

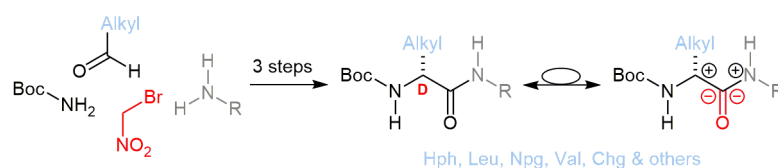
Synform

People, Trends and Views in Chemical Synthesis

2015/08

Enantioselective Synthesis of D- α -Amino Amides from Aliphatic Aldehydes

Highlighted article by K. E. Schwietz, J. N. Johnston



Contact

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Dear Readers,

We've just been through the 'Impact Factors 2014' week, the most critical period of the scientific publishing year when Journals, Publishers and Editorial Boards find out about the new Impact Factors (IF) and can either get the party started for celebrating an IF increase (sometimes even just a ridiculously minor one, but always better than a drop, isn't it...) or start tearing their hair out because the IF has gone down. In the latter case the immediate action would be to start planning the next campaign of artificial IF pumping by publishing more maxi-reviews, mini-reviews & nano-reviews, by luring more top authors and rising stars to publish in the journal, and by catching the eye of readership and prospective authors with foolish or tabloid-inspired articles' titles and headlines... We are all affected – to some extent – by this IF madness, even those who claim and pretend to be IF immune actually are not. I know many colleagues who select the journals where to submit their manuscripts following a rigid IF-based ranking list, sometimes neglecting more important aspects such as the journal's research area and readership which could guarantee better visibility and more citations to their articles. On the other hand, publishers and journals are ruthlessly fighting among each other to win the elusive IF war. But all wars have their innocent victims, which in this case are authors and readers themselves. It is far beyond the scope of this Editorial to analyze (yet again) the IF issue, but I suspect it is everybody's experience and impression that IFs are not doing a good service to research. Is there a way out? Not an easy one, I am afraid, and not any time soon, but perhaps we should all start looking at IFs with a wee bit of healthy irony. At the end of the day IFs are just stupid numbers, aren't they? At least until the next academic performance evaluation...

Frankly, I feel so lucky I do not have to worry about SYNFORM's IF! Let's have a look at this IF-free editorial

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wonder then. We start with Akkattu Biju (India) who is the protagonist of this month's Young Career Focus, and we get at full speed with Jeffrey Johnston (USA) who talks about his recent enantioselective synthesis of D- α -amino amides from aliphatic aldehydes. Third article is focused on Christopher Vanderwal's (USA) synthesis of the potent antimalarial compound kalihinol B. Last but not least Wei-Liang Duan (P. R. of China) and his novel method for the synthesis of *P*-stereogenic compounds.

Enjoy your IF-free reading!



Contact

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

Young Career Focus: Dr. Akkattu T. Biju (CSIR-National Chemical Laboratory, Pune, India)

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. Akkattu T. Biju (CSIR-National Chemical Laboratory, Pune, India).

Biographical Sketch



Dr. A. T. Biju

Akkattu T. Biju was born and raised in Cochin, Kerala (India). He received his B.Sc. and M.Sc. degrees from Mahatma Gandhi University, Kerala (India) and his Ph.D. under the guidance of Dr. Vijay Nair at the CSIR-NIIST, Trivandrum (India). Subsequently, he has been a postdoctoral fellow with Professor Tien-Yau Luh at the National Taiwan University, Taipei (Taiwan) and an Alexander von Humboldt fellow with Professor Frank Glorius at the Westfälische Wilhelms-Universität Münster (Germany). In June 2011, he began his independent research career at the CSIR-National Chemical Laboratory, Pune (India). His research focuses on the development of transition-metal-free carbon-carbon and carbon-heteroatom bond-forming reactions using aryne chemistry and N-heterocyclic carbene (NHC) organocatalysis, and their application in organic synthesis. He is the recipient of the CRSI Young Scientist Award (2015), NCL-Research Foundation Scientist of the Year Award (2014), ISCB Young Scientist Award (2014), Thieme Chemistry Journals Award (2014), OPPI Young Scientist Award (2012), Alexander von Humboldt Fellowship (2009), and is a member of the National Academy of Sciences, India (NASI), Allahabad (2012).

INTERVIEW

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

Dr. A. T. Biju Our present research focuses on the development of transition-metal-free carbon-carbon and carbon-heteroatom bond-forming reactions, and their implementation in organic synthesis. Specifically, we employ aryne chemistry for the rapid synthesis of various 1,2-disubstituted arenes. We also use N-heterocyclic carbene (NHC) based organocatalysis for the enantioselective construction of heterocycles and carbocycles. In addition to the synthesis of benzo-fused compounds and chiral heterocycles, evaluation of the biological activity of these molecules forms part of our research.

SYNFORM *When did you get interested in synthesis?*

Dr. A. T. Biju I have been very fortunate to be taught by talented chemistry teachers throughout my studies. During my college days, I was fascinated by the remarkable properties of carbon, and the concepts of isomerism and catenation. This interest in organic chemistry persisted through all my studies and was transformed to synthetic chemistry during my Ph.D. studies, where I was introduced to the enchanting world of organic synthesis. All my mentors (Dr. V. Nair, Professor T.-Y. Luh and Professor F. Glorius) have had a tremendous influence on my academic development over the years, and they very much inspired me to pursue a career in synthetic organic chemistry.

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

Dr. A. T. Biju Over the years, organic synthesis has played a pivotal role in human wellbeing. The recent developments in synthetic chemistry include the invention of mild and effi-

cient concepts for C–H bond activation, advances in asymmetric organocatalysis, synthesis of complex molecular architectures using multicomponent reactions, and the application of these methods to the synthesis of natural and unnatural compounds of biological importance. These methods are vital for the pharmaceutical, petrochemical and agrochemical industries. Also the fundamental understanding of organic synthesis is essential for the growth of materials chemistry, nanotechnology and other interdisciplinary areas. I strongly believe that organic synthesis will continue to flourish and lead to surprising developments in the years to come.

