



## CCMR Educational Programs

<b>Title:</b>	<b>Esterfication</b>
<b>Date Created:</b>	July 21, 2006
<b>Author(s):</b>	Frank La Gatta
<b>Appropriate Level:</b>	Regents and Honors Chemistry
<b>Abstract:</b>	<p>An ester is produced when an organic acid reacts with an alcohol in a reaction called esterification. In the synthesis of an ester the functional group <math>-OH</math> of an alcohol and the <math>-COOH</math> of a carboxyl group combine to form the <math>-COO</math> group of an ester. The functional group for the ester is responsible for many of its physical and chemical properties. Many esters occur naturally and are responsible for distinctive odors and flavors. Esters are used in perfumes and artificial flavors.</p>
<b>Time Requirement:</b>	Three 45-minute class periods
<b>NY Standards Met:</b>	<ul style="list-style-type: none"><li>• V11.3 Functional groups have distinctive physical and chemical properties to organic compounds. (3.1hh)</li><li>• V11.6 Types of Organic reactions: Esterification</li></ul>
<b>Resources</b>	<ul style="list-style-type: none"><li>• <a href="http://www.en.wikipedia.org/wiki/esters">http://www.en.wikipedia.org/wiki/esters</a></li><li>• <a href="http://www.chemguide.co.uk/organicprops/esters/background.html">http://www.chemguide.co.uk/organicprops/esters/background.html</a></li><li>• <a href="http://home.att.net/~cat6a/org_chem-X.htm">http://home.att.net/~cat6a/org_chem-X.htm</a></li><li>• <a href="http://departments.oxy.edu/tops/Esters/esterspre-post.htm">http://departments.oxy.edu/tops/Esters/esterspre-post.htm</a></li></ul>
<b>Equipment/Materials List:</b>	<p>Molecular model kits Artificial flavorings(banana extract) Hot plates Beakers (400ml) Test tubes (medium size) Stirring rods Alcohols: 3-methyl -1-butanol           1- butanol           Benzyl alcohol           Methanol Organic Acids: Acetic acid                   Butanoic acid                   Salicylic acid Concentrated sulfuric acid Filter paper Safety: well ventilated room           Fume hood</p>

	Goggles Aprons Gloves Sodium Bicarbonate
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## Desk Top Demonstration

**Purpose:** To demonstrate to students how esters are synthesized.  
To illustrate to students that esters generally have pleasant odors.

**Materials:** 1 beaker  
1 test tube  
1 stirring rod  
Hot plate  
Organic acid (acetic acid)  
Alcohol (iso- amyl alcohol)  
Watch glass  
Filter paper  
Concentrated sulfuric acid

**Safety:** Goggles  
Well Ventilated Room  
Fume Hood

**Procedure:** Fill beaker half fill of water, heat (do not boil) on the hot plate.  
Add 2ml of an alcohol to 2 ml of an organic acid to the test tube.  
Add 2 drops of concentrated sulfuric acid to the test tube.  
To mix contents of test tube, tap the bottom of the tube with your finger.  
Place the test tube in hot water for a few minutes.  
Place filter paper on watch glass.  
Dip stirring rod into the test tube and wet the filter paper by tipping the stirring rod to the paper.

**Observation:** Have students record any noticeable changes in the reaction. Have students try to identify the odor of the ester.

**Conclusion:** Students should be able to discuss the synthesis of an ester.  
Students should be able to name one property of an ester.

## Organic Functional Groups

Directions: Fill in the table below. Use the molecular model kits to help draw and visualize the structures of the organic compounds.

Class of Compound	Functional Group	Molecular Formula	Structural Formula	Name the Compound
Alcohol	-OH	CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> OH		
Ether	-O-			diethyl ether
Aldehyde		CH <sub>3</sub> CHO		
Ketone	$\begin{array}{c} \text{O} \\    \\ \text{-C-} \end{array}$			propanone
Organic Acid	$\begin{array}{c} \text{O} \\    \\ \text{-C-OH} \end{array}$		$\begin{array}{c} \text{H O} \\      \\ \text{H-C-C-O-H} \\   \\ \text{H} \end{array}$	
Ester	$\begin{array}{c} \text{O} \\    \\ \text{C-O} \end{array}$	CH <sub>3</sub> COOC <sub>8</sub> H <sub>17</sub>		
Amine	$\begin{array}{c}   \\ \text{-N-} \end{array}$			<b>methylamine</b>

