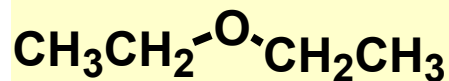


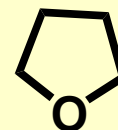
# **GRIGNARD REAGENTS**

ALKYLMAGNESIUM HALIDES, R-Mg-X, ARE KNOWN AS **GRIGNARD REAGENTS**.

GRIGNARD REAGENTS ARE PREPARED BY REACTING ALKYL HALIDES WITH EXCESS MAGNESIUM METAL IN DRY ALCOHOL-FREE DIETHYL ETHER OR TETRAHYDROFURAN (THF). DIETHYL ETHER AND THF ARE SOLVENTS.



diethyl ether



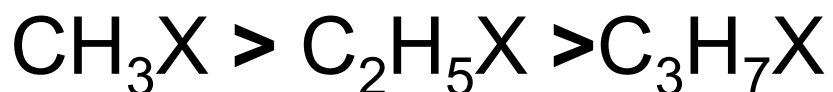
tetrahydrofuran  
(THF), a cyclic ether

# GRIGNARD REAGENTS

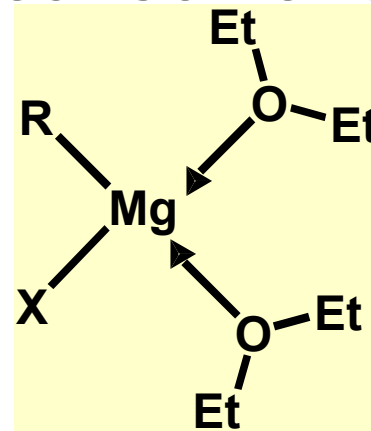
## PREPARATION



Ease of formation follows the trends shown below



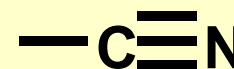
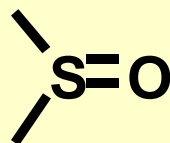
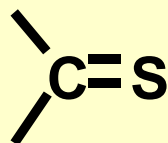
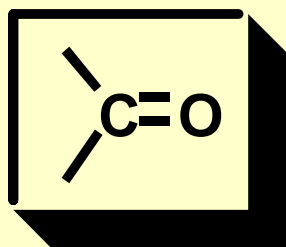
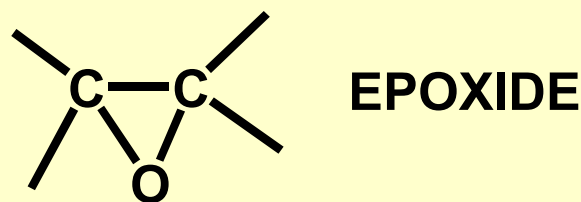
Grignard reagents are usually closely associated with two molecules of the ethereal solvent in which they have been prepared.



# REACTIONS OF GRIGNARD REAGENTS

Most reactions of Grignard reagents fall into one of two categories.

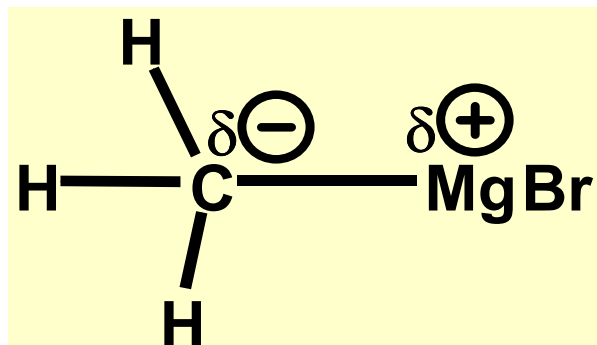
1. Reactions with compounds containing active hydrogen, e.g.  $\text{H}_2\text{O}$ ,  $\text{ROH}$ .
2. Addition to epoxides and to multiply bonded groups.



# REACTIONS OF GRIGNARD REAGENTS

1. Reactions with compounds containing active hydrogen, e.g.  $\text{H}_2\text{O}$ ,  $\text{ROH}$ .

The Mg-C bond in a Grignard reagent, e.g. methylmagnesium bromide, is polarized as shown.



