One- and Two –Component Domino reactions

Dong group at UT Austin

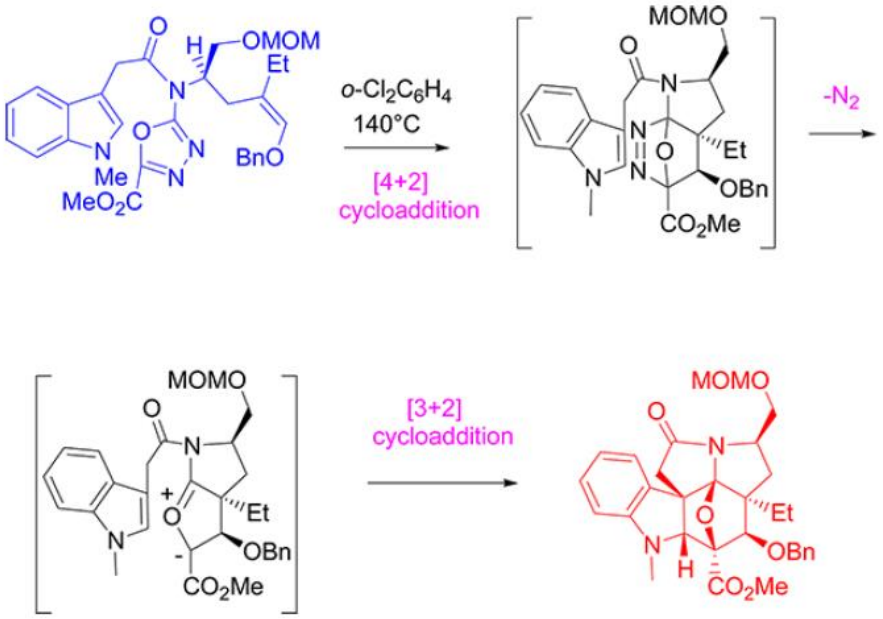
Xuan Zhou

04/15/2015

CHEMICAL REVIEWS

Stereocontrolled Domino Reactions

Hélène Pellissier*



Chem. Rev. **2013**, *113*, 442–524

One- and Two –Component Domino reactions

Domino reaction: two or more bond-forming in one reaction vessel, and no additional reagents, catalysts, or additives can be added during the reaction.

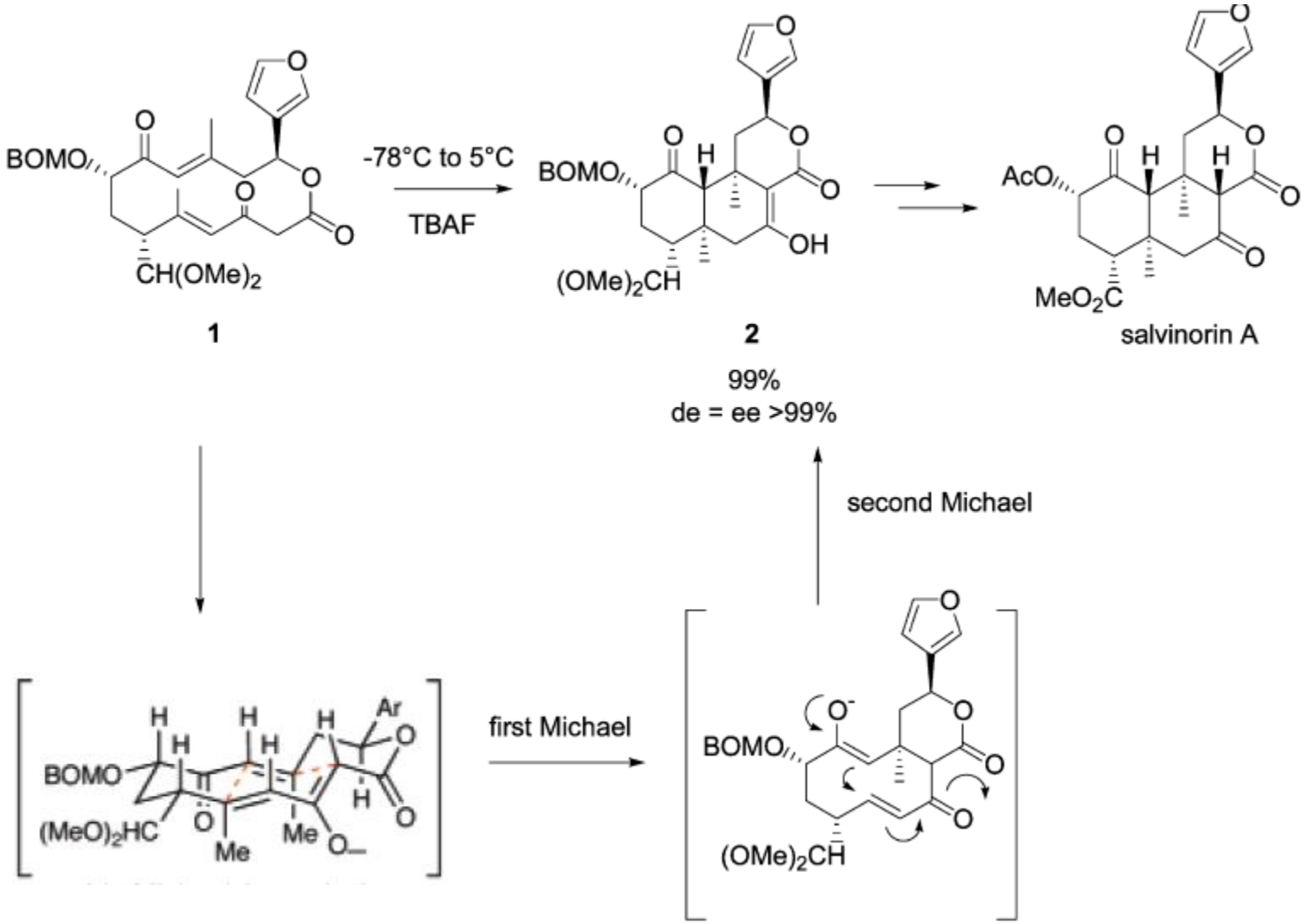
Content

A, Anionic primary step
B, Cationic sequence
C, Initiated by a pericyclic primary step
D, Carbene sequence
E, Palladium catalyzed domino reaction
F, Ruthenium catalyzed domino reaction
G, Miscellaneous domino reactions

Reviews about domino reactions:
Chem. Rev. **2014**, *114*, 2390; *Chem. Rev*. **2014**, *114*, 8323; *Green Chem*. **2014**, *16*, 2958; *Chem. Soc. Rev*. **2014**, *43*, 4368; *Tetrahedron* **2013**, *69*, 7171; *Chem. Soc. Rev***. 2013**, *42*, 4948

Anionic primary step

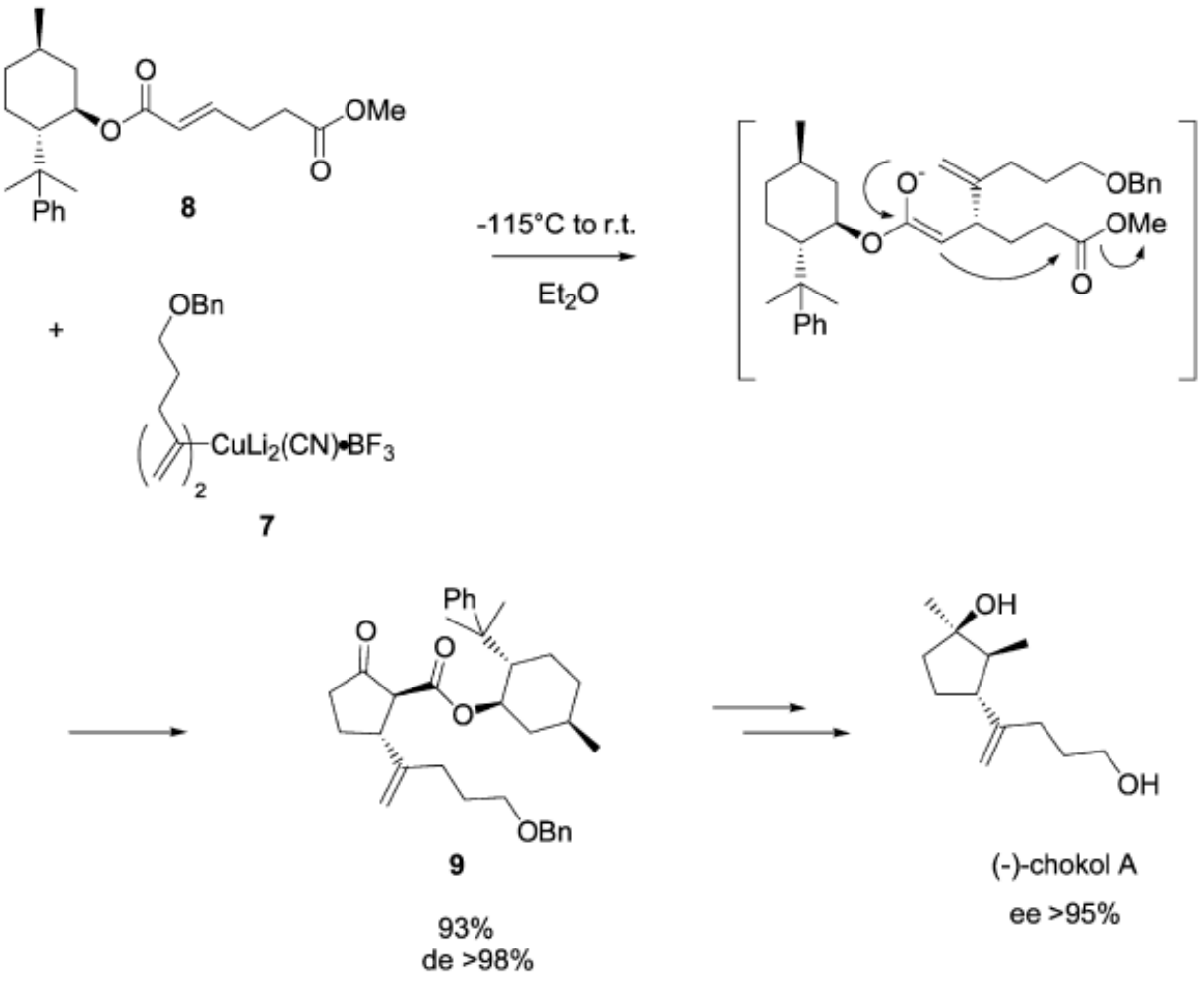
Synthesis of Salvinorin A through Domino Michael/Michael Reaction



Evans, D. A. *J. Am. Chem. Soc*. **2007**, *129*, 8968.

Anionic primary step

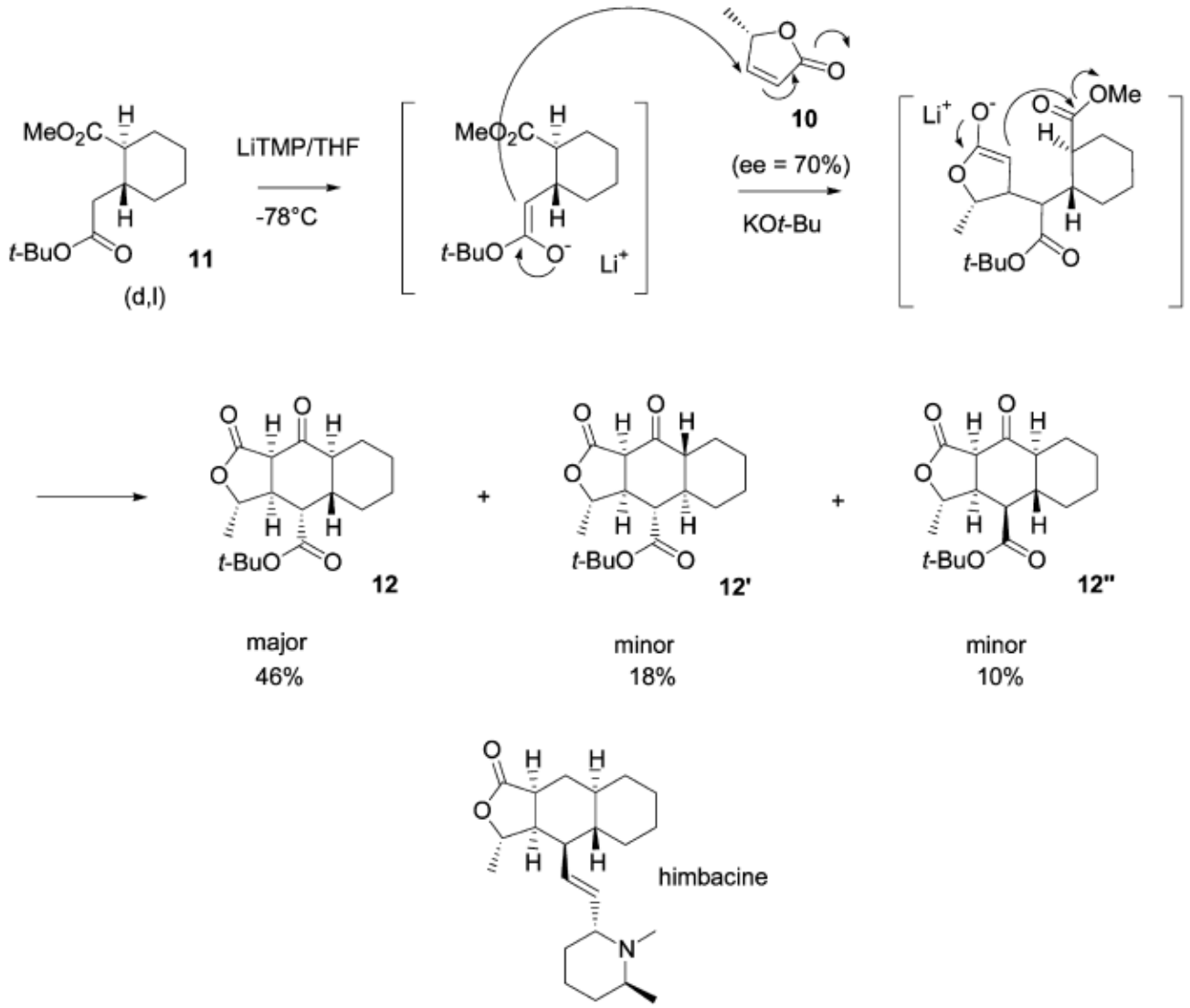
Synthesis of (-)-Chokol A through Domino Michael/Dieckmann Reaction



Kreye, P. *Synlett* **2006**, 2223

Anionic primary step

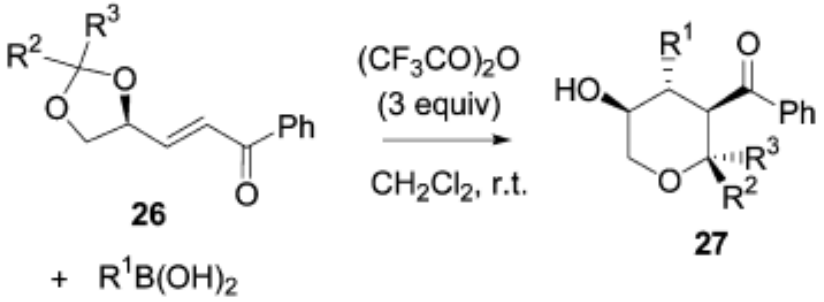
Synthesis of Key Intermediate in the Synthesis of Himbacine through Domino Michael/Dieckmann Reaction



McCarthy, R. *Synlett* **2011**, 801

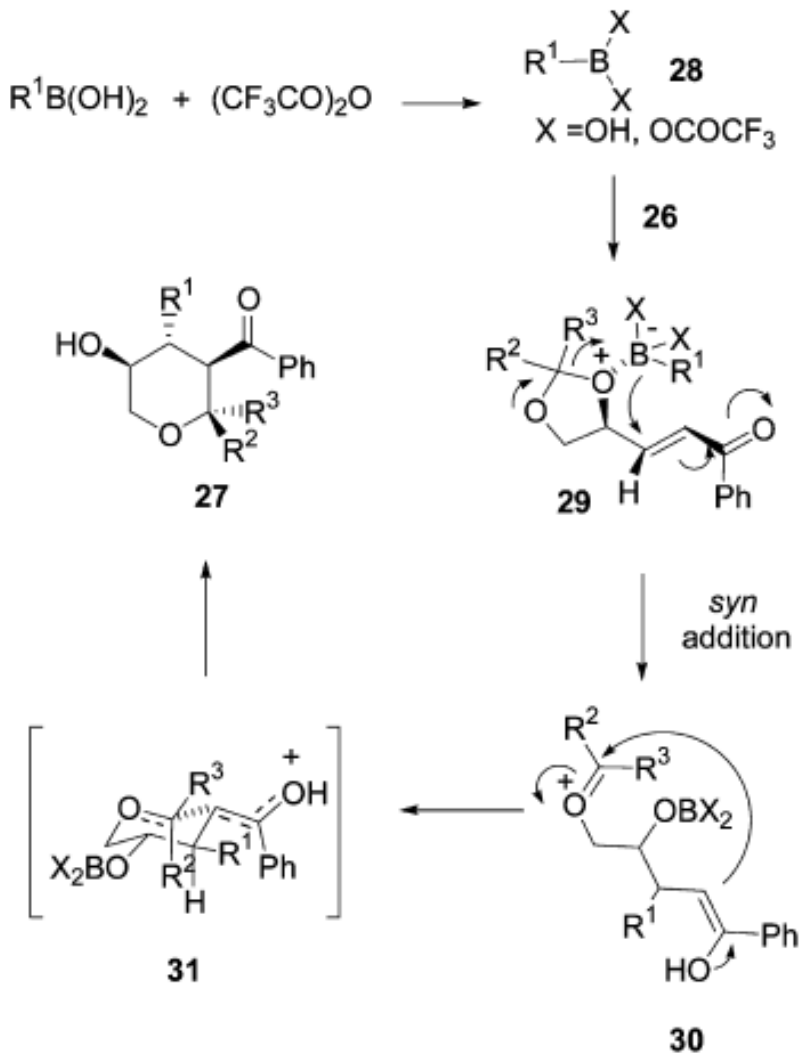
Anionic primary step

Domino Michael/Acetal Ring-Opening Reaction



R^1 = PhCH=CH, R^2 = R^3 = Me: 80%, de >96%
R^1 = *p*-FC_6H_4, R^2 = R^3 = Me: 85%, de >96%
R^1 = *p*-Tol, R^2 = R^3 = Me: 70%, de >96%
R^1 = *p*-ClC_6H_4, R^2 = R^3 = Me: 75%, de >96%
R^1 = PhCH=CH, R^2,R^3 = $(CH_2)_5$: 75%, de >96%
R^1 = *p*-FC_6H_4, R^2,R^3 = $(CH_2)_5$: 75%, de >96%
R^1 = PhCH=CH, R^2 = Me, R^3 = Et: 80%, de = 80%
R^1 = *p*-FC_6H_4, R^2 = Me, R^3 = Et: 65%, de = 90%
R^1 = *p*-Tol, R^2 = Me, R^3 = Et: 75%, de = 80%

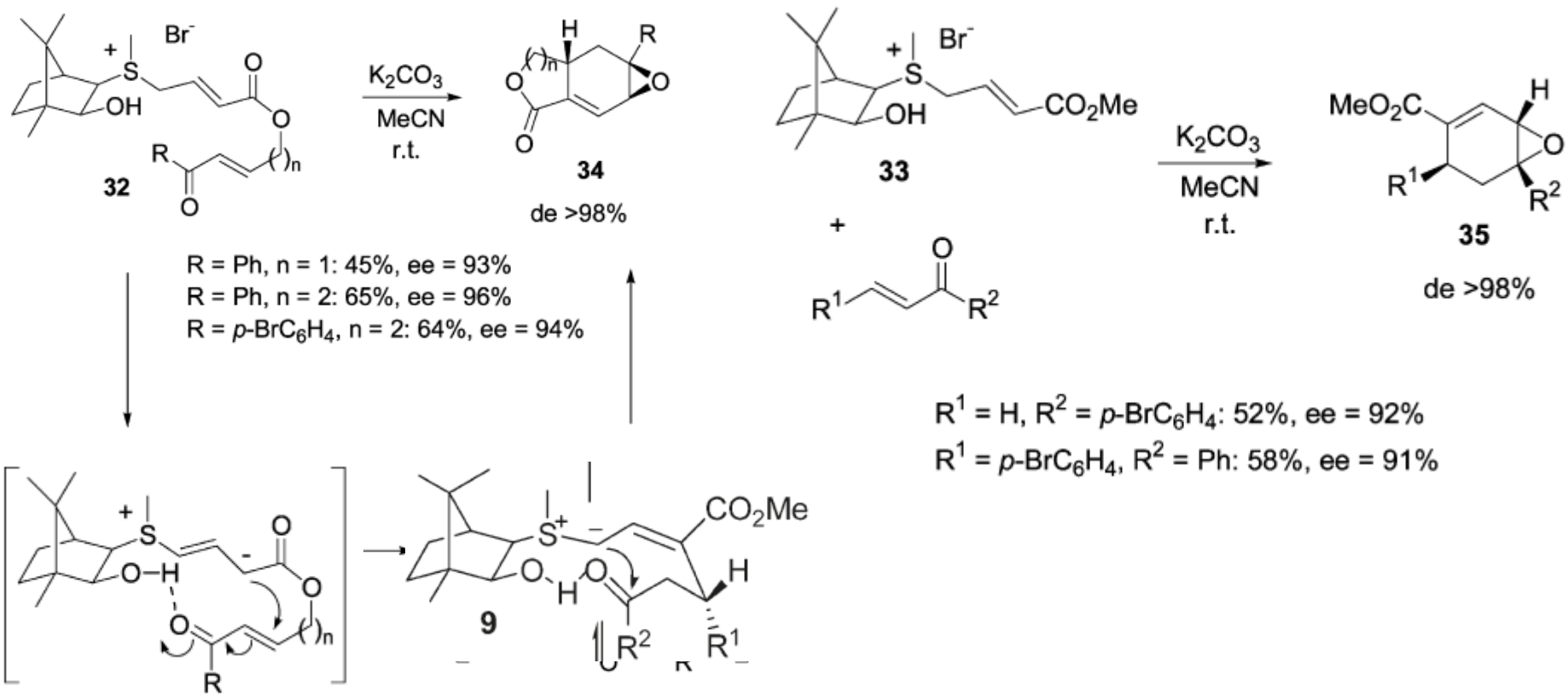
proposed mechanism:



Csaky, A. G. *Org. Lett*. **2012**, *14*, 1187

Anionic primary step

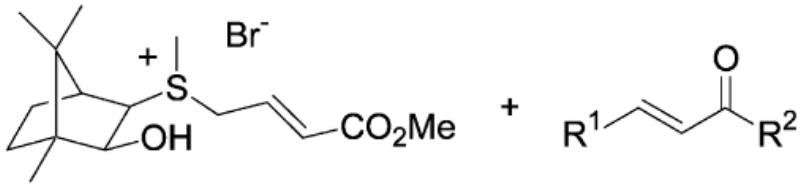
Intra- and Intermolecular Domino Michael/ Ylide Epoxidation Reactions



Tang, Y. *J. Am. Chem. Soc*. **2008**, *130*, 5408

Anionic primary step

Domino Michael/Ylide Cyclopropanation Reaction

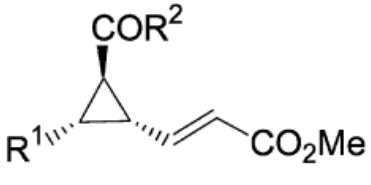


33

+

t-BuOK

THF, -78°C



major **36**

de >92%, ee = 99%

$R^1 = R^2 = Ph$: 77%

$R^1 = p\text{-}ClC_6H_4$, $R^2 = Ph$: 57%

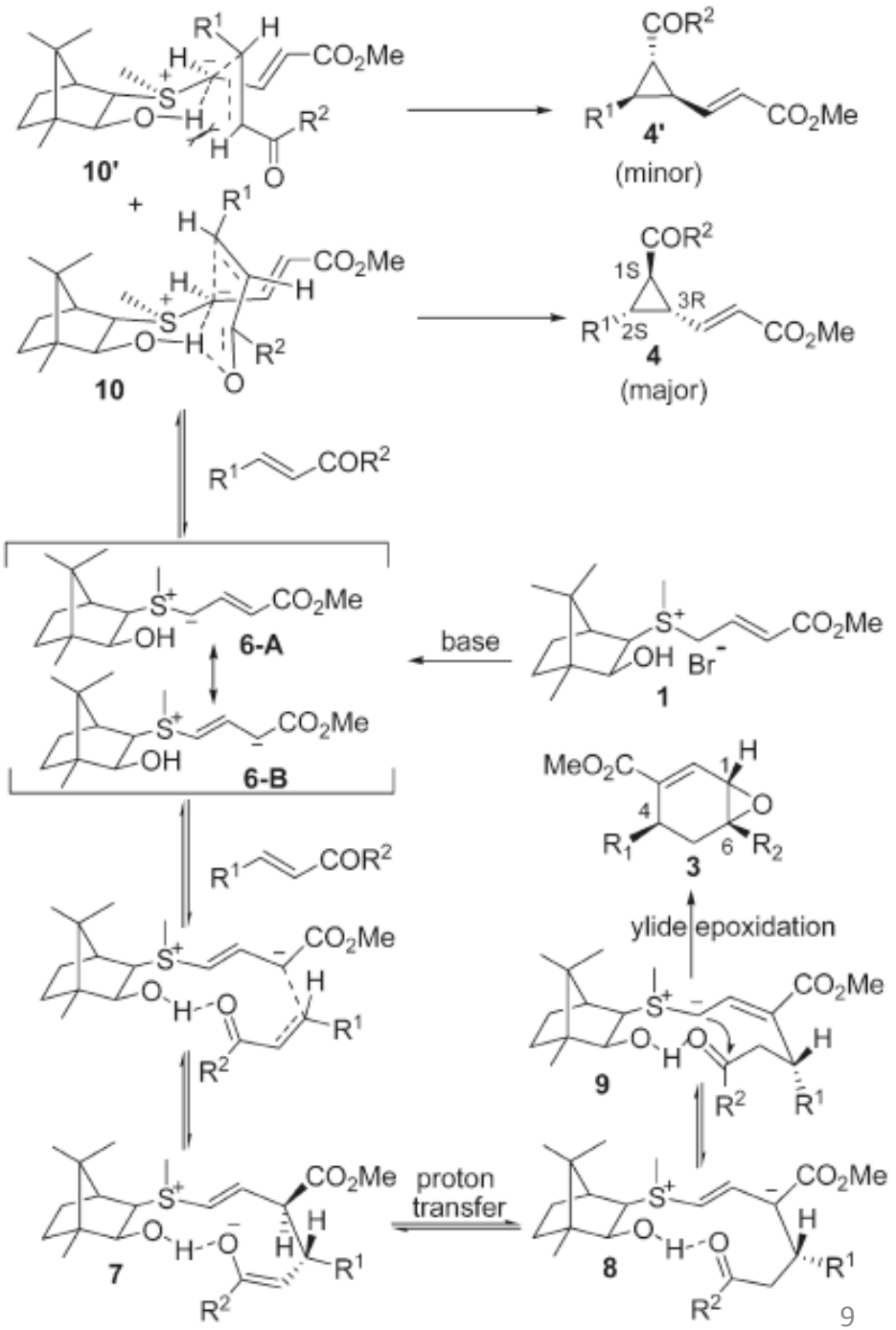
$R^1 = p\text{-}BrC_6H_4$, $R^2 = Ph$: 61%

