Tools for the Organic Chemist – Free stuff from the internet

ACDC – Asymmetric Counteranion-Directed Catalysis
(Catalysis with Chiral Phosphoric Acid Counteranions)

List, B. *et al. Angew. Chem. Int. Ed.* **2006**, *45*, 4193.
List, B. *et al. J. Am. Chem. Soc.* **2006**, *128*, 13368.
List, B. *et al. J. Am. Chem. Soc.* **2007**, *129*, 11336.
Toste, D. *et al. Science* **2007**, *317*, 496.
Rueping, M. *et al. Angew. Chem. Int. Ed.* **2007**, *46*, 6903.

Aman Desai

21st Sep. 2007

A Group Meeting Literature Presentation

Tools for the Organic Chemist – Free stuff from the internet

ACDC – Asymmetric Counteranion-Directed Catalysis
(Catalysis with Chiral Phosphoric Acid Counteranions)

List, B. *et al. Angew. Chem. Int. Ed.* **2006**, *45*, 4193.
List, B. *et al. J. Am. Chem. Soc.* **2006**, *128*, 13368.
List, B. *et al. J. Am. Chem. Soc.* **2007**, *129*, 11336.
Toste, D. *et al. Science* **2007**, *317*, 496.
Rueping, M. *et al. Angew. Chem. Int. Ed.* **2007**, *46*, 6903.

Aman Desai

21st Sep. 2007
A Group Meeting Literature Presentation

Tools for the Organic Chemistry – *Free stuff from the internet*

General Websites

Tools

Research Group Websites

Lab Techniques

Blogs

Industrial/Pharmaceutical Links

The Fun Stuff

General Websites

1. Google Scholar (www.scholar.google.com)
   - Search across many disciplines and sources: peer-reviewed papers, theses, books, abstracts and articles, from academic publishers, professional societies, preprint repositories, universities and other scholarly organizations.
   - Features like Gmail.

2. Google Reader (www.reader.google.com)
   - Subscribe to various journals/news websites/blogs.
   - Get regular updates in your reader inbox from those websites – without going to those websites.
   - For example, ASAP articles from JACS.
   - Features like Gmail.

3. Organic Division (www.organicdivision.org)
   - A million links
   - Organic data tables – Chemical reaction/Chemical data/Spectroscopy/Organometallic topics/Nomenclature/Organic Compounds/Techniques *ands links therein!*
   - Organic weblinks – 9 categories and links therein.
   - *An amazing resource.*

4. Organic Syntheses (www.orgsynth.org)
   - Annual/collective volumes

Many thanks to Luis S., Dima, Yu, Keith, Aniket (Iowa State U.), Harshal (UCD), Dad.

Tools

1. Web of Science
   (http://portal.isiknowledge.com/portal.cgi?DestApp=WOS&Func=Frame&Init=Ye)
   - For citation alerts.
   - *Room service* – Every time a reference cites your selected articles, they send you an email.

2. e-EROS – Encyclopedia of Reagents for Organic Synthesis
   (http://www3.interscience.wiley.com/cgi-bin/mrwhome/104554785/HOME?CRETR)
   - Database of 70,000 reactions & 4,000 most frequently consulted reagents.
   - Search by: chemical structure – substructure – reagent – reaction type – experimental conditions – etc.
   - *Very useful and practical.*

3. NMR Databases
   - Spectral database for organic compounds, SDBS (http://riodb01.ibase.aist.go.jp/sdbs/cgi-bin/cre_index.cgi?lang=eng)
   - http://www.chem.wisc.edu/areas/organic/index-chem.htm
   - www.sigmaaldrich.com

4. Boiling point calculation at different temperatures/pressures
   - http://www.ch.cam.ac.uk/magnus/boil.html
   - http://www.sigmaaldrich.com/Area_of_Interest/Research_Essentials/Solvents/Key_Resources/nomograph.html

---

Many thanks to Luis S., Dima, Yu, Keith, Aniket (Iowa State U.), Harshal (UCD), Dad.

Tools

5. Named Reactions
   - http://themerckindex.chemfinder.com/TheMerckIndex/NameReactions/TOC.asp
   - http://www.monomerchem.com/display4.html
   - http://orgchem.chem.uconn.edu/namereact/named.html
   - http://www.geocities.com/chempen_software/reactions.htm

Many thanks to Luis S., Dima, Yu, Keith, Aniket (Iowa State U.), Harshal (UCD), Dad.

Research Group Websites

1. Allison Frontier – Not Voodoo (Demystifying Synthetic Organic Lab. Techniques) (http://chem.chem.rochester.edu/~nvd/)
   - Tour of collective wisdom – browse by experience level.
   - Magic formulas eg. work up formulas etc.
   - Interesting, funny statistics.
   - Troubleshooting, tips and advices – practical and lab level.

2. David Evans, Harvard University

3. Douglas Taber (www.organic-chemistry.org)

Many thanks to Luis S., Dima, Yu, Keith, Aniket (Iowa State U.), Harshal (UCD), Dad.

Lab Techniques

1. Allison Frontier – Not Voodoo (Demystifying Synthetic Organic Lab. Techniques) (http://chem.chem.rochester.edu/~nvd/)

2. Al's Notebook (www.alsnotebook.com)
    - A collection of commonly used experimental procedures and other interesting stuff for synthetic chemists

Many thanks to Luis S., Dima, Yu, Keith, Aniket (Iowa State U.), Harshal (UCD), Dad.

Blogs

1. Corante "In The Pipeline" – Derek Lowe (www.pipeline.corante.com)
    - Pharmaceutical industry blog.

2. www.totallysynthetic.com
    - The latest and best total syntheses – dissected nicely.
    - Retrosynthesis and key forward steps.

3. www.blog.chembark.com

Many thanks to Luis S., Dima, Yu, Keith, Aniket (Iowa State U.), Harshal (UCD), Dad.

Industrial/Pharmaceutical Links

1. Product/chemical search – product information/vendors/suppliers
   - www.emolecules.com – Over 7 million chemicals
   - www.chemnet.com – Chinese website with good information about Indian/Chinese vendors
   - www.globalspec.com – Engineering Search Engine – Product/Suppliers

2. Patents
   - www.uspto.gov – US patents
   - www.espacenet.com – Worldwide/European patents
   - www.freepatent.com
   - www.pat2pdf.org
   - www.patentstorm.us
   - www.google.com/patents

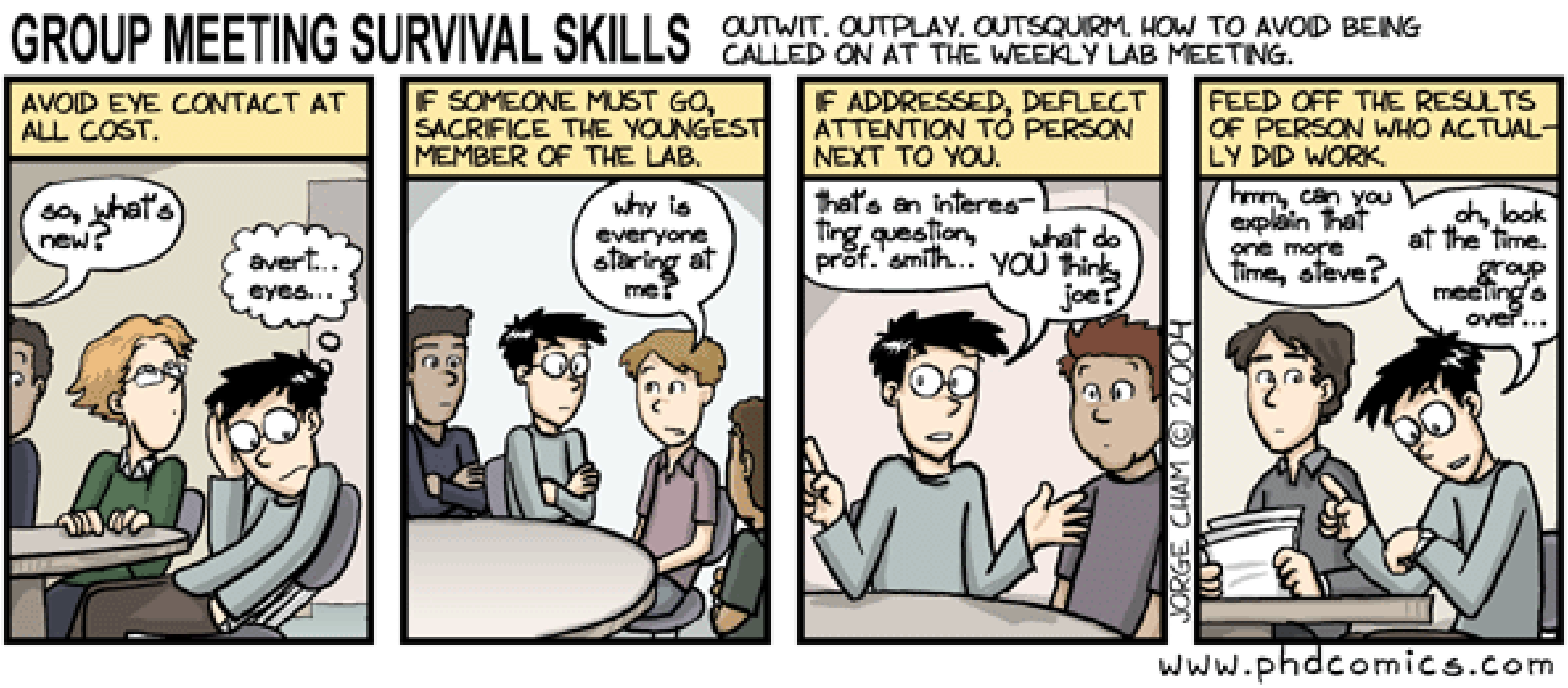
3. MSDS (Material Safety Data Sheets)
   - www.msds.com

Many thanks to Luis S., Dima, Yu, Keith, Aniket (Iowa State U.), Harshal (UCD), Dad.

The Fun Stuff

1. Molecules with silly/unusual names
   - http://www.chm.bris.ac.uk/sillymolecules/sillymols.htm

2. www.phdcomics.com
   - *you are not a phd student if you haven't spent hours on this website!*



Many thanks to Luis S., Dima, Yu, Keith, Aniket (Iowa State U.), Harshal (UCD), Dad.

Tools for the Organic Chemist – Free stuff from the internet

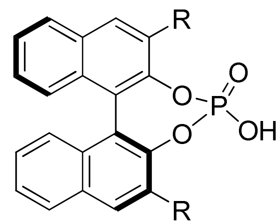
ACDC – Asymmetric Counteranion-Directed Catalysis
(Catalysis with Chiral Phosphoric Acid Counteranions)

List, B. *et al. Angew. Chem. Int. Ed.* **2006**, *45*, 4193.
List, B. *et al. J. Am. Chem. Soc.* **2006**, *128*, 13368.
List, B. *et al. J. Am. Chem. Soc.* **2007**, *129*, 11336.
Toste, D. *et al. Science* **2007**, *317*, 496.
Rueping, M. *et al. Angew. Chem. Int. Ed.* **2007**, *46*, 6903.