The carbon attached to Mg bears a partial negative charge. This carbon is **NUCLEOPHILIC**, and is subject to attack by electrophiles.

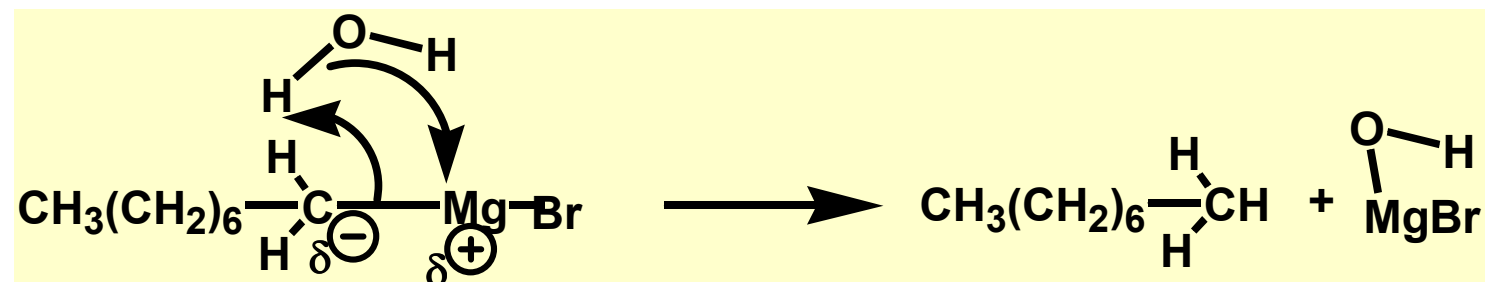
An **ELECTROPHILE** is a chemical species which seeks electrons.

# REACTIONS OF GRIGNARD REAGENTS

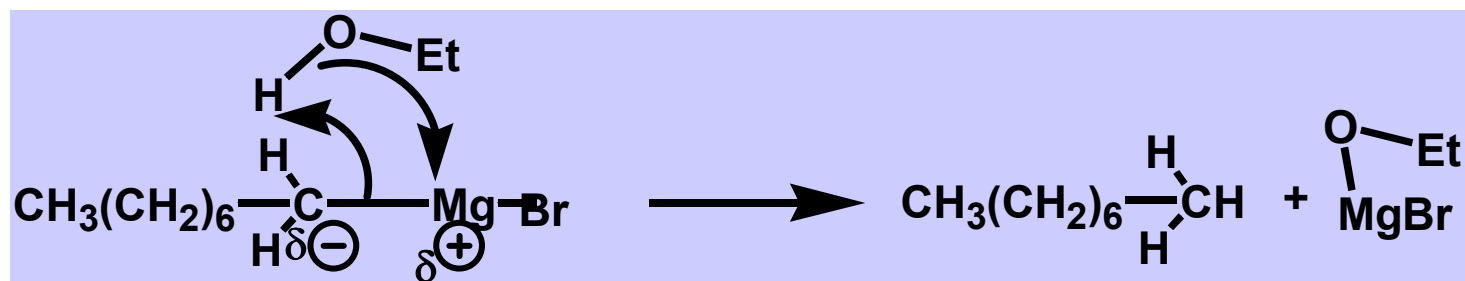
## 1. Reactions with compounds containing active H, e.g. H<sub>2</sub>O, ROH.

The carbon bonded to Mg in Grignard reagents is nucleophilic. The hydrogens on the O-H groups in H<sub>2</sub>O and alcohols (ROH) are effective **ELECTROPHILES**.

*n*-octylmagnesium bromide + H<sub>2</sub>O:



A similar reaction occurs with alcohols, e.g. ethanol:



What would the reaction be with D<sub>2</sub>O?

# REACTIONS OF GRIGNARD REAGENTS

## 2. Addition to epoxides and to carbonyl groups (aldehydes, ketones, esters, CO<sub>2</sub>).

### Experimental procedure

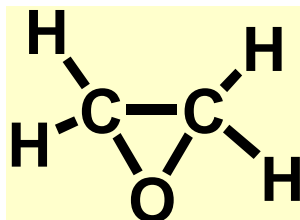
- (i) A solution of the epoxide/aldehyde/ketone/ester in anhydrous Et<sub>2</sub>O or THF is added to the Grignard reagent in Et<sub>2</sub>O or THF.
- (ii) After a short time, dilute acid or aqueous NH<sub>4</sub>Cl (a proton source) is added to the reaction mixture. The product of the reaction is then isolated.