$R^1 = p\text{-}Tol$, $R^2 = Ph$: 87%

$R^1 = p\text{-}MeOC_6H_4$, $R^2 = Ph$: 78%

$R^1 = Ph$, $R^2 = p\text{-}Tol$: 75%

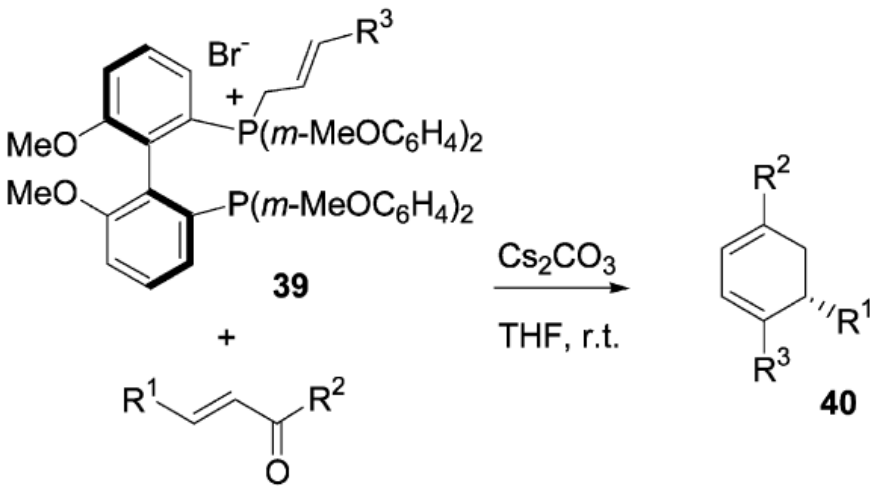
$R^1 = Ph$, $R^2 = p\text{-}ClC_6H_4$: 56%



Tang, Y. *J. Org. Chem*. **2010**, *75*, 3454

Anionic primary step

Domino Michael/Wittig Reaction



$R^1 = R^2 = Ph$, $R^3 = CO_2Me$: 64%, ee = 84%

$R^1 = R^2 = Ph$, $R^3 = CO_2t\text{-}Bu$: 55%, ee = 79%

$R^1 = p\text{-}BrC_6H_4$, $R^2 = Ph$, $R^3 = CO_2Me$: 73%, ee = 80%

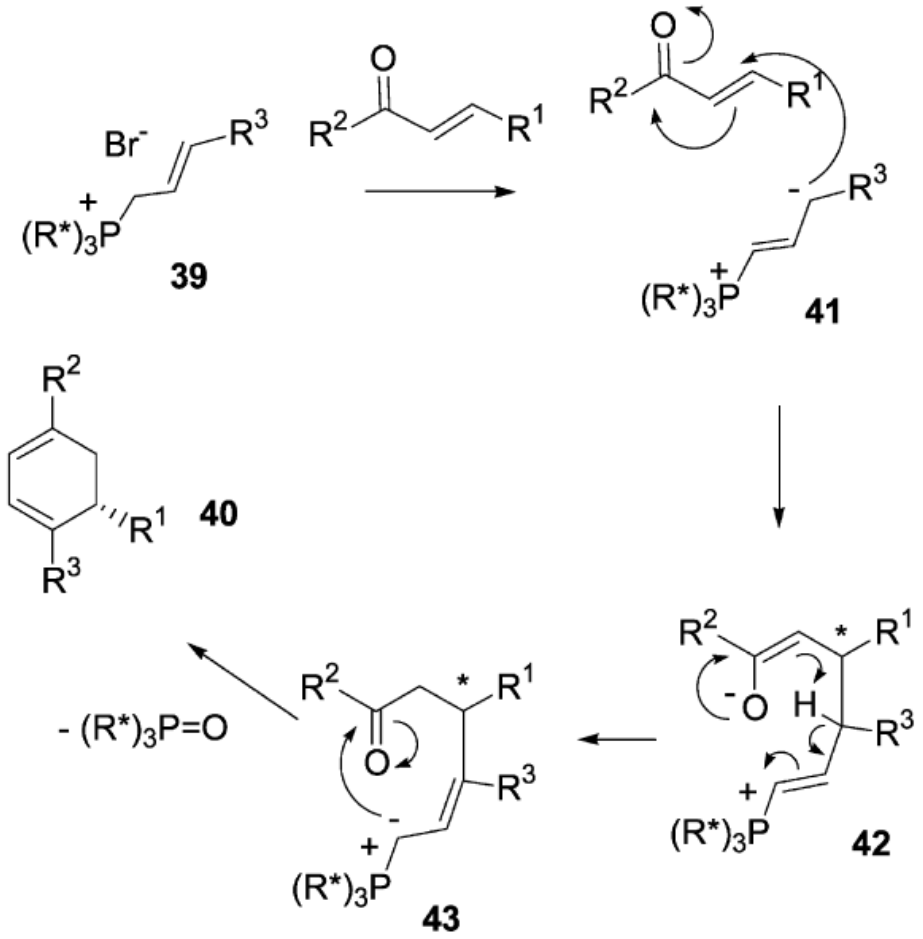
$R^1 = o\text{-}BrC_6H_4$, $R^2 = Ph$, $R^3 = CO_2Me$: 60%, ee = 80%

$R^1 = p\text{-}MeOC_6H_4$, $R^2 = Ph$, $R^3 = CO_2Me$: 65%, ee = 90%

$R^1 = Me$, $R^2 = Ph$, $R^3 = CO_2Me$: 53%, ee = 78%

$R^1 = Me$, $R^2 = H$, $R^3 = CO_2Me$: 67%, ee = 25%

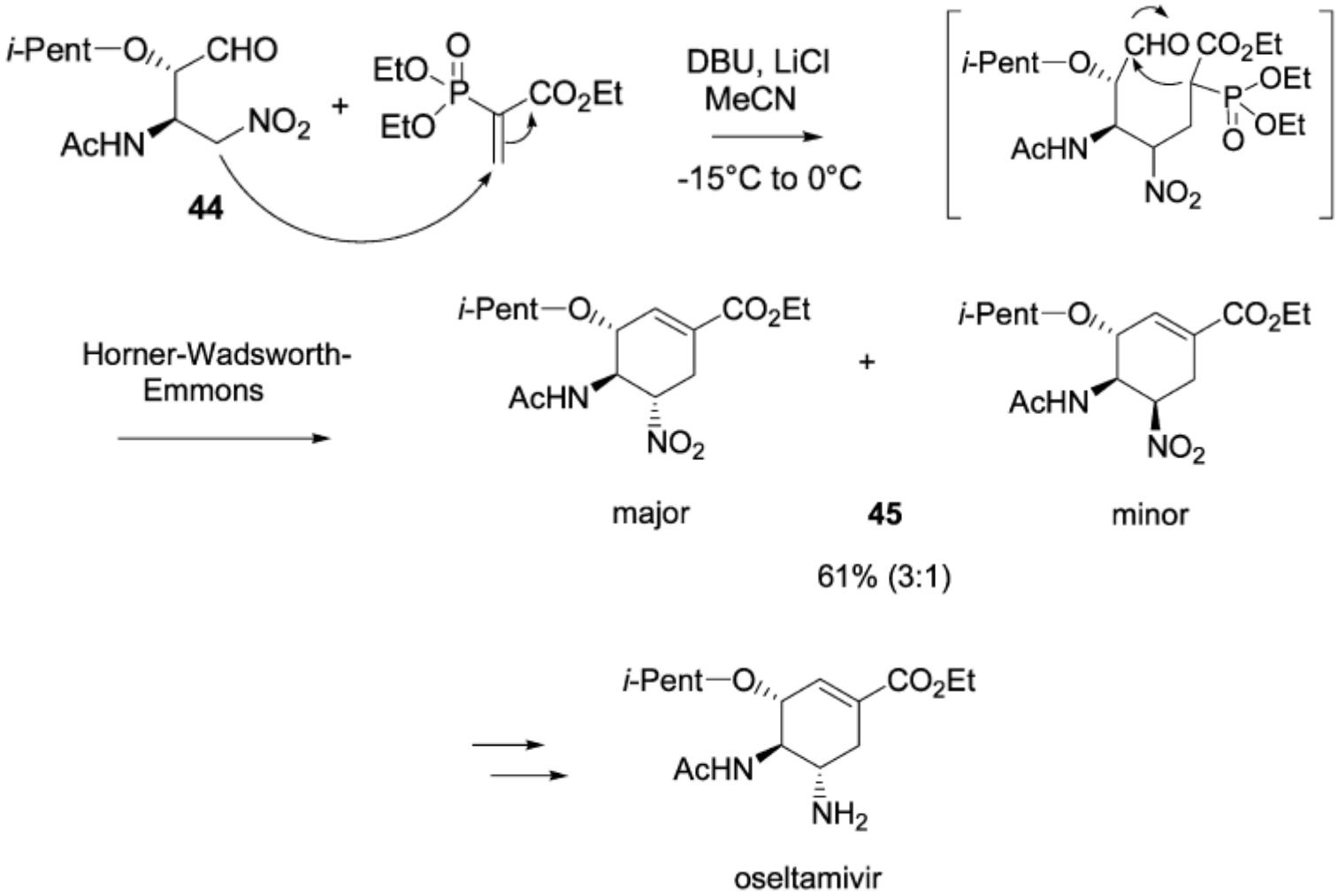
proposed mechanism:



Zhou, Y.-G. *Chem. Commun*. **2009**, 3092

Anionic primary step

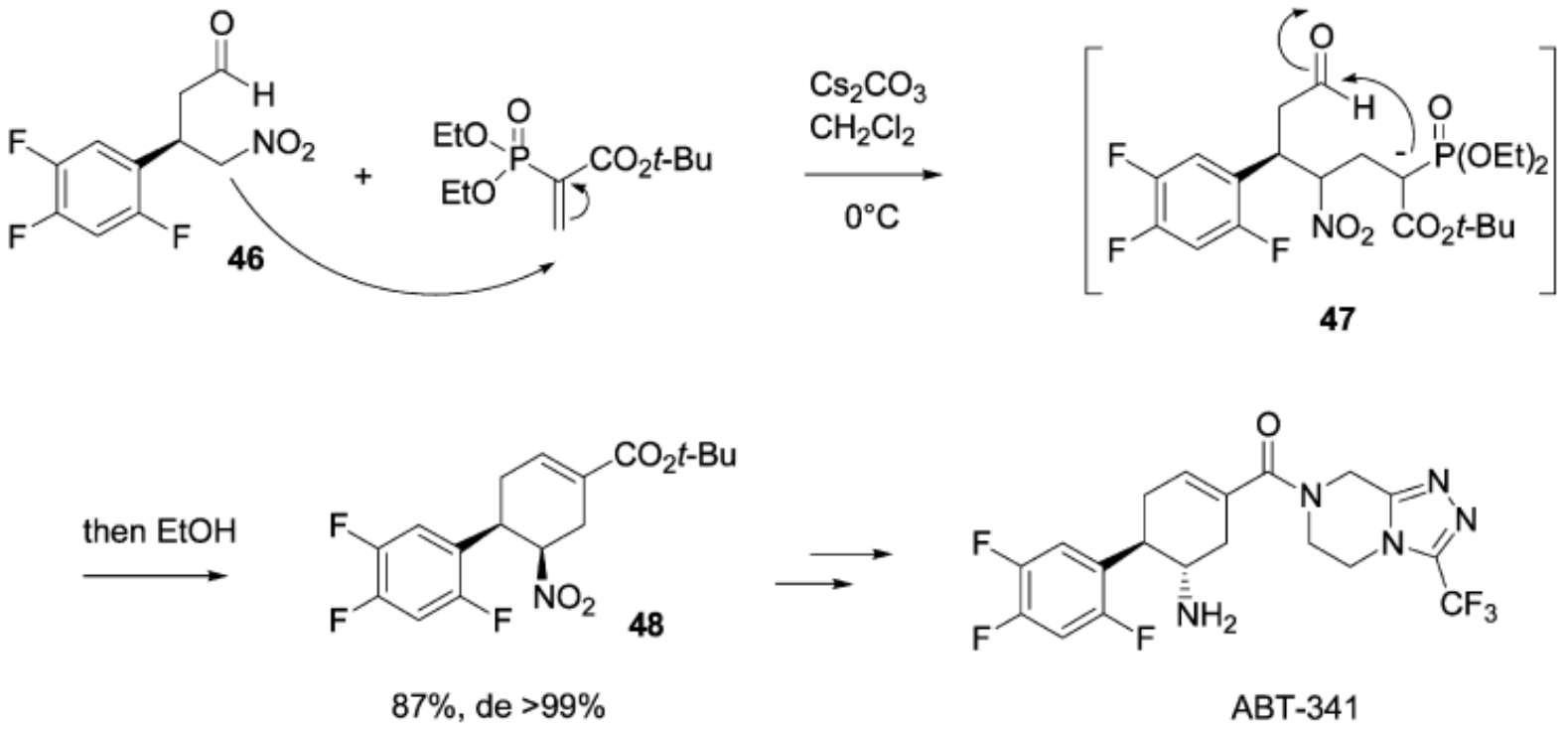
Synthesis of Oseltamivir through Domino Michael/Horner-Wadsworth-Emmons Reaction



Lu, G. *J. Org. Chem*. **2010**, *75*, 3125

Anionic primary step

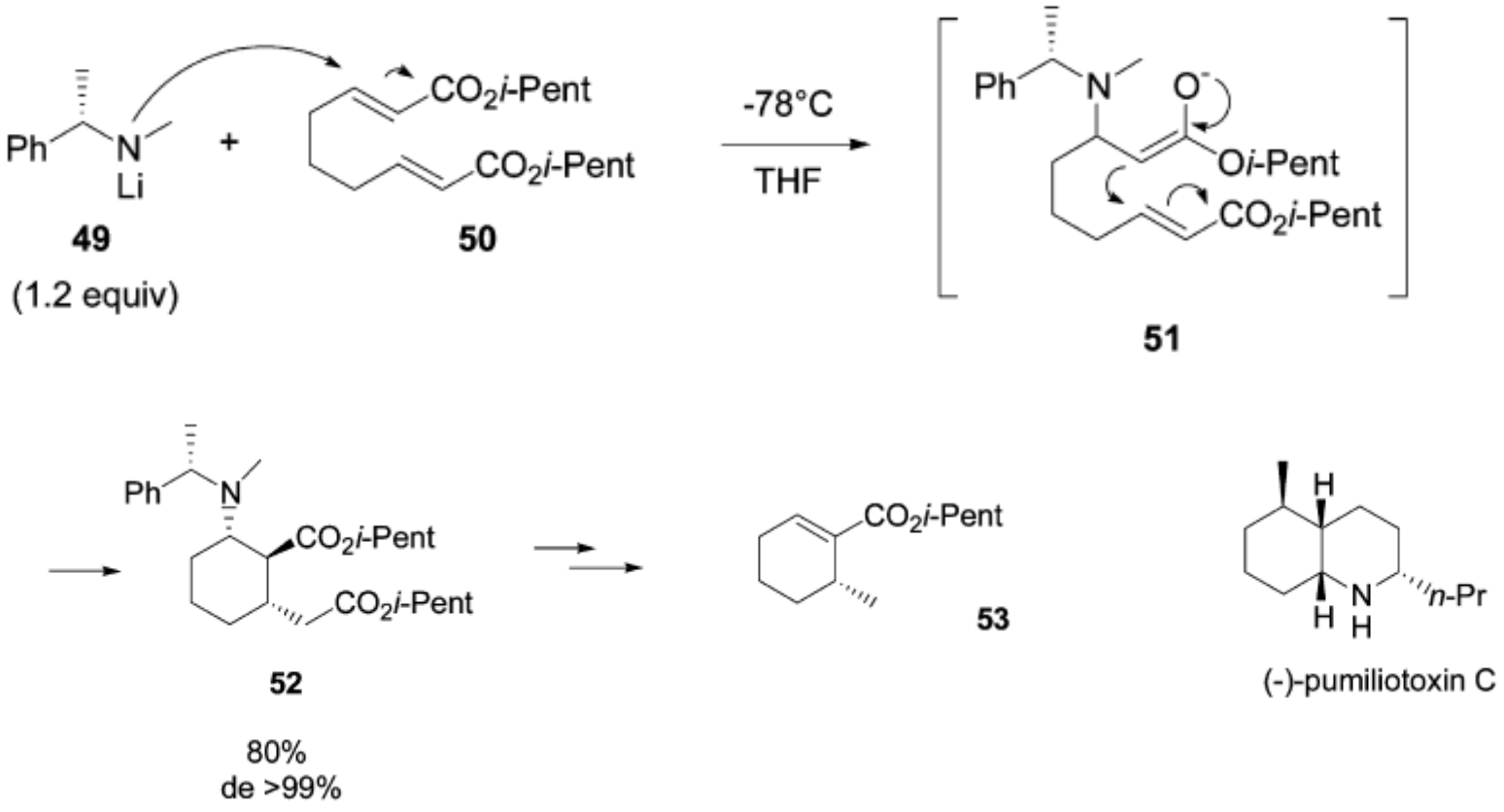
Synthesis of ABT-341 through Domino Michael/ Horner-Wadsworth-Emmons Reaction



Hayashi, Y. *Angew. Chem., Int. Ed*. **2011**, *50*, 2824

Anionic primary step

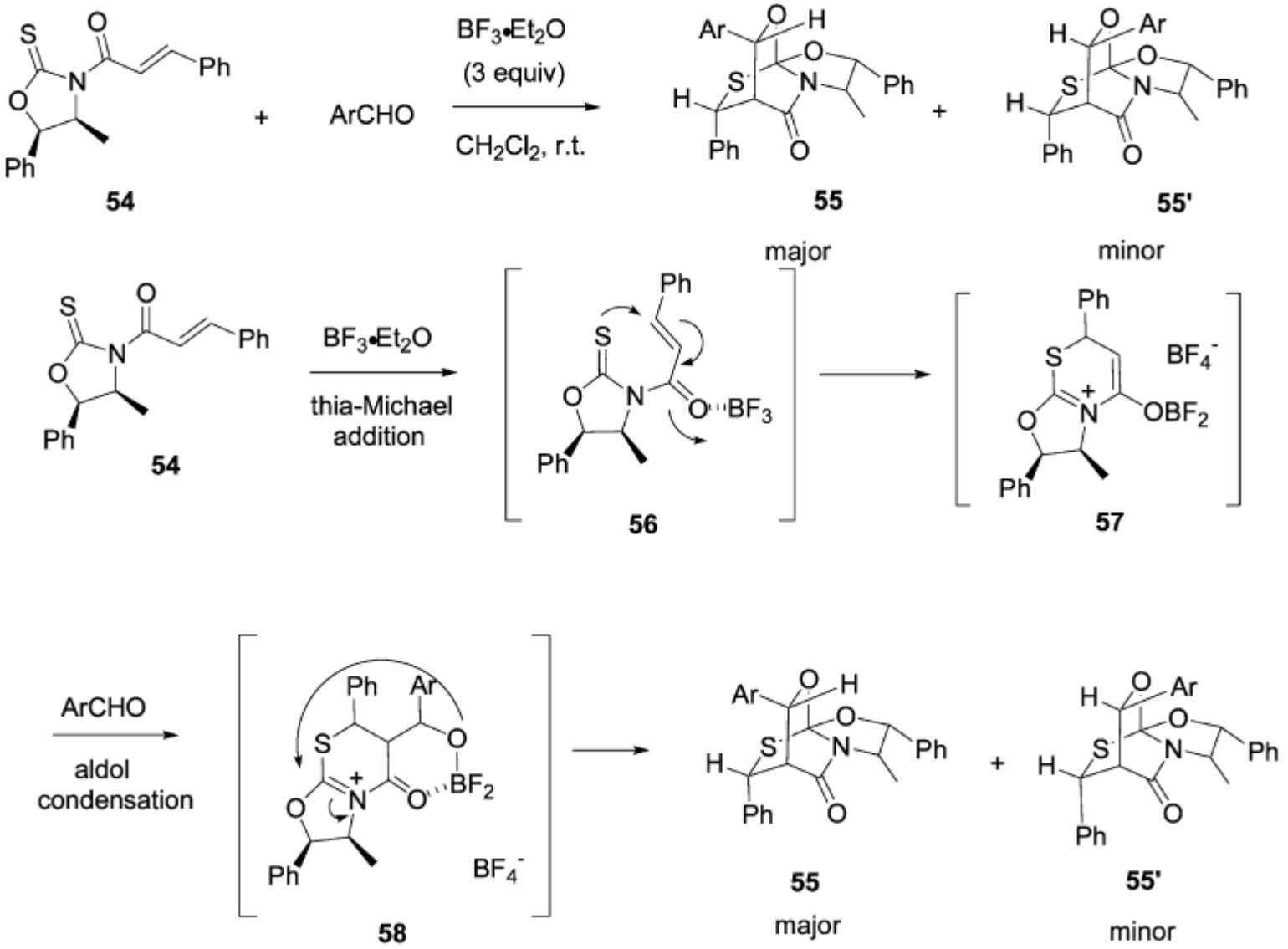
Synthesis of Precursor of (-)-Pumiliotoxin C through Domino Aza-Michael/Michael Reaction



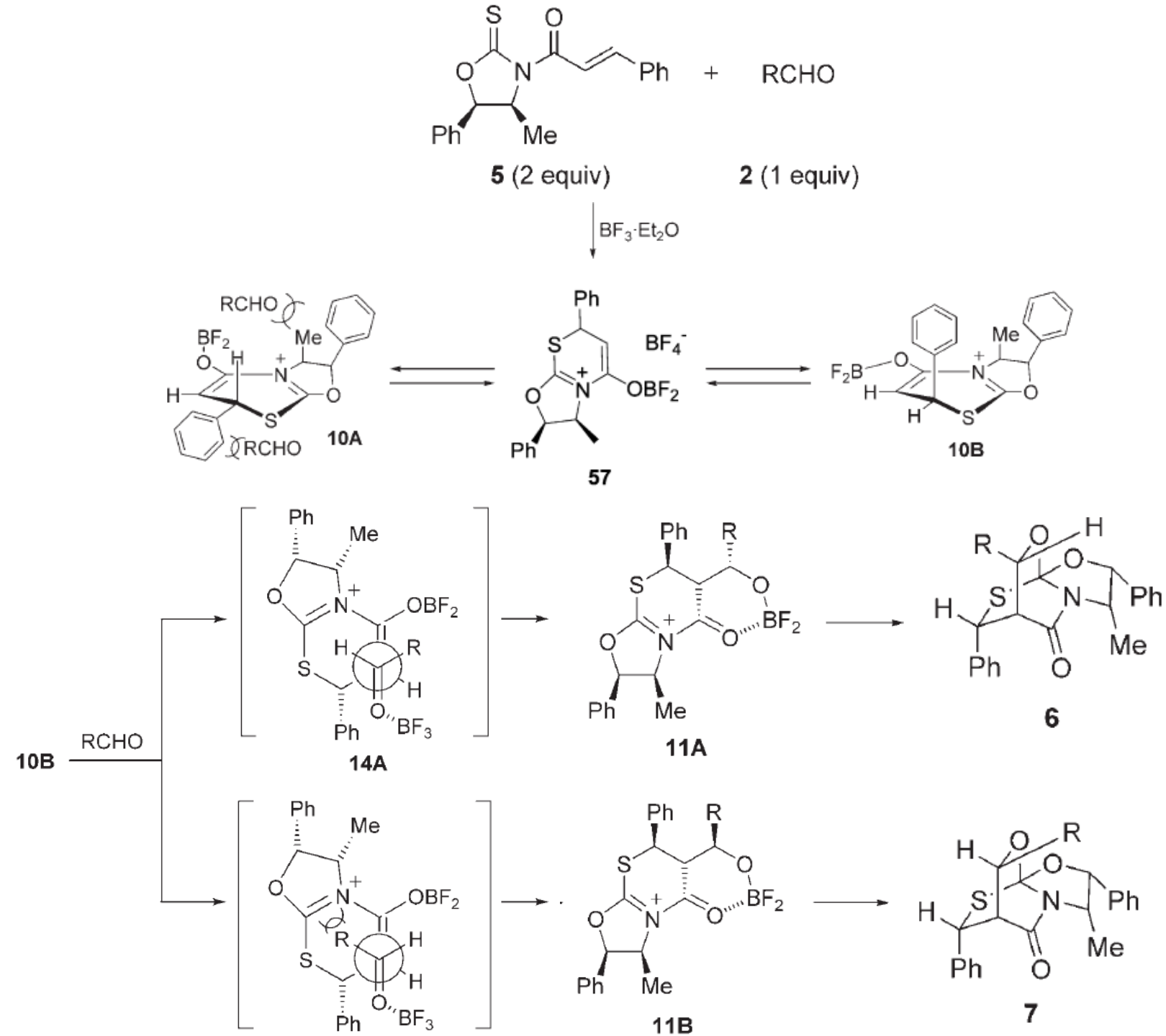
Davies, S. G. *Tetrahedron: Asymmetry* **2006**, *17*, 2183

