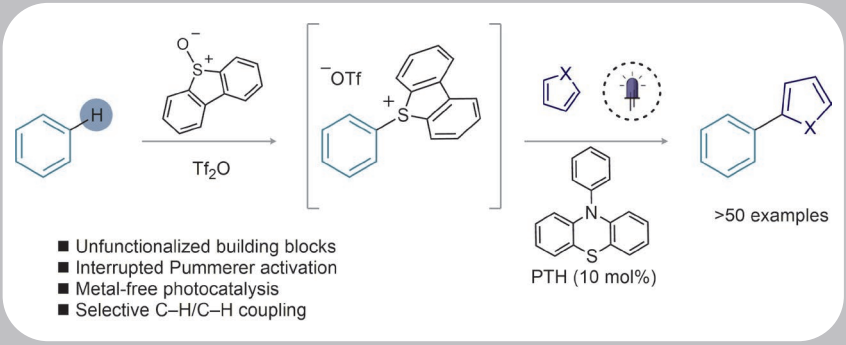
Synform

People, Trends and Views in Chemical Synthesis

2020/07

Metal-Free Photoredox-Catalysed Formal C–H/C–H Coupling of Arenes Enabled by Interrupted Pummerer Activation

Highlighted article by M. H. Aukland, M. Šiaučiulis, A. West, G. J. P. Perry, D. J. Procter



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Thieme

Dear Readers,

This is going to be a very different summer: hardly any meaningful travel will be possible, quarantine periods are lurking in several countries, face masks will be mandatory indoor or even outdoor, getting too close to other people is not recommended. But hey, things are getting better at last! We will be able to meet friends and relatives, dine al fresco, go to the beach, get tanned, buy a gelato, perhaps even a pint of beer, and – most importantly – we can finally see some light at the end of this corona-tunnel. For scientists like us, there is the added bonus that labs are cautiously re-opening, although terms like "staggering", "alternate working" and "social distancing" will be the norm for quite some time, and sadly the pace of our research will inevitably be slower than it used to be. However, a few months ago we would not even have dared to dream about resuming our research, so I am determined to see the glass half full on this occasion. One thing that fortunately has not suffered any interruption during the last few extraordinary and difficult months is SYNFORM, which keeps marching on with its usual cargo of excellent research authored by top scientists. This issue is no different: the start could not be better, as Prof. André B. Charette (Université de Montréal, Canada) is interviewed about his article that won the *SYNTHESIS Best Paper Award 2019*. In the second article we make the acquaintance of the new Editorial Board Member of *Organic Materials*, Prof. Pol Besenius, from Johannes Gutenberg University Mainz (Germany). What comes next is a literature coverage article on the recent ground-breaking catalytic C(sp^3)–H activation of tertiary alkylamines developed by M. Gaunt (UK). Then, we get the opportunity to learn more about the interrupted Pummerer reaction used by D. Procter (UK) for the photoredox catalytic C–H cross-coupling of arenes and heteroarenes. The issue closes with a celebration of 20 years of Science of Synthesis.

Enjoy your reading!!

In this issue

SYNTHESIS Highlight
SYNTHESIS Best Paper Award 2019: Enantioselective Synthesis of *cis*- and *trans*-Borocyclopropylmethanol: Simple Building Blocks To Access Heterocycle-Substituted Cyclopropylmethanols A94

Editorial Board Focus
Editorial Board Focus: Professor Pol Besenius (Johannes Gutenberg University Mainz, Germany) A97

Literature Coverage
Catalytic C(sp^3)–H Bond Activation in Tertiary Alkylamines A99

Literature Coverage
Metal-Free Photoredox-Catalysed Formal C–H/C–H Coupling of Arenes Enabled by Interrupted Pummerer Activation A102

Literature Coverage
20th Anniversary of Science of Synthesis: Your Expert Guide to Making Molecules A105

Coming soon A107

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SYNTHESIS Best Paper Award 2019: Enantioselective Synthesis of *cis*- and *trans*-Borocyclopropylmethanol: Simple Building Blocks To Access Heterocycle-Substituted Cyclopropylmethanols

Synthesis **2019**, *51*, 3834–3846

Background. Thieme Chemistry and the Editors of SYNTHESIS and SYNLETT present the 'SYNTHESIS/SYNLETT Best Paper Awards'. These annual awards honor the authors of the best original research papers in each of the journals, considering their immediate impact on the field of chemical synthesis.

Professor André Charette and co-workers, from Université de Montréal, Canada, are the recipients of the SYNTHESIS Best Paper Award 2019. The authors are recognized for their stereospecific approach to alkylamines. In announcing the award, Paul Knochel, Editor-in-Chief of SYNTHESIS, indicated that the selection committee was impressed by the important methodology study on several levels, including the high synthetic interest of the products, the elegant enantioselective method, the extensive potential applications, and the engaging composition and presentation of the study.

SYNFORM spoke with Professor André Charette, who was happy to share some background information regarding the prize-winning paper as well as current research activities ongoing in his group.

Biographical Sketch

Professor A. B. Charette

André B. Charette received his B.Sc. in 1983 from Université de Montréal. He then moved south of the border to the University of Rochester to continue his graduate studies. Under the supervision of Robert K. Boeckman Jr., he completed the total synthesis of the ionophore calcimycin, which earned him the degrees of M.Sc. (1985) and Ph.D. (1987). Following an NSERC postdoctoral fellowship at Harvard University with D. A. Evans, he began his academic career at Université Laval (Quebec City) in 1989 as Assistant Professor. In 1992, he joined once again his alma mater (Université de Montréal), where he has been promoted to the rank of Full Professor since 1998 and where he also serves in a variety of current functions. Among others, he is the holder of a Canada Research Chair in Stereoselective Synthesis of Bioactive Molecules (2005–2018), the Co-Director of the FRQNT Centre in Green Chemistry and Catalysis (2009–), the Co-Director of the NSERC CREATE Training Program in Continuous Flow Science, and the Director of his Department of Chemistry (2014–2020).