# REACTIONS OF GRIGNARD REAGENTS

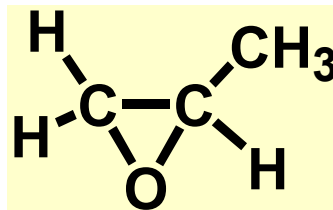
## 2. (a) Addition to epoxides.

**Epoxides**, also known as oxiranes, are three-membered cyclic compounds. The ring consists of two carbon atoms and one oxygen atom. The simplest epoxide is

**ethylene oxide.**



The carbons of the ring can bear substituents other than hydrogen, e.g.

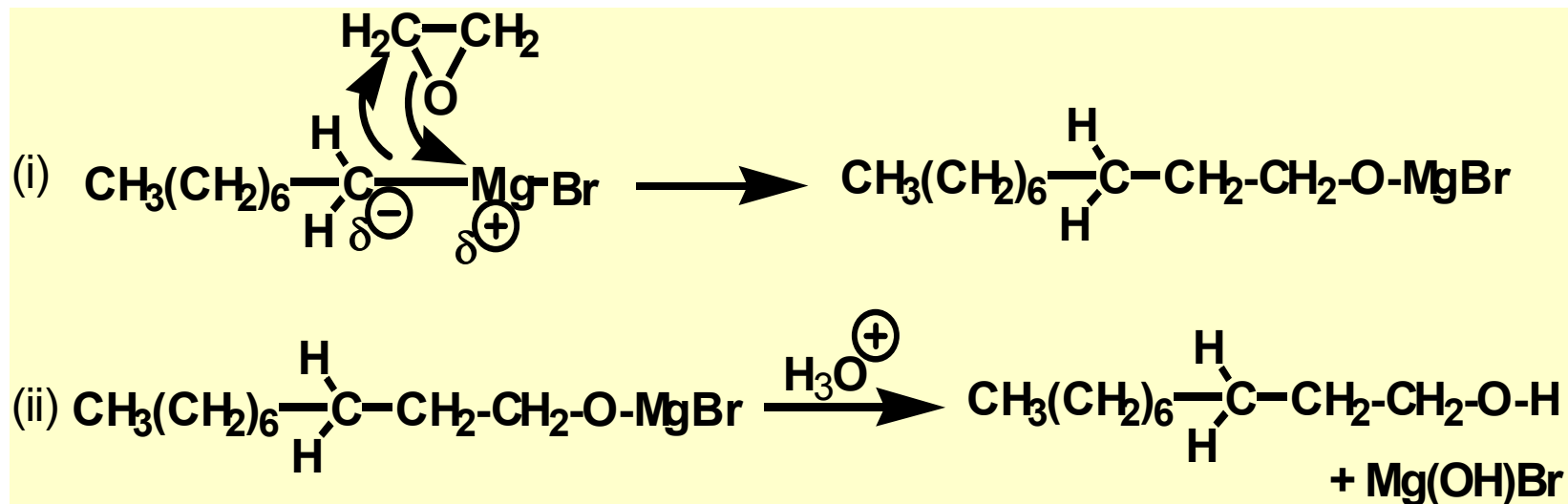


The three-membered ring is highly strained, as the angles between the oxygen and carbon atoms are significantly less than the tetrahedral angle of  $\sim 109^\circ$ . Epoxides therefore open readily, and are quite reactive.

# REACTIONS OF GRIGNARD REAGENTS

## 2. (a) Addition to epoxides

*n*-octylmagnesium bromide + ethylene oxide



The product is a 1° alcohol. The carbon chain of the alcohol is two carbons longer than the carbon chain of the alkyl group in the Grignard reagent.

