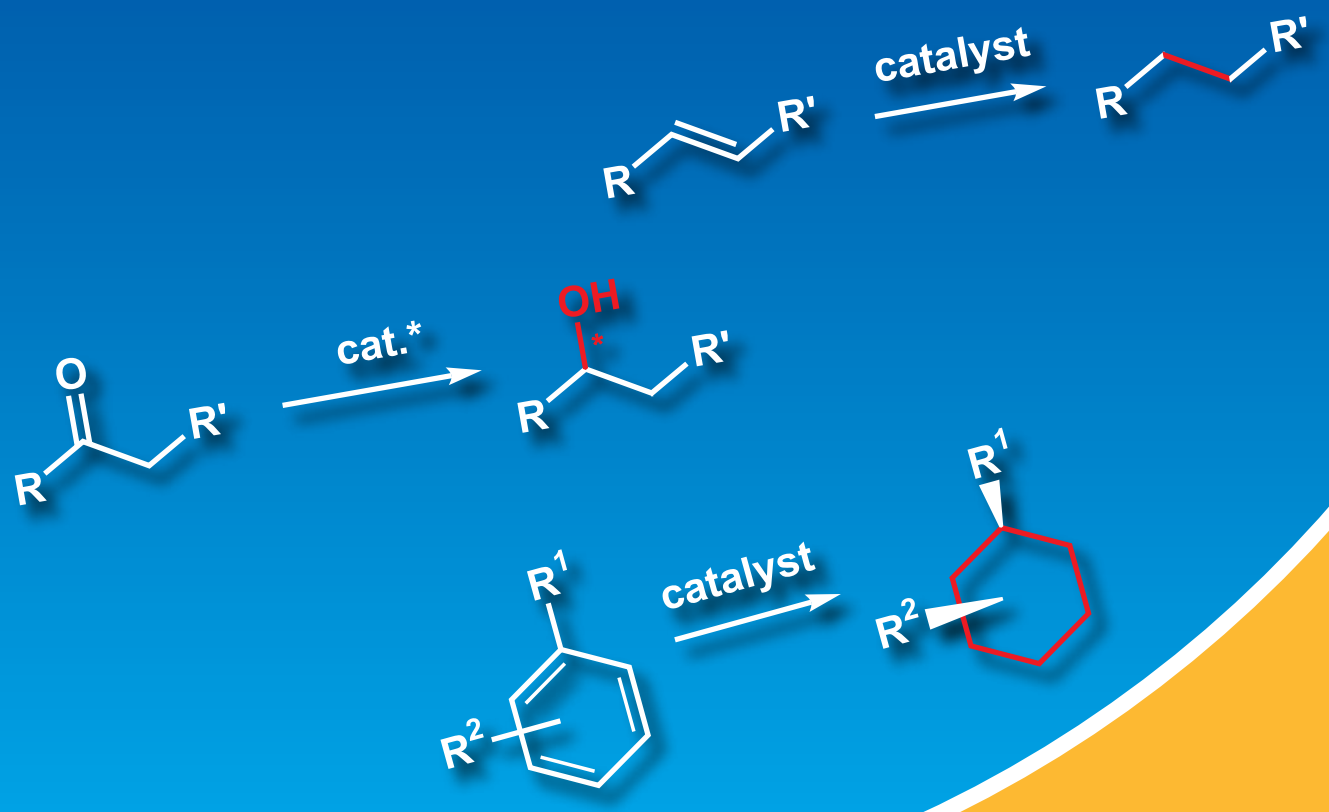
CHEMISTRY

TCI

Hydrogenation Catalysts



Catalysts for Hydrogenation

Catalysts for Asymmetric Hydrogenation

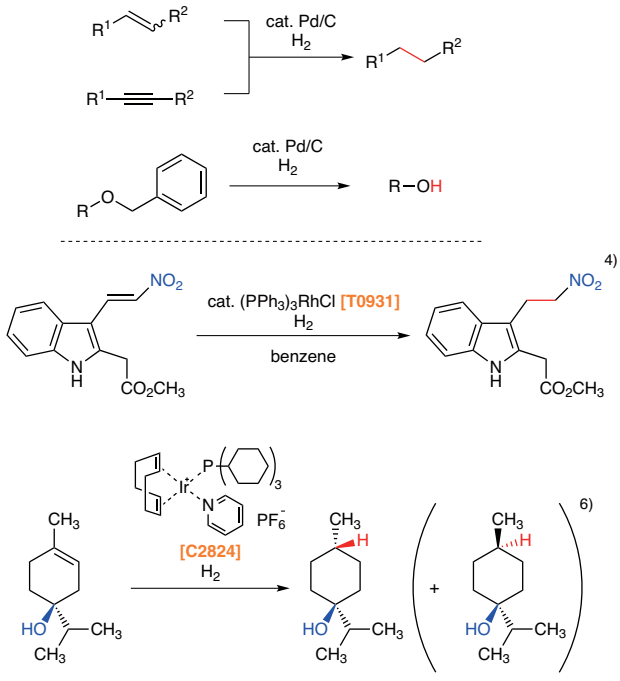
Hydrogenation Catalysts

Hydrogenation is a common reaction wherein H_2 is added across a double or triple bond, and is widely utilized in the laboratory and in industry applications. This reaction generally requires a metal catalyst to proceed, under which it is known as catalytic reduction or catalytic hydrogenation. These conditions are also used in the deprotection of benzyl and benzyloxycarbonyl groups.

Catalysts for hydrogenation also include heterogeneous catalysts such as palladium/charcoal (Pd/C), homogeneous catalysts such as Wilkinson's catalyst, and catalysts for asymmetric hydrogenation as well, and are used in numerous settings. This brochure introduces a variety of catalysts for hydrogenetic reduction.

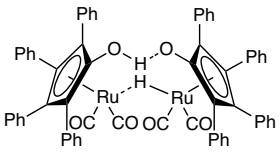
Catalysts for Hydrogenation

Catalytic reduction is widely utilized in the hydrogenation of carbon-carbon bonds, nitro group reduction, and the removal of benzyl and benzyloxycarbonyl groups.