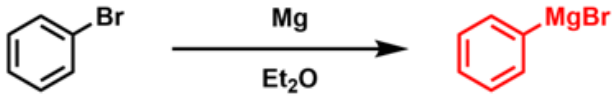
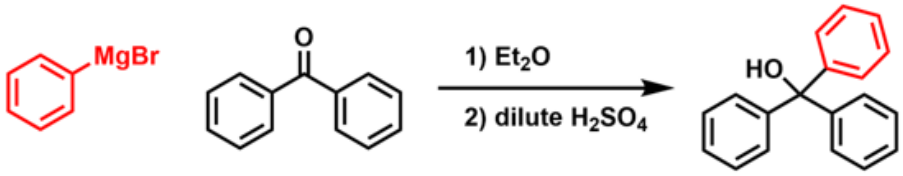
Activity 7: Grignard Reactions: Synthesis of Triphenylmethanol

The Experiment

Part 1. Grignard reagent synthesis



Part 2. Carbonyl addition reaction



Lab Activity Goal

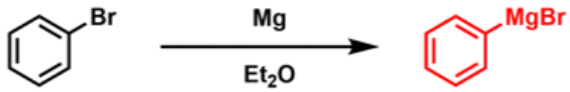
Prepare a Grignard reagent (phenyl magnesium bromide) and demonstrate its utility as a carbon nucleophile in the addition reaction to a carbonyl electrophile (benzophenone).

Pre-Laboratory Assignment

See the Activity 7 Pre-Lab Preparation and Outline document in Labflow.

Experimental Procedure

Part 1. Preparation of Phenylmagnesium Bromide (Phenyl Grignard Reagent)



All glassware must be dry!! Grignard reagents are strong bases and will be quenched (protonated) by any water that is present on the glassware or in the reagents and solvents you use. Thus, you CANNOT wash your labware on the day you perform the experiment. Hand drying is not sufficient to remove water from the inside walls of your reaction glassware.

1. Place 1.5 g of Mg metal turnings into a dry 250-mL round-bottomed flask and add a magnetic stir bar. Clamp the round bottom flask to the monkey bar over a stir plate sitting on top of a lab jack that is raised one or two inches. Begin stirring the Mg vigorously for 5-10 minutes with the glass stopper on.

    - Note: The stirring process mechanically removes the oxide coating on the magnesium turnings.

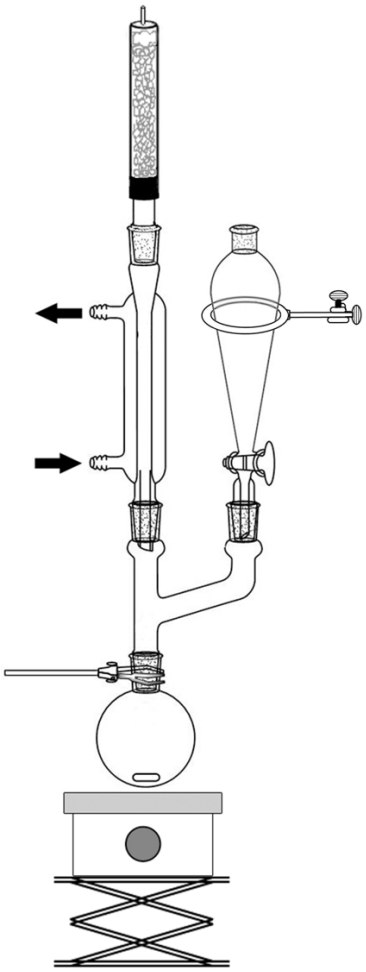
2. Prepare a drying tube: put a **loose** plug of cotton in each cap of the drying tube. Attach one of the caps to the tube and fill it with anhydrous $CaCl_2$ (**DO NOT** pack it too tightly). Attach the other cap.

    - Note: The drying tube will reduce the amount of atmospheric water that can become dissolved in the reaction mixture.

3. After dry stirring the Mg, ask your instructor to add a small iodine crystal to your reaction flask.

- Note: The addition of iodine helps to initiate the formation of the Grignard reagent.

4. Attach clear Tygon tubing to a condenser nozzle ensuring that the tubing will reach from the cup sink to the reflux assembly that you are about to build on top of your Mg turning flask. Wait to turn on the water until the full apparatus has been set up.



