**Isoborneol from Camphor: A Reduction**

Adapted by R. Minard (Penn State Univ.) from Introduction to Organic Laboratory Techniques: A Microscale Approach, Pavia, Lampman, Kriz & Engel, 1989. Revised 6/29/06

**Introduction:**

This experiment involves the use of a reducing agent (sodium borohydride) for converting a ketone (camphor) to a secondary alcohol (isoborneol) as illustrated in the second step of the two-step oxidation/reduction sequence shown below. The spectra of borneol, camphor, and isoborneol will be compared to detect structural differences and to determine the extent to which the final step produces a pure alcohol isomeric with the starting material.

\[ \text{Borneol} \xrightarrow{\text{Oxidation}} \text{Camphor} \xrightarrow{\text{Reduction}} \text{Isoborneol} \]

**Prelaboratory Exercises:**

1. Explain why the gem-dimethyl groups appear as separate peaks in the proton NMR spectrum of isoborneol while they are an unresolved singlet in borneol.

2. The reduction mechanism is often shown with a hydride ion (H\(^-\)) attacking the carbonyl carbon. Why might one assign a partial negative charge to the hydrogens in sodium borohydride?

**Cautions:**

This reaction involves diethyl ether which is extremely flammable. Make certain that no open flames or other sorts of ignition are in your vicinity when you are using ether.

**Synthesis:**

The sodium borohydride should be checked to see whether it is active. Place a small amount of powdered material in some methanol and heat it gently. The solution should bubble vigorously if the hydride is active.

In a reaction tube, place 100 mg of camphor. Add 0.5 mL of methanol to the camphor and agitate to dissolve. In portions, cautiously and intermittently add 0.060 g of sodium borohydride to the solution. When all the borohydride is added, reflux (at the boiling point of methanol, 68°C) the contents of the tube on a sand bath for 2 minutes. Run a TLC analysis. Plates should have three spots (or lanes) on the origin: one for the main organic starting material that is being transformed (Camphor), one for a cospot (starting material and the reaction mixture), and one for the reaction mixture. Carefully dip a TLC capillary tube into the reaction mixture and spot the plate on the cospot and reaction mixture lanes. Allow the MeOH to dry from the spots before developing the plate. Use 50% EtOAc in hexanes as the mobile phase. Visualize the spots using the iodine chamber.

**Isolation and Purification:**

Allow the mixture to cool for several minutes and carefully add 3.5 mL of ice water. Isolate the white solid by
removing the solvent with a Pasteur pipet. Add 3.5 to 4 mL of ether (use the wet ether found in a supply bottle in each hood) to the tube to dissolve the product, pipet off the lower water layer if one forms, and then add 3-4 microspatulafuls of anhydrous sodium sulfate to dry the solution. Cork and shake intermittently for 5 min to be sure all the water is captured by the magnesium sulfate. To remove the drying agent, filter the mixture through a clamped filtering pipet (pipet with cotton) into a tared 10-mL-Erlenmeyer flask. Use 1 mL of ether to rinse the reaction tube and magnesium sulfate and also filter this into the collection flask. Allow the solvent to evaporate in your locker until the next class period. Alternately, evaporate the solvent in the hood with a gentle stream of dry air or nitrogen gas while heating the Erlenmeyer flask on a sand bath at 40-50°C. Watch the progress of the evaporation carefully and as soon as a solid appears, remove the flask from the heat source immediately; otherwise the product may sublime and be lost. Lay the warm flask on its side on the bench top and roll around to allow the ether vapors to escape.

Determine the weight of the product and calculate the percent yield. Add a small amount of your sample to a melting point capillary tube and seal the top with parafilm. (Ask your TA for assistance.) Determine the melting point; pure racemic isoborneol melts at 212°C. Analyze the product by the spectral method assigned.

The percentage of each of the isomeric alcohols in the borohydride reduction mixture can be determined by NMR or GC analysis. IR analysis, unfortunately, does not allow this. The NMR spectra of the pure alcohols are attached. The hydrogen on the carbon bearing the hydroxyl group appears at 4.0 ppm for borneol and 3.6 ppm for isoborneol. One can obtain the product ratio by integrating these peaks (using an expanded presentation). Alternatively, approximate percentages can also be obtained by gas chromatography.

**Analysis**

In addition to TLC analysis, you will be instructed to analyze your final product by IR, NMR, GC or GC-MS. Analyze your sample according to your assignment sheet and prepare it as per the instructions on Sample Preparation in the Lab Guide.

**Cleaning Up:**

The initial methanol/water filtrate containing traces (about 100 mg) of borate (similar to "Boraxo" soap) can be flushed down the drain.

**Final Report:**

In your final report, include copies of any spectral data with structures and interpretation or chromatographic data with GC analysis parameters attached. Note the presence of any unreduced starting material in the product and tell how you determined this. If you obtained an NMR of your product, compare your spectrum with the NMR included in this report. If you obtained an IR of your product, compare your spectrum with the IR included in this report.

**PostLab Questions:**

1. A sample of isoborneol prepared by reduction of camphor was analyzed by infrared spectroscopy and showed a band at 1760 cm⁻¹. This result was unexpected. Why?

2. Explain the comparative reactivity and hazards of NaBH₄ as compared to LiAlH₄. Also, compare the different results when they are added to A) water; B) ethyl acetate; C) methanol.

3. How would the geometry of the product change (OH in an endo or exo position?) if all the methyl groups of camphor were replaced with H?

**References:**

Brown, H. C. and Muzzio, J. "Rates of Reaction of Sodium Borohydride with Bicyclic Ketones." Journal of the


NMR spectrum of camphor, CCl₄.

NMR spectrum of borneol, CDCl₃.

NMR spectrum of isoborneol, CDCl₃.