Preparation of Alcohols

Alcohols can be formed from many, many different sources. More than 7 different functional groups can be converted to an alcohol.

Legend:
A: Substitution only. Hydroxide nucleophile; difficult reaction because of competing elimination (E2). See Carey Chpt. 8.

B: Hydration can go in two ways to give different regioselectivities. Oxymercuration-demercuration gives Markovnikov product, hydroboration/oxidation gives opposite. Generally clean and high-yielding. Carey 6.10-11. Diols (“vicinal” diols) also can be formed by two complementary sequences. Hydroxylation (KMnO₄ or OsO₄ with reductive cleavage) yields vicinal diols with syn addition (Carey 15.5). Epoxidation followed by cleavage (peracid, then acid or basic cleavage) yields anti- or trans addition.

C: Benzyl ethers can be cleaved by hydrogenolysis (H₂/Pt or Pd) to give the alcohol.

D: Addition of hydride reagents (LiAlH₄, or NaBH₄) or organometallic reagents (RMgBr or R-Li) yield alcohols. The process converts the carbonyl carbon to a carbinol carbon (1° from reduction of aldehyde; 2° from reduction of ketone or alkylation of aldehyde; 3° from alkylation of ketone). Carey 15.2.

E: Addition of hydride reagents (LiAlH₄, or NaBH₄) or organometallic reagents (RMgBr or R-Li) yield alcohols. Attack of the nucleophile is usually on the less hindered carbon, and trans geometry usually is seen. Carey 15.4.


G: Alcohols are formed by the use of hydride reagents: LiAlH₄, BH₃. NaBH₄ doesn't work (not reactive enough), even though BH₃ does. Go figure. Carey Table 15.3.

H: Two ways to do this, depending on which part of the ester should yield the alcohol. First, simple hydrolysis of an ester gives an alcohol and an acid. Second, reduction of an ester gives two alcohol products. Often, with simple esters, one of the alcohols is small, water soluble or volatile, and can be separated easily from the other (Carey Table 15.3):
Hydration of Alkenes

\[
\begin{align*}
\text{Hg(OAc)}_2 & \quad \text{H}_{2}\text{O} & \quad \text{NaBH}_4 & \quad \text{H}_2\text{O} \\
\end{align*}
\]

Hydroxylation of Alkenes

\[
\begin{align*}
\text{OsO}_4 & \quad \text{Pyridine} & \quad \text{NaHSO}_3 & \quad \text{H}_2\text{O} \\
\end{align*}
\]

Reduction of Carbonyl Compounds

<table>
<thead>
<tr>
<th>Aldehydes</th>
<th>Ketones</th>
<th>Esters</th>
<th>Carboxylic Acids</th>
</tr>
</thead>
</table>
| \[
\begin{align*}
\text{H}_3\text{C} & \quad \text{CH}\quad \text{H}_2\text{C} & \quad \text{H}_2\text{CO} \\
\text{H}_3\text{C} & \quad \text{CH}\quad \text{H}_2\text{C} & \quad \text{H}_2\text{CO} \\
\end{align*}
\] | \[
\begin{align*}
\text{H}_3\text{C} & \quad \text{CH}\quad \text{H}_2\text{C} & \quad \text{H}_2\text{CO} \\
\text{H}_3\text{C} & \quad \text{CH}\quad \text{H}_2\text{C} & \quad \text{H}_2\text{CO} \\
\end{align*}
\] | \[
\begin{align*}
\text{H}_3\text{C} & \quad \text{CH}\quad \text{H}_2\text{C} & \quad \text{H}_2\text{CO} \\
\text{H}_3\text{C} & \quad \text{CH}\quad \text{H}_2\text{C} & \quad \text{H}_2\text{CO} \\
\end{align*}
\] | \[
\begin{align*}
\text{H}_3\text{C} & \quad \text{CH}\quad \text{H}_2\text{C} & \quad \text{H}_2\text{CO} \\
\text{H}_3\text{C} & \quad \text{CH}\quad \text{H}_2\text{C} & \quad \text{H}_2\text{CO} \\
\end{align*}
\] |