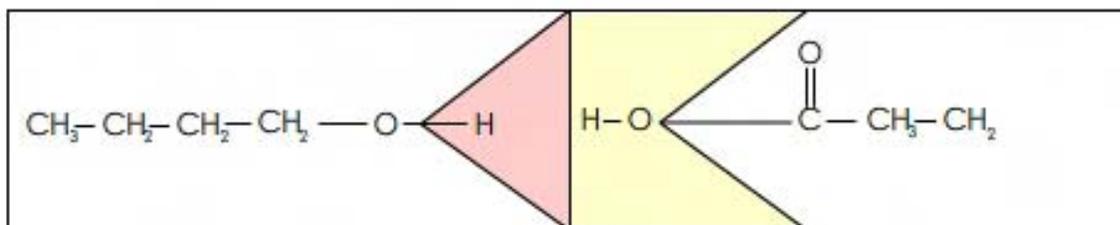
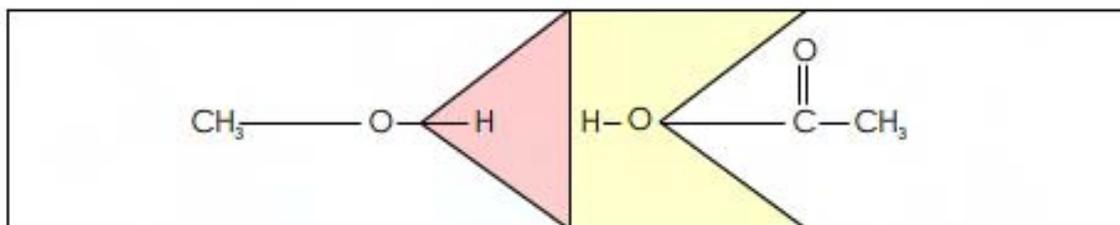
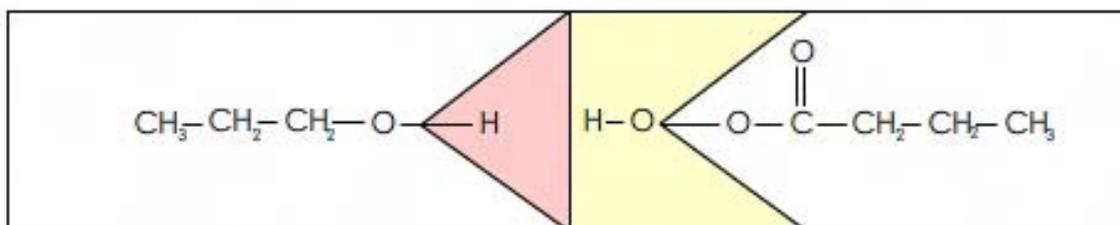
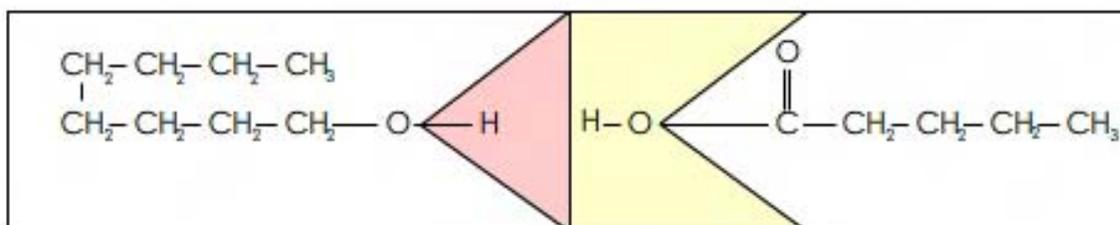
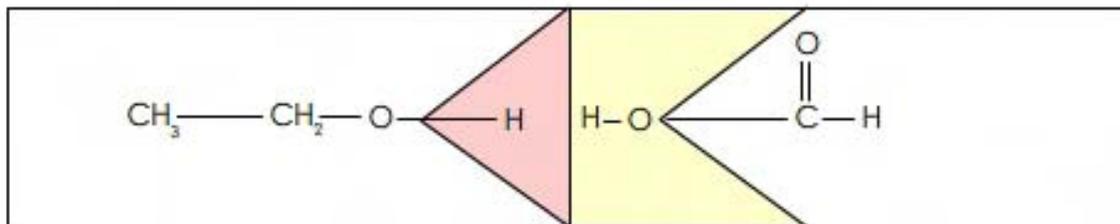
## Esterification

### Directions:

- Cut the individual alcohol and acid rectangles on the following page. Match the appropriate alcohol rectangle with an acid rectangle to obtain the following five esters:
- 1. ethyl pentanoate
- 2. octyl acetate
- 3. propyl methanoate
- 4. butyl butanoate
- 5. methyl propanoate

Cut off the OH of the acid and H portion of the alcohol (represents the loss of the water).