With a publication record that encompasses over 230 articles in international journals, 13 book chapters, and 3 patents, he has achieved worldwide recognition in the area of asymmetric processes, new synthetic methodologies in batch and under continuous flow conditions. His research lies primarily in the development of new methods for the stereoselective synthesis of organic compounds and natural products. More particularly, he has devised conceptually novel and practical approaches to the design of catalysts and reactions for the synthesis of cyclopropanes, heterocyclic derivatives and greener functional group transformations, which can find many applications in the pharmaceutical industry. More recently, his efforts have focused on preparing and using highly sensitive reagents, such as diazo reagents, under continuous flow conditions to make the process much safer to use on larger scale.

Throughout his career, he has received >20 international awards from both academic and industrial communities. Among his most prestigious honors are the CIC Medal (2018), a Doctorate Honoris Causa from INSA-Rouen (2015), the CSC Alfred Bader Award (2009), the Marie Victorin Award from the Government of Quebec (2008) and an ACS Arthur C. Cope Award (2007). He is currently the Editor-in-Chief of the Encyclopedia of Reagents for Organic Synthesis (e-EROS). As an academic leader, he has been training together >200 postdoctoral fellows, graduate students and undergraduate interns and has helped raise them to the rank of highly qualified scientists.

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INTERVIEW

SYNFORM *Could you highlight the value of your award-winning paper with respect to the state-of-the-art, as well as the potential or actual applications?*

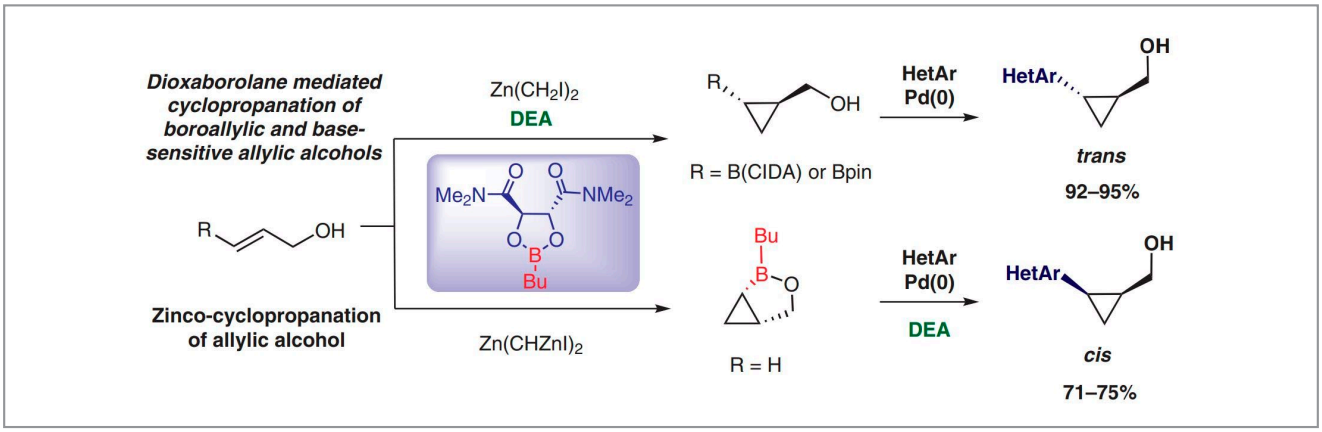
Prof. A. B. Charette Several asymmetric borocyclopropanation methodologies have emerged over the last decade. However, access to enantioenriched borocyclopropanes has remained limited and many of these borocyclopropanes are prone to decomposition through protodeboronation. We have developed a versatile zinc-mediated enantioselective cyclopropanation of a tetracoordinate boronate-bearing allylic alcohol for the preparation of enantioenriched borocyclopropane building blocks (Scheme 1). One of the challenges was to develop conditions that would be highly chemoselective, thus avoiding the traditional oxidative work-up procedure. The resulting borocyclopropylmethanol derivatives allowed us to access *N*-heterocyclic substituted cyclopropanes in very good yields with excellent diastereo- and enantiocontrol. Enantioenriched borocyclopropanes are highly valuable building blocks and can be used in various C–C bond-forming reactions. This enantioselective borocyclopropanation reaction is a significant addition to the highly versatile and robust enantioselective zinc carbenoid mediated cyclopropanation reactions which can now be extended to base-sensitive substrates.

SYNFORM *Can you explain the origin, motivations and strategy used for conducting the award-winning research?*

Prof. A. B. Charette Our group has previously published a diastereoselective borocyclopropanation using a boromethylzinc carbenoid to access borocyclopropanes in racemic form. In this work, we developed an enantioselective borocyclopropanation version of the zinc carbenoid cyclopropanation in the presence of a chiral dioxaborolane ligand that has been one of the trademarks of our research group for many years. We hoped to synthesize borocyclopropanes bearing tetracoordinate borocyclopropanes to access bench-stable borocyclopropylmethanol derivatives. To do so, we strategically planned to overcome the insolubility of existing tetracoordinate boronate derivatives by synthesizing *N*-cyclohexyliminodiacetic acid (CIDA) boronate bearing allylic alcohols instead and targeted an alternative to the oxidative conditions used for the removal of the dioxaborolane ligand. A major contribution to this methodology was the discovery that diethanolamine can be used to cleave dioxaborolane bound to the desired cyclopropane. With these borocyclopropanes in hand, we then used these building blocks in C–C bond coupling reactions to access *N*-heterocycle substituted cyclopropanes. This class of compounds is rather difficult to prepare in enantio- and diastereo-enriched form using known methodologies.

SYNFORM *What is the focus of your current research activity, both related to the award paper and in general?*

Prof. A. B. Charette Our laboratory focuses on the stereoselective synthesis of organic compounds, the development of new tools for synthetic organic chemists (amide bond formation, amide bond cleavage, synthetic methodologies that take advantage of continuous flow synthesis such as safe preparation and use of highly reactive diazo reagents), as well as the synthesis of biologically relevant compounds. In the specific area of borocyclopropanes, we developed the borocyclopropanation of allylic ethers using a boromethylzinc reagent as well as a UV light mediated borocyclopropanation of styrenes



Scheme 1

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using continuous flow technology. Our group has broadly studied new reagents leading to cyclopropanes with better chemoselectivities, higher enantiocontrol, and milder reaction conditions. We have characterized zinc carbenoid reagents and explored gem-dizinc carbenoids to access trisubstituted cyclopropanes.