[1] Platinum metals are used in many forms such as Pd/C, and catalysts like Wilkinson's catalyst **[T0931]**[2-4] and Crabtree's catalyst **[C2824]**[5]. Both Wilkinson's catalyst and Crabtree's catalyst can hydrogenate alkenes and alkynes selectively. Furthermore, Crabtree's catalyst can hydrogenate stereoselectively due to its coordinating functional groups.[6]

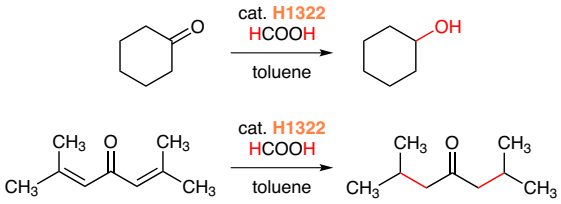


1. Shvo Catalyst

Shvo's group has reported a ruthenium binuclear complex **[H1322]** that catalyzes a hydrogenation of carbonyl groups and olefin moieties.[7] Formic acid is utilized as the hydrogen source. When α,β-unsaturated ketones are treated with Shvo catalyst, the olefin moiety is selectively hydrogenated.

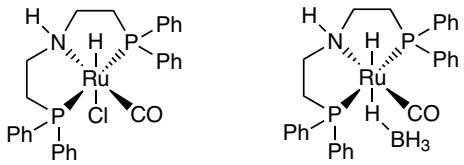


[H1322]

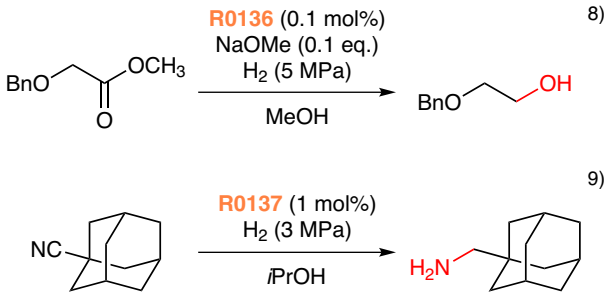


2. Ruthenium-complex Catalyst

The ruthenium catalyst **[R0136]** **[R0137]** can reduce esters to alcohols. In this condition, wide-ranged solvents can be chosen and the hydrogenation can proceed even under neat conditions.[8] However, benzyl and benzyloxycarbonyl groups, which are typically removed via conventional condition, are retained. Furthermore, **R0137** can also hydrogenate aldehydes, amides, and nitriles.[9]



[R0136] [R0137]



