

Fischer Esterification: Preparation of Banana Oil

In this experiment, students prepare isopentyl acetate by a Fischer esterification of isopentyl alcohol and acetic acid. They use gas chromatography to then detect and verify the reactants, crude product, and final product.

ESTIMATED TIME

We estimate that this experiment can be completed in one, 3-hour class period.

TIPS

1. In the Electronic Resources you will find PDF and word-processing files of the student experiment. You can print the PDF, distribute it to students electronically, or post the file to a password-protected class web page or learning management system. Edit the word-processing file if you would like to tailor the experiment to suit your equipment and students. Sign in to your account at **www.vernier.com/account** to access the Electronic Resources.
2. As an alternative to using the Peak Analysis feature of the software, your students can manually determine the retention time for a compound by using the Examine feature. Because of the manner in which the Mini GC operates, the retention time is the x-value, in minutes, at the maximum y-value of the peak. If you want students to use the Examine feature, consider modifying the student version of the experiment.
3. The temperature-pressure profile is set so that each data collection run will last approximately 17 minutes. You may remind your students that some of the substances will have passed through the column and detector well before 17 minutes and they can stop the data collection early to save time.
4. It is important that students inject a consistent volume for each test.
5. To optimize the reproducibility of your retention times, it is best practice to let the Go Direct Mini GC return to 45°C between each trial.

HAZARD ALERTS

The chemical safety signal words used in this experiment (**DANGER** and **WARNING**) are part of the Globally Harmonized System of Classification and Labeling of Chemicals (GHS). Refer to the Safety Data Sheet (SDS) that came with the chemical. These can also be found online from the manufacturer. See the Preface for additional chemical safety information.

Acetic acid, glacial, CH₃COOH: **DANGER:** Keep away from heat, sparks, open flames, and hot surfaces—flammable liquid and vapor. May be harmful if swallowed. Causes severe skin burns and eye damage. Avoid breathing mist, vapors, or spray—toxic if inhaled.

Experiment 5

Acetone, CH_3COCH_3 : **DANGER**: Highly flammable liquid and vapor. Keep away from heat, sparks, open flames, and hot surfaces. Causes serious eye irritation. Avoid breathing mist, vapors, or spray. May cause drowsiness or dizziness.

Calcium chloride, solid, CaCl_2 : **WARNING**: Do not eat or drink when using this product—harmful if swallowed. Causes serious eye irritation.

Isopentyl alcohol, $\text{C}_5\text{H}_{12}\text{O}$, **DANGER**: Flammable liquid and vapor. Keep away from heat, sparks, open flames, and hot surfaces. Skin and serious eye damage, corrosion or irritation. Acute toxicity, inhalation. Harmful if inhaled.

Sodium bicarbonate, solid, NaHCO_3 : **WARNING**: May be harmful if swallowed. Treat as a non-food-grade chemical. Prudent laboratory practices should be observed.

Sodium sulfate, solid, Na_2SO_4 : **WARNING**: May be harmful in contact with skin.

Sulfuric acid, concentrated, H_2SO_4 : **DANGER**: Causes severe skin burns and eye damage. Do not breathe mist, vapors, or spray. Maybe harmful if inhaled. Harmful to aquatic life. Considerable heat generated when diluted with water. Industrial exposure to vapors and mists is listed as a known human carcinogen by the International Agency for Research on Cancer (IARC).

PRE-LAB ACTIVITY

Table 1			
Compound	Boiling temperature (°C)	Molar mass (g/mol)	Chemical structure
isopentyl alcohol	129	88.1	$\begin{array}{c} \text{CH}_3 \\ \\ \text{H}_3\text{C}-\text{C}-\text{C}-\text{C}-\text{OH} \\ \\ \text{H} \end{array}$
isopentyl acetate	142	130.2	$\begin{array}{c} \text{O} \\ \\ \text{H}_3\text{C}-\text{C}-\text{O}-\text{C}-\text{C}-\text{C}-\text{CH}_3 \\ \\ \text{H} \end{array}$