SYNFORM *What do you think about the modern role, major challenges and prospects of organic chemistry?*

Prof. A. B. Charette Organic synthesis plays a fundamental role in medicinal chemistry, in the agrochemical industry, as well as in materials science and energy-related areas to name a few. The modern role of organic chemistry is to address the continuous demand of making molecules faster, safer, easier, and under environmentally benign conditions. Researchers are often faced with relatively simple synthetic blockades despite the development of numerous methodologies available and therefore any contribution that addresses functional group compatibility or an in depth understanding of fundamental concepts of organic chemistry should be embraced. You never know whether the next reaction that you are developing will constitute a breakthrough to synthesize the next life-saving drug. In the field of research, it is difficult to predict which novel methodologies could be the next standard for bond forming or breaking chemistry or for which applications it could play a major role. As a scientist, it is important to keep an open mindset and embrace new perspectives while also continuing to obtain a better understanding of the fundamentals of organic chemistry. This is the beauty about doing fundamental research. My philosophy about productive research goes far beyond the publishing rate of scientists; research should really focus on the quality of science that is being done and the level of impact it has on society.

SYNFORM *What does this award mean to you/your group?*

Prof. A. B. Charette The objective of the paper was to overcome a fundamental limitation of the enantioselective cyclopropanation reaction using zinc carbenoids in a manner that would further broaden its scope and motivate synthetic chemists to embrace this approach to make heterocycle-substituted cyclopropanes. The SYNTHESIS Best Paper Award recognized our paper for studying the enantioselective cyclopropanation reaction of boroalkenes and it impacts us on several levels. This award encourages us to continue our research to produce novel synthetic methodologies and push the boundaries of organic synthesis. It is also a major motivation boost for the students and postdoctoral researchers who are working in synthesis to have their work widely recognized.

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Editorial Board Focus: Professor Pol Besenius (Johannes Gutenberg University Mainz, Germany)

Background and Purpose. From time to time, SYNFORM portraits Thieme Chemistry Editorial Board or Editorial Advisory Board members who answer several questions regarding their research interests and revealing their impressions and views on the developments in organic chemistry as a general research field. This Editorial Board Focus presents Professor Pol Besenius (Johannes Gutenberg University Mainz, Germany) who joined the Editorial Board of ORGANIC MATERIALS with effect of June 2018.

Biographical Sketch

Prof. P. Besenius

Pol Besenius is Professor for Macromolecular Chemistry in the Department of Chemistry at the Johannes Gutenberg University in Mainz (Germany). Pol was born in Wiltz (Luxembourg) in 1981, where he grew up and completed secondary school education. From 2000 to 2004 Pol studied chemistry at the Vienna University of Technology (Austria) and University of Strathclyde in Glasgow, Scotland (UK). He completed his PhD studies at the University of Strathclyde and WestCHEM Research School in Glasgow, under the supervision of Prof. Peter Cormack and Prof. David C. Sherrington FRS, in collaboration with Prof. Sijbren Otto and Prof. Jeremy K. M. Sanders FRS at the University of Cambridge (UK). In 2008 Pol moved to the Eindhoven University of Technology (the Netherlands) to work with Prof. Anja Palmans and Prof. E. W. "Bert" Meijer as a Marie-Curie Fellow. In 2011 Pol started his independent research as group leader (Habilitand), in the Organic Chemistry Institute at the Westfälische Wilhelms-Universität Münster (Germany), under the mentorship of Prof. Bart Jan Ravoo, and received the *venia legendi* in Organic Chemistry. In January 2015 Pol was appointed as Professor (W2) for Macromolecular Chemistry at JGU Mainz. Pol has received numerous awards and fellowships, and is the recipient of an ERC Consolidator Grant (2019), Liebig-Fellowship of the Fonds der Chemischen Industrie (2011), was member of the 'Junges Kolleg der Nordrhein-Westfälischen Akademie der Wissenschaften und der Künste' (2013–2014) and recently began to act as vice spokesperson of the DFG Research Training Group (RTG 2516) 'Structure Formation of Soft Matter at Interfaces' (since 2020).

INTERVIEW

SYNFORM *Please comment on your role as a member of the Editorial Board of Organic Materials?*

Prof. P. Besenius As editor of the recently launched journal ORGANIC MATERIALS, I am responsible for the peer review process and associated editorial decisions, along with the two other editors Prof. Michael Mastalerz (Ruprecht-Karls-Universität Heidelberg) and Prof. Xiaozhang Zhu (Institute of Chemistry at Chinese Academy of Sciences, Beijing).

SYNFORM *How do you describe the value of a product such as Organic Materials to the chemistry community?*

Prof. P. Besenius ORGANIC MATERIALS is an open access journal and aims to broaden the knowledge in the interdisciplinary fields of chemistry and materials. The scope is broad and covers the synthesis and characterisation of molecular and polymeric functional materials. We welcome exciting contributions and the latest discoveries of the growing community engaged in organic materials, on topics ranging from porous materials, supramolecular chemistry, organic electronics, molecular machines, sensors, functional polymers or polycyclic aromatics. ORGANIC MATERIALS offers the opportunity to publish both experimental and theoretical studies as well as to publish scientific primary data.

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

Prof. P. Besenius The research in my lab focuses on the synthesis of organic and supramolecular functional systems. We design molecular and macromolecular building blocks that self-assemble into programmable polymers, adaptive materials in aqueous media and in the bulk. Utilising natural

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and non-natural supramolecular interactions we investigate multifunctional systems for applications as temperature-, pH-, oxidative-stress- and mechano-responsive hydrogels and biomaterials. We are also very excited to translate the design of our biomedical carriers into the development of synthetic vaccines for applications in immunotherapy.

