

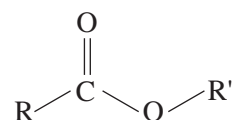
Esters

Performance Goals

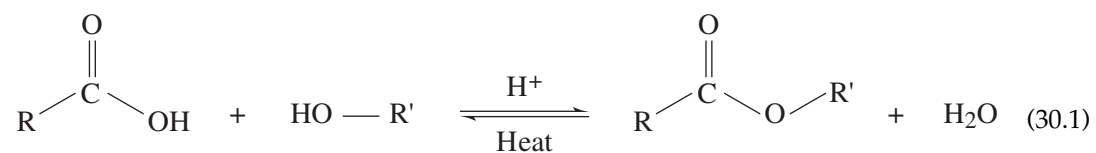
- 30-1 Perform reactions between a series of carboxylic acids and alcohols to form esters.
- 30-2 Identify an unknown ester by its specific odor.

CHEMICAL OVERVIEW

Esters are functional groups of the configuration shown below where R and R' represent alkyl groups (hydrocarbon). Many esters have pleasant aromas, which can be found in natural foodstuffs such as banana oil, pineapples, raspberries, oil of wintergreen, and oranges. Because of their pleasant odor, esters are often added into household products, cleaners, and foods to give them a specific scent. Helping their appeal as odor additives, esters are relatively volatile, meaning that they readily go into the gaseous state where they can be smelled.

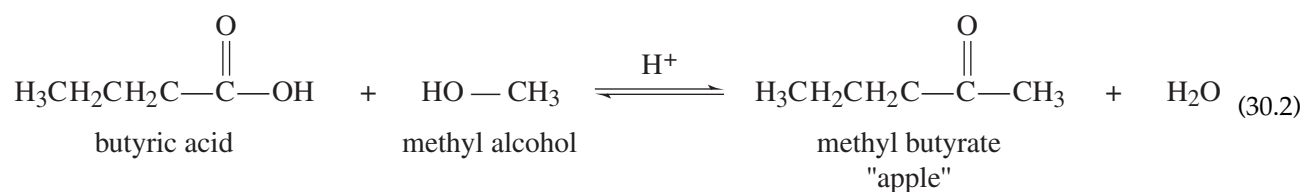


One of the most common ways to synthesize esters is to cause a reaction between an alcohol and a carboxylic acid in the presence of an acid. The acid acts as a catalyst to increase the rate of reaction. This reaction produces an ester and a water molecule.



A specific example would be the formation of methyl butyrate from the carboxylic acid (butyric acid) and the alcohol methyl alcohol. Butyric acid

is associated with the smell of "rancid butter" or "sweat" and the resulting ester smells like "apple."



In this experiment, several esters will be formed from their corresponding alcohol and carboxylic acid. The resulting ester will be identified by its particular odor.

SAFETY PRECAUTIONS AND DISPOSAL METHODS

This experiment requires the use of a concentrated sulfuric acid. If this acid comes into contact with the skin, dab with a paper towel and then rinse the area with plenty of cold water. Be careful when using a water bath. Handle test tubes in the hot-water bath by using a test-tube holder. When smelling chemicals, make sure to waft the fumes toward your nose.

Dispose of the resulting esters in the containers provided.

PROCEDURE

1. Formation of Octyl Acetate

- A. Add 15 drops of 1-octanol and 3 drops of 6 M sulfuric acid to a test tube containing 15 drops of concentrated acetic acid.
- B. Mix the solution thoroughly.
- C. Place the test tube containing the solution in a hot-water bath and heat.
- D. Periodically take the test tube out of the water bath and note the aroma of the solution. The reaction should be complete after approximately 5 minutes. Be careful to waft the fumes toward your nose.

2. Formation of the Remaining Esters

- A. Follow the table below by putting 15 drops of an alcohol and 15 drops of the paired carboxylic acid into a test tube. Add 3 drops of sulfuric acid and heat as outlined in Procedure 1. Note and record the odor of the resulting product.
- B. Note that salicylic acid is a solid and not a liquid. To dissolve the acid, add a small scoop of salicylic acid to 15 drops of ethyl alcohol. Then add 3 drops of 6 M sulfuric acid, and then add the methanol.

3. Unknown Test

Obtain an unknown from your instructor and record the unknown number. Place 3 drops of 6 M sulfuric acid and approximately 5 mL of an unknown into the test tube, and heat in the water bath for at least 5 minutes. Determine the identity of your ester by noting and recognizing its particular odor.

Name

Date

Section

Experiment 30

Advance Study Assignment

1. Write the reaction of pentanoic acid with 1-butanol in the presence of an acid.
2. What is the purpose of adding acid to the synthesis of esters?
3. What alcohol and carboxylic acid are used to form propyl hexanoate?
4. What molecule, besides an ester, is formed when an alcohol and a carboxylic acid react to form an ester?

