Aziridination of Alkenes

Research Center for Molecular Recognition and Synthesis

Reporter: Haolin Chen

Supervisor: Prof. Zhangjie Shi

Fudan University

2022-6-10

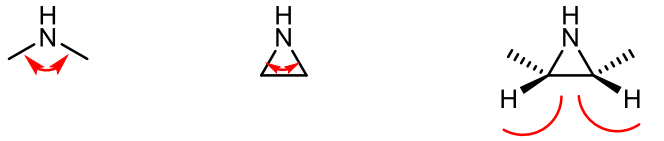
Catalogue

1. Background
2. Aziridination of Alkenes
    1. Catalyzed by Transition Metals
    2. By Electrochemical Oxidation
3. Summary and Outlook

Catalogue

1. Background
2. Aziridination of Alkenes
    1. Catalyzed by Transition Metals
    2. By Electrochemical Oxidation
3. Summary and Outlook

Background



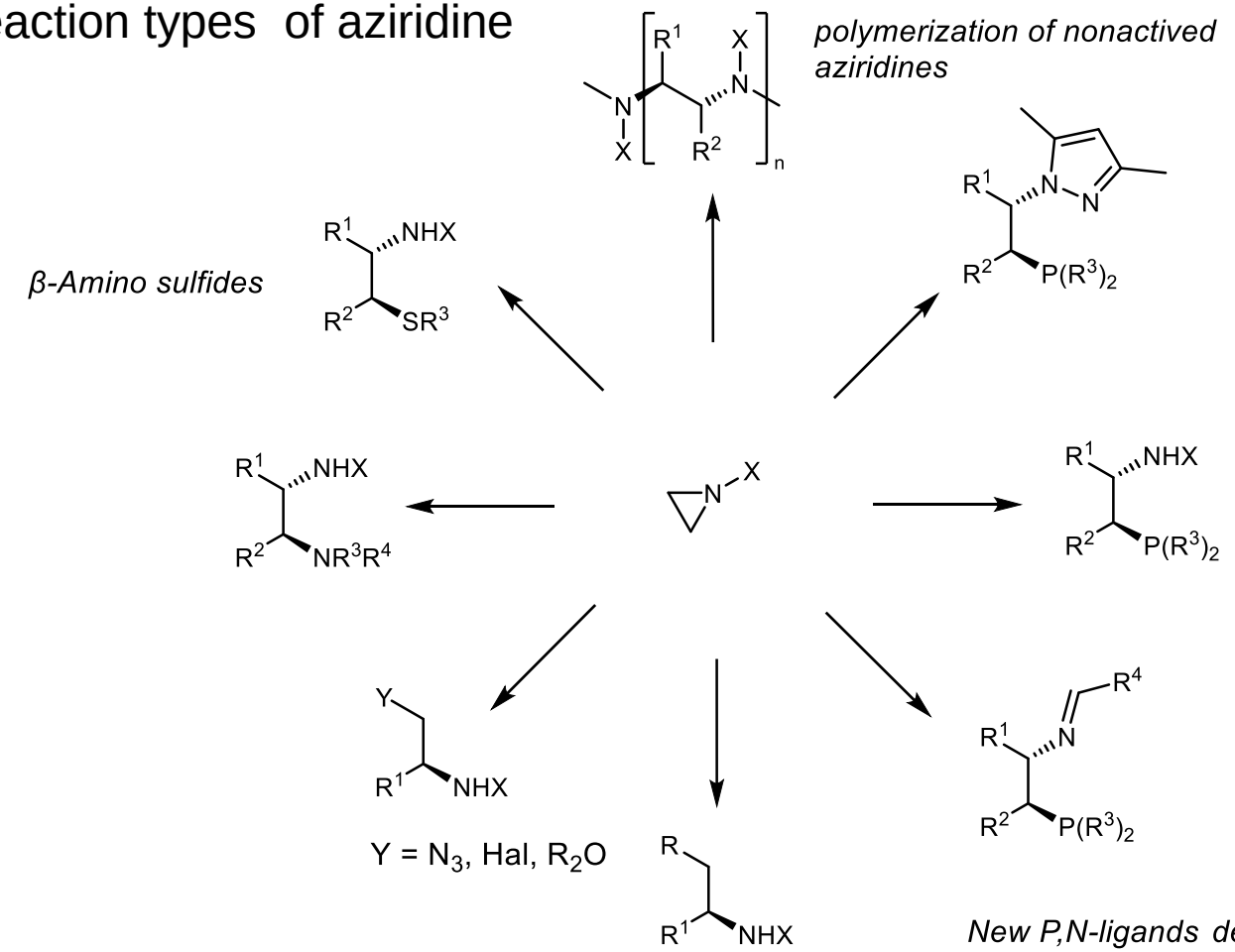
Bæyer strain/kJ·mol^{-1}


~111


~115

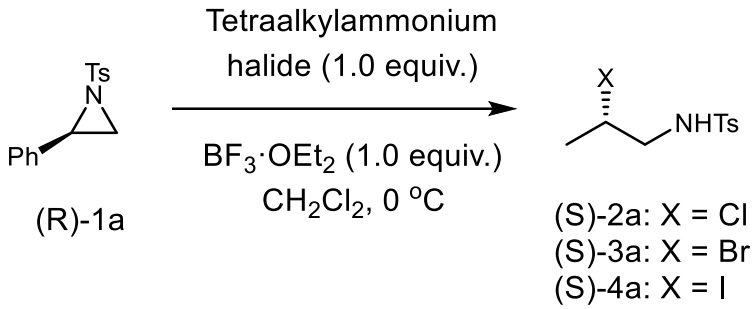

~114

Reaction types of aziridine

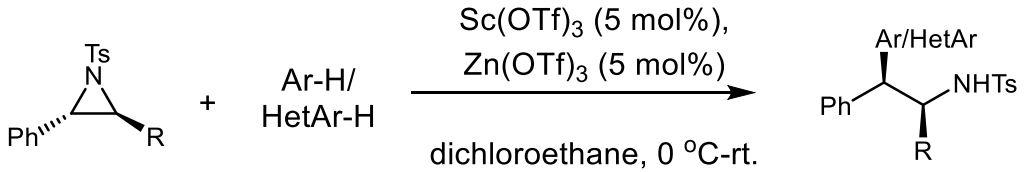


Background

Ghorai (2010)



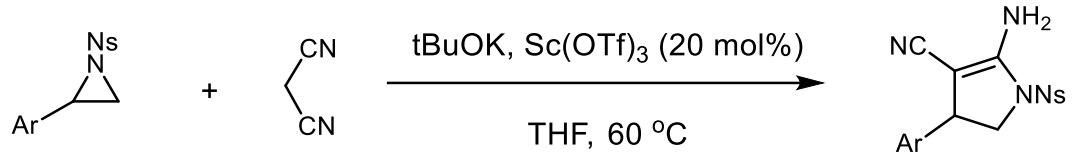
Ghorai (2013)

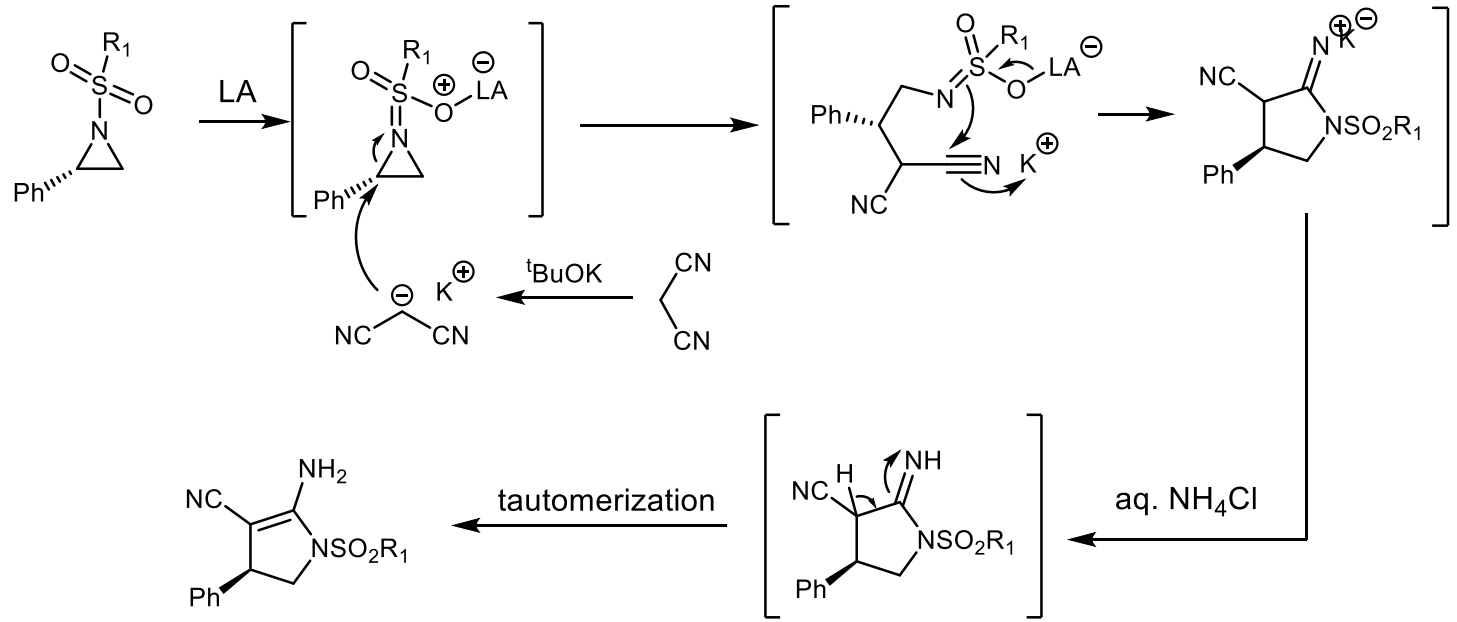


Ghorai, M. K., Kumar, A., Tiwari, D. P. *J. Org. Chem.* **2010**, *75*, 137–151.
Ghorai, M. K., Tiwari, D. P., Jain, N. *J. Org. Chem*. **2013**, *78*, 7121–7130.

