Notes on the Grignard Reaction

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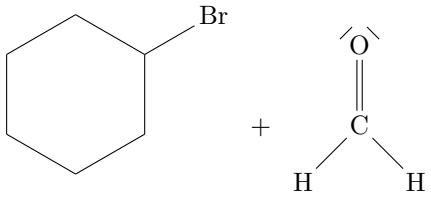
1 Introduction

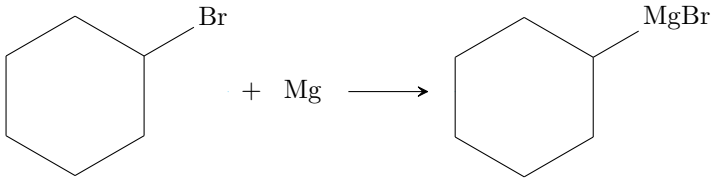
The Grignard reaction proceeds in two parts: the formation of the reactant, which is relatively simple, and the reaction itself, which is relatively complicated. The Grignard reactant is a hydrocarbon with magnesium and a halogen (which we'll assume is bromine from now on). Note that the bromine is much more electronegative than the magnesium (and the rest of the molecule), so the bromine will be electron-rich. The Grignard reactant will react with a carbonyl compound. In a carbonyl group, the oxygen is more electronegative than the carbon, so the carbon takes on a partial positive charge and will be attracted to the bromine (in organic chemistry, we would call the carbon *electrophilic*). That's the driving force for the reaction. The end result is that the carbonyl compound displaces the magnesium and bromine, and water donates a proton, turning the double-bonded oxygen into an alcohol group.

In the following, I'll use the example from the lecture, starting with bromocyclohexane and formaldehyde (shown below). Keep in mind that any Grignard reactant and any carbonyl compound will work.



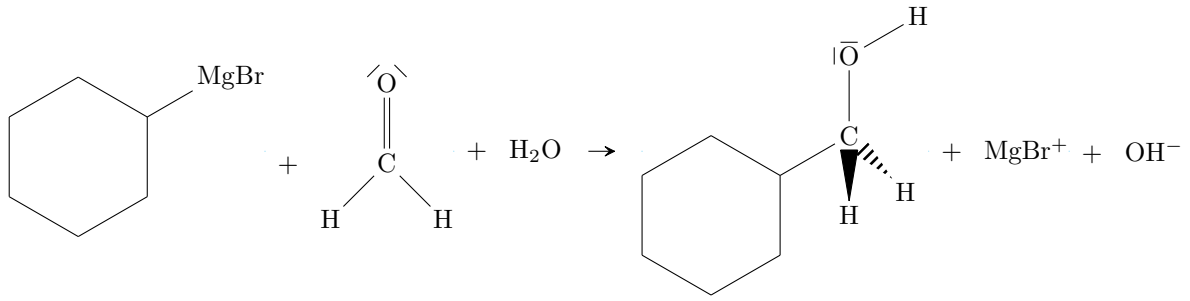
2 Preparation of the Reactant

This is the easy part: we start with the bromine-containing compound, and add in the magnesium.

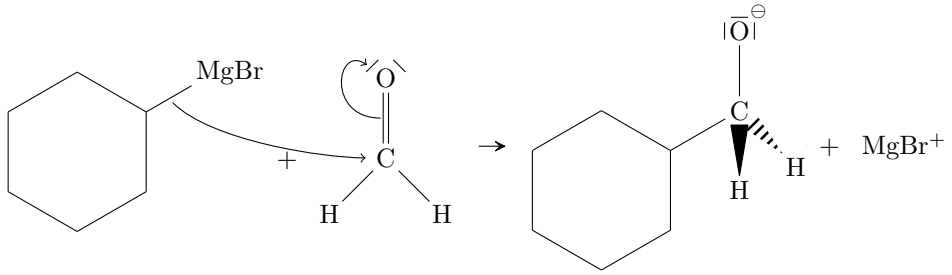


3 Grignard Reaction

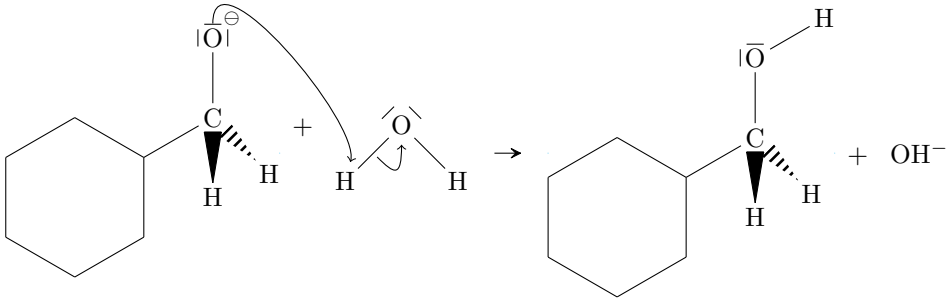
Now for the hard part: the carbonyl displaces the magnesium halide and becomes an alcohol group. Here's the overall reaction:



The mechanism isn't terribly complicated. First, the bond between magnesium and the rest of the Grignard reactant has to attack the carbonyl compound, in what resembles a single replacement reaction:



Next, one of the three lone pairs on the oxygen with a -1 formal charge will attack the bond between hydrogen and oxygen in water, completing the reaction:



It is simple to verify that these two intermediate steps are together equivalent to the overall reaction above.