

Name: _____
Lab Partner: _____
Date: _____
Class Period: _____

Ester Synthesis Lab (Student Handout)

Lab Report Components:

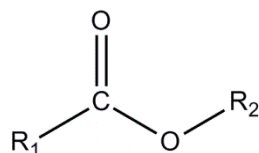
The following must be included in your lab book in order to receive full credit.

1. Purpose
2. Hypothesis
3. Procedure
4. Observation/Data Table
5. Results
6. Mechanism (In class)
7. Conclusion

Introduction

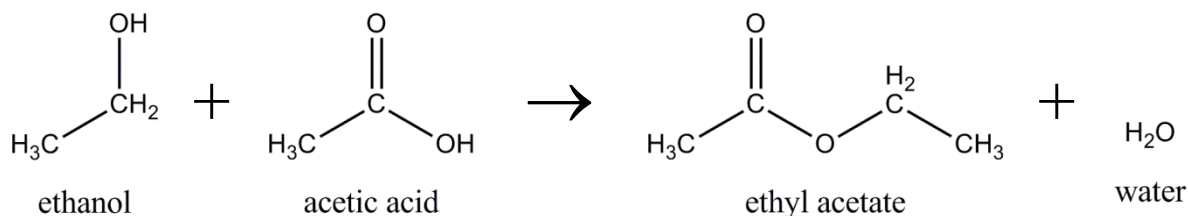
The compounds you will be making are also naturally occurring compounds; the chemical structure of these compounds is already known from other investigations.

Esters are organic molecules of the general form:



where R_1 and R_2 are any carbon chain. Esters are unique in that they often have strong, pleasant odors. As such, they are often used in fragrances, and many artificial flavorings are in fact esters.

Esters are produced by the reaction between alcohols and carboxylic acids. For example, reacting ethanol with acetic acid to give ethyl acetate is shown below.



In the case of ethyl acetate, R_1 is a CH_3 group and R_2 is a CH_3CH_2 group.

Naming esters systematically requires naming the functional groups on both sides of the bridging oxygen. In the example above, the right side of the ester as shown is a CH_3CH_2

group, or ethyl group. The left side is $\text{CH}_3\text{C}=\text{O}$, or acetate. The name of the ester is therefore ethyl acetate. Deriving the names of the side from the carboxylic acid merely requires replacing the suffix $-\text{ic}$ with $-\text{ate}$.

Materials

- Alcohol
 - 1
 - 2
 - 3
 - 4
- Carboxylic Acid
 - A
 - B
 - C

Observation Parameters:

- Record the combination of carboxylic acid and alcohol
- Observe each reactant
- Observe each product

Procedure

1. Construct a data table that lists each ester to be synthesized, along with the alcohol and carboxylic acid you will use in the synthesis reaction. Provide space to note observations about the properties of each reactant and product. Your teacher will review and approve your data table before you begin.
 - a. **You will make a total of three combinations!!**
2. Before you begin, put on your goggles, and wear them properly throughout the investigation.
3. Prepare a hot-water bath by adding ~50 mL tap water to a 100-mL beaker. Place the beaker on a hot plate, and heat the water until it is near boiling ($60\text{-}70^\circ\text{C}$). Be sure that no flames or sparks are in the area. (Note: Use a hot plate, not a Bunsen burner, to heat the water bath.)
4. Obtain a small, clean test tube. Place 20 drops of the appropriate alcohol into the tube. Next add 0.1 g or 60 drops of the carboxylic acid (as identified in your table). Then add 2 drops of concentrated sulfuric acid to the tube.
 - a. Caution: Concentrated sulfuric acid is corrosive and will cause burns to skin or fabric. Add the acid slowly and very carefully. If any sulfuric acid accidentally spills on you, ask a classmate to notify your teacher immediately. Wash the affected area immediately with tap water and continue rinsing for several minutes. Other than water and sulfuric acid, the substances used in this investigation are volatile and flammable.
5. As you dispense these compounds, record any observations you notice.
6. Place the test tube in the hot-water bath you prepared using a test tube clamp.

