

## The Grignard Reaction: Triphenylmethanol from Methylbenzoate

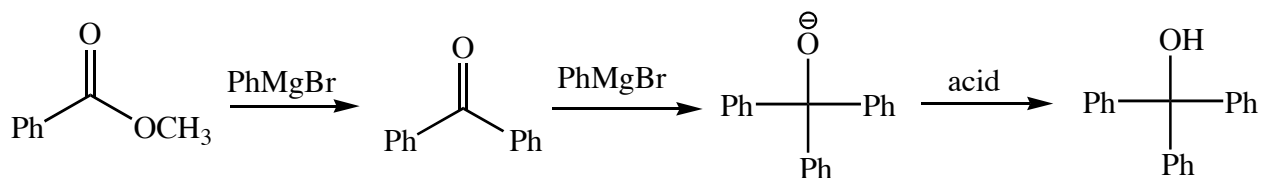
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### Background

The Grignard reaction is a versatile method for the creation of new carbon-carbon bonds; bonds that are otherwise quite difficult to make. The Grignard reagent (an alkyl or arylmagnesium halide) is a powerful nucleophile (reacting as a carbanion), and may be reacted with any substrate suitable for nucleophilic attack. One common practice is to react Grignard reagents with carbonyl compounds to yield alcohols. We will use this type of chemistry in this lab to generate a new alcohol from an ester.

### Overall Reaction

The general reaction scheme is as follows. Be sure to include a balanced equation and the full mechanism in your notebook!



### Cautions and Warnings

**AVOID EXCESSIVE HEATING. OPEN FLAMES PROHIBITED.** Diethyl ether is a very volatile, highly flammable solvent. Care must be taken to avoid fires. Even hot plates have been known to ignite ether! Exercise extreme caution throughout this lab.

**AVOID ALL WATER UNTIL THE WORKUP!** Grignard reagents are very basic, and will react with water to give the conjugate acid (benzene, in this case). All glassware must be scrupulously dry.

### Preparation of the Grignard Reagent (Phenylmagnesium Bromide)

Prepare a macroscale addition apparatus as pictured on page 87 of Pavia et al, using a 50 mL round-bottomed flask. Also include a stopper for the addition funnel. Each piece of glassware must be scrupulously dry, preferably by heating in an oven at 110° C overnight. (DO NOT heat the Teflon® stopcock – it will melt!). Ideally, a drying tube should be placed on top of the condenser.

To the flask, add 0.5 g dry, crushed magnesium turnings and a stirbar. Assemble the apparatus (while still warm), taking care that all joints are properly lubricated. Add 5 mL of anhydrous

diethyl ether to the round-bottomed flask through the addition funnel. Close the stopcock and replace the stopper on the funnel. Ensure a flow of cooling water through the condenser (check for leaks!). Prepare a solution of 2.4 mL bromobenzene in 5 mL anhydrous diethyl ether in a dry Erlenmeyer flask. Swirl the mixture to obtain homogeneity, then add it to the addition funnel (stopcock closed!).

Add a small amount of bromobenzene solution (~0.5 mL) to the round-bottomed flask, and observe. If bubbles are evolved, or the solution turns chalky, the reaction has started. The flask should become noticeably warmer. If the reaction has not started, follow the optional procedure below.

(Optional Procedure – If Reaction Has Not Started)

Warm the mixture gently for several minutes. If the reaction has still not started, add an additional amount of well-crushed magnesium and resume heating for 3-5 minutes. If the reaction is not going at this point, it may be necessary to add a small crystal of iodine. Call for assistance with this step.

(End Optional Procedure)

With the reaction started, gently heat the mixture to obtain a smooth reflux. Add 5 mL of anhydrous diethyl ether to the round-bottomed flask through the condenser and continue reflux. Add the remaining bromobenzene solution dropwise, such that smooth reflux is maintained. If the reaction becomes too vigorous, remove the heat source and cool the round-bottomed flask with an ice bath. After addition is complete, continue reflux for an additional 15 minutes. If necessary, add anhydrous diethyl ether to the reaction flask to maintain a minimum of 15 mL of solution. As the reaction proceeds, the solution should take on a darker, chalky appearance.

At the end of the reflux period, allow the solution to begin cooling.

### Preparation of Methylbenzoate

As the phenylmagnesium bromide solution is cooling, prepare a solution of 1.2 mL methylbenzoate in 5 mL of anhydrous diethyl ether. Add this solution to the addition funnel (stopcock closed!). Once the phenylmagnesium bromide solution is near room temperature, cool it further with an ice bath.

Begin dropwise addition of the methylbenzoate solution, using the ice bath to control the rate of the reaction. This is a very exothermic reaction, and it will reflux without external heating. If the condensate ring rises more than 1/3 of the way up the condenser, stop the addition and apply the ice bath until the solution is no longer refluxing, then cautiously resume the addition.

After the addition is complete, continue by doing ONE of the following.

Heat the reaction at reflux for 30 minutes (time permitting) OR cool the apparatus to room temperature, stopper the flask, and leave it until the next lab period. Water is no longer a concern at this point.

### Workup

Pour the reaction mixture into a beaker containing 10 mL of cold 6M sulfuric acid and 5-10 g of crushed ice. Solvent-grade diethyl ether may be used to rinse the flask. Stir the resulting mixture until all solids have dissolved, adding additional ether if necessary. Verify that the aqueous layer is acidic; if not, add 6M sulfuric acid in small portions until it is. Remaining solids may be dissolved by adding 2-3 mL portions of ether, then a similar amount of water.

Transfer the entire mixture to a separatory funnel and shake while venting. Drain the aqueous layer, then extract the organic layer once with 5 mL 3M sulfuric acid, twice with 5 mL portions of saturated aqueous sodium bicarbonate solution then once with 5 mL saturated aqueous sodium chloride solution. CONSIDERABLE PRESSURE will build up during these washes. VENT FREQUENTLY!

Dry the organic layer with anhydrous sodium sulfate for 10-15 minutes. Filter or decant the ethereal solution into a beaker, and gently evaporate the ether. The crude product may be recrystallized from cyclohexane (about 10 mL / gram of product). Collect the purified crystals via vacuum filtration and set them aside to dry. Obtain the mass and melting range, and compute the percent yield.