Anionic primary step

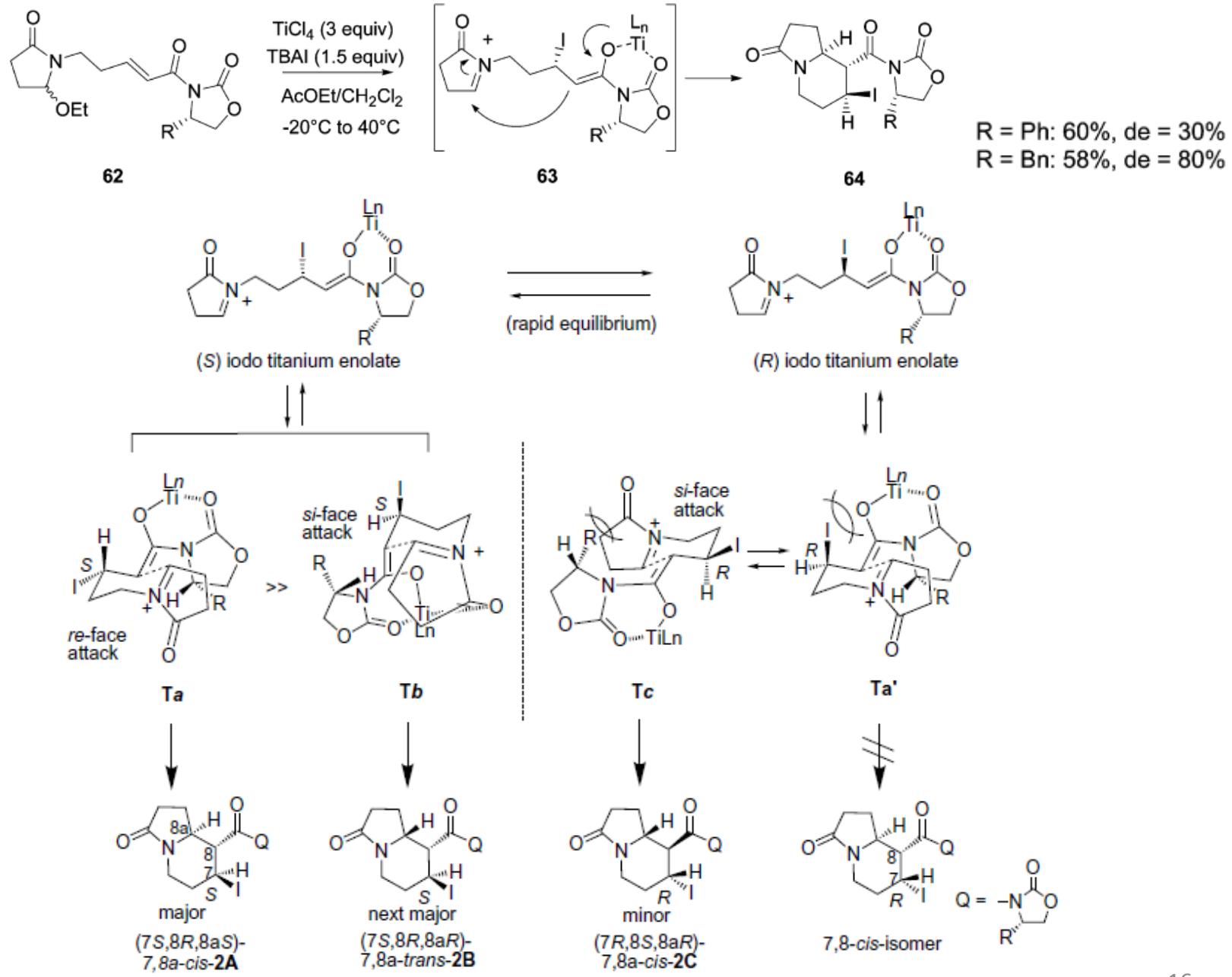
Domino Thia-Michael/Aldol Reaction of Chiral 3-Cinnamoyloxazolidine-2-thione with Aromatic Aldehydes



Tanabe, G. *Chem.—Eur. J.* **2006**, *12*, 3896


Ph + RCHO
5 (2 equiv)
2 (1 equiv)
BF3·Et2O
10A
57
10B
10B
RCHO
14A
11A
6
11B
7

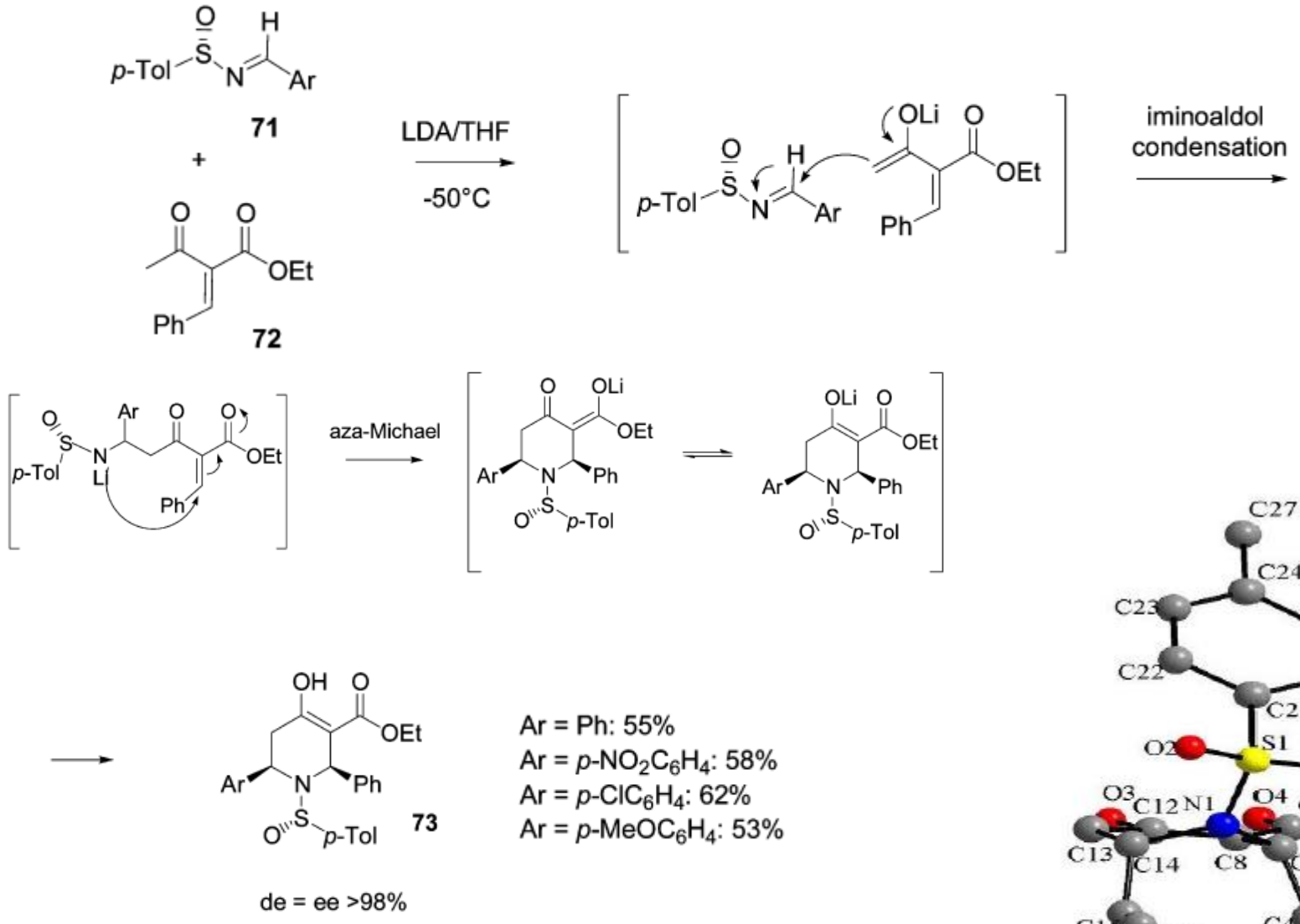
Intramolecular Domino Hetero-Michael/Mannich-type Reaction

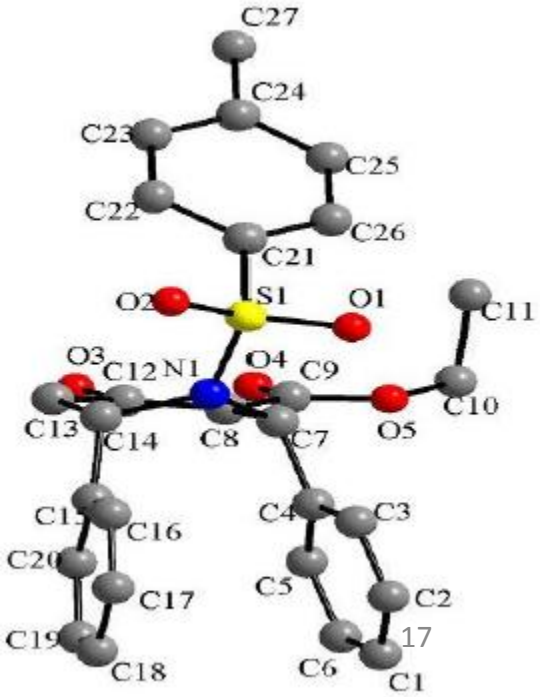


Nagasaka, T. *Tetrahedron: Asymmetry* **2007**, *18*, 1533

Anionic primary step

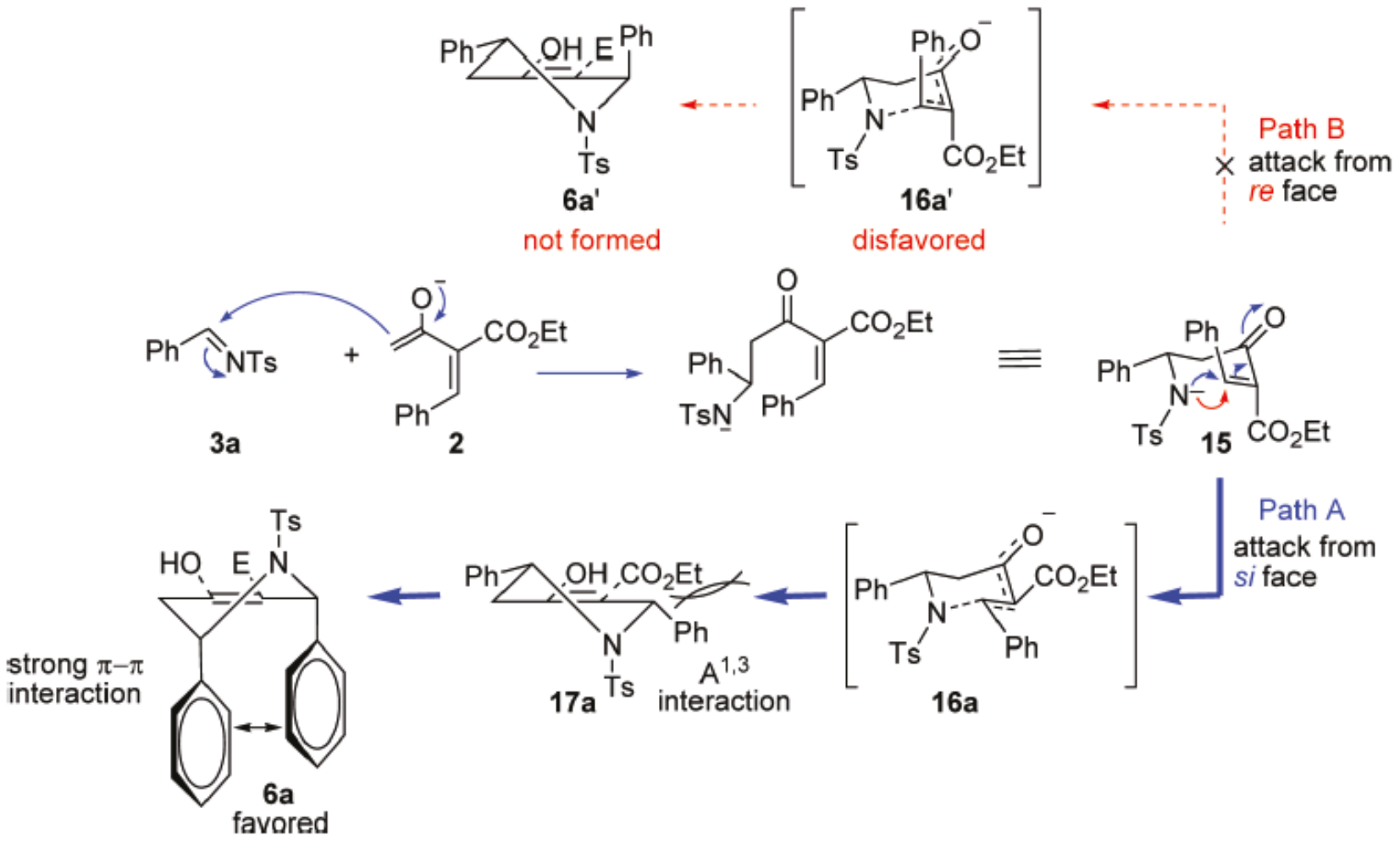
Domino Imino-Aldol/Aza-Michael Reaction





Das, R. K. *J. Org. Chem*. **2010**, *75*, 7061

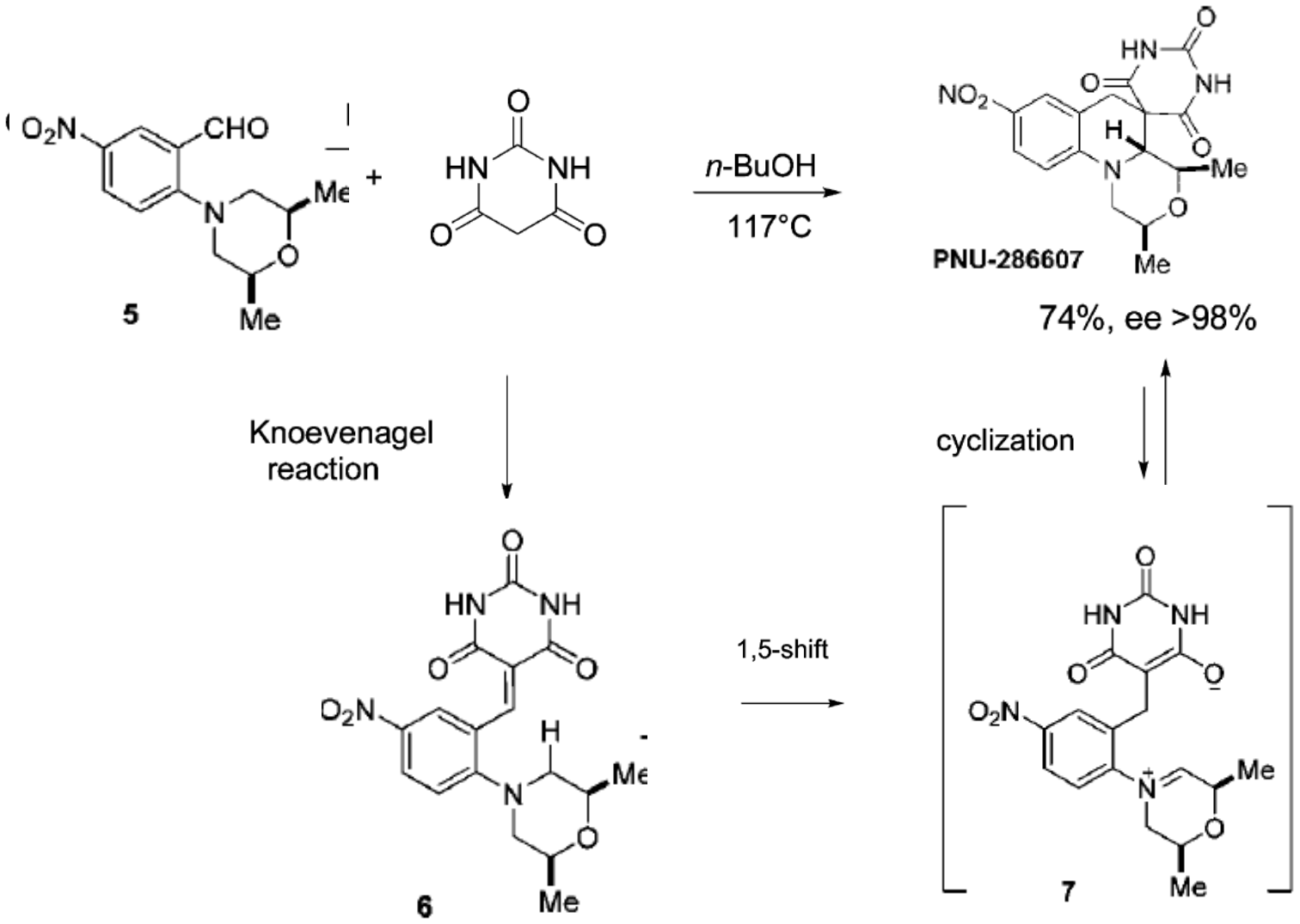
Domino Imino-Aldol/Aza-Michael Reaction



Das, R. K. *J. Org. Chem.* **2010**, *75*, 7061

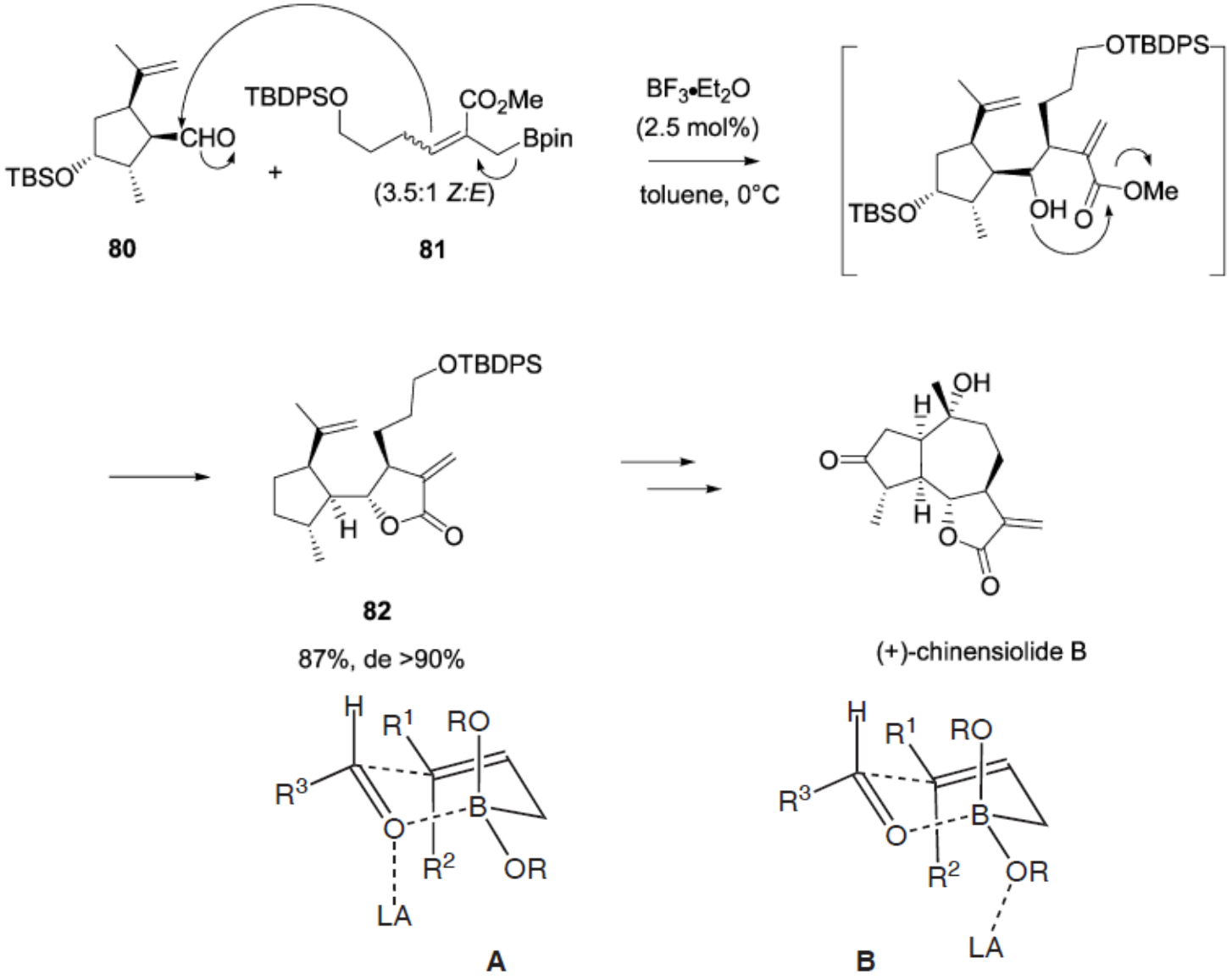
Anionic primary step

Synthesis of (-)-PNU-286607 through Domino Knoevenagel/[1,5]-Hydrogen Shift/Cyclization Reaction



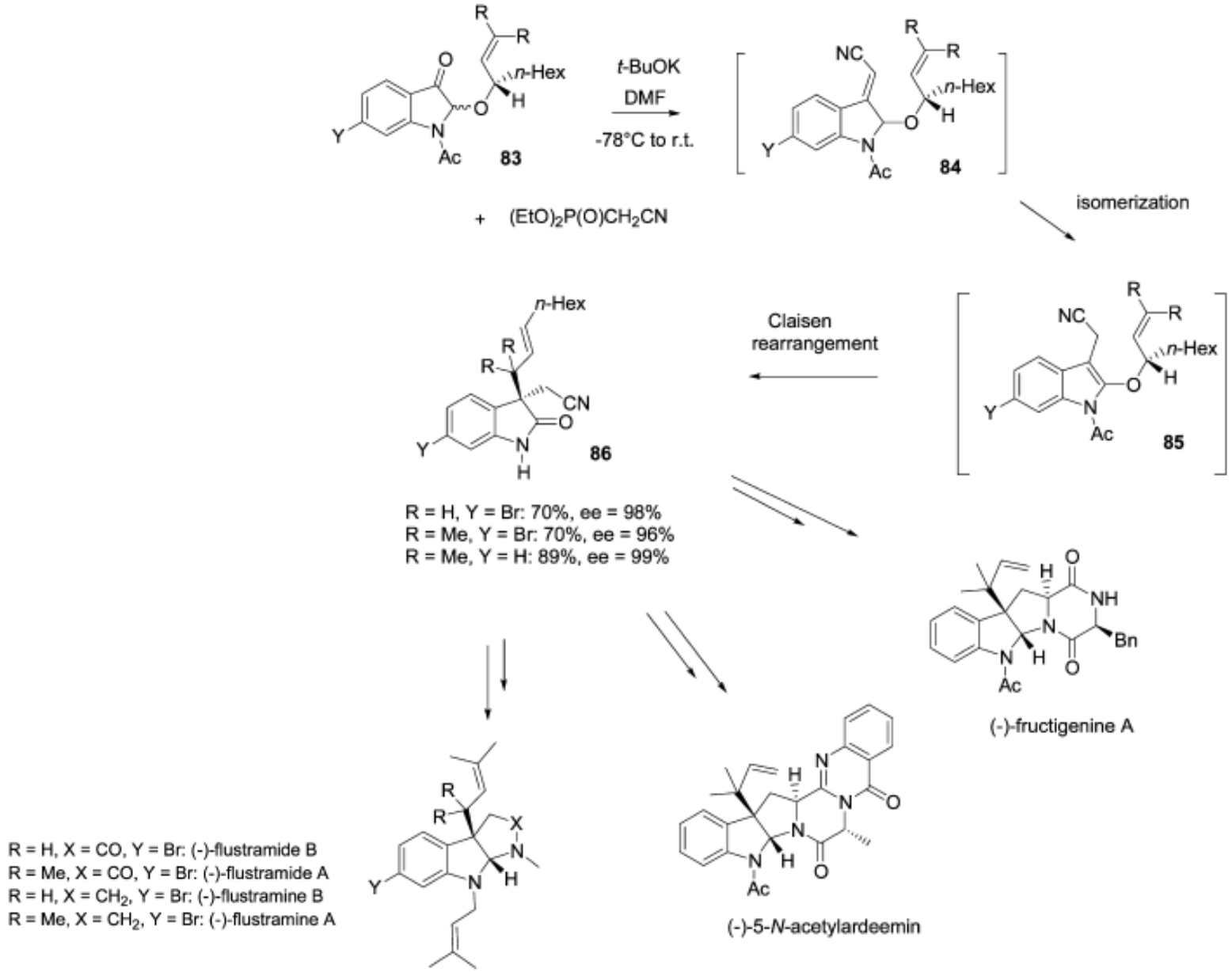
Kamilar, G. M. *J. Am. Chem. Soc*. **2009**, *131*, 3991