SYNFORM Your research group is active in the areas of catalysis and development of new methodologies. Could you tell us more about your research and its aims?

Dr. A. T. Biju Our research aims at developing transition-metal-free carbon–carbon and carbon–heteroatom bond-forming reactions using aryne chemistry and NHC-organocatalysis. In the area of aryne chemistry, we have recently developed a mild, efficient and scalable Diels–Alder reaction of arynes with challenging diene systems such

as pentafulvenes, 1,2-benzoquinones, styrenes, indenes/benzofurans, and tropones. Moreover, the synthetic utility of N-heterocycles such as pyridine, and (iso)quinoline in aryne multicomponent reactions (MCRs) has been demonstrated for the synthesis of various heterocycles. In addition, we recently developed aryne MCRs triggered by phosphines for the synthesis of functionalized benzooxaphospholes, and the use of CO₂ as a one-carbon synthon in aryne MCRs has been developed. Furthermore, a transition-metal-free protocol for the N-arylation of tertiary amines has been developed. The results are summarized in Figure 1.

In another phase of the work using NHC catalysis, we have developed an efficient and facile Stetter reaction using vinyl sulfones, and vinyl phosphonates as Michael acceptors. Moreover, an efficient homoenolate annulation reaction with hydroxy chalcones for the synthesis of cyclopentane-fused coumarins has been realized. We are also working on asymmetric catalysis using NHCs. We recently demonstrated a facile method for the enantioselective synthesis of functionalized dihydropyranones and dihydropyridinones by the reaction of modified enals with β-dicarbonyl compounds or enamines, enolizable aldehydes, and heterocyclic C–H acids.