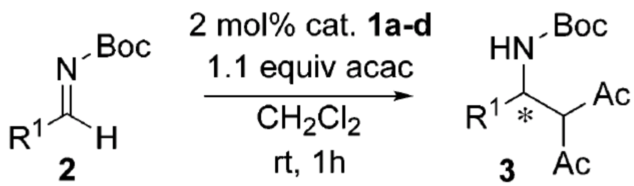
Aman Desai

21st Sep. 2007
A Group Meeting Literature Presentation

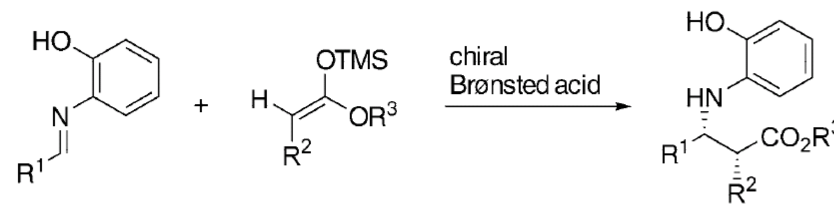
Chiral Phosphoric Acids – Powerful Organocatalysts



Terada, *JACS* **2004**, 5356
Mannich Reaction: R = 4-(β-naph.)-C_6H_4

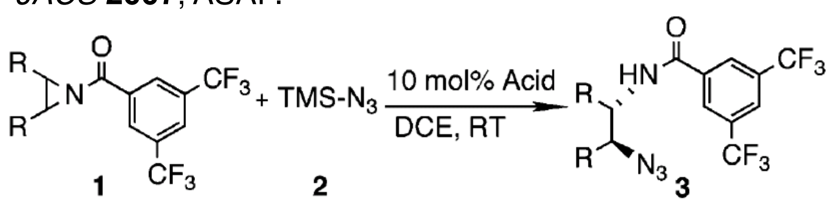


Akiyama, *ACIEE* **2004**, 1566
Mannich Reaction: R = 4-$NO_2C_6H_4$

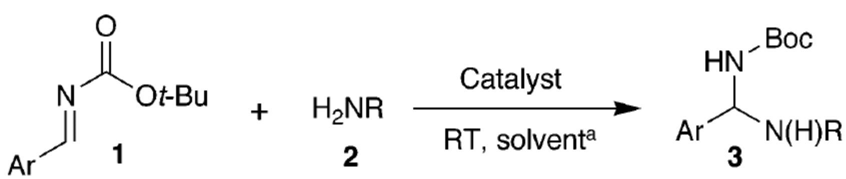


Explosive growth in the field in the last 4 years

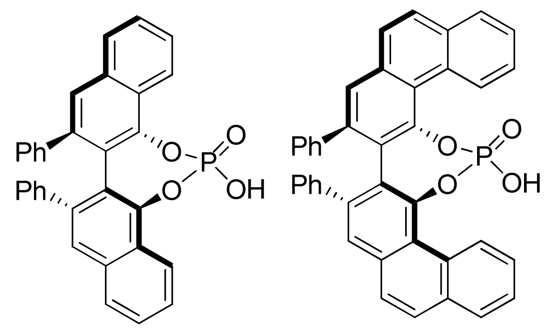
JACS **2007**, ASAP.



JACS **2005**, *127*, 15696



Jon C. Antilla, Wulff Group Alumni



Chiral Counteranions – Emerging Field in Catalysis

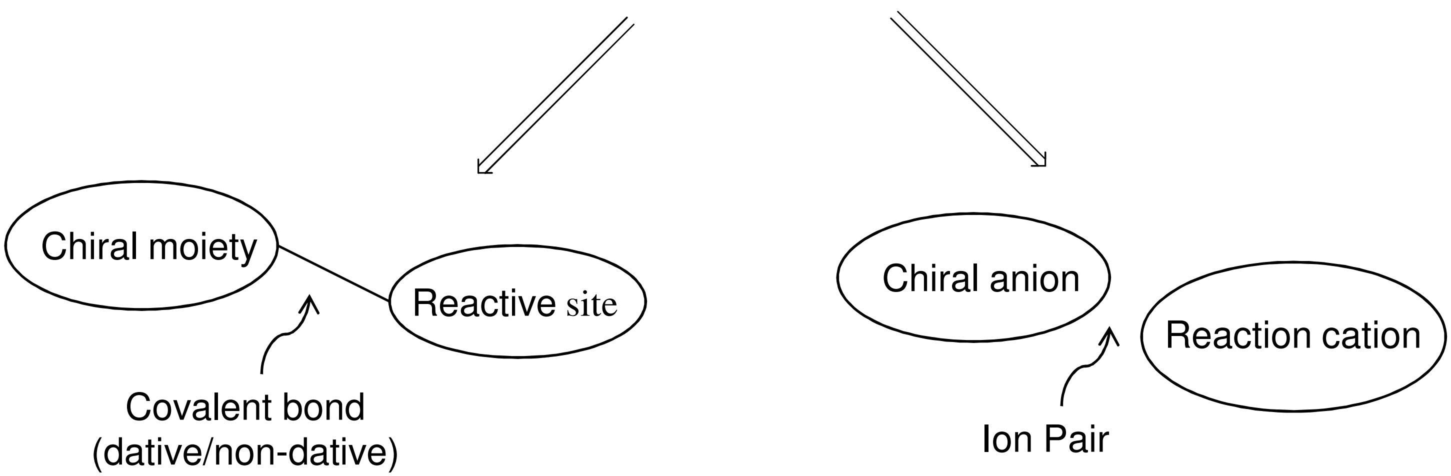
Chiral compounds – requirement for agrochemical/pharmaceutical purposes

⇓

Nature's "chiral pool" or

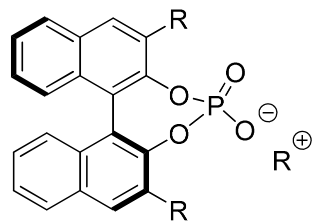
Resolution of a racemate or

Asymmetric synthesis by chiral catalysts



Same or small library of chiral anionic counteranions –
make a wide range of cationic catalysts enantioselective

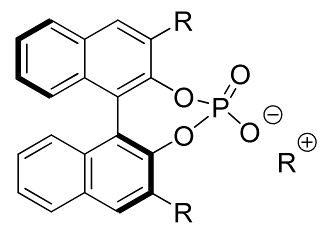
Chiral Phosphoric Acid Counteranions – Emerging Field in Catalysis



Benjamin List – ACDC

Mayer, S.; List, B. *Angew. Chem. Int. Ed.* **2006**, *45*, 4193

Chiral Phosphoric Acid Counteranions – Emerging Field in Catalysis

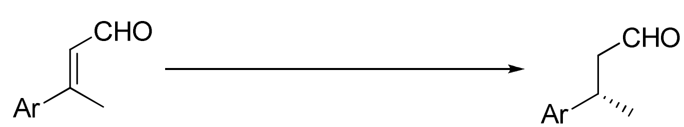


Benjamin List – *ACDC*

*A*symmetric *C*ounteranion-*D*irected *C*atalysis

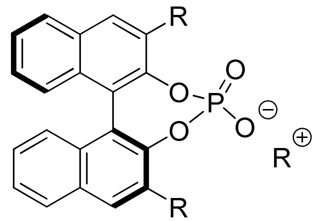
"….catalytic reactions that proceed via cationic intermediates can be conduced asymmetrically via the use of a chiral enantiomerically enriched anion incorporated into the catalyst."

List, *ACIEE*, **2006**, 4193

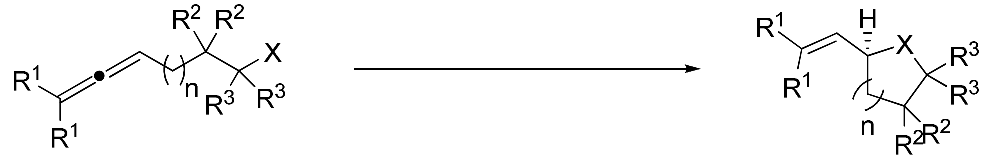


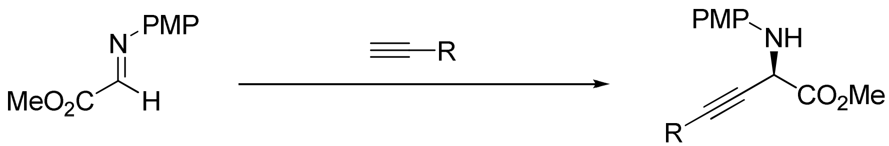
Mayer, S.; List, B. *Angew. Chem. Int. Ed.* **2006**, *45*, 4193

Chiral Phosphoric Acid Counteranions – Emerging Field in Catalysis



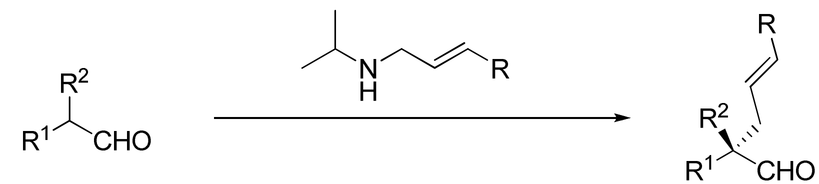
Toste, *Science* **2007**, 496

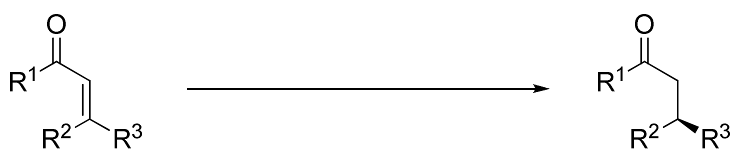




Rueping, *ACIEE* **2007**, *46*, 6903.