Background

Ghorai (2013)

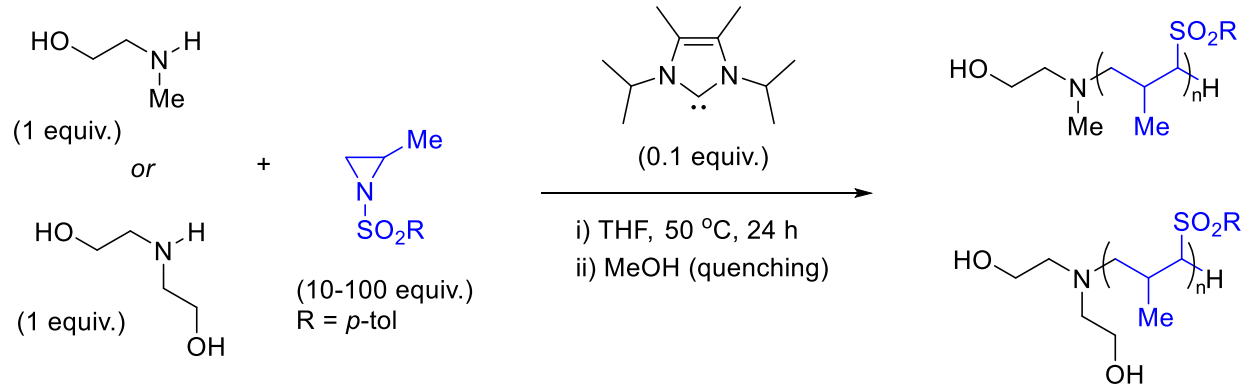


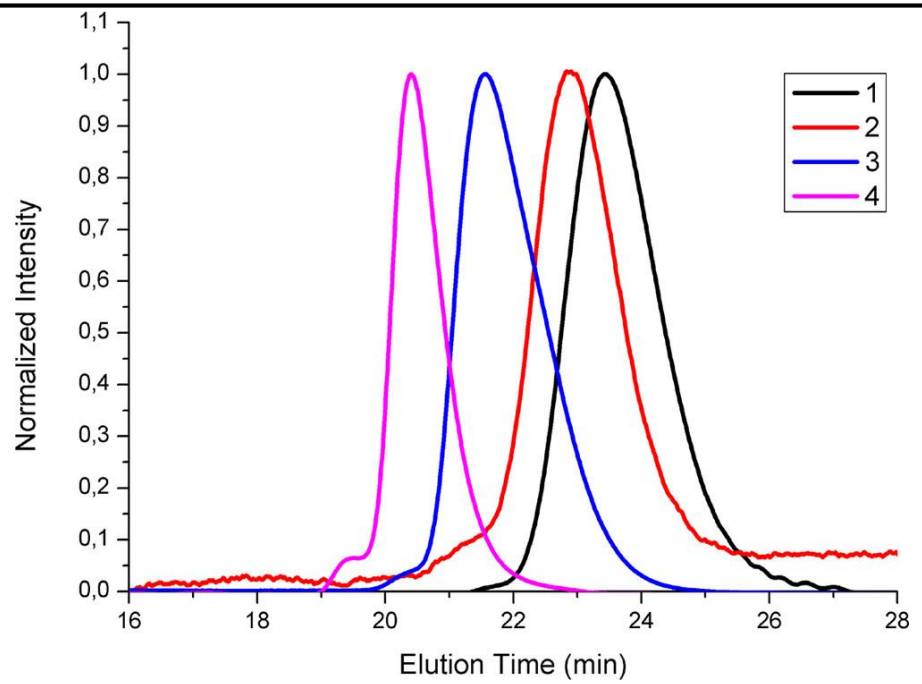


Ghorai, M. K., Tiwari, D. P. *J. Org. Chem*. **2013**, *78*, 2617-2625.

Background

Taton (2018)



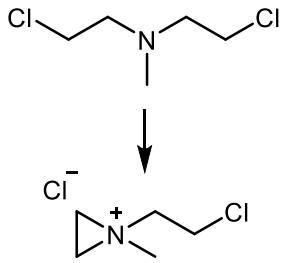


Run	[Az]/[Initiator]/[NHC]	$\overline{M_n}$
1	10/1/0.1	2650
2	20/1/0.1	3750
3	50/1/0.1	7800
4	100/1/0.1	16600

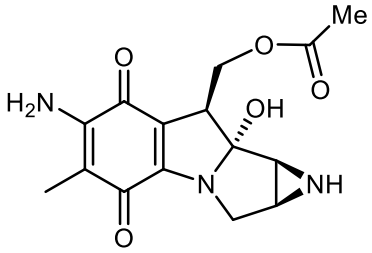
D. Taton, *et. al, Macromolecules,* **2018**, *51*, 2533-2541.

Background

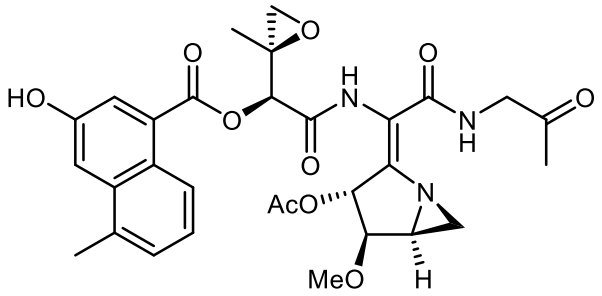
Nitrogen Mustard



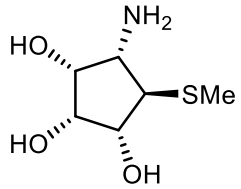
Mitomycin C



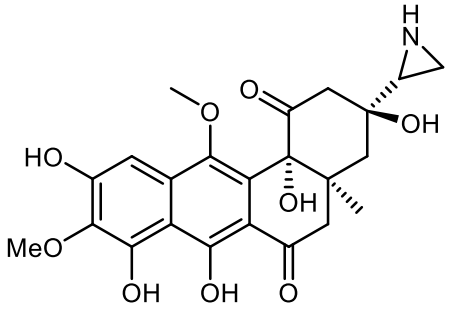
Azinomycin A



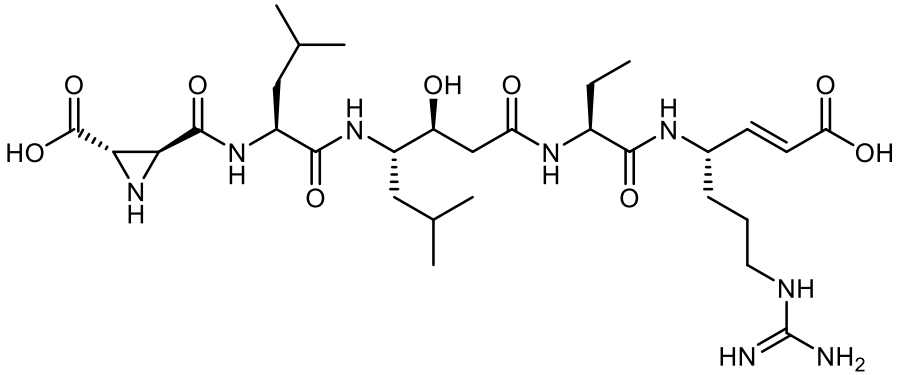
Mannostatin A



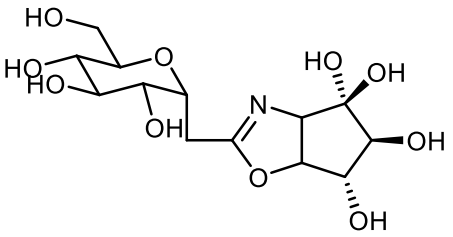
Azicemicin



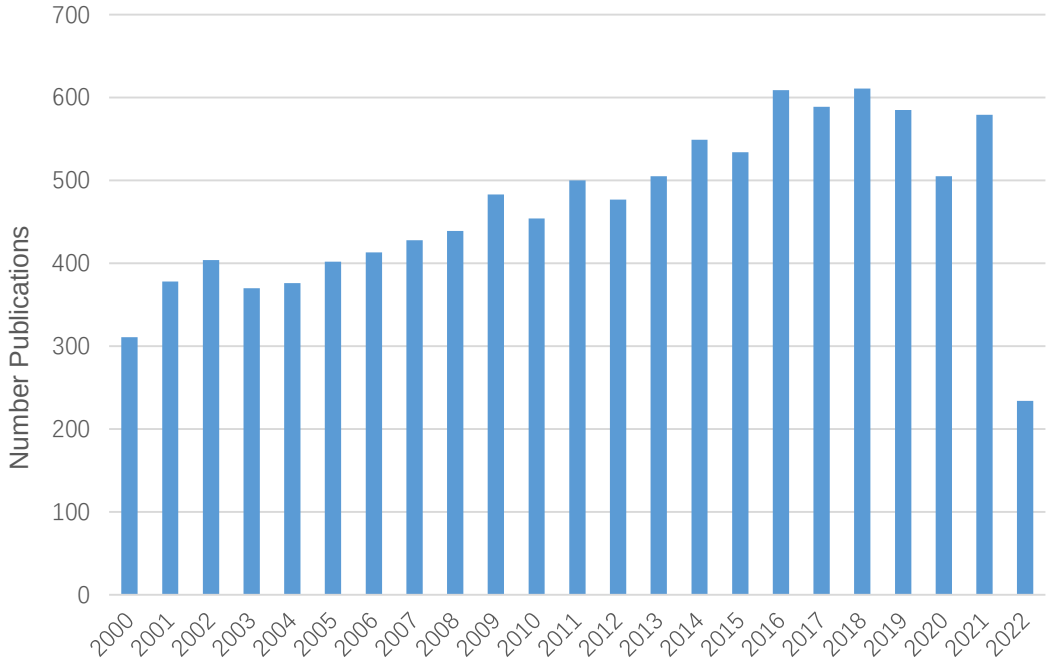
Miraziridine

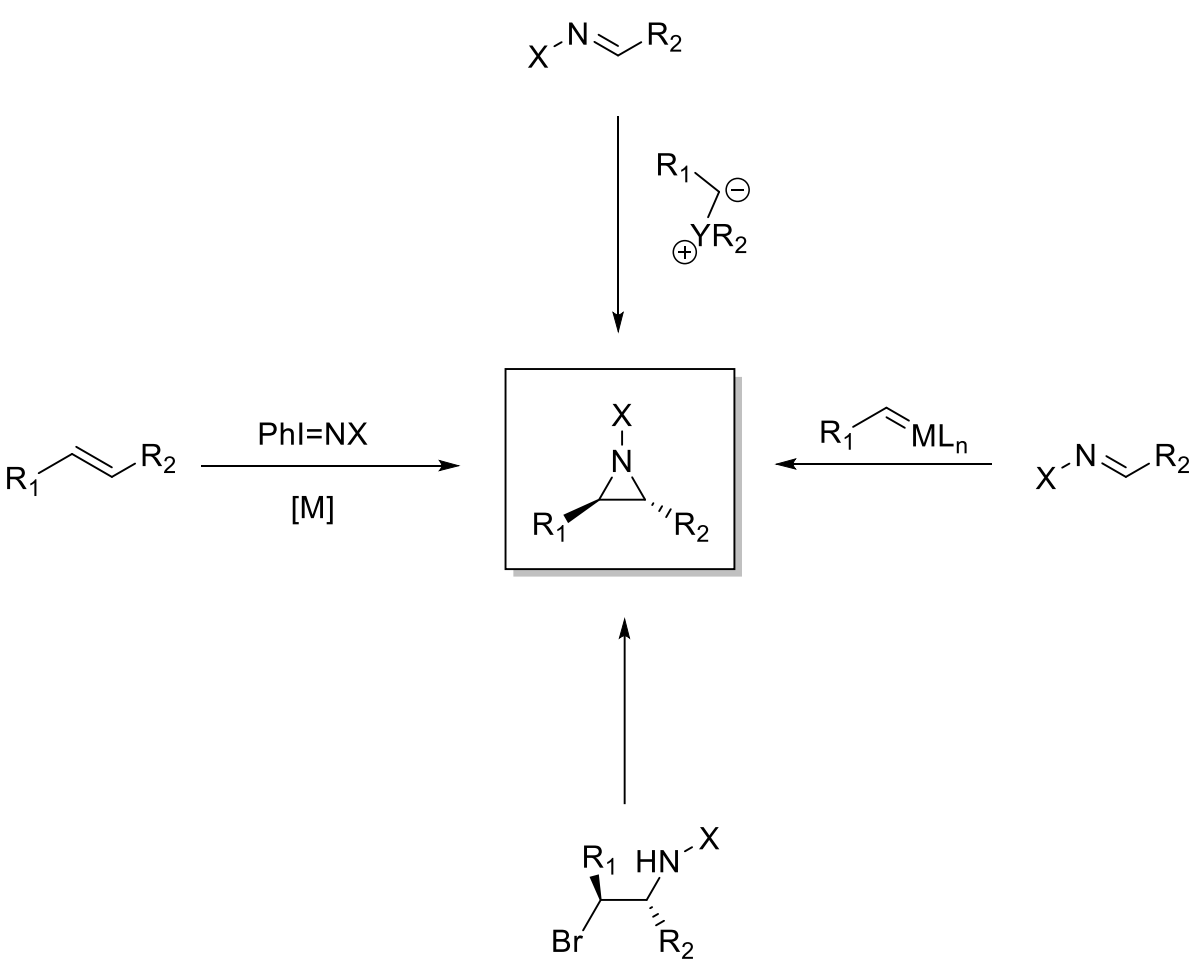


Trehazolin



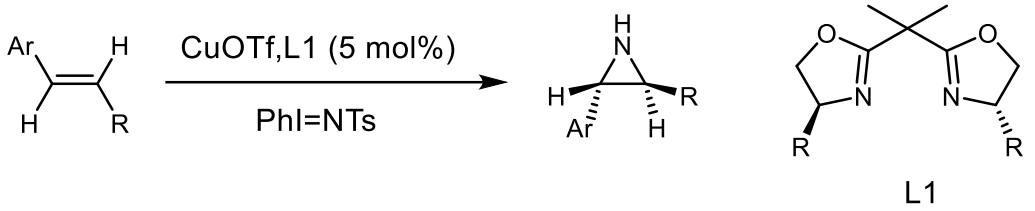
Background


Number Publications
700
600
500
400
300
200
100
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022