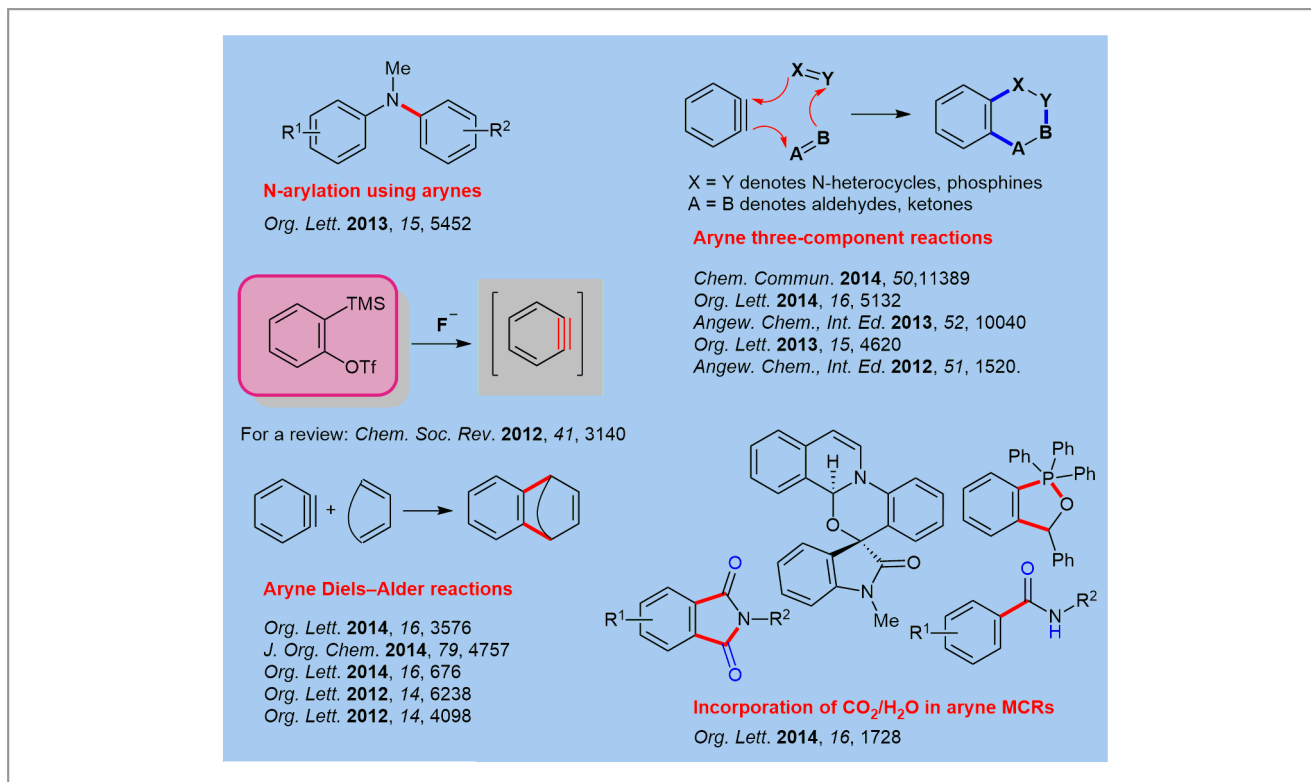


Figure 1

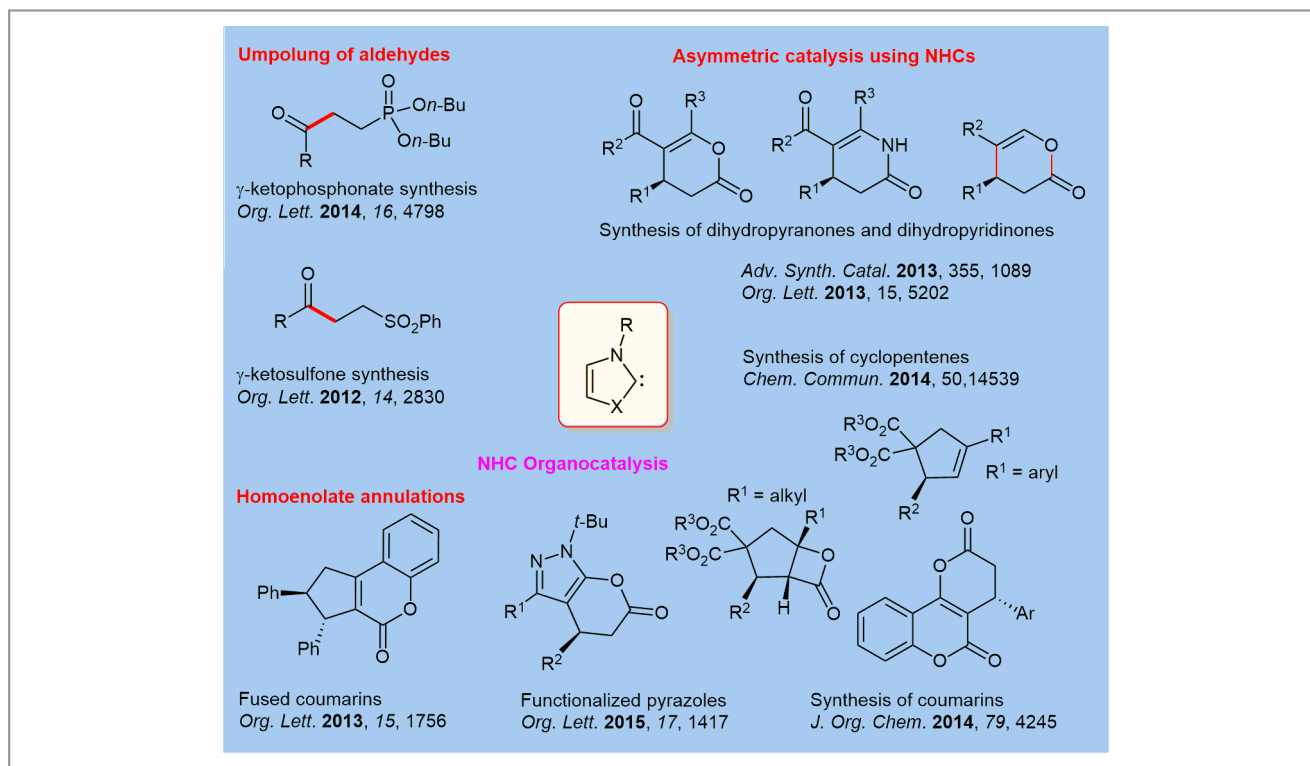


Figure 2

Furthermore, we have disclosed the enantioselective synthesis of functionalized cyclopentenones, β -lactone-fused cyclopentanes, and functionalized pyrazoles by the NHC-catalyzed reaction proceeding via the α,β -unsaturated acyl azolium intermediates. The results are summarized in Figure 2.

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

Dr. A. T. Biju Being at the beginning of my independent research career, my greatest scientific achievements lie ahead of me (I hope!). However, one of our recent results that I am proud of is the generation of a highly nucleophilic pyridylidene intermediate in the aryne MCRs triggered by pyridine using N-substituted isatins as the third component (*Angew. Chem. Int. Ed.* **2013**, *52*, 10040). These reactions resulted in the formation of indolin 2-one derivatives in good yields. This is the first time that NHCs have been found to be intermediates in aryne MCRs.

Annette Fenske

Enantioselective Synthesis of D- α -Amino Amides from Aliphatic Aldehydes

Chem. Sci. **2015**, *6*, 2590–2595

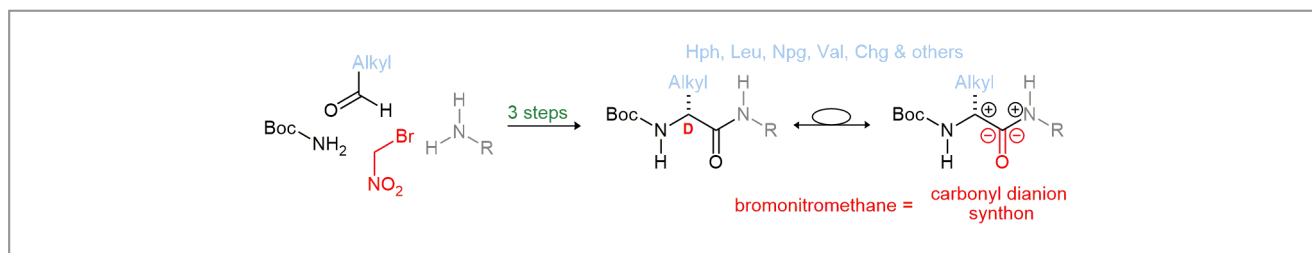
The development of a synthesis platform that provides access to any non-natural amino amide, with either configuration (L or D), in a peptide context is an overarching goal of Professor Jeffrey N. Johnston's group at Vanderbilt University (Nashville, USA). "Thinking long-term, for such a platform to be universally adopted, it needs to be based mostly on inexpensive starting materials that vary broadly in structure, provide the α -amino amide product in just a few steps, and be highly stereoselective," said Professor Johnston. "This work is a significant step in that direction, providing relatively general access to D- α -amino amides bearing alkyl side chains."

