

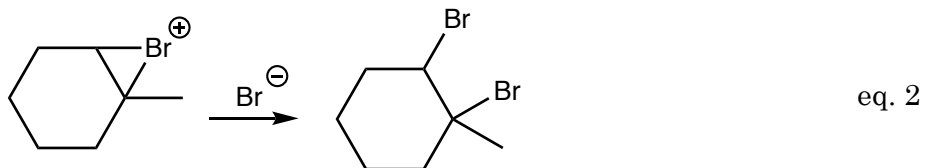
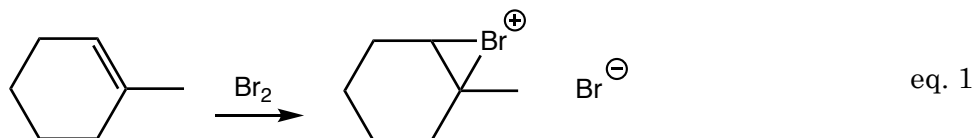
Regioselectivity: Electrophilic Addition and Bromohydrin Formation

Purpose

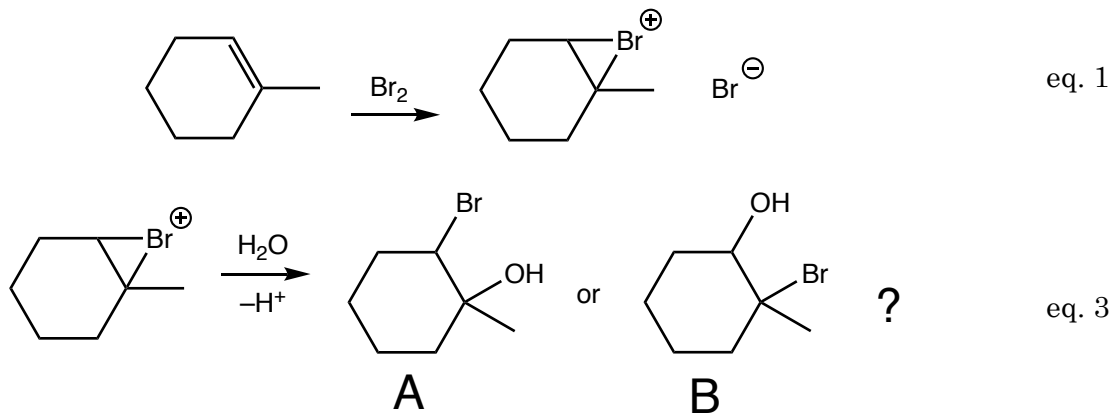
To perform an electrophilic addition reaction and determine the regioselectivity of the reaction. To introduce an organic technique: collecting IR spectral data for the determination of chemical structure (identify the product as an alcohol). To perform chemical analyses to determine the structure of a molecule.

Background

Alkenes are nucleophilic, and as such, they react with electrophiles. The reaction of an alkene with an electrophile occurs in two steps. First, the alkene is attacked by the electrophile and a charged intermediate forms. In the second step, a nucleophile completes the reaction and a stable substituted alkane is formed.



If the appropriate reagents are chosen, one can learn where the nucleophile and electrophile add to the alkene. For example, if the previous reaction is performed in water, a nucleophilic solvent, the solvent participates in the reaction. Since the water is present at a much higher concentration than the Br^- ion, which forms during the first step of the reaction (eq. 1), the water plays the role of the nucleophile and a bromohydrin results (eq 3).



Since water cannot play the role of the electrophile, the formation 2-bromo-2-methylcyclohexanol (eq. 3 product A) would reveal that the electrophile adds to the more substituted carbon and the nucleophile adds to the less substituted carbon. Likewise, the

formation of 2-bromo-1-methylcyclohexanol (eq. 3 product A) would reveal that the electrophile adds to the less substituted carbon.

Procedure¹

Formation of a Bromohydrin

1. Add a magnetic spin vane, 0.350 g *N*-bromosuccinimide (NBS), 1.0 mL of water, and 0.75 mL tetrahydrofuran to a 5.0-mL conical vial.
2. Add 0.24 mL of 1-methylcyclohexene.
3. Stir the suspension until no solid NBS remains. Add additional 1-methylcyclohexene (10 μ L at a time) if solid NBS remains or if the solution has a yellow tinge.
4. After the NBS has been consumed, add 2.0 mL water.
5. Transfer the organic layer to a second vial and dry it with anhydrous sodium sulfate.
Note: The organic layer can be difficult to identify. The best way to identify the organic layer and the aqueous layer is to carefully observe the vial while the 2.0 mL of water are added. Confirming the identity of the aqueous layer after performing the separation is a good idea. Do this by adding more water to the layer that is presumed to be the aqueous layer.