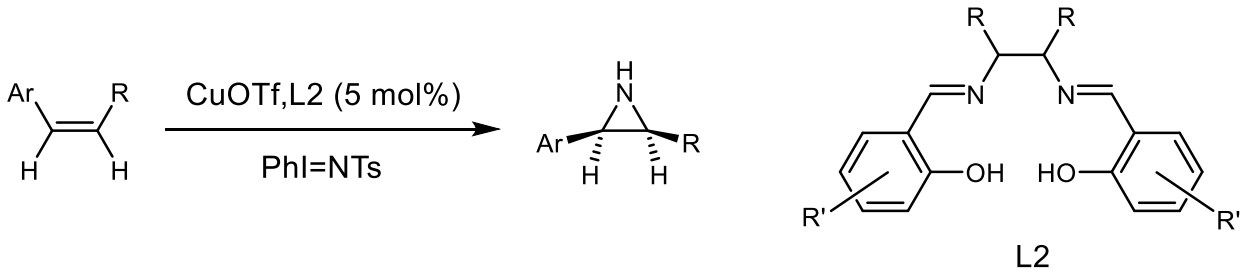

X N R2
R1
YR2
PhI=NX
[M]
R1 R2
X
N
R1
R2
R1 MLn
X N R2
R1 HN X
Br
R2

Background

Evans (1991)



Jacobsen (1993)

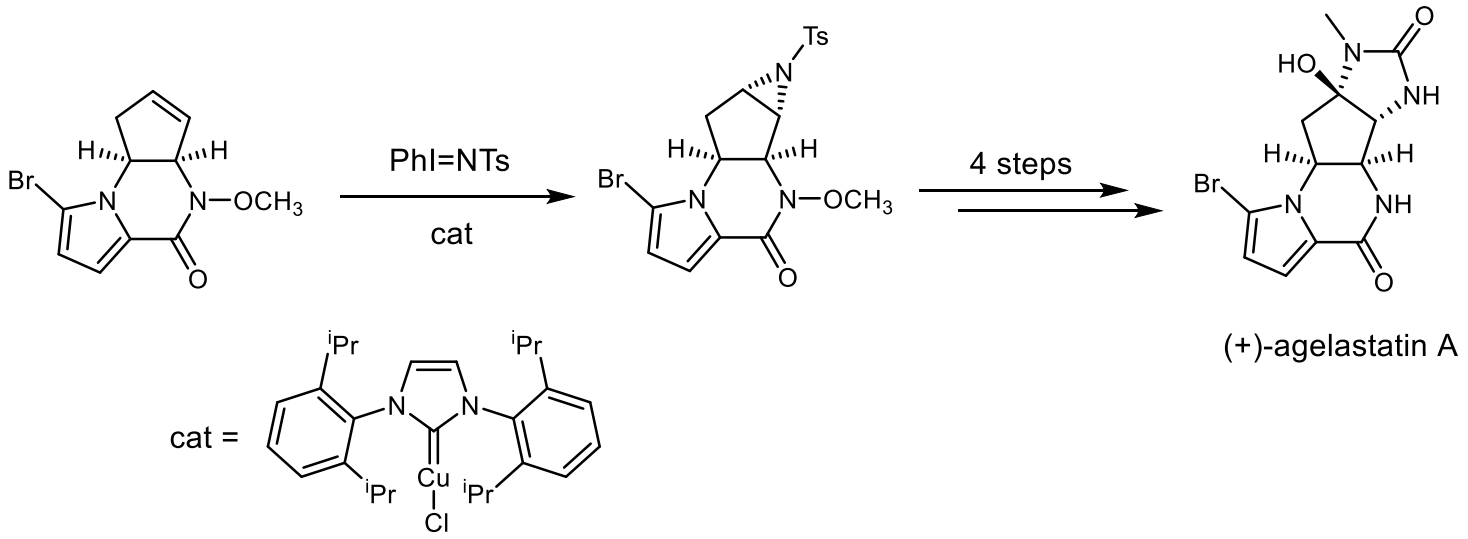


D. A. Evans et. al. *J. Org. Chem.* **1991**, *56*, 6744-6746.
E. N. Jacobsen et. al. *J. Am. Chem. Soc.* **1993**, *115*, 5326-5327.

Background

Trost (2006)

Total Synthesis of (+)-Agelastatin A



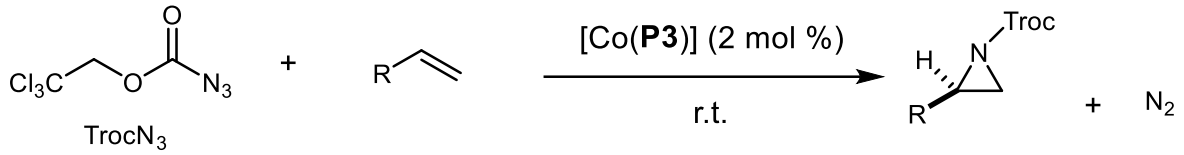
Barry M. Trost et. al. *J. Am. Chem. Soc.* **2006**, *128*, 6054-6055.

Catalogue

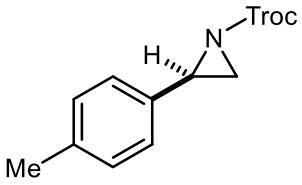
1. Background
2. Aziridination of Alkenes
    1. Catalyzed by Transition Metals
    2. By Electrochemical Oxidation
3. Summary and Outlook

Aziridination of Alkenes——Catalyzed by Co Complexes

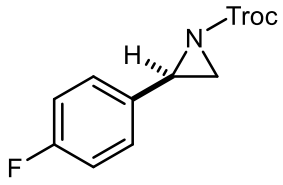
Zhang (2021)