Professor Johnston continued by explaining that there are countless ways to prepare protected α -amino acids in enantio-enriched/pure form, but it's not clear that these are used very often in peptide synthesis, especially by a non-specialist. "Our goal is to simplify the homologation of a peptide chain with an unnatural amino acid without compromising the ideals of a synthetic organic chemist (1:1 stoichiometry, minimal waste generation, straightforward purification, in addition to high yield)," he said, continuing: "Our strategy is first to redirect focus from protected α -amino acids to an α -bromonitroalkane, a functional group that we've shown can serve as an acyl anion equivalent in amide synthesis (B. Shen, D. M. Makley, J. N. Johnston *Nature* **2010**, *465*, 1027). We've prepared many aryl glycine donors in this way, but we struggled to adapt our catalysis to enolizable *N*-Boc imines, the electrophile progenitors to α -alkyl α -amino amides. These electrophiles can easily convert into their non-electrophilic *N*-Boc enamide tautomers. This publication describes our use of chiral phase-transfer catalysis to solve a major part of this problem."

Palomo and co-workers developed an elegant enantioselective phase-transfer-catalyzed addition of primary nitroalkanes to *N*-Boc aldimines (*J. Am. Chem. Soc.* **2005**, *127*, 17622),

and in order to dovetail this method with their synthetic plan, Professor Johnston and his co-workers simply needed bromonitromethane to substitute for nitromethane. "Certainly Palomo and co-workers merely overlooked this commercially available reagent, right?" Professor Johnston commented, ironically. He continued: "Well, when Ken – PhD student Kenneth Schwieter – first added bromonitromethane to cesium hydroxide, he quickly learned that the solid base was rather resentful of this bait-and-switch. There was significant heat generated, and the evolution of a gas concomitant with an oily material coating the CsOH. To cut a long story short," said Professor Johnston, "Ken ultimately reasoned that an *aliphatic* nitroalkane might 'temper' the solid base, producing a heterogeneous catalyst amenable to productive reaction with bromonitromethane. The protocol he developed successfully avoids the decomposition, allowing the desired reaction to occur."

According to Professor Johnston, this is the first use of bromonitromethane in an enantioselective aza-Henry reaction with enolizable imines. The chiral non-racemic alkyl β -amino- α -bromonitroalkane products are α -amino amide precursors that can be incorporated into any peptide via Umpolung Amide Synthesis (UmAS) coupling with an amine. The sequence provides homologation in only three steps from an aliphatic aldehyde. "This method for the synthesis of α -amino amides is competitive with current literature methods, and Figure 2 in the *Chem. Sci.* paper provides a comparative analysis of key methods to homologate with Boc-D-Adod," explained Professor Johnston, who concluded: "Experimentally, the biggest challenge was overcoming the incompatibility of CsOH-H₂O and bromonitromethane, which was achieved by the addition of a nitroalkane additive. Curiously, Ken also found that the presence of the nitroalkane additive led to an



increase in enantioselection – clearly the synthetic chemist's bonus for brokering peace between CsOH and bromonitromethane!"

Matt's favorite

About the authors



From left: K. E. Schwieter, Prof. J. N. Johnston

Kenneth E. Schwieter was born and raised in Cincinnati, OH (USA). He received his B.S. degree in chemistry from Xavier University in Cincinnati in 2011. He is currently a Ph.D. student at Vanderbilt University (USA) under the mentorship of Professor Jeffrey Johnston. His research focuses on the enantioselective synthesis of α -amino amides and Umpolung Amide Synthesis (UmAS) reaction development.

Jeffrey N. Johnston received his Ph.D. in 1997 from The Ohio State University (USA), working with Professor Leo A. Paquette, and worked as an NIH Postdoctoral Fellow with David A. Evans at Harvard University (USA). In 1999, he began his independent career at Indiana University (USA), moving to Vanderbilt University (USA) in 2006 where he is currently Stevenson Professor of Chemistry. His group is focused on reaction and reagent development that realizes the synthesis chemist's ideals of efficiency and streamlined access, ultimately enabling complex molecule synthesis.

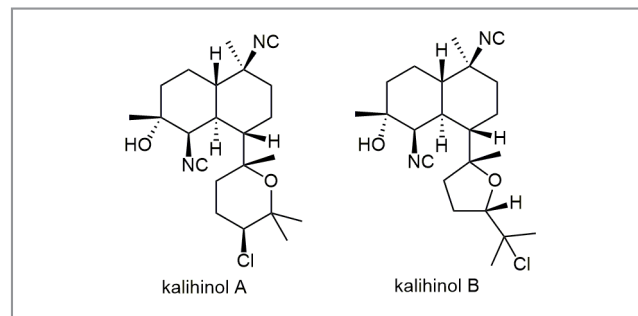
Synthesis and Potent Antimalarial Activity of Kalihinol B