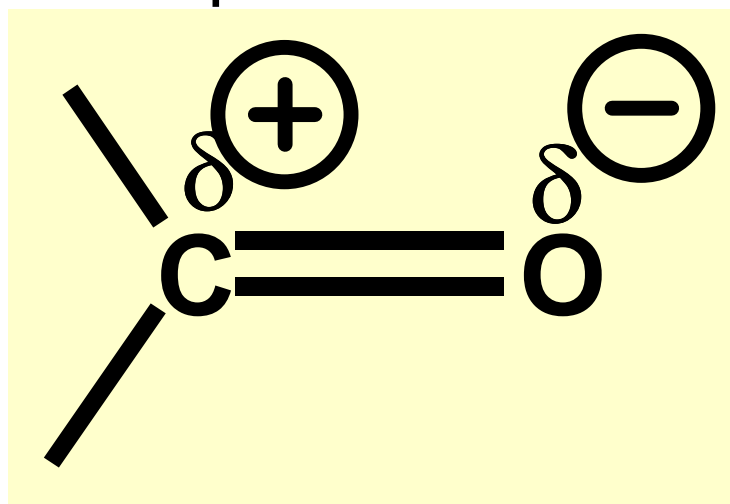
***Grignard reagents react with epoxides → 1° alcohols, with 2 carbon homologation.***



# REACTIONS OF GRIGNARD REAGENTS

## 2. Addition to carbonyl compounds

The difference in electronegativity between oxygen and carbon causes the carbon-oxygen bond of carbonyl groups to be polarized as shown.



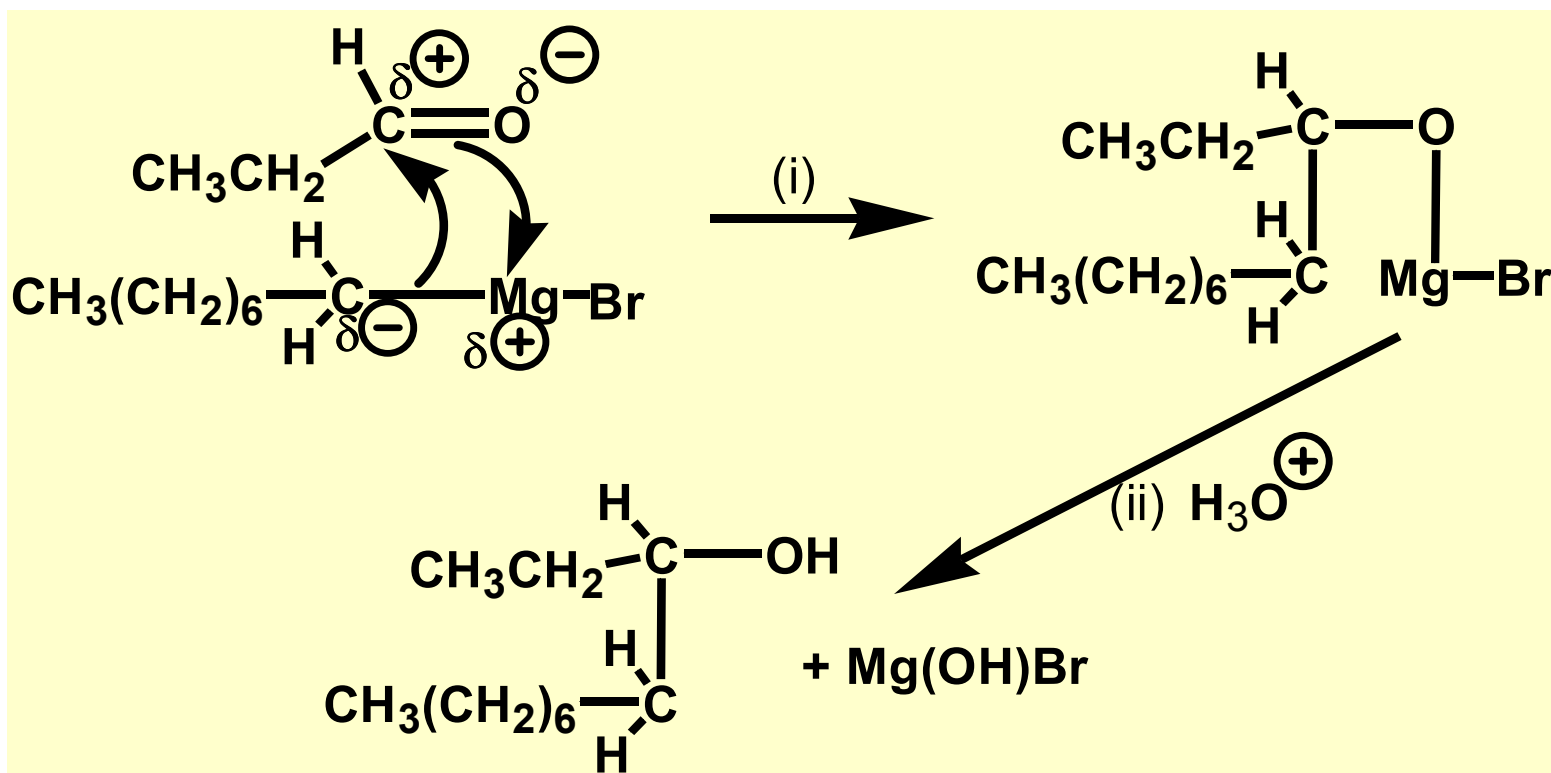
The carbon atoms of carbonyl groups are **ELECTROPHILIC**, and will be attacked by the nucleophilic carbons of Grignard reagents.