SYNFORM *You are a leading researcher with regard to organic materials chemistry. Could you tell us more about how important you perceive this particular topic to be?*

Prof. P. Besenius The capacity to design and synthesise molecules and macromolecules, further guided by computational methods, puts us chemists into a very privileged and central position to interact with many adjacent research fields. Curiosity-driven developments of synthetic methodology, coupled with creativity, allows us to prepare (macro)molecules with exquisite control over functionality, size and shape. These are key in the discovery of fundamental new properties, and in mechanistic understanding and can be exploited for unique electronic, mechanical or biological function. I am excited to be part of this vibrant research field and look forward to many spectacular achievements at the frontiers of chemistry and materials science.

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

Prof. P. Besenius Since 2011 I have had the privilege to work with a group of very talented chemists. Eight students have successfully defended their PhD since, and secured positions in industry or started their own independent research group. They have all massively contributed to the success of our group and brought in a good mix of creative molecular designs, ambitious synthetic routes and exciting biomedical applications. There is not one achievement I would like to single out here.

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Catalytic C(sp³)–H Bond Activation in Tertiary Alkylamines

Nat. Chem. **2020**, *12*, 76–81

Over the last decade, the field of C–H activation has evolved from using bespoke strongly chelating functional groups to the development of much more appealing transformations which exploit the directing ability of native functionalities such as carboxylic acids, amides and amines, among others. In this regard, the group of Professor Matthew Gaunt at the University of Cambridge (UK) recently reported the first examples of a tertiary alkylamine directed C(sp³)–H activation reaction. "Tertiary alkylamines have been historically used in palladium-catalysed reactions to reduce a Pd(II) pre-catalyst into the desired active Pd(0) species to initiate, for example, a Suzuki cross-coupling reaction," said Professor Gaunt, who continued: "A consequence of this reaction pathway is the oxidative decomposition of the tertiary alkylamine, which has precluded their use in C–H activation reactions."

The Gaunt group discovered that a simple *N*-acetyl amino acid ligand was capable of preventing amine decomposition, thereby facilitating the desired C–H activation pathway and ultimately leading to a method of directly introducing functionalized aryl groups into the tertiary alkylamine scaffolds. "The tertiary alkylamine starting materials are readily available and a plentiful supply of diversely functionalized arylboronic acid coupling partners can be acquired from commercial sources; all other reaction components are available from commercial vendors," said Professor Gaunt. He added: "We believe that the operational simplicity of this new high-yielding transformation, combined with its broad substrate scope, will be appealing to practitioners of the synthetic and medicinal communities in academic and industrial institutions. For example, starting from a common tertiary alkylamine, it is possible to incorporate many different aromatic features directly into the amine scaffold, enabling the rapid assembly of a library of compounds with potentially promising biological activity."

"We aim to use this new platform to introduce other functionalisations into tertiary alkylamines, while continuing to improve the efficiency and sustainability of the process," explained Professor Gaunt. He concluded: "Furthermore, we are also investigating the capacity of this transformation to effect enantioselective C–H bond functionalizations at the γ-methylene position in tertiary alkylamines, which would provide direct access to valuable non-racemic molecules of potential biological interest."

