MEERWEIN-PONNDORF-VERLEY REDUCTION & OPPENAUER OXIDATION

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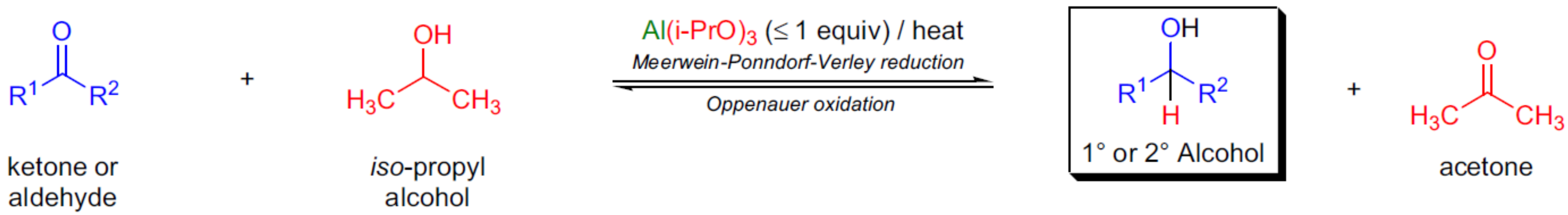
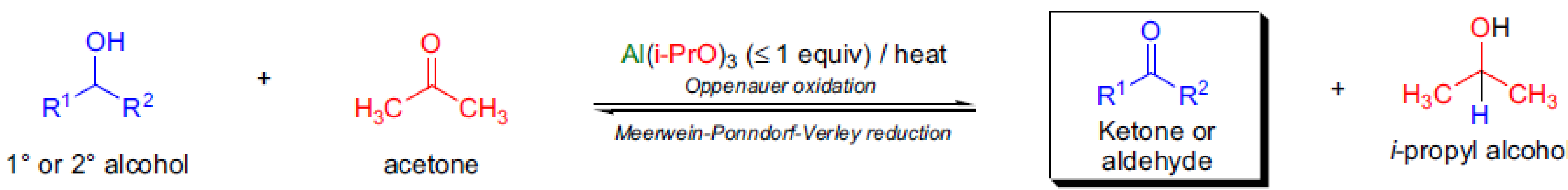
Introduction

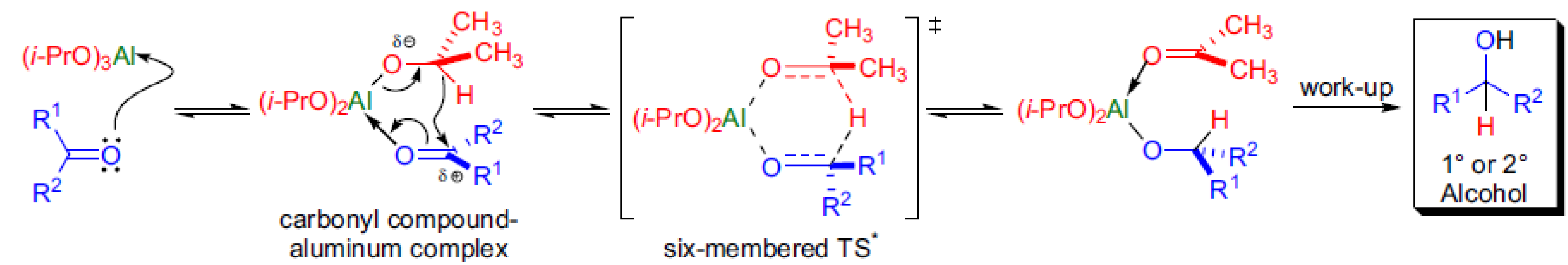


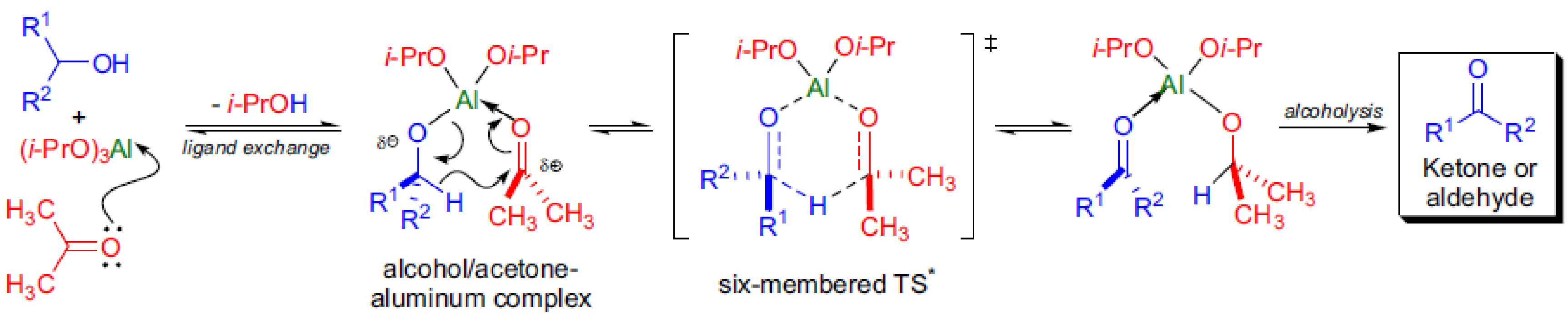
R^1 = alkyl, aryl, alkenyl; R^2 = H, alkyl, aryl, alkenyl