Synthesis of (+)-Chinensiolide B through Domino Allylboration/Lactonization Reaction



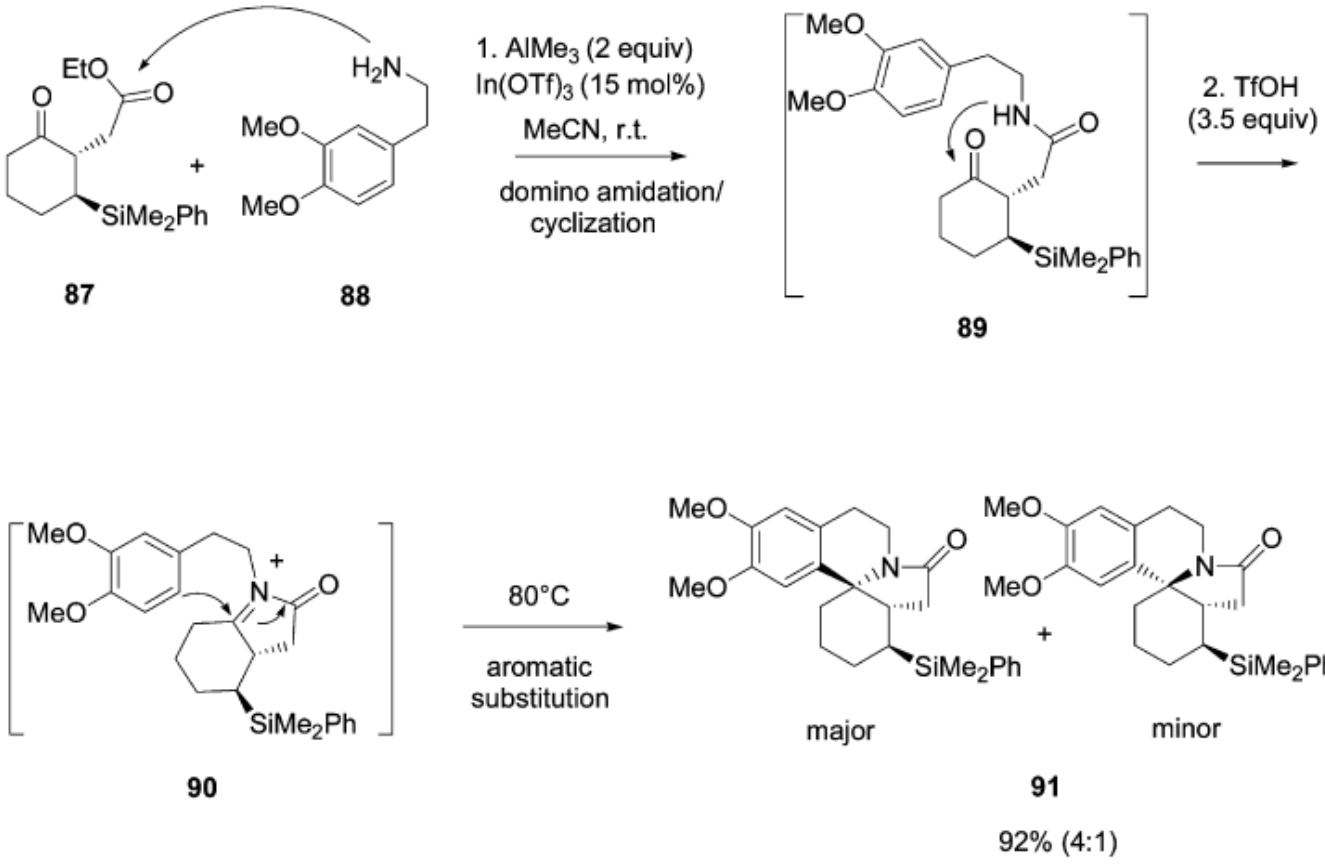
Hall, D. G. *J. Am. Chem. Soc*. **2010**, *132*, 1488

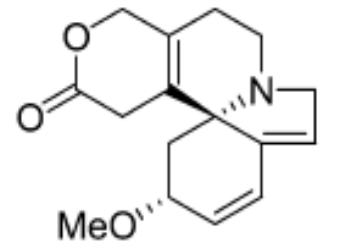
Synthesis of Alkaloids through Domino Horner-Wadsworth-Emmons/Isomerization/Claisen Rearrangement Reaction



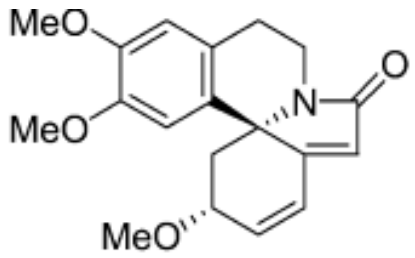
Kawasaki, T. *J. Org. Chem*. **2010**, *75*, 1126

Domino Amidation/Cyclization Reaction Followed by Intramolecular Electrophilic Aromatic Substitution





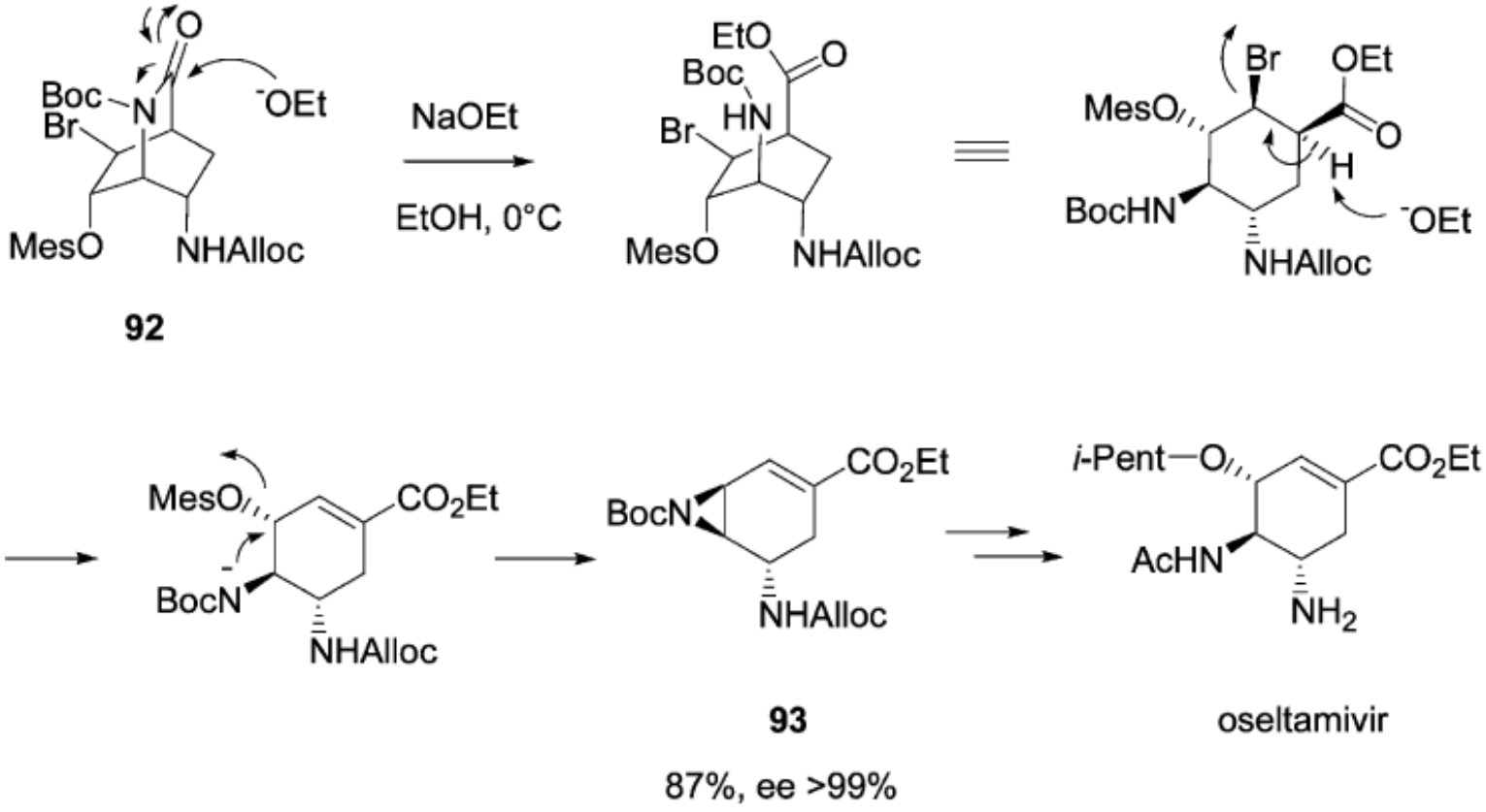
(+)-β-erythroidine (**2**)



erysotramidine (**3**)

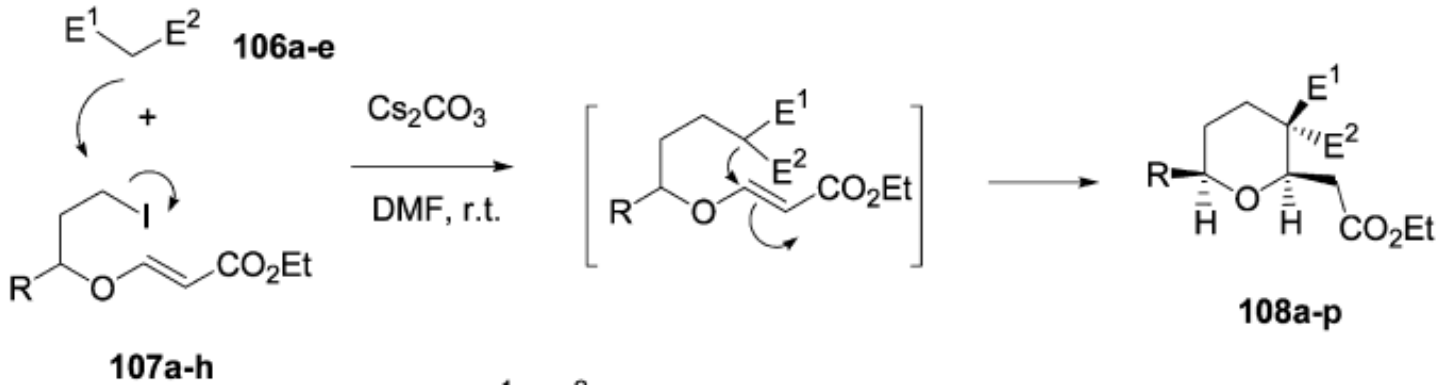
Stalke, D. *Org. Lett*. **2009**, 11, 5230

Domino Ethanolysis/Dehydrobromation/ Aziridination Reaction



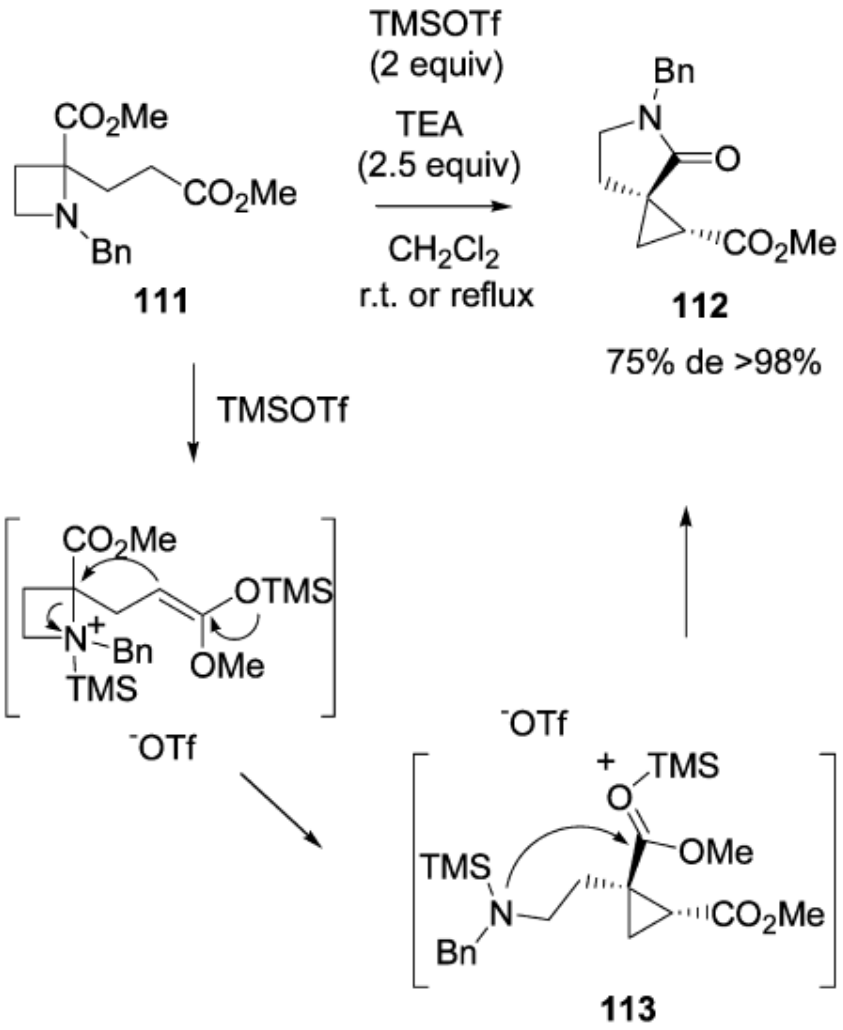
Fukuyama, T. *Tetrahedron* **2009**, 65, 3239

Domino SN2/Michael Reactions



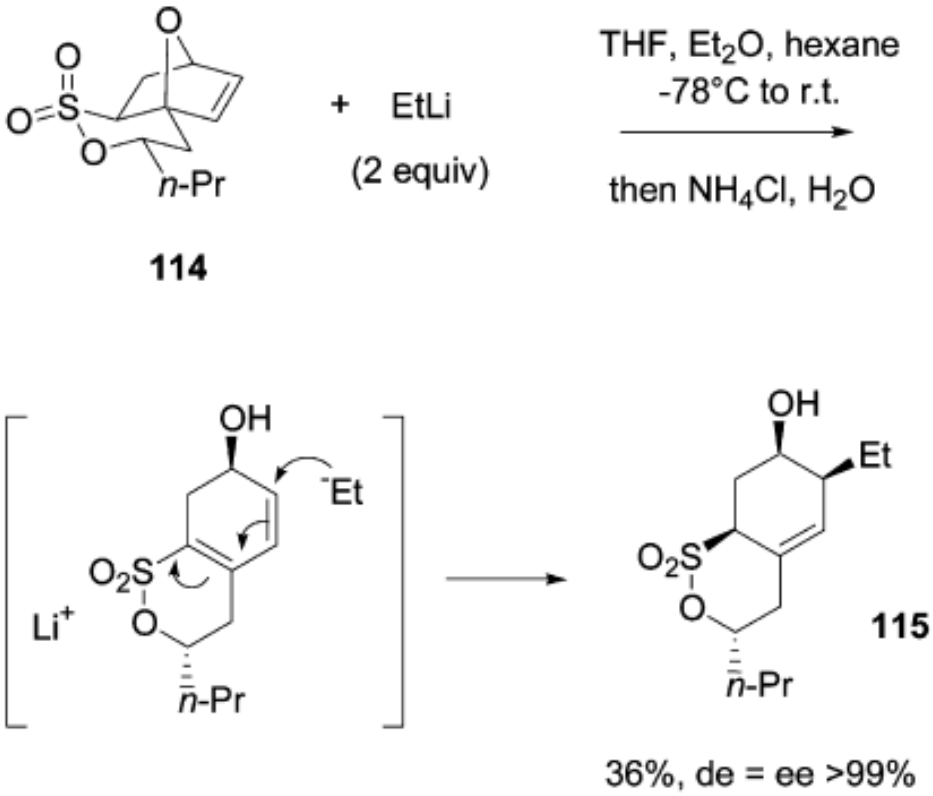
Reddy, S. R. B. *Org. Lett*. **2009**, *11*, 2519

Domino Intramolecular Azetidine RingOpening/Closing Reaction



Compain, P. *Eur. J. Org. Chem*. **2011**, 6619

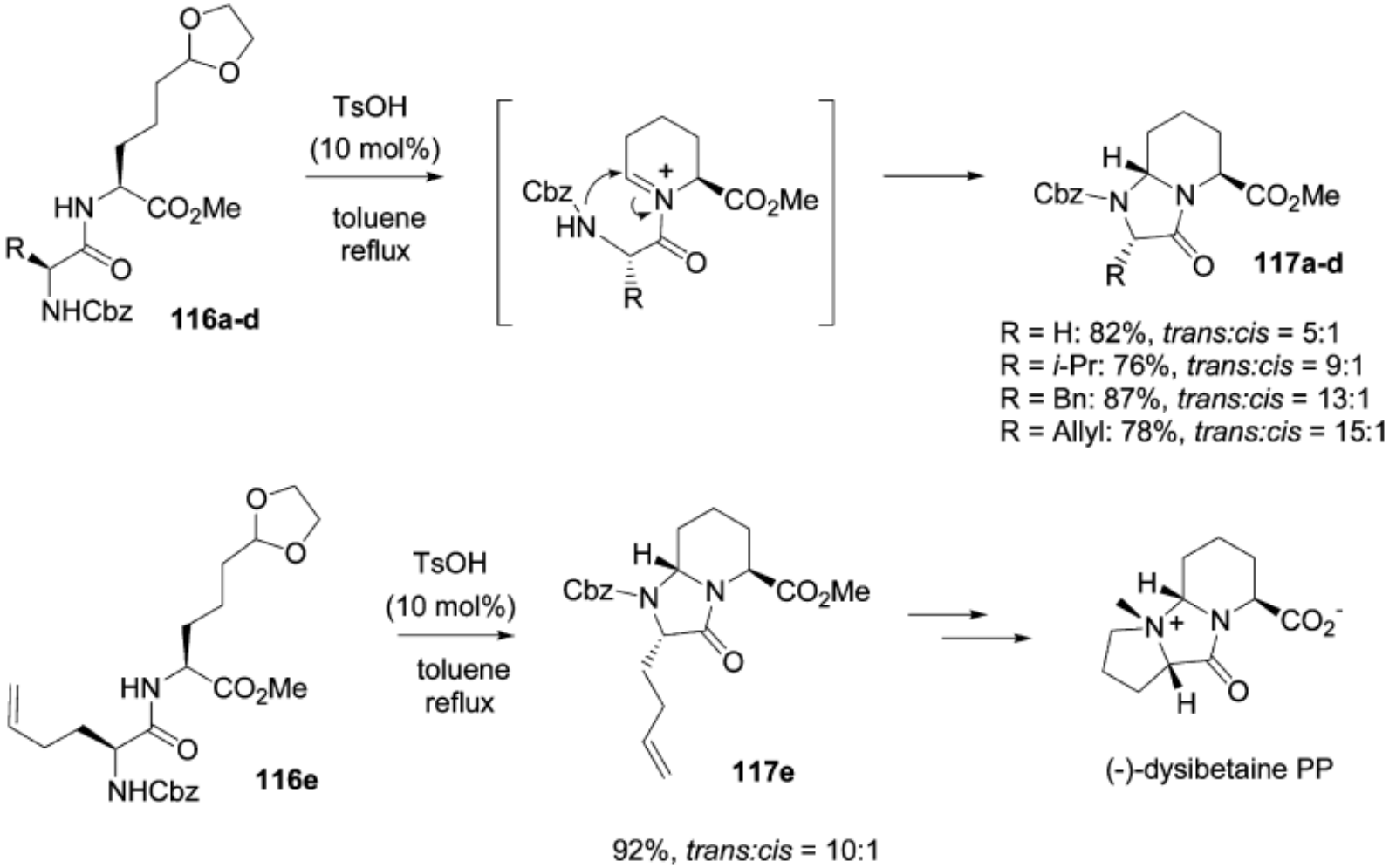
Domino Elimination/1,6-Addition Reaction



114

Metz, P. *Chem.—Eur. J*. **2011**, *17*, 13334

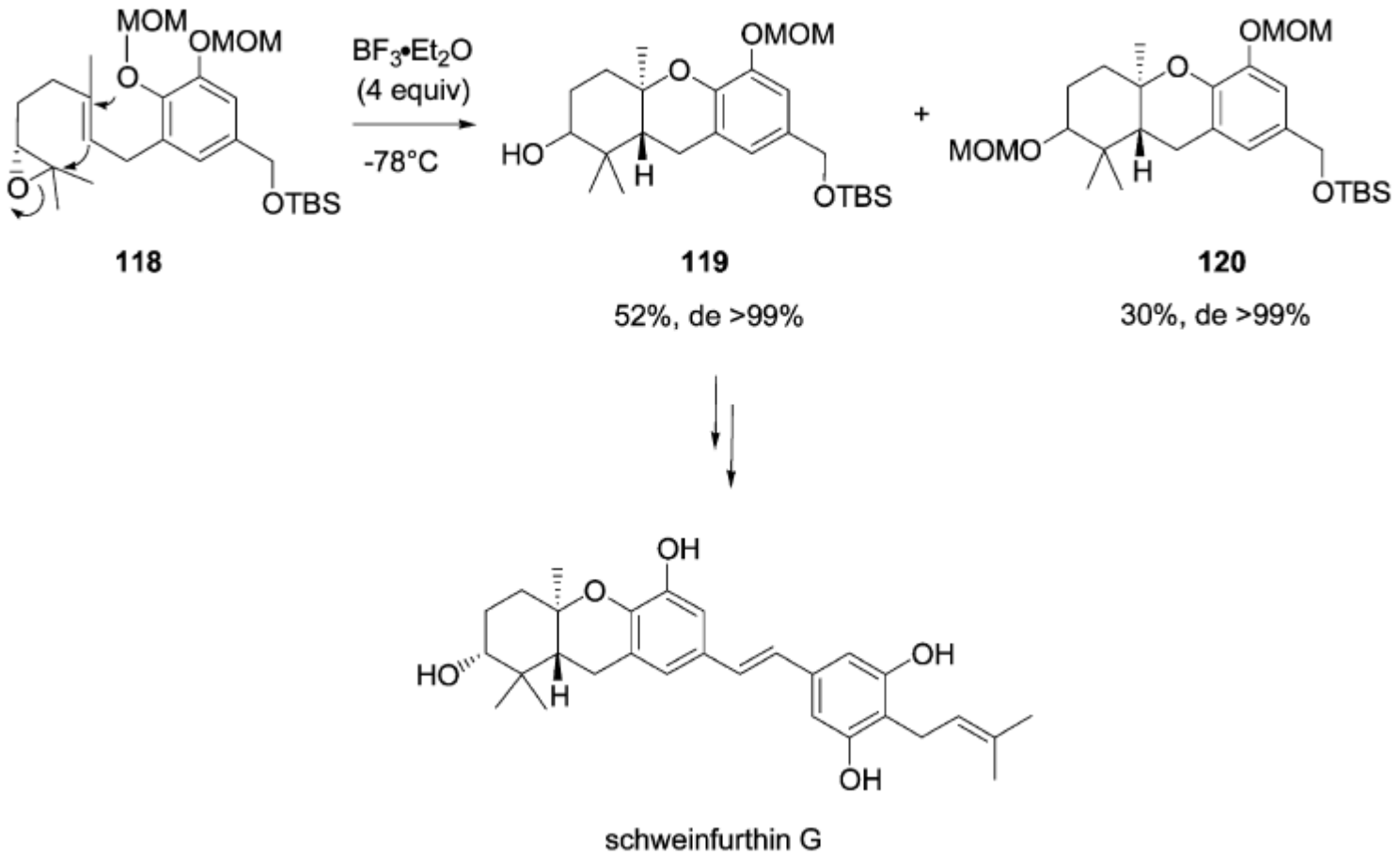
Synthesis of (-)-Dysibetaine PP through Domino Cyclization Reaction