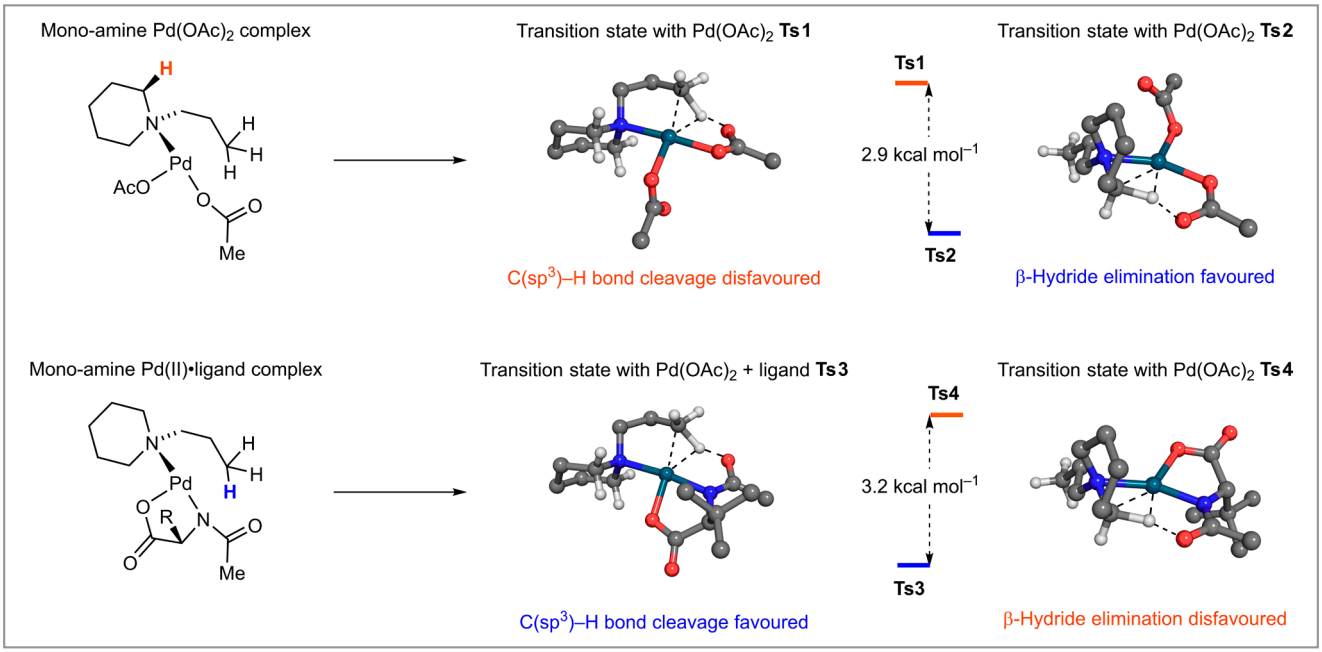

Figure 1 Mechanism of the reaction

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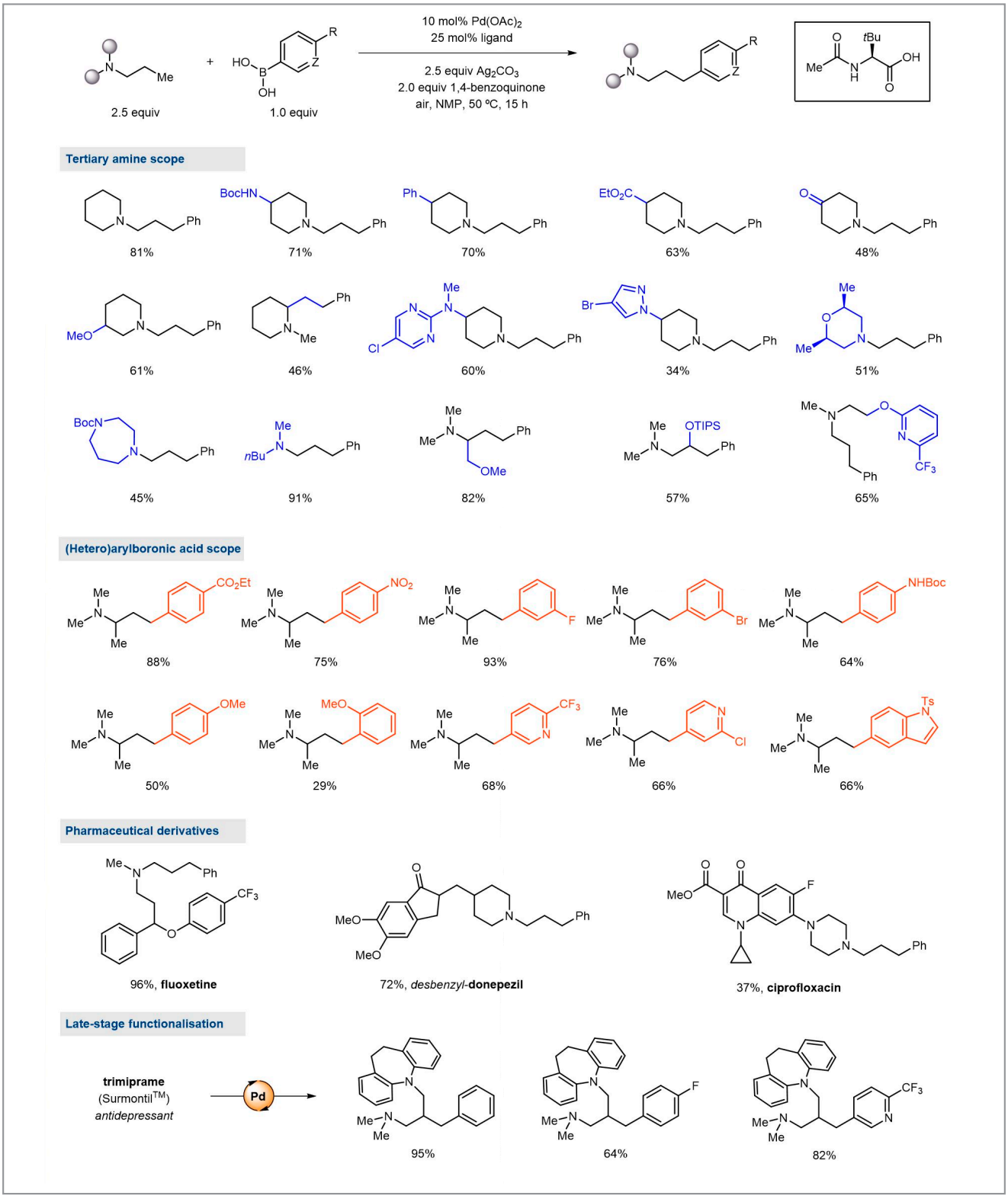

Scheme 1 Selected scope and applications of the palladium-catalysed arylation of tertiary alkylamines

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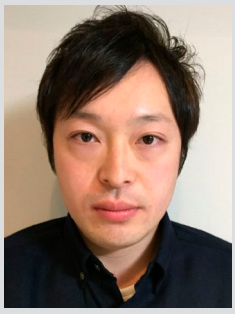
About the authors

J. Rodrigalvarez

Jesus Rodrigalvarez obtained his BS in 2016 at University of Barcelona (Spain), where he conducted undergraduate research with Prof. Fèlix Urpí and Prof. Pedro Romea. In 2016, he moved to University of Cambridge (UK) to complete an MPhil degree under the supervision of Prof. Matthew Gaunt. Currently, he is a PhD student in the same research group. His research focuses in C–H activation, computational chemistry, and reaction mechanisms.

Dr. M. Nappi

Manuel Nappi was born in Torino (Italy), where he obtained his Bachelor's (2008) and MPhil degrees in organic chemistry (2010). He completed his PhD studies in 2014 under the supervision of Prof. Paolo Melchiorre at ICIQ, Tarragona (Spain). During 2012, he joined Professor David MacMillan's group at Princeton University (USA). Since 2015, he is a postdoctoral researcher in the group of Prof. Matthew J. Gaunt, University of Cambridge (UK). His research interests include photochemistry and photoredox catalysis, palladium-catalysed C–H activation, organocatalysis and biochemistry.



Dr. H. Azuma

Hiroki Azuma was born in Japan and obtained his BS in 2009 from Tohoku University (Japan), where he carried out undergraduate research under the supervision of Prof. Hideo Takeuchi. He obtained his M.S. degree in 2011 and PhD in 2014 at the same university under the direction of Professor Hidetoshi Tokuyama. He works for Mitsubishi Tanabe Pharma Corporation (Japan) since 2014. From 2018 to 2019, he joined Prof. Matthew J. Gaunt's research group as a postdoctoral researcher at the University of Cambridge (UK).

N.J. Flodén

Nils J. Flodén was born in Sweden and received his MSci degree from Imperial College London (UK) in 2016. He then began PhD studies at the University of Cambridge (UK) where he develops radical methods for the synthesis of aliphatic amines under the supervision of Prof. Matthew J. Gaunt.