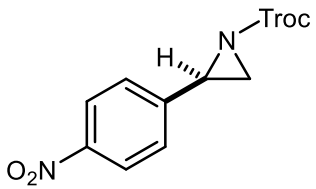
Selected Substrates



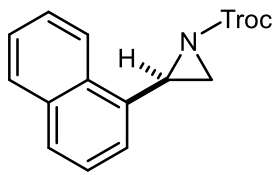
71%
90%ee



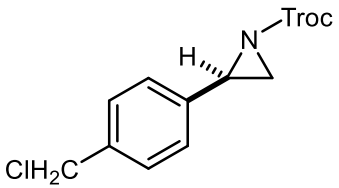
92%
94%ee



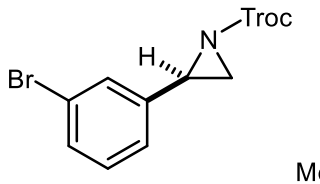
79%
90%ee



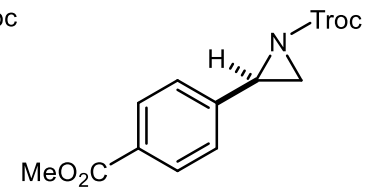
93%
94%ee



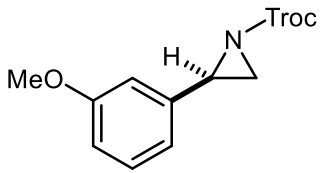
61%
92%ee



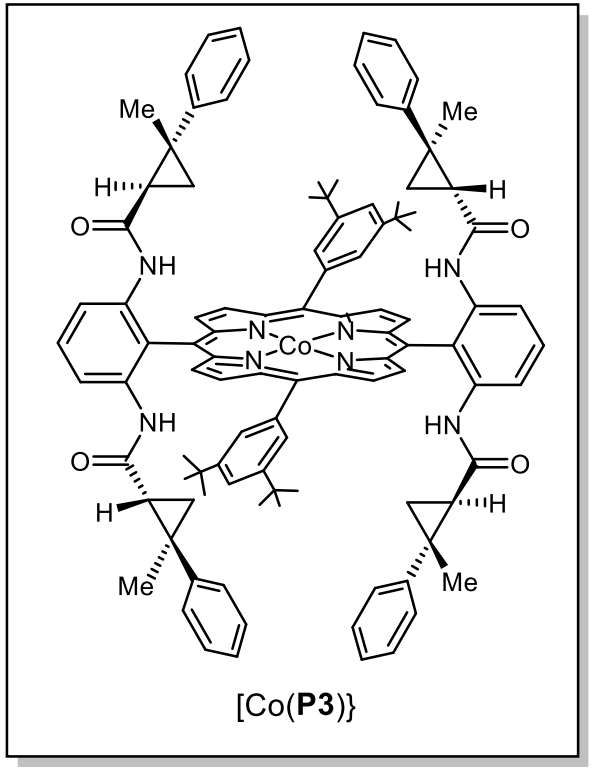
98%
88%ee



71%
92%ee

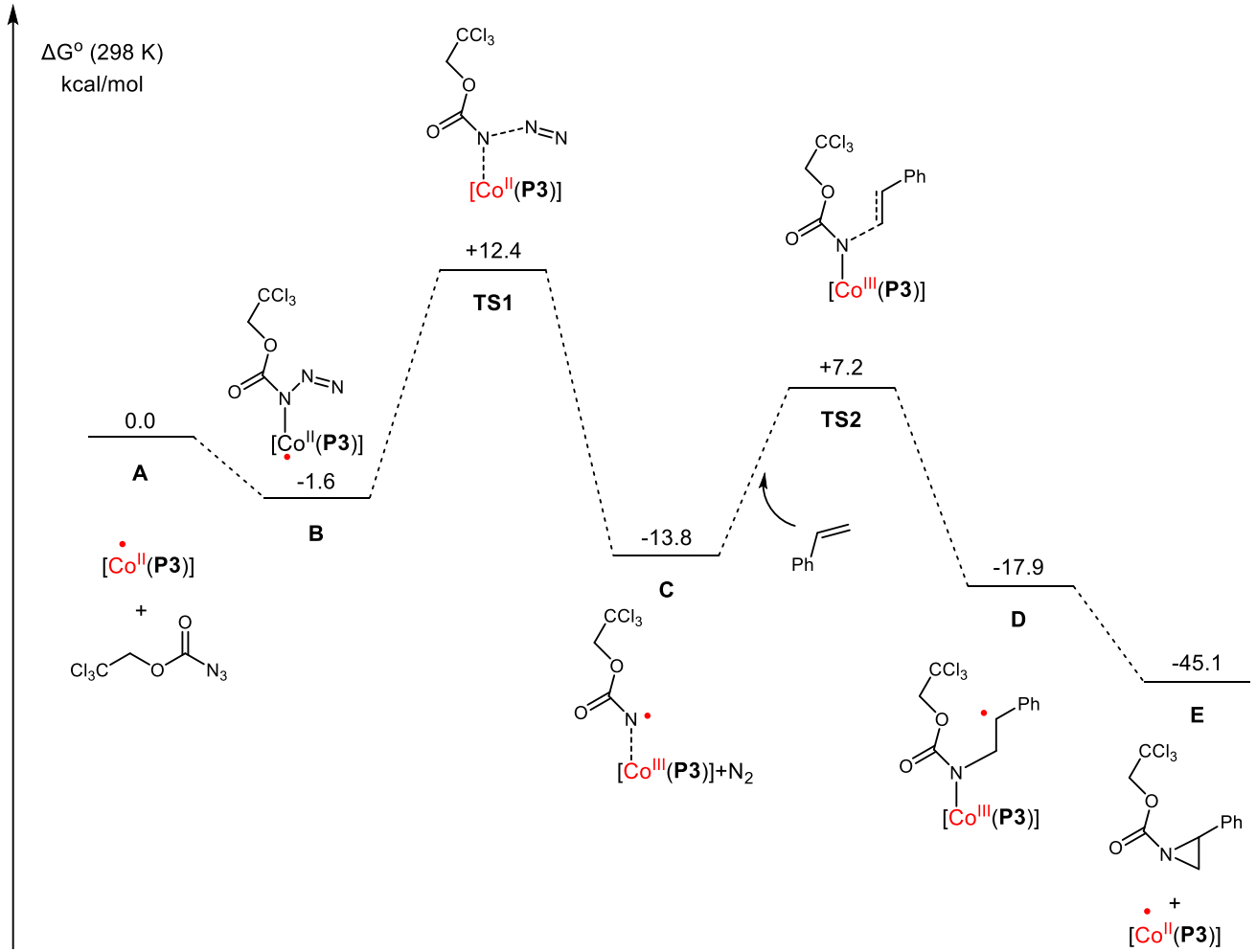


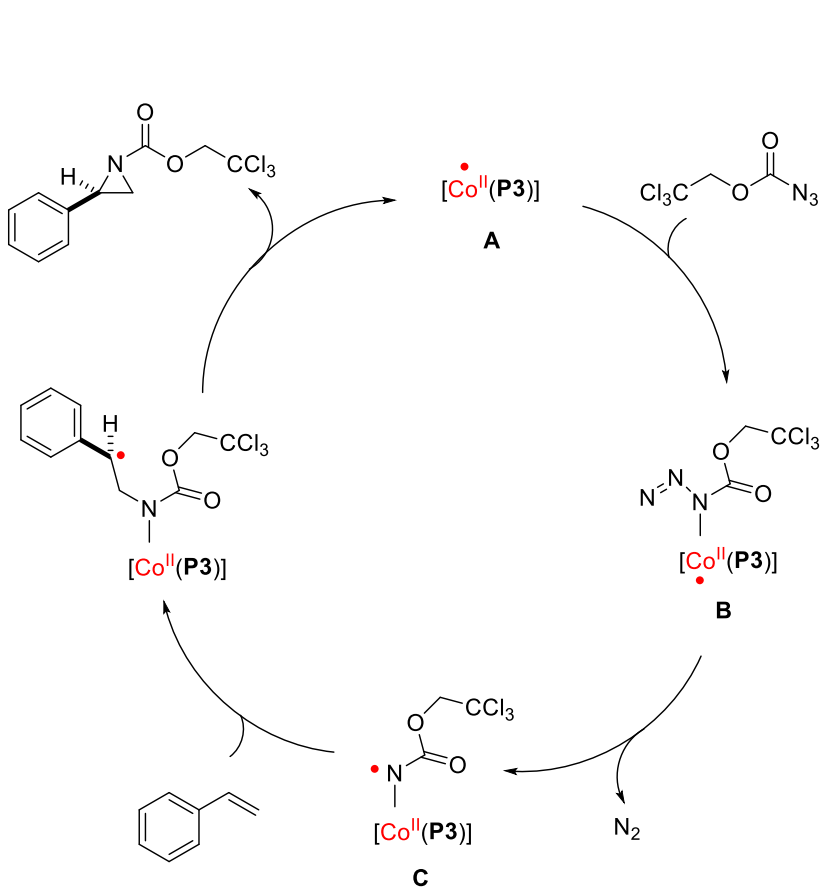
68%
90%ee



X. P. Zhang,*et. al, Chem.* **2021**, *7*, 1120-1134

Aziridination of Alkenes——Catalyzed by Co Complexes

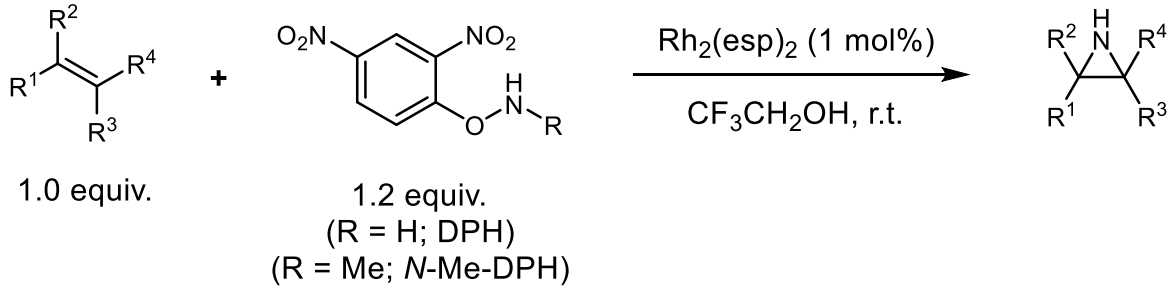


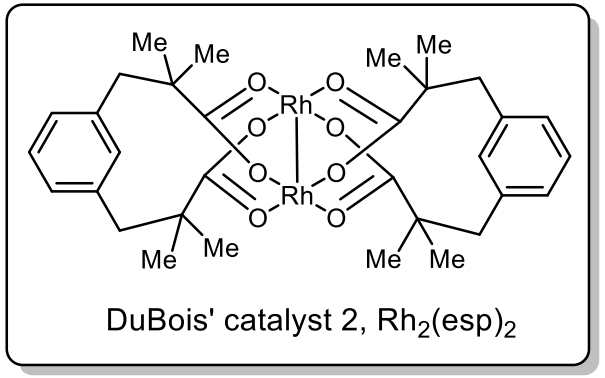


X. P. Zhang,*et. al, Chem.* **2021**, *7*, 1120-1134

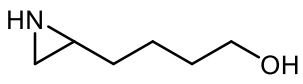
Aziridination of Alkenes——Catalyzed by Rh Complexes

John (2014)

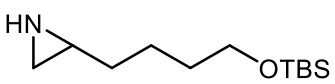




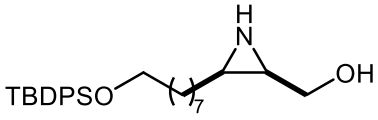
Selected Substrates



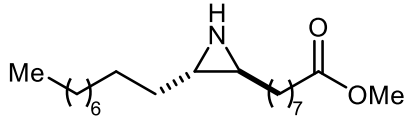
59%



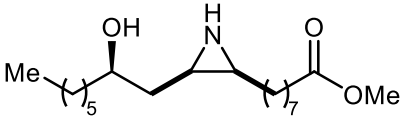
72%



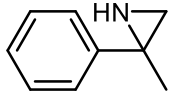
64%



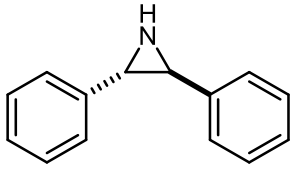
91%



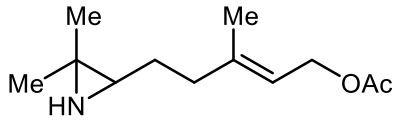
82% [1:1 dr]



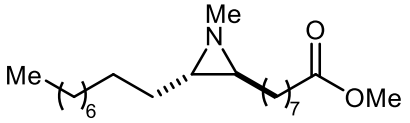
64%



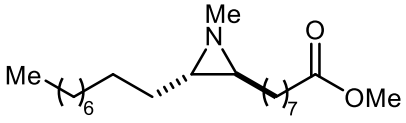
51%



83%



80%

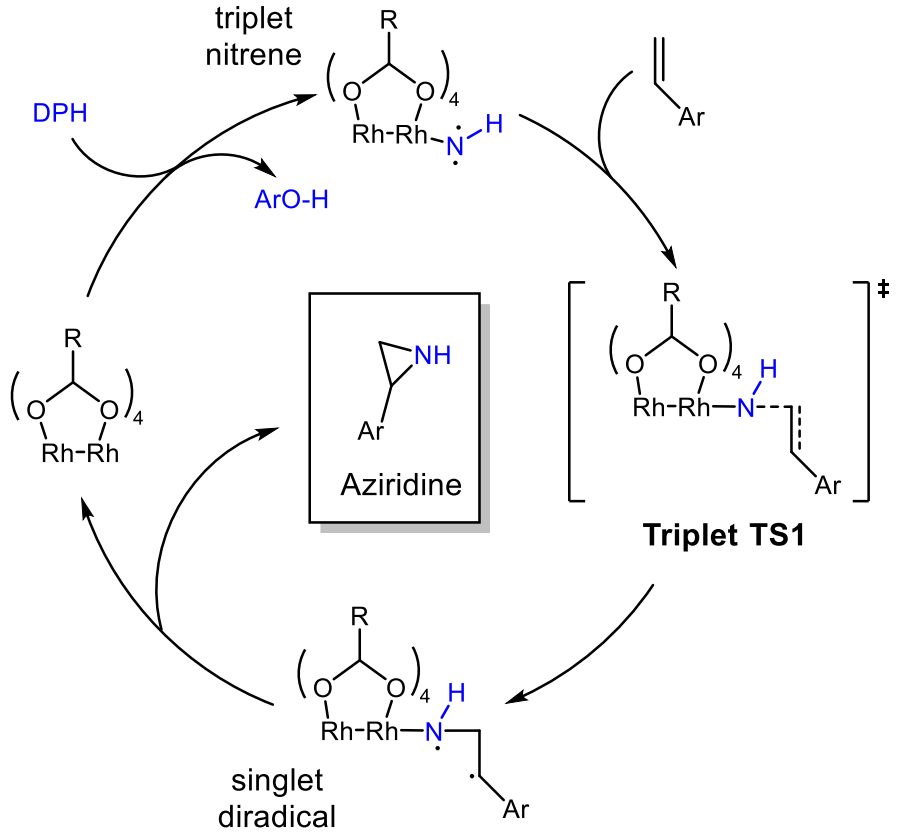


78%

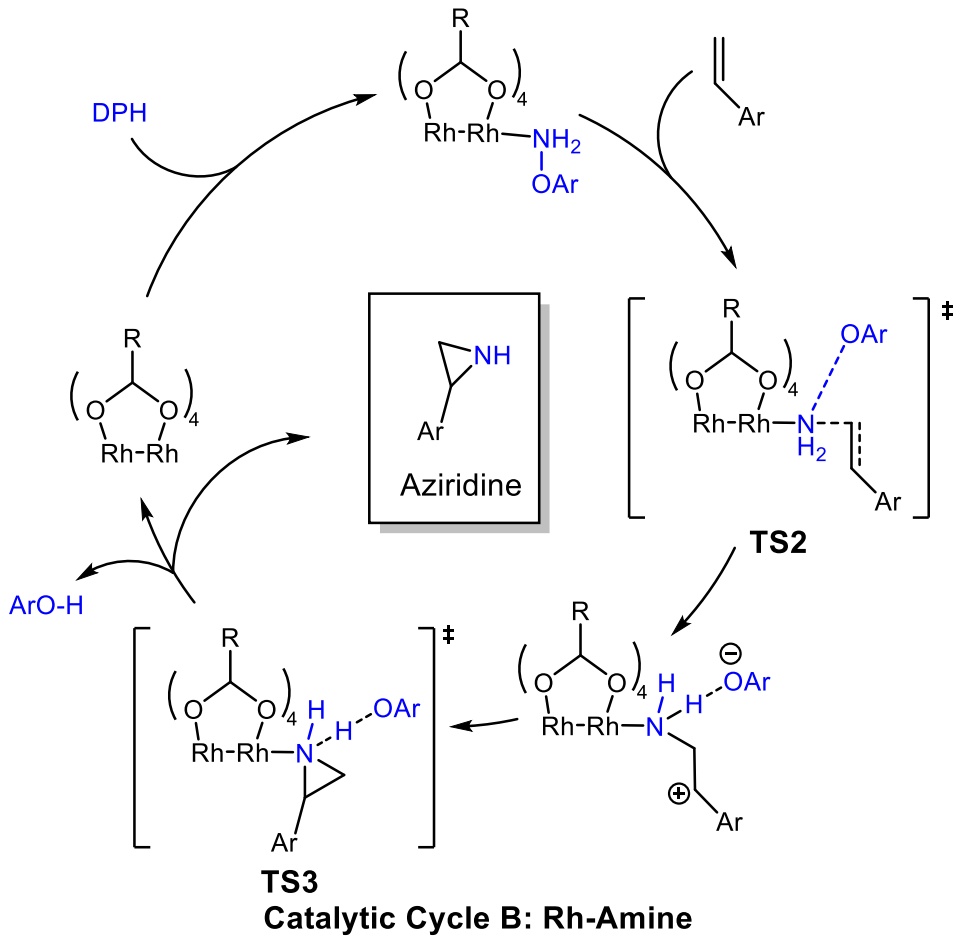
John R. F. et. al. *Science* **2014**, *343*, 61-65.