Blaauw, R. H. *Org. Lett*. **2006**, *8*, 239

Cationic sequence

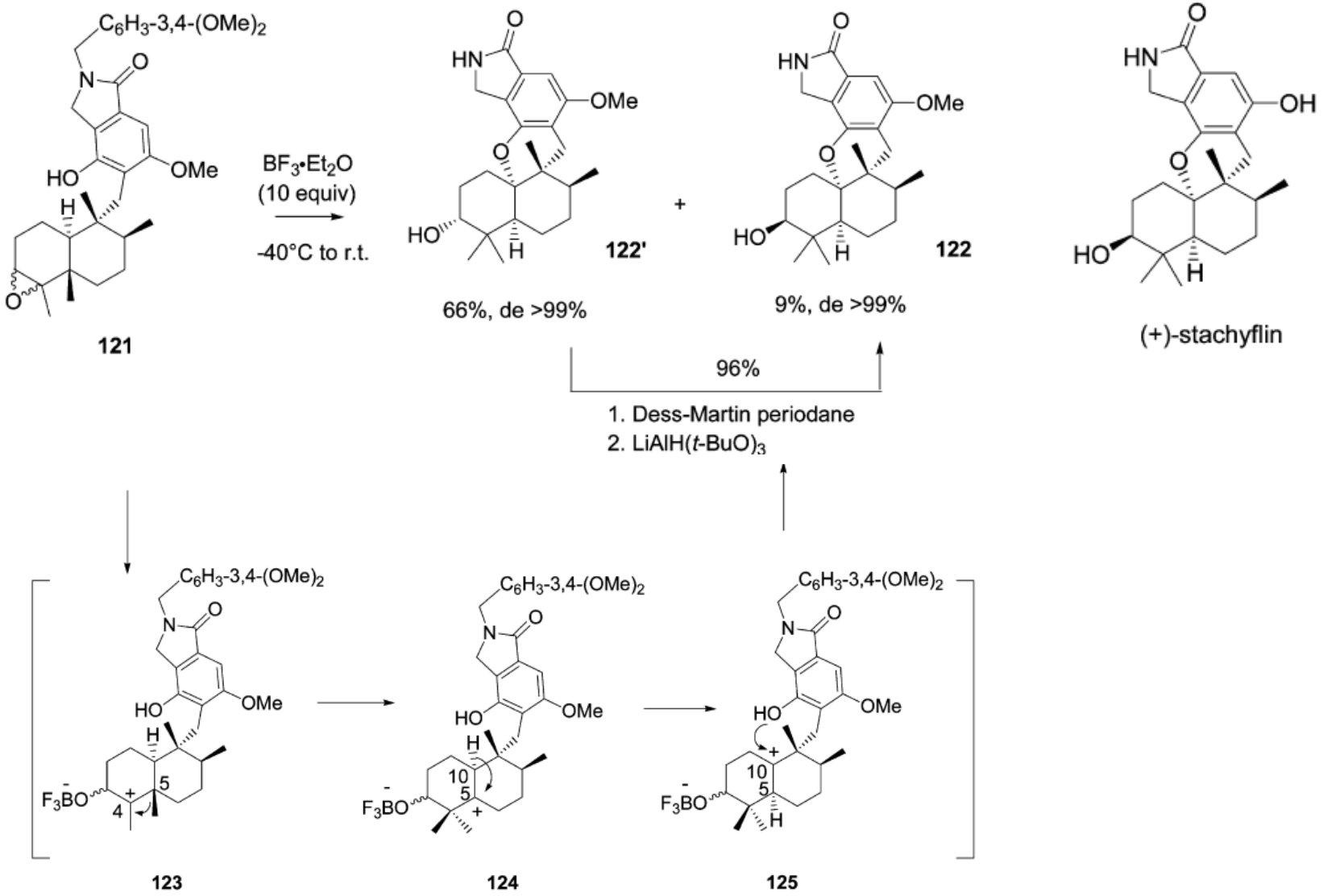
Synthesis of Schweinfurthin G through Domino Epoxide-Opening/Cyclization Reaction



Wiemer, D. F. *J. Org. Chem*. **2008**, *73*, 7963

Cationic sequence

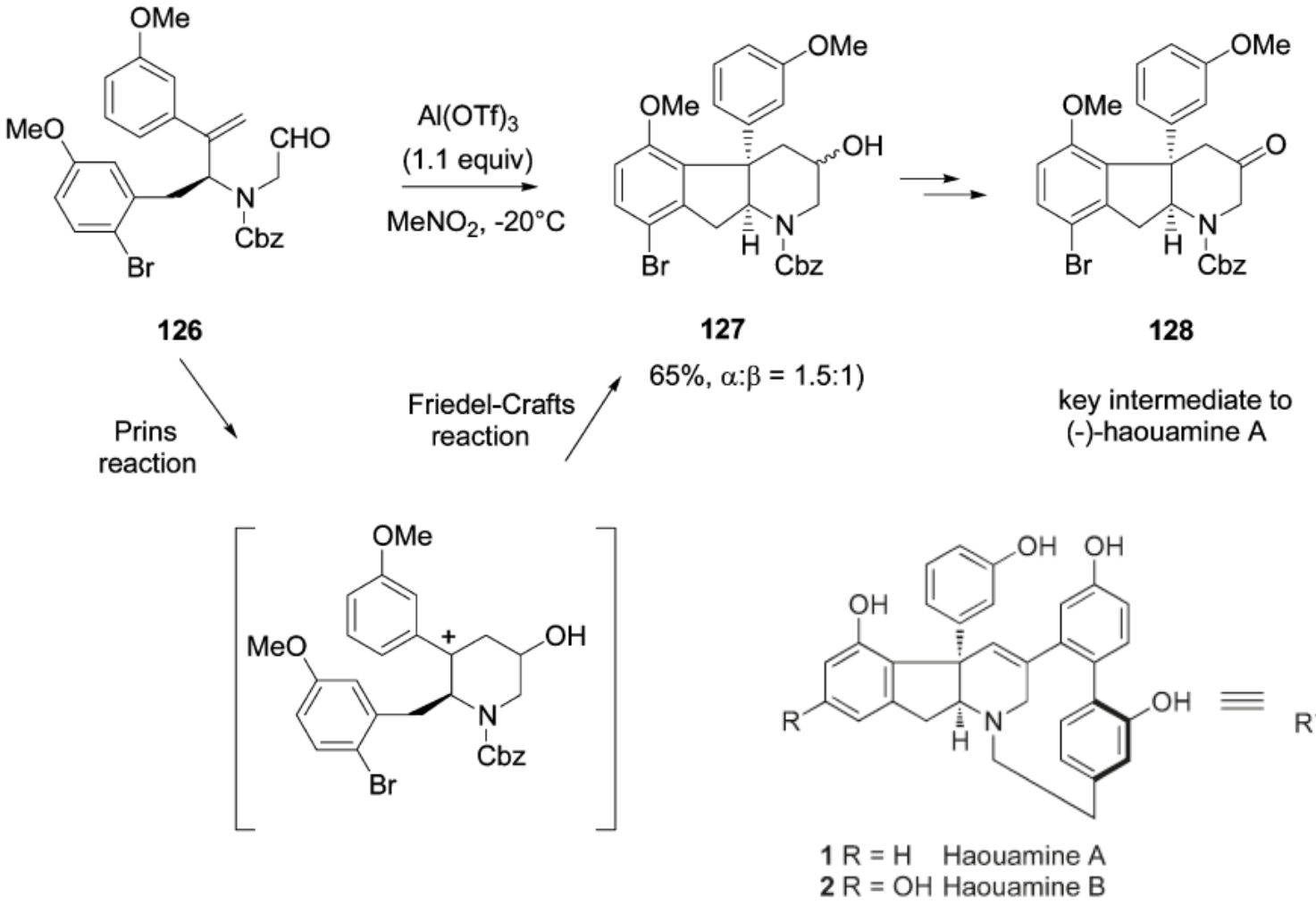
Synthesis of (+)-Stachyflin through Domino Epoxide-Opening/Rearrangement/Cyclization Reaction



Katoh, T. *Chem. Commun*. **2010**, *46*, 4055

Cationic sequence

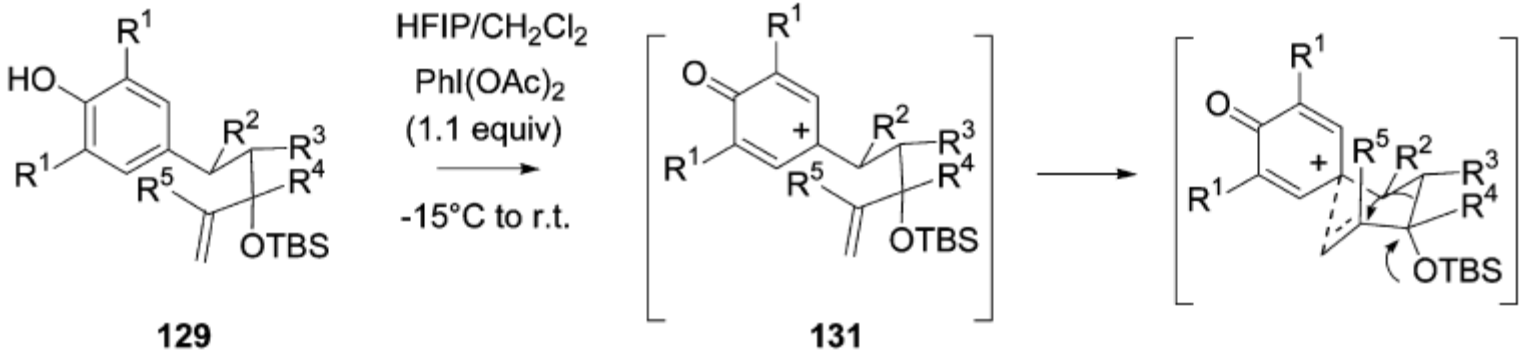
Domino Prins/Friedel-Crafts Reaction



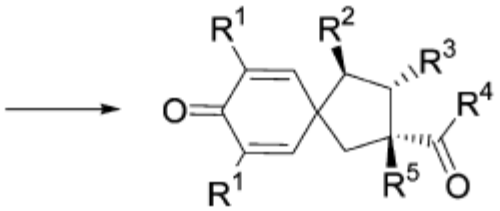
Aub'e, J. *Org. Lett*. **2011**, *13*, 2614

Cationic sequence

Oxidative Domino Prins/Pinacol Reaction



129 **131**



130

de >90%

$R^1 = R^3 = R^5 = H$, $R^2 = R^4 = Me$: 50%

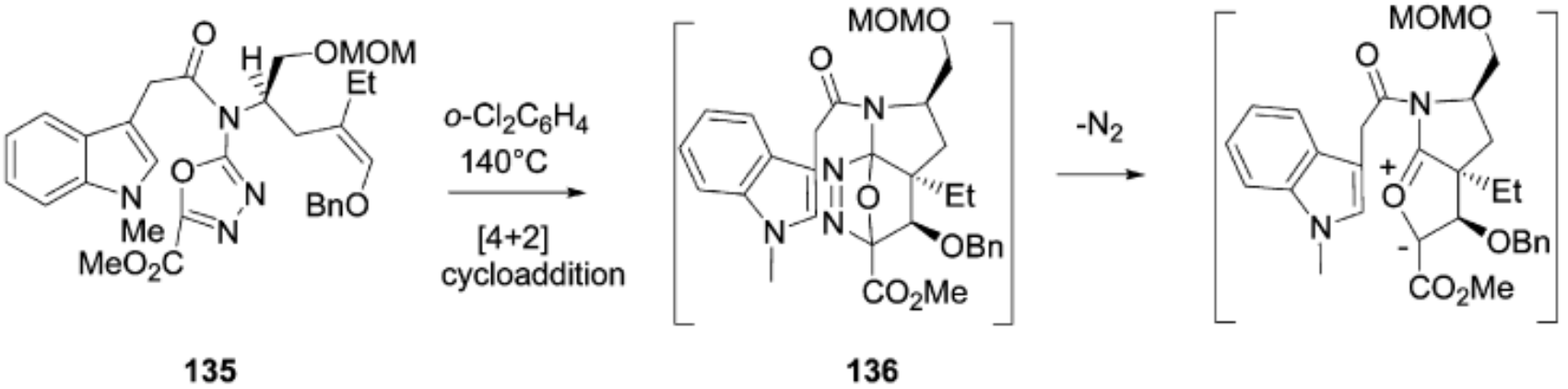
$R^1 = R^2 = R^5 = H$, $R^3 = allyl$, $R^4 = CH{=}CH_2$: 55%

$R^1 = R^2 = R^5 = H$, $R^3 = R^4 = Me$: 30%

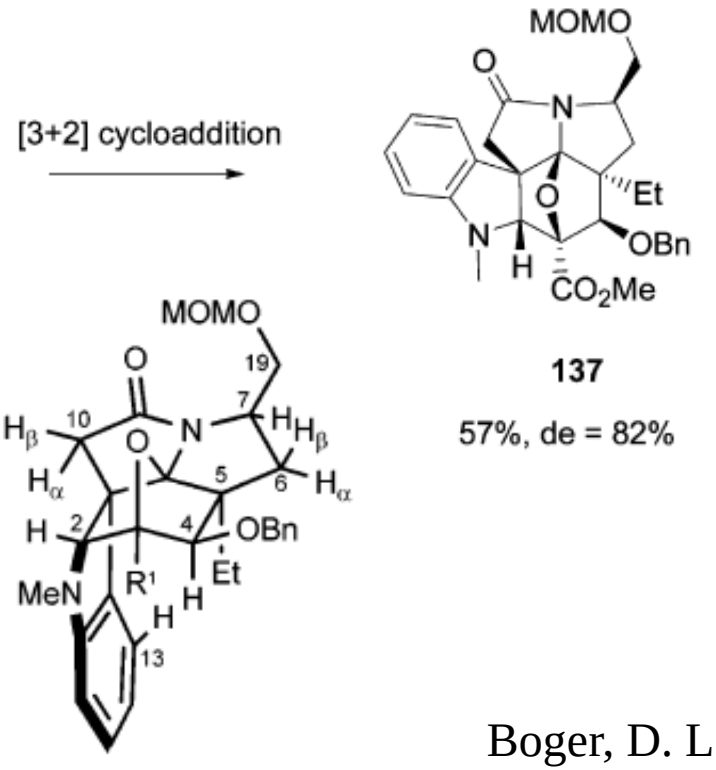
Canesi, S. *J. Org. Chem*. **2011**, 76, 9460

Initiated by a pericyclic primary step

Domino Intramolecular Diels-Alder Cycloaddition/1,3-Dipolar Cycloaddition Reaction

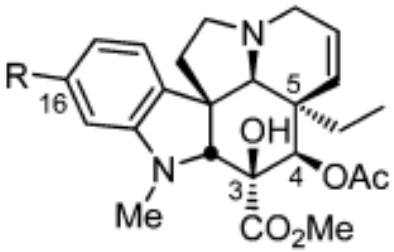


135 **136**

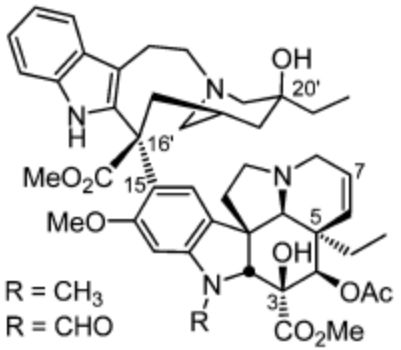


137

57%, de = 82%



1, R = OMe, Vindoline
2, R = H, Vindorosine

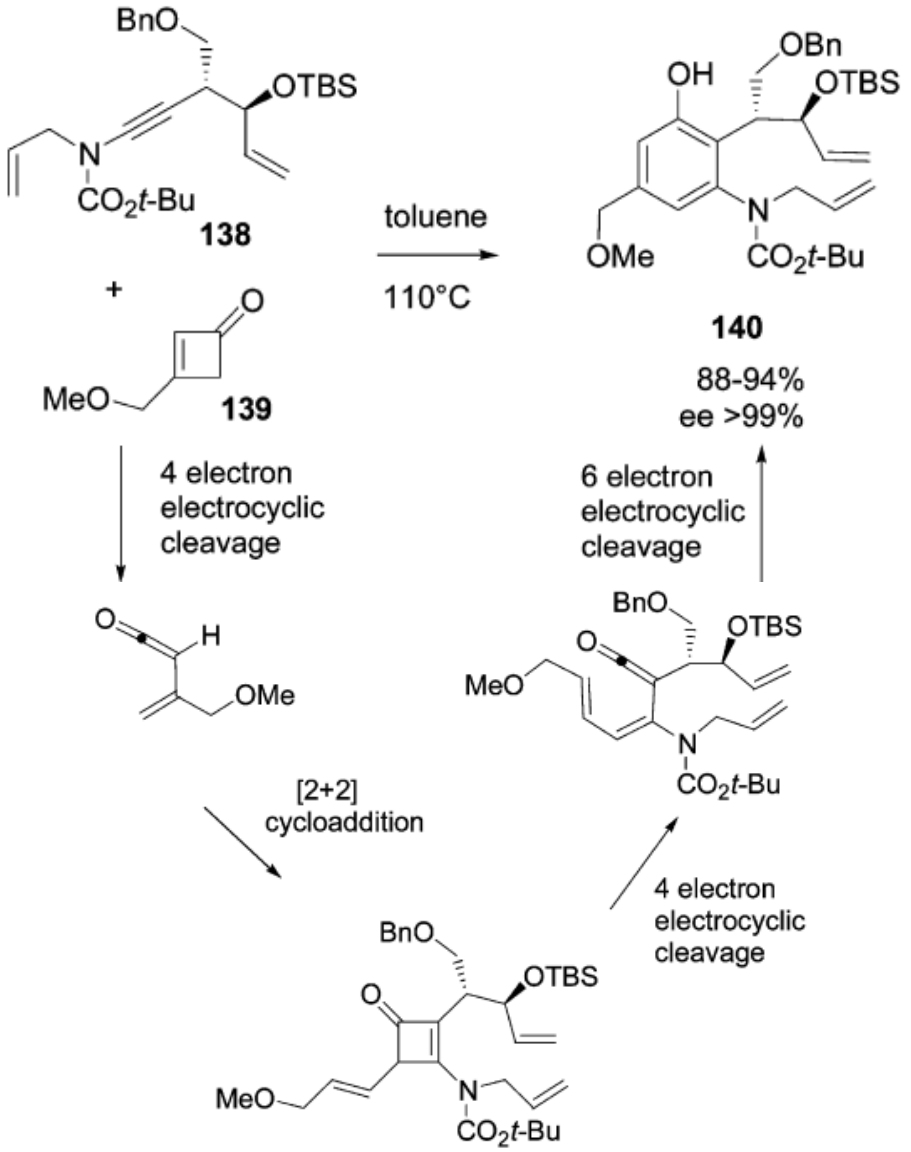


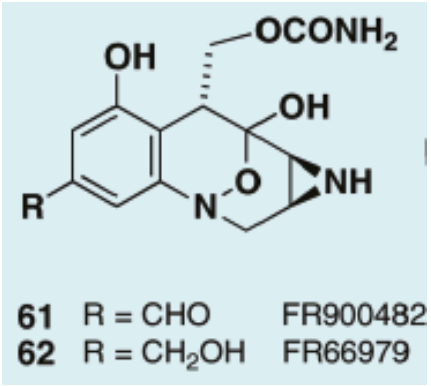
4, Vinblastine R = CH_3
5, Vincristine R = CHO

Boger, D. L. *J. Am. Chem. Soc*. **2010**, *132*, 13533

Initiated by a pericyclic primary step

Domino Intramolecular Ynamide Benzannulation Reaction

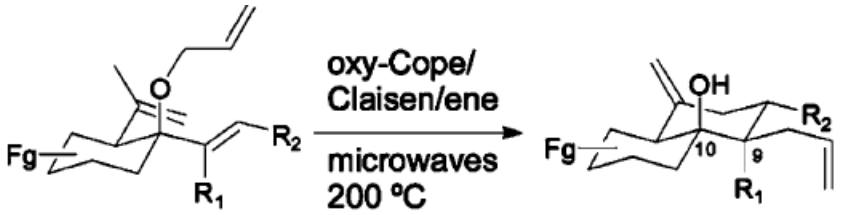


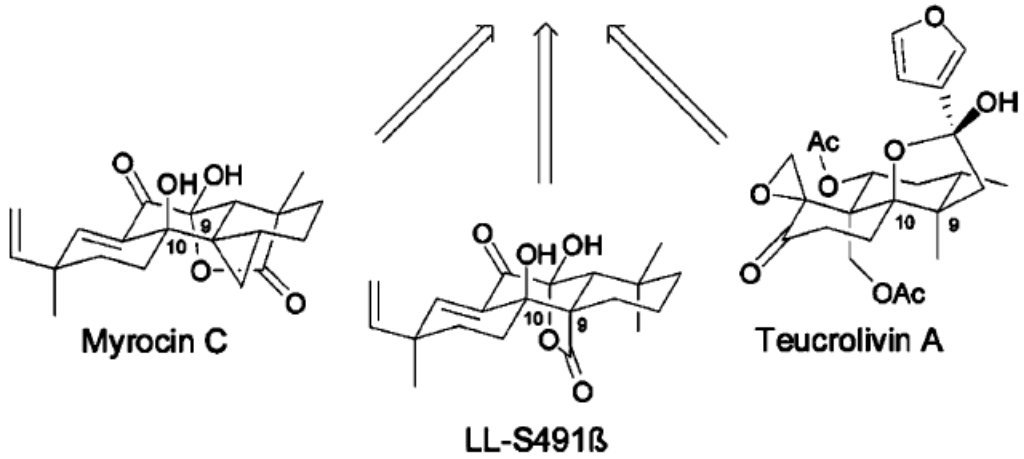


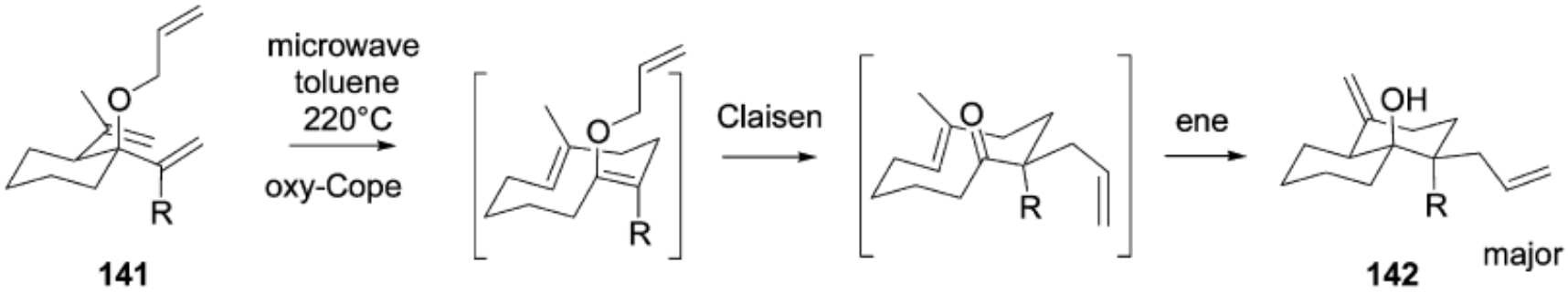
Danheiser, R. L. *J. Org. Chem*. **2011**, *76*, 1852.

