Oxidation of Benzhydrol

Adapted by R. Minard and D. Dorisio (Penn State Univ.) from a microscale experiment developed by J. Grezlak, Shippensburg University and published in Smaller is Better. Revised 2/24/99

Introduction:

Benzhydrol, 1, is oxidized to benzophenone, 2, by sodium hypochlorite (commonly known as bleach) in the presence of a phase-transfer catalyst, using a procedure that is a slight modification of the one by Durst and Gokel\(^1\). Under the new reaction conditions, despite the presence of the catalyst and excess sodium hypochlorite, the reaction is incomplete. TLC analysis of the product mixture readily shows the presence of benzophenone contaminated with unreacted benzhydrol. Separation and purification of the benzophenone is then effected by column chromatography. TLC is used to monitor this separation.

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\text{CH}_2\text{C}=\text{O} \quad \text{NaOCl} \quad \text{CH}_2=\text{C}(\text{O})\text{OH} \]

benzhydrol \hspace{1cm} \text{ benzophenone}

PreLab Exercises:

1. What product, if any, would result from the oxidation of triphenylmethanol?
2. From the oxidation of 3-pentanol?

TLC

You are required to run a TLC to monitor the progress of the reaction. Plates should have three spots (or lanes) on the origin: one for the main organic starting material that is being transformed, one for a cospot (starting material and the reaction mixture), and one for the reaction mixture.

Synthesis:

In a 20-mL green capped vial, place 1.5 mL of ethyl acetate, 100 mg (0.54 mmol) of benzhydrol and a few drops of methyltricaprylammonium chloride solution (Stark's catalyst or tricaprylmethyl-ammonium chloride). Add a half-inch magnetic stirring bar, and stir until all reagents are dissolved. Cool the solution in an ice bath and add 2 mL of 5% NaOCl \(aq\) (bleach) dropwise using a 2.5-mL syringe. After the addition of the hypochlorite is complete, allow the reaction to stir for five minutes in the ice-water bath and then stir for a period of one hour at room temperature.

Isolation and Purification:

Using a filter pipet, remove and discard the lower aqueous phase. Add 1 mL of distilled water to the organic phase, cap tightly, and shake vigorously. Allow the phases to separate and remove the aqueous phase with a Pasteur pipet. Repeat this washing procedure first with 1 mL of 5% sodium bicarbonate (be careful to release pressure often) followed by 1 mL of saturated aqueous NaCl solution. Dry the organic layer over a thin layer of anhydrous sodium sulfate for 10 minutes, test for clumping with a small portion of additional sodium sulfate. If the solution appears to be dry, transfer the solution into a 10-mL Erlenmeyer flask using a Pasteur pipet. Rinse the sodium sulfate with 0.5 mL of fresh ethyl acetate, combining the rinse with the previous ethyl acetate portion. Evaporate the solvent on a sand bath in a hood. Prepare 50 mL of a 50 v/v% ether/ligroin mixture. Dissolve the product residue in 5-10 drops of this solvent mixture.

Chromatographic Separation and Analysis:

TLC analysis of the product mixture is carried out with 1- by 4-in. silica gel plastic-backed plates containing fluorescent indicator which can be obtained from the stockroom. With a pencil lightly mark the plate with a row of three evenly spaced dots parallel to, and 1 cm from, the bottom of the plate. Using
fine capillaries, place a 1-mm spot of a solution prepared by dissolving a few crystals of benzhydrol in 0.5 mL of dichloromethane on one of the pencil marks. Spot the second dot with a standard 1% benzophenone solution (Hooded shelf) and the third dot with your product solution. Place the plate in a developing chamber containing dichloromethane to a depth of 0.5 cm and cover the chamber. Allow the solvent to rise to about 1 cm from the top of the plate. Remove the plate, marking the solvent front with a pencil. After allowing the plate to dry, observe the plate under UV light and circle all spots that appear. Calculate the $R_f$ value of each and identify the contents of your product solution.

If sufficient product is visible by TLC, it should be separated from the starting material by column chromatography. Assemble the chromatography column from the Williamson kit and pack as follows: Fill the column three-fourths full with a 50 v/v% ether/ligroin solvent mixture. While periodically tapping the column lightly with a spatula or wooden pencil to compact the adsorbent, slowly and sequentially load the column with 2.0 g alumina (neutral, Brockman Activity #1) and a 1/2-inch-layer of sand. Open the stopcock and allow solvent to drain until it drops just slightly below the top of the sand layer. Transfer the product mixture, dissolve in a few drops of solvent, onto the column and let it soak in below the upper sand level. Add a few drops of the solvent to the sample flask to rinse it out and transfer this to the top of the column. Open the stopcock and again allow the solvent level to drop just slightly below the top of the sand. Now gently add 0.5 mL of the solvent mixture down the side of the column with a Pasteur pipet. Open the stopcock again and let this drain into the sand. Finally add additional solvent mixture to a level 1 in. from the top of the column. Open the stopcock and start collecting 1-mL fractions in flasks, beakers, test tubes, or vials. Maintain the solvent level in the column by regularly adding more solvent mixture to the top. (Should time become a factor, the elution rate can be increased by applying pressure to the top of the column with a rubber bulb. This may, however, result in a decrease in resolution.) Discard the first 0.5 mL of eluent and collect the next 4 mL in 1-mL aliquots. Using TLC as before, analyze the contents of all four vials. In a tared 20-mL vial, combine the solutions containing only benzophenone. Place the vial in a prewarmed sand bath in a hood and evaporate the solvent or allow to evaporate in your hood or desk until the next lab period. Reweigh the vial and its contents. Calculate the yield and % yield of benzophenone. Tape all your developed and marked TLC plates in your notebook for your final report.

**Analysis**

In addition to TLC analysis, you may be instructed to analyze your final product by IR or UV-Vis. Analyze your sample according to your Assignment sheet and the instructions on Sample Preparation in Lab Guide.

**Cleaning Up:**

The aqueous layer from the reaction can be discarded down the drain. Any residual organic solvents should be disposed of in the Nonhalogenated Organic Waste container. The chromatography column can be placed in a 125-mL Erlenmeyer flask in your locker where it will dry out by the next lab period, and then the dry sand, alumina, and magnesium sulfate can be disposed of in the solid waste container.

**Final Report:**

Carry out analysis as per your assignment sheet and instructions on sample preparation in the Lab Guide. Mark all your TLC plates clearly in terms of the identity and $R_f$s of the spots.

**Postlab Questions**

1. What role does the phase-transfer catalyst play in the oxidation reaction carried out in this experiment?
2. What is the oxidizing agent in this reaction and what is the final product?
3. Calculate the oxidation state of the carbon undergoing a chemical reaction, before and after the reaction.
4. With respect to disposal, what advantage does NaOCl offer over Cr(VI) salts?