

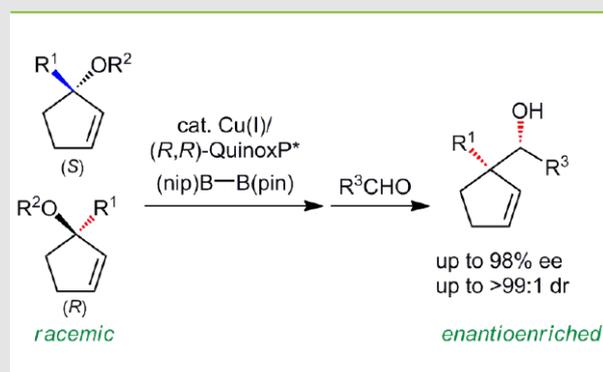
SYNFORM

People, Trends and Views in Synthetic Organic Chemistry

2011/01

SYNSTORIES ■ ■ ■ ■

■ **Direct Enantioconvergent Transformation of Racemic Substrates without Racemization or Symmetrization**



■ **Palladium-Catalyzed Cross-Coupling of Aryl Chlorides and Tosylates with Hydrazine**

■ **SYNTHESIS/SYNLETT Advisory Board Focus: Professor Max Malacria (Pierre and Marie Curie University – Paris VI, France)**

CONTACT ++++

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Dear readers,

We all find hopes in the New Year and most of us give thought to the positive things we would like to see the next twelve months bring to us in terms of good health, success and family peace. Personally I would also love to see

more attention for science, research and higher education by politicians and decision makers because it's especially in recession times like these that the three items above must be seen as a key investment rather than an expense. Key discoveries in the fields of Energy, Biomedicine and Materials Science have the potential to act once again as powerful springboards for a future of wellness and economic growth for the humankind, whereas with less science, research and education the future could just be worse, much worse.

Luckily, there is still a lot of great research ongoing and this first 2011 issue of **SYNFORM** reports on two examples of great research in organic chemistry: a new stunning methodology to achieve a biomimetic enantioconvergent transformation of racemic substrates developed by Professor H. Ito (Japan) and the first methodology allowing for the direct use of hydrazine in metal-mediated cross-coupling reactions discovered by Professor M. Stradiotto (Canada). The issue is completed by a profile of Professor M. Malacria (France), member of the **SYNTHESIS/SYNLETT** Advisory Board.

Enjoy your reading!

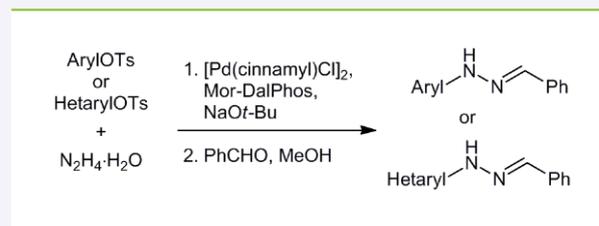
Matteo Zanda

Editor of SYNFORM

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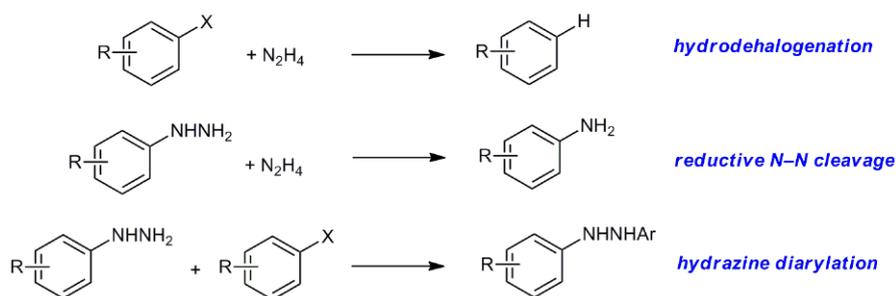
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Synform@chem.polimi.it

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

Palladium-Catalyzed Cross-Coupling of Aryl Chlorides and Tosylates with Hydrazine

Angew. Chem. Int. Ed. **2010**, *49*, 8686–8690



Common side reactions accompanying the use of hydrazine in cross-coupling reactions

■ Aryl hydrazines are key intermediates in the preparation of nitrogen-containing heterocycles, such as indoles (Fischer indole synthesis), indazoles and pyrazoles; however, the use of hydrazine in cross-coupling reactions is affected by several problematic metal-mediated side reactions.