R^1 = alkyl, aryl, alkenyl; R^2 = H, alkyl, aryl, alkenyl

Mechanisms


work-up
carbonyl compound-aluminum complex
six-membered TS*
1° or 2° Alcohol


- i-PrOH
ligand exchange
alcoholysis
alcohol/acetone-aluminum complex
six-membered TS*
Ketone or aldehyde

Common features

- Totally reversible, the equilibrium can be moved according to Le Chatelier's principle;
- Mild condition and excellent chemoseletivity;
- Addition of protic acids dramatically increases the rate of reaction;
- Side reactions: Aldol condensation of aldehyde with an α-hydrogen atom, but not common in ketones; Tishchenko reaction of aldehyde with no α-hydrogen atom which can be suppressed by using anhydrous solvents; migration of the double bond (α,β-unsaturated ketones and allylic and homoallylic alcohol); dehydration of alcohol especially at high temperature.

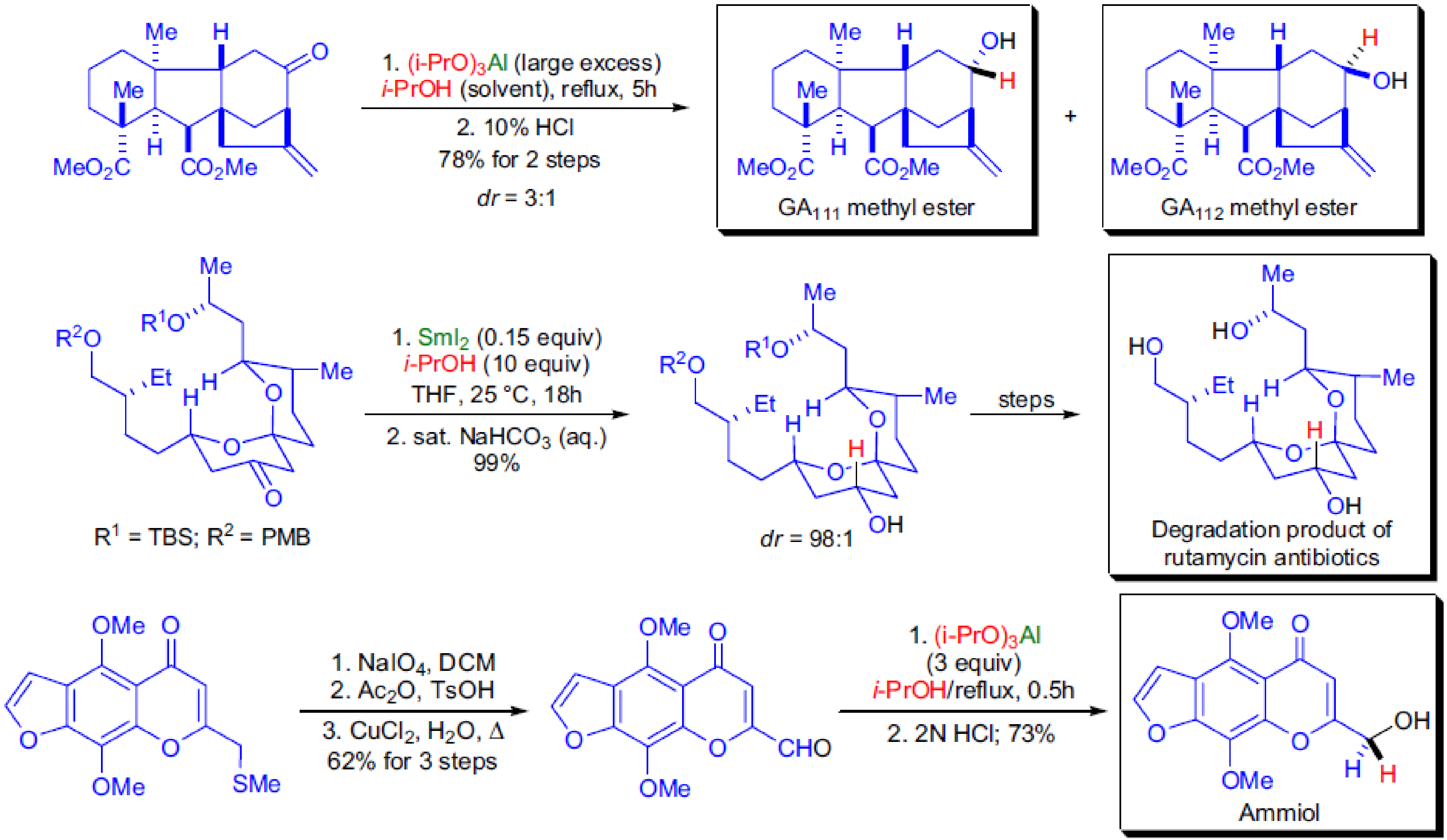
For reduction

- Aluminum alkoxides (stoichiometrically) are the most popular, and Ln(III) alkoxides (e.g., Sm(O*t*-Bu)I_2) can be applied in catalytic amounts;
- Aldehydes react faster than ketones and the method is sensitive to steric hindrance;
- β-diketones or β-keto esters cannot be reduced due to the formation of stable β-enolate chelate complexes with metal alkoxides;
- To increase the rate of reduction for slow reactions, the alcohol solvents may be mixed with higher boiling solvents (e.g., toluene, xylene) or multiple equivalents of aluminum alkoxide should be applied.

