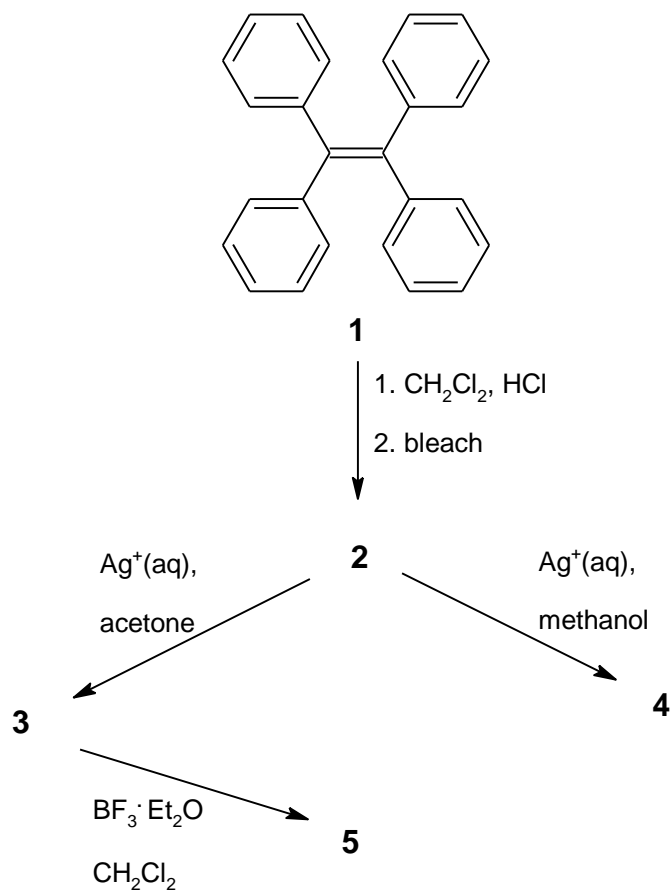


Information for instructors is available by sending an email to amschoff@UCCS.edu

This project is a multi-step synthesis experiment not found in our lab text. You will be given starting materials, procedures, and the reagents to make it happen. By using your chemical intuition, organic resources, and IR/NMR spectroscopy, you will figure out the structures of the intermediates and the final products and propose a mechanism for their formation. The concepts illustrated by this lab are addition, substitution, and rearrangement. From an organic topics standpoint, both Chem. 3310 and 3320 are represented. The general scheme is shown below.



You will be doing the lab in pairs over a four day period. Lab partners will be assigned on day one. It will be up to you to plan all the work so that everything gets done. In addition to the syntheses, you will need to characterize all the products via MP, IR, and ^1H NMR. For preliminary planning purposes, use the chart shown below. Deviations must be approved by your instructor.

| | Student 1 | Student 2 | Both |
|-------|-----------------------|-----------------------|---------|
| Day 1 | Rxn 1 \rightarrow 2 | Rxn 1 \rightarrow 2 | spectra |
| Day 2 | Rxn 2 \rightarrow 3 | Rxn 2 \rightarrow 3 | spectra |
| Day 3 | Rxn 3 \rightarrow 5 | Rxn 2 \rightarrow 4 | spectra |
| Day 4 | catch up as needed | | spectra |

Prelab (Notebook)

- Title (Discovery Lab)
- Purpose
- Procedural Reference – (See below.)
- Table of reagents – tetraphenylethene, dichloromethane, hydrochloric acid, bleach, chlorine, acetone, silver nitrate, methanol, ethanol, boron trifluoride etherate.
- Reactions – HCl + bleach
- Calculations – LR for reaction 1 → 2 (no theoretical yield)
- Procedures: normal two-column format. You only need the procedures for what you are doing on a particular day, i.e., all the procedures don't need to be there on day one.

During lab

- Carry out the procedures for that day. Record all data and observations in your notebook.

Postlab (Notebook) - following all the procedures

- Reactions proposed
- Calculations as needed – theoretical yields, % yields, MP % error, etc.
- No discussion needed in notebook.

Report (typed) – Results and Discussion

- Normal formatting – 1 inch margins, 1.5 line spacing, 11 point Arial or Times New Roman.
- Results – brief intro, then tabulated results. You decide what's important.
- Discussion – a paragraph for each reaction would be a good way to organize this section.
 - Reaction (ChemSketch).
 - Name of each proposed intermediate and the rationale for its structure.
 - A few thoughts on the possible mechanism. Cite references as appropriate. A ChemSketch diagram is not necessary.
 - A final paragraph (can be short) on the overall assessment of the lab and any recommendations for future use.
- References – ACS style
- Overall length – probably 2-3 pages. Concise, but thorough.
- One report per team. This is a joint effort worth 60 points. Please submit an electronic copy.