5. Assemble the entire reflux apparatus shown to the above according to the directions below. Make sure that you set up this apparatus on one side of the hood so that it can easily reach the steam bath needed in Part 2, step 3.
    - Note: For Part 1 of this experiment, exothermic reactions release the heat that sustains the reflux temperature.

a. Attach a Claisen adapter to the round bottom flask containing the Mg turnings (and iodine).
b. To the straight arm of the Claisen adapter, attach a condenser equipped with a thermometer adapter and the prepared drying tube (step 2).
c. To the curved arm of the Claisen adapter, carefully attach a 125-mL dropping funnel with glass stopper secured by the iron ring.
d. Ensure that the entire apparatus is secure.

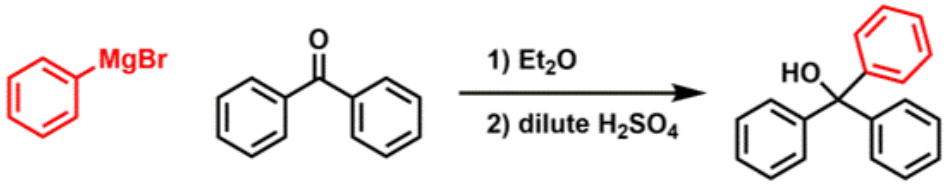
Special Note: Solvent and reactant solutions will be added to the round bottom flask using the dropping funnel three times during this experiment. DO NOT add these solvents/solutions to the dropping funnel while it is attached to the reflux apparatus. Instead, temporarily remove the dropping funnel from the apparatus and place it in another secure iron ring before adding the solvents or solutions. This ensures that accidental spills will not come into contact with a refluxing system. Always ensure the funnel's stopcock is closed before adding liquids to the funnel and that when dropping liquids from the funnel its stopper is removed.

6. Remove the funnel from the reflux apparatus and ensure that its stopcock is closed. It is good practice to stopper the curved arm of the Claisen adapter in the absence of the funnel. To the dropping funnel, add 40 mL of **anhydrous** ethyl ether. Return the filled dropping funnel to the reflux apparatus.
7. Carefully turn on the water to condenser. One lab partner should carefully hold the tubing to the condenser nozzles while the other should turn on the water until there is a strong stead flow (not blasting) and then reduce the flow to a steady drip.
8. Remove the funnel stopper and then open the stopcock fully to add the ether solvent quickly to the stirring Mg turnings. Record any observed color changes.
9. Add 5.3 mL of bromobenzene and 15 mL of **anhydrous** ethyl ether into the dropping funnel away from the assembly. You may want to rinse the

graduated cylinder with a small amount of ether to ensure transfer of all bromobenzene to the funnel. Swirl the funnel gently to mix and vent often. Return the funnel to the reflux apparatus.

10. Remove the dropping funnel stopper and open the stopcock carefully to add half of the bromobenzene solution at one time with stirring. Observe and record any color change.
11. After the color change, add the remaining bromobenzene solution **dropwise**. Note: If added too quickly, a side reaction between phenyl magnesium bromide and bromobenzene to form a biphenyl side product may occur. If a color change has not yet occurred, consult your instructor.
12. The reaction mixture should reflux spontaneously. Keep the reaction stirring for 10 minutes. Record observed color changes.

Part 2. Addition of Phenylmagnesium Bromide to Benzophenone



1. Dissolve 9.1 g of benzophenone in 100 mL of **anhydrous** ethyl ether in a beaker and transfer the solution to the dropping funnel away from the reflux assembly.
2. Add this solution to the Grignard reagent (stirring in the round bottom flask) dropwise with stirring.
3. After the addition is complete, replace the stir plate with a steam bath. Reflux the reaction mixture on a steam bath for 15 minutes.
4. Cool the reaction to room temperature then cool in an ice water bath on top of a stir plate.

Activity 7: Procedure (Chem 0345)

Important: Safety Pause

****SAFETY CONCERN**** Steps 5 and 6 must be performed very cautiously as concentrated H_2SO_4 is extremely corrosive. Read the procedure carefully.

Safety Pause

5. Carefully prepare the cold acidic solution for quenching the Grignard reaction: fill a 50-mL beaker with ice. Obtain 4.5 mL of concentrated H_2SO_4 via pipette from the stock beaker in the reagent hood. Carefully pour the concentrated acid onto the ice. *If you spill concentrated acid anywhere immediately let your instructor know. Gloves contaminated with concentrated acid should be changed immediately.*

Important: Safety Pause

CAUTION: Always add concentrated acid to ice or water, not the other way around (see step 6 below).