Isolation of the Bromohydrin

1. Prepare a silica gel chromatography column in a Pasteur pipet.
 - a. Create a filter in a Pasteur pipet by placing a small amount of glass wool in the neck of the pipet
 - b. Scoop silica gel into the pipet. Add enough silica gel to form a column approximately 2 cm tall.
 - c. Wet the column with a small amount of ethyl acetate.
2. Working quickly, transfer the crude product to the chromatography column.
3. Rinse the drying agent, the Na_2SO_4 used above, with four drops of CH_2Cl_2 and add that CH_2Cl_2 solution to the chromatography column too.
4. Allow the solution in the chromatography column to drain until the very top of the silica gel is dry. Remember to catch the eluant in a clean, dry vial.
5. Add CH_2Cl_2 (3.0 mL) and allow the solution to drain completely.
6. Collect all of the CH_2Cl_2 -bromohydrin solution and evaporate the CH_2Cl_2 with the help of a warm water bath. Continue evaporating the CH_2Cl_2 until the mass of the bromohydrin solution stops changing.

Identification of the Bromohydrin

IR Spectrum

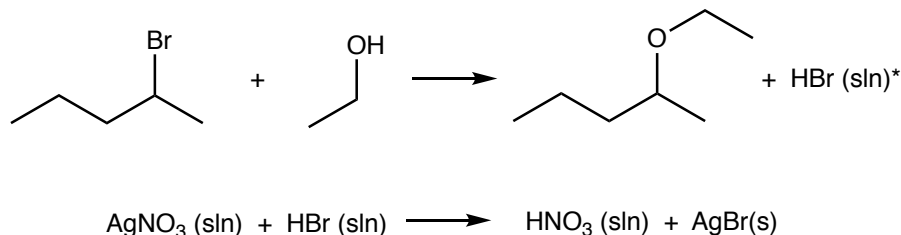
1. Collect an IR spectrum of the bromohydrin. The presence of a characteristic OH stretch in the IR spectrum will confirm that the product is an alcohol.
2. Compare the IR spectrum of the bromohydrin to the IR spectra of the other alcohols available in the lab. Comparing the aforementioned IR spectra with an IR spectrum of a hydrocarbon will clearly identify the "characteristic OH stretch".

Silver Nitrate Test

¹Porter, D.J.; Stewart, A. T.; and Wigal, C. T. *J. Chem. Ed.* **1995**, *72*, 1039.

The presence of a halogen is confirmed by a silver nitrate test. Halogenated organic compounds are reactive molecules, and the halogens can be replaced (we will discuss this type of reaction extensively later in the class). In the presence of silver ions, a precipitate forms when the halogen leaves the molecule. In the absence of a halogen, a precipitate will not form. The reactions are summarized in Figure 1.

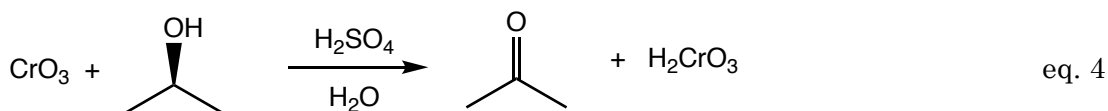
Figure 1. The Silver Nitrate Test



1. Add 1 drop of the bromohydrin (the molecule that you made today) to 1 mL of an ethanolic silver nitrate solution (silver nitrate dissolved in ethanol).
2. Add 1 drop of 2-bromobutane (an alkyl halide) to 1 mL of an ethanolic silver nitrate solution.

*Reminder: Strong acids that are dissolved in H-bond accepting solvents, as HBr and HNO₃ are here, will ionize and protonate the solvent.

Chromic acid/Jones oxidation test



Determining the location of the hydroxyl group, and thus the Br, is accomplished by performing a Jones oxidation test.

1. Dissolve one drop of the chromic acid reagent (Jones reagent) in 1 mL of reagent grade acetone.
2. Add one drop of your bromohydrin to the chromic acid–acetone solution. Record your observations, but ignore anything that happens after the first 15 seconds.
3. In a second tube, repeat the chromic acid test using 2-propanol (isopropanol) instead of your bromohydrin.
4. In a third test tube, repeat the chromic acid test using 2-methyl-2-propanol (*t*-butyl alcohol), which can also be called *t*-butanol.

Compare the results of the reaction of the bromohydrin and the Jones reagent (the chromic acid solution—chromium(VI) oxide in sulfuric acid) with the reactions of 2-propanol, a 2° alcohol, and 2-methyl-2-propanol, a 3° alcohol, with the Jones reagent (observe the color for 5 seconds and note any change that occurs with this time). If this test reveals that the OH is bonded to the secondary C atom on the bromohydrin that you made, then the Br must be bonded to the tertiary C atom. If the test reveals that the OH is bonded to the tertiary C atom, then the Br must be bonded to the secondary C atom.

Report

Draw the reaction of 1-methyl-1-cyclohexene with Br_2 in the presence of water. Make certain the reaction you draw shows the correct product.

List and explain the evidence that you collected that supports the conclusion that your product has a bromine atom attached to it.

List and explain the evidence that you collected that supports the conclusion that your product has an OH group attached to it.

List and explain the evidence that you collected that supports your assignment of the regioselectivity of the reaction.