Dr. M. Burns

Matthew Burns received his PhD from the University of Bristol (UK) in 2014 under the supervision of Prof. V. K. Aggarwal. Subsequently, he moved to Colorado State University (USA) as a Marie-Curie postdoctoral research fellow in the lab of Prof. T. Rovis, working there from 2014–2017. He returned to the UK in 2017 and joined the group of Prof. Matthew J. Gaunt at Cambridge University (UK) to complete his fellowship. Currently, he works as a senior process chemist for AstraZeneca.

Prof. M. Gaunt

Prof. Matthew Gaunt is the 1702 Yusuf Hamied Professor of Chemistry in the Department of Chemistry at the University of Cambridge (UK). Matthew began his higher education at the University of Birmingham and graduated with first class honours in 1995. He moved to Cambridge for his PhD studies to work under the supervision of the late Dr Jonathan Spencer. He graduated in 1999 before moving to the University of Pennsylvania, Philadelphia (USA) as a GlaxoWellcome Postdoctoral Fellow. In 2000, he returned to Cambridge as a Junior Research Fellow at Magdalene College and a Ramsay Memorial Trust Fellow, where he worked with Professor Steven V. Ley. Matthew began his independent research career in 2003 and was awarded a Royal Society University Research Fellowship at the University of Cambridge in 2004. He was promoted to Lecturer in 2006, Reader in 2010, Full Professor in 2012, and was Elected to the 1702 Chair in 2019.

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Metal-Free Photoredox-Catalysed Formal C–H/C–H Coupling of Arenes Enabled by Interrupted Pummerer Activation

Nat. Catal. **2020**, *3*, 163–169

(Hetero)biaryl scaffolds are ubiquitous in the molecules that drive the main chemical industries. Such motifs are most commonly assembled using transition-metal-catalysed cross-couplings; however, the requirement to pre-functionalise both coupling partners and the use of precious-metal catalysts can result in costly procedures that produce substantial amounts of waste. According to Professor David Procter – an expert of cross-coupling chemistry and catalysis at the University of Manchester (UK) – a strong movement has recently formed within the synthetic community with the aim of developing (i) cross-couplings of non-prefunctionalised partners, that take place at the expense of C–H bonds, and (ii) cross-couplings that operate without using metals.

Professor Procter's group have long been drawn to the idea that sulfur can replace metals in cross-couplings by (i) activating substrates, and (ii) providing a center around which coupling partners can be assembled prior to coupling. In particular, the group have recently developed a range of C–H functionalisation processes that utilise the so-called interrupted Pummerer reaction of sulfoxides.

In their latest account, Professor Procter and his group have developed a highly effective strategy for the synthesis of (hetero)biaryls by combining the interrupted Pummerer activation of arenes with a subsequent visible-light-mediated reduction, using an organic photoredox catalyst. "The application of sulfonium salts in photoredox catalysis is underexplored. We had already shown that the interrupted Pummerer reaction of sulfoxides could be used to make *alkenyl*sulfonium salts that fed into a base-metal-catalysed process, and we were confident that similarly formed *aryl*sulfonium salts would be excellent substrates for photocatalysis," explained Professor Procter.

Indeed, by exploiting a commercial sulfoxide, dibenzothiophene *S*-oxide (DBTSO), as the process mediator, the authors achieved high selectivity and reactivity in C–H sulfenylation and sulfonium salt formation. EPSRC Doctoral Prize Fellow, Dr. Miles Aukland, continued: "We prepared a range of sulfonium salts and tested several photoredox catalysts, but identified the salt derived from dibenzothiophene and an organic photoredox catalyst, 10-phenylphenothiazine (PTH), as the most efficient combination." The photoredox catalyst is responsible for generating a reactive aryl radical from the sulfonium salt, which then engages in cross-coupling with the heteroarene partner. When compared to existing photoredox-catalysed approaches to make heterobiaryls, the group's approach avoids the practical issues of safety, stability and availability that are associated with aryl diazonium salts, and the highly negative reduction potentials of aryl halides. The authors also highlighted that the dibenzothiophene byproduct can be easily recovered and recycled, further improving the atom economy of the procedure. Lecturer Dr. Gregory Perry added: "By transforming simple arenes into sulfonium salts, we gained access to a class of bench-stable aryl radical precursors of complementary reactivity for use in formal C–H/C–H cross-couplings."

The authors showed how their strategy is suitable for the synthesis of a wide variety of (hetero)biaryl architectures (>50 examples). PhD student Mindaugas Šiaučiulis emphasised: "The process tolerates the presence of halide and triflate functional groups thus signalling its orthogonality to traditional cross-coupling." The team also showed that the process could be applied to the late-stage functionalisation of complex bioactive molecules and in the synthesis of natural products, such as the pseudilins.

When asked about the future of the field, Professor Procter responded, "The influence of light on the chemistry of sulfonium salts has long fascinated chemists. For example, a report by R. M. Kellogg in the 1970s described the light-mediated reduction of sulfonium salts and is viewed as one of the first examples of photoredox catalysis. The field of photoredox catalysis has exploded in the past ten to fifteen years; however, the photoredox chemistry of sulfonium salts has remained largely untouched. We hope that our report not only illustrates the accessibility and utility of sulfonium salts, but also showcases how the introduction of new substrates, prepared in innovative new ways, can lead to significant advancements in the burgeoning field of photoredox catalysis."