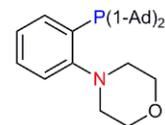
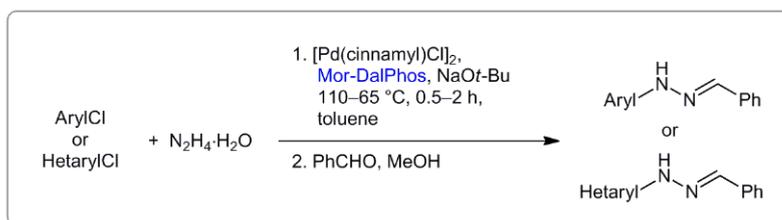
Recently, the group of Professor Mark Stradiotto from Dalhousie University (Halifax, Nova Scotia, Canada) published a novel methodology which promises to open new perspectives for hydrazine in metal-mediated organic synthesis. “Prior to our publication, the synthesis of aryl hydrazines directly from hydrazine sources had not been reported,” said Professor Stradiotto. “While hydrazine surrogates (which require deprotection following the cross-coupling reaction) with attenuated reactivity such as benzophenone hydrazone have been employed previously in cross-coupling chemistry, such strategies are not ideal from atom-efficiency or economic standpoints.” In this context, and given the success of Buchwald–Hartwig amination protocols, Professor Stradiotto and co-worker Rylan Lundgren sought to identify Pd catalysts supported by appropriately designed ancillary ligands that might enable the synthesis of aryl hydrazines directly from aryl halides/pseudohalides and hydrazine. “However, hydrazine is a very good reducing agent,” said Professor Stradiotto, “so side reactions where both the Pd catalyst and the aryl chloride substrate are converted into undesirable products was anticipated to be a major problem. The solution to the problem

that we discovered is found in the implementation of appropriate ancillary ligands to circumvent undesirable reactivity.” The methodology affords very good results and has a broad scope when applied to aromatic and heteroaromatic chlorides.

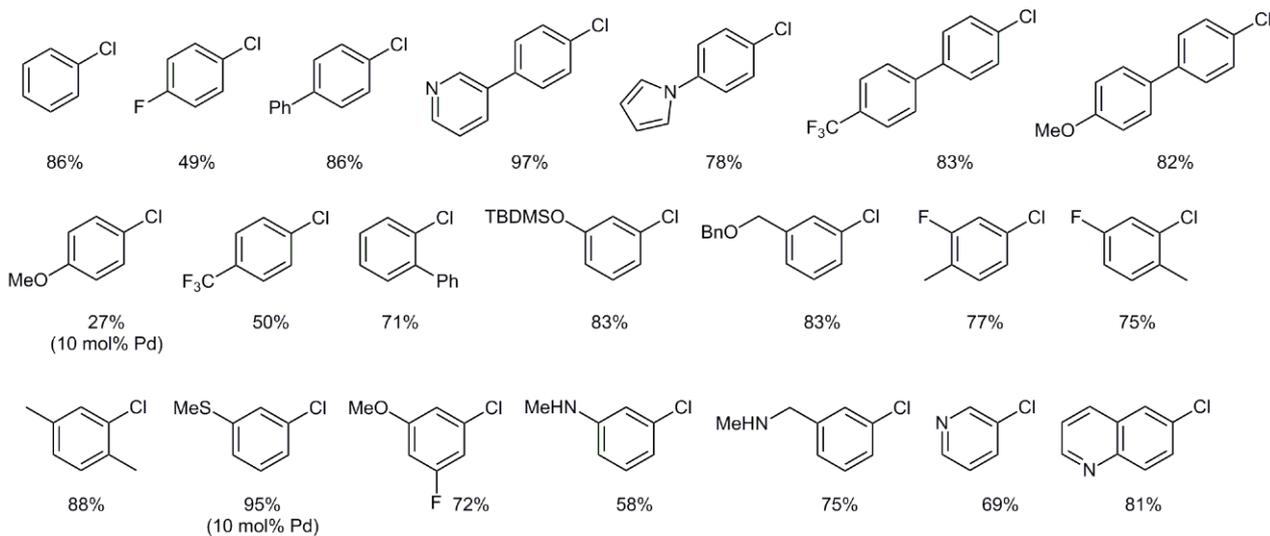
Very interesting results were also achieved with the corresponding tosylates.

