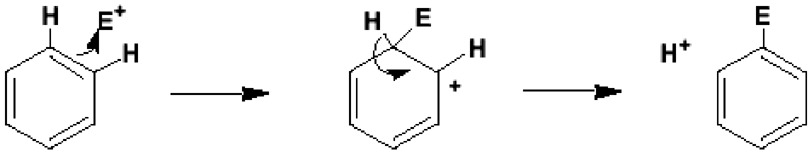
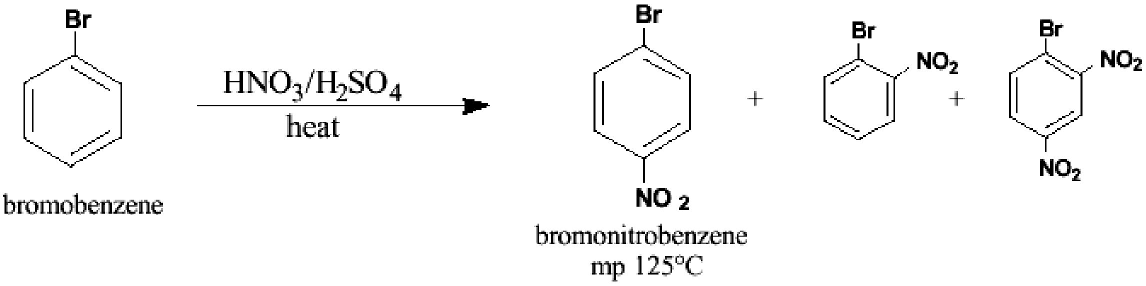
NS207 Laboratory 4: Nitration of Bromobenzene

Introduction:

The introduction of various substituents onto aromatic ring systems is critical to the production of many pharmaceuticals (example: sulfonamide antibiotics), pesticides (example: 2,4-D weed killer), fuels (alkyl substituted aromatic compounds) and a host of other industrially important materials. This is most often done via an electophilic aromatic substitution reaction, shown below for the generalized electrophile, E$^+$:



In the aromatic nitration reaction, the electrophile is the nitronium ion, NO$_2^+$, formed by the reaction of concentrated nitric and sulfuric acid. The main product is the para substituted product; other products are the ortho isomer and the dinitro product.



Cautions:

Concentrated nitric and sulfuric acid are very corrosive: avoid contact with skin and clothes .The reaction is very exothermic and noxious gases are evolved: run in a hood. Bromobenzene is toxic. Handle all reagents with care.

Synthesis:

Place 2.0 mL of conc. sulfuric acid, 1.6 mL of conc. nitric acid, and 1.0 mL of bromobenzene in a 20-mL vial along with a 1/2-inch stir bar. DO NOT CAP. Stir the solution for 10 minutes. (The brown gases produced.are nitrogen oxides) A white solid should form. If this does not happen, then place the vial in boiling water for 15 minutes.

Isolation and Purification:

Let the vial cool to room temperature and pour the reaction mixture into approximately 10 mL of cold water. Rinse the vial with water if necessary. Crush the product and filter by suction filtration. Transfer the filtered product to a small beaker, add 3 mL of water, and crush the product well to release any acid present. Filter the crystals again and rinse with water. Press the crystals between paper towels to remove as much of the moisture as possible. Set aside a few milligrams of this crude product for TLC analysis.

Purify the remainder of the crude product by recrystalization. Set up and start heating a sand bath. Weigh approximately 0.5 grams of your product into a small beaker or 20-mL vial. Add about 10 mL of 95% ethanol. Insert a boiling stick and heat to reflux in a sand bath. If the solid had not yet completely dissolved after a minute of boiling, add addtitional ethanol (no more than 12 mL should be used). After all of the solid has dissolved, remove the solution from the heat and allow it to cool slowly. While this is cooling, put approximately 0.5-1 mL of 95% ethanol in a small test tube and cool in an ice bath. If crystals haven't formed after 10 minutes, scratch the side of the beaker or vial with a glass stirring rod. When the solution is close to room temperature, cool it in ice. Vascuum filter on a Hirsch funnel and wash the crystals with 10-15 drops of the previously cooled ethanol. Draw air through the crystals in the suction filtration funnel for about 15 to 20 minutes to dry them. Transfer the crystals in a tared beaker and weigh. After weighing, take a melting point of this product. Perform TLC on this material, as well as the crude product, and the starting material, bromobenzene using silica gel plates and 10% CH_2Cl_2 in hexane (v:v) as the developing solvent.

Analysis:

Look for 1,4-, 1,2- and 1,2,4- substituted products in the TLC analysis. Perform other analyses as directed.

Cleaning Up:

Dilute the aqueous filtrate in water and pour down the drain.

Final Report:

Include TLC plates properly marked. Interpret any spectra. Answer these questions:

1. Explain the fact that the *para* isomer is generally the least soluble in a given set of *ortho*, *meta*, and *para* isomers.
2. How would you prepare the meta bromonitrobenzene from benzene?
3. Why is the bromine an ortho/para director?

Also, please answer the following:

1. What role does the sulfuric acid play in the formation of the nitronium ion? (Show mechanism with full structures for nitric and sulfuric acid.) Since nitric acid *itself* is an acid, then why should a *second* acid (the sulfuric acid) be added?
2. Write the mechanism for an electrophilic substitution reaction of toluene with nitronium ion. Be sure to show the arenium ion intermediate and final product.