Aziridination of Alkenes——Catalyzed by Rh Complexes

Selected DFT-examined pathways



Catalytic Cycle A: Rh-Nitrene

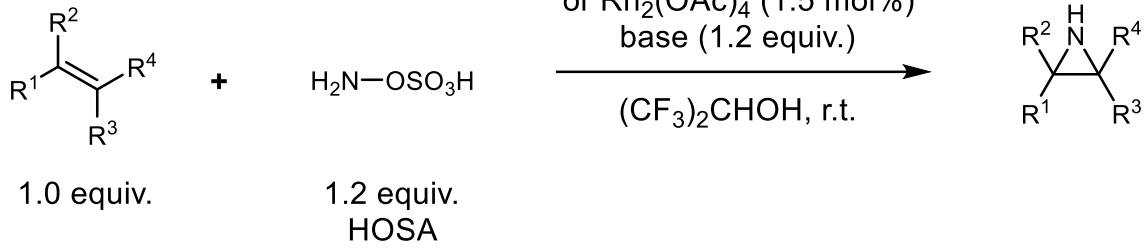


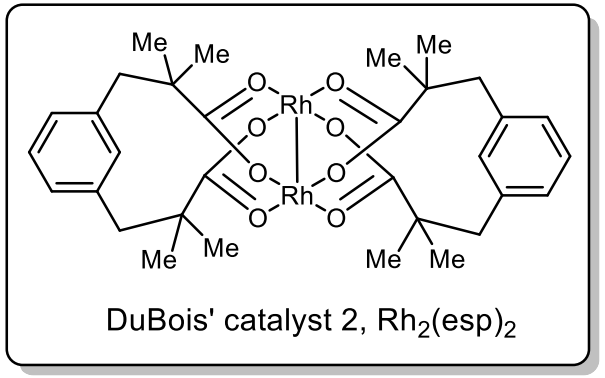
Catalytic Cycle B: Rh-Amine

John R. F. et. al. *Science* **2014**, *343*, 61-65.

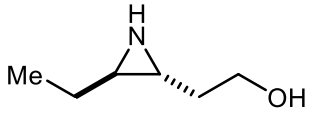
Aziridination of Alkenes——Catalyzed by Rh Complexes

LÁSZLÓ (2017)

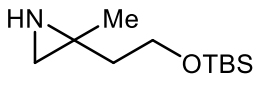




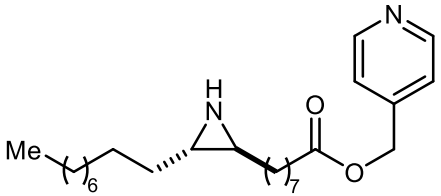
Selected Substrates



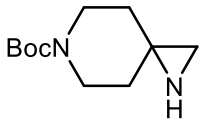
80%



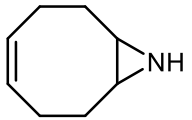
72%



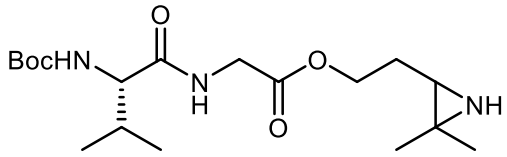
77%



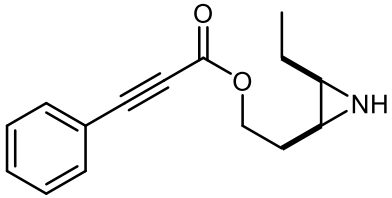
63%



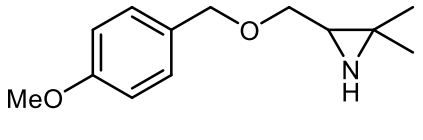
76%



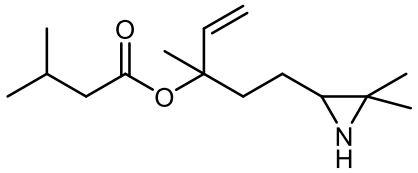
83% [1:1 dr]



62%



85%

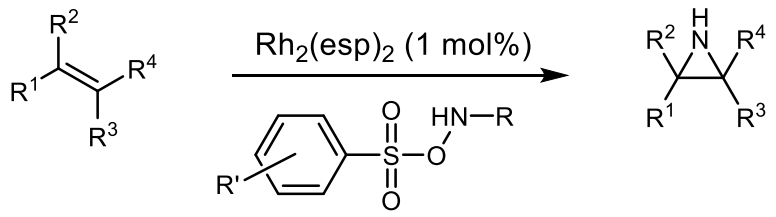


84%

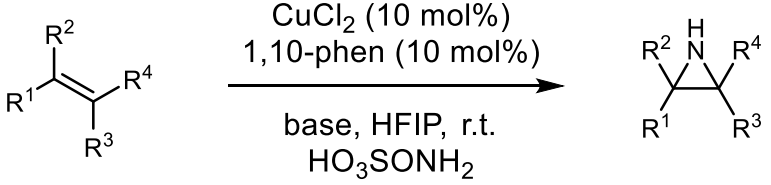
LÁSZLÓ, K. et. al. *Angew. Chem. Int. Ed.* **2017**, *56*, 9886-9890.

Aziridination of Alkenes

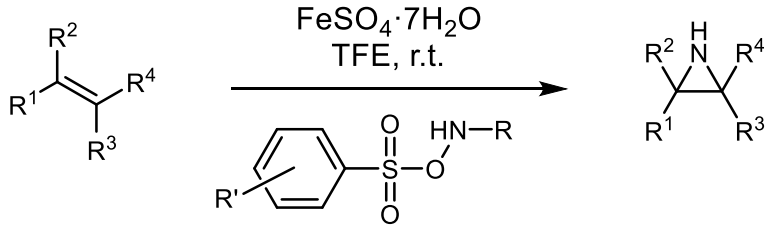
Jawahar (2018)



John (2019)



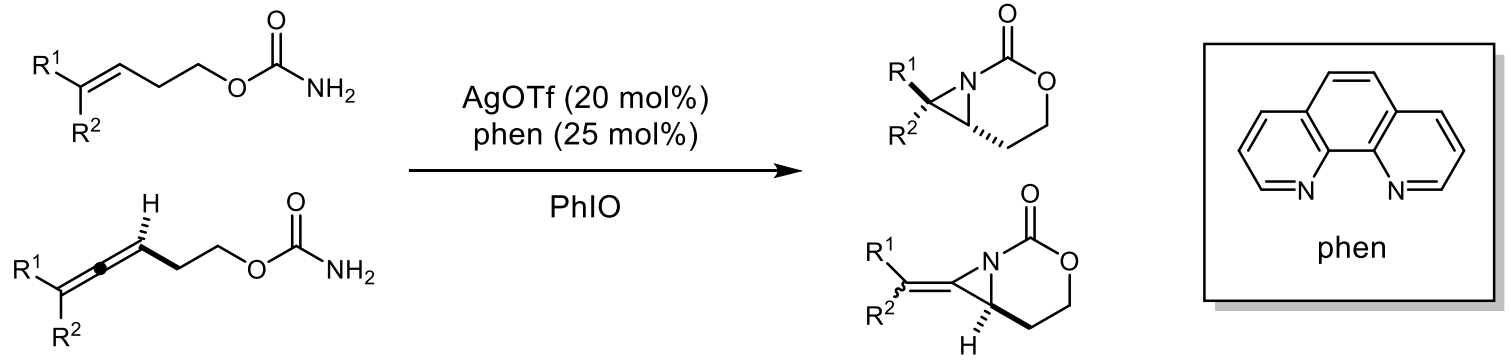
Jawahar (2021)

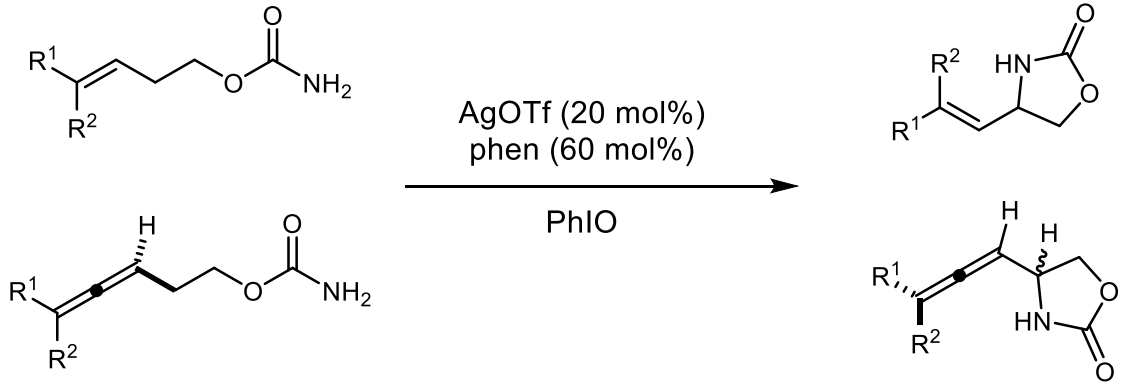


John, R. F. et. al. *Org. Lett.* **2019**, *21*, 1926-1929.
Jawahar, L. J. et. al. *J. Org. Chem.* **2018**, *83*, 12255-12260.
Jawahar, L. J. et. al. *ChemistrySelect* **2021**, *39*, 10524-10526.

