

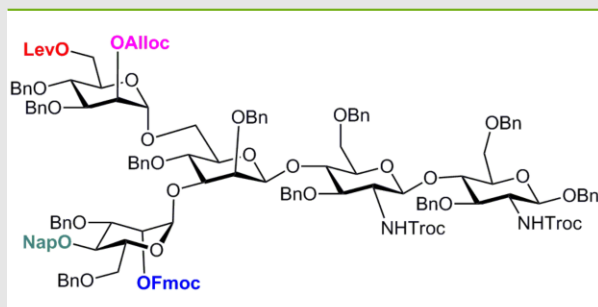
SYNFORM

People, Trends and Views in Synthetic Organic Chemistry

2013/11

SYNSTORIES ■ ■ ■ ■

■ A General Strategy for the Chemoenzymatic Synthesis of Asymmetrically Branched *N*-Glycans



■ Total Synthesis of Vinigrol

■ Palladium-Catalyzed Reductive Carbonylation of Aryl Halides with *N*-Formylsaccharin as a CO Source

■ Young Career Focus:
Professor Mary P. Watson
(University of Delaware, Newark, USA)

CONTACT +++++

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



Dear readers,

I have been in Brussels this week, dealing with one of the last activities of the Framework Programme 7 (FP7), which is about to be replaced by the new giant and glittering Horizon 2020, the new European Framework Programme for Research and Innovation that will run from 2014 to 2020 with a budget of about 70 billion Euros. At first sight one may think that there won't be much on the plate for chemists, but actually there is more than that which meets the eye. In fact, chemistry is progressively becoming a pervasive and essential component of many projects and research initiatives in biomedical research, environmental and materials sciences, and energy, just to mention a few. No surprise therefore in realizing that, although a bit beneath the surface, chemistry is actually scattered throughout the whole Horizon 2020, with huge opportunities for all of us, chemists. The keyword is: collaborations! Inter- and multidisciplinary collaborations, to be precise. Chemistry is the enabling tool that will allow many projects in Horizon 2020 to take-off and fly. Let's look for collaborations then, and let's take on this new exciting opportunity for chemistry and for us chemists, because chemistry is and will continue to be "the central science", in Horizon 2020 and beyond.

Let's have a look at this new **SYNFORM** issue now. Well, it's also very exciting, I have to say. The first **SYNSTORY** takes us through the daunting synthetic efforts that allowed Professor J. T. Nyardarson (USA) to assemble the structure of vinigrol. Next, we'll learn about the Pd-catalyzed carbonylation reaction discovered by Professor K. Manabe (Japan), and then about the groundbreaking synthesis of branched *N*-glycans developed by Professor G.-J. Boons (USA). Last but not least, we'll know more about a young up-and-coming researcher, Professor M. Watson (USA) and her research.

Enjoy your reading!

Matteo Zanda

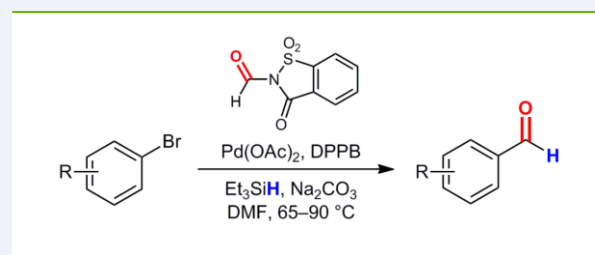
Editor of **SYNFORM**

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COMING SOONA144

CONTACT + + + +

If you have any questions or wish to send feedback, please write to Matteo Zanda at:
Synform@chem.polimi.it