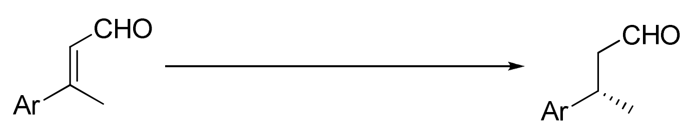
List, *JACS*, **2007**, 11336





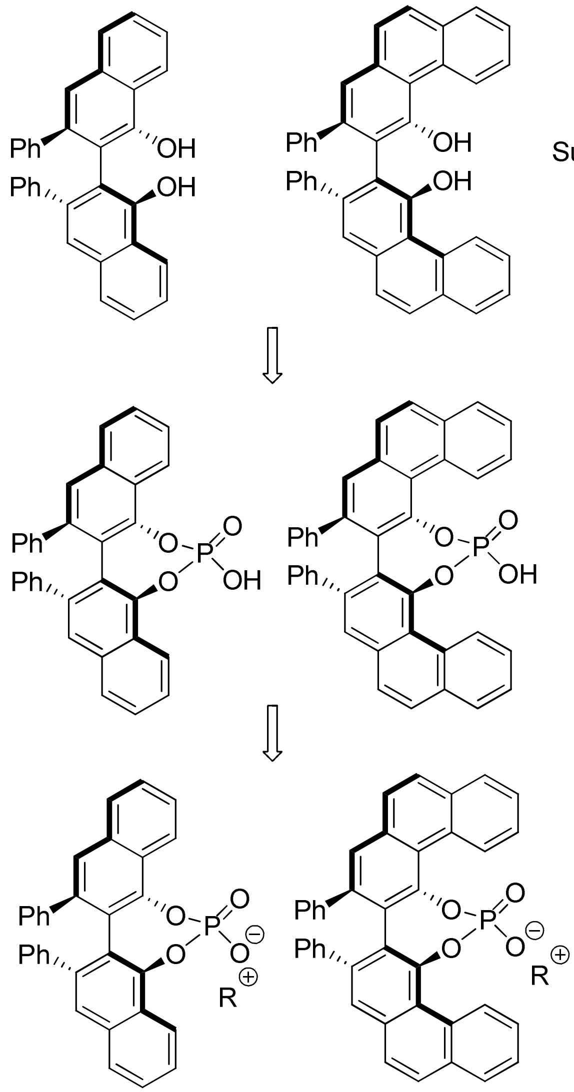
List, *JACS*, **2006**, 13368

List, *ACIEE*, **2006**, 4193



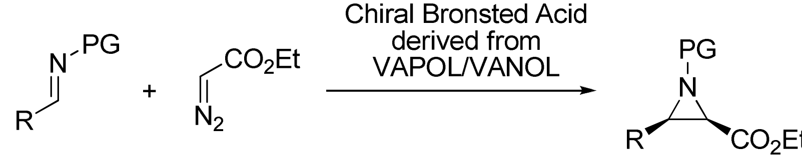
But Why Do I Care?

The Ultimate Dream
VAPOL & VANOL – “Privileged” Ligands



Successfully applied in various catalytic asymmetric protocols

Promising Bronsted acid catalysts

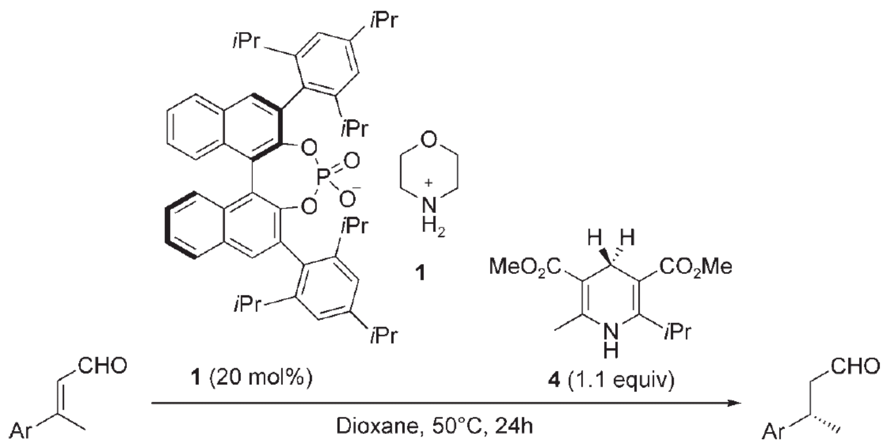


Dual Catalysts????

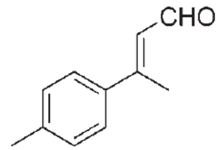
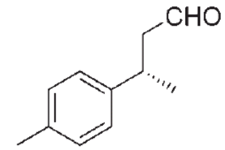
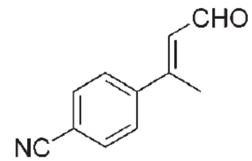
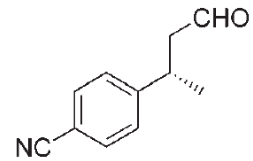
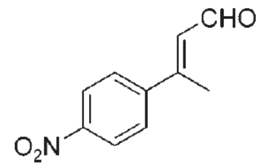
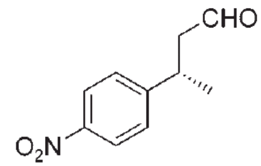
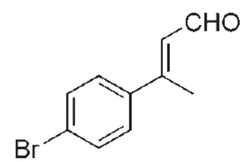
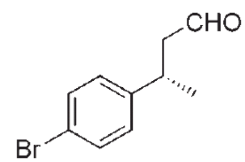
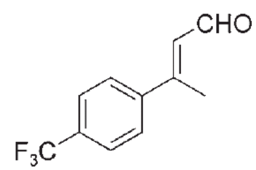
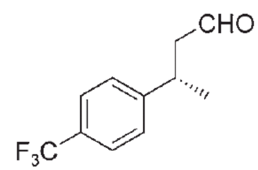
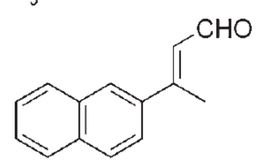
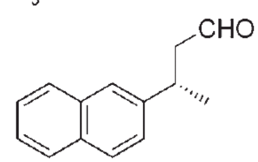
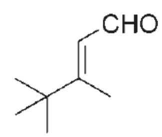
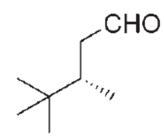
Now wouldn’t that be cool???

Ideas anyone? ☺

List's ACDC – Transfer H_2 of Enals

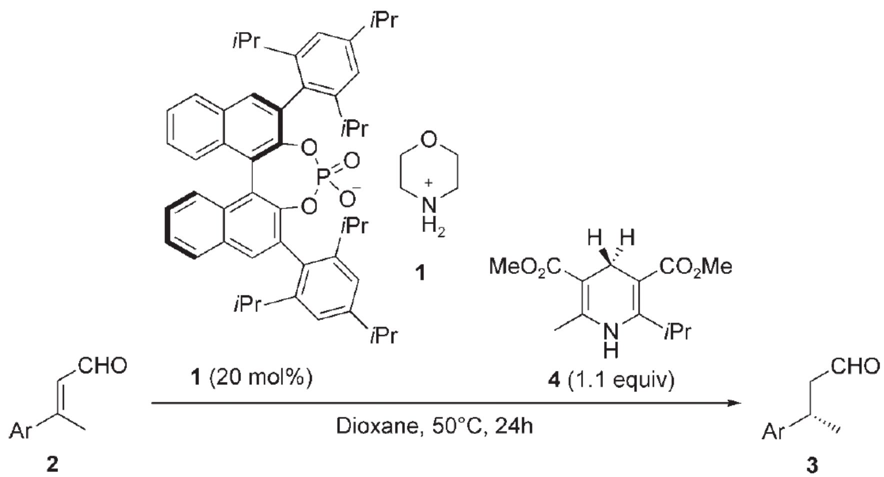


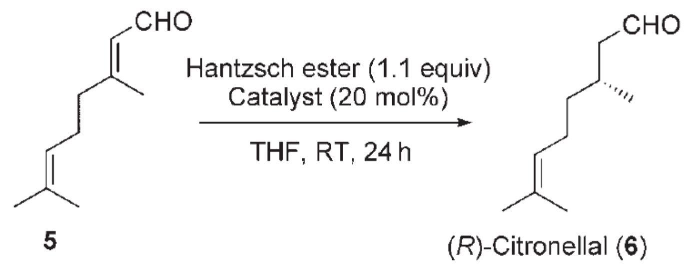
2 → 3

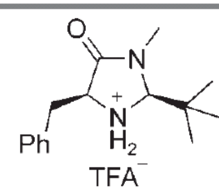
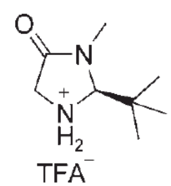
Substrate		Product		Yield [%]	e.r.[a]
	2a		3a	87	98:2
	2b		3b	84	99:1
	2c		3c	90	99:1
	2d		3d	67	98:2
	2e		3e	63	99:1
	2f		3f	72	>99:<1
	2g		3g	<5	n.d.

Mayer, S.; List, B. *Angew. Chem. Int. Ed.* **2006**, *45*, 4193

List's ACDC – Transfer H_2 of Enals

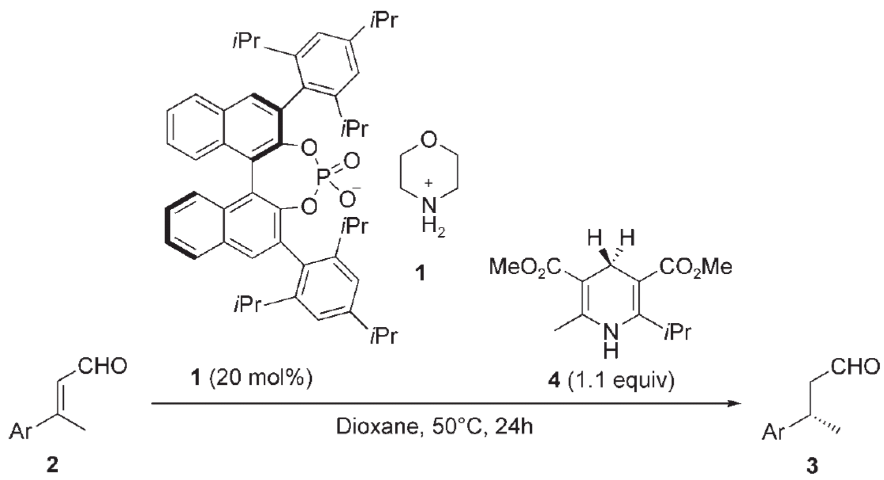


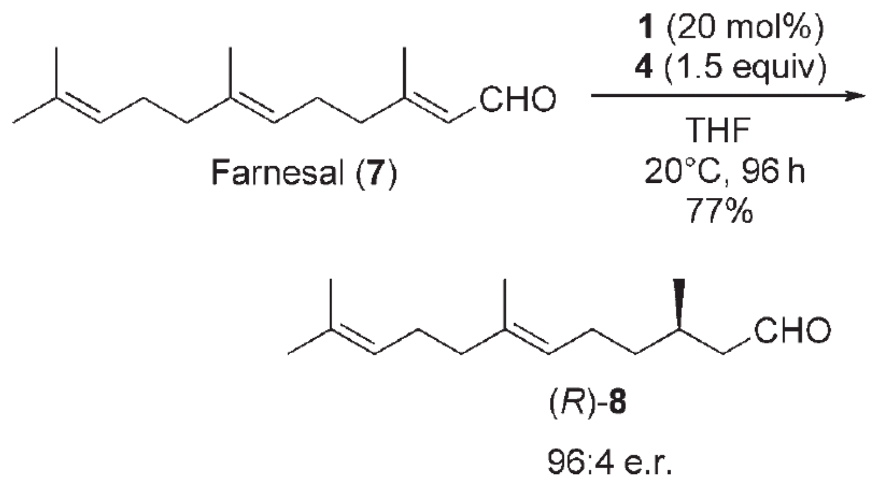


	Catalyst	Product	Yield [%]	e.r.[a]
List, *ACIEE* **2005**, 110		(*S*)-**6**	58[a]	70:30[c]
Macmillan *JACS* **2005**, 32		(*S*)-**6**	82[a]	70:30[d]
This work	**1**	(*R*)-**6**	71	95:5