SAMPLE CHROMATOGRAMS

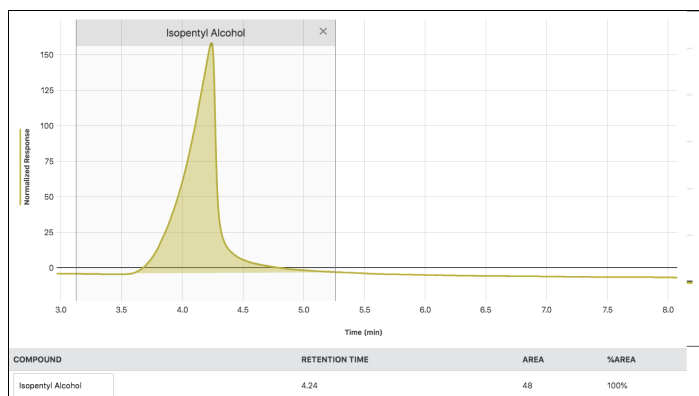


Figure 1 Sample chromatogram of isopentyl alcohol

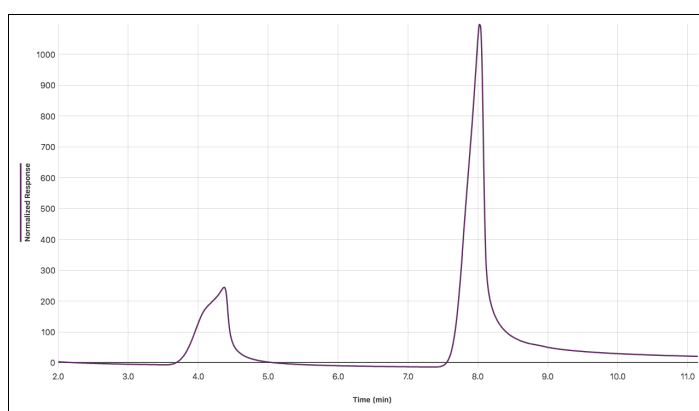


Figure 2 Sample chromatogram of crude isopentyl acetate

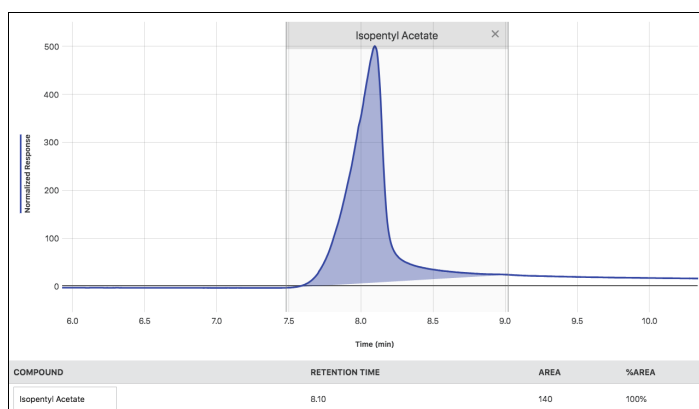


Figure 3 Sample chromatogram of final isopentyl acetate

SAMPLE DATA

Compound	Mass (g)	Retention time (min)	Peak area
isopentyl alcohol	3.87	4.24	48
isopentyl acetate (crude)		8.02	330
isopentyl acetate	2.43	8.10	140

ANSWERS TO DATA ANALYSIS QUESTIONS

1. Answers will vary. Based on the sample data: 140.5°C – 142.0°C
2. Answers will vary. Based on the sample data: $(3.87 \text{ g} - 2.43 \text{ g}) / 3.87 \text{ g} = 37\%$ yield
3. The ester product (isopentyl acetate) smells very sweet, like bananas. Whereas the reactants (acetic acid and isopentyl alcohol) smell much worse, like chemicals.
4. Answers will vary. Based on the sample data, the range is on the lower end of the literature value. This is not unsurprising, given that there was only a 37% yield. Contaminants lowered the boiling point range.