NEWS AND VIEWS ■ ■ NEWS AND VIEWS ■ ■ NEWS AND VIEWS ■ ■

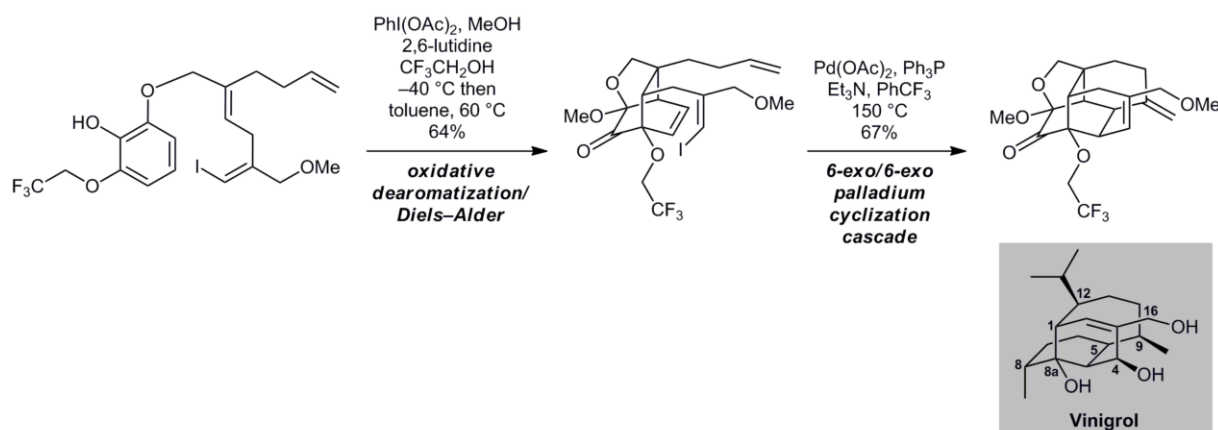
Total Synthesis of Vinigrol

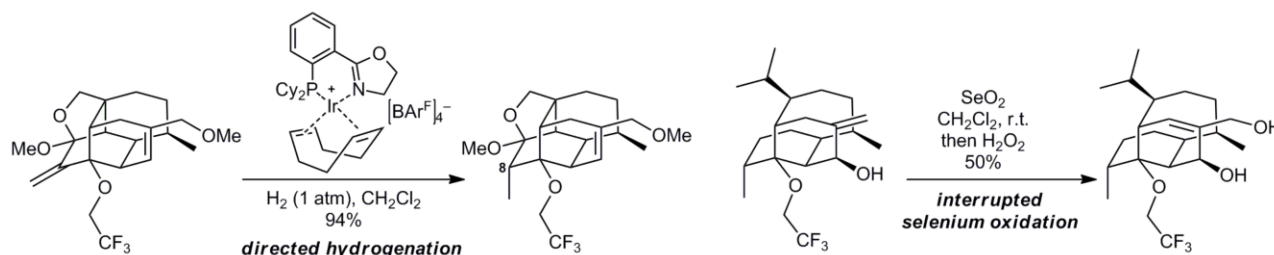
Angew. Chem. Int. Ed. **2013**, *52*, 8648–8651

■ Vinigrol is a diterpenoid first reported in 1987 (*J. Org. Chem.* **1987**, *52*, 5292). The molecule was isolated from the fungal strain *Virgaria nigra* and its structure was elucidated by spectroscopic and X-ray diffraction studies. From the biological activity viewpoint, vinigrol has anti-hypertensive and platelet aggregation inhibiting properties, and was also demonstrated to be capable of arresting the progression of HIV to AIDS. Vinigrol has remarkable structural complexity, as it contains a cis-decalin bridged by an eight-membered ring containing eight contiguous stereocenters. The first total synthesis of vinigrol was reported by Baran in 2009 (*J. Am. Chem. Soc.* **2009**, *131*, 17066). Recently, Professor Jon T. Njardarson from the University of Arizona (Tucson, USA) published a conceptually new total synthesis of vinigrol.

Professor Njardarson said: “I am particularly proud of our total synthesis of vinigrol, not only because of the excellent and creative efforts of the individuals involved but because we never compromised on the key design aspects of the route.” He continued: “Although the details of our route have evolved over time (*Tetrahedron Lett.* **2009**, *50*, 1684; *Synlett* **2009**, *23*; *Org. Lett.* **2009**, *11*, 4492), the route’s design has always involved an oxidative dearomatization reaction followed by an intramolecular Diels–Alder cyclo-

