



# New Green Sophomore Organic Labs

## Green Oxidation of Borneol to Camphor

Borneol is a bicyclic organic compound. It can be found in plants such as ***Kaempferia galanga*** (right). It is a secondary alcohol, which when oxidized makes Camphor. Camphor is a highly useful solid. Some of its uses are:

- Embalming
- In medicine as a slight local anesthetic
- Cough suppressant
- Anti-itch and cooling gels
- Vapor-steam products e.g. Vicks
- Skin clarification masks



## Oxidants

Oxidants are substances that remove electrons from another substance.

These include:

- Clayfen (Iron III nitrate)
- Claycop (Copper II nitrate)
- Iodobenzene Diacetate (IBD)
- Sodium Dichromate
- Sodium Hypochlorite
- Chromium VI Oxide
- Active Manganese Dioxide (AMD) with silica gel

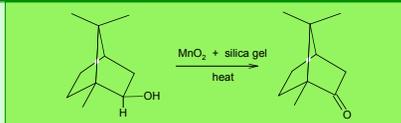
However in order to observe the **Principles of Green Chemistry** which calls for use of safe or no solvents, the best oxidant was determined to be Active Manganese Dioxide with silica gel because any other oxidant would require a solvent. AMD on silica method also results in less hazardous waste in comparison to the other methods, hence obeying another principle.



Figure 1.

## Experiment

The mixture of Borneol, AMD and silica gel simply needs to be ground up and piled on a watch glass. The apparatus in fig.1 can be set up and heated. The camphor sublimates and collects on the powder funnel above the watchglass. Experiment takes very little time (~30 minutes) and students can see and smell camphor. The reaction scheme can be seen in fig.2. The reaction has high yields (70%+) and it is a facile way for students to grasp oxidation as well as some components of green



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## Diels-Alder Reaction In Water

The Diels-Alder reaction is an important carbon-carbon bond forming reaction. In this reaction a diene (a hydrocarbon containing two double bonds) reacts with a dienophile (a compound containing a double bond). The result of this cycloaddition is an adduct. The adduct is a combination of both the diene and the dienophile but the dienophile component of the product will not have the double bond it had as a reagent. The electrons from the double bond on the dienophile flow to the diene as the two compounds become one. The rate of Diels-Alder reactions can be enhanced by using Lewis acid catalysts or increasing pressure and or temperature.

This experiment is carried out using anthracene-9-methanol (diene) and N-methylmaleimide (dienophile) and water. The high cohesive energy density of water and hydrophobic interactions between water and anthracene-9-methanol also serve to increase the rate of the reaction.

## Reaction

The reaction scheme is as follows:

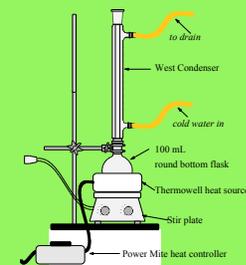
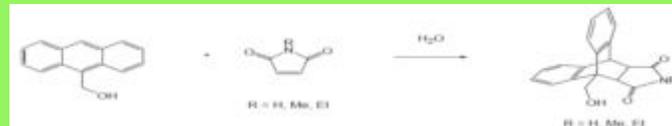


Figure 3. Reflux Apparatus

This experiment is very simple. The reagents are boiled until reflux in a round bottom flask. The reaction apparatus can be seen in Figure 3. After approximately one hour, the reaction can be cooled and the product is allowed to precipitate out of the reaction. The product is collected using vacuum filtration and if the filtrate is collected and boiled, it will boil close to 100°C. This is because the only waste product should be water but there maybe a little anthracene-9-methanol and N-methylmaleimide. The atom economy is 100%. The yields should be high, in the ranges of 70-80%. Although the product is an unknown compound the melting points should be in the range of 228°C – 235°C.

## Green Lessons

The use of water as a solvent also obeys the **Principle of Green Chemistry** which encourages the use of safe solvents. It also addresses the issue of waste. In this case if the water will not be reused. It is safe to dispose of it in the drain with copious

## Summary

The laboratory experiments discussed were researched to determine if they would be suitable for students to perform. They can be added to the Sophomore Organic Laboratory curriculum. Students can carry them out with ease. Safe chemical and solvent use, maximizing atom economy, waste and pollution reduction are blatantly addressed and both of these experiments enhance the students' understanding of

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