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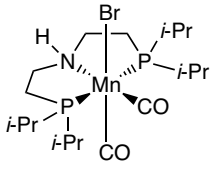
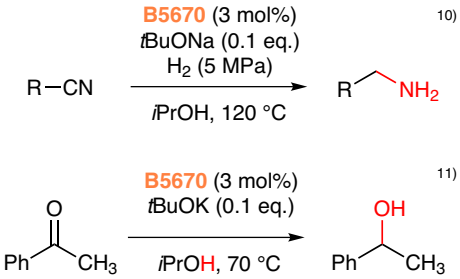
3. Manganese-complex Catalyst

Beller's group has reported that the manganese complex **[B5670]** is an excellent catalyst for the hydrogenation of nitriles.[10] This complex can also catalyze the reduction of ketones via a hydrogen atom transfer from isopropanol.[11]

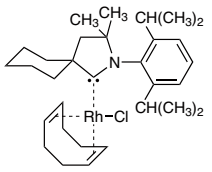


[B5670]

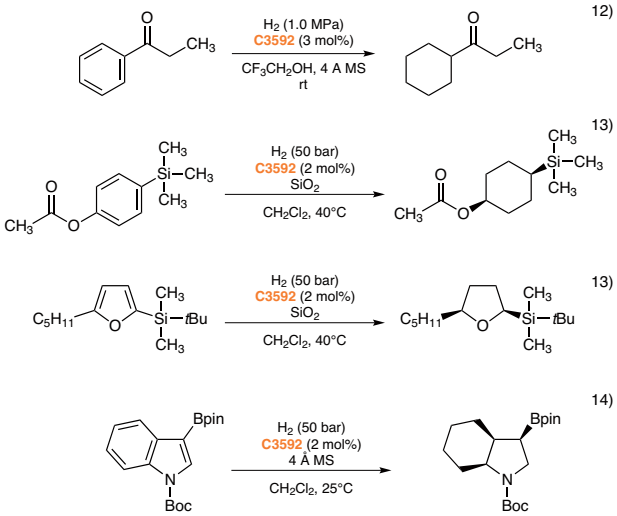


4. Rhodium Catalyst for *cis*-Selective Hydrogenation of Aromatic Rings

(Cyclohexyl-CAAC)Rh(COD)Cl **[C3592]** is used as an efficient and selective aromatic hydrogenation catalysts owning from the strongly σ-donating ligand. **C3592** can be used for the synthesis of cyclohexane moieties while still retaining various functional groups like carbonyls,[12] silyls,[13] and boryls[14] in a single step. Under these conditions, the *cis*-configured saturated hydrocarbon is selectively provided.

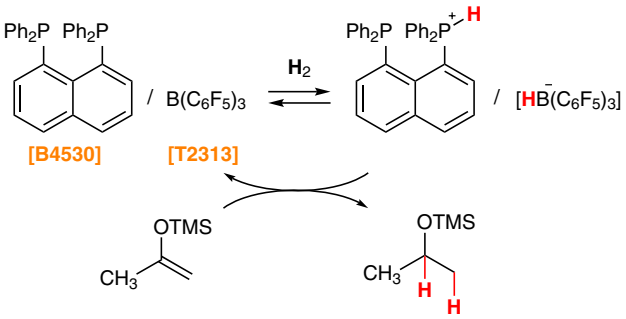


[C3592]



5. Organocatalysts for Metal-free Hydrogenations

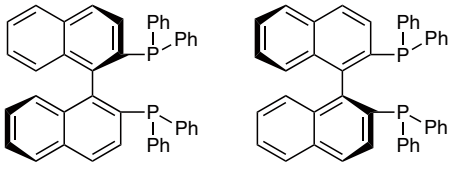
1,8-Bis(diphenylphosphino)naphthalene **[B4530]** contains two diphenylphosphino groups and acts as a bulky Lewis base. The bulkiness of **B4530** is also effective for forming unquenched Lewis acid-base pairs, "frustrated Lewis pairs (FLPs)", by treatment with a Lewis acid like tris(pentafluorophenyl)borane **[T2313]**. Erker *et al.* have applied them to activate a molecular hydrogen and the subsequent metal-free hydrogenations of silyl enol ethers. In this reaction, molecular hydrogens seem to be activated by the FLP-induced acid-base cooperation.[15]