J. Am. Chem. Soc. **2015**, *137*, 4912–4915

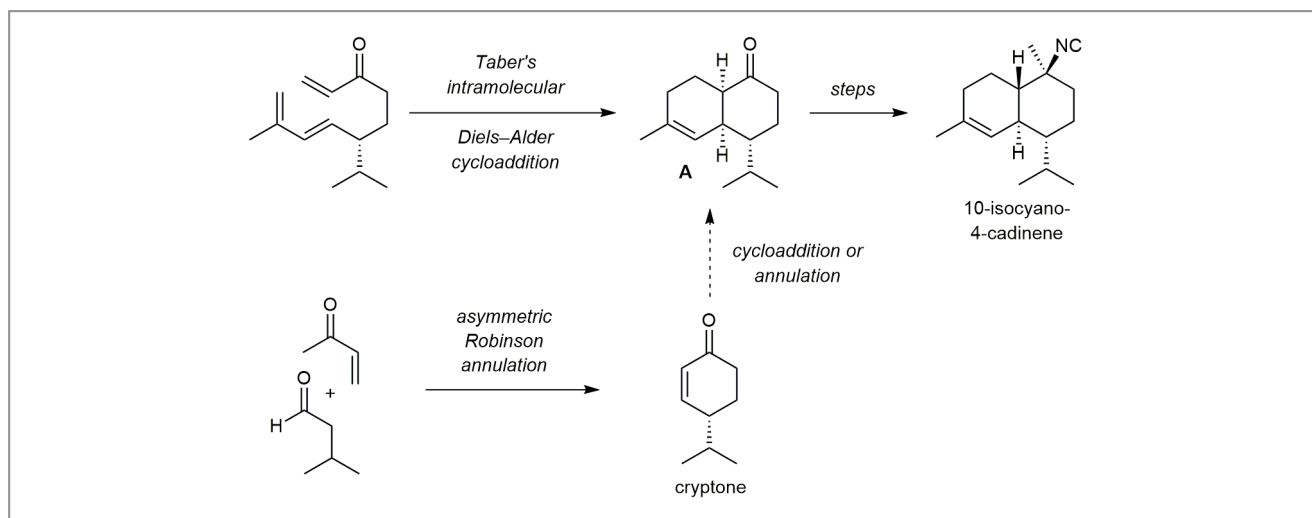
The treatment of malaria remains a medical challenge and the current best practice relies on combination therapy, namely the use of two or more drugs mostly for reducing the risk of therapy failure and developing resistance. Access to a broad portfolio of effective antimalarial drugs is an urgent medical need; therefore, the discovery and development of novel affordable antimalarial drugs continues to be a vibrant research area. Sponge-derived kalihinanes have been reported to have antimalarial activity; however, a systematic study of kalihinanes as antimalarial agents has not been described. Recently, Professor Christopher D. Vanderwal from the University of California (Irvine, USA), described a 12-step synthesis of kalihinol B, which was found to have potent antimalarial properties.

Professor Vanderwal said: “Although there had been synthesis work on the kalihinanes before by the Wood and Miyaoka groups (see the original JACS paper for references), my PhD student Mary Beth Daub and I began our studies because we believed that a general approach to many members of the family might offer a better understanding of the mechanism of action of these potent antimalarials, assuming that we could engage excellent collaborators (which we have, in Professor Karine Le Roch and Jacques Prudhomme!). After all,” he continued, “there are over 50 known naturally occurring kalihinanes at the last count and, because the antimalarial activity of kalihinol A ($EC_{50} = 1.2$ nM against a drug-resistant malaria parasite) was reported after many of these com-

pounds were discovered, only five natural products had been tested for antimalarial activity.”



The group's synthesis strategy arose from a 'Molecule of the Quarter' challenge, in which the group breaks up into teams, each of which develops a strategy for the synthesis of the target molecule. Professor Vanderwal explained: “Kalihinol A, with its incredible antimalarial activity, was the target. The key idea came from a different way of looking at the simpler but related sesquiterpene, isocyanocadinene.” The Wood and Shenvi groups had made this molecule previously by application of an intramolecular Diels–Alder cycloaddition originally described by Taber for his synthesis of torreyol. That same type of cycloaddition also featured in the Wood and Miyaoka syntheses of the kalihinanes. Professor Vanderwal said: “We looked at the decalone cycloadduct **A** as a possible

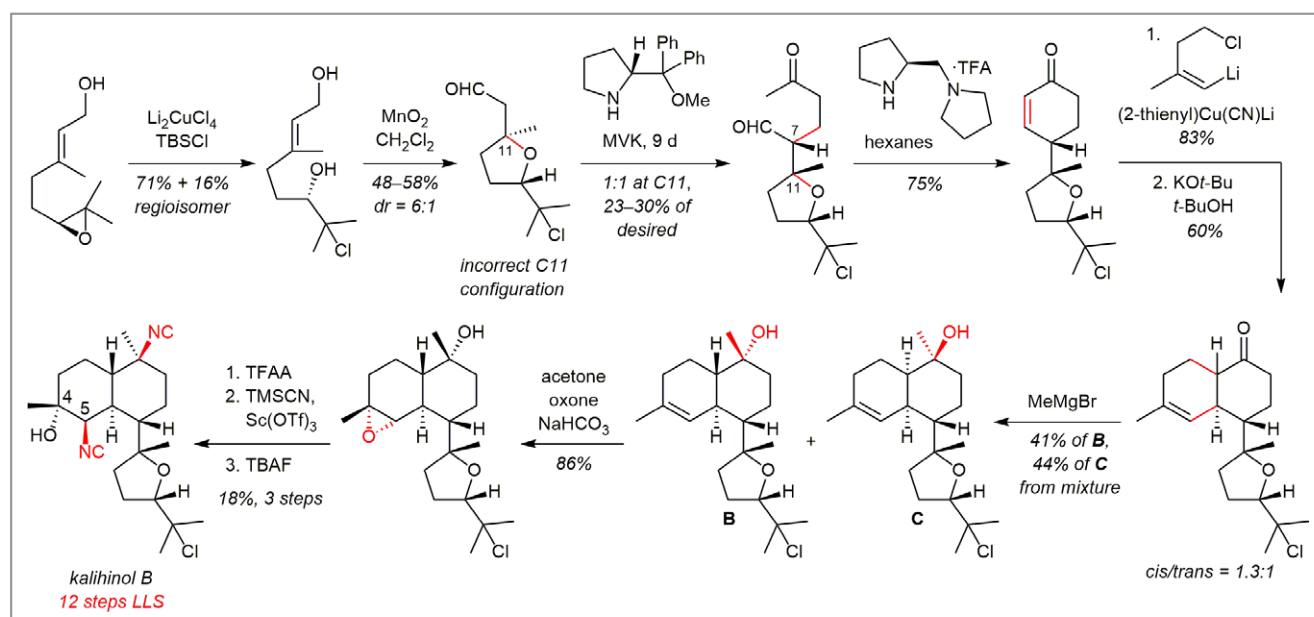
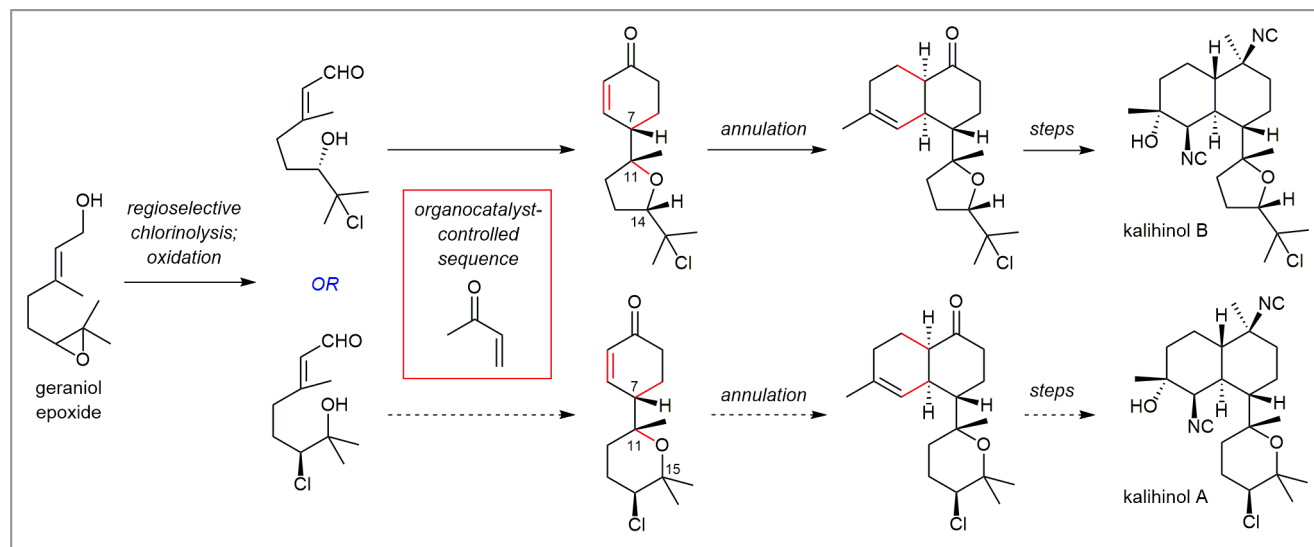