Initiated by a pericyclic primary step

Domino Oxy-Cope/Claisen/Ene Reaction



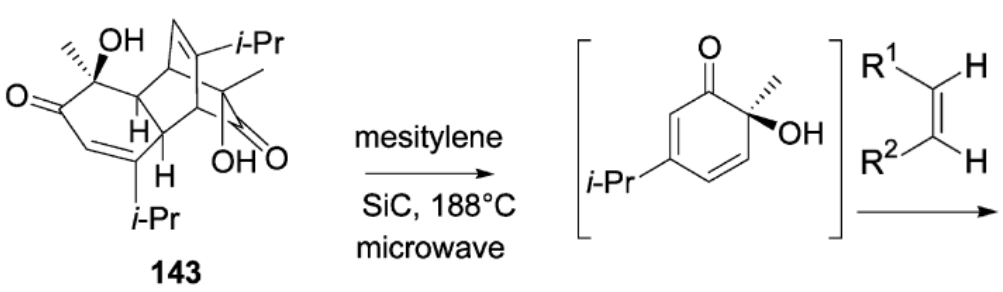


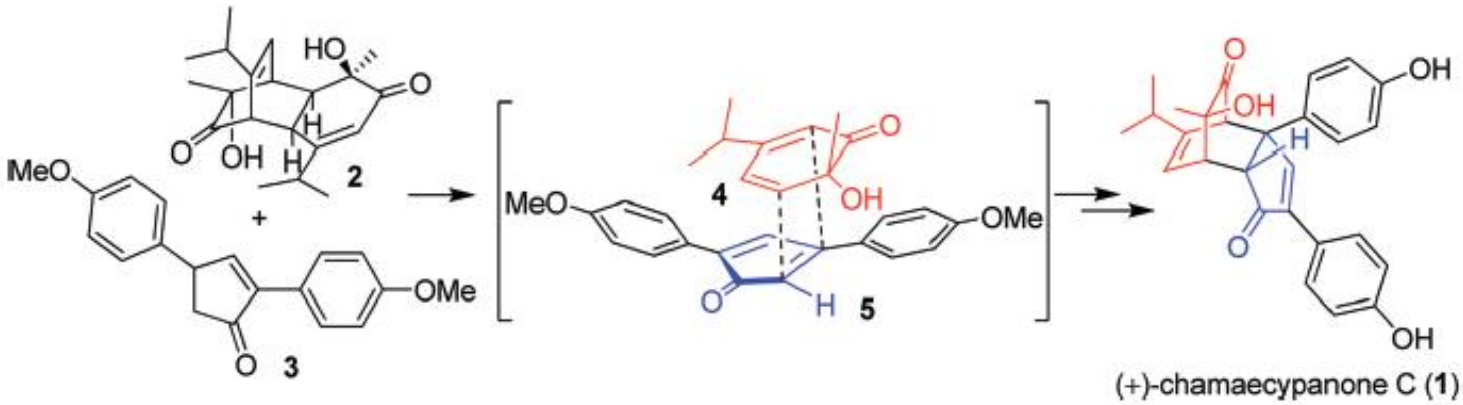


Barriault *J. Am. Chem. Soc*. **2007**, *129*, 2112

Initiated by a pericyclic primary step

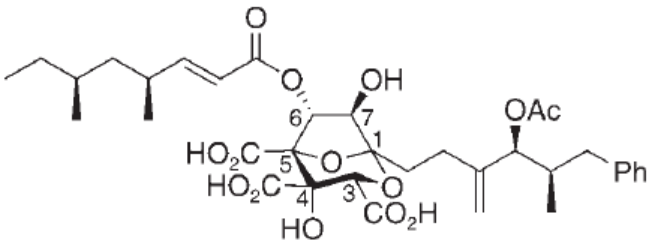
Domino Retro-Diels-Alder Cycloaddition/ Diels-Alder Cycloaddition Reactions



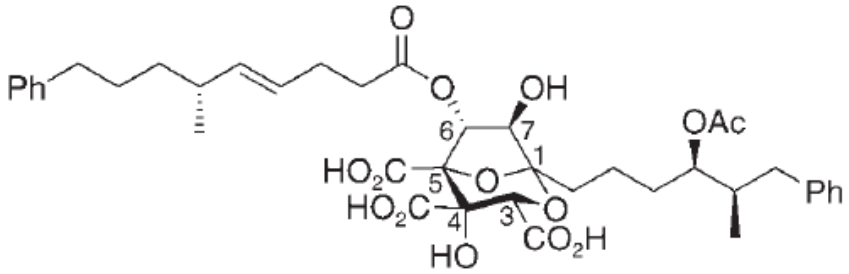


Porco, J. A., Jr. *J. Org. Chem*. **2011**, *76*, 8944

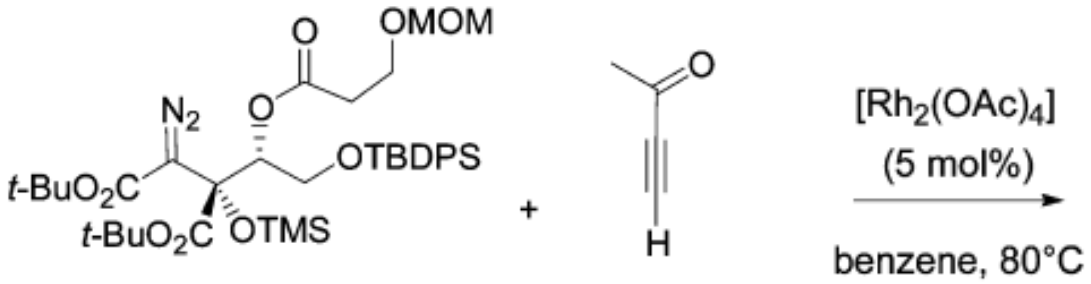
Domino Carbonyl Ylide Formation/1,3-Dipolar Cycloaddition Reaction



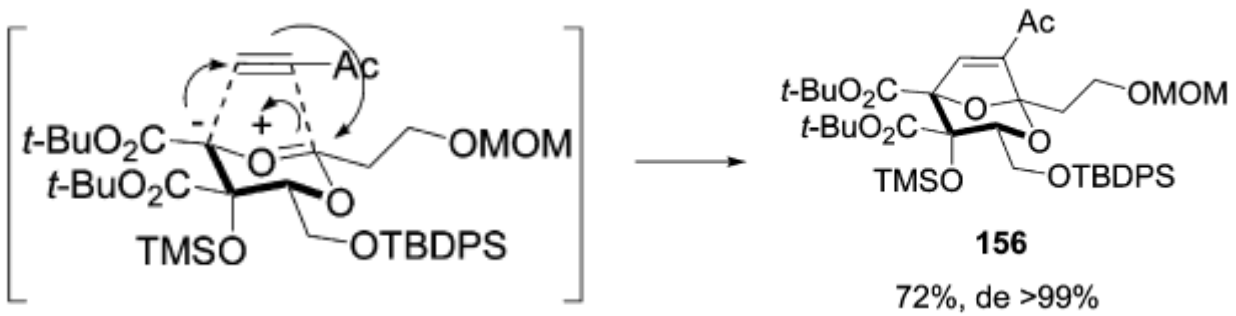
zaragozic acid A (**1**)



zaragozic acid C (**2**)



154 **155**



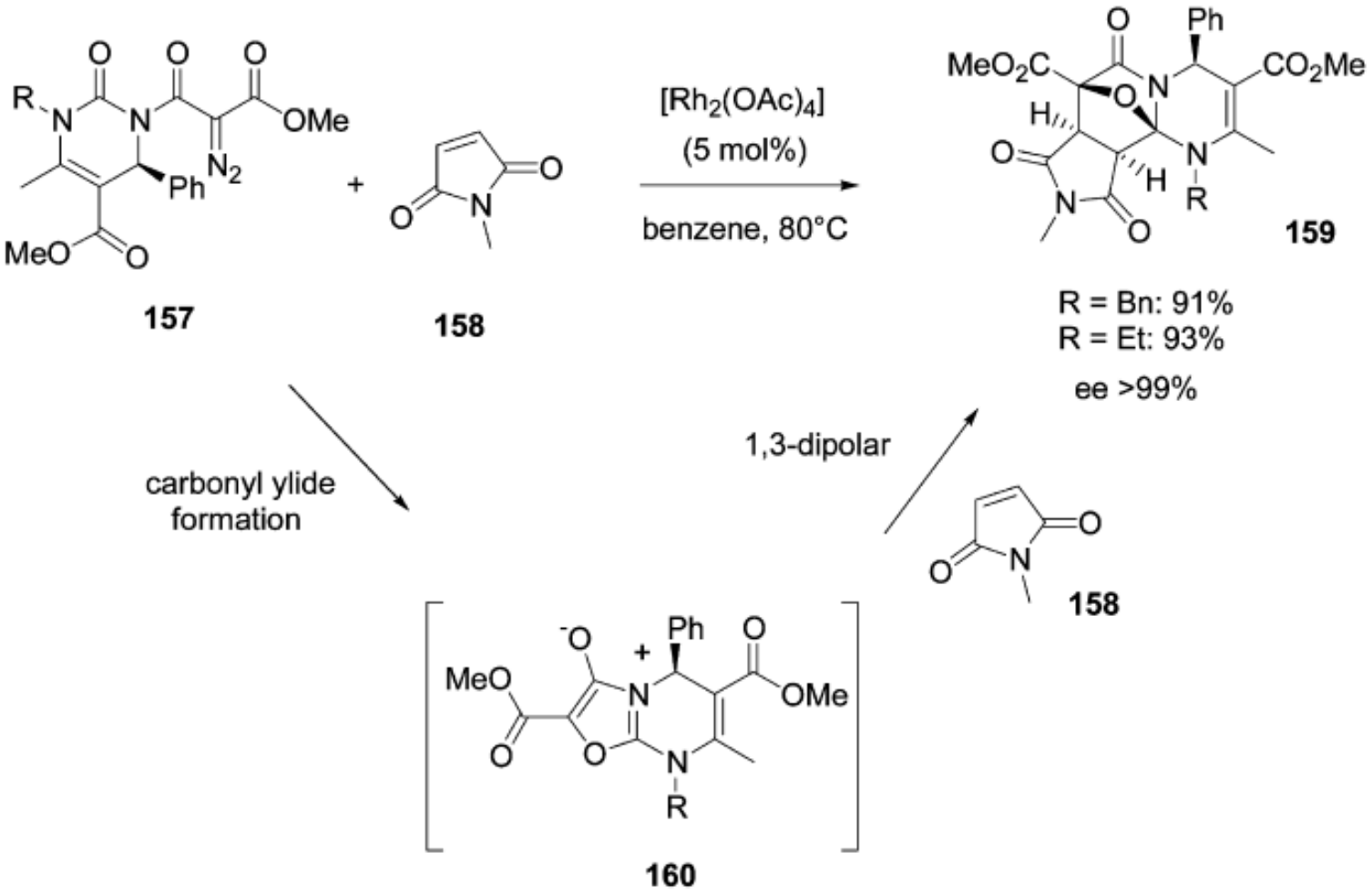
156

72%, de >99%

Hashimoto, S. *Chem.—Eur. J*. **2006**, *12*, 8898

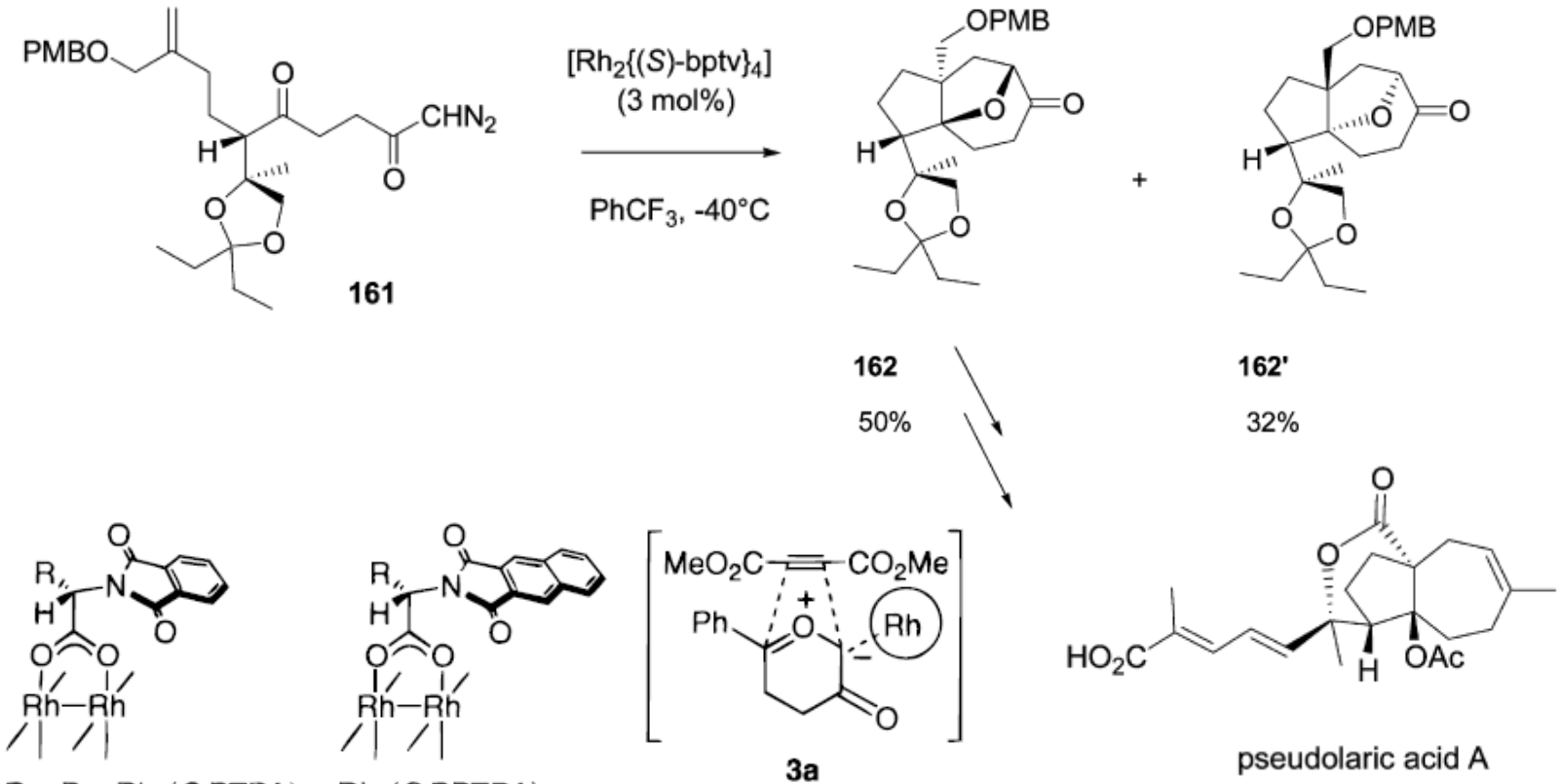
Carbene sequence

Domino Carbonyl Ylide Formation/1,3-Dipolar Cycloaddition Reaction



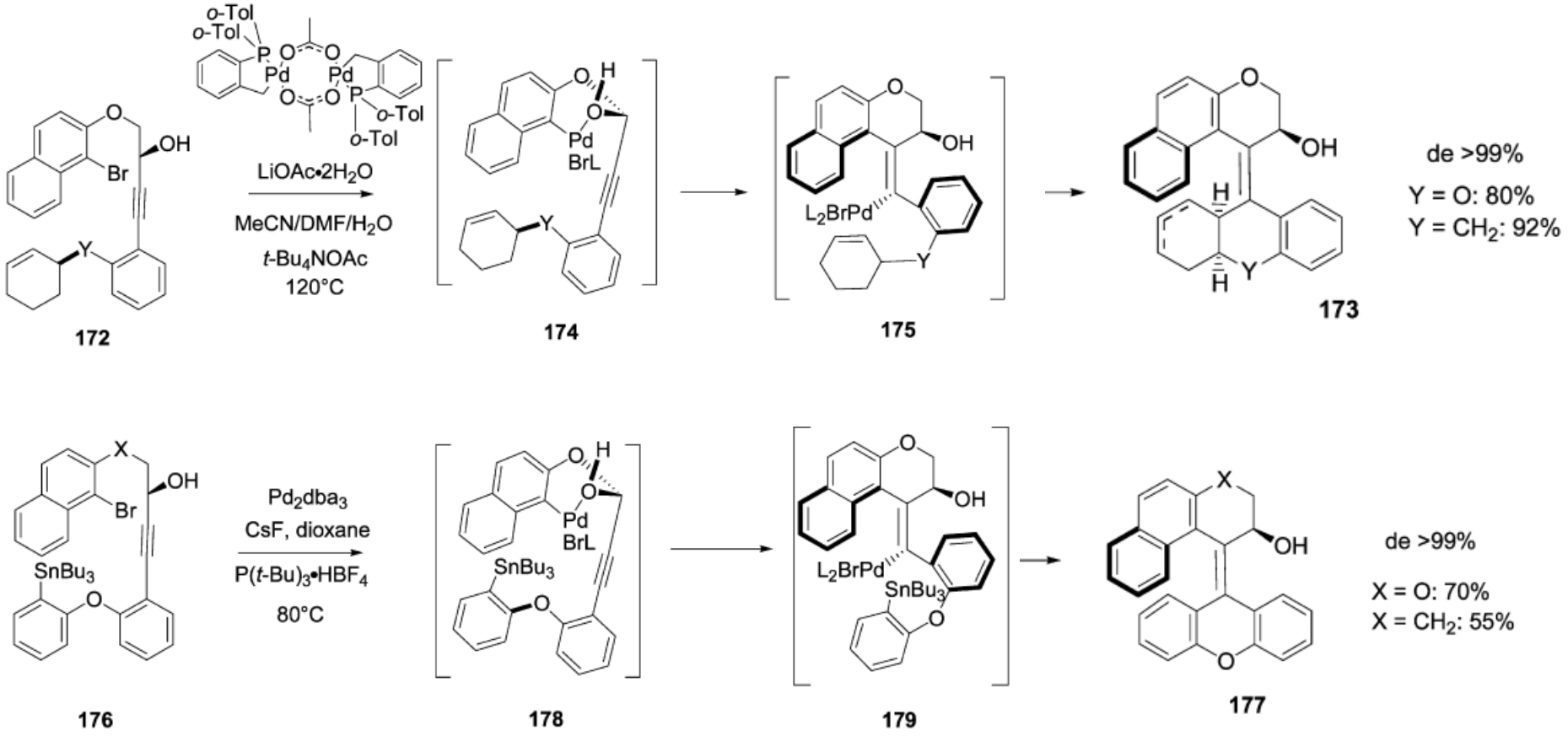
Schaus, S. E. *J. Org. Chem*. **2007**, *72*, 9998

Domino Carbonyl Ylide Formation/1,3-Dipolar Cycloaddition Reaction and Total Synthesis of Pseudolaric Acid A



Chiu, P. *Angew. Chem., Int. Ed*. **2006**, *45*, 6197

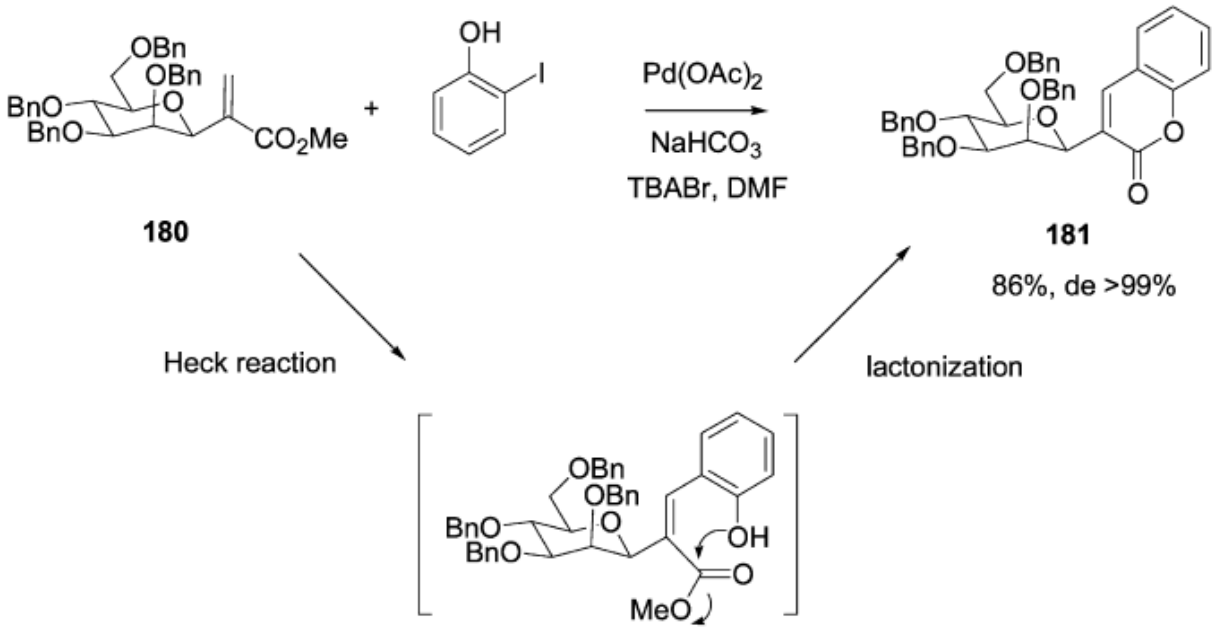
Domino Carbopalladation/Heck Reaction and Domino Carbopalladation/Stille Reaction



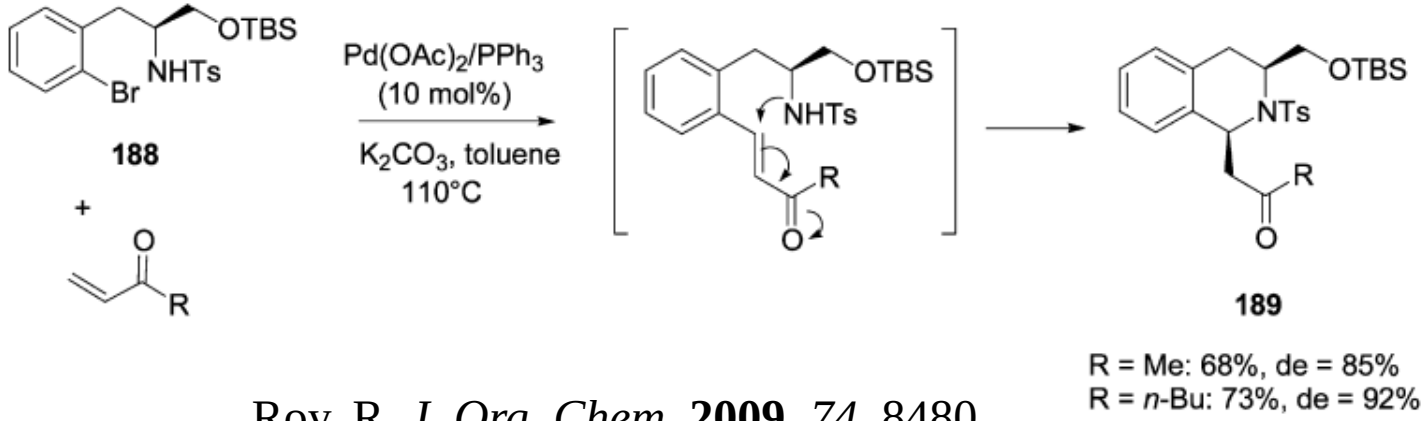
Herbst-Immer, R. *J. Am. Chem. Soc*. **2009**, *131*, 17879