# REACTIONS OF GRIGNARD REAGENTS

## 2. Addition to carbonyl compounds

**ALDEHYDES** react with Grignard reagents to yield 2° alcohols. An example of this reaction is shown.

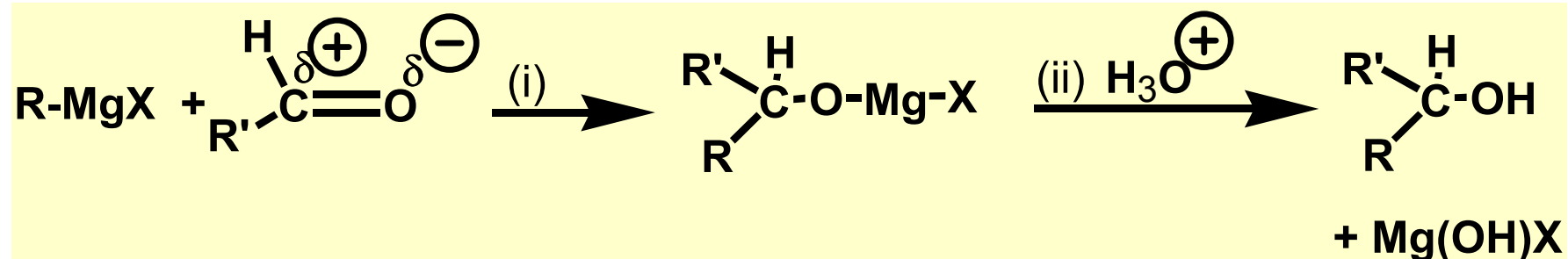
*n*-octylmagnesium bromide + propanal



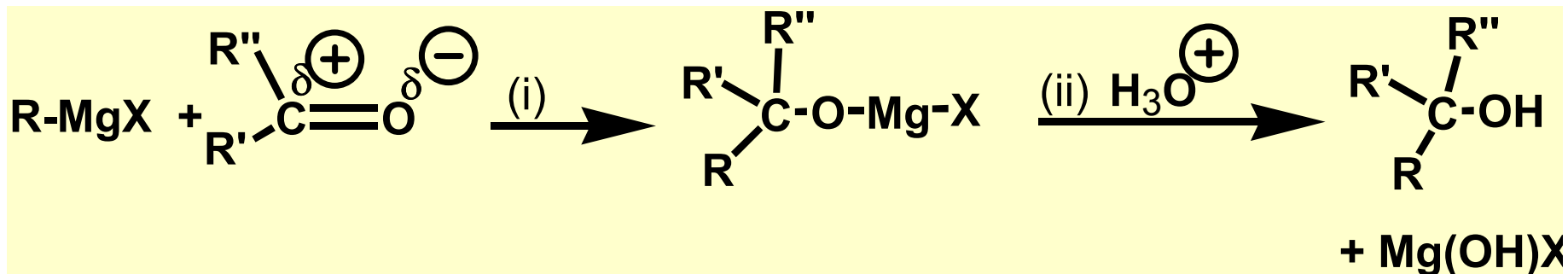