7. Keep the tube in the hot water, and do not spill the contents.
8. Continue heating for five minutes.
9. While this is heating, fill an Erlenmeyer flask about 1/3 way full with water.
10. Once heating is finished, carefully add the combination of the acid and alcohol to the flask.
11. Repeat Steps 3 through 7 using 20 drops of alcohol and 60 drops or 0.1 g (depending upon physical state) of carboxylic acid, along with 2 drops of concentrated sulfuric acid for each of the esters in your table. (Caution: Avoid inhaling any test tube C fumes)
12. Dispose of your products as directed by your teacher.
13. Wash your hands thoroughly before leaving the laboratory.

Observation/Results

*Make a detailed data table to record the combination of carboxylic acid and alcohols and the observations that go along with that.

Results/Mechanism

1. Write the chemical reactions for each of the esters produced in the above procedures.

Conclusion

1. Octanol, methanol, propanol and n-butanol contain what functional group of all alcohols?
2. Acetic acid and salicylic acid contain what functional group characteristic of all carboxylic acids?
3. The esters produced in this laboratory experiment contain what functional group characteristic of all ester?
4. Isobutyl alcohol and formic acid combine to produce a raspberry odor. Predict the name of the ester.

Teacher Information

- Here are the mixtures and labels

| Carboxylic Acid | Alcohol | Ester | Scent |
|--------------------|-----------------|-------------------|-------------|
| Salicylic Acid (A) | Methanol (1) | Methyl salicylate | Wintergreen |
| Propanoic Acid (B) | Methanol (1) | Methyl propionate | Rum |
| Ethanoic acid (C) | Butan-1-ol (2) | Butyl Ethanoate | Banana |
| Ethanoic Acid (C) | Octan-1-ol (3) | Octyl Ethanoate | Orange |
| Ethanoic acid (C) | Propan-1-ol (4) | Propyl Ethanoate | Pear |

In this investigation, students will synthesize esters. The esters produced have very familiar and pleasing fragrances. Many perfumes and artificial flavorings contain esters. In fact, the characteristic aromas of many herbs and fruits arise from esters found naturally in those plants. The compounds your students will be making are also naturally occurring compounds; the chemical structure of these compounds is already known from other investigations. Note how the functional groups of the acid and alcohol combine to form a water molecule, while the remaining atoms join to form an ester molecule. Construct a data table that lists each ester to be synthesized, along with the alcohol and carboxylic acid you will use in the synthesis reaction. Provide space to note observations about the properties of each reactant and product.

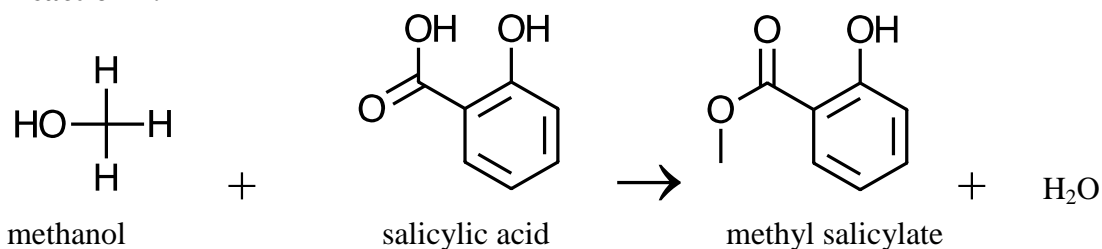
ANSWERS

Results/Mechanism

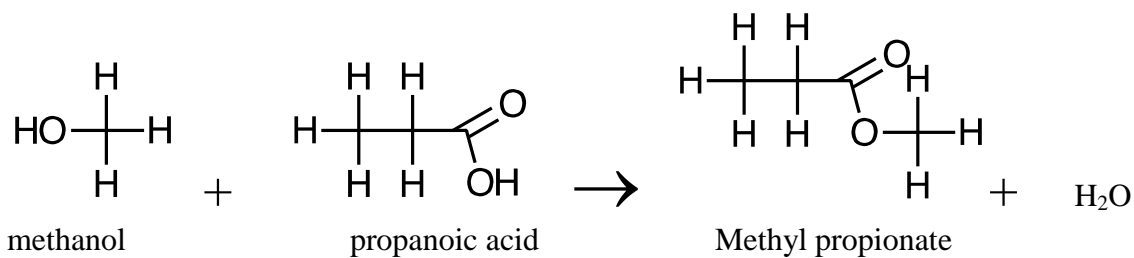
- Write the chemical reactions for each of the esters produced in the above procedures.