addition, a cyclization cascade to form a tetracyclic cage, late-stage unraveling of the vinigrol core via a C–C bond-fragmentation reaction and strategic substrate-controlled transformations to set key stereocenters.” As shown in the scheme below, the Arizona-based researchers have realized the originally envisioned in situ oxidative dearomatization/Diels–Alder cascade as well as a palladium-mediated cyclization cascade to form the complex tetracyclic pre-fragmentation core in only two steps from an achiral resorcinol-based aromatic precursor. “The trifluoroethyl protecting group is particularly noteworthy in this sequence,” remarked Professor Njardarson. “It plays two important deactivation roles: to ensure that 1) the oxidative dearomatization is directed to the more hindered phenolic ether, and 2) the intermediate quinol monoketal does not fragment prior to undergoing the intramolecular Diels–Alder cycloaddition.” This protecting group was also essential for ensuring a high-yielding Dakin oxidation reaction in the previous step. Professor Njardarson continued: “From what we can gather, this is the first use of a trifluoroethyl ether protecting group in targeted organic synthesis. The last step of the total synthesis involves a highly unusual trifluoroethyl ether deprotection strategy employing LDA and osmium(IV) oxide.”





As is often the case with complex molecule synthesis, it invariably reveals the limits and strengths of existing methods while also demanding new solutions and strategies (new protecting group). “Because of the rigidity and compactness of the tetracyclic cage,” said Professor Njardarson, “our synthetic route showcases many interesting reactions in ‘tight’ spaces as exemplified by the transformations shown below, wherein in one case a remarkable directed hydrogenation ensured formation of the C8 stereocenter, while in the other a favorable

interruption of the classic allylic oxidation promoted by selenium dioxide resulted in a one-step incorporation of the C16 hydroxyl group.”

Professor Njardarson concluded: “Our long-term goal is to develop an asymmetric oxidative dearomatization protocol that we can apply to vinigrol and other complex diterpenoid natural products.”

Matteo Zanda

About the authors



Prof. J. T. Njardarson

he joined the research group of a newly hired assistant professor, John L. Wood, after becoming affected by his enthusiasm, energy and exciting new research program. During his doctoral studies Jon worked on the total synthesis of the nonadride natural products CP-225,917 and CP-263,114. At the end of his graduate studies Jon was presented with the irresistible offer of moving to New York City to work in the laboratory of Professor Samuel J. Danishefsky at the Memorial Sloan-Kettering Cancer Center (MSKCC). While in the Danishefsky group, as a General Motors Cancer Research Scholar, he worked on the total syntheses of the natural products epothilone 490 and migrastatin. Jon moved to Ithaca in 2004 to start his

Jon T. Njardarson was born and raised in the small town of Akranes, Iceland. After graduation, he left his hometown and moved to Reykjavik to start his studies at the University of Iceland. Jon then followed in the footsteps of his Icelandic ancestors and moved west, to America. This journey brought him to New Haven, Connecticut (USA), where he chose to pursue a graduate career in Organic Chemistry at Yale University. While at Yale,

independent career at Cornell University, where he launched a research program focused on natural products and the development of new methods. In 2010 Jon and his group loaded the wagons, journeyed across the continent, and settled in Tucson where he is currently an associate professor of chemistry at the University of Arizona.



Dr. C. Graghici

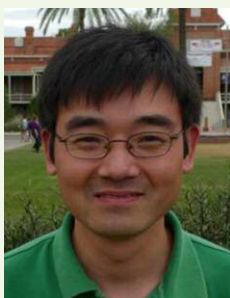
independent career at Cornell University, where he launched a research program focused on natural products and the development of new methods. In 2010 Jon and his group loaded the wagons, journeyed across the continent, and settled in Tucson where he is currently an associate professor of chemistry at the University of Arizona.

Cristian Draghici received his BS degree in chemistry and biochemistry in 2003 from Western Connecticut State University (USA). During this time he worked in the laboratory of Professor Paula M. Secondo. Cristian then moved to the University of Vermont (USA) where he received his Ph.D. in 2009 under the guidance of Professor Matthias Brewer. While in Professor Brewer's laboratory, Cristian developed a new carbon-carbon

bond-fragmentation protocol and pursued natural products targets using this new strategy. Cristian joined Professor Jon T. Njardarson's laboratory at Cornell University as a postdoctoral fellow, during which time he worked on the total synthesis of vinigrol and assisted with the creation and launch of a new

>>

educational app (Chemistry By Design). Cristian is currently a postdoctoral fellow with Professor David A. Spiegel at Yale University.