Resources and Acknowledgements

- Carey, Francis A., Organic Chemistry (textbook)
- Wade, L. G., Organic Chemistry (textbook)
- SDDBS spectra database. http://riodb01.ibase.aist.go.jp/sdbs/cgi-bin/cre_index.cgi?lang=eng
- These notes were prepared by John Balyeat, Department of Chemistry and Biochemistry, UCCS. The information for instructors contains the literature reference. We gratefully acknowledge the authors and the NSF, DUE for funding grant #0736941

UCCS Procedures for the Discovery Project Chem 3380

Prepared by: J. Balyeat, D. E. Mendes, A. M. Schoffstall.
(The literature source not shown for pedagogical reasons.)

Reaction 1

Reaction 1 → **2**. To a stirred solution of To a stirred solution of tetraphenylethene, **1** (0.250 g, 0.752 mmol) in dichloromethane (~5 mL) and 1 M HCl (1.8 mL, 1.8 mmol) in a 4-dram vial, Clorox bleach (1.5 mL, 1.2 mmol) was added dropwise over 1-2 minutes [Notes 1 - 3]. After 15 min of stirring, the aqueous layer was removed with a Pasteur pipet. The organic layer was washed twice with 1-2 mL portions of water [Notes 4 and 5], then dried over anhydrous sodium sulfate. The reaction vial was rinsed with ~ 1 mL of CH₂Cl₂ and added to the drying organics. The dried solution was filtered into a small dry, tared beaker through a Pasteur pipet containing a small cotton plug and approx 1 cm of Na₂SO₄. The sodium sulfate in the Erlenmeyer was rinsed with an additional 1-2 mL of CH₂Cl₂ and also filtered. The solvent was then removed by evaporation (low heat) on a hot plate [Note 6]. After cooling, the product was weighed and characterized [Note 7]. Typical yields were 80-90%. The product was used without purification.

Note 1. Be sure all the tetraphenylethene is dissolved before adding the bleach.

Note 2. A 5-mL graduated pipet was use to measure both the HCl and the bleach. The HCl was added directly to the CH₂Cl₂ solution. The bleach was placed in a small test tube and then transferred via Pasteur pipet to the organic-HCl solution. The addition of the bleach **must** be done in a hood. Loosely cap the reaction vial after adding the bleach.

Note 3. The solution must be stirred vigorously to make sure the organic and aqueous layers mix thoroughly. A small spin bar in the vial works well.

Note 4. After the aqueous layer was removed each time and the water re-added, the solution was stirred vigorously for 2-3 minutes.

Note 5. After the second wash, both layers were transferred to a centrifuge tube where the organic layer was easily removed and put into a clean, dry 25-mL Erlenmeyer flask. Na₂SO₄ was then added.

Note 6. Do not overheat. Dichloromethane has a very low boiling point. When there is a small amount of solvent still remaining, take the beaker off the heat. A small stream of air may be blown over the product to remove the last traces of solvent if deemed necessary.

Note 7. MP (lit) of the product is >180 °C. However, one report puts it at 160-162 °C. IR and ¹H NMR should also be done. All samples used in the spectra should be recovered. Following the NMR, the sample solution can be poured back into the beaker and reheated to evaporate the CDCl₃. You should prepare two MP tubes before running the spectra (if you're going to do MP the same day as the synthesis). Be sure to record all major absorbencies in your notebook.

Reaction 2 → 3. To a stirred solution of **2** (0.100 g, 0.248 mmol) in acetone (20.0 mL) in a 50-mL Erlenmeyer flask was added distilled water (2.5 mL) and 2.50 M AgNO₃ (200 μL, 0.500 mmol). [Notes 1-3] After 20 min, 1 drop of 2 M NaCl was added to precipitate the remaining silver ion. [Note 4] After 5 min of stirring, methylene chloride (7mL) was added with stirring to dissolve the organic product. [Note 5] The silver salts were removed by gravity filtration. The reaction flask, silver salts, and filter paper were rinsed with three, 2-mL portions of acetone and also filtered. [Note 6] The filtered organic solution was heated to boiling on a hot plate (low heat) and the volume reduced to ~10 mL. Water was added while stirring until a distinct cloudiness remained. The solution was removed from the heat and allowed to come to room temperature followed by an ice bath. Vacuum filtration and air-drying resulted in an average student yield of 79%. [Note 7]

Note 1. According to the literature, the concentrations (and, hence the volumes) need to pretty close. You can use a 10-mL graduated cylinder for both the acetone and the water. Be as close as possible. Use an Eppendorf auto-pipetter for the silver nitrate.

Note 2. Use a large stir bar in the Erlenmeyer flask. A moderate stir rate is fine.

Note 3. Wait until compound **2** dissolves before adding the water and silver nitrate.

Note 4. After adding the NaCl, the liquid may become somewhat cloudy.

Note 5. Compound **3** is a white solid that dissolves in the methylene chloride. The silver chloride salt is a grayish-purple ppt that does not dissolve. If, after 5-10 minutes of stirring, the ppt looks grey-purple, you're done.

Note 6. The filter paper was "fluted". See your lab text if you don't know what this means (p. 46) At this point there will be 30-32 mL of liquid in the beaker. When you rinse the Erlenmeyer flask with the acetone, be sure to transfer all the silver salts to the filter paper. The filter paper containing the salts must be collected for recycling. Do not put it in the trash! The solvent was collected in a 50-mL beaker.

