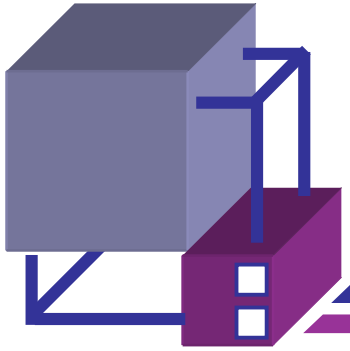
DENEB™

Oxo-Tethered Ruthenium(II) Complex



Asymmetric Transfer Hydrogenation Catalyst

—Highly efficient asymmetric reduction without hydrogen—

Takasago International Corporation

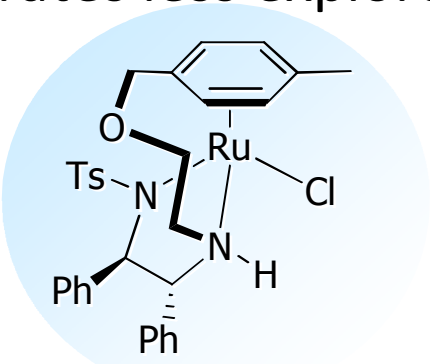
Fine Chemicals Division

TAKASAGO

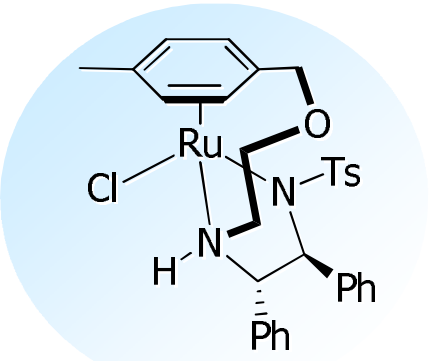
DENEB™; *Oxo-Tethered Ruthenium(II) Complex*

Extremely highly efficient catalytic asymmetric reduction
without special equipment;
Easy to screen and commercialize ！

1. High Catalytic Activity;
   catalyst loading can be cut down to 1/60*
2. High Enantioselectivity;
   improvement process of optical purity can be skipped
3. Wide Scope of Substrate;
   substrates less explored by conventional cat. can be applied



(*R*,*R*)-Ts-DENEB



(*S*,*S*)-Ts-DENEB

*compared with conventional catalysts

TAKASAGO

Asymmetric Transfer Hydrogenation

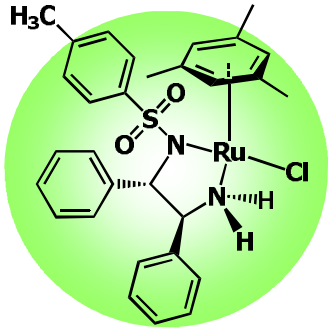
Conventional Technology

Advantage; a) Easy handling
b) No hydrogen
c) No special equipment such as autoclave

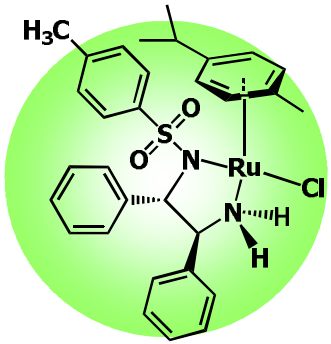
→ ***Maintain !***

Disadvantage; a) Low catalytic activity (around S/C=500)
b) Applicable substrates are limited

→ ***Overcome !***



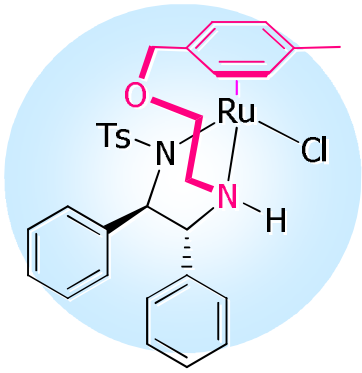
RuCl(TsDPEN)(Mesitylene)



RuCl(TsDPEN)(*p*-Cymene)

Conventional catalysts

J. Am. Chem. Soc. **1996**, *118*, 2521

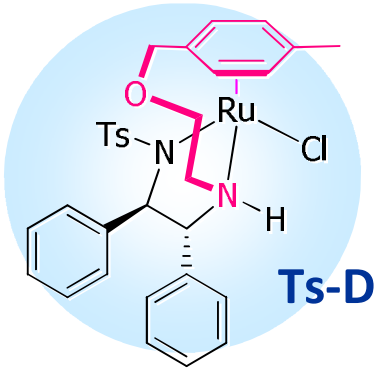


Ts-DENEB™

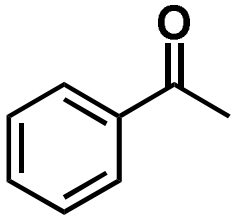
J. Am. Chem. Soc. Accepted
DOI: 10.1021/ja207283t