Mayer, S.; List, B. *Angew. Chem. Int. Ed.* **2006**, *45*, 4193

List's ACDC – Transfer H_2 of Enals



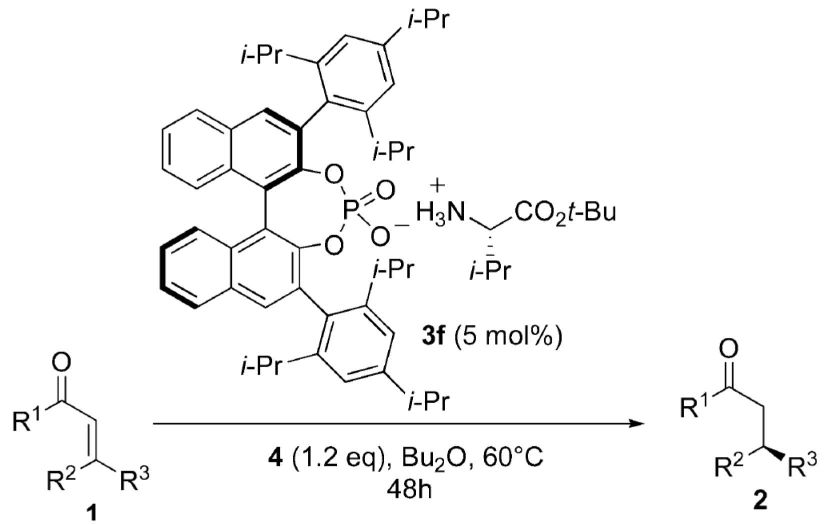


Both E & Z isomers and mixtures provide same enantiomer – Stereoconvergent process

Protocol not good for α,β-unsaturated ketones

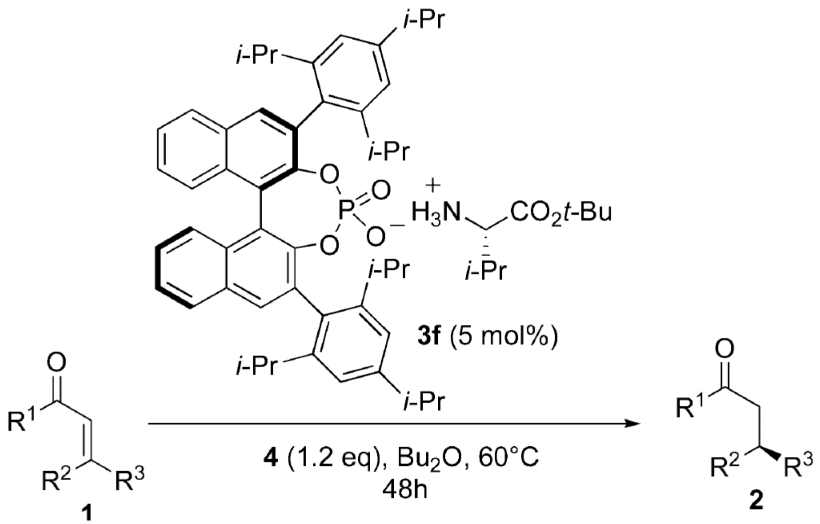
Mayer, S.; List, B. *Angew. Chem. Int. Ed.* **2006**, *45*, 4193

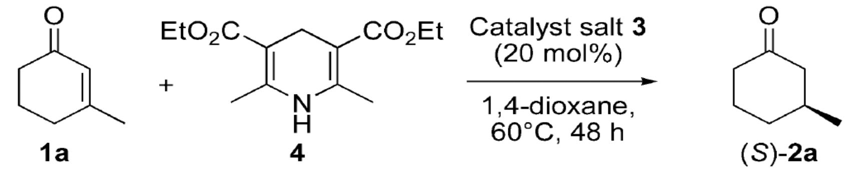
List's ACDC – Transfer H_2 of Enones

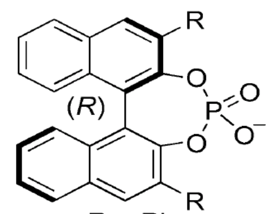


Martin, N. J. A.; List, B. *J. Am. Chem. Soc.* **2006**, *128*, 13368

List's ACDC – Transfer H_2 of Enones

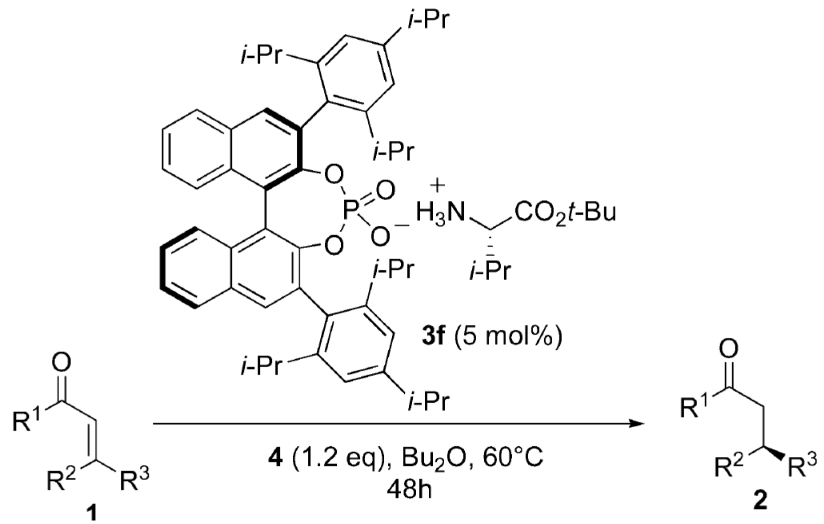


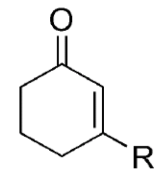
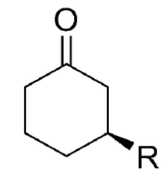
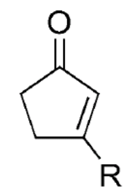
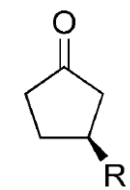
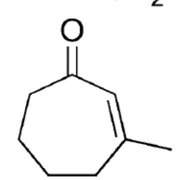
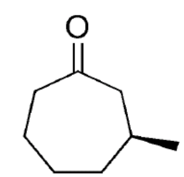
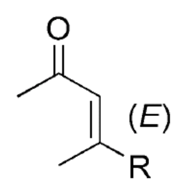
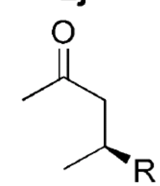


entry	catalyst-cation	-anion	cat.	conv. [%][b]	er[b]
1	$^{+}NH_3$ Me CO_2t-Bu	CF_3COO^-	**3a**	23	75:25
2	$^{+}NH_3$ *i*-Pr CO_2t-Bu	CF_3COO^-	**3b**	66	77:23
3	$^{+}NH_3$ *t*-Bu CO_2t-Bu	CF_3COO^-	**3c**	72	76:24
4	$^{+}NH_3$ *t*-Bu CO_2Me	CF_3COO^-	**3d**	42	64:36
5[c]	$^{+}NH_3$ *i*-Pr CO_2t-Bu	 R = Ph	**3e**	25	87:13
6	$^{+}NH_3$ *i*-Pr CO_2t-Bu	R = 2,4,6-(i-Pr)$_3C_6H_2$	**3f**	14	95:5
7[c]	$^{+}NH_3$ *i*-Pr CO_2t-Bu	R = 2,4,6-(i-Pr)$_3C_6H_2$	**3f**	81	97:3
8	$^{+}NH_3$ CO_2t-Bu	R = 2,4,6-(i-Pr)$_3C_6H_2$	**3g**	66	74:26
9[c]	H^+	R = 2,4,6-(i-Pr)$_3C_6H_2$	**3h**	5	40:60
10[c]	$^{+}NH_3$ *i*-Pr CO_2t-Bu	R = 2,4,6-(i-Pr)$_3C_6H_2$ (*S*)-Enantiomer	**3i**	45	58:42