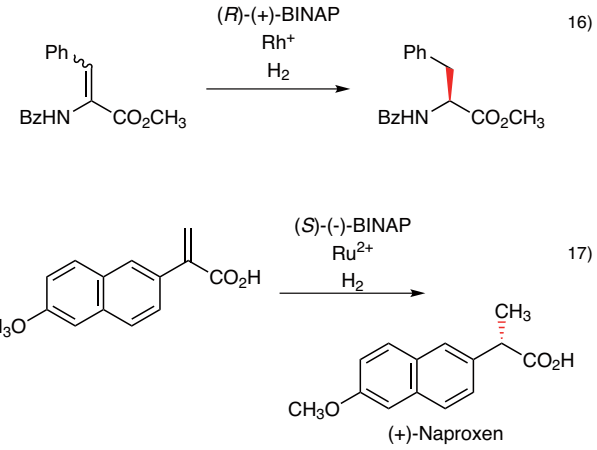
[B4530] **[T2313]**

Catalysts for Asymmetric Hydrogenation

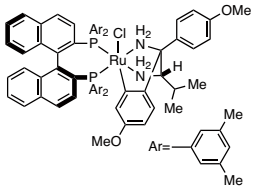
Noyori *et al.* have reported that the metal complex with a chiral 2,2'-bis(diphenylphosphino)-1,1'-binaphthyl (BINAP) ligand can act as a catalyst for asymmetric hydrogenation of alkene moiety in high yields and enantioselectivity.[16,17] This method has been utilized in the manufacturing of aroma chemicals and medicines.



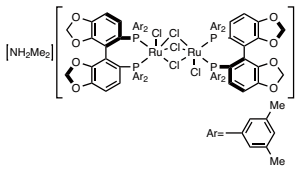
(*R*)-(+)-BINAP (*S*)-(-)-BINAP



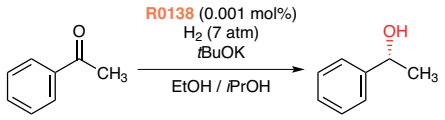
Catalysts with a BINAP moiety have high turnover number (TON) and some catalysts such as **R0138** are able to reach a TON of 100 000.[18] So far, many types of BINAP analogues have been developed.The catalyst **N1023** is utilized in asymmetric amination like as well as reduction of ketones and olefins.[19]



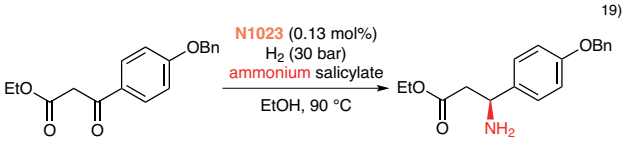
[R0138]



[N1023]

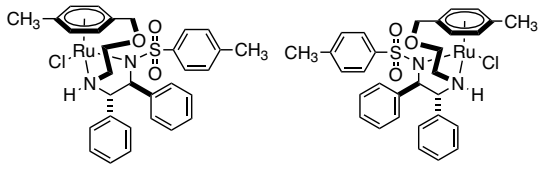


18)



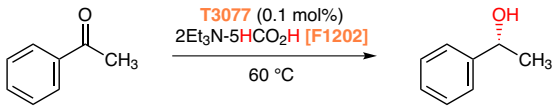
19)

Ikariya *et al.* have reported an asymmetric hydrogenation using formic acid salt **[F1022]** as a proton source and ruthenium catalysts with a chiral diamine ligand **[T3077]** **[T3078]**.[20] Conventional catalysts have often required high pressure conditions, but these catalysts can hydrogenate substances under atmospheric pressure requiring no special apparatuses.

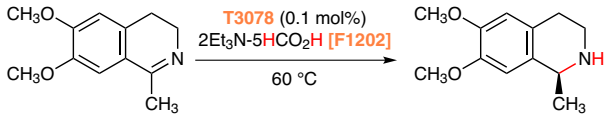


[T3077]

[T3078]



Y. >99%
98% ee



Y. >99%
92% ee

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Catalysts for Hydrogenation

Heterogeneous Catalysts

P1490 5g 25g

Pd

Palladium 5% on Carbon
(wetted with *ca.* 55% Water)
CAS RN: 7440-05-3

P1491 5g 25g

Pd

Palladium 10% on Carbon
(wetted with *ca.* 55% Water)
CAS RN: 7440-05-3

P1785 5g 25g

Pd

Palladium 10% on Carbon
(wetted with *ca.* 55% Water) [Useful catalyst for coupling reaction, etc.]
CAS RN: 7440-05-3