Dr. Q. Yang

Qingliang Yang was born and raised in a small village in Hubei province (P. R. of China). He completed his undergraduate education at Sichuan University in Chengdu (P. R. of China) and studied medicinal chemistry with Professor William Groutas at Wichita State University (USA), and received his M.S. degree in 2006. After working briefly as research scientist at AMRI in New York, he attended Cornell University and studied natural

product total synthesis with Professor Jon T. Njardarson. Shortly after completing the total synthesis of vinigrol he obtained his Ph.D. (summer 2013).

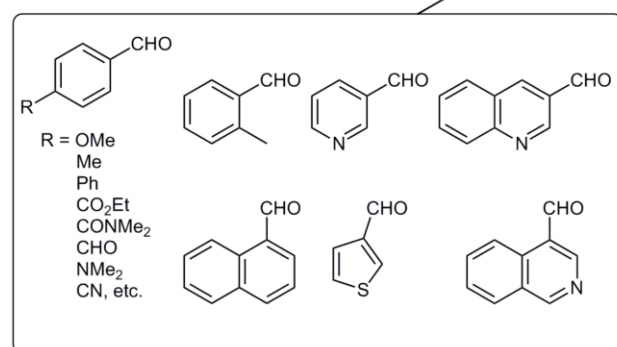
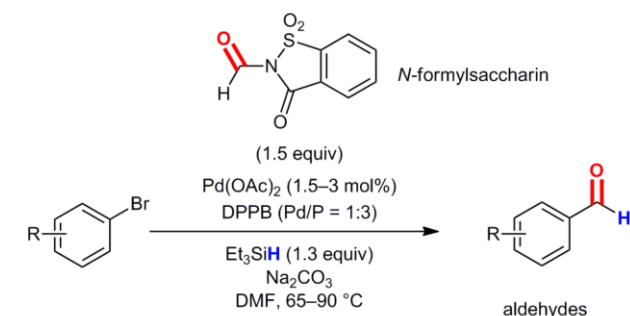
Palladium-Catalyzed Reductive Carbonylation of Aryl Halides with *N*-Formylsaccharin as a CO Source

Angew. Chem. Int. Ed. **2013**, *52*, 8611–8615

Carbon monoxide (CO) is widely used for transition-metal-catalyzed carbonylation reactions, such as hydroformylations, Reppe-type chemistry or CO insertions on aromatic halides and related substrates. However, CO gas is highly toxic and not easy to handle safely. Therefore, “CO gas free” carbonylation chemistry has become the focus of extensive research. Recently, Professor Kei Manabe and members of his group in the School of Pharmaceutical Sciences at the University of Shizuoka (Japan) reported on the palladium-catalyzed carbonylation of aryl halides with CO sources such as phenyl formate (*Org. Lett.* **2012**, *14*, 3100) and 2,4,6-trichlorophenyl formate (*Org. Lett.* **2012**, *14*, 5370) for the synthesis of carboxylic acid derivatives. Professor Manabe said: “Now, we have developed a method of reductive carbonylation for the

synthesis of aldehydes. The key of the reaction is the use of *N*-formylsaccharin as a crystalline CO source that can be handled easily. *N*-Formylsaccharin was originally developed by Professor Cossy as a new and inexpensive formylating agent for amines (*Synlett* **2011**, 1920), and we found that it gradually generates CO in situ in the presence of Na₂CO₃.” Aromatic and heteroaromatic aldehydes can be synthesized from the corresponding halides and triflates in good yields. This reductive carbonylation is advantageous over traditional reactions under an atmosphere of CO gas, not only because *N*-formylsaccharin is easy to handle but also because gradual generation of near-stoichiometric CO can avoid the catalyst deactivation that is sometimes observed in reactions under an atmosphere of CO gas (i.e., in the presence of large excess of CO).

Professor Manabe concluded: “Thus, this ‘easy-peasy’ reductive carbonylation will provide an efficient method for the synthesis of various aldehydes.” Indeed, the reaction scope is remarkably broad, and structurally diverse bromoaryl or bromoheteroaryl derivatives having either electron-deficient or electron-rich cores can be successfully subjected to this carbonylation reaction, which holds promise to find wide application in organic synthesis.



