

6. Grignard Reaction

M. Jones: Grignard reagent, 6.3, pgs 236-238
 Grignard reaction, 16.12-16.13, pgs 859-866, Figures 16.71 and 16.72

This procedure has been adapted from the microscale procedure described in the third edition of *Macroscale and Microscale Organic Experiments* by Kenneth L. Williamson (Houghton Mifflin, Boston, 1999).

Introduction

In this experiment, you will prepare a Grignard reagent and then use it as a nucleophile to add to the carbonyl group of benzophenone.

Background

Grignard Reagent. The first thing to do is to define some terms and discuss the background of this reaction. In organic chemistry, one of the important reactions is one where a C-C bond is formed.

If an alkyl, benzyl, or aromatic halide is reacted with magnesium using an anhydrous solvent (for example, diethyl ether or tetrahydrofuran), then a Grignard reagent is formed. It is considered to be an organometallic reagent, a combination of a metal and organic molecule.

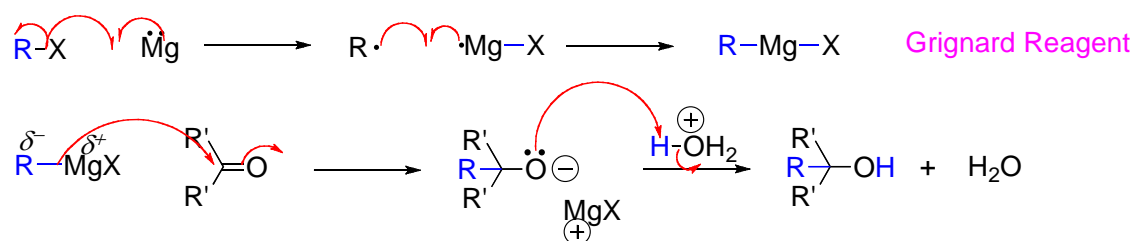


Figure 1. General reaction mechanism for the Grignard reaction.

The mechanism is depicted in Figure 1. As pictured previously, the first part of the reaction is the formation of the Grignard reagent. The first step is a free radical coupling of the Mg to the halide X leaving the alkyl radical, R[•]. Then, the alkyl radical and the Mg-X combine to form the Grignard reagent.

When a Grignard reagent is reacted with a ketone or aldehyde, the product is an alcohol. There is a dipole in the C-MgX bond toward the C making it electronegative. As seen in the resonance form, another way to look at the Grignard reagent is to consider it as a carbanion. Then, it acts like a nucleophile

and adds to the carbonyl carbon forming an alkoxide. In the workup of the reaction, an acid is added so that the alkoxide is protonated to form the alcohol product. See Figure 2 for the general reaction.

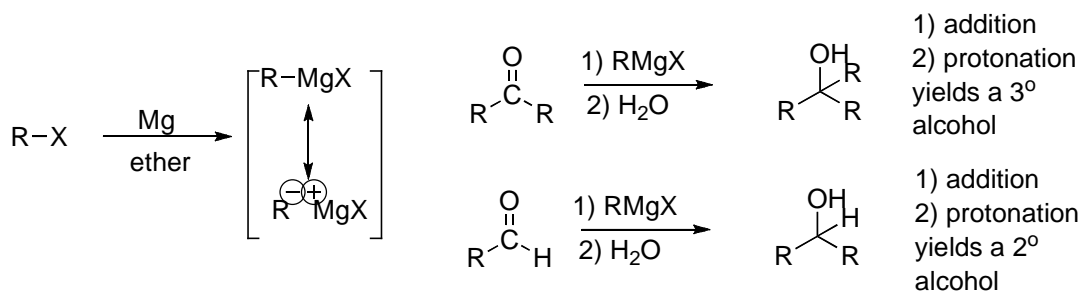


Figure 1. General reaction for the Grignard reaction.

In this experiment, you will be performing a Grignard reaction (see Figure 3). You will first synthesize the Grignard reagent starting from bromobenzene and magnesium using ether as the solvent. The reaction and thus the reagent are moisture sensitive so you will be using anhydrous ether. In the second step, you will be adding your Grignard reagent to benzophenone to form triphenylmethanol.