Safety Pause

6. Fill a separate 250-mL beaker with 75 mL of DI water. Once the sulfuric acid/ice mixture has melted, add this acid mixture to the 250 mL beaker containing 75 mL of DI water.
7. Remove the drying tube and add the cold sulfuric acid solution dropwise via pipette through the condenser (to contain spattering) to protonate the product and react with any remaining Mg metal. Stir the mixture over the stir plate during the acid addition in order to dislodge any solid so that it may come in contact with the acidic solution.
8. Transfer the quenched reaction solution to a 500-mL separatory funnel. Once the layers separate isolate the ether layer and return the aqueous layer to the separatory funnel.

9. Extract the **aqueous layer** with 50 mL of ethyl ether twice. Make sure to keep track of which layer is your organic layer and which one is the aqueous layer.

Pro-tip

If necessary, you can test if a single layer is the organic layer by adding 5-10 mL of ether, an organic solvent, to that layer. If a single layer is observed (i.e. not a biphasic mixture), then this layer is the organic layer.

10. Combine the ether layers and dry with $MgSO_4$. Gravity filter to remove the $MgSO_4$. Collect the product ethereal solution.

Part 3. Purification of Triphenylmethanol Product

1. Transfer the crude product solution to a 250-mL Erlenmeyer flask. Evaporate the crude product ethereal solution on a steam bath to dryness. Make sure to put boiling stones in your flask before boiling.
2. Cool the Erlenmeyer flask to room temperature then cool in an ice water bath to solidify.
3. Recrystallize the crude solid triphenylmethanol from a minimal amount of methanol. Only use the steam bath as a heat source. Note: Never use a heating mantle to heat an open container of a flammable liquid (like methanol).
4. Use vacuum filtration to collect the pure triphenylmethanol and save your product for next week.
5. For characterization next week, you will characterize your product by melting point and IR. Make sure to weigh your final product next week so you can calculate a final percent yield.

Clean-Up and Waste Disposal

Activity 7 Specific Clean-Up

- **Special Mg Waste:** any excess Mg metal must be isolated into its own waste container. Your instructor will properly dispose of excess Mg. Be sure your instructor knows that you have excess Mg. Never put Mg metal into the organic liquid waste container.
- **Organic Liquid Waste**:
  - Excess bromobenzene, diethyl ether
  - Acetone rinse from glassware washing (includes the final products)
  - Methanol from recrystallization and any unused methanol
- **Aqueous Waste**:
  - Sulfuric acid along with water rinses used to clean acid containing glassware
  - Aqueous sodium bicarbonate (if you were directed to use by your instructor)
- **Solid Waste:**
  - $MgSO_4$
  - $CaCl_2$ and used cotton
  - Excess benzophenone (if applicable)
  - Used filter paper
  - Used gloves

Routine Clean-Up

- Clean up your hood space of all trash, spilled chemicals, etc. Don't leave a mess for the people who share this hood at other time slots. Up to 24 other people are sharing this space at various time slots throughout the week. Clean up your mess!
- No dirty or clean glassware should be left in the sink. No used filter paper or wadded up dirty paper towels should be left in the sink.
- **Dirty paper towels go into the REGULAR TRASH** not the red solid waste trash. This saves the university a lot of waste disposal money!

- Dispose of dirty filter paper in the red solid waste container.
  - Do **NOT** deposit filter paper in the liquid waste eco-funnel as this will cause a clog which will lead to a messy overflow of waste.
  - Do **NOT** leave filter paper in the sink as this is poor lab etiquette and rude.
- Used gloves should be disposed of into the red solid waste.
- **Ask your instructor if you are in charge of cleaning up the balance area** for this week. If you are in charge do the following:
  - Be sure all reagent bottles are properly capped.
  - Use the small brush to clean off balances.
  - Use small broom and dustpan (located on the wall surrounding the balance area) to remove excess solid from counter. Dispose of excess solids in red solid waste container. Return broom and dustpan to proper location.
  - Wipe down the counter with a moist paper towel.
- **Ask your instructor if you are in charge of making sure the sink area is presentable** for the next lab group.
  - Wash any dirty glassware rudely left in the sink. Let clean glassware air dry on rack or windowsill area.
  - Dispose of any paper towels, filter paper, or cotton rudely left in the sink.
  - **Do not remove broken glass from the drain or the sink**. Rather, tell your instructor and then fill out a "something wrong form" located in the cabinet above the solid waste containers. Be sure to record room number and the Left/Right location of the sink.

Post-Lab Assignment

The Activity 7 Post-Lab Assessment is posted on Labflow and is due before the posted deadline on Labflow. If you have questions regarding the due date, consult with your lab instructor.