# REACTIONS OF GRIGNARD REAGENTS

## 2. Addition to carbonyl compounds

**ALDEHYDES** react with Grignard reagents to yield 2° alcohols. The general reaction is:



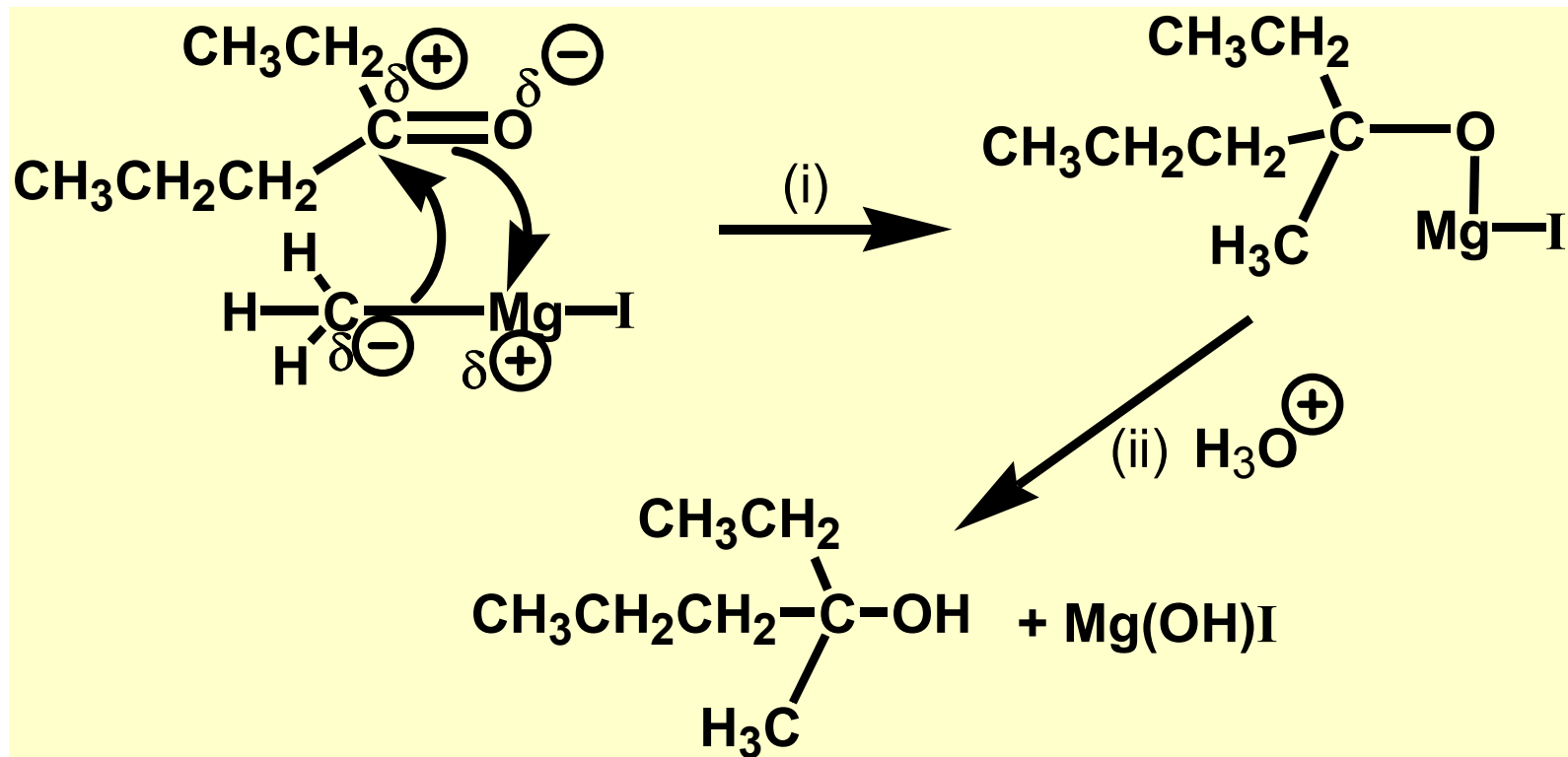
**KETONES** add to Grignard reagents to produce 3° alcohols. The general reaction is shown.