“We are still in the process of understanding what makes the Mor-DalPhos ligand such a good ligand for hydrazine (and ammonia – as shown in our previous report in *Angew. Chem. Int. Ed.* **2010**, *49*, 4071) cross-coupling,” continued Professor Stradiotto. “It is a sterically demanding, bidentate ligand which may help the selectivity of the reaction. The bidentate ligand framework may also help in maintaining a monomeric catalyst species, preventing catalyst decomposition steps, as well as in promoting the C–N reductive elimination.”

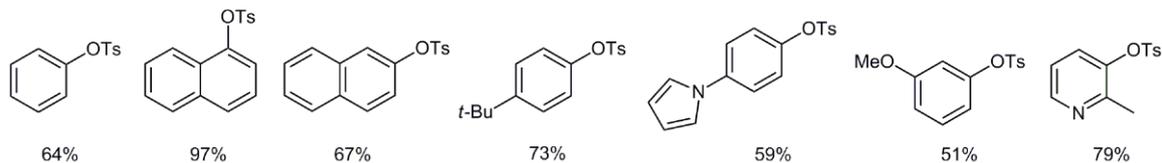
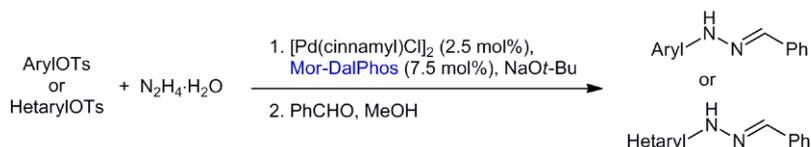
Professor Stradiotto explained that in their paper they also demonstrated that the bidentate bis(phosphine) ligand Josiphos worked well in this hydrazine cross-coupling reaction. “It should be noted that John Hartwig has extensively studied the use of Josiphos in alternative cross-coupling amination chemistry (including reactions involving ammonia) and we drew inspiration from his seminal work,” he acknowledged. “The transformations featured in our report are likely to have applications in pharmaceutical synthesis, including in the preparation of substituted indoles and related heterocyclic



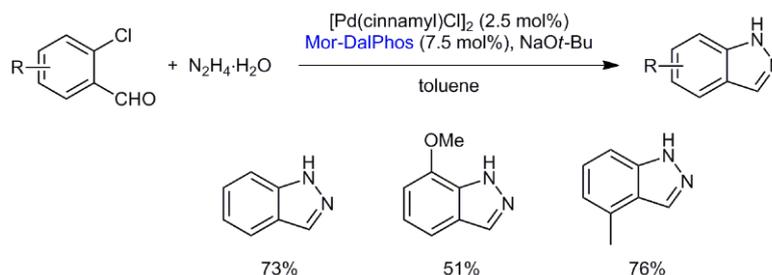
3–5 mol% Pd
4.5–7.5 mol% **Mor-DalPhos**



Stradiotto's methodology applied to aromatic and heteroaromatic chlorides



Stradiotto's methodology applied to aromatic and heteroaromatic tosylates



Stradiotto's methodology applied to the synthesis of indoles

molecules, especially if we can continue to improve on the reaction conditions (less Pd, milder bases, lower temperatures) and broaden the substrate scope.”

“We are working on improving these aspects of the reaction as well as on incorporating hydrazine cross-coupling into tandem catalytic reactions,” concluded Professor Stradiotto.

Matteo Zanda

About the authors



Dr. R. J. Lundgren

Professor Stradiotto, and he successfully defended his PhD thesis in October 2010. Rylan is now a Natural Sciences and Engineering Research Council of Canada Postdoctoral Fellow in the group of Professor Greg Fu at the Massachusetts Institute of Technology (USA).