Name _____

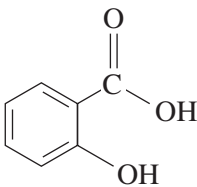

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
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Experiment 30

Work Page

Part 1—Formation of Esters

<i>Carboxylic acid</i>	<i>Alcohol</i>	<i>Structure of resulting ester</i>	<i>Expected odor</i>	<i>Odor of product</i>
$\begin{array}{c} \text{O} \\ \parallel \\ \text{H}_3\text{C}-\text{C}-\text{OH} \end{array}$ Acetic acid	$\text{HO}(\text{CH}_2)_7\text{CH}_3$ Octanol		Orange peelings	
 Salicylic acid	$\text{H}_3\text{C}-\text{OH}$ Methanol		Wintergreen	
$\begin{array}{c} \text{O} \\ \parallel \\ \text{H}_3\text{C}-\text{C}-\text{OH} \end{array}$ Acetic acid	$\text{HO}(\text{CH}_2)_4\text{CH}_3$ Pentanol		Banana oil	
$\begin{array}{c} \text{O} \\ \parallel \\ \text{H}-\text{C}-\text{OH} \end{array}$ Formic acid	$\begin{array}{c} \text{CH}_3 \\ \\ \text{HOH}_2\text{C}-\text{C}-\text{CH}_3 \\ \\ \text{H} \end{array}$ Isobutyl alcohol		Raspberry	
$\begin{array}{c} \text{O} \\ \parallel \\ \text{H}_3\text{C}-\text{C}-\text{OH} \end{array}$ Acetic acid	$\text{HOH}_2\text{C}-$  Benzyl alcohol		Jasmine	

$\begin{array}{c} \text{O} \\ \parallel \\ \text{H}_3\text{CH}_2\text{C}-\text{C}-\text{OH} \end{array}$ Propanoic acid	HOCH ₂ CH ₃ Ethanol		Rum	
$\begin{array}{c} \text{O} \\ \parallel \\ \text{H}_3\text{CH}_2\text{CH}_2\text{C}-\text{C}-\text{OH} \end{array}$ Butyric acid	H ₃ C—OH Methanol		Apple	
$\begin{array}{c} \text{O} \\ \parallel \\ \text{H}_3\text{CH}_2\text{CH}_2\text{C}-\text{C}-\text{OH} \end{array}$ Butyric acid	HOCH ₂ CH ₃ Ethanol		Pineapple	
$\begin{array}{c} \text{O} \\ \parallel \\ \text{H}_3\text{CH}_2\text{CH}_2\text{C}-\text{C}-\text{OH} \end{array}$ Butyric acid	HOH ₂ C—  Benzyl alcohol		Cherry	

Part 2—Identity of an Unknown Ester

Unknown number _____

Odor of unknown:

Draw the structure of the unknown.

Name _____

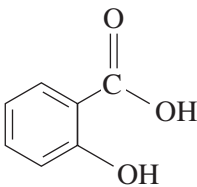
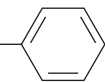
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
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Experiment 30

Report Sheet

Part 1—Formation of Esters

<i>Carboxylic acid</i>	<i>Alcohol</i>	<i>Structure of resulting ester</i>	<i>Expected odor</i>	<i>Odor of product</i>
$\begin{array}{c} \text{O} \\ \parallel \\ \text{H}_3\text{C}-\text{C}-\text{OH} \end{array}$ Acetic acid	$\text{HO}(\text{CH}_2)_7\text{CH}_3$ Octanol		Orange peelings	
 Salicylic acid	$\text{H}_3\text{C}-\text{OH}$ Methanol		Wintergreen	
$\begin{array}{c} \text{O} \\ \parallel \\ \text{H}_3\text{C}-\text{C}-\text{OH} \end{array}$ Acetic acid	$\text{HO}(\text{CH}_2)_4\text{CH}_3$ Pentanol		Banana oil	
$\begin{array}{c} \text{O} \\ \parallel \\ \text{H}-\text{C}-\text{OH} \end{array}$ Formic acid	$\begin{array}{c} \text{CH}_3 \\ \\ \text{HOH}_2\text{C}-\text{C}-\text{CH}_3 \\ \\ \text{H} \end{array}$ Isobutyl alcohol		Raspberry	
$\begin{array}{c} \text{O} \\ \parallel \\ \text{H}_3\text{C}-\text{C}-\text{OH} \end{array}$ Acetic acid	$\text{HOH}_2\text{C}-$  Benzyl alcohol		Jasmine	

$\begin{array}{c} \text{O} \\ \parallel \\ \text{H}_3\text{CH}_2\text{C}-\text{C}-\text{OH} \end{array}$ Propanoic acid	HOCH_2CH_3 Ethanol		Rum	
$\begin{array}{c} \text{O} \\ \parallel \\ \text{H}_3\text{CH}_2\text{CH}_2\text{C}-\text{C}-\text{OH} \end{array}$ Butyric acid	$\text{H}_3\text{C}-\text{OH}$ Methanol		Apple	
$\begin{array}{c} \text{O} \\ \parallel \\ \text{H}_3\text{CH}_2\text{CH}_2\text{C}-\text{C}-\text{OH} \end{array}$ Butyric acid	HOCH_2CH_3 Ethanol		Pineapple	
$\begin{array}{c} \text{O} \\ \parallel \\ \text{H}_3\text{CH}_2\text{CH}_2\text{C}-\text{C}-\text{OH} \end{array}$ Butyric acid	$\text{HOH}_2\text{C}-$  Benzyl alcohol		Cherry	

Part 2—Identity of an Unknown Ester

Unknown number _____

Odor of unknown:

Draw the structure of the unknown.