Aziridination of Alkenes——Catalyzed by Ag Complexes

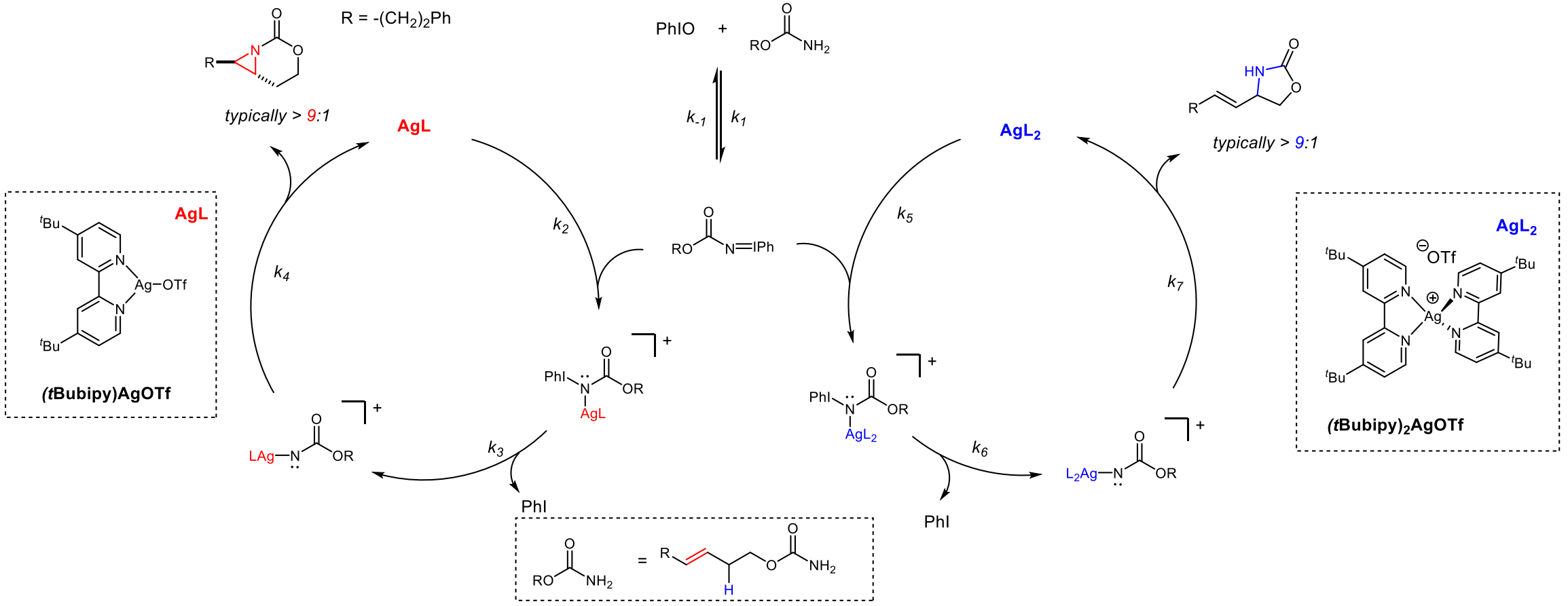
Schomaker (2013)





J. M. Schomaker et. al. *J. Am. Chem. Soc.* **2013**, *135*, 17238-17241.

Aziridination of Alkenes——Catalyzed by Ag Complexes



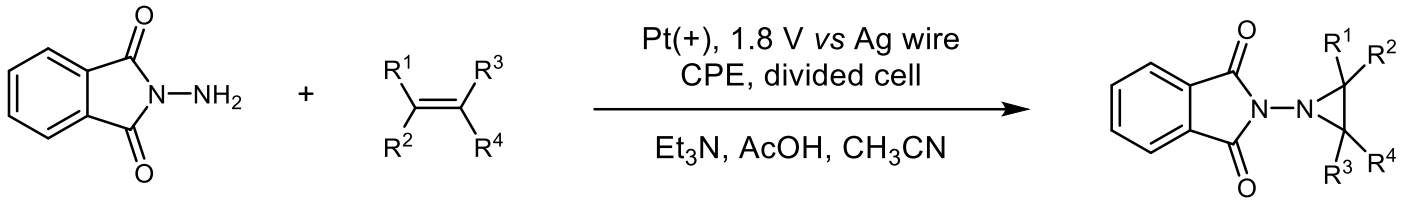
J. M. Schomaker et. al. *J. Am. Chem. Soc.* **2013**, *135*, 17238-17241.

Catalogue

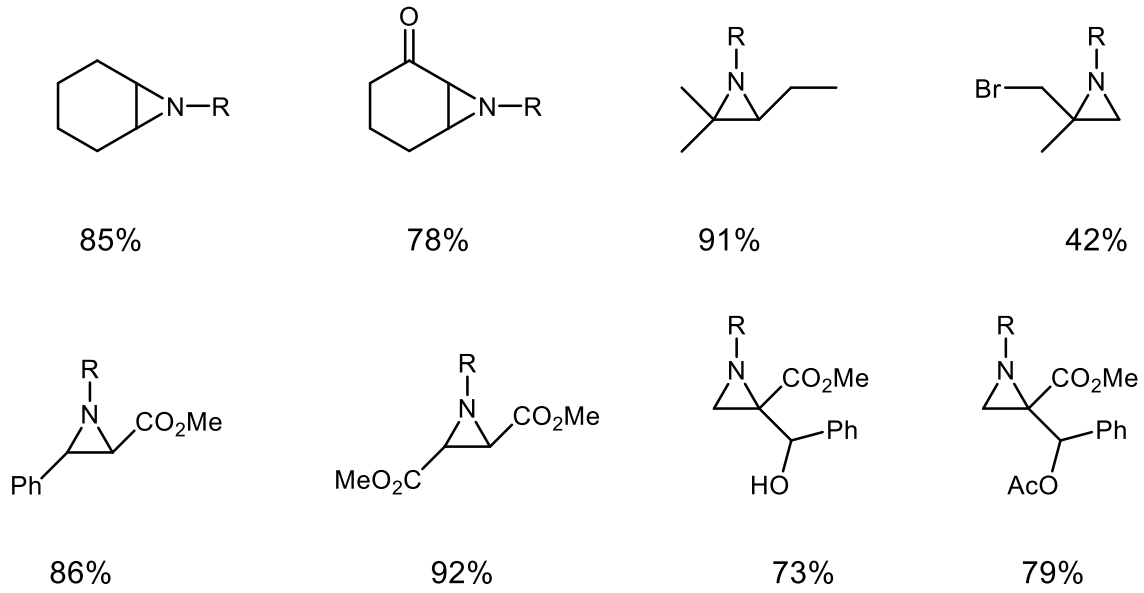
1. Background
2. Aziridination of Alkenes
    1. Catalyzed by Transition Metals
    2. By Electrochemical Oxidation
3. Summary and Outlook

Aziridination of Alkenes by Electronchemical Oxidation

Yudin (2002)



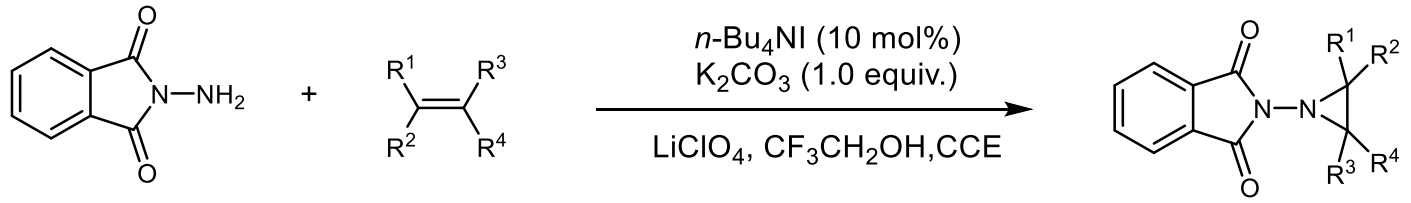
Selected Substrates



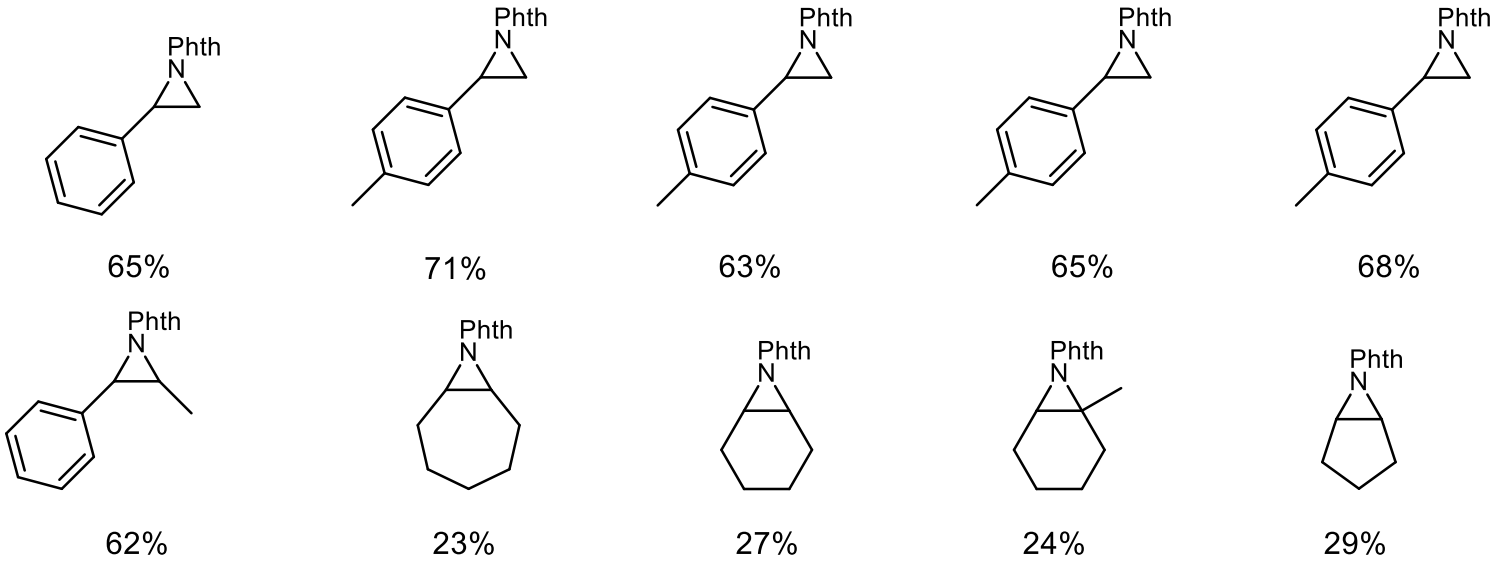
A. K. Yudin, et. al. *J. Am. Chem. Soc.* **2002**, *124*, 530-531.

Aziridination of Alkenes by Electronchemical Oxidation

Zeng (2015)