| Reaction # | Carboxylic Acid | Alcohol | Ester | Scent |
|------------|--------------------|-----------------|-------------------|-------------|
| 1 | Salicylic Acid (A) | Methanol (1) | Methyl salicylate | Wintergreen |
| 2 | Propanoic Acid (B) | Methanol (1) | Methyl propionate | Rum |
| 3 | Ethanoic acid (C) | Butan-1-ol (2) | Butyl Ethanoate | Banana |
| 4 | Ethanoic Acid (C) | Octan-1-ol (3) | Octyl Ethanoate | Orange |
| 5 | Ethanoic acid (C) | Propan-1-ol (4) | Propyl Ethanoate | pear |

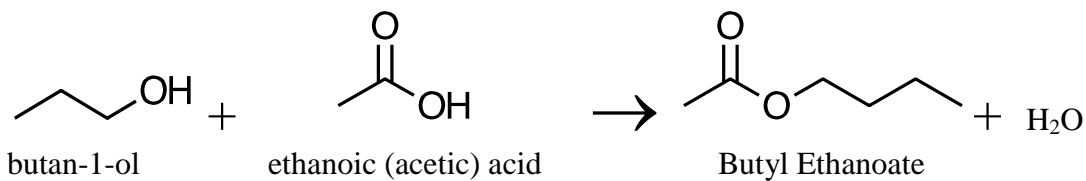
Reaction 1:



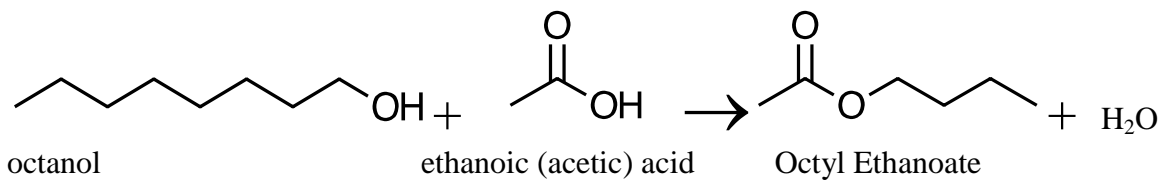
Reaction 2:



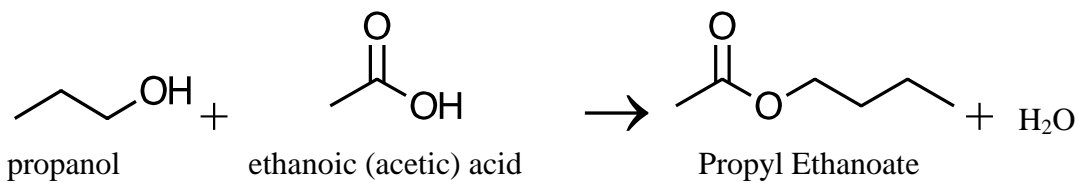
Reaction 3:



Reaction 4:



Reaction 5:



Conclusion

- Octanol, methanol, propanol and n-butanol contain what functional group of all alcohols?
 - OH
- Acetic acid and salicylic acid contain what functional group characteristic of all carboxylic acids?
 - COOH
- The esters produced in this laboratory experiment contain what functional group characteristic of all ester?
 - COOR
- Isobutyl alcohol and formic acid combine to produce a raspberry odor. Predict the name of the ester.
 - Isobutyl formate

Nylon Synthesis-Demonstration Explanation

Explanation: (Adapted from Flinn Scientific Demonstration Kit)

Nylon is a generic