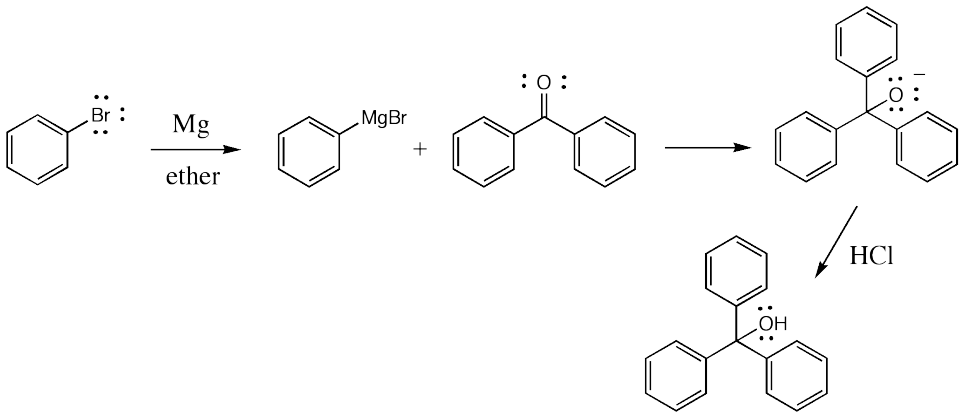
Addition of a Grignard to a Ketone

Introduction

In this experiment you will generate a Grignard reagent, react it with a ketone, then use mild aqueous acid to form a tertiary alcohol. Bromobenzene will be used to create the Grignard, and benzophenone will be the ketone, forming triphenylmethanol as the product.



Reagents	volume	density	mass	MW	mmol	eq
bromobenzene	0.220 ml					
magnesium	x	x	54 mg			
benzophenone	x	x	275 mg			
triphenylmethanol	x	x				

Melting point of triphenylmethanol _____

Extreme care must be taken to prevent the Grignard from coming in contact with moisture until it has reacted with the ketone. We will dry the reaction vessel by using a flame. We will use only anhydrous ether than has been prepared by distilling the ether over flakes of sodium metal and benzophenone, which react with any water present, then form a dark blue complex when all water (and oxygen) has been removed. However, once the reaction has been quenched with aqueous acid, using anhydrous reagents is no longer necessary.

The most difficult part of making this reaction work is getting the Grignard reagent to form, so we'll use a few tricks to increase our chances of success. First, we'll grind the magnesium using a mortar and pestle to remove the coating of magnesium oxide that may hinder the reaction. We'll also add a few drops of 1,2-dibromoethane to make the magnesium surface more reactive.

During the first step of the reaction, it is possible for the newly formed Grignard to react with the bromobenzene already present in the solution, giving biphenyl, a side product. You may see this product in the TLC as a very nonpolar spot which is rather bluish under UV light. To minimize this, we will add the bromobenzene solution slowly so that there isn't much of it around to react with the Grignard.

Procedure

Before lab:

- Please read this lab through completely to understand what you will be doing.

- Review the following techniques. We have used most of them before, but you may have forgotten some details, so please look over them again before coming to lab. Filtering a solid and taking a melting point will be new to you, so read these carefully.

    Measuring chemicals
    Extracting and Washing
    Drying an Organic Solution
    Evaporating an Organic Solution
    Water Sensitive Reactions
    Filtering a Solid from a Solution
    Taking a Melting Point
    Analyzing a Mixture by TLC

- Do all of the calculation needed to fill out the table above.

- Write an introduction in your lab notebook, making sure to include the reaction and the table.

- Answer the pre-lab questions online.

During lab:

Prepare the glassware and set up the reaction:

- Prepare a $CaCl_2$ drying tube, and attach it to the bent end of a Claisen adapter with a yellow clip. Put a septum and cap on the straight end.

- Grind up some magnesium turnings with a mortar and pestle. Weigh out the amount needed, place it in a 10 ml round bottom flask, and add a spin bar.