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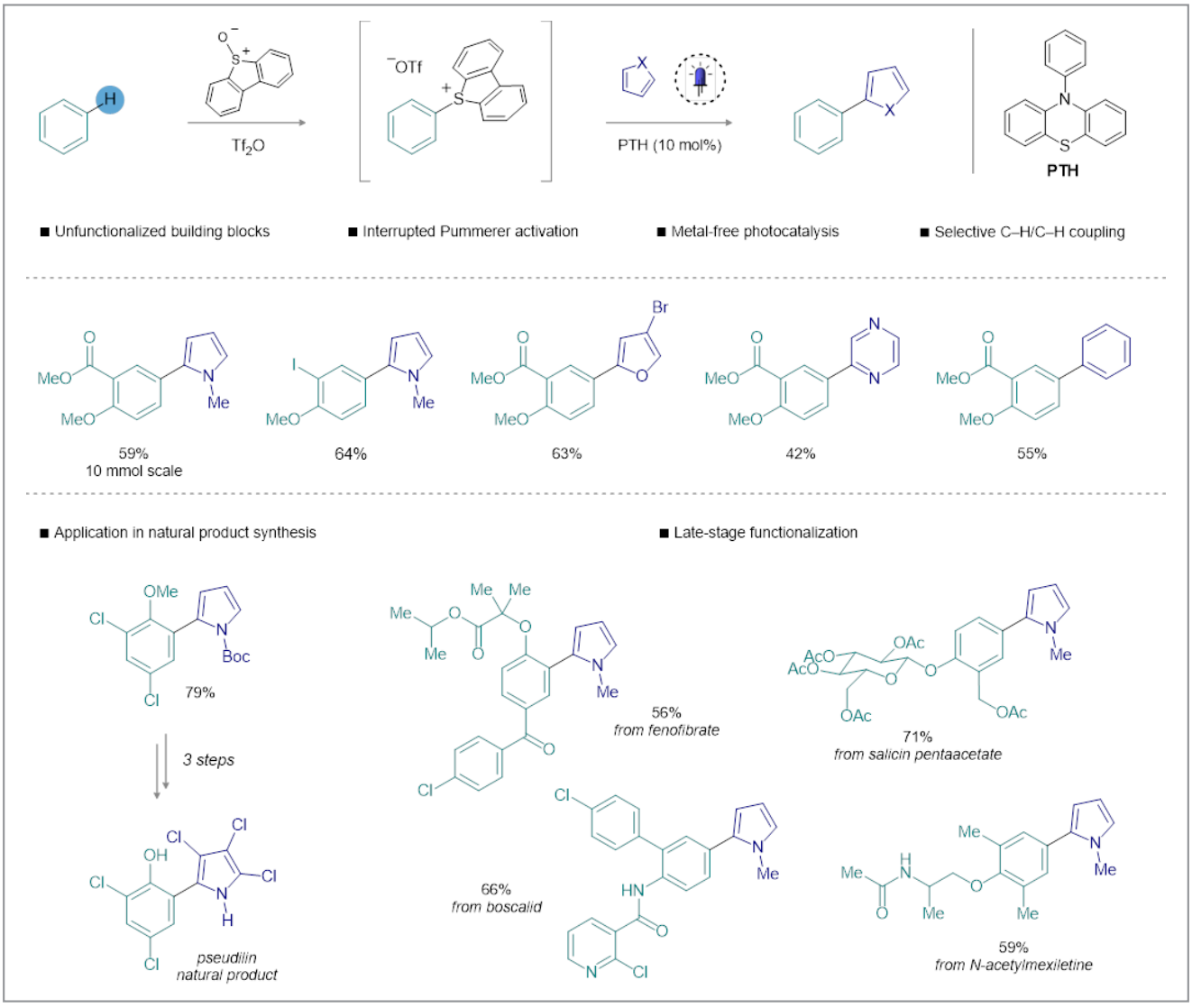

Scheme 1 Procter's strategy for metal-free, photoredox-catalysed, formal C–H/C–H coupling and selected examples

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About the authors

Dr. M. H. Aukland

Dr. Miles H. Aukland obtained his MChem degree from the University of Manchester (UK) in 2014, working under the supervision of Prof. David J. Procter. He then continued in the Procter group to study towards his Ph.D., where he developed new sulfur-mediated C–H functionalization strategies using low-cost metals. In 2018, he was awarded a prestigious EPSRC Doctoral Prize Fellowship to work on the application of sulfonium salts in photoredox processes for C–C bond formation. In 2019, Miles moved to the Max-Planck-Institut für Kohlenforschung (Germany) to conduct postdoctoral research with Prof. Benjamin List.

M. Šiaučiulis

Mindaugas Šiaučiulis obtained his MSci Chemistry degree from the University of Nottingham (UK) in 2016, having completed a research project under the supervision of Dr. Elaine O'Reilly. He then moved to the University of Manchester (UK) for his doctoral studies in the group of Prof. David J. Procter, where he worked on the development of novel cross-coupling reactions mediated by sulfonium salts. Later in 2020, Mindaugas will move to a postdoctoral research position in the group of Prof. Lee Cronin at the University of Glasgow (UK).

A. West

Adam West received his MChem degree from the University of Manchester (UK) in 2019. During his degree he spent a year at Chromition Ltd., working on novel fluorescent polymer nanoparticles for bioimaging applications. His final-year research project was carried out under the supervision of Prof. David J. Procter and Dr. Miles Aukland, and focused on the use of photoredox catalysis for C-–C bond formation. After graduation, Adam took up a position in the chemistry research department at Pfizer UK Ltd.

Dr. G. J. P. Perry

Dr. Gregory J. P. Perry received his MChem from the University of Liverpool (UK) in 2012 and his PhD in 2016 from the University of Manchester (UK). His doctoral studies were carried out in the group of Prof. Igor Larrosa and focused on decarboxylative and C–H transformations. In 2017, he moved to Nagoya University (Japan) to work with Prof. Kenichiro Itami on the application of C–H activation in chemical biology. Since 2018, Greg has been working as a Lecturer in Organic Chemistry within the group of Prof. David J. Procter at the University of Manchester (UK).

Prof. Dr. D.J. Procter

Prof. Dr. David J. Procter was awarded a BSc in chemistry from the University of Leeds in 1992 and his PhD in 1995 working with Prof. Christopher Rayner on organosulfur and organoselenium chemistry. He then spent two years as a Postdoctoral Research Associate with Prof. Robert Holton at Florida State University in Tallahassee (USA) working on the synthesis of Taxol. In late 1997 he took up a Lectureship at the University of Glasgow in Scotland and was promoted to Senior Lecturer in 2004. In 2004, he moved to a Readership at the University of Manchester (UK). David was promoted to Professor in 2008 and is currently Head of the Department of Chemistry.