# REACTIONS OF GRIGNARD REAGENTS

## 2. Addition to carbonyl compounds

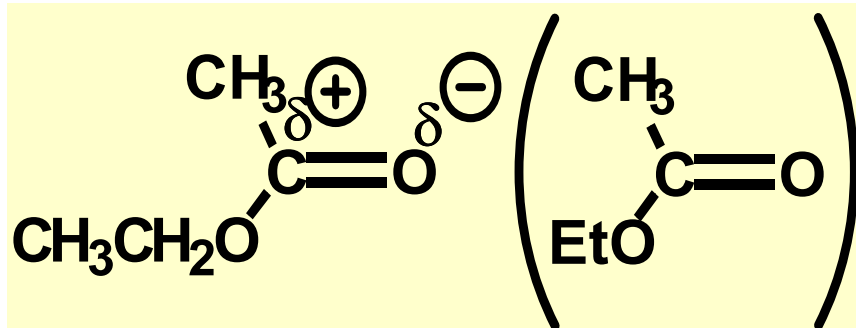
An example of the reaction between ketones and Grignard reagents is the addition of methylmagnesium bromide to 3-hexanone.



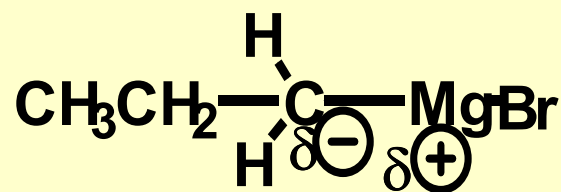
# REACTIONS OF GRIGNARD REAGENTS

## 2. Addition to carbonyl compounds – esters

The addition of Grignard reagents to esters is illustrated by the reaction between ethyl acetate and *n*-propylmagnesium bromide.