Palladium catalyzed domino reaction

Domino Heck/Lactonization Reaction



Domino Heck/Aza-Michael Reaction

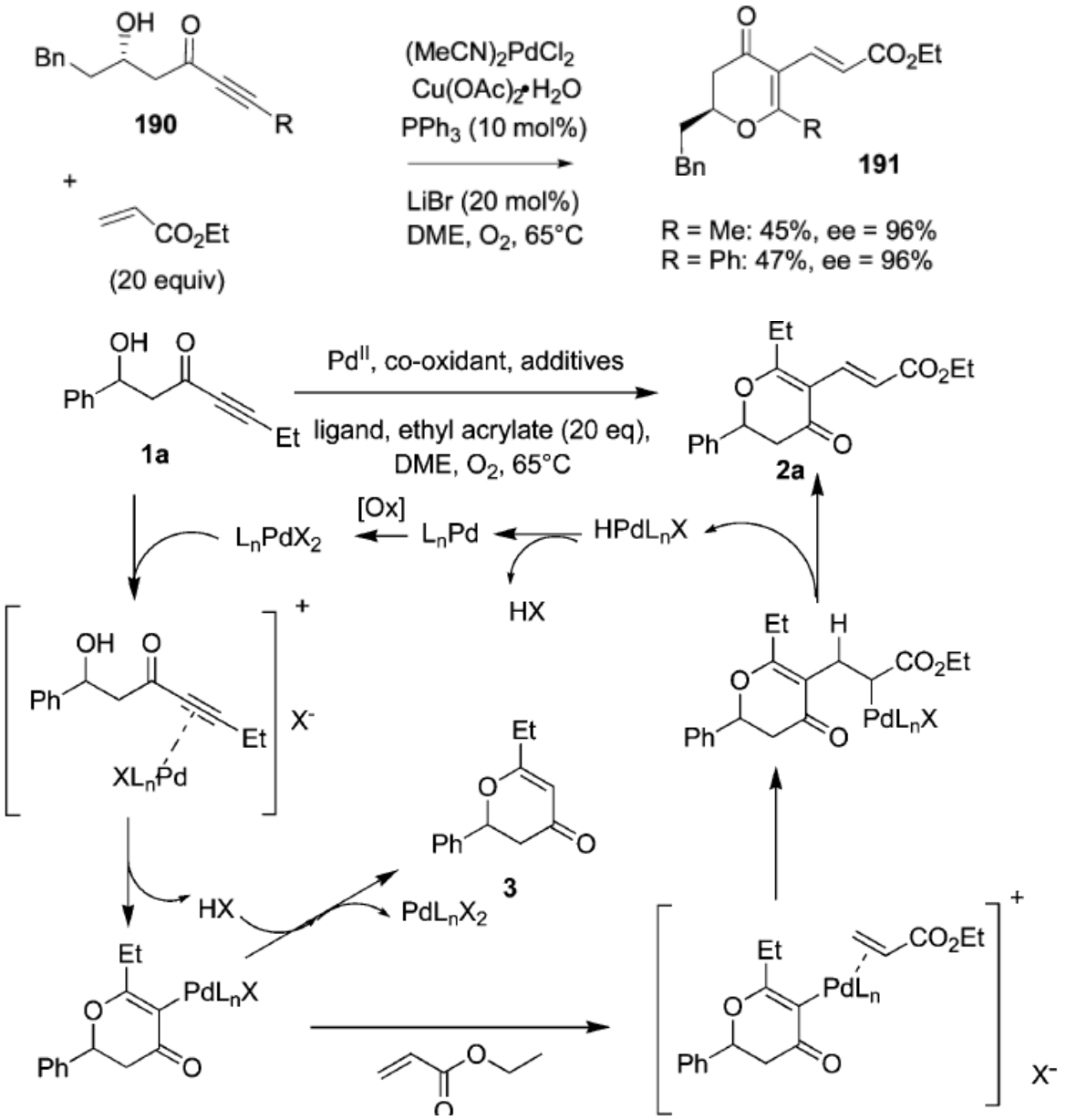


Roy, R. *J. Org. Chem*. **2009**, *74*, 8480

Pfeffer, F. M. *Tetrahedron Lett*. **2012**, *53*, 1468

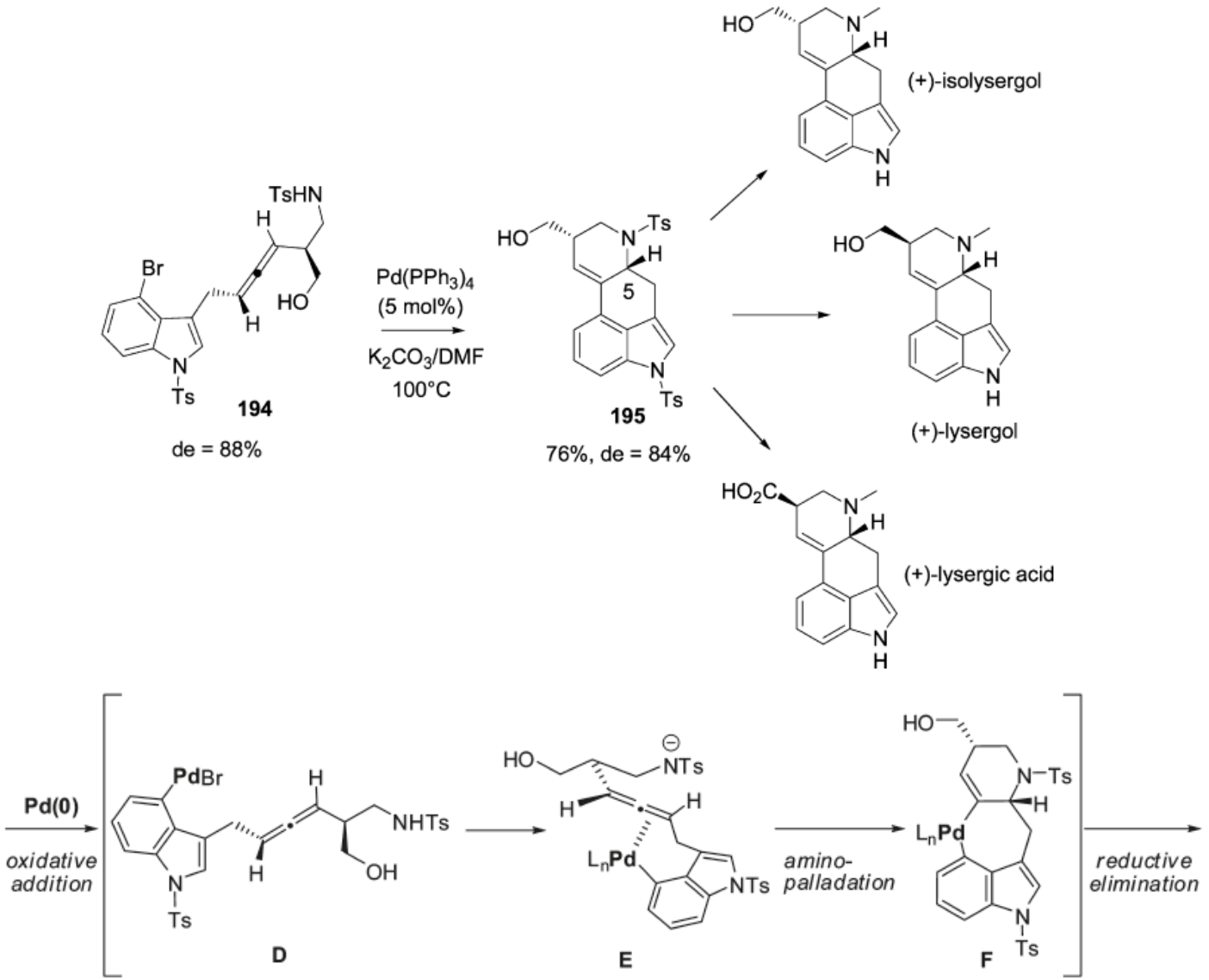
Palladium catalyzed domino reaction

Domino Wacker/Heck Reaction



Gouverneur, V. *J. Org. Chem*. **2006**, *71*, 8390

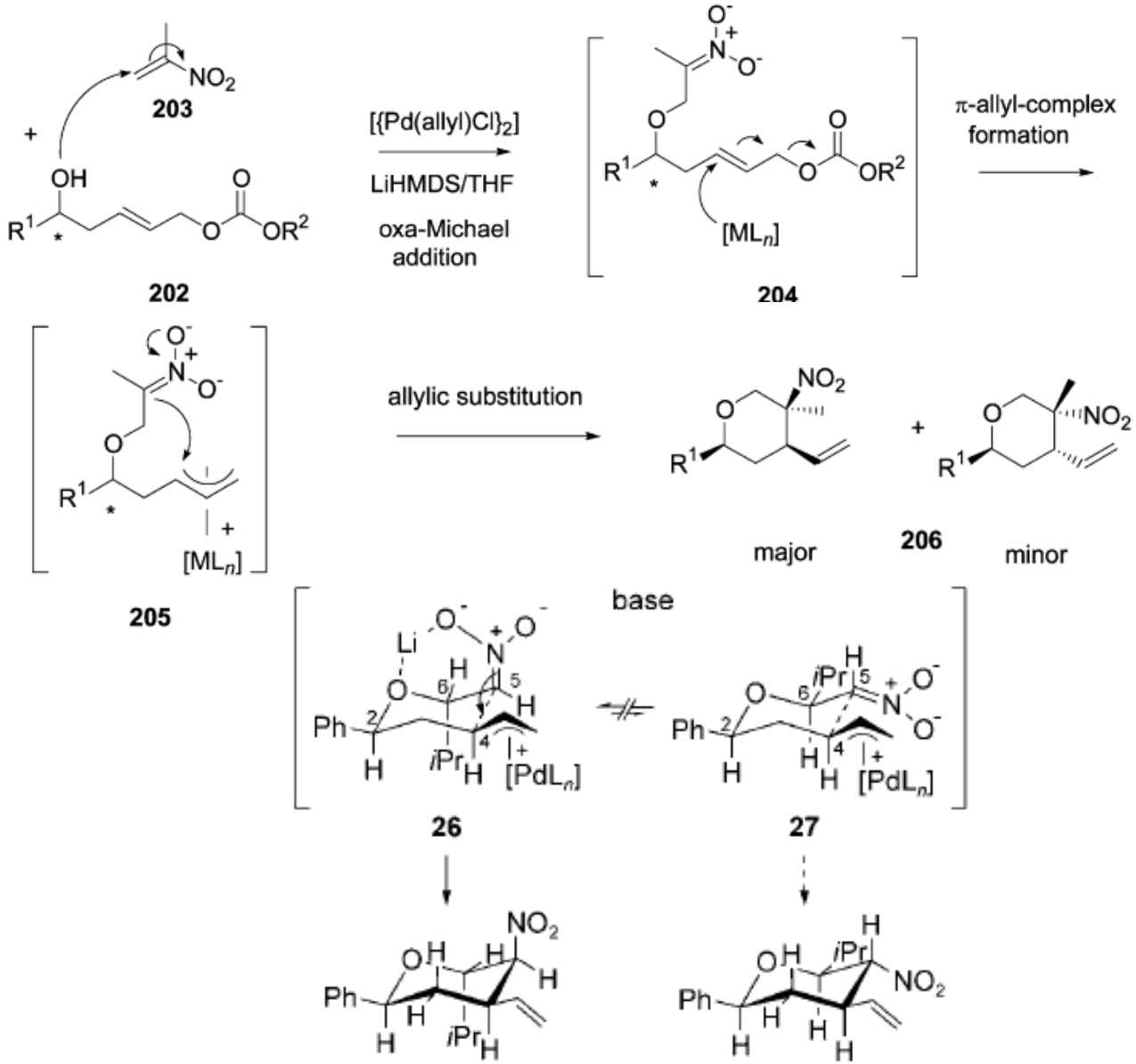
Syntheses of (+)-Lysergic Acid, (+)-Lysergol, and (+)-Isolysergol through Domino Cyclization Reaction



Ohno, H. *J. Org. Chem*. **2011**, *76*, 2072

Palladium catalyzed domino reaction

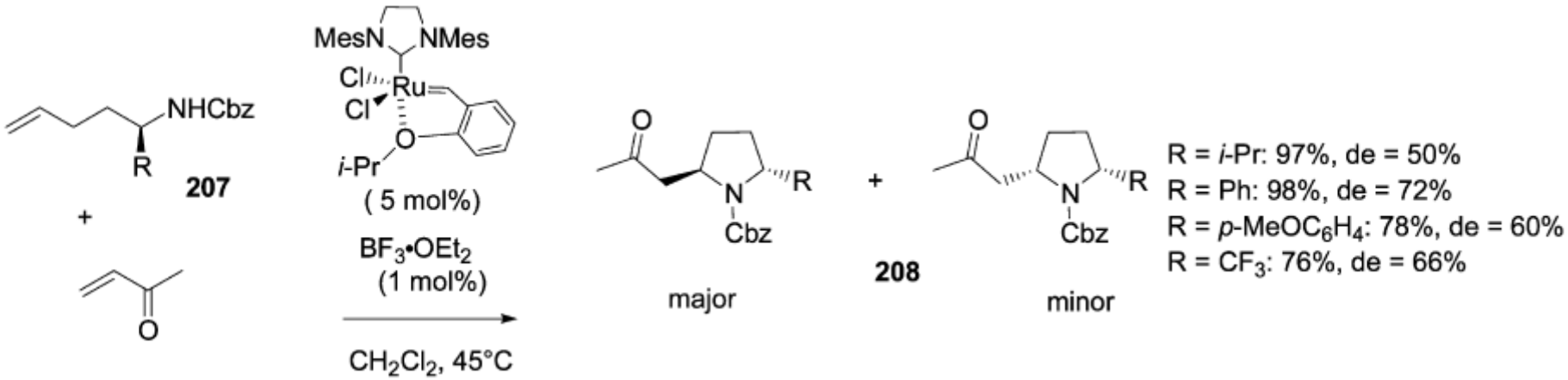
Domino Oxa-Michael/Tsuji-Trost Reaction



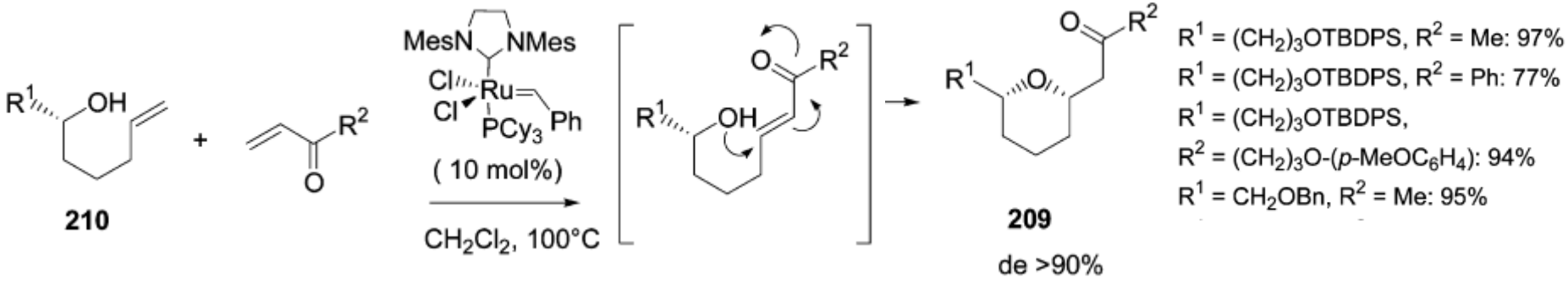
Menche, D. *Angew. Chem., Int. Ed*. **2010**, *49*, 9270

Ruthenium catalyzed domino reaction

Domino Olefin Cross-Metathesis/Intramolecular Aza-Michael Reaction



Domino Olefin Cross-Metathesis/Intramolecular Oxa-Michael Reaction

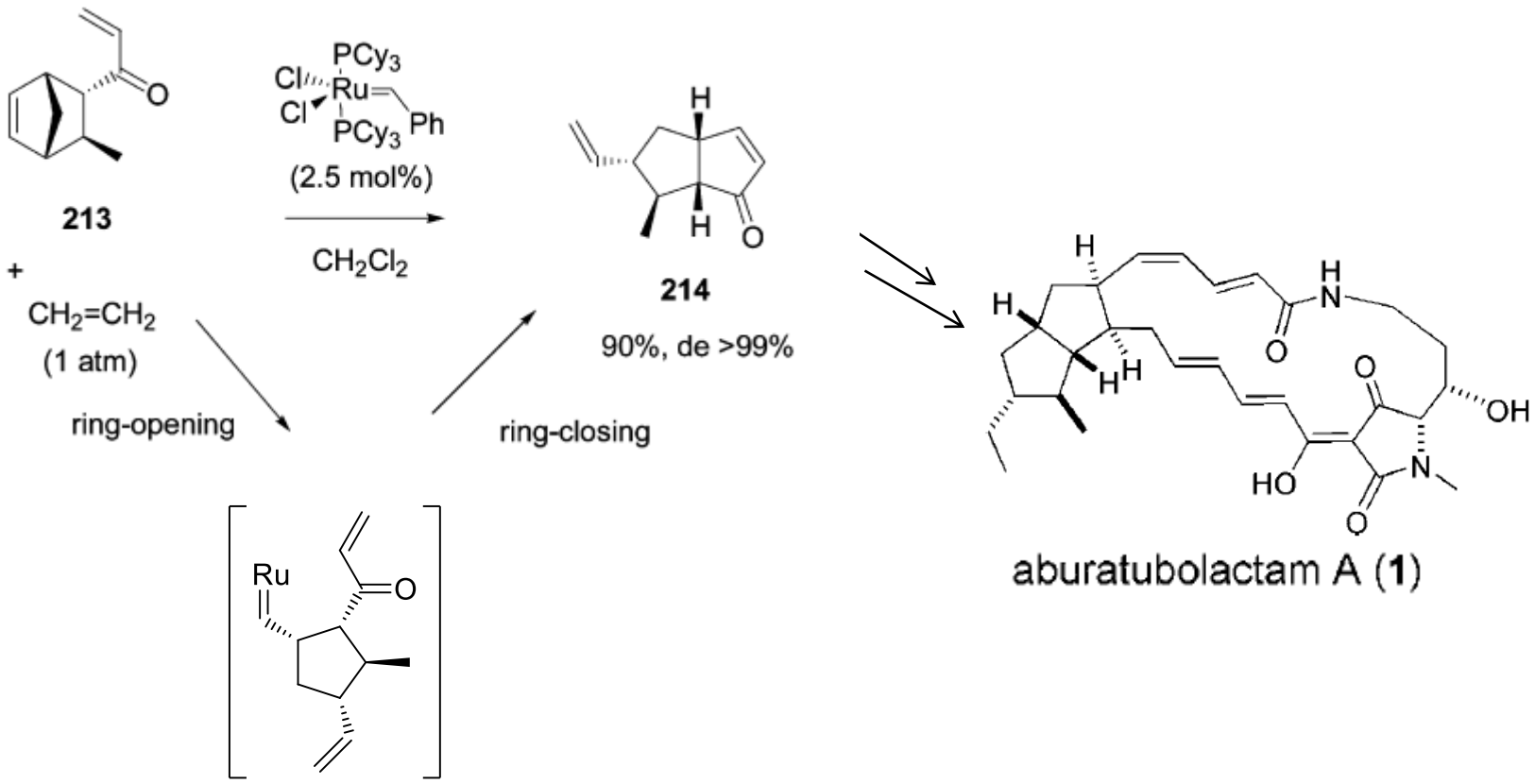


Pozo, C. *J. Am. Chem. Soc*. **2007**, *129*, 6700

Sasaki, M. *Org. Lett*. **2010**, *12*, 1636

Ruthenium catalyzed domino reaction

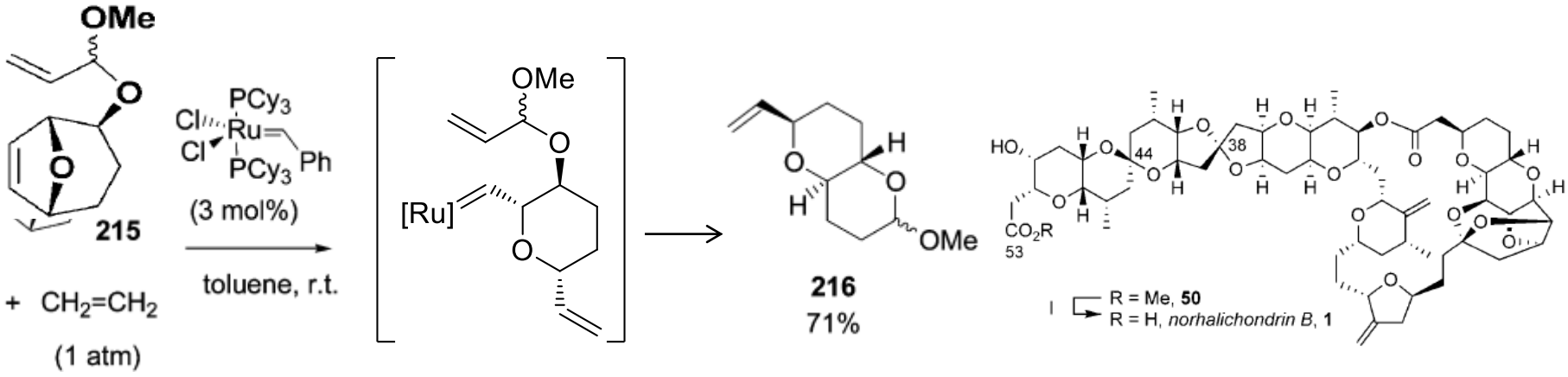
Domino Ring-Opening/Ring-Closing Metathesis Reactions



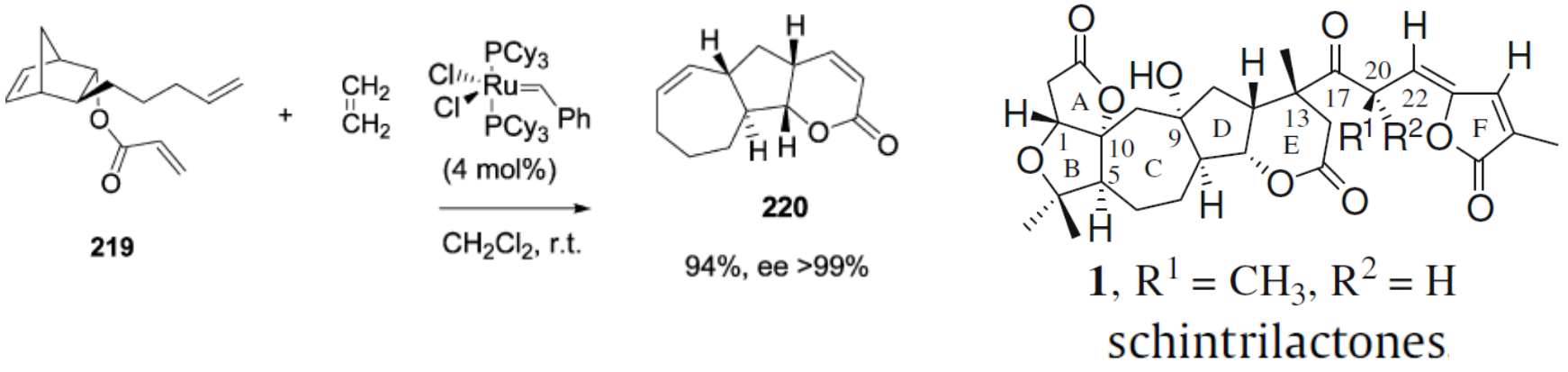
Phillips, A. J. *Angew. Chem., Int. Ed*. **2008**, *47*, 8499

Ruthenium catalyzed domino reaction

Domino Ring-Opening/Ring-Closing Metathesis Reactions

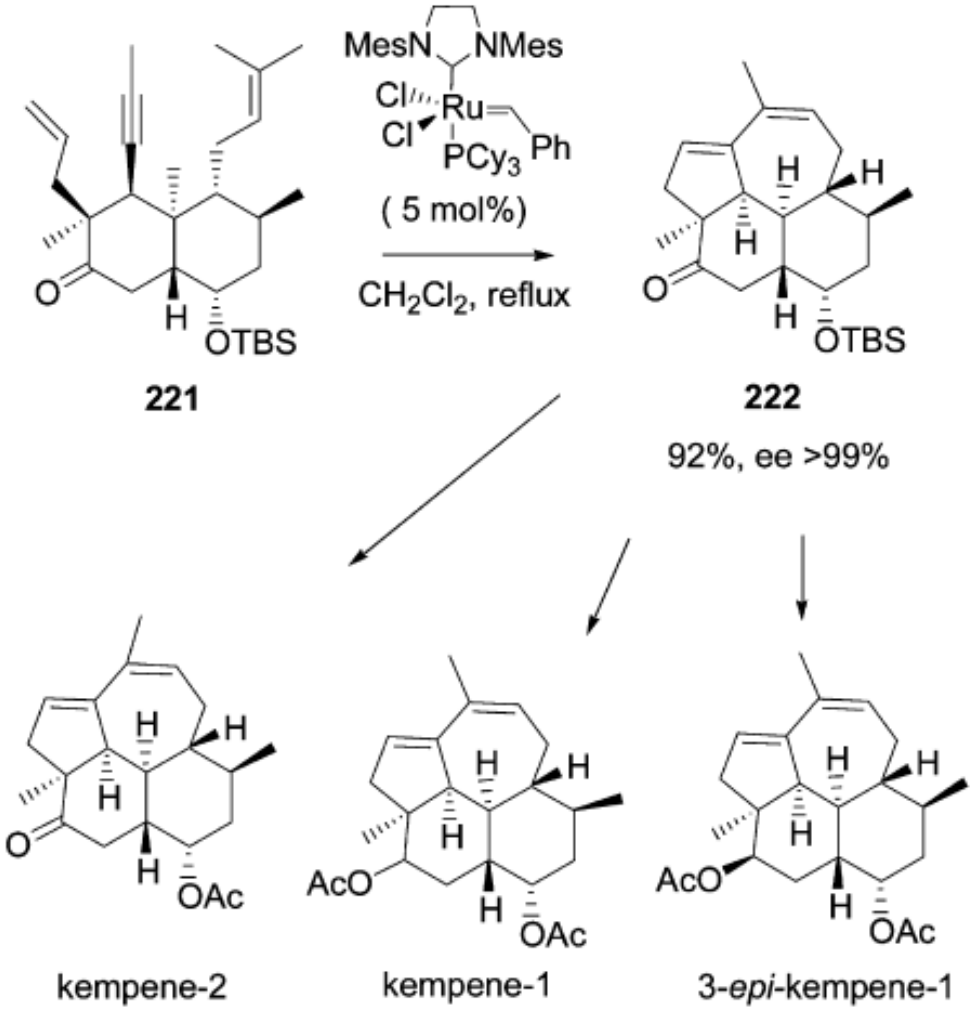


Phillips, A. J. *Angew. Chem., Int. Ed*. **2009**, *48*, 2346



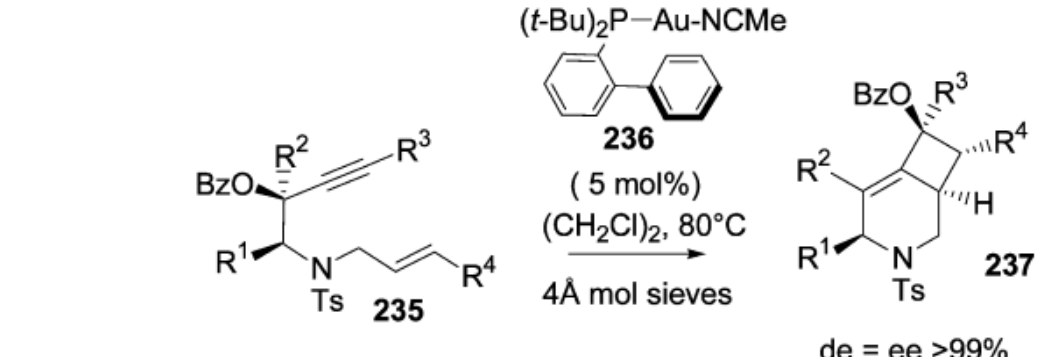
Ghosh, S. *Tetrahedron Lett*. **2010**, *51*, 2754

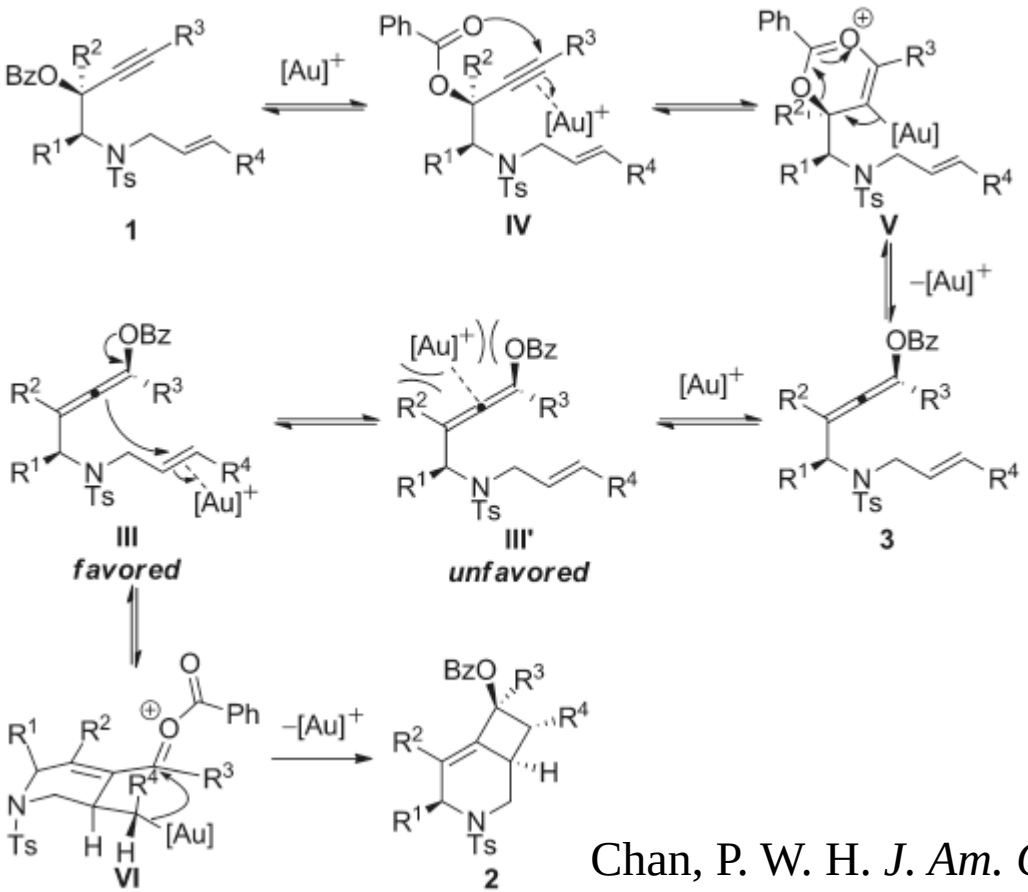
Synthesis of Kempene-2, Kempene-1, and 3-epi-Kempene-1 through Domino Enyne Metathesis Reaction