P1701 10g

Pd

Palladium 5% on Barium Carbonate
CAS RN: 7440-05-3

P1702 5g 25g

Pd

Palladium 5% on Barium Sulfate
CAS RN: 7440-05-3

P1703 5g 25g

Pd

Palladium 5% on Calcium Carbonate (poisoned with Lead)
CAS RN: 7440-05-3

P1786 1g

Palladium on SH Silica Gel
(0.1mmol/g)

P1528 10g 50g

$Pd(OH)_2$

Pearlman's Catalyst
(contains Pd, PdO)
(wetted with *ca.* 50% Water)
CAS RN: 12135-22-7

P1720 200mg

PtO_2

Platinum(IV) Oxide
CAS RN: 1314-15-4

S0487 50g

Ni

Raney Nickel slurry in Water
CAS RN: 7440-02-0

R0075 1g

Rh

Rhodium 5% on Carbon
(wetted with *ca.* 55% Water)
CAS RN: 7440-16-6

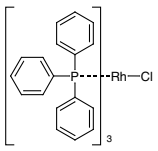
R0076 5g 25g

Ru

Ruthenium 5% on Carbon
(wetted with ca. 50% Water)
CAS RN: 7440-18-8

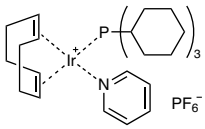
Homogeneous Catalysts

T0931 1g 5g



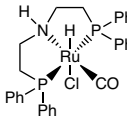
Wilkinson Catalyst
CAS RN: 14694-95-2

C2824 100mg



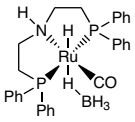
Crabtree's Catalyst
CAS RN: 64536-78-3

R0136* 200mg 1g



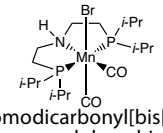
Ru-MACHO® (contains 5% Toluene at maximum)
CAS RN: 1295649-40-9

R0137* 200mg 1g



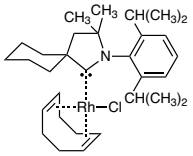
Ru-MACHO®-BH
CAS RN: 1295649-41-0

B5670 100mg



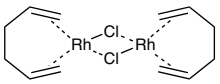
Bromodicarbonyl[bis[2-(diisopropylphosphino)-ethyl]amine]manganese(I)
CAS RN: 1919884-90-4

C3592 100mg 1g



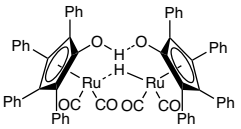
(Cyclohexyl-CAAC)Rh(COD)Cl
CAS RN: 1801869-83-9

C3194 100mg



Chloro(1,5-hexadiene)-rhodium(I) Dimer
CAS RN: 32965-49-4

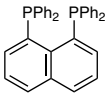
H1322 100mg



Shvo's Catalyst
CAS RN: 104439-77-2

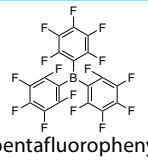
Others

B4530 1g 5g



1,8-Bis(diphenylphosphino)-naphthalene
CAS RN: 153725-04-3

T2313 1g 5g

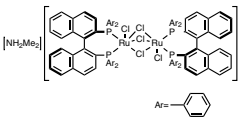


Tris(pentafluorophenyl)-borane
CAS RN: 1109-15-5

Catalysts for Asymmetric Hydrogenation

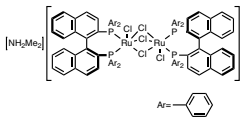
Catalysts for Asymmetric Hydrogenation of Olefins and Functionalized Ketones

N1015* 200mg 1g



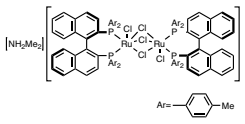
$[NH_2Me_2][(RuCl((R)\text{-binap}))_2(\mu\text{-}Cl)_3]$
CAS RN: 199684-47-4

N1016* 200mg 1g



$[NH_2Me_2][(RuCl((S)\text{-binap}))_2(\mu\text{-}Cl)_3]$
CAS RN: 199541-17-8

N1017* 200mg 1g



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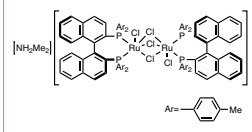
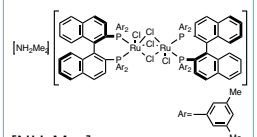
CAS RN: 749935-02-2