ethyl acetate

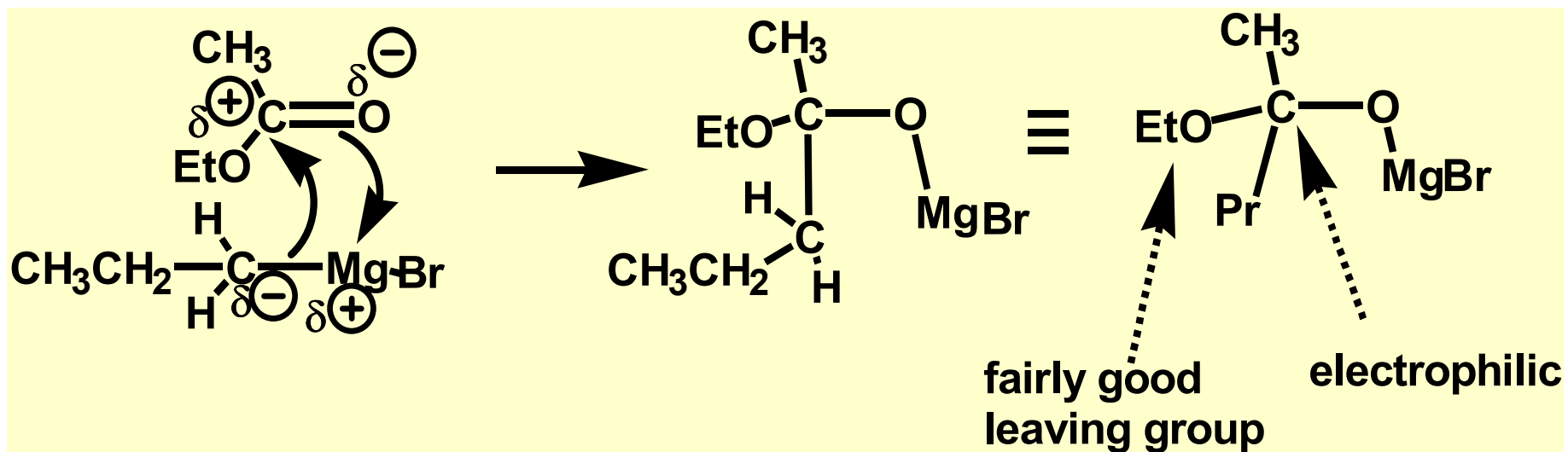


*n*-propylmagnesium bromide

# REACTIONS OF GRIGNARD REAGENTS

## 2. Addition to carbonyl compounds – esters

ethyl acetate + *n*-propylmagnesium bromide



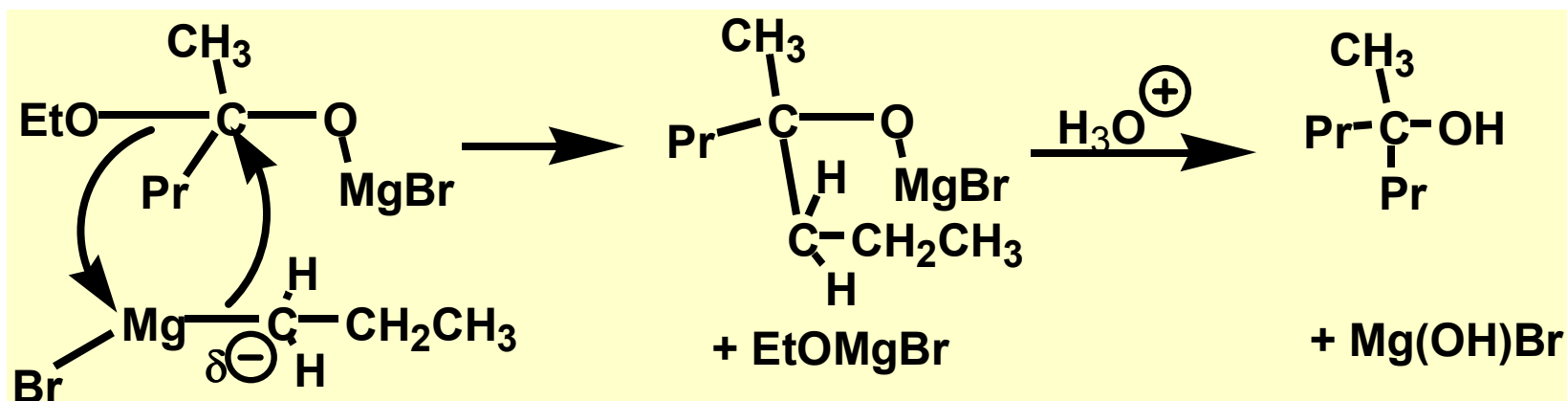
# REACTIONS OF GRIGNARD REAGENTS

## 2. Addition to carbonyl compounds – esters

ethyl acetate + *n*-propylmagnesium bromide

The initially formed adduct reacts with a second equivalent of the Grignard reagent. After workup a 3° alcohol is obtained.

Two of the alkyl groups on the 3° alcohol are identical, and originate from the Grignard reagent.

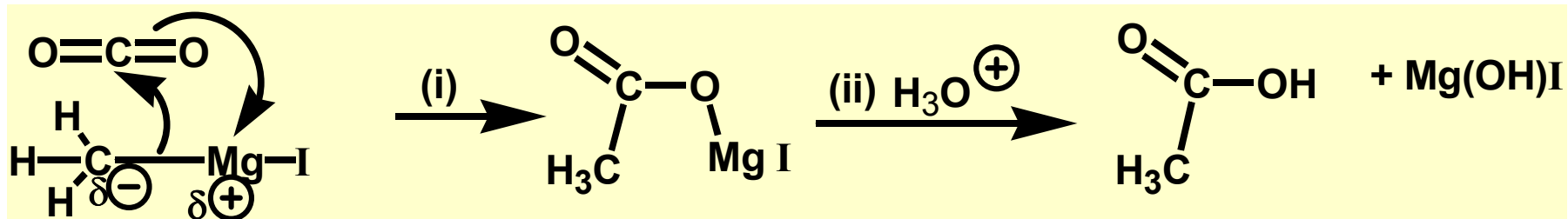


# REACTIONS OF GRIGNARD REAGENTS

## 2. Addition to carbonyl compounds

### carbon dioxide (dry ice or CO<sub>2</sub> gas)

The addition of methylmagnesium iodide to CO<sub>2</sub> is illustrative. The product is a carboxylic acid.



The general reaction is:

