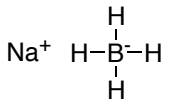
## Experiment 4: $NaBH_4$ Reduction of an Unknown Aromatic Ketone

[See: Ege's book, Section 14.4, pp 545-549]

Two commonly used hydride-based reducing agents:

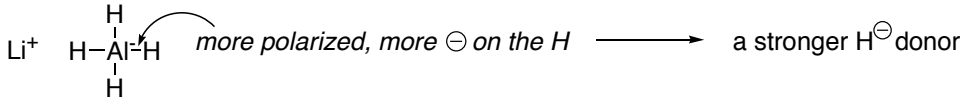
1. Sodium borohydride ($NaBH_4$)



- mild reducing agent
- relatively stable reagent (against moisture, air)

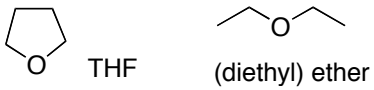
electronegativity values:
H 2.1; B 2.0; Al 1.5
|Δe.n.| for B-H: 0.1
|Δe.n.| for Al-H: 0.6

2. Lithium aluminum hydride ($LiAlH_4$)




In addition, the size differences between B and H and Al and H should make the dissociation of H- more effective for the Al-H bond.

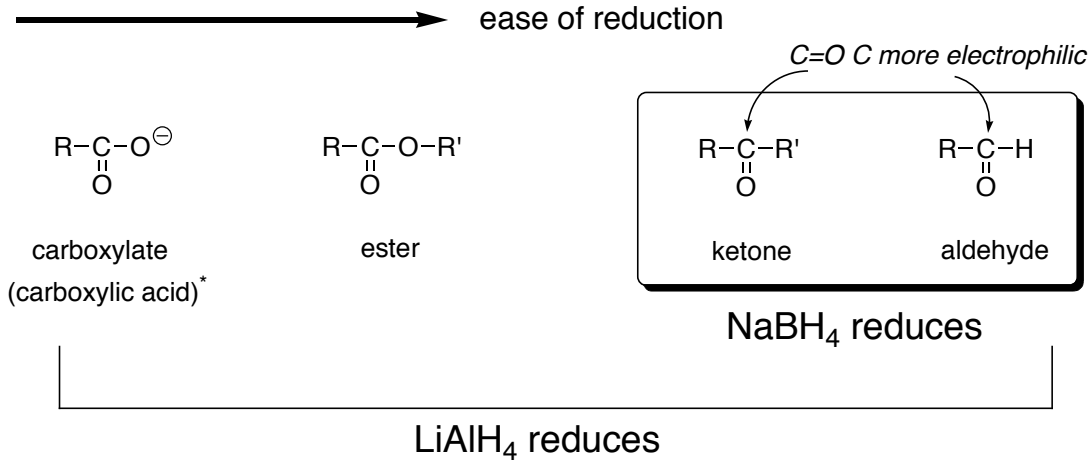
- powerful reducing agent
- reacts *violently* with water, ROH to produce $H_2$ gas
- Reactions with LiAhH are usually carried out in a polar aprotic solvent such as anhydrous tatrahydrofuran (THF) and anhydrous (diethyl) ether ($CH_3CH_2OCH_2CH_3$)

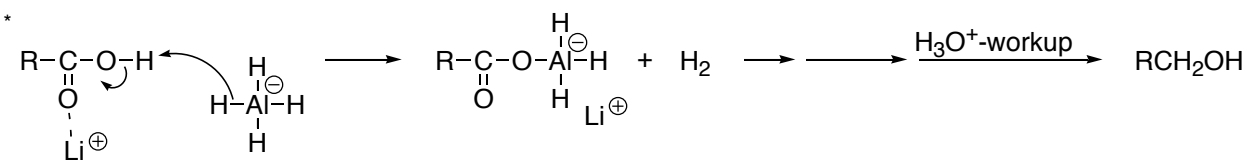



In addition, the difference in the coordination power of $Na^+$ and $Li^+$ (stronger) on the carbonyl oxygen further contributes to make the reactivity of $LiAlH_4$ stronger.

*Reduction with $LiAlH_4$ requires an aqueous (usually acidic) workup.*

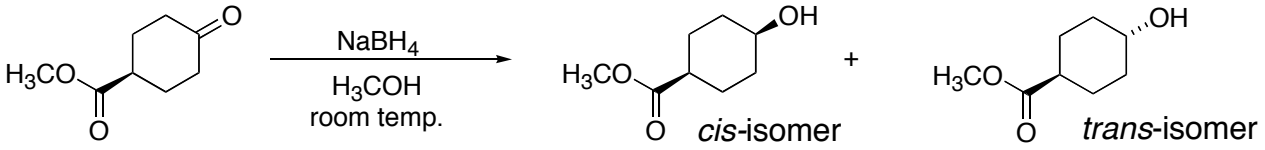
## Carboxylates/esters vs ketones/aldehydes



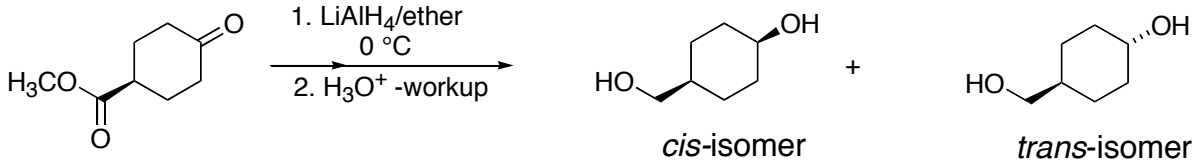



$NaBH_4$ reduces ketone and aldehyde carbonyls to their corresponding alcohols
and reduces ester/lactone carbonyls *extremely slowly* at room temperatures
Therefore, selective reduction of a ketone/aldehyde in the presence of an ester/lactone group in the same molecule is generally attainable.

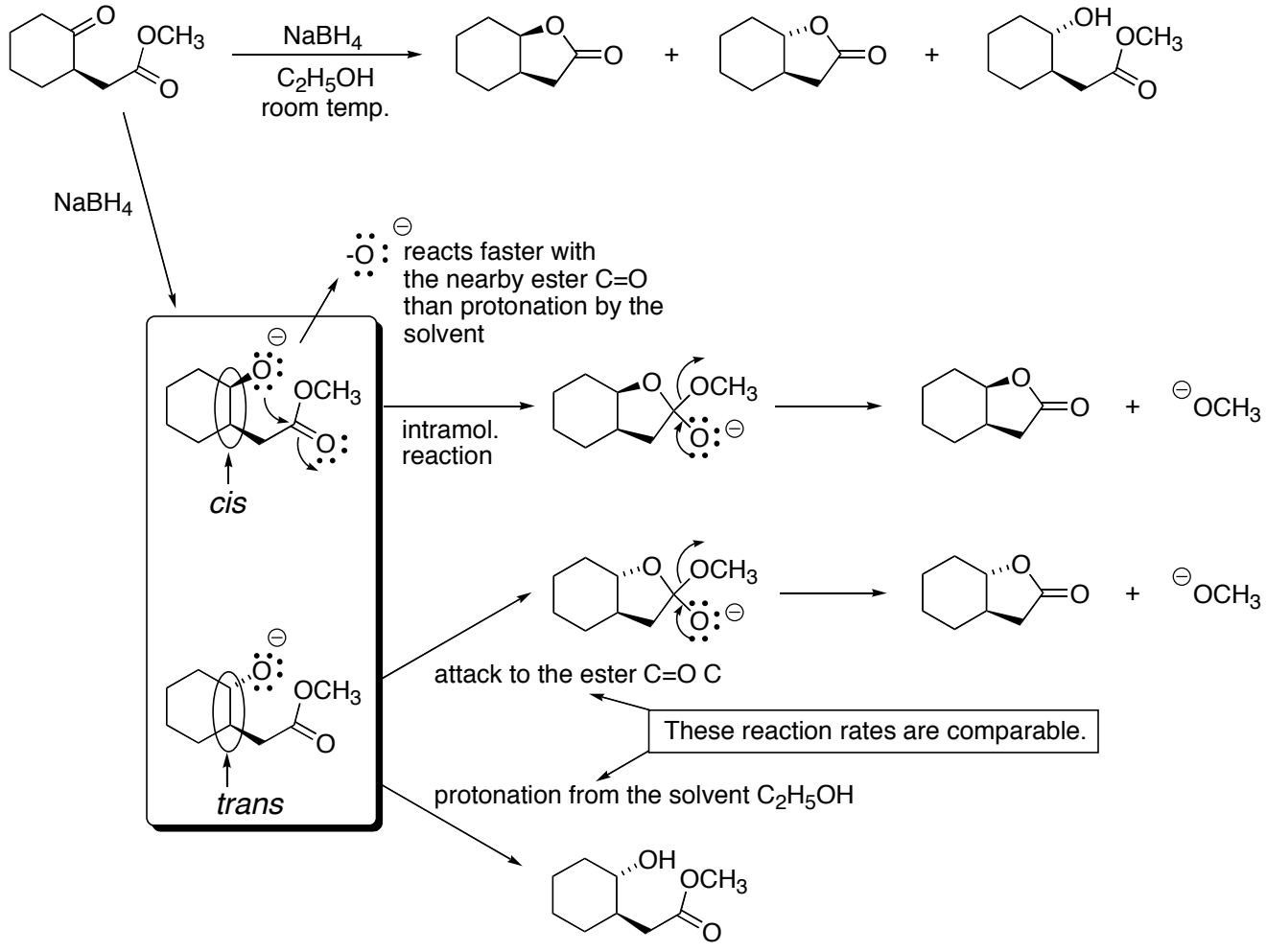
For example, with $NaBH_4$:



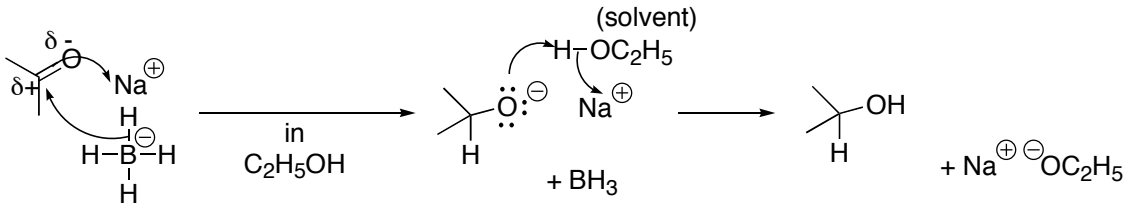

In contrast, with $LiAlH_4$:




An intramolecular reaction involving a ketone/aldehyde C=O and an ester C=O during $NaBH_4$ reduction reaction is often observed:



Mechanism of $NaBH_4$ reduction [see: Ege's, p. 546].




$BH_3$ becomes $B(OC_2H_5)_3$ by reacting with ethanol, then, when heated with water, becomes $B(OH)_3$.

The mechanism of the $NaBH_4$ reduction in a protic solvent such as ethanol, methanol, and water is known to be quite complex since $NaBH_4$ reacts with the solvent,

e.g., $NaBH_4 + C_2H_5OH \rightarrow NaBH_3(OC_2H_5) + H_2$

Because of this, usually *at least* one **mol.** equivalents of $NaBH_4$ are used for the reaction in a protic solvent. What makes the kinetics of the reaction more complicated is the fact that these solvent reacted reagents such as $NaBH_3(OC_2H_5)$ and $NaBH_2(OC_2H_5)_2$ reduce ketones/aldehydes much faster than the original $NaBH_4$ does.

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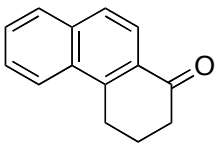
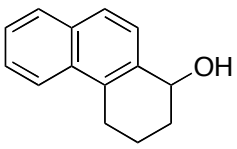
Pre-lab Experiments: In Experiment 4, you need to go through a few pre-lab experiments (see p. 10 of the lab manual) on your unknown aromatic ketone. After narrowing down to one or two possibilities for the structure of your unknown aromatic ketone, obtain the information on the mp/bp and IR of your expected *REDUCTION* product(s) (i.e., an alcohol, *not* your starting ketone) through the use of Reaxys [https://www.reaxys.com/reaxys/secured/start.do;jsessionid=8DEDFF0EA14EB7ABC856F12631DBD642]. The web address of the URL user guide of the Reaxys written by Dr. Ye Li is: http://guides.lib.umich.edu/chem216

If your unknown ketone is likely to be




Draw the structure of its reduction product on the "structure editor" screen of the Reaxys program.




The information you need to obtain is: bp or mp (the solvent used for recrystallization) and where to find the IR data or spectrum of the reduction product. Please note that the Reaxys program does not show you any IR data/spectra. It only gives you references to find such information.