N1018* 200mg 1g



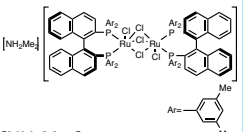
$[NH_2Me_2][(RuCl((S)\text{-tolbinap}))_2(\mu\text{-}Cl)_3]$
CAS RN: 309735-86-2

N1019* 200mg 1g



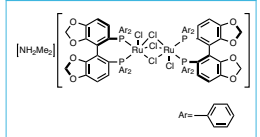
$[NH_2Me_2][(RuCl((R)\text{-xylbinap}))_2(\mu\text{-}Cl)_3]$
CAS RN: 944451-08-5

N1020* 200mg 1g



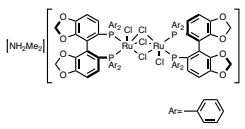
$[NH_2Me_2][(RuCl((S)\text{-xylbinap}))_2(\mu\text{-}Cl)_3]$
CAS RN: 944451-10-9

N1021* 200mg 1g



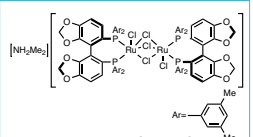
$[NH_2Me_2]$ [(RuCl((*R*)-segphos®))$_2$(μ-Cl)$_3$]
CAS RN: 346457-41-8

N1022* 200mg 1g



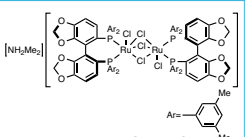
$[NH_2Me_2]$ [(RuCl((*S*)-segphos®))$_2$(μ-Cl)$_3$]
CAS RN: 488809-34-3

N1023* 200mg 1g



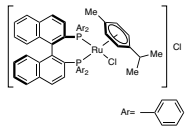
$[NH_2Me_2]$[(RuCl((*R*)-dm-segphos®))$_2$(μ-Cl)$_3$]
CAS RN: 935449-46-0

N1024* 200mg 1g



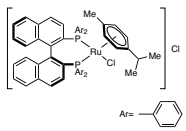
$[NH_2Me_2]$[(RuCl((*S*)-dm-segphos®))$_2$(μ-Cl)$_3$]
CAS RN: 944451-14-3

R0146* 200mg 1g



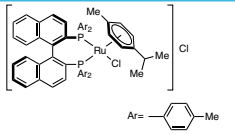
[RuCl(*p*-cymene)((*R*)-binap)]Cl
CAS RN: 145926-28-9

R0147* 200mg 1g



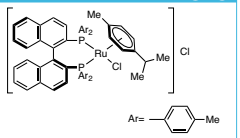
[RuCl(*p*-cymene)((*S*)-binap)]Cl
CAS RN: 130004-33-0

R0148* 200mg 1g



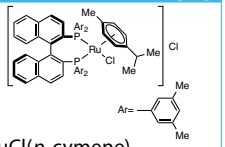
[RuCl(*p*-cymene)((*R*)-tolbinap)]Cl
CAS RN: 1034001-51-8

R0149* 200mg 1g



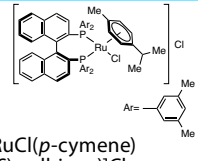
[RuCl(*p*-cymene)((*S*)-tolbinap)]Cl
CAS RN: 228120-95-4

R0150* 200mg 1g



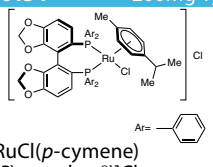
[RuCl(*p*-cymene)((*R*)-xylbinap)]Cl
CAS RN: 944451-24-5

R0151* 200mg 1g



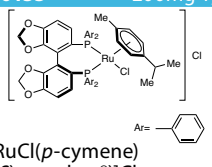
[RuCl(*p*-cymene)((*S*)-xylbinap)]Cl
CAS RN: 944451-25-6

R0154* 200mg 1g



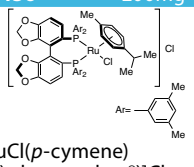
[RuCl(*p*-cymene)((*R*)-segphos®)]Cl
CAS RN: 944451-28-9

R0155* 200mg 1g



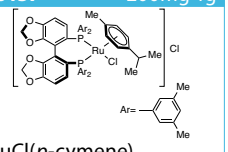
[RuCl(*p*-cymene)((*S*)-segphos®)]Cl
CAS RN: 944451-29-0