Martin, N. J. A.; List, B. *J. Am. Chem. Soc.* **2006**, *128*, 13368

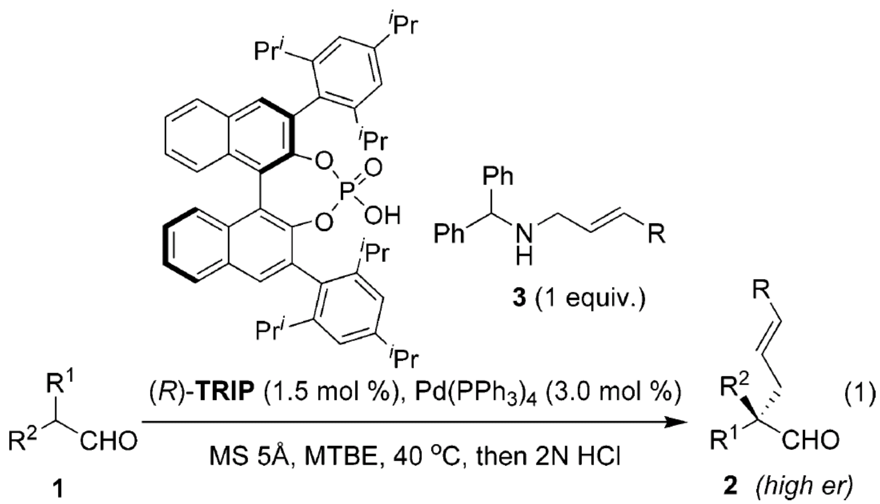
List's ACDC – Transfer H_2 of Enones

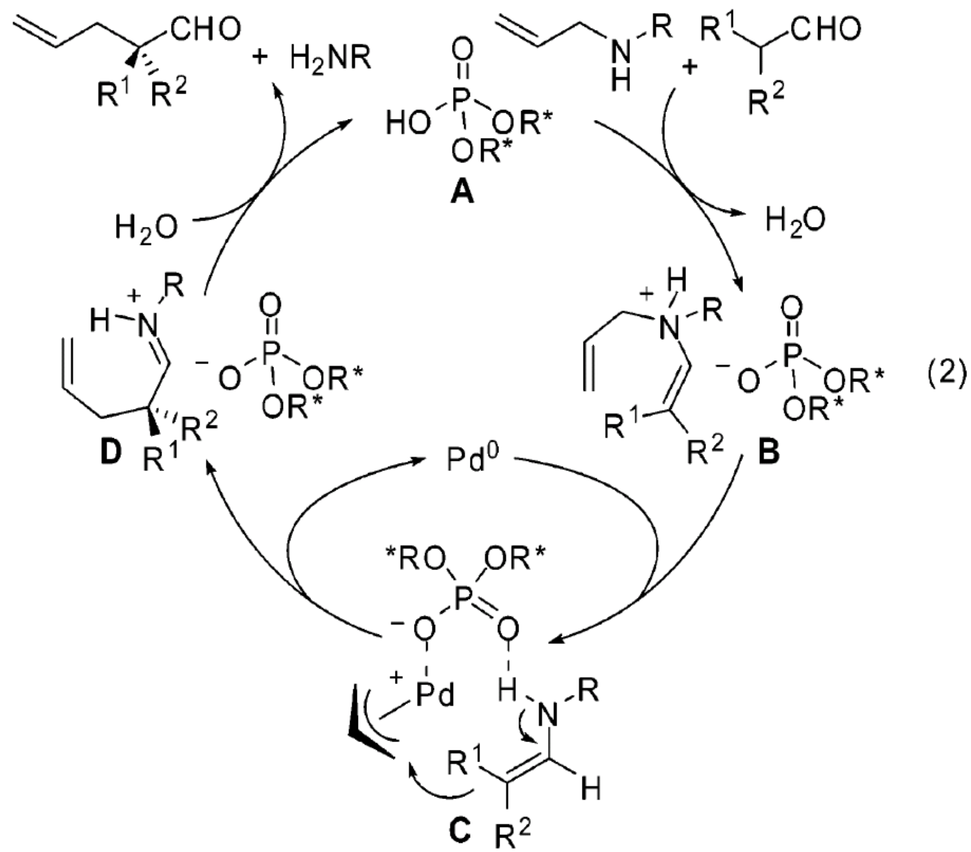


enone	product	yield [%][a]	er[a,b]
			
R= Me	**2a**	99	97:3
R= Et	**2b**	98	98:2
R= *i*-Bu	**2c**	89	98:2
R= *i*-Pr	**2d**	94	99:1
R= CH_2CH_2Ph	**2e**	99[c]	98:2[d]
R= Ph	**2f**	99	92:8
			
R= Me	**2g**	78[e]	99:1
R= Et	**2h**	71[e]	98:2
R= CH_2CH_2Ph	**2i**	68[d,e]	98:2[d]
	 **2j**	>99	98:2
			
R= CO_2Et	**2k**	>99	92:8
R= Ph	**2l**	81	85:15

Martin, N. J. A.; List, B. *J. Am. Chem. Soc.* **2006**, *128*, 13368

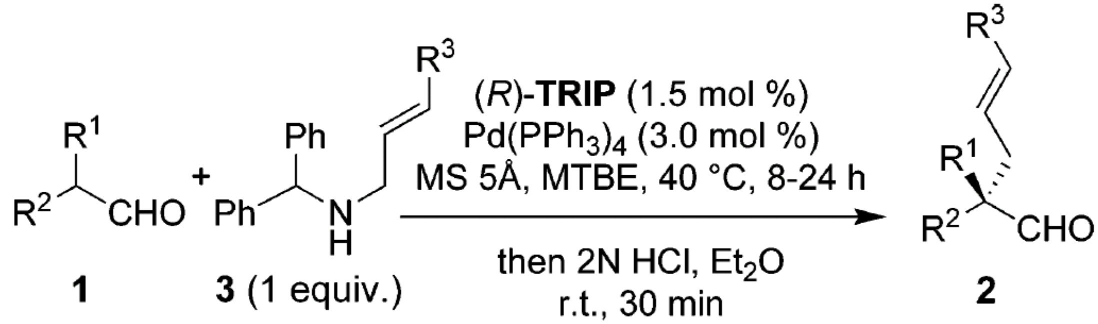
List's ACDC – α-Allylation of Aldehydes

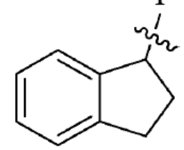




Mukherjee, S.; List, B. *J. Am. Chem. Soc.* **2007**, *129*, 11336

List's ACDC – α-Allylation of Aldehydes

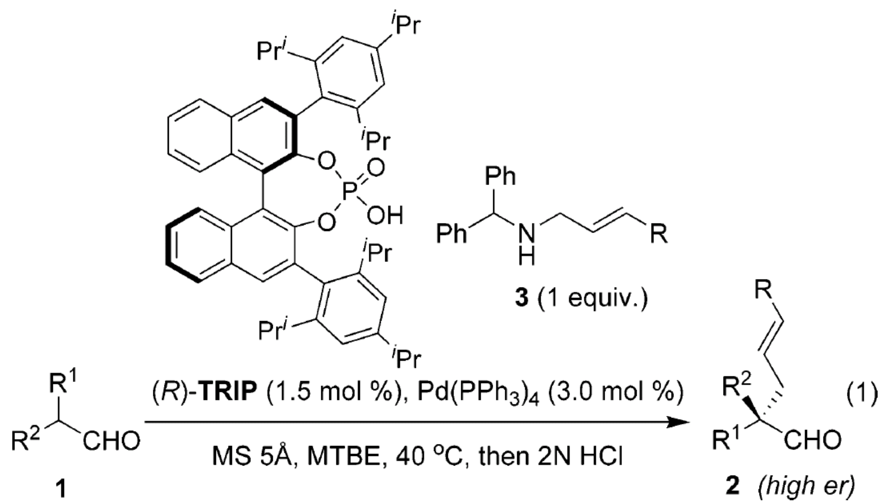


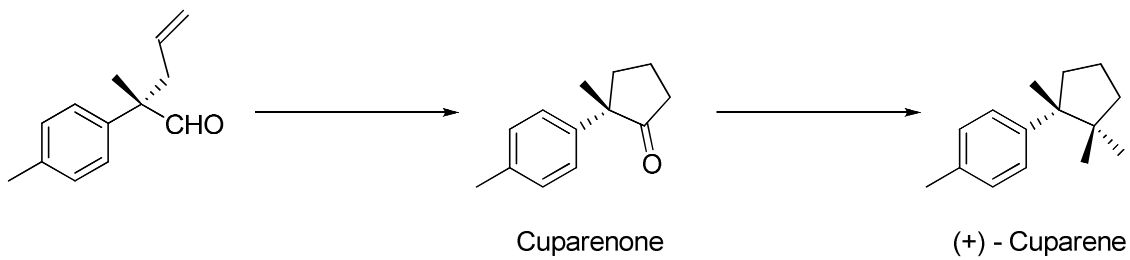
entry	R^1	R^2	R^3		yield (%)	er[a]
1	Me	Ph	H	**2a**	85	98.5:1.5
2	Me	4-Me-C_6H_4	H	**2b**	89	97:3
3	Me	3-Me-C_6H_4	H	**2c**	84	98:2
4	Me	3-F-C_6H_4	H	**2d**	85	98:2
5[b]	Me	2-F-C_6H_4	H	**2e**	74	97:3
6	Me	4-*i*-Bu-C_6H_4	H	**2f**	76	97.5:2.5
7	Me	2-naph	H	**2g**	71	97:3
8	Me	2-thiophenyl	H	**2h**	80	93:7
9			H	**2i**	45	95:5
10[c]	Me	*c*-hex	H	**2j**	65	85:15
11[d,e]	Me	Ph	Me	**2k**	40	96:4
12[d,e]	Me	Ph	Ph	**2l**	82	91:9

[a] From GC or HPLC. [b] Reaction run at 50 °C. [c] Reaction run at 110 °C in toluene. [d] Reaction run at 60 °C. [e] Reaction run for 72 h.