Rylan J. Lundgren was born in Winnipeg (Canada) and received his BSc (Hons.) in chemistry from the University of Manitoba (Winnipeg, Canada) in 2006 where he performed research under the guidance of Professor M. Bieringer. He also conducted research in 2005 with Professor D. Fogg at the University of Ottawa (Canada). In 2006, he began his PhD studies at Dalhousie University (Canada) under the supervision of



Prof. M. Stradiotto

the rank of Professor with tenure. Mark was awarded the Dalhousie University Undergraduate Chemistry Society Teaching Award in 2002, and again in 2005. In 2005, he was also awarded the Dalhousie University Killam Research Prize, and in 2006 the Dalhousie Innovation Award as well as the Harry Shirreff Research Prize. In 2009, Mark became a member of the editorial board of *Organometallics*, and was a recipient of the Thieme Chemistry Journal Award.

Mark Stradiotto completed his PhD in organometallic chemistry in 1999 at McMaster University (Hamilton, Ontario, Canada) under the supervision of Professors M. A. Brook and M. J. McGlinchey, and then worked at the University of California at Berkeley (USA) as an NSERC Postdoctoral Fellow with Professor T. D. Tilley. In 2001, he moved to the Department of Chemistry at Dalhousie University as an Assistant Professor, and now holds

Direct Enantio-Convergent Transformation of Racemic Substrates without Racemization or Symmetrization

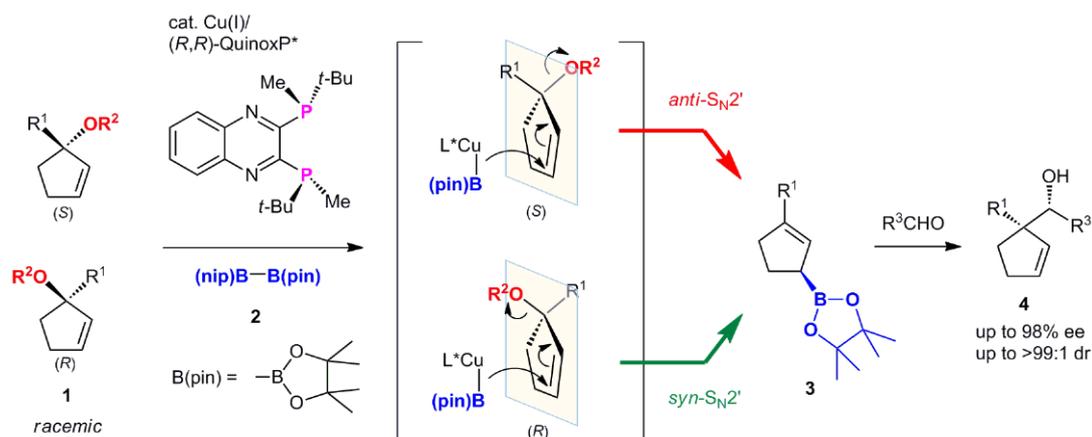
Nat. Chem. **2010**, *2*, 972–976

Catalytic asymmetric synthesis has been attracting a great deal of attention because optically active compounds are very important as fine chemicals and drugs and therefore, have generally high value. Racemic compounds, which are considerably less expensive than enantiopure compounds, are convenient starting materials for enantiomeric enrichment or separation. Prochiral substrates are also attractive for the preparation of non-racemic molecules through asymmetric processes. Conventional kinetic resolution can afford a maximum of only 50% of the products even in an ideal case. Elegant deracemization methods that can afford optically active compounds after 100% conversion of the racemic substrates, such as dynamic kinetic resolution (DKR) and dynamic kinetic asymmetric transformation (DYKAT), were thus developed. However, these processes require racemization or symmetrization of the substrates or intermediates, and are therefore limited in terms of substrate scope.

Recently the group of Professor Hajime Ito from Hokkaido University (Japan) developed the first chemical direct enantioconvergent transformation of racemic substrates. This striking reaction does not include racemization or symmetrization processes but can convert racemic starting material into the enantioenriched desired product with high enantiomeric purity even at full conversion conditions. The key of this counterintuitive reaction is that the catalyst can promote two independent pathways for each enantiomer.

“This reaction is based on the copper-catalyzed borylation,” explained Professor Ito, “which was first reported by us in 2000 and further developed to allylic substitution in 2005.^{1–3} The reaction of racemic allylic electrophile **1** with bis(pinacolato)diboron **2** was carried out in the presence of copper(I) catalyst with chiral diphosphine ligand (*R,R*)-QuinoxP*. The racemate was fully converted into the corresponding optically active allylboronate **3** in high yield with high enantioselectivity,” he explained. “In this reaction, one enantiomer of the starting material reacts with the borylcopper species through a stereoinversion-like *anti*-S_N2' pathway, whereas the other enantiomer undergoes a stereoretention-like *syn*-S_N2' pathway. These two different pathways gave the same desired product, resulting in an enantioconvergent transformation.”