R0156* 200mg 1g



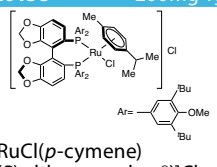
[RuCl(*p*-cymene)((*R*)-dm-segphos®)]Cl
CAS RN: 944451-30-3

R0157* 200mg 1g



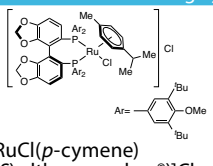
[RuCl(*p*-cymene)((*S*)-dm-segphos®)]Cl
CAS RN: 944451-31-4

R0158* 200mg 1g



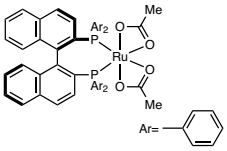
[RuCl(*p*-cymene)((*R*)-dtbm-segphos®)]Cl
CAS RN: 944451-32-5

R0159* 200mg 1g



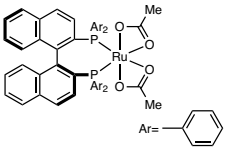
[RuCl(*p*-cymene)((*S*)-dtbm-segphos®)]Cl
CAS RN: 944451-33-6

R0166* 200mg 1g



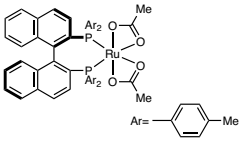
Ru(OAc)$_2$[(*R*)-binap]
CAS RN: 325146-81-4

R0167* 200mg 1g



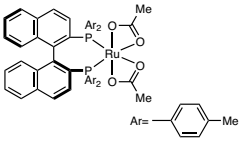
Ru(OAc)$_2$[(*S*)-binap]
CAS RN: 261948-85-0

R0168* 200mg 1g



Ru(OAc)$_2$[(*R*)-tolbinap]
CAS RN: 116128-29-1

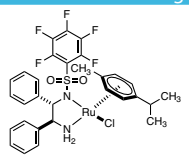
R0169* 200mg 1g



Ru(OAc)$_2$[(*S*)-tolbinap]
CAS RN: 106681-15-6

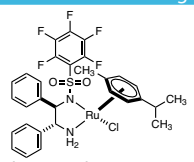
Catalysts for Asymmetric Hydrogenation of Ketones

R0122* 200mg 1g



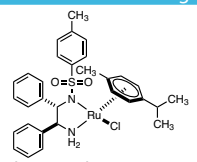
RuCl[(*S,S*)-Fsdpen](*p*-cymene)
CAS RN: 1026995-72-1

R0123* 200mg 1g



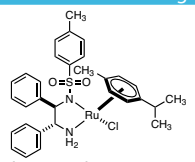
RuCl[(*R,R*)-Fsdpen](*p*-cymene)
CAS RN: 1026995-71-0

R0124* 200mg 1g



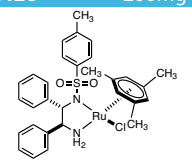
RuCl[(*S,S*)-Tsdpen](*p*-cymene)
CAS RN: 192139-90-5

R0125* 200mg 1g



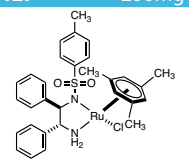
RuCl[(*R,R*)-Tsdpen](*p*-cymene)
CAS RN: 192139-92-7

R0126* 200mg 1g



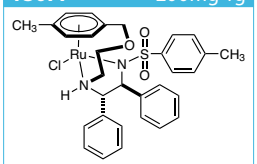
RuCl[(*S,S*)-Tsdpen](mesitylene)
CAS RN: 174813-81-1

R0127* 200mg 1g



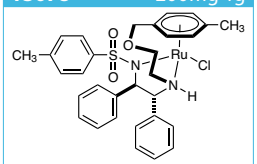
RuCl[(*R,R*)-Tsdpen](mesitylene)
CAS RN: 174813-82-2

T3077* 200mg 1g



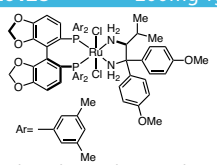
(*S,S*)-Ts-DENEB®
CAS RN: 1384974-37-1

T3078* 200mg 1g



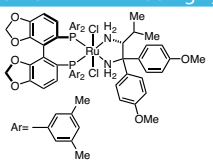
(*R,R*)-Ts-DENEB®
CAS RN: 1333981-84-2

R0128* 200mg 1g



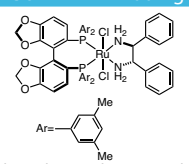
RuCl$_2$[(*S*)-dm-segphos®][(*S*)-daipen]
CAS RN: 944450-44-6