Mukherjee, S.; List, B. *J. Am. Chem. Soc.* **2007**, *129*, 11336

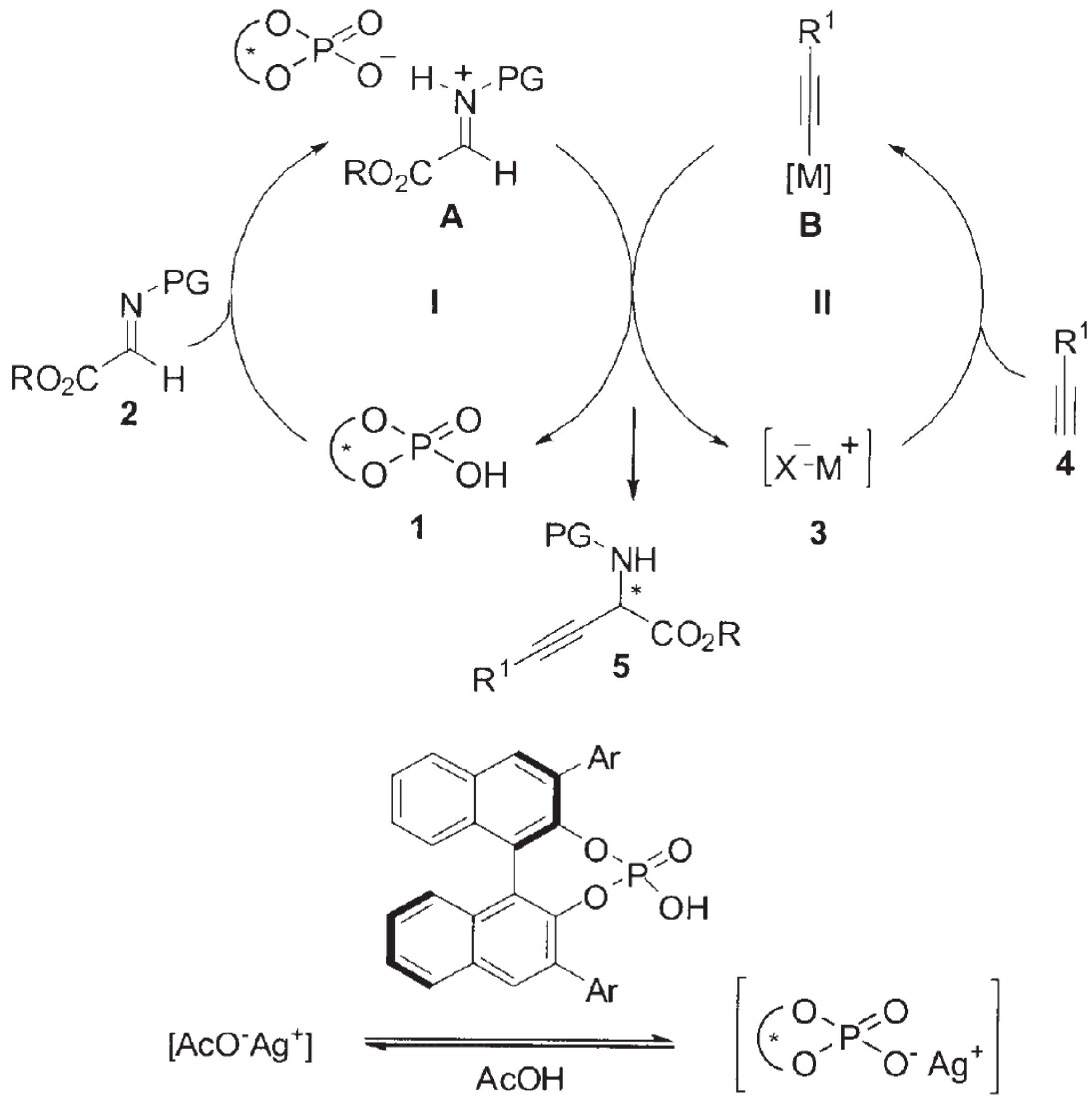
List's ACDC – α-Allylation of Aldehydes





Mukherjee, S.; List, B. *J. Am. Chem. Soc.* **2007**, *129*, 11336

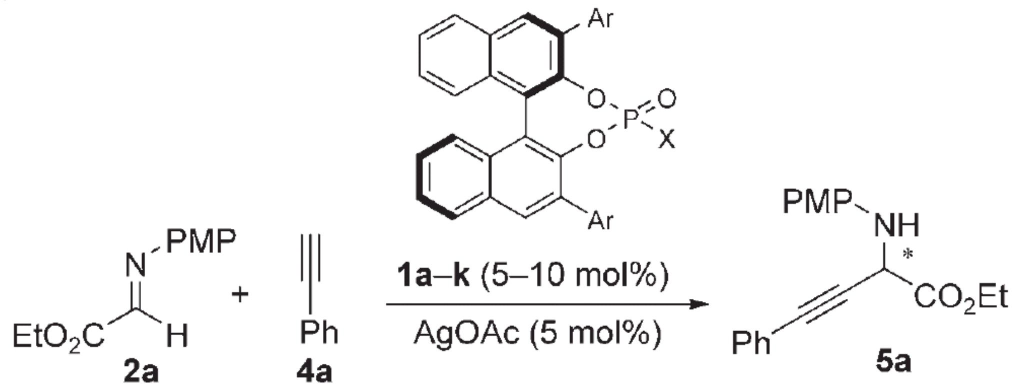
Rueping's *ACDC* – Alkynylation of α-Imino Esters



Rueping, M.; Antonchick, A. P.; Brinkmann, C. *Angew. Chem. Int. Ed.* **2007**, *46*, 6903.

Rueping's *ACDC* – Alkynylation of α-Imino Esters

Table 1: Chiral Brønsted acids in the enantioselective silver-catalyzed alkyne addition.

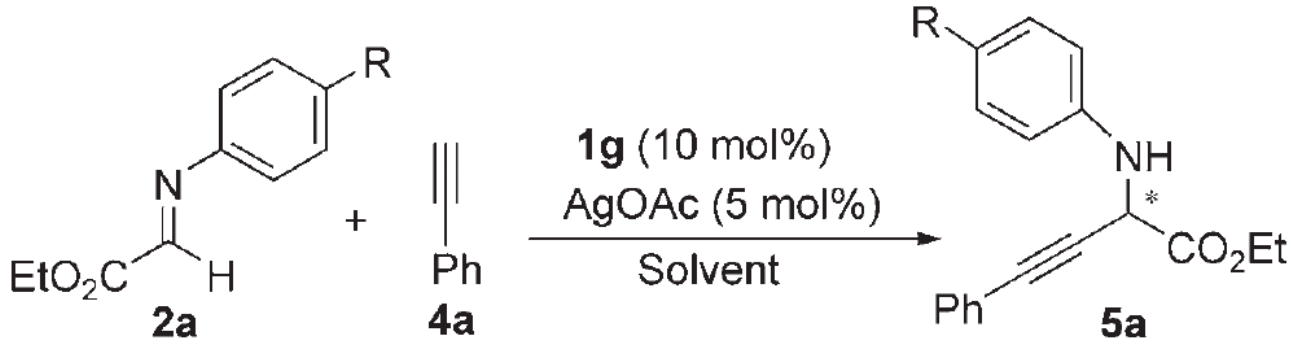


Entry[a]	1	Ar	X	**1** [mol %]	e.r.[b]
1	**1a**	phenyl[c]	OH	10	57:14
2	**1b**	4-biphenyl	OH	5	55:45
3	**1c**	1-naphthyl[c]	OH	10	55:45
4	**1d**	2-naphthyl	OH	10	54:46
5	**1e**	3,5-$(CF_3)_2$-C_6H_3	OH	5	62:38
6	**1f**	3,5-*t*Bu_2-PMP	OH	5	49:51
7	**1g**	9-phenanthryl	OH	5	86:14
8	**1g**	9-phenanthryl	OH	10	91:9
9	**1h**	$[H]_8Ph_3Si$	OH	5	69:31
10	**1i**	9-anthracenyl	OH	10	91:9
11	**1j**	9-phenanthryl[d]	NHTf	10	41:59
12	**1k**	9-anthracenyl[d]	NHTf	10	31:69

Rueping, M.; Antonchick, A. P.; Brinkmann, C. *Angew. Chem. Int. Ed.* **2007**, *46*, 6903.

Rueping's ACDC – Alkynylation of α-Imino Esters

Table 2: Evaluation of solvents and protecting groups.

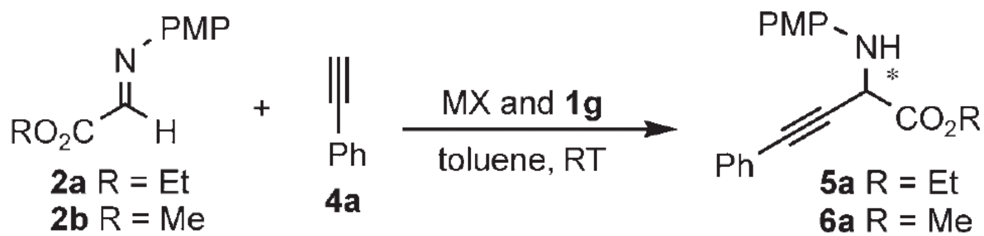


Entry[a]	Solvent	R	e.r.[b]
1	benzene	OMe	86:14
2	toluene	OMe	91:9
3	p-xylene	OMe	84:16
4	CH_2Cl_2	OMe	76:24
5	$CHCl_3$	OMe	53:47
6	$(n\text{Bu})_2O$	OMe	73:27
7	toluene	OEt	82:18
8	toluene	Opentyl	88:12
9	toluene	OCF_3	58:42
10	toluene	OPh	76:24

Rueping, M.; Antonchick, A. P.; Brinkmann, C. *Angew. Chem. Int. Ed.* **2007**, *46*, 6903.

Rueping's ACDC – Alkynylation of α-Imino Esters

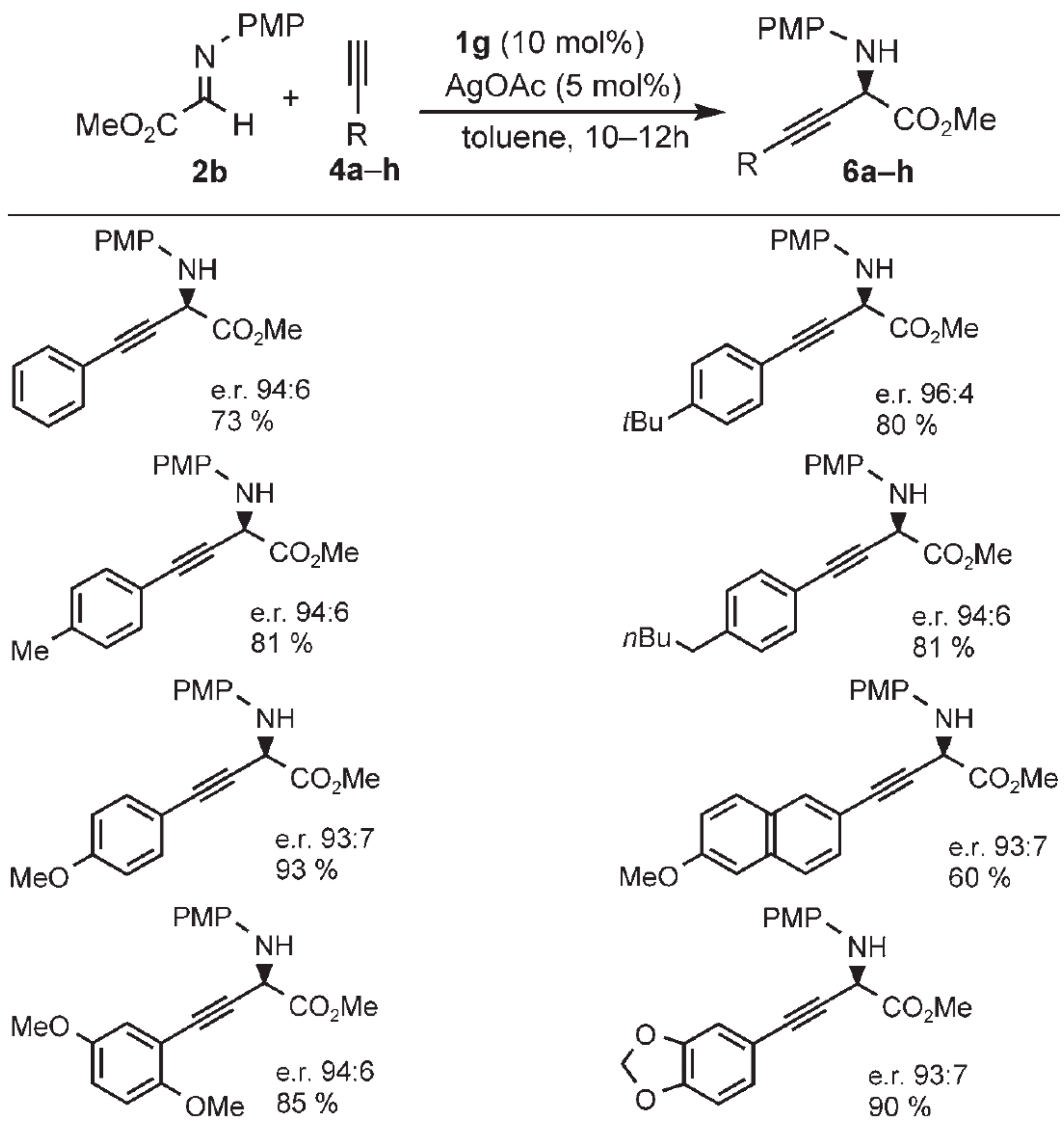
Table 3: Variation of the metal salts, catalyst loading, and *N*-PMP-imino ester.