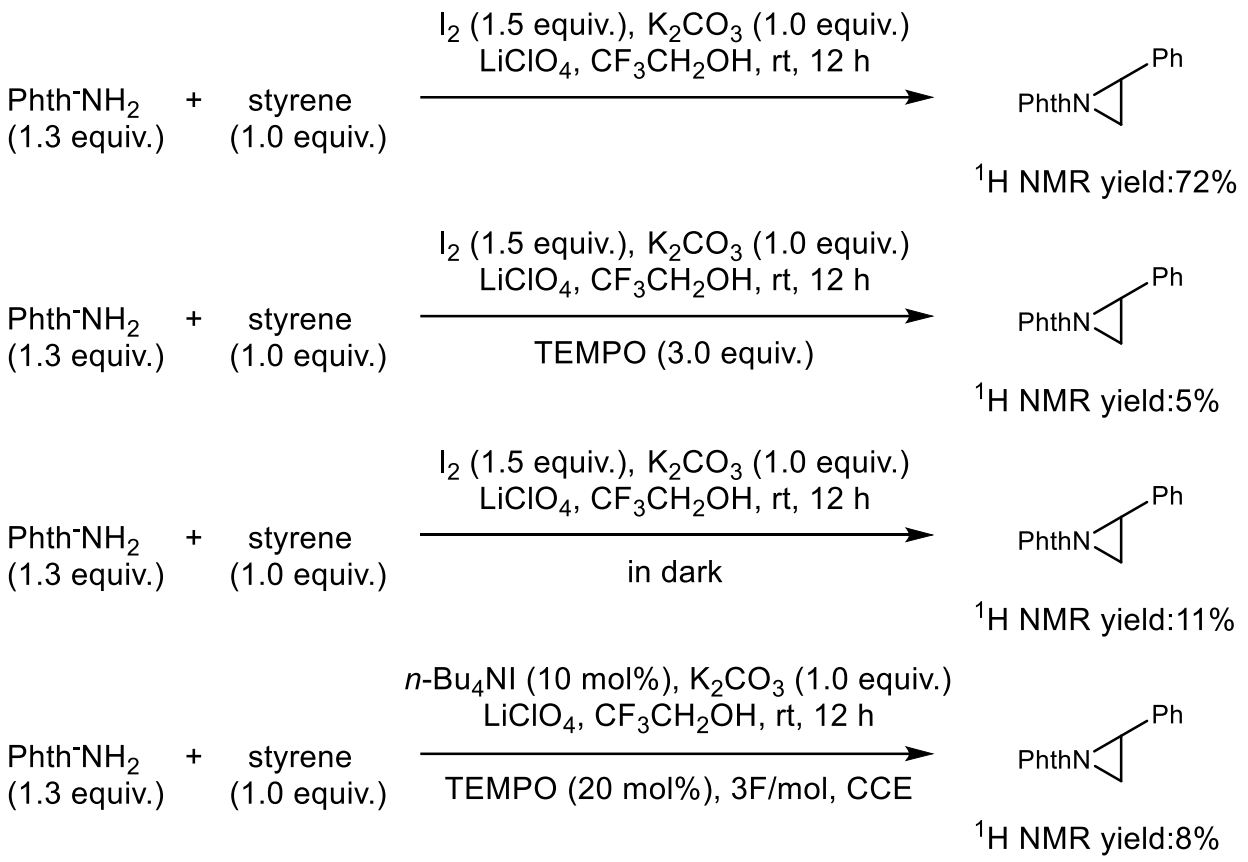


Selected Substrates



C. C. Zeng, et. al. *Org. Lett.* **2015**, *17*, 986-989.

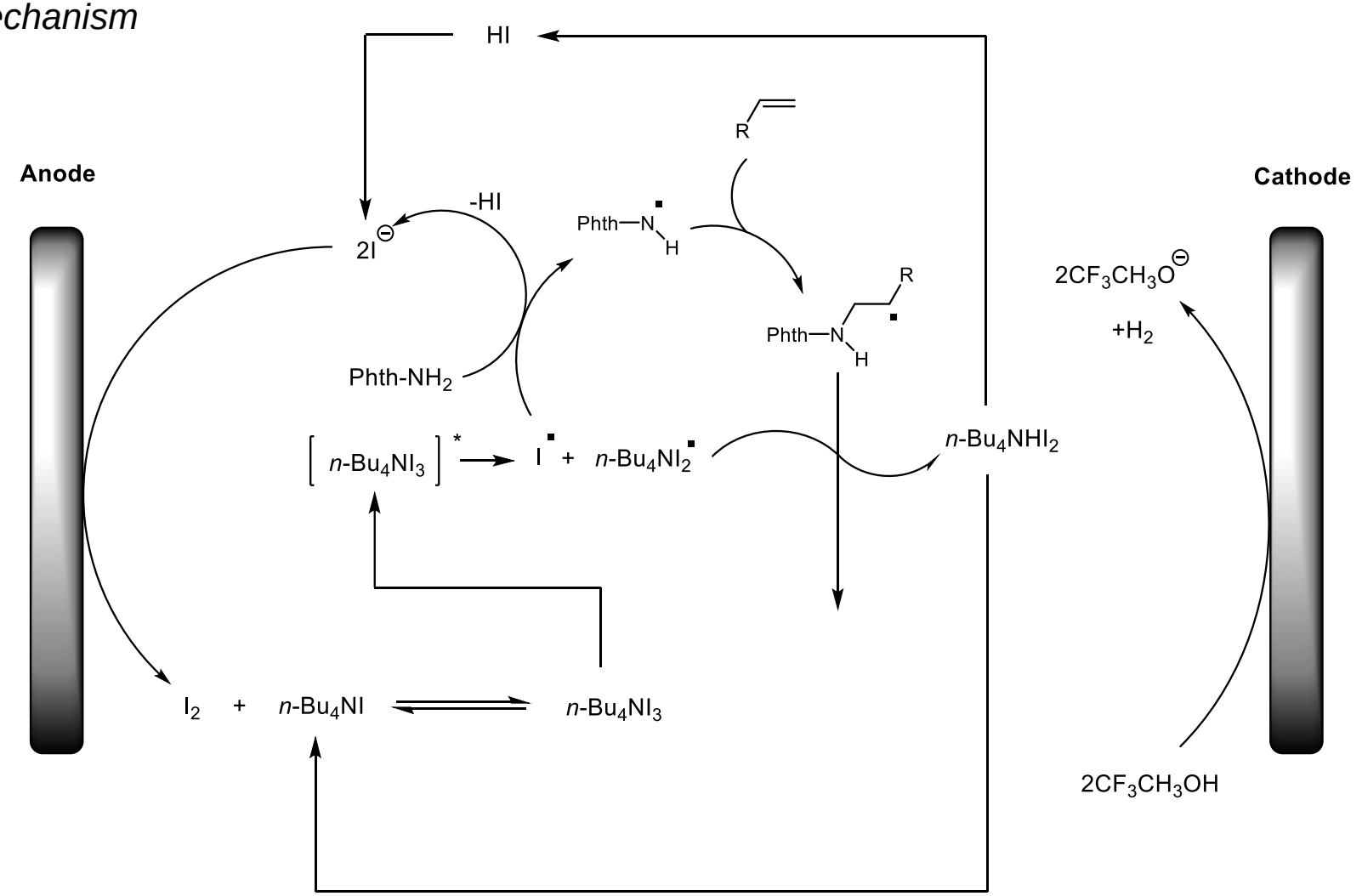
Aziridination of Alkenes by Electronchemical Oxidation



C. C. Zeng, et. al. *Org. Lett.* **2015**, *17*, 986-989.

Aziridination of Alkenes by Electronchemical Oxidation

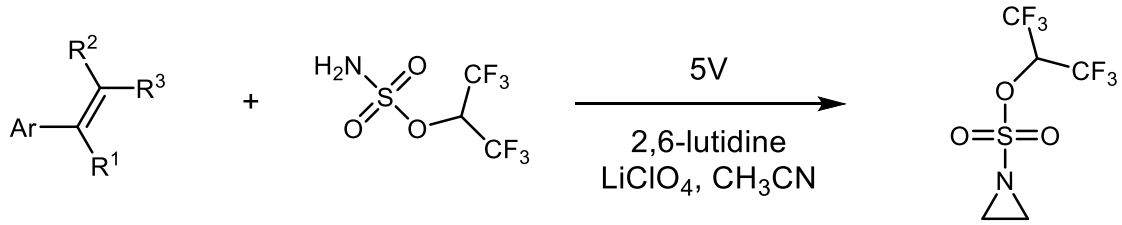
Proposed Mechanism



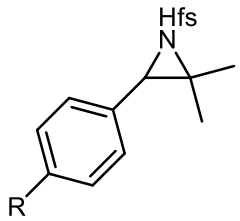
C. C. Zeng, et. al. *Org. Lett.* **2015**, *17*, 986-989.

Aziridination of Alkenes by Electronchemical Oxidation

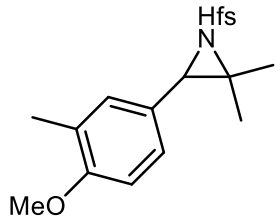
Cheng (2018)