product of an annulation or cycloaddition onto cryptone, a known building block available in enantiopure form by asymmetric organocatalytic Robinson annulation.”

He continued: “That was the insight we needed to be able to connect the oxygen-heterocycle synthesis with the ‘B’-ring synthesis via a sequence of oxa-Michael addition and Robinson annulation. The possibilities for organocatalytic stereocontrol of the C7,C11 relationship, which admittedly didn’t work out quite perfectly, were really exciting. We felt that this approach to the synthesis of the pendant heterocycle – targeting the C11–O bond whereas Wood and Miyaoka forged the C14(15)–O bond (likely also the biosynthetic process) – set

our approach apart from the previous work and offered the possibility of a very short synthesis. Fortunately, Mary Beth was able to reduce this relatively simple idea to practice in a way that I am very proud of.”

According to Professor Vanderwal, the short step count (12 or 13 steps, depending upon the starting epoxidation) would not have been possible without application of the excellent invertive isocyanation of tertiary trifluoroacetates developed by Shenvi and Pronin. “We have the good fortune of being friendly with Professor Shenvi and of having Professor Sergey Pronin as our newest colleague here at UCI,” said Professor Vanderwal. “At the outset of our work, we anticipated needing to de-



velop this type of reaction; having been beaten to it so nicely obviated any work by us in that area. We can tell you, that reaction works as advertised! What was so fortunate for us was that the conditions developed by Shenvi and Pronin also behaved well in the epoxide isocyanolysis. If that hadn't worked out, our endgame would have been much, much longer."

"We were ecstatic to learn that our synthetic sample of kalihinol B had nearly identical activity against drug-resistant

malaria parasite to that reported for kalihinol A," said Professor Vanderwal, who concluded: "That is the first of many SAR data points that we hope to add to the literature as we work with Jacques and Karine to understand how some of the kalihinanes exert their exciting antimalarial activity."

About the authors



M. B. Daub

Mary Beth Daub was born and raised in Claremont, California (USA). She received a B.A. in chemistry from Williams College in Williamstown, MA (USA) in June 2011, where she worked towards the synthesis of polyketide natural products in the lab of Professor Thomas E. Smith. She is currently a fourth-year Ph.D. student at the University of California, Irvine (USA) working under the direction of Professor Chris Vanderwal. Her research in the Vanderwal group focuses on the development of a unified synthetic approach towards the kalihinane family of antimalarial isocyanoterpene natural products.



J. Prudhomme

Jacques Prudhomme was born in Los Angeles, California (USA). After earning his B.Sc. degree in biochemistry at the University of California, Riverside (UCR, in the USA), he joined the laboratory of Professor Irwin Sherman studying the cytoadherent properties of the malaria parasite, *Plasmodium falciparum*, as well as the endothelial cells with which they interact. In 2006, he joined the laboratory of Professor Karine Le Roch and began evaluating the effect of natural products and chemical compounds on *Plasmodium* parasites and their potential as novel antimalarial agents. He is a Research Associate in the Department of Cell Biology and Neuroscience at UCR and is well published with over 25 years experience working with malaria parasites.

Karine Le Roch is an Associate Professor at the University of California, Riverside (UCR, in the USA). She obtained her Master's degree in parasitology at the University of Lille II (France) and the University of Oxford (UK) in 1997. She completed her Ph.D.