Entry[a]	MX	MX [mol %]	**1g** [mol %]	R	e.r.[b]
1	–	–	10	Et	n.d.[c]
2	AcOAc	10	–	Et	n.d.
3	AgOAc	5	2	Et	76:24
4	AgOAc	5	5	Et	86:14
5	AgOAc	5	10	Et	91:9
6	AgOAc	5	10	Me	94:6
7	AgOAc	5	20	Et	87:13
8	AgOBz	5	5	Et	65:35
9	Ag_2O	2.5	5	Et	55:45
10	Ag_2CO_3	2.5	5	Et	73:27
11	$AgCO_2CF_3$	5	10	Et	85:15
12	$AgSO_3CF_3$	5	10	Et	72:28
13	$AgNO_3$	5	10	Et	81:19
14	$AgBF_4$	5	10	Et	79:21
15	CuOAc	5	10	Et	92:8
16	$Cu(OAc)_2$	5	10	Et	93:7

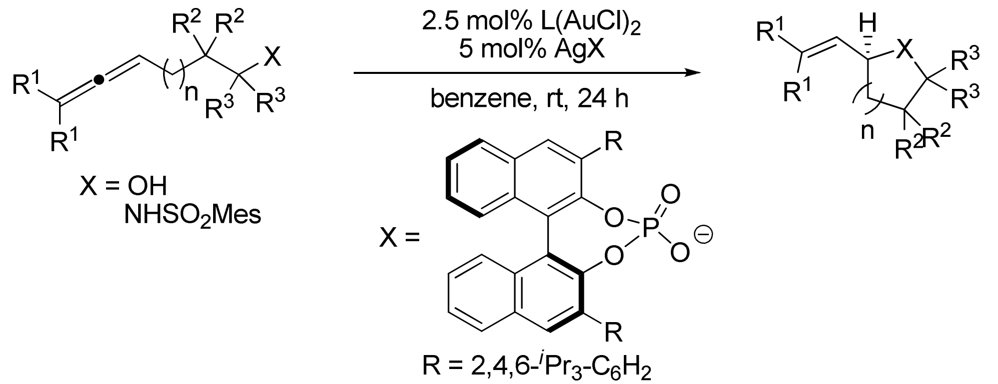
Rueping, M.; Antonchick, A. P.; Brinkmann, C. *Angew. Chem. Int. Ed.* **2007**, *46*, 6903.

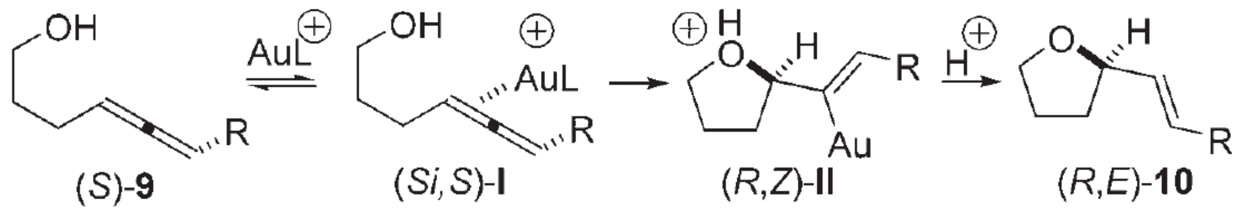
Rueping's *ACDC* – Alkynylation of α-Imino Esters



Rueping, M.; Antonchick, A. P.; Brinkmann, C. *Angew. Chem. Int. Ed.* **2007**, *46*, 6903.

Toste's ACDC – Hydro-Alkoxylation/Amination of Allenes



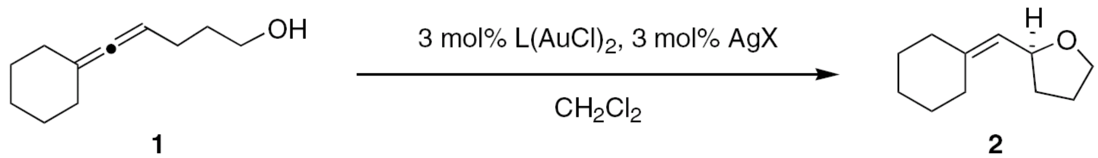


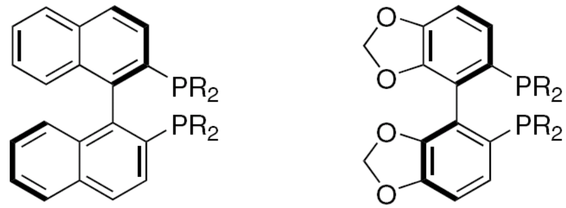
Zhang, Z.; Weidenhofer, R. *ACIEE* **2007**, *46*, 283.

Hamilton, G. L.; Kang, E. J.; Mba, M.; Toste, F. D. *Science* **2007**, *317*, 496.

Toste's ACDC – Hydro-Alkoxylation/Amination of Allenes

A

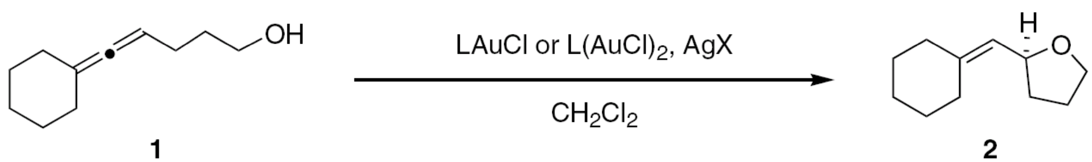


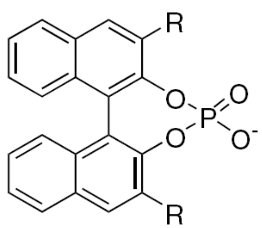


3, R = Ph
4, R = 3,5-$(CH_3)_2$-C_6H_3
5, R = 3,5-*t*-Bu_2-4-(CH_3O)-C_6H_2

L = **3**, X = BF_4^-	52% yield, 6% ee
L = **4**, X = BF_4^-	68% yield, 0% ee
L = **5**, X = BF_4^-	79% yield, 2% ee
L = **4**, X = 4-(NO_2)-C_6H_3-CO_2^-	89% yield, 8% ee

B





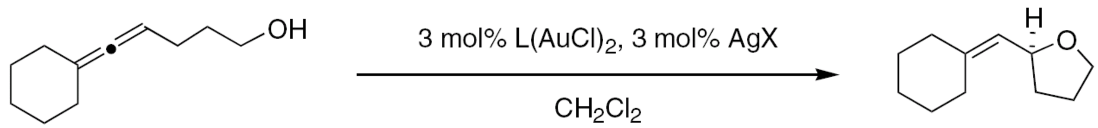
6, R = 2,4,6-*i*-Pr_3-C_6H_2

L = Ph_3P (5 mol%), X = (*R*)-**6** (5 mol%)	89% yield, 48% ee
L = dppm (2.5 mol%), X = (*R*)-**6** (5 mol%)	76% yield, 65% ee

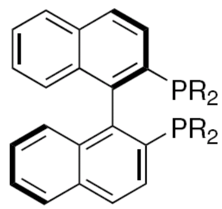
Hamilton, G. L.; Kang, E. J.; Mba, M.; Toste, F. D. *Science* **2007**, *317*, 496.

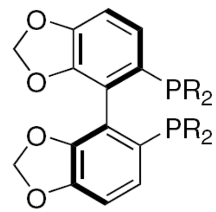
Toste's ACDC – Hydro-Alkoxylation/Amination of Allenes

A



1 **2**



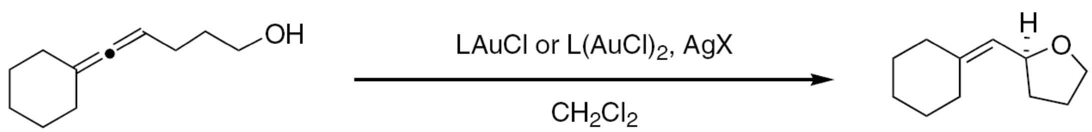


3, R = Ph
4, R = 3,5-$(CH_3)_2$-C_6H_3

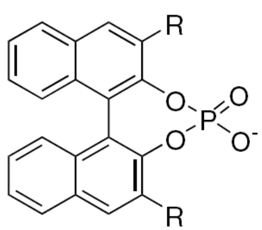
5, R = 3,5-*t*-Bu_2-4-(CH_3O)-C_6H_2

L = **3**, X = BF_4^-	52% yield, 6% ee
L = **4**, X = BF_4^-	68% yield, 0% ee
L = **5**, X = BF_4^-	79% yield, 2% ee
L = **4**, X = 4-(NO_2)-C_6H_3-CO_2^-	89% yield, 8% ee

B



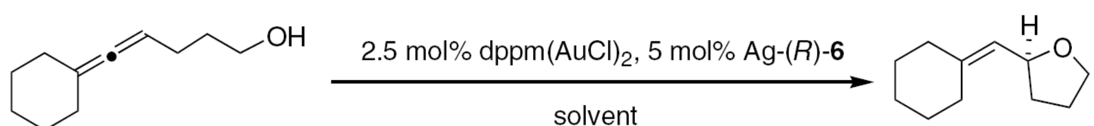
1 **2**



6, R = 2,4,6-*i*-Pr_3-C_6H_2

L = Ph_3P (5 mol%), X = (*R*)-**6** (5 mol%)	89% yield, 48% ee
L = dppm (2.5 mol%), X = (*R*)-**6** (5 mol%)	76% yield, 65% ee

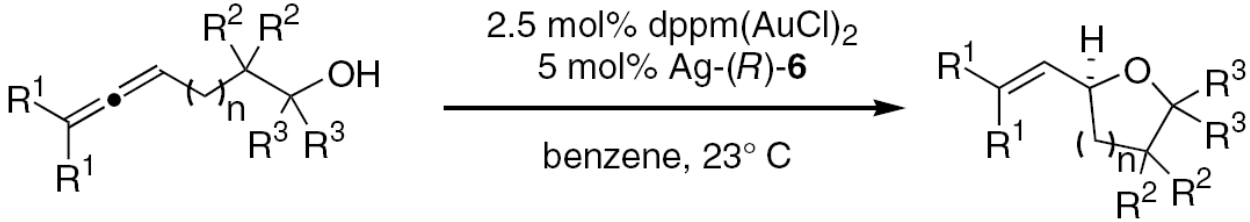
C

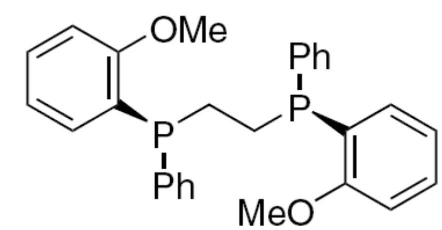


1 **2**

CH_3NO_2	60% yield, 18% ee	THF	83% yield, 76% ee
acetone	71% yield, 37% ee	benzene	90% yield, 97% ee