Scheme 1 Pd-catalyzed reductive carbonylation using *N*-formylsaccharin as a CO source

Matteo Zanda

About the authors



Dr. T. Ueda

Dr. T. Ueda is currently an Associate Senior Researcher in Daiichi Sankyo Co., Ltd., working on the development of practical synthetic methods and large-scale synthesis of active pharmaceutical ingredients.



Prof. H. Konishi

Tsuyoshi Ueda was born in Ishikawa prefecture (Japan) in 1978. He received his M.S. degree in 2003 in Industrial Chemistry from Meiji University (Japan) and subsequently joined the Department of Process Development at Sankyo Co., Ltd. He completed his Ph.D. under the guidance of Professor Kei Manabe at the University of Shizuoka (Japan) in 2013. He is currently an Associate Senior Researcher in Daiichi Sankyo

Hideyuki Konishi was born in Takamatsu (Japan) in 1979. He obtained his Ph.D. in Pharmaceutical Sciences at The University of Tokyo (Japan) in 2008 under the direction of Professor Shū Kobayashi. He carried out his postdoctoral research in Professor Viresh H. Rawal's laboratory at the University of Chicago (USA). In 2009, he became a Research Assistant Professor in the group of Professor Kei Manabe at the University of

Shizuoka. His research interests include the development of practical and efficient catalytic reactions for the construction of pharmaceutically and synthetically important compounds.



Prof. K. Manabe

Professor in 2009. His research interests include the development of new catalytic reactions for organic synthesis.

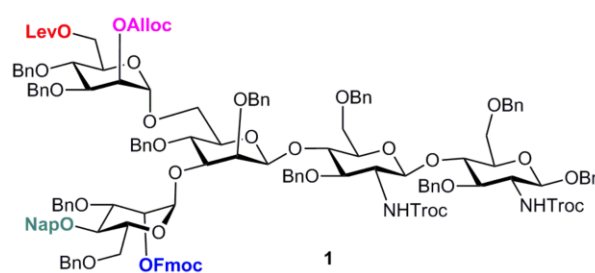
Kei Manabe was born in Kanagawa (Japan). He completed his doctoral work in 1993 at The University of Tokyo. After working as a postdoctoral fellow at Columbia University (USA), he went back to the University of Tokyo and worked as an Assistant Professor, Lecturer, and Associate Professor. In 2005, he moved to RIKEN (Japan) as an Initiative Research Scientist. He joined the faculty at the University of Shizuoka as a

A General Strategy for the Chemoenzymatic Synthesis of Asymmetrically Branched *N*-Glycans

Science 2013, 341, 379–383

■ Glycans are oligo- or polysaccharides in which monosaccharide units are linked through O-glycosidic bonds. *N*-Linked glycans constitute a particular class of glycans, which are attached in the cellular endoplasmic reticulum to the side-chain nitrogen of asparagine in the so-called ‘sequon’, which is an Asn-X-Ser or Asn-X-Thr tripeptide sequence, where X is any amino acid except proline and the glycan can be *N*-acetyl galactosamine, galactose, neuraminic acid, fructose or other monosaccharides. Of all the post-translational modifications of proteins, complex *N*-linked glycans are the most prominent in terms of complexity and diversity. Although these compounds, which are essential mediators of a number of biological processes such as protein folding, cell signalling and proliferation, are usually asymmetrically branched, synthetic efforts have focused almost exclusively on the preparation of simpler symmetrical structures. This stems from the difficulties in controlling diversification at the various sites of branching, especially when several different complex terminal structures need to be appended. Recently, the group of Professor Geert-Jan Boons from the University of Georgia (Athens, USA), in collaboration with researchers from the Scripps Research Institute (La Jolla, USA), published a novel revolutionary chemo-enzymatic strategy that makes it possible to prepare libraries of highly complex symmetrical and asymmetrical *N*-glycans.

Professor Boons said: “Unique aspects of the approach include the use of a core pentasaccharide **1** that is common to all eukaryotic *N*-linked glycans and is modified at key branching positions by a set of orthogonal protecting groups that makes it possible to diversify by chemical glycosylation.” The speed of oligosaccharide synthesis and the complexity of the targets were further increased by the identification of saccharide appendages that allowed each antenna of deprotected compounds to be uniquely extended by glycosyltransferases. Professor Boons continued: “Further control of regioselectivity in antenna modification was achieved by exploiting the inherent selectivities of glycosyltransferases. It is the *unique combination of these strategic features* that made it possible to prepare the most complex *N*-glycan ever reported, being tri-antennary and having different complex oligosaccharide extensions at each antenna.”



The new synthetic strategy will make it possible to fabricate the next generation of glycan microarrays, to develop algorithms for the assignment of MS spectra, and prepare well-defined glycoforms of glycoproteins.

“We are focusing on the preparation of full *N*-glycomes of bronchial epithelial cells, oocytes and immune cells,” said Professor Boons. He concluded: “The resulting compounds will be employed to define the biological glycan receptors of influenza virus, and glycans that are important for fertilization and modulating immunological reactions. The novel compounds will also be employed as standards in developing better protocols for structural identification of glycans isolated from natural sources.” ■

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About the authors



Dr. G.-J. Boons

Geert-Jan Boons received an M.Sc. in Chemistry in 1987 and a Ph.D. in Synthetic Carbohydrate Chemistry in 1991 from the State University of Leiden (The Netherlands). Prior to joining the faculty at the Complex Carbohydrate Research Center (CCRC) at the University of Georgia (Athens, USA) in 1998, he spent seven years in the UK, first as a Postdoctoral Fellow at Imperial College, London, and the University of Cambridge, and then as a Lecturer and Professor at the University of Birmingham. In 2003, Dr. Boons was awarded the Carbohydrate Research Award for Creativity in Carbohydrate Science by the European Carbohydrate Association. Also in 2003, he was elected Chairman for the 2005 Gordon Research Conference on Carbohydrates. In 2004, Dr. Boons received the Horace Isbell Award by the Division of Carbohydrate Chemistry of the American Chemical Society and was appointed Franklin Professor of Chemistry in the College of Arts and Sciences at the University of Georgia. In 2012, he received the Creative Research Inventor's Award by the University of Georgia Research Foundation and was appointed Distinguished Professor in Biochemical Science in the Franklin College of Arts and Sciences at the University of Georgia. He was awarded the Roy L. Whistler International Award in Carbohydrate Chemistry for 2013 by the International Carbohydrate Organization. The research of the Boons group deals with the synthesis and biological functions of complex carbohydrates and glycoconjugates.



Z. S. Chinoy

Zoeisha S. Chinoy received her Bachelor of Science in Chemistry from the University of West Georgia (Carrollton, USA) in 2008, where she pursued undergraduate research under the supervision of Professor Partha S. Ray. She then enrolled in the PhD Program in Chemistry at the University of Georgia. Since 2009, she has been a student in Professor Geert-Jan Boons' laboratory. Her doctoral studies focus on the synthesis of glycopeptides and the chemo-enzymatic synthesis of complex *N*-glycans.



Dr. Z. Wang

Zhen Wang received his Ph.D. from the University of Toledo (USA) in 2008 under the supervision of Professor Xuefei Huang. After one year postdoctoral training at Michigan State University (East Lansing, USA) in the same research group, he joined the CCRC as a Postdoctoral Research Associate under the guidance of Professor Geert-Jan Boons. He is currently a research scientist at Momenta Pharmaceuticals, Inc.



Dr. S. Ambre

Shailesh Ambre was born in Baroda (India). He was awarded his Bachelors in Applied Chemistry from Sardar Patel University (India) in 2001 and his Masters in Organic Chemistry from M. S. University of Baroda (India) in 2004. After a short productive stay in industry as a process chemist, Shailesh moved to the University of Georgia to pursue doctoral studies. He joined the group of Professor Geert Jan Boons at the CCRC and graduated with a PhD in the summer of 2012. Currently, Shailesh is a Postdoctoral Fellow at the Centennial Centre for Interdisciplinary Science, University of Alberta (Canada) in the group of Professor Ratmir Derda.

Young Career Focus: Professor Mary P. Watson (University of Delaware, Newark, USA)

■ **Background and Purpose.** *SYNFORM* will from time to time meet 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 *SYNSTORY* with a **Young Career Focus** presents Professor Mary P. Watson, University of Delaware, Newark, USA.

BIOGRAPHICAL SKETCH



Prof. M. P. Watson

Mary P. Watson was born in Boston, MA (USA) in 1977 and grew up in Tampa, FL (USA). She completed an A.B. in Chemistry at Harvard University (USA) in 2000. During college, she performed undergraduate research with Professor David A. Evans at Harvard University, as well as with Professor Kenneth B. Wagener at the University of Florida (USA). Under the direction of Professor

Larry E. Overman, Mary earned a Ph.D. in organic chemistry in 2006 from the University of California, Irvine (USA). Her doctoral thesis focused on the development and mechanistic investigation of the palladium(II)-catalyzed asymmetric allylic imidate rearrangement. During the course of this work, she had the opportunity to collaborate with Professor Robert G. Bergman at the University of California, Berkeley (USA), where she performed kinetic and computational studies.

From 2006–2009, Mary was a National Institutes of Health NRSA Postdoctoral Fellow at Harvard University in Professor Eric N. Jacobsen's research group. During her postdoc, she developed a nickel-catalyzed method for enantioselective olefin arylation via activation of C–CN bonds.

In July 2009 Mary joined the faculty at the University of Delaware, where she has been working with her research group to develop new catalytic methods for the synthesis of organic molecules. The group's work has been recognized by a Rising Star Award from the American Chemical Society Women Chemists' Committee and a Thieme Chemistry Journal Award. Their research has been generously supported by the University of Delaware Research Foundation, the American Chemical Society Petroleum Research Fund, the NIH COBRE program, and an NSF CAREER grant.

INTERVIEW

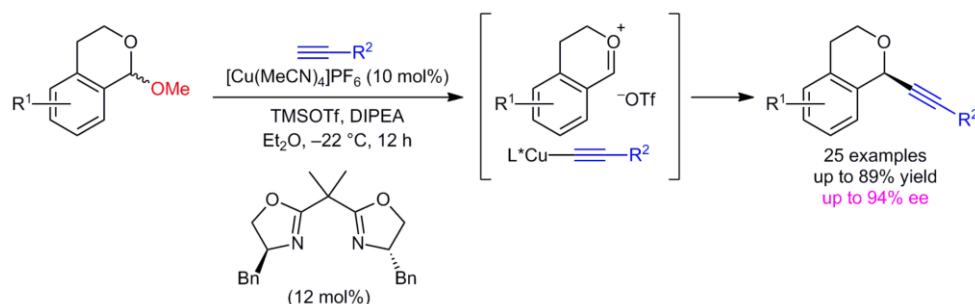
SYNFORM | *What is the focus of your current research activity?*

Prof. M. P. Watson | We are developing new catalytic methods for organic synthesis. In particular, we are focused on transition-metal catalysis of non-traditional electrophiles to enable the efficient preparation of highly enantioenriched products. In one area, we are developing enantioselective additions to cationic intermediates, such as oxocarbenium ions, to deliver highly enantioenriched α -substituted heterocycles. In a second area, we have begun to develop enantiospecific, nickel-catalyzed cross-couplings of benzylic electrophiles to provide di- and tri-aryllkanes in high ee.

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

Prof. M. P. Watson | As a high-school and college student, one of the first things that intrigued me about chemistry was its hands-on aspect. I loved being able to observe color changes, crystals forming, exotherms, etc. I felt a special satisfaction from collecting a high yield of pure, white solid at the end of a reaction and purification sequence. That was when I knew I wanted to synthesize organic compounds as my career.

As I matured in my understanding of chemistry, I became increasingly motivated by the many unsolved problems in organic synthesis. There are still so many reactions we cannot yet accomplish with high efficiency and selectivity and so many synthetic disconnections that we haven't discovered yet. Further, although we have begun to understand how catalysts impart reactivity and selectivity, we still lack the depth of understanding to rationally design catalysts in many cases and must rely on an empirical approach at least in part. These challenges highlight how much we have yet to discover in synthetic chemistry, and I am excited to be part of the community pushing our knowledge and capabilities forward.



Scheme 1

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

Prof. M. P. Watson | The importance of organic synthesis to human health, materials science, and energy research is undeniable. These applications emphasize the tremendous impact that advances in synthetic chemistry have on our daily lives.