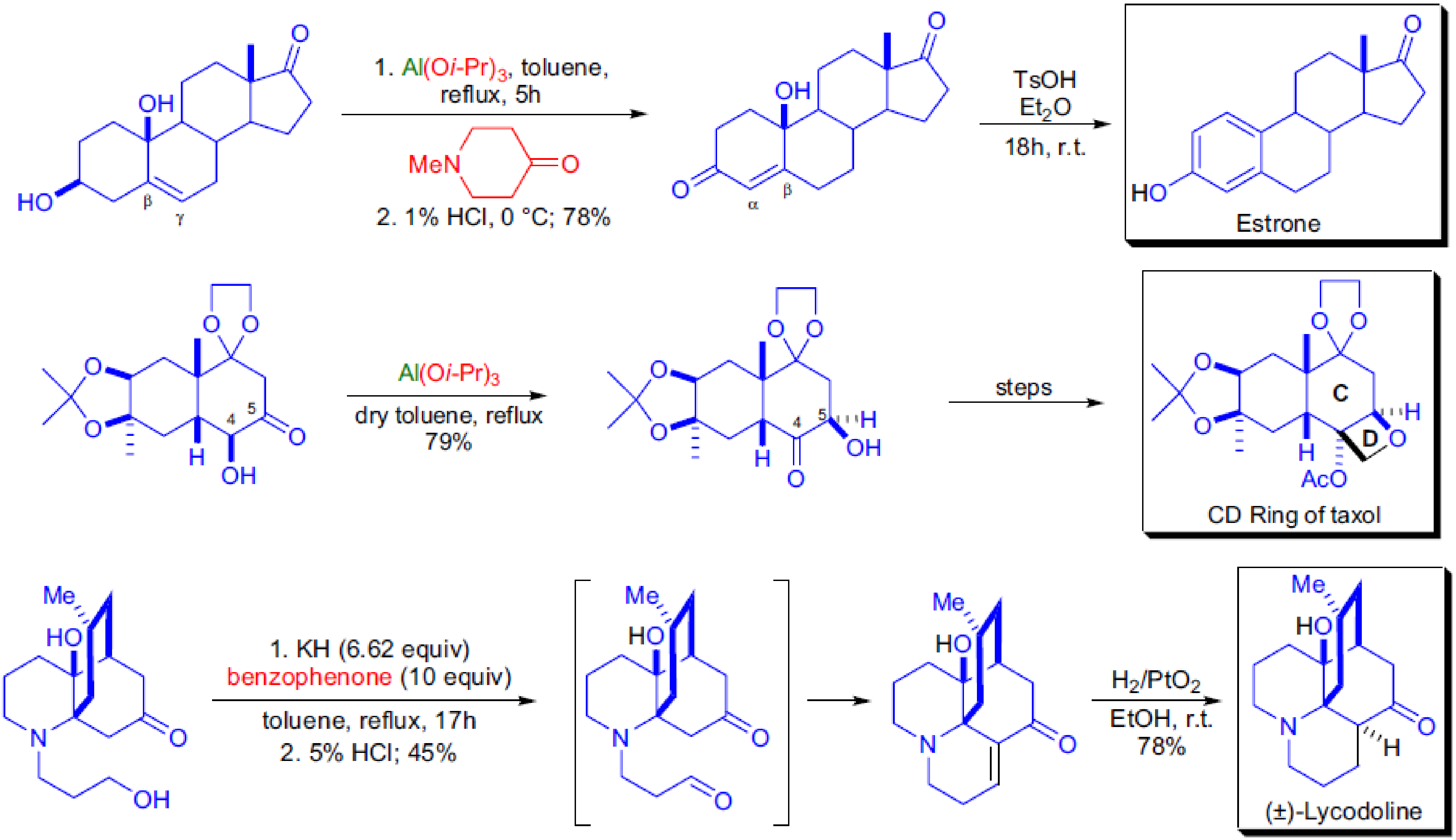
For oxidation

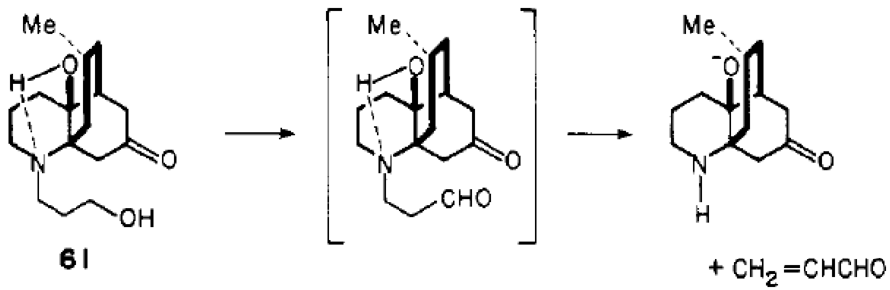
- If the substrate contains basic nitrogen atoms, the use of alkali metal alkoxides is necessary in place of aluminum alkoxides;
- Aluminum isopropoxide, t-butoxide, and phenoxide are used most commonly;
- Secondary alcohols are oxidized much faster than primary alcohols, so complete chemoselectivity can be achieved (this feature makes the Oppenauer oxidation unique compared to other oxidations);