Note 7. If there is a significant amount of product that ends up in the filtrate, transfer the filtrate back to the beaker and reheat. The suction flask can be rinsed with ~2 mL of acetone and also added to the beaker. When the solution is boiling, add water until there is a definite cloudiness. Then cool and filter as previous. This will not be as pure as the first crop so don't combine with the first crop unless absolutely necessary for the next step.

Reaction 2 → 4. To a stirred solution of Compound **2** (0.100g, 0.248 mmol), methanol (15.0 mL) and 2.5 M AgNO₃ (200 μL, 0.500 mmol) were combined in a 50-mL Erlenmeyer flask and stirred for 10 min [Notes 1-3]. One drop of 2 M NaCl was added to the reaction mixture to precipitate remaining silver ion. After 5 minutes, dichloromethane (7 mL) was added and the mixture was stirred until all of the organic material dissolved [Note 4]. The solution was gravity filtered into a clean, tared 30-mL beaker with 2-3 boiling chips; the Erlenmeyer flask, silver salts, and filter paper were rinsed with three, 2-mL portions of dichloromethane [Note 5]. The solvent was removed by heating on a hot plate with low heat [Note 6]. The crude product was weighed, then recrystallized (from a minimum quantity of boiling 95% ethanol, Note 7). Student yields averaged 77%. Characterize via MP, IR and ¹H NMR. GC-MS may be provided.

Note 1. According to the literature, the concentrations (and, hence the volumes) need to pretty close. You can use a 10-mL graduated cylinder for the methanol. Once you get to about 9 mL, use a Pasteur pipet to get exactly to 10. Do the same thing getting to 5 on the second amount.

Note 2. Use a large stir bar in the Erlenmeyer flask. A moderate stir rate is fine.

Note 3. Compound 2 never did dissolve in the methanol. But it did become a finely divided suspension after about 5 minutes. The AgNO₃ was added at this in time in one portion from an Eppendorf auto-pipetter. The solution then becomes milky white.

Note 4. Compound 4 is a white solid that dissolves in the methylene chloride. The silver chloride salt is a grey colored ppt that does not dissolve. If, after 5-10 minutes of stirring, the ppt looks grey, you're done.

Note 5. The filter paper was "fluted". See your lab text¹ if you don't know what this means (p. 46) At this point there will be 25-26 mL of liquid in the beaker. When you rinse the Erlenmeyer flask with the methylene chloride, be sure to transfer the silver salts to the filter paper. The filter paper containing the salts must be collected for recycling. Do not put it in the trash!

Note 6. This could take 20-25 minutes depending on the heat. Don't overheat. Reduce the heat as the volume approaches zero. Remove from heat just before the last little bit of liquid evaporates. You can remove the last traces of methanol with a small stream of air as the beaker cools. You may recrystallize right in the same 30-mL beaker.

Note 7. It should take less than 5 mL of EtOH. Be careful not to add too much solvent. The product is a pure white powder. Literature MP is 179-180 °C.

Reaction 3 → 5. To a stirred solution of To a vigorously stirred solution of compound **3**, (0.087 g, 0.25 mmol) in dichloromethane (2 mL) in a 5-mL conical vial, was added via a syringe, boron trifluoride etherate (36 μ L, 0.28 mmol). [Note 1-3] After stirring for 5 min, the reaction was quenched via the addition of water (2 mL). After two min of additional, vigorous stirring, the aqueous layer was removed via a Pasteur pipet and the organic portion was washed with saturated NaCl (2 mL) followed by drying over anhydrous sodium sulfate. [Note 4] Solvent removal (hot plate on low heat) afforded the desired material; student average yield, 90%. [Note 5] Characterization was accomplished by MP, IR, and ^1H NMR.

Note 1. Make sure compound **3** is dissolved in the dichloromethane before adding the BF_3 solution. Use a spin vane in the conical vial.

Note 2. If you do not have 87 mg of compound **3**, notify your instructor. More than likely you will simply scale down the reaction accordingly.

Note 3. Upon adding the boron trifluoride etherate, the solution turned from clear to amber colored. The bottle of boron trifluoride etherate needs to be tipped on its side slightly in order to get the needle into the solution. Ask your instructor for assistance. Hamilton 50 μ L GC syringes were used.

Note 4. As always, it will work best if you remove the bottom (organic) layer first, then the aqueous layer. Put the organic layer back into the vial before washing with saturated NaCl.

Note 5. After drying over sodium sulfate the organic layer was filtered through a Pasteur pipet containing a cotton plug and \sim 1 cm of sodium sulfate into a dry, tared 10-mL beaker containing 1-2 boiling chips. The sodium sulfate was rinsed with \sim 2 mL of dichloromethane and also filtered. Do not overheat.

Reference

1. Schoffstall, A. M., Gaddis, B. G. and Druelinger, M. L., Microscale and Miniscale Laboratory Experiments, 2nd Edit., 2004, McGraw-Hill, Boston, 2004.