The reaction products are optically active α -chiral allylboronates, which are valuable synthetic reagents because these compounds can react with aldehydes in a stereospecific manner. “The cyclic allylboronate with an alkyl substituent at the γ -position of the boryl group can only be obtained by this method. These allylboronates produced optically active compounds **4** with an all-carbon stereocenter, which is an important synthetic target structure. This reaction provides a new synthetic method for optically active allylboronates and their derivatives with high value,” said Professor Ito.



“However, the most important point of this study is that our findings represent a conceptually new asymmetric reaction,” he continued. According to Professor Ito, this type of direct enantioconvergent reaction has already been found in a few biocatalyst systems and is potentially a very powerful way to convert racemates into optically active compounds.⁴ “However, this reaction has received little attention from synthetic chemists,” said Professor Ito. “One reason for this could be the very stringent requirements of this reaction. In fact, the catalyst should recognize two substrate enantiomers and promote two distinctive pathways for each enantiomer, and each pathway should have opposite stereospecificity to produce the same enantiomer of the product. We have found that this enantioconvergent method can be achieved by a chemical catalyst,” said Professor Ito. “This reveals a new concept for designing asymmetric reactions for racemic compounds that have robust chirality – this is a remarkable innovation because those racemates with stereogenic structures that are difficult to racemize or symmetrize have long been abandoned in this field. We believe that our paper will open the way to the development of new efficient asymmetric synthetic processes from racemates,” he concluded. ■

Matteo Zanda

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- (4) K. Faber *Chem. Eur. J.* **2001**, *7*, 5004.

About the authors



From left: Prof. H. Ito, Mr. S. Kunii (Prof. M. Sawamura not present)

Hajime Ito graduated from Kyoto University (Japan) in 1991 where he received his PhD degree as a student of Professor Yoshihiko Ito in 1996. After working with Professor Akira Hosomi from 1996 to 1999 as an Assistant Professor at Tsukuba University (Japan), he moved to the Institute for Molecular Science (Okazaki, Japan). He also pursued his academic career at The Scripps Research Institute (USA) from 2001 to 2002 under the guidance of Professor Kim D. Janda. After he joined the research group of Professor Masaya Sawamura at Hokkaido University as an Associate Professor in 2002, he was promoted to Full Professor at the Graduate School of Engineering, Hokkaido University in 2010. In 2008, he was selected as a researcher of the JST PRESTO project on “Photon on Soft Materials”. His research interests include new synthetic reactions with transition-metal catalysts and new functional organometallic materials. He received The Progress Award in Synthetic Organic Chemistry, Japan (2007).

Shun Kunii is a graduate student of the Graduate School of Science, Hokkaido University (Japan). He started his research course in Professor Ito’s group in 2008. Shortly after he started his research on the copper(I)-catalyzed substitution of allylic substrates, he found a racemic allylic substrate which was fully converted into the corresponding optically active allylboronate. Most of the experiments in this paper were carried out by him.

SYNTHESIS/SYNLETT Advisory Board Focus: Professor Max Malacria (Pierre and Marie Curie University – Paris VI, France)

■ **Background and Purpose.** *SYNFORM* will from time to time portrait *SYNTHESIS/SYNLETT* 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. In this issue, we present Professor Max Malacria from the Pierre and Marie Curie University – Paris VI (France).

INTERVIEW

SYNFORM | Professor Malacria, which are your main current research interests?

M. Malacria | Radical and organometallic chemistry in sustainable chemistry.

These two subjects are directed toward the same goal which is a quick and controlled access to complex polycyclic molecules starting from acyclic polyunsaturated derivatives. These two axes lead to total synthesis of natural molecules and analogues. Besides, physical chemistry interfaces are developing rapidly, and this is carried out in symbiosis with homologues, on the other side of the interface.