R0129* 200mg 1g



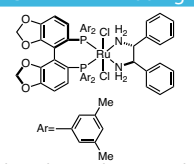
RuCl$_2$[(*R*)-dm-segphos®][(*R*)-daipen]
CAS RN: 944450-43-5

R0130* 200mg 1g



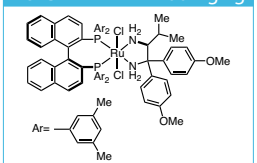
RuCl$_2$[(*S*)-dm-segphos®][(*S,S*)-dpen]
CAS RN: 944450-46-8

R0131* 200mg 1g



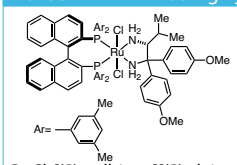
RuCl$_2$[(*R*)-dm-segphos®][(*R,R*)-dpen]
CAS RN: 944450-45-7

R0132* 200mg 1g



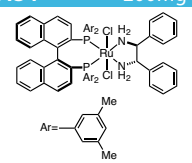
RuCl$_2$[(*S*)-xylbinap][(*S*)-daipen]
CAS RN: 220114-01-2

R0133* 200mg 1g



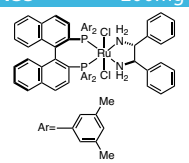
RuCl$_2$[(*R*)-xylbinap][(*R*)-daipen]
CAS RN: 220114-32-9

R0134* 200mg 1g



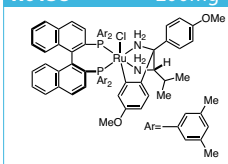
RuCl$_2$[(*S*)-xylbinap][(*S,S*)-dpen]
CAS RN: 220114-03-4

R0135* 200mg 1g



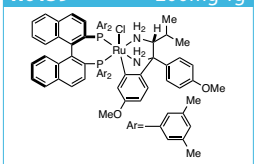
RuCl$_2$[(*R*)-xylbinap][(*R,R*)-dpen]
CAS RN: 220114-38-5

R0138* 200mg 1g



(*S*)-RUCY®-XylBINAP
CAS RN: 1312713-89-5

R0139* 200mg 1g

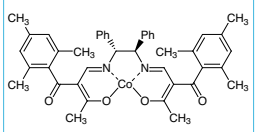


(*R*)-RUCY®-XylBINAP
CAS RN: 1384974-38-2

Please inquire for pricing and availability of listed products to our local sales representatives.

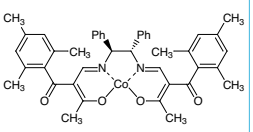
Others

B1844 100mg



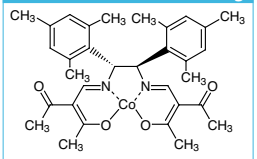
(*R*)-MPAC
CAS RN: 212250-92-5

B1845 100mg



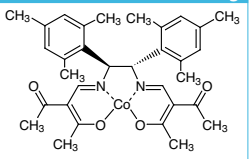
(*S*)-MPAC
CAS RN: 171200-71-8

B2314 100mg



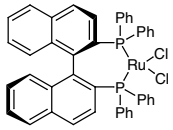
(*R*)-AMAC
CAS RN: 361346-80-7

B2315 100mg



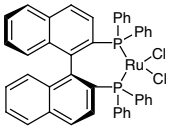
(*S*)-AMAC
CAS RN: 259259-80-8

B3067 250mg



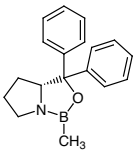
[(*R*)-2,2'-Bis(diphenylphosphino)-1,1'-binaphthyl]ruthenium(II) Dichloride
CAS RN: 132071-87-5

B3068 250mg



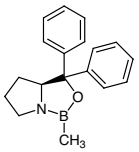
[(*S*)-2,2'-Bis(diphenylphosphino)-1,1'-binaphthyl]ruthenium(II) Dichloride
CAS RN: 134524-84-8

D2130 1g 5g



(*R*)-Me-CBS Catalyst
CAS RN: 112022-83-0

D2131 1g 5g



(*S*)-Me-CBS Catalyst
CAS RN: 112022-81-8

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