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20th Anniversary of *Science of Synthesis*: Your Expert Guide to Making Molecules

Chimia Report/Company News CHIMIA **2020**, *74*, 214

2020 marks the 20th anniversary of Science of Synthesis (SOS), the online synthetic methodology review compendium used by synthetic chemists worldwide. SOS, the successor to the well-known Houben-Weyl series, was established in 2000 by an esteemed Editorial Board of international chemistry experts including Nobel Prize winner Ryoji Noyori. Today under the guidance of Editor-in-Chief Alois Fürstner, a team of eminent editors commission quality content from expert authors and ensure the selection of useful and practical methods. Chemists therefore have quick access to thorough and quality overviews on the entire range of organic synthesis topics saving them hours of searching and literature research. SOS is considered the place to begin when writing a thesis, preparing a talk, writing a paper, starting out in a new area of chemistry or preparing consultancy work.

A Place to Begin

SOS is a multi-authored reference work of synthetic methods that offers "a place to begin". It comprises the largest collection of evaluated methods in organic synthesis worldwide. Its elegant, didactic presentation of synthetic methodology means it is an essential treatise for organic chemistry students, lecturers, and researchers.

SOS is organized in a logical hierarchical system based on the target molecule to be synthesized. The critical coverage of methods is supported by information intended to help the user choose the most suitable methods for their application, thus providing a strong foundation from which to develop a successful synthetic route. Within each category of product, illuminating background information, such as history, nomenclature, structure, stability, reactivity, properties, safety, and environmental aspects, is presented along with a detailed selection of reliable methods. Each method and variation is accompanied by reaction schemes, tables of examples, experimental procedures, and a background discussion of mechanistic rationale, stereochemistry, scope of the reaction described and its limitations, and functional group compatibility. All published results from journals, books, and patent literature from the early 1800s until the year of publication are considered by the authors, who are among the leading experts in their field.

Evaluation of Methods by Experts

The SOS Editorial Board comprises expert chemists from academia and industry: E. M. Carreira (ETH Zurich), M. Faul (Amgen Inc.), A. Fürstner (Editor-in-Chief, MPI/Mülheim), S. Kobayashi (University of Tokyo), G. Koch (Topadur Pharma AG), G. Molander (University of Pennsylvania), C. Nevado (University of Zurich), B. M. Trost (Stanford University), and S.-L. You (Shanghai Institute of Organic Chemistry). The Editorial Board's overarching goal is to make the suite of SOS resources the first and foremost focal point for critically evaluated information on chemical transformations for those individuals involved in the design and synthesis of organic molecules. Over 56 volume editors and 2,000 authors worldwide have contributed to the series over the last 20 years.

Online, Updated, and Topical

The online version (web-based interface) of SOS enables text, structure, substructure, and reaction searching via a simple interface with powerful functionality. Continual updating of the

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electronic version means that the content of SOS remains pertinent and relevant to the synthetic organic chemist's needs. Also supplementing current content with special topics acknowledges the broad spectrum of organic chemistry today and the need for chemists to appreciate many different peripheral scientific fields in addition to the core subject area. The electronic product is designed so that it:

- Provides an exclusive overview of the synthetic chemistry literature
- Provides easy access to the best and most reliable synthetic methods in organic and organometallic chemistry
- Allows researchers to tailor their structure, text and reaction searches to accommodate their chemical information needs
- Provides personalized support for scientific queries through a professionally staffed (PhD chemists) Editorial Office and technical support desk
- Supports the chemical community by responding to its need for relevant and value-added synthetic chemistry information

The SOS Advisory Board comprises experts who have significant experience of chemical information systems in both industry and academia: G. Baysinger (Stanford Univ.), L. Betschart (ETH Zurich), J. Currano (Univ. of Pennsylvania), J. Goodman (Univ. of Cambridge), C. Keil (Pfizer), Ye Li (MIT), Xiaoxia Li (CAS, China), and Donna Wrublewski (Caltech). They regularly contribute to discussions regarding the development of the electronic product.

Women in Chemistry Award

In addition to providing an important editorial contribution for the chemistry community, the dynamic and forward-thinking SOS Editorial Board founded the first major international synthetic chemistry award for Women in Chemistry. As a result, the first award was presented to Sarah Reisman (Caltech) at the 21st ESOC in Vienna in 2019.

SOS: We Transform Synthesis!

Over 20 years some 96,000 "pages" of evaluated information have been published, including over 2 million molecules, 425,000 selected reactions and no fewer than 54,000 experimental procedures. SOS has proven to be the perfect research companion for the organic synthetic chemist and will continue to provide the chemistry community with valuable synthetic methodology reviews in the years to come! Anyone interested in having free trial access to the online product for two weeks at their institution should contact the publisher.

Contact

Science of Synthesis/Thieme Chemistry
Thieme Group
Ruedigerstrasse 14
70469 Stuttgart
Germany
Editorial/Technical Queries: SOS_techsupport@thieme.com
Access/Marketing: marketing@thieme-chemistry.com
Website: sos.thieme.com

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Coming soon

Literature Coverage

Synthesis of a Mechanically Planar Chiral Rotaxane Ligand for Enantioselective Catalysis

Literature Coverage

DMSO-Catalyzed Late-Stage Chlorination of (Hetero)arenes

Literature Coverage

Enantioselective Three-Component Aminomethylation of α-Diazo Ketones with Alcohols and 1,3,5-Triazines

Further highlights

Synthesis **Review: Alkynyl Prins and Alkynyl Aza-Prins Annulations: Scope and Synthetic Applications**
(by A. J. Frontier and co-workers)

Synlett **Account: Recent Advances in Ruthenium-Catalyzed Carbene/Alkyne Metathesis (CAM) Transformations**
(by C. Saá and co-workers)

Synfacts **Synfact of the Month in category "Metals in Synthesis": Nickel-Catalyzed Enantioconvergent Coupling of Racemic Partners**

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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
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