- Gently heat the flask over a Bunsen burner to remove all water. Attach the Claisen adapter and drying tube with a yellow clip; then allow it to cool.

Run the reaction:

- Add 0.5 ml of anhydrous ether to the flask using a syringe. Hold the syringe by the top so that the heat from your hand doesn't expand the ether vapor in the syringe and force the liquid out.

- Clamp it to the stirrer/hot plate and begin stirring. Ask the instructor for 2 drops of 1,2-dibromoethane. (Why?)

- Prepare a solution of bromobenzene in ether by adding the bromobenzene to a clean conical vial, then adding 1 ml of anhydrous ether using the same syringe as you used in the first step.

Stir the solution with the needle, then draw it up into the syringe.

- Stick the syringe through the septum. Add the solution to the magnesium dropwise over 10 minutes. A grayish or brownish solution is evidence that the Grignard has formed. You may also see tiny bubbles on the surface of the magnesium.

- Prepare a solution of benzophenone in ether by adding the benzophenone to the same conical vial (don't rinse it out!), then 1 ml of anhydrous ether with a new syringe. Stir until the crystals dissolve. Draw the solution into the syringe and stick it into the septum. Add the solution slowly over a period of 30 minutes. A pink-red color should appear, followed by a white solid. (What is falling out of solution?)

- Remove the cap and septum and add 3M HCl dropwise to protonate the alkoxide, quench any remaining Grignard, and destroy the magnesium. To determine when you've added enough, test the pH of the water layer using pH paper to see if it is acidic yet.

Isolate the product:

- Add a layer of regular, nondistilled ether. (Why is this ok now?) Transfer the reaction to a sep funnel, rinsing the flask with a little more ether. Drain off the water layer and the ether layer into two separate containers.

- Add the water layer back to the sep funnel and extract it with ether, then drain off the water layer.

- Add the original ether layer to the ether extract, and wash the combined ether layers with a few ml of water. Drain off the water wash.

- Dry the ether layer over sodium sulfate.

- Run a TLC plate comparing your crude product with both starting materials, using dichloromethane as the developing solvent. Observe whether the product is present, and whether there are any impuritites.

- Evaporate the ether layer to obtain the crude product.

Purify the product:

- Add a few ml of petroleum ether to the crude product, and stir to dissolve the nonpolar impurities.

- Pour the mixture into a beaker to make it easier to filter, rinsing with a little petroleum ether. Then filter off the product. Save the liquid to check by TLC.

Characterize the product:

- Observe the appearance of your product. Authentic triphenylmethanol is a white, crystalline solid.

- Obtain a mass of the product and calculate the % yield.

- Prepare a TLC solution of your product, and run a TLC comparing the two starting materials, your product, and the liquid you filtered off during the purification. Compare this to your earlier TLC to see whether the purification was effective.

- Obtain a melting point of your product. Compare it to the authentic value, and use the range to determine purity.

After lab:

- Finish writing up your procedure and observations.

- Write your conclusion, making sure to include the appearance of the product compared with what you should expect, the mass and % yield, interpretation of your TLC data, and the melting point, as well as what you can conclude from it.

- Print out the questions on the next page and fill them out. Turn in this sheet with the carbon copies of your lab (in 2 separate piles).

Questions for Grignard Reaction

Name: _____

1) Write out the mechanism for the reaction of the Grignard reagent with the ketone. Label the nucleophile and the electrophile. (2 pts)

2) Why does the reaction turn solid when benzophenone is added? Draw the structure of the solid compound. (2 pts)

3) Write out the reaction that would occur if you failed to completely dry the round bottom flask so that traces of moisture were present when the Grignard was formed. (1 pt)

4) Write the reactions by which the hydrochloric acid added during the work-up reacts with

a) the magnesium salt of the alkoxide (1 pt)

b) any unreacted magnesium (1 pt)

c) any unreacted Grignard (1 pt)

5) What two compounds react to give biphenyl, a side product of the reaction?

6) What have we done in this procedure to minimize the formation of biphenyl?

7) Based on the TLC of your crude product, did you have much biphenyl present?