Paste the portions of the rectangles in the number provided below indicating the correct products formed when each of the esters are produced.



1.

2.

3.

4.

5.

**Part B.**

Write structures for five more esters formed from the same five alcohols and acids. Write the names of the esters synthesized.

## Preparation of Esters

**Pre- Lab Discussion:** Esters are responsible for the smell of many fruits and perfumes. In this experiment, a microscale technique is used to prepare four different esters. The esters are identified by their odors.

**Objectives:** Students will use qualitative skills to determine the esters formed in this lab. Students will combine small amounts of organic acids and alcohols, heat them in a hot water bath, pour the products into water and identify it by its odor.

**Safety:** Goggles must be worn. An apron may be worn. The concentrated sulfuric acid is hazardous. Wash spills immediately with large amounts of water. Neutralize spills with sodium bicarbonate. All organic acids and alcohols are poisonous. Organic acids and alcohols are flammable. Heat gently, and keep away from open flames. Use a hot plate instead of a Bunsen burner. Methyl alcohol is absorbed by the skin. Wash yourself with soap and water if you spill some on yourself. All reactions should be done in a fume hood. Never smell mixtures directly under your nose. Instead, carefully waft the vapors toward your nose.

**Disposal:** The chemical products can be diluted with water and disposed of down the drain.

**Materials:** test tubes(13 x 100- mm), test tube rack, test tube tongs, beakers(250 ml), beakers(400 ml), hot plate, spatula, dropper bottles, Organic acids ( acetic acid (ethanoic acid), butyric acid (butanoic acid), salicylic acid), Organic alcohols ( isopentyl alcohol, n- octyl alcohol, methyl alcohol, ethyl alcohol), sulfuric acid .

**Procedure:**

1. Organize the test tubes according to the data table and be sure they are labeled so they can be identified.
2. Add 10 drops of each unknown acid to 12 drops of the unknown alcohol to a clean dry test tube according to the data table.
3. Add 2 drops of concentrated sulfuric acid. If the acid is solid use the amount which will cover the end of a small spatula.
4. Gently warm the reaction mixture using a hot plate. Do not let the mixture boil.
5. Pour the contents of the each test tube into separate beakers of water.
6. Carefully waft the vapors coming from the beaker toward your nose.
7. Enter your observations of the reaction in the boxes provided on the data table. Be sure to identify the odor and name the ester.

**Analysis:**

1. Write the name of the four esters formed and identify their odors on the data table.
2. The solutions used in this lab are the following:
  1. acetic acid
  2. salicylic acid
  3. butyric acid or butanoic acid
  4. n octyl alcohol
  5. ethyl alcohol
  6. isopentyl alcohol
  7. methyl alcohol

3. The following clues should be used to help with the elimination portion of the qualitative analysis:
  1. methyl butyrate – odor of apples
  2. n octyl acetate- odor of oranges
  3. isopentyl acetate- odor of banana oil
  4. methyl salicylate- odor of wintergreen
  
4. Using your observations, data table and clues provided, identify each of the seven solutions.
  - A.
  - B.
  - C.
  - a.
  - b.
  - c.
  - d.

Important: A, B, C, dropper bottles are the organic acids  
a, b, c, d, dropper bottles are the alcohols

- Conclusion:
1. What reaction involves carboxylic acids and alcohols?
  2. What is the structural formula for an alcohol?
  3. What is the structural formula for a carboxylic acid?
  4. Why is concentrated sulfuric acid added to the mixture of acid and alcohol?
  5. What are two properties of esters?
  6. Write the four reactions for the esters formed in question 3 in the analysis. Include the structural formulas for the reactants and products.

Data Table  
ORGANIC ACIDS

		A	B	C
A L C O H O L S	a			
	b			
	c			
	d			