Prof. K. Le Roch

in June 2001 at the University of Paris Sorbonne (France), working on the cell cycle of the human malaria parasite, *Plasmodium falciparum*. In 2001, as a postdoctoral fellow, she joined the Scripps Research Institute, San Diego, California (USA) to carry out the functional analysis of the *P. falciparum* genome using micro-array technologies. She joined the Genomics Institute of the Novartis Research Foundation (California, USA) in January 2004 where she developed the malaria drug discovery program. Since April 2006 at UCR, Karine Le Roch is using functional genomics and system biology approaches to elucidate critical regulatory networks driving the malaria parasite life cycle and identify novel drug targets.



Prof. C. D. Vanderwal

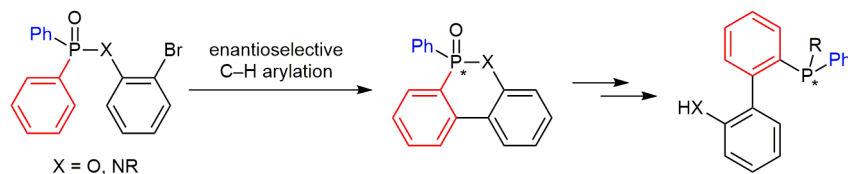
Christopher D. Vanderwal received B.Sc. (biochemistry, 1995) and M.Sc. (chemistry, 1998) degrees from the University of Ottawa (Canada). He then moved to the Scripps Research Institute (La Jolla, USA) for doctoral studies in the group of Professor Erik Sorensen. After obtaining his Ph.D. in 2003, Chris joined the group of Professor Eric Jacobsen at Harvard University (USA) as a Jane Coffin Childs Postdoctoral Associate. In 2005, he began his independent academic career at the University of California, Irvine (USA). In 2011, Chris was promoted with tenure to Associate Professor and was named a UCI Chancellor's Faculty Fellow, and in 2013, he was promoted to Professor and Vice Chair of Chemistry for Graduate Affairs. His research group at UC Irvine aims to develop practical and divergent syntheses of complex, bioactive natural products.

Palladium-Catalyzed Enantioselective Synthesis of *P*-Stereogenic Compounds via C–H Arylation

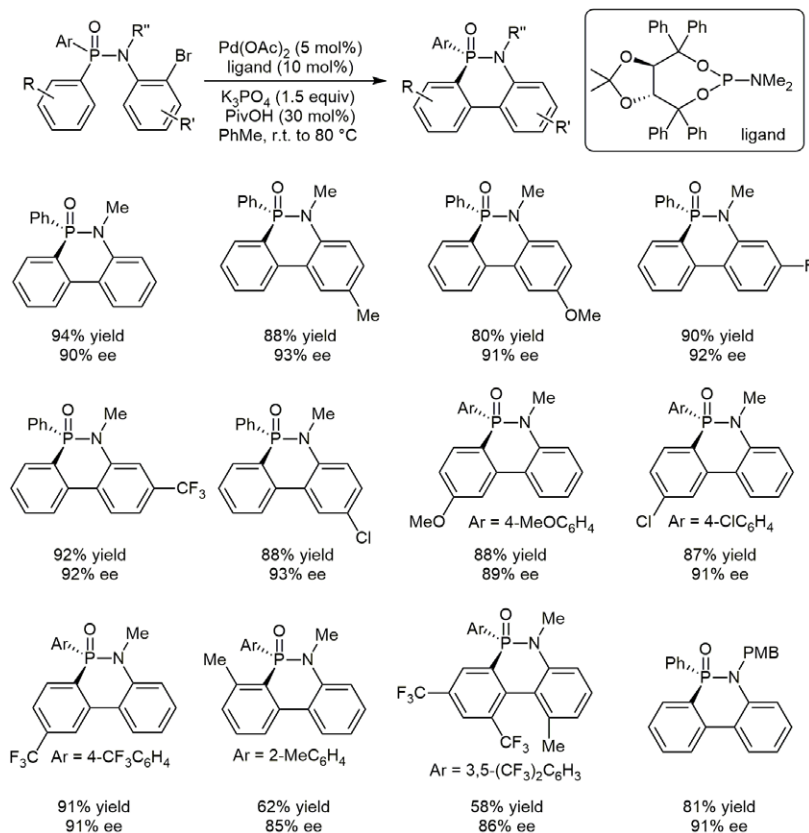
Angew. Chem. Int. Ed. 2015, 54, 6265–6269

Chiral phosphine compounds are extremely useful ligands in catalysis. However, phosphorus (*P*)-chiral ligands have not been explored as extensively in catalytic reactions as axially chiral, carbon (*C*)-chiral, or planar-chiral compounds such as binap, diop, or josiphos. This is probably because *P*-chiral

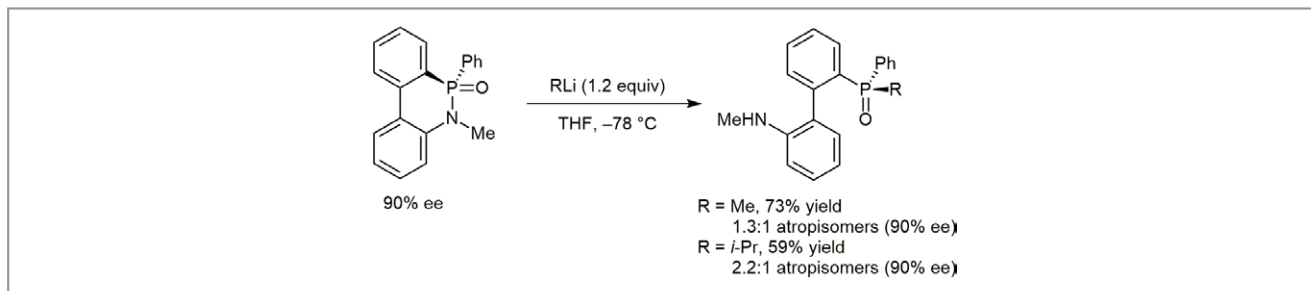
compounds are less easily available and more difficult to synthesize than other types of chiral compounds. Asymmetric catalysis has the potential to provide a more direct and efficient synthetic route compared to traditional resolution methods of constructing *P*-chiral compounds.



Scheme 1 Construction of *P*-chiral compounds through enantioselective C–H arylation



Scheme 2 Enantioselective C–H arylation of diarylphosphinic amides



Scheme 3 Preparation of chiral biaryl monophosphine oxides from the obtained *P*-chiral compounds

C–H bond functionalization has been an extremely popular topic over the past decade, and numerous methods based on a C–H bond activation strategy have been developed to build diverse complex molecules from unfunctionalized materials. The group of Professor Wei-Liang Duan at the Shanghai Institute of Organic Chemistry, Chinese Academy of Sciences (P. R. of China) has a longstanding interest in both the asymmetric synthesis of chiral phosphorus compounds (*J. Am. Chem. Soc.* **2010**, *132*, 5562; *Org. Chem. Front.* **2014**, *1*, 541) and C–H bond functionalization reactions (*J. Am. Chem. Soc.* **2013**, *135*, 16754). Professor Duan said: “We asked ourselves the question of whether the enantioselective C–H arylation strategy could be utilized for the synthesis of useful *P*-stereogenic compounds (Scheme 1).”

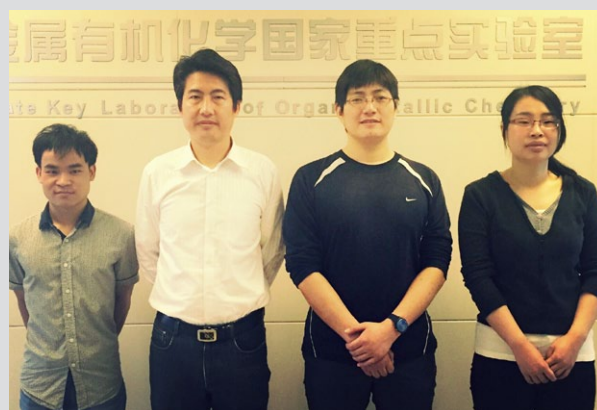
Professor Duan explained: “Initially, *ortho*-bromophenyl diphenylphosphinate was chosen as the model substrate for palladium-catalyzed intramolecular C–H arylation reactions; however, formation of racemic products – with no enantiocontrol – was observed with several ligands examined (*Synthesis* **2014**, *46*, 1067).” He continued: “Then, diarylphosphinic amides were prepared and investigated under palladium catalysis and using various chiral phosphine ligands. Finally, the use of a Taddol-based dimethylaminophosphoramidite ligand successfully generated an array of *P*-stereogenic compounds with up to 93% ee (Scheme 2).”

It is worth pointing out that the P–N bond of the products can be cleaved with alkyllithium reagents, and *P*-chiral monophosphine oxides were obtained without erosion of enantioselectivity (Scheme 3).

Professor Duan concluded: “Now, we are trying to synthesize *P*-chiral biaryl monophosphine ligands based on the developed protocols, and we hope that the resulting *P*-chiral phosphines can be utilized as efficient ligands in some asymmetric reactions.”

Mattias Forsberg

About the authors



From left: S. Yan, Prof. W. Duan, W. Wang, Z. Lin

Ziqi Lin received her BSc degree from Shandong University (P. R. of China) in 2010. She later joined the research group of Professor Weiliang Duan and is currently a PhD student at Shanghai Institute of Organic Chemistry, Chinese Academy of Sciences (P. R. of China).

Weizhen Wang was born in Anhui (P. R. of China) in 1990. He received his BSc degree from Hubei University (P. R. of China) in 2013 and is now working with Professor Weiliang Duan for his Master's degree at Shanghai Institute of Organic Chemistry, Chinese Academy of Sciences (P. R. of China).

Shaobai Yan was born in Hunan (P. R. of China) in 1989. He received his BSc degree (under the supervision of Professor Yuefa Gong) from Huazhong University of Science and Technology (P. R. of China) in 2012. Currently, he is a postgraduate student (under the supervision of Professor Weiliang Duan) at Shanghai Institute of Organic Chemistry, Chinese Academy of Sciences (P. R. of China).

>>

Weiliang Duan received his PhD in chemistry in 2007 from Kyoto University (Japan) under the guidance of Professor Tamio Hayashi. He then carried out postdoctoral work in the laboratory of Professor Scott E. Denmark (University of Illinois at Urbana Champaign, USA). In 2008, he joined the Shanghai Institute of Organic Chemistry, Chinese Academy of Sciences (P. R. of China) as an associate professor. In 2014, he was promoted to professor. His research focuses on transition-metal-catalyzed C–H bond activation and the development of chiral ligands for asymmetric catalysis.

Coming soon

Literature Coverage

Isostrychnine Synthesis Mediated by Hypervalent Iodine Reagent

SYNLETT Highlight

Metal-Free Trifluoromethylthiolation of Alkyl Electrophiles via a Cascade of Thiocyanation and Nucleophilic Cyanide- CF_3 Substitution

Literature Coverage

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

Further highlights

Synthesis Special Topic on “Multicomponent Methods, Strategies, and Synthesis”

Synlett Account: Hypervalent Iodine(III) in Direct Carbon-Hydrogen Bond Functionalization
(by A. P. Antonchick and co-workers)

Synfacts Synfact of the Month in category “Polymer-Supported Synthesis”: Enantioselective Hydrogenation of Ketones on Palladium Cellulose Nanocrystals

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