- Overoxidation of aldehydes to carboxylic acids never happens, but the oxidation of 1,4- and 1,5-diols usually yields lactones;
- Acetone is used most often as the oxidant, but aromatic and aliphatic aldehydes are suitable as oxidants due to their low reduction potentials.

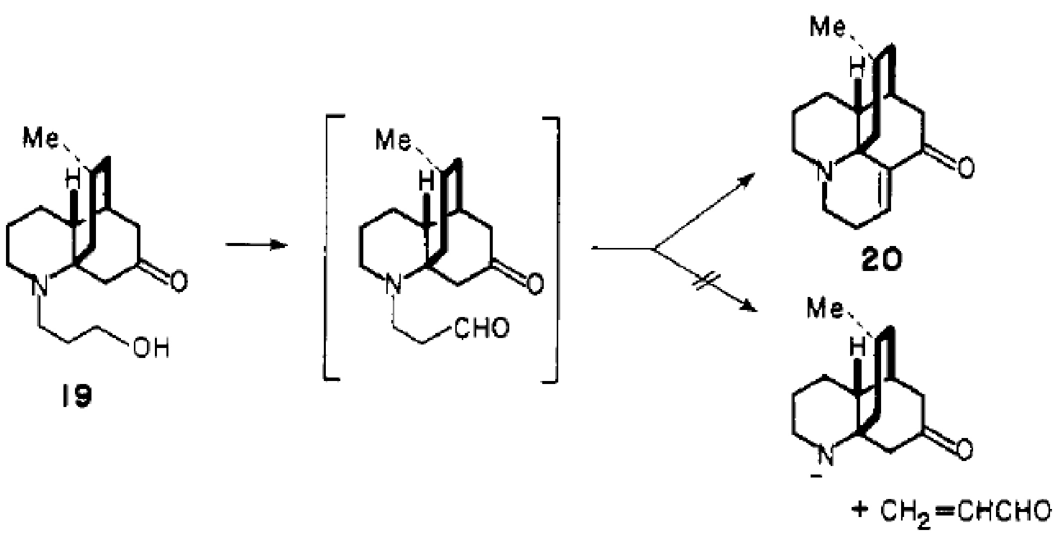
Synthetic applications



Synthetic applications




Me
H
O
N
O
OH
61
Me
H
O
N
O
CHO
Me
O
N
H
O
+ CH2=CHCHO


Me
H
N
O
OH
19
Me
H
N
O
CHO
Me
H
N
O
20
Me
H
N
O
+ CH2=CHCHO