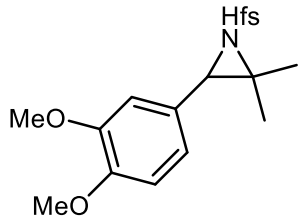
Selected Substrates



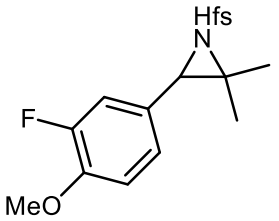
R = OMe, 73%
OPh, 66%
OBn, 57%
Me, 32%



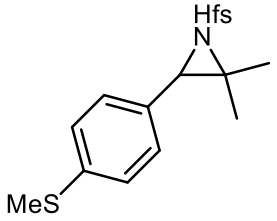
44%



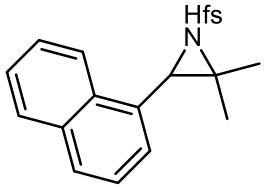
56%



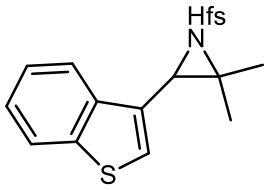
61%



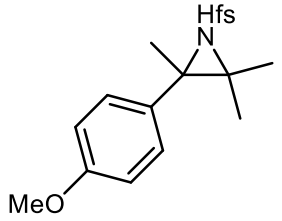
62%



44%



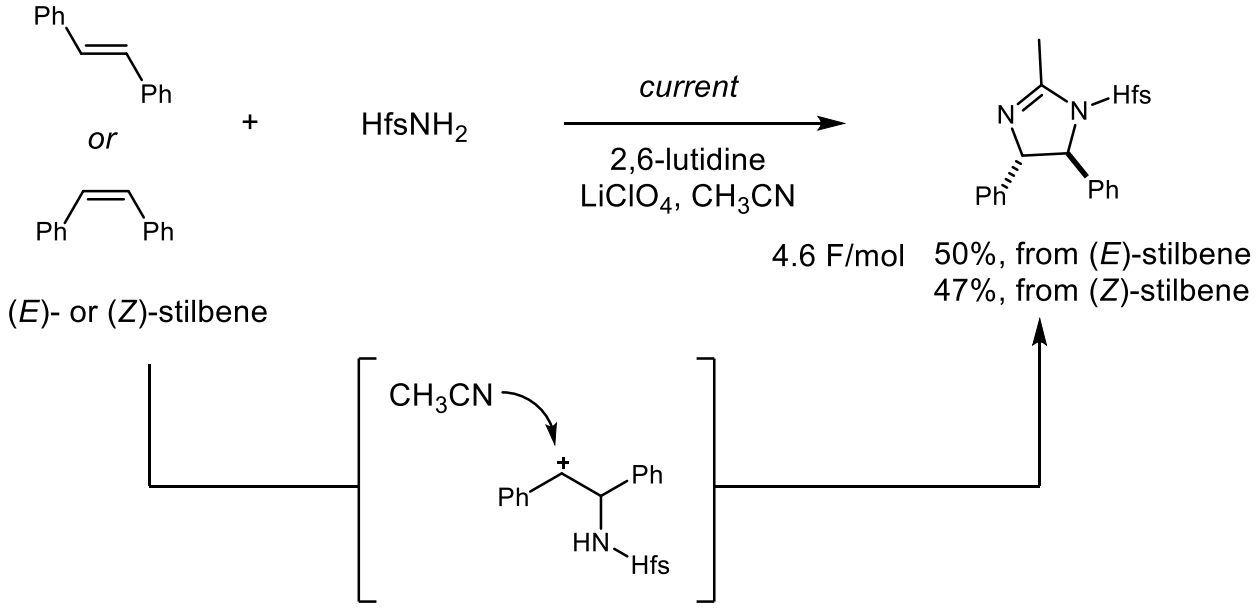
47%

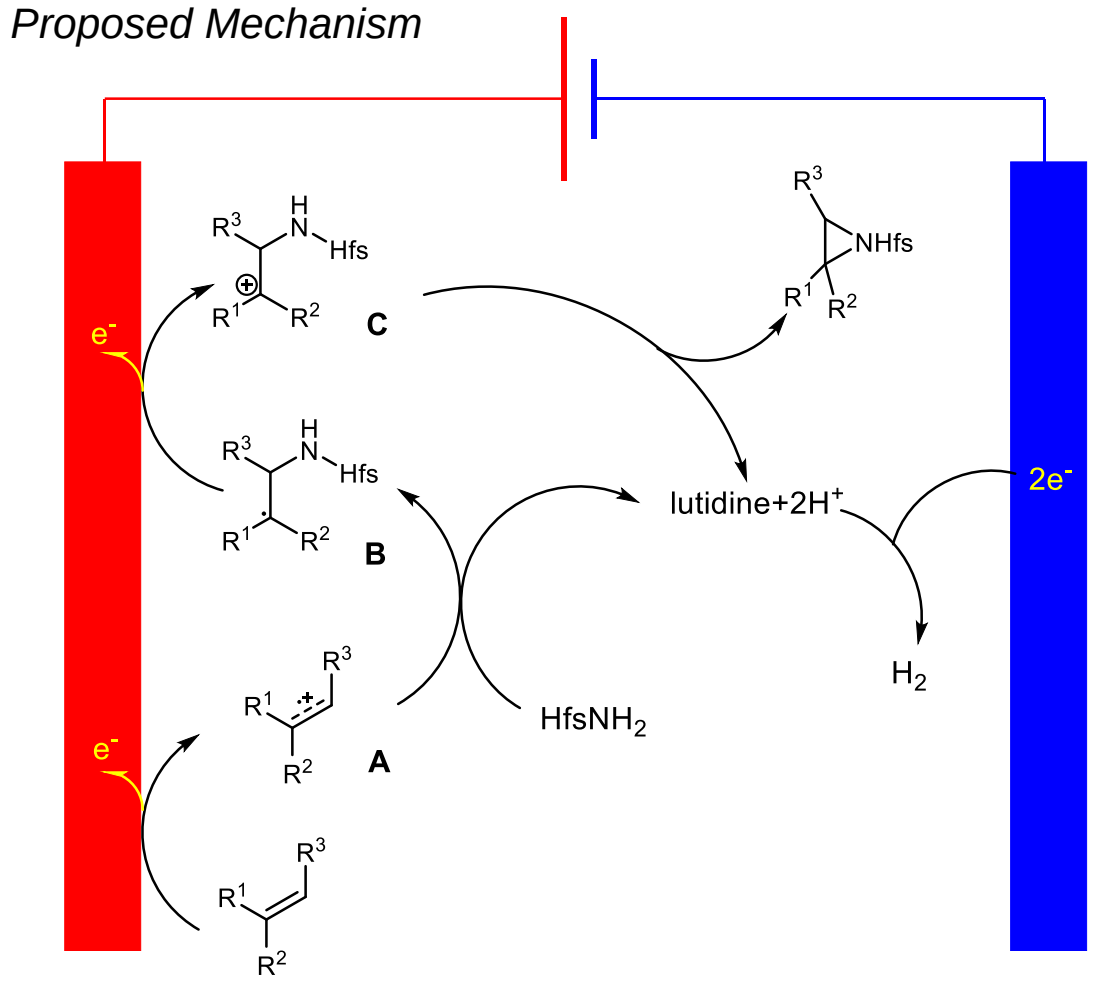


74%

X. Cheng, et. al. *Angew. Chem. Int. ed.* **2018**, *57*, 5695-5698.

Aziridination of Alkenes by Electronchemical Oxidation

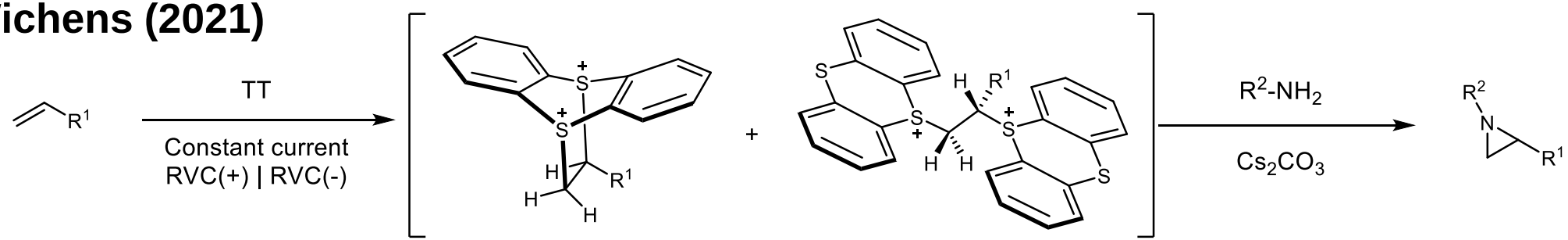




X. Cheng, et. al. *Angew. Chem. Int. ed.* **2018**, *57*, 5695-5698.

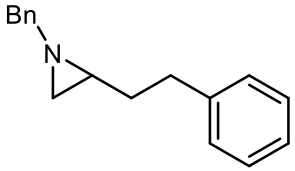
Aziridination of Alkenes by Electronchemical Oxidation

Wichens (2021)

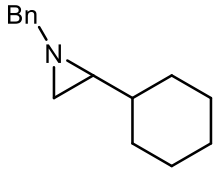


Reactive intermediates pooled but not isolated

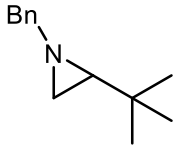
Alkene Scope



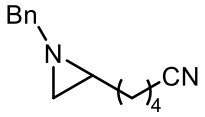
73%



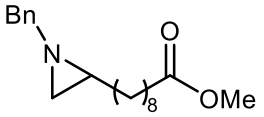
74%



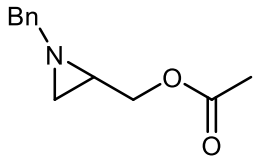
32%



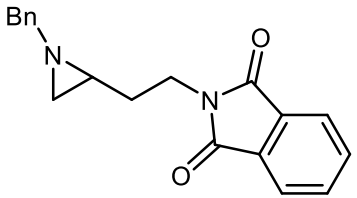
77%



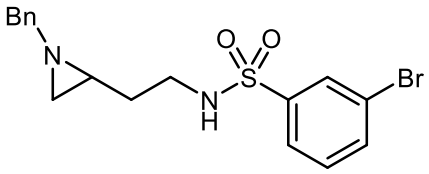
81%



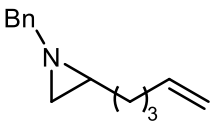
70%



62%



63%

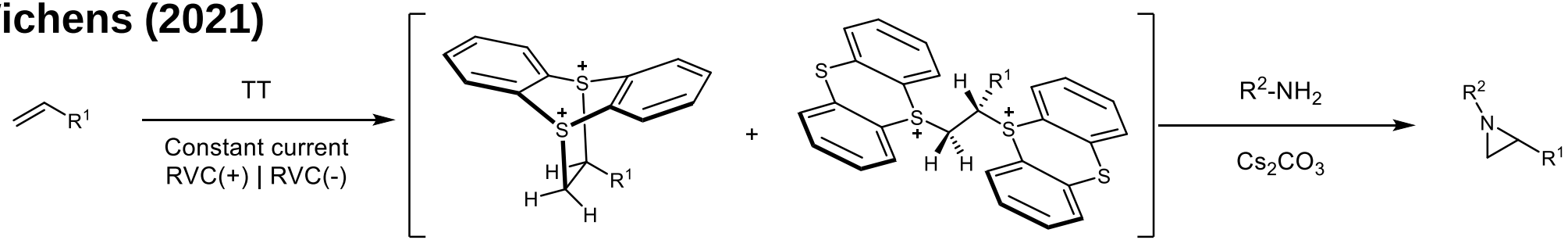


67%

Z. Wichens. et. al. *Nature* **2021**, *596*, 74-79.

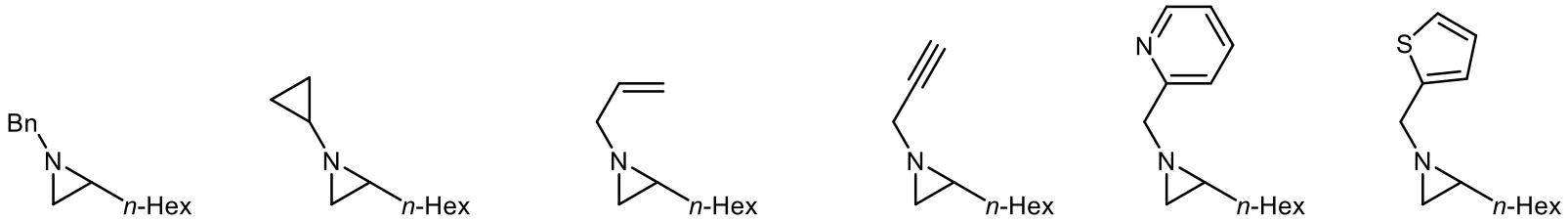
Aziridination of Alkenes by Electronchemical Oxidation

Wichens (2021)

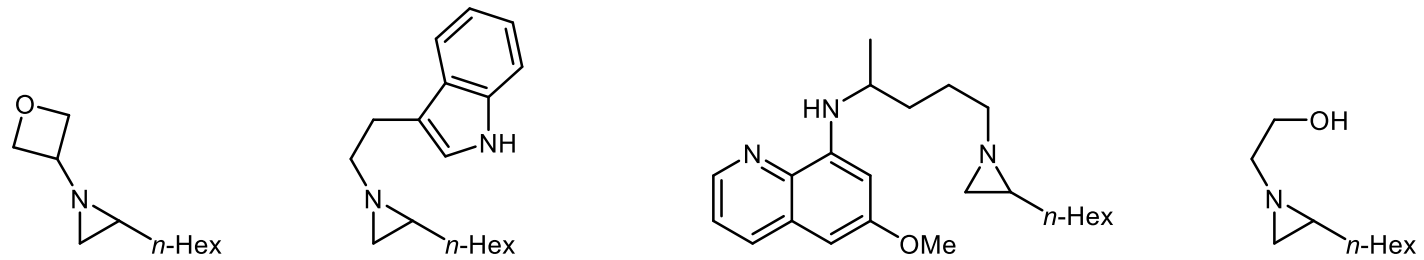


Reactive intermediates pooled but not isolated

Amine Scope



70% 50% 59% 52% 75% 70%



55% 56% 61% 71%

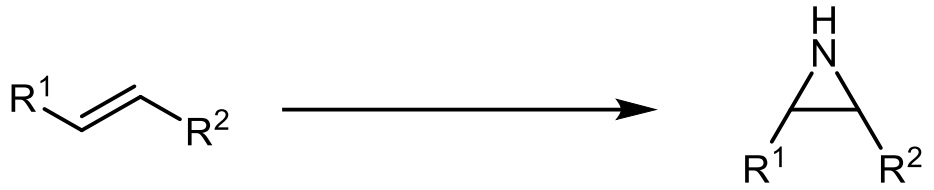
Z. Wichens. et. al. *Nature* **2021**, *596*, 74-79.

Catalogue

1. Background
2. Aziridination of Alkenes
    1. Catalyzed by Transition Metals
    2. By Electrochemical Oxidation
3. Summary and Outlook

Summary and Outlook

Summary



Catalyzed by Transition Metals

Advantages:
- Amounts of methods
- Long history

Disadvantages:
- High consumption
- Poor atomic economy

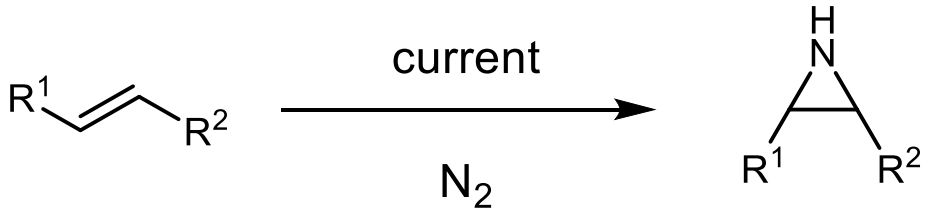
By Electronchemical Oxidation

Advantages:
- Hign atomic economy
- Less reagents used

Disadvantages:
- Difficult to regulate and control
- Still developing

Summary and Outlook

Outlook



More efficient
More environmentally friendly
More atomic economical

THANKS FOR YOUR ATTENTION