Toste's ACDC – Hydro-Alkoxylation/Amination of Allenes



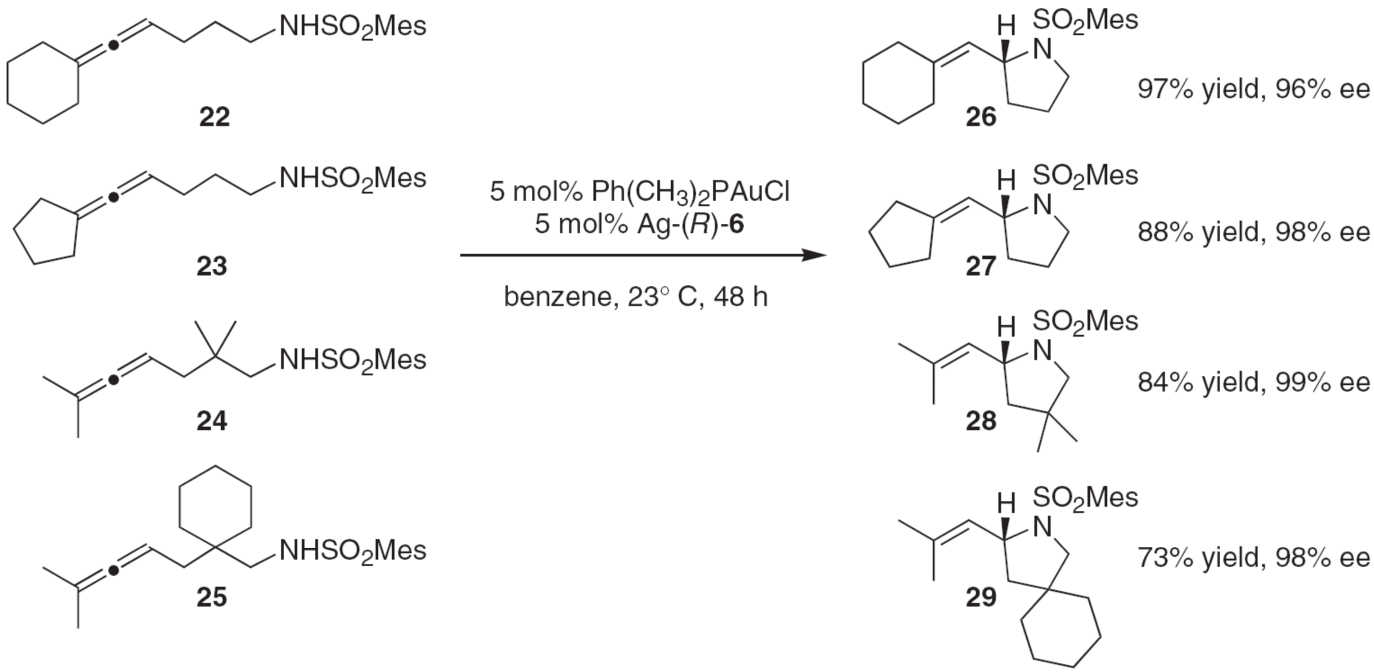


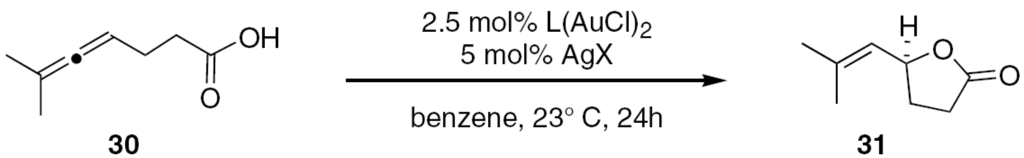
Entry	Substrate	n	R^1	R^2	R^3	Time (h)	Product	% Yield	% ee
1	**1**	1	$-(CH_2)_4-$	H	H	1	**2**	90	97
2	**8**	1	CH_3	H	H	1	**15**	91	95
3	**9**	1	CH_2CH_3	H	H	5	**16**	89	96
4	**10**	1	$-(CH_2)_4-$	H	CH_3	2	**17**	79	99
5	**11**	1	$-(CH_2)_4-$	H	Ph	30	**18**	86	92
6	**12**	1	$-(CH_2)_4-$	CH_3	H	13	**19**	90	90
7	**13**	2	CH_3	H	H	15	**20**	81	90
8	**14**	2	H	H	H	24	**21**	96	92 (80)

Match / Mismatched studies

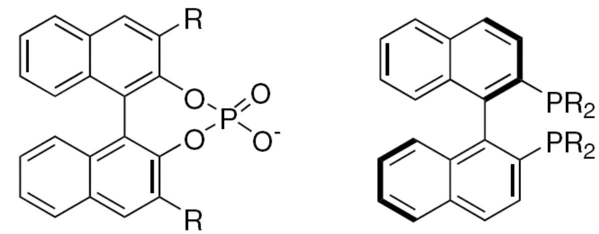
Hamilton, G. L.; Kang, E. J.; Mba, M.; Toste, F. D. *Science* **2007**, *317*, 496.

Toste's ACDC – Hydro-Alkoxylation/Amination of Allenes





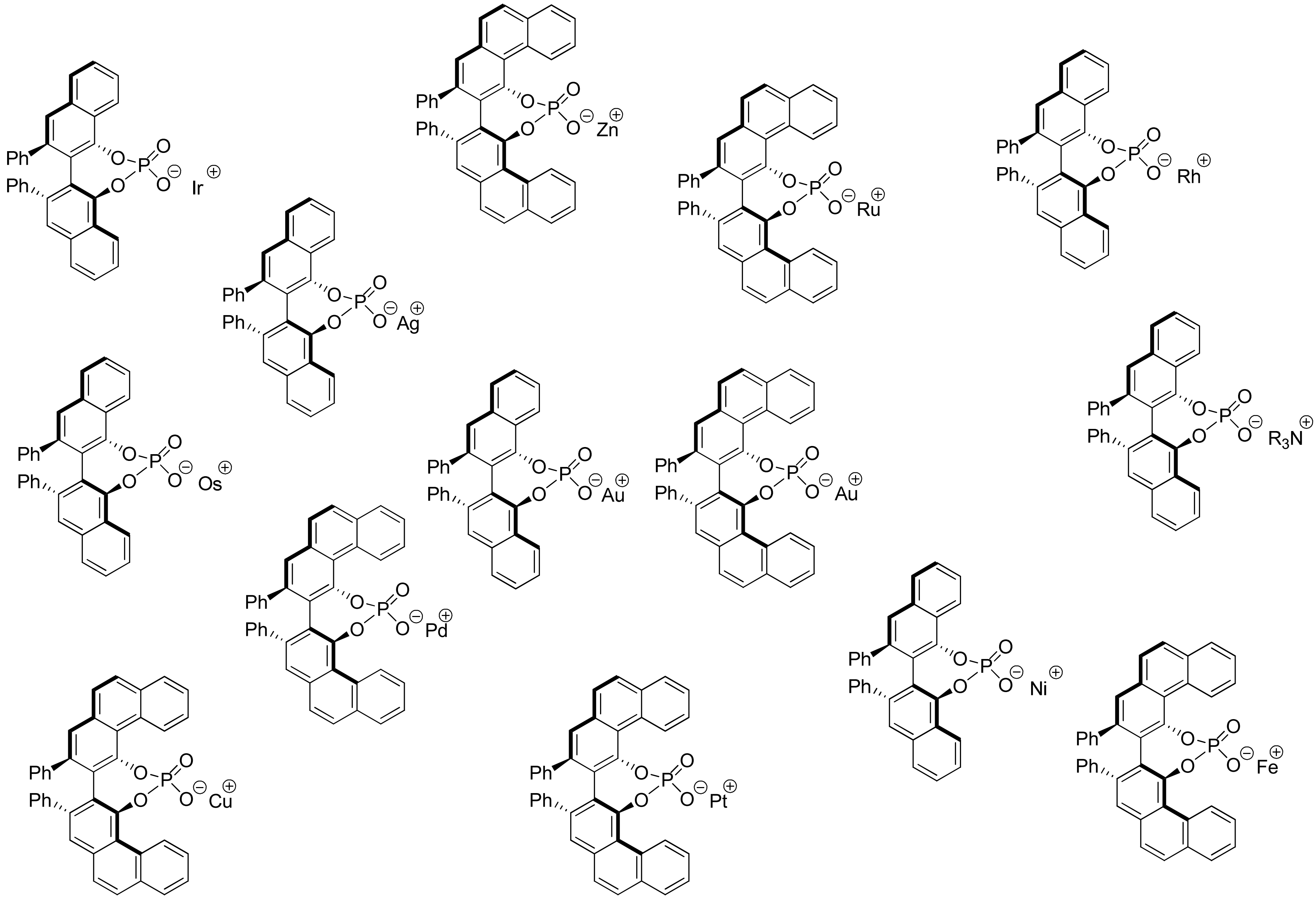
L = (*R*)-**3**, X = 4-(NO$_2$)-C$_6$H$_3$-COO$^-$	80% yield, 38% ee (*R*)
L = dppm, X = (*R*)-**6**	89% yield, 12% ee (*S*)
L = (*R*)-**3**, X = (*R*)-**6**	91% yield, 3% ee (*R*)
L = (*S*)-**3**, X = (*R*)-**6**	88% yield, 82% ee (*S*)



6, R = 2,4,6-*i*-Pr$_3$-C$_6$H$_2$ **3**, R = Ph

Hamilton, G. L.; Kang, E. J.; Mba, M.; Toste, F. D. *Science* **2007**, *317*, 496.

The Ultimate Dream – VAPOL & VANOL: “Privileged” Ligands



The Original – and the Best ACDC

The Original – and the Best ACDC

Austrialian rock band – formed in 1973 by two brother guitarists – Malcolm & Angus Young.

Phil Rudd – drums, Mark Evans – bass, Bon Scott – lead vocals.

Present: Malcolm & Angus, Phil, Mark & Brian Johnson.

Pioneers of heavy metal, alongwith Led Zeppelin, Deep Purple & Black Sabbath.

150 million albums worldwide.

Back in Black – 42 million worldwide & 21 million in USA (5th highest selling album in USA).

Ranked 4th on VH1 list of the Rock's Greatest 100.

Ranked 7th on MTV's Greatest Heavy Metal Bands of All Time.

Damn good!

The Original – and the Best ACDC