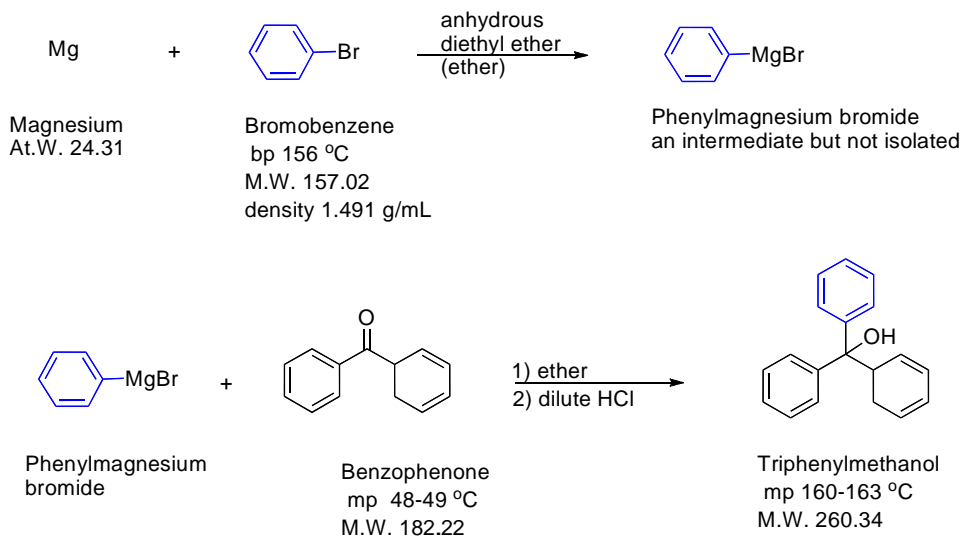


Figure 3. The overall reaction of this experiment.

Experiment

There are three parts to the experiment. Make sure to read and follow the warnings listed in the procedure. The preparation of the Grignard reagent and reaction are exothermic. Before proceeding, make sure all glassware is clean and completely **DRY** (no noticeable water droplets)!

Grignard Reagent Preparation

Add 230 mg of magnesium turnings and 5 mL anhydrous diethyl ether to a large reaction tube. Add 1 mL of bromobenzene to the tube and then have your TA add one iodine crystal. Shake the reaction tube vigorously until the brown color starts to fade away. As the mixture becomes cloudy, look for signs of bubbling (if not, gently grind the mixture with a glass rod). Once refluxing begins, slowly add another 3 mL of bromobenzene, and cap the reaction tube with a rubber septum containing a needle through the center. Swirl the contents periodically. The reaction is completed when either the magnesium is all consumed or refluxing has ceased.

Synthesis of Triphenylmethanol

Then, slowly begin adding a solution containing 1.7 g of benzophenone dissolved in 4 mL of anhydrous diethyl ether by pipette. [**Caution: This reaction is exothermic and rapid addition of the benzophenone solution can result in the violent release of the reaction tube contents.**] Refluxing should commence after 1 mL of reagent is added. Continue to add the benzophenone at a rate to maintain a refluxing solution. Once all the benzophenone has been added, cap the tube with septum and swirl the contents for two minutes.

Reaction Workup

Cautiously vent the tube and begin adding a 50% aqueous HCl solution dropwise to the contents of the reaction tube [**Caution: This reaction is exothermic and rapid addition of the HCl solution can result in the violent release of the reaction tube contents.**]. Continue adding the HCl solution until the organic layer is clear and free of any magnesium. Remove the aqueous layer with a pipette and discard. Dry the organic layer with sodium sulfate. Pipette out the organic layer and transfer into a small Erlenmeyer flask. Evaporate the solvent down to approximately 2-3 mL on a hotplate located in the hood. Cool the contents using an ice-bath. Wash the solid with three 4 mL portions of petroleum ether, removing each colored (yellow) wash with a pipette. Additional washes may be necessary until the solid becomes white. Add 4 mL of ethanol and place on hotplate until gentle reflux occurs (swirling occasionally). Add 1-2 mL additional ethanol until any remaining solid dissolves. Remove the Erlenmeyer flask from the hotplate and allow to cool slightly before placing it into an ice bath. After crystallization is complete, vacuum filter, collect and weigh the remaining solid.