It is exciting that new discoveries – new reactions, as well as synthetic strategies – are reported every day, pushing the frontier of organic synthesis forward. Current challenges to organic synthesis (increased efficiency, decreased cost and waste, greener reaction and purification conditions, etc.) require further innovation and discovery and are very motivating for my generation of chemists.

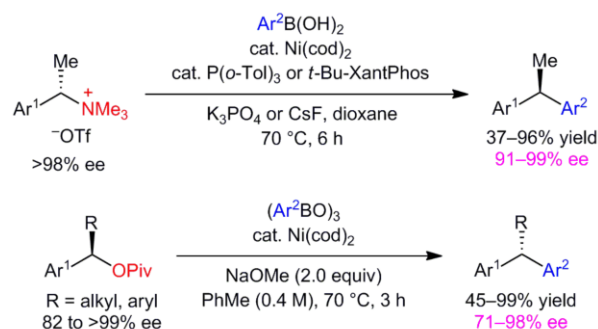
SYNFORM | Your research group is active at the frontier of organic synthesis and catalysis. Could you tell us more about your research and its aims?

Prof. M. P. Watson | In the celebrations for Nobel Laureate Richard Heck at the University of Delaware, I had the opportunity to interview him about his research and his motivation for developing the Heck reaction. He humbly stated that he was just trying to make life a little simpler. This pursuit – to make life simpler, to facilitate access to important molecules – sums up the ultimate goal of my research program. By discovering new catalytic methods, we hope to enable preparation of molecules crucial for advancing science.

More specifically, in our research on enantioselective additions to oxocarbenium ion intermediates, we have demonstrated that chiral copper catalysts enable highly enantioselective additions of terminal alkynes to prochiral oxocarbenium ions, formed in situ from racemic acetals (Scheme 1). We are excited about the potential of a metal-catalyzed

strategy for enantioselective additions to such intermediates and are aggressively developing analogous reactions with other classes of cationic intermediates, as well as other nucleophiles.

In our efforts on enantiospecific cross-couplings of benzylic electrophiles, we have demonstrated that di- and tri-arylalkanes can be prepared in exceptional levels of enantiopurity via nickel-catalyzed couplings of organoboranes with either benzylic ammonium triflates or benzylic pivalates (Scheme 2). Both these classes of electrophiles are particularly attractive, because they can be readily prepared with high enantioenrichment. Our mild reaction conditions enable excellent functional group tolerance, setting the stage for further elaboration of the enantioenriched products. We are now pursuing a deeper mechanistic understanding, as well as increased scope, of these reaction manifolds.



substrates widely available in high ee
excellent levels of stereoinversion
organoborane coupling partners
nickel-based catalysts
mild conditions
great functional group tolerance

Scheme 2

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

Prof. M. P. Watson | Within our research program on metal-catalyzed transformations of non-traditional electrophiles, we have demonstrated that metal catalysts can be effectively used to control reactivity and selectivity with a range of non-traditional electrophiles, including oxocarbenium and iminium ion intermediates, as well as benzylic ammonium salts and pivalates. Our results greatly expand the range of electrophiles amenable to transition-metal catalysis and offer exciting possibilities for organic synthesis. ■

Matteo Zanda



COMING SOON ►► COMING SOON ►►

SYNFORM 2013/12

is available from November 18, 2013

In the next issues:

SYNSTORIES ■ ■ ■ ■

■ Synchronous Ar–F and Ar–Sn Bond Formation through Fluorostannylation of Arynes

(Focus on an article from the current literature)

■ Direct Catalytic Cross-Coupling of Organolithium Compounds

(Focus on an article from the current literature)

■ Total Synthesis of the Daphniphyllum Alkaloid Daphenylline

(Focus on an article from the current literature)

FURTHER HIGHLIGHTS + + + +

SYNTHESIS

Review on: Current Developments in the Synthesis of 1,2-Dihydropyridines

(by A. M. S. Silva et al.)

SYNLETT

Special Issue dedicated to the 5th Young Investigators Workshop, July 4–6, 2013, Marseille, France*(contributions by all participants)*

SYNFACTS

Synfact of the Month in category "Synthesis of Heterocycles":

Organocatalytic Route to 2,3,4,6-Tetra- and 2,3,4,5,6-Pentasubstituted Pyridines

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