BIOGRAPHICAL SKETCH



Prof. M. Malacria

Max Malacria obtained his PhD degree in chemistry at the University of Aix-Marseille III (France) with Professor M. Bertrand in 1974. He then started his academic career as *Assistant* at the University of Lyon I (France) and was appointed *Maître Assistant* in 1978. After postdoctoral work with Professor K. Peter C. Vollhardt at the University of California at Berkeley (USA), he moved back to the University of Lyon I as *Maître de Conférences* in 1983. From July to September 1986, he returned to the University of California at Berkeley as a Fulbright Scholar. In 1988, he was promoted Professor of Organic Chemistry at Pierre and Marie Curie University – Paris VI where now he is also a senior member of the *Institut Universitaire de France*. He has been a visiting professor at various places, namely in Switzerland (Fribourg 1996, Zurich 2000), Italy (Florence 1997, Milan 2006), Belgium (Namur 2004, Louvain la Neuve 2004), Spain (Alicante 2005), Israel (Haifa 2004), Japan (Osaka, 2003), Taiwan (Taichung, 2006), and recently in China (2007). He developed links with the world of industry thanks to

collaborations with various pharmaceutical or chemical companies (Sanofi–Aventis, Rhodia, Pierre Fabre, Glaxo, Servier, etc.). Professor Malacria has supervised the work of 66 PhD students and published their work in over 260 scientific papers. He has developed new directions for research, centered both on organometallic chemistry (Pd, Co) and on radical chemistry. These two subjects were directed toward the same goal which was a quick and controlled access to complex polycyclic molecules starting from acyclic polyunsaturated derivatives. These two axes have diverged in several directions, leading to organometallic chemistry of platinum and gold compounds, to the introduction of heteroelements as a means of controlling selectivity in radical chemistry and beyond in a very precise way, and to the total synthesis of natural molecules and analogues. Recently, Professor Malacria has extended his fields of interest to include the development of physical chemistry interfaces (modelling of organometallic reactivity), nanotechnologies (study of auto-assemblies), and inorganic and biological molecular chemistry (synthesis of hybrid polyoxometallates able to interact with biopolymers). His work was rewarded with the *Médaille d'Argent du CNRS* in 2001 and with the *Catalan Sabatier Prize of the Real Sociedad Española de Química* (2009).

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

M. Malacria | My most important achievement is the discovery of very efficient radical or transition-metal-catalyzed reaction cascades allowing the chemo-, regio- and stereo-selective construction of complex polycyclic natural or unnatural compounds as well as the development of new platinum- and gold-catalyzed cycloisomerization reactions.

SYNFORM | *What is the main goal in your scientific career?*

M. Malacria | My main goal is to transfer my passion for chemistry to my students and co-workers. And of course my priority is to spend as much time as possible in my lab to keep in touch with the teams and the research in progress. I always find that other tasks take so much time that I can't devote to my students and researchers! Apart from teaching, the weekly seminar of my own team is a highlight of my activities and an essential one, giving the opportunity for each PhD researcher to share his work with others and with me and exchange questions and remarks.

SYNFORM | *Do you have hobbies, besides chemistry?*

M. Malacria | I live in Paris for the sake of chemistry but I love the south of France where I was born, and nature in general, my favorite color is green! So, I need the contact with nature and that's why hiking is one of my hobbies. I particularly love to go for long walks in Corsica, which I visit regularly.

Yet, Paris can be compared to nothing when I want to go and watch films, new or old ones, listen to music or go to restaurants, which are hobbies I am also profoundly dedicated to! ■

Matteo Zanda



COMING SOON ►► COMING SOON ►►

SYNFORM 2011/02 is available from January 19, 2011

In the next issues:

SYNSTORIES ■ ■ ■ ■ ■

■ Chiral Brønsted Acid Catalyzed Enantioselective α -Aminoxylation of Enecarbamates

(Focus on an article from the current literature)

■ Catalytic Intermolecular Tail-to-Tail Hydroalkenylation of Styrenes with α -Olefins

(Focus on an article from the current literature)

FURTHER HIGHLIGHTS + + + +

SYNTHESIS

Review on: Nitrogen-Centered Radical Scavengers

(by M. R. Heinrich)

SYNLETT

Account on: Enantioselective Synthesis of Indole Alkaloids from Chiral Lactams

(by M. Amat)

SYNFACTS

Synfact of the Month in category "Polymer-Supported Synthesis": [Asymmetric Catalysis with MOFs Prepared via Chiral Induction Effect](#)

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