S/C = Substrate mol/ Catalyst mol; catalyst loading against substrate
TON (Turnover Number); the number of moles of substrate that a mole of catalyst can convert before inactivated

Extremely High Catalytic Activity



Ts-DENEB™



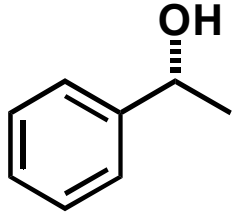
HCO_2H-TEA (5:2) 2M

S/C=30,000

Catalyst loading

1/60 !

compared with conventional cat.



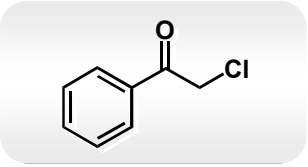
95% conv.
97% ee

- Significant reduction of catalyst loading !
- Low residual Ru in reaction liquid enables to simplify purification process !

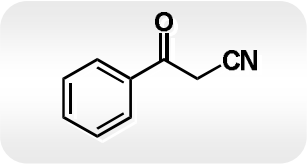
Expanded Scope of Substrate

1. Applicable Substrates to Conventional Catalysts

Remarkable improvement in cat. loading and optical purity !



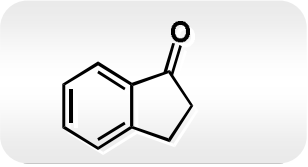
RuCl(TsDPEN)(Mesitylene); S/C = 500, 97.7% conv., Sel. 66.1%, 90.9% ee
Ts-DENEB; S/C = 1,000, 97.7% conv., Sel. > 95%, 97.3% ee



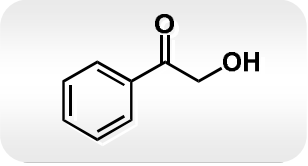
RuCl(TsDPEN)(*p*-Cymene); S/C = 500, 23.0% conv., 86.0%ee
Ts-DENEB; S/C = 1,000, 100% conv., 94.7%ee

2. Less Explored Substrates by Conventional Catalysts

Innovative results can be achieved !



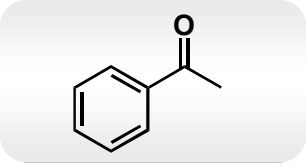
RuCl(TsDPEN)(Mesitylene); S/C = 500, 17.4%conv., 90.1%ee
Ts-DENEB; S/C = 1,000, 97.1%conv., 98.4%ee



RuCl(TsDPEN)(Mesitylene); S/C = 300, 5.3%conv., 6.5%ee
Ts-DENEB; S/C = 1,000, 97.6%conv., 96.0%ee

Economical Benefit for Industrialization

1. Efficient Production with Less Amount of Catalyst

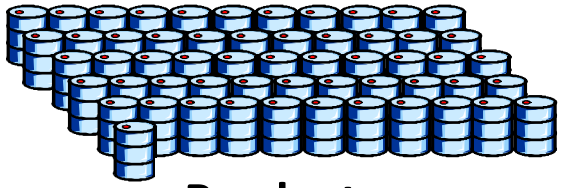


RuCl(TsDPEN)(Mesitylene); S/C = 500, >98% Conv. 98% ee
Ts-DENEB; S/C = 30,000, 95% Conv. 97% ee

RuCl(TsDPEN)(Mesitylene)

Product
98kg

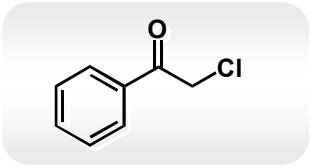
Ts-DENEB



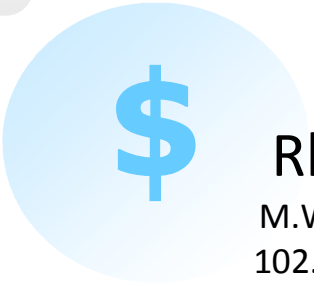
Product
5,699kg

Output with 1kg catalyst;
60 times more!!

2. Comparison against Rh Catalyst



RhCl(TsDPEN)(Cp*); S/C = 1,000, > 99% Conv. 96% ee
Ts-DENEB; S/C = 1,000, 98% Conv. 97% ee



Rh
M.W.
102.91

Ru
M.W.
101.07

Metal cost of catalyst;
Less than 10%!!

Contact

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