Metz, P. *Angew. Chem., Int. Ed*. **2011**, *50*, 2954

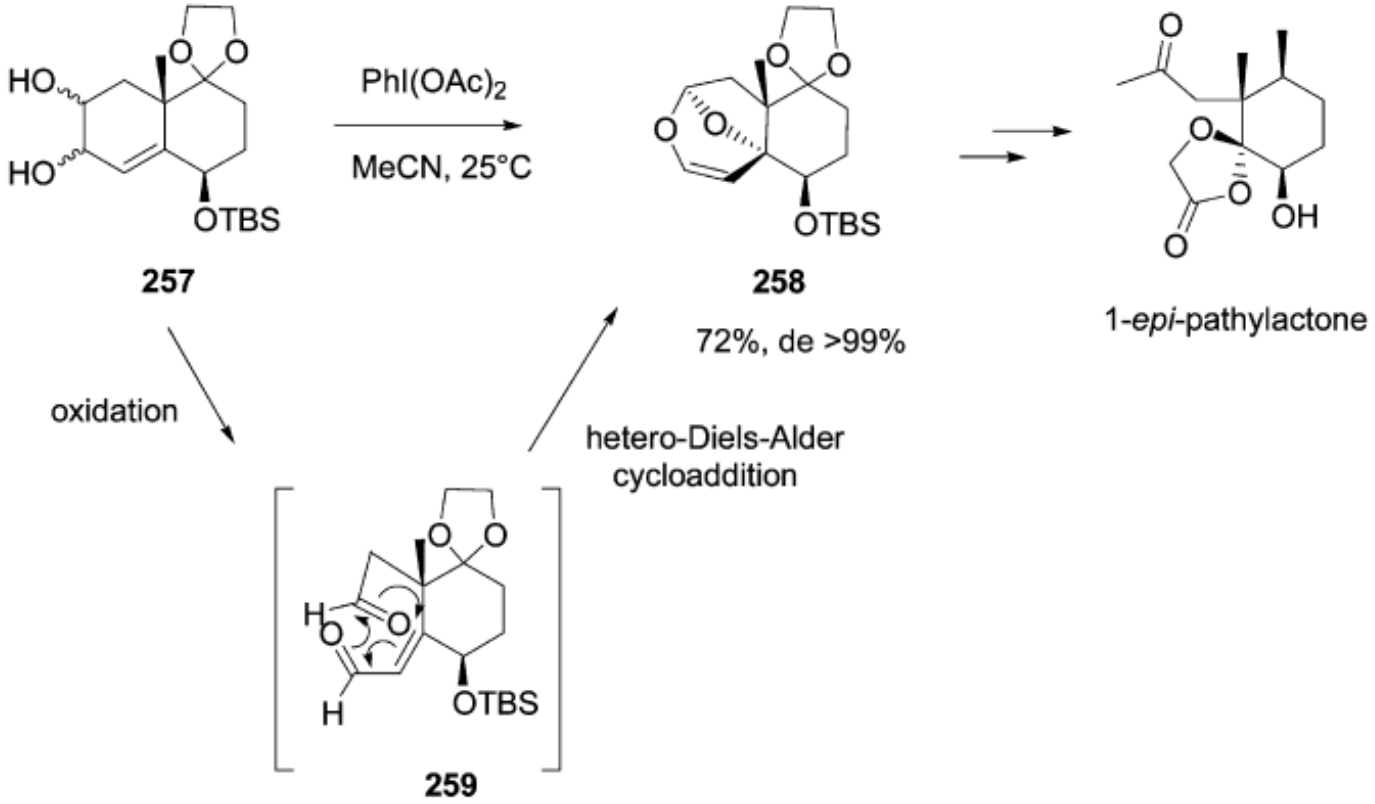
Domino 1,3-Migration/[2 + 2]-Cycloaddition Reaction





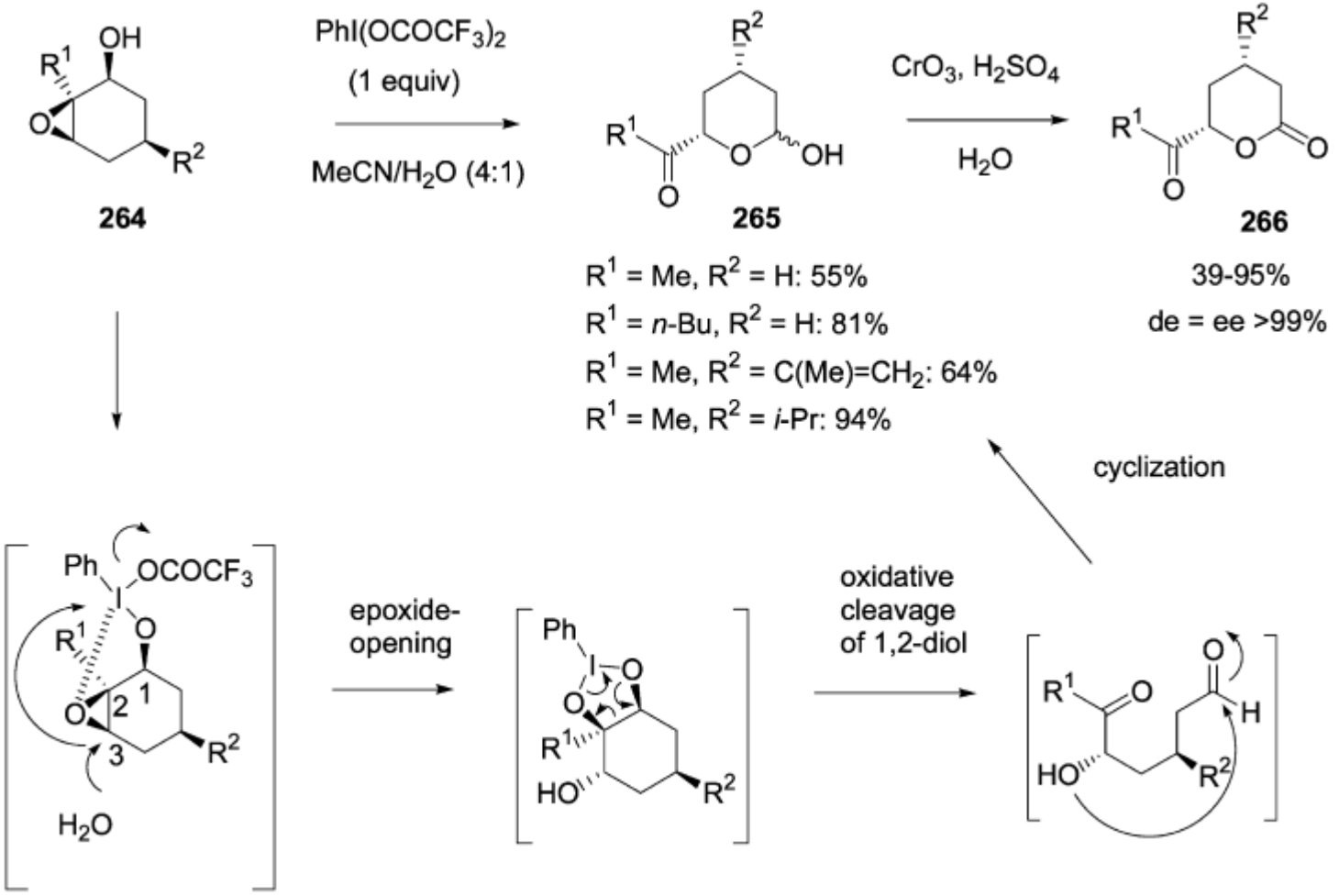
Chan, P. W. H. *J. Am. Chem. Soc*. **2011**, *133*, 15248

Domino Oxidation/Intramolecular Hetero-Diels-Alder Cycloaddition Reaction



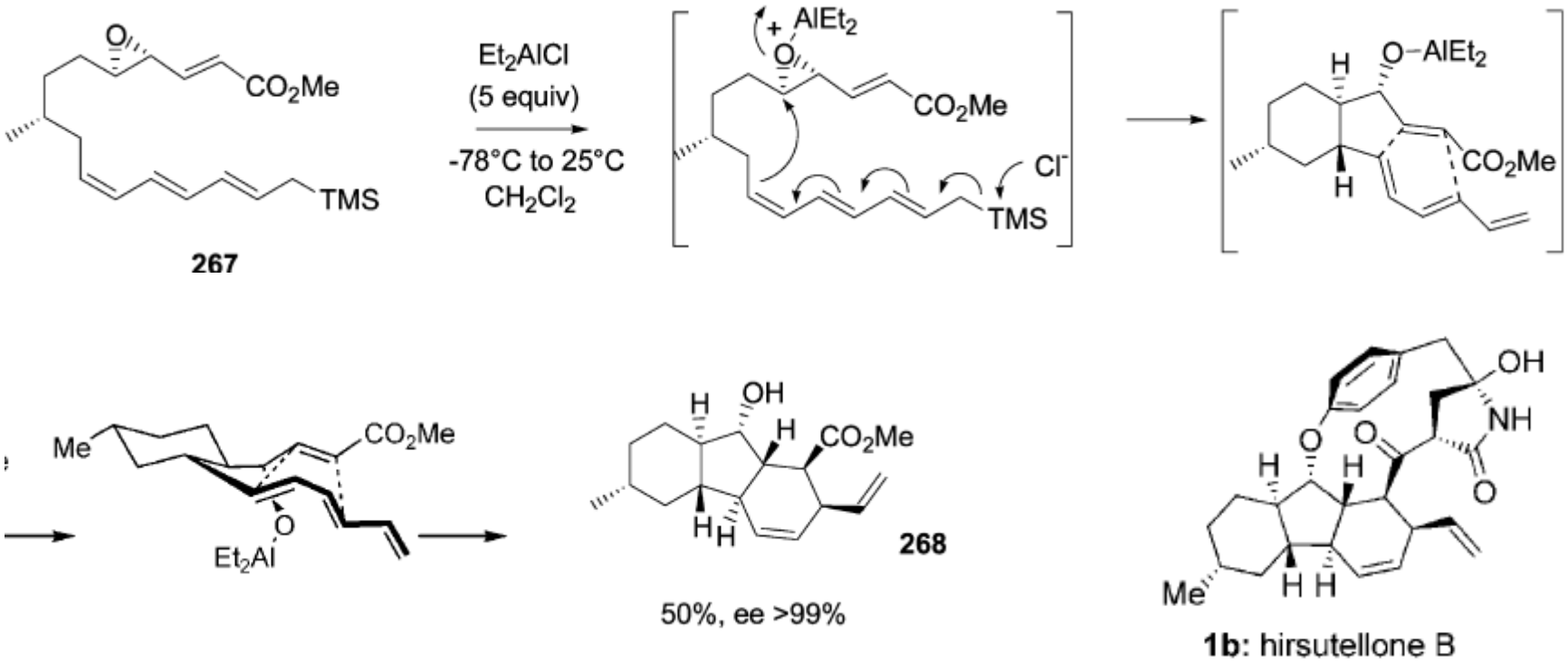
Arseniyadis, *S.Org. Lett*. **2007**, *9*, 1351

Domino Epoxide-Opening/Oxidative Cleavage/Cyclization Reaction



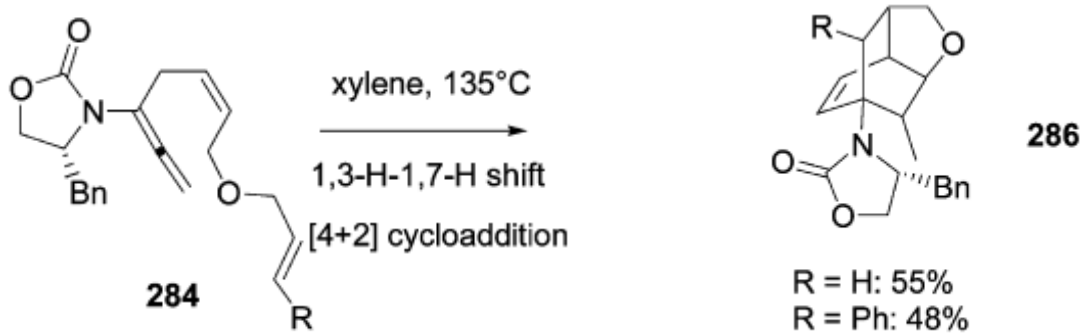
Kita, Y. *Chem.—Eur. J*. **2007**, *13*, 5238

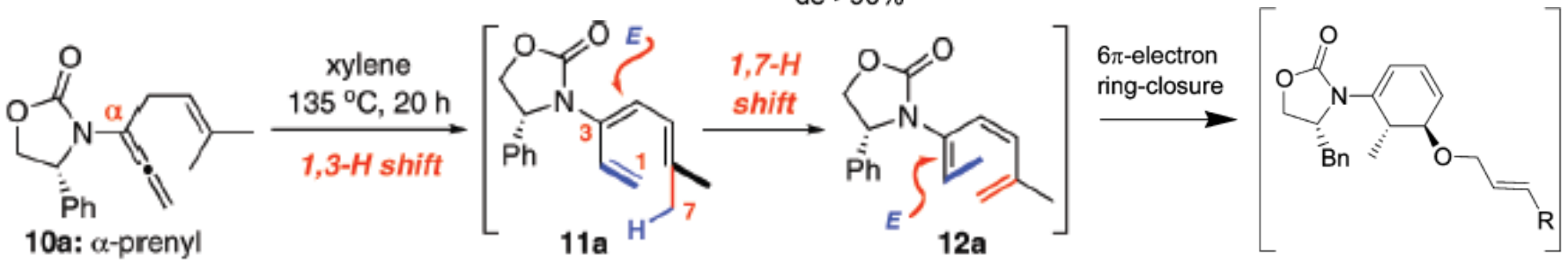
Synthesis of Hirsutellone B through Al-Catalyzed Domino Epoxide-Opening/Diels-Alder Reaction

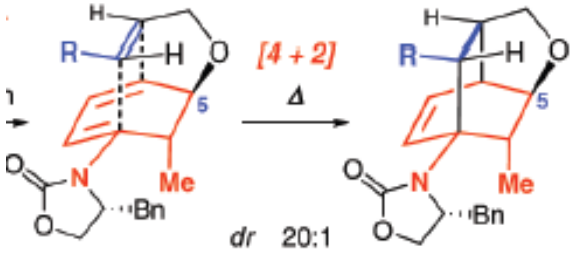


Nicolaou, K. C.; Sarlah, D.; Wu, T. R.; Zhan, W. *Angew. Chem., Int. Ed*. **2009**, *121*, 7002.

Domino 1,3-H-1,7-H Shift/6π Electron Pericyclic Ring-Closure/[4 + 2]-Cycloaddition Reaction

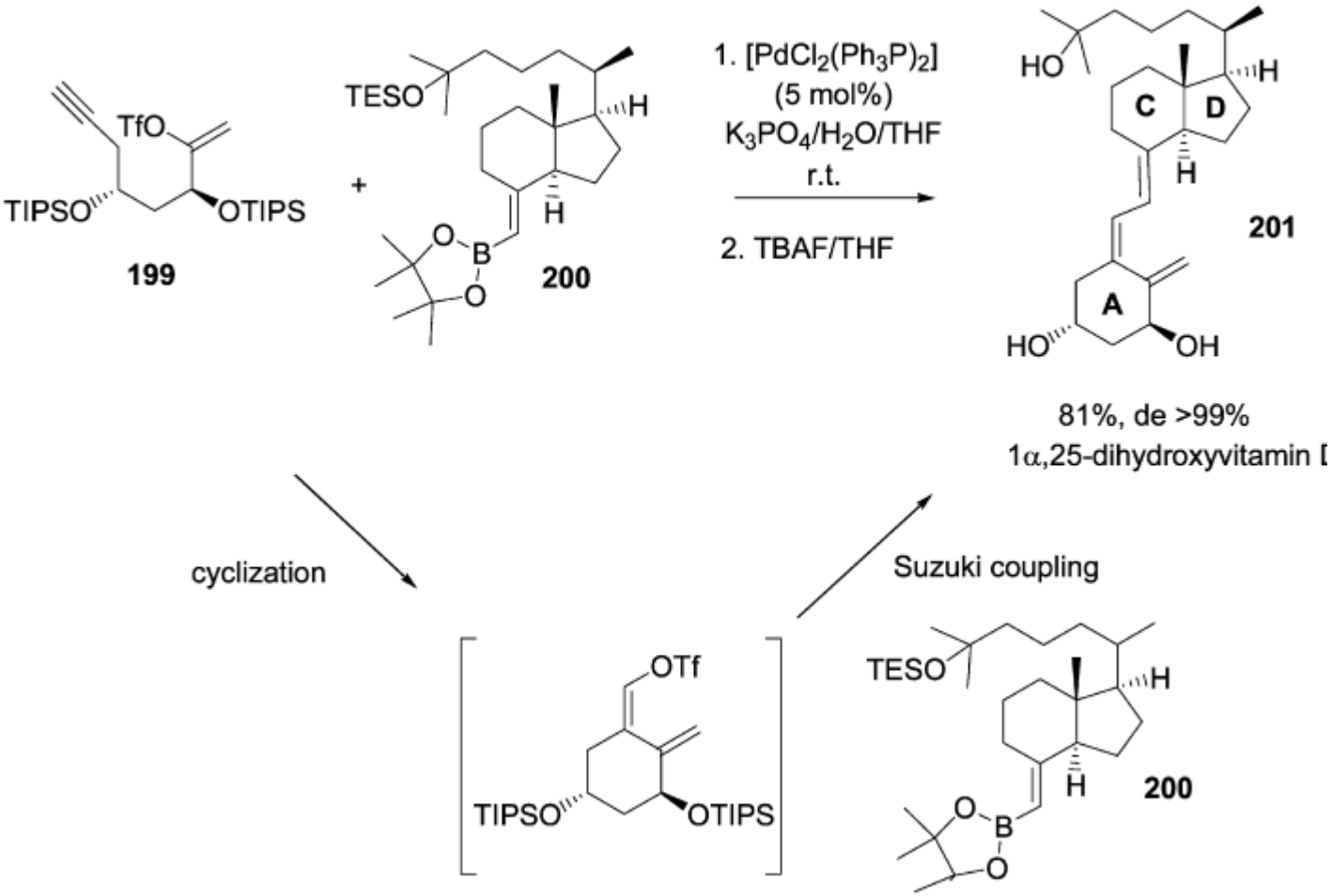






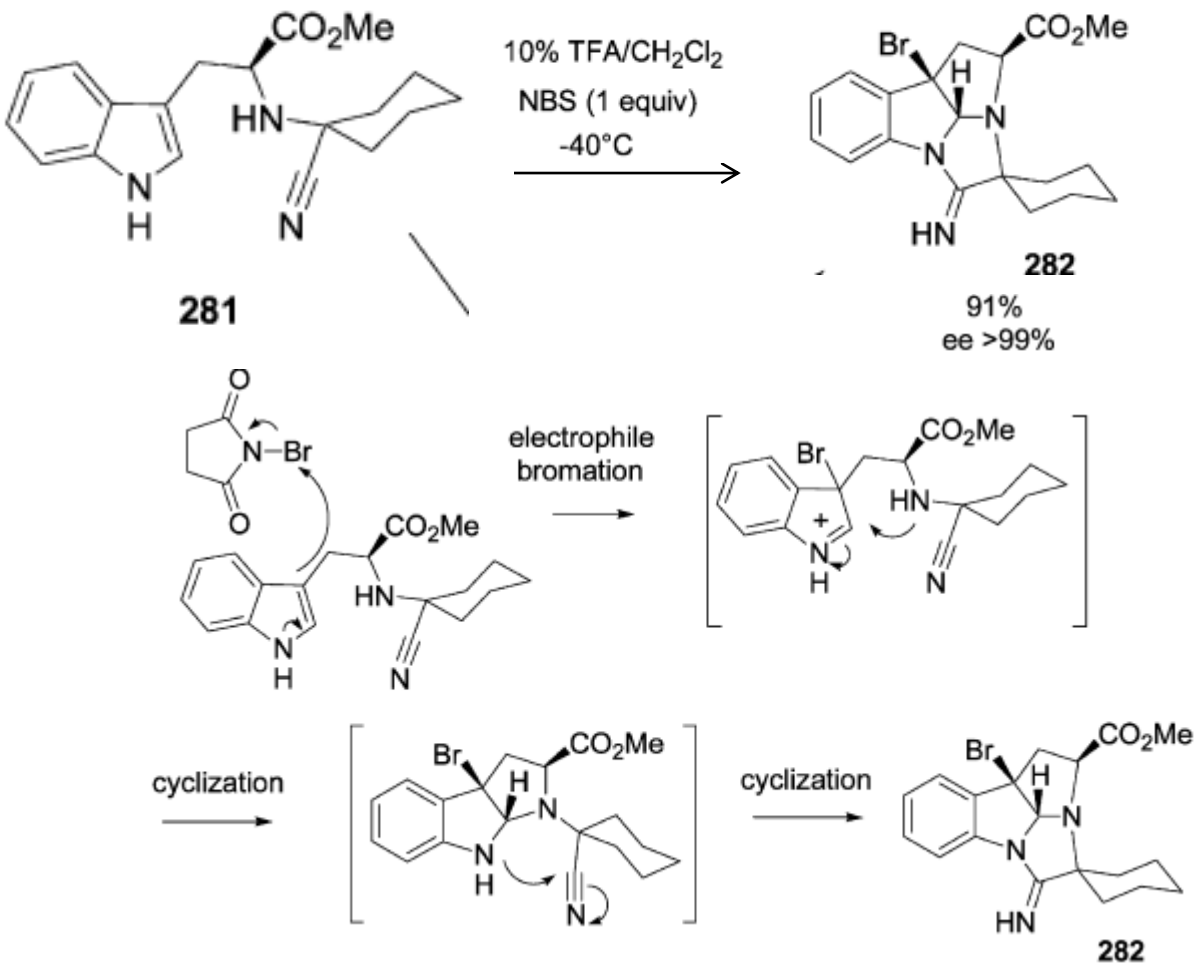
Hsung, R. P. *Org. Lett*. **2010**, *12*, 1152

Synthesis of 1α,25-Dihydroxyvitamin D3 through Domino Cyclization/Suzuki Coupling Reaction

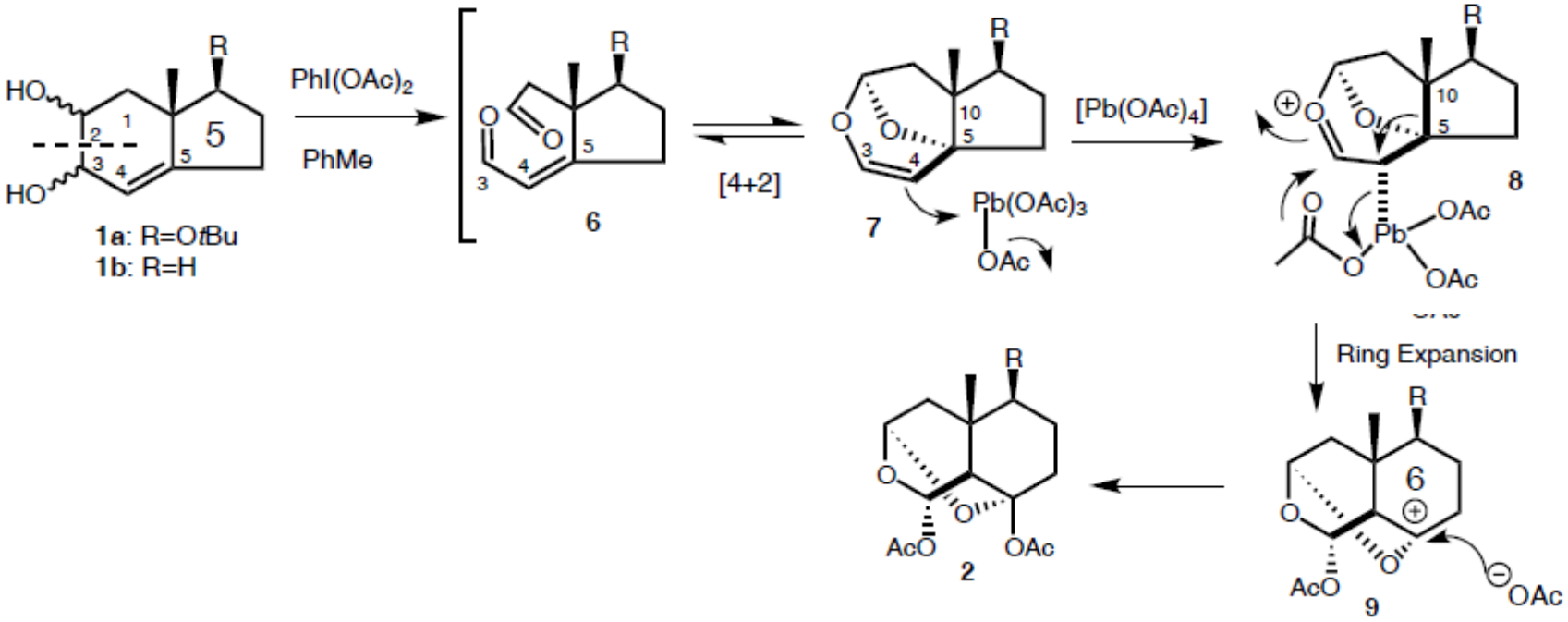


Mourino, *A. Chem.—Eur. J*. **2010**, *16*, 1432

Domino bromination/Cyclization Reactions



Herranz, R. *J. Org. Chem*. **2007**, *72*, 5395


HO
R
5
HO
1a: R=OtBu
1b: R=H
PhI(OAc)2
PhMe
6
[4+2]
7
Pb(OAc)3
OAc
[Pb(OAc)4]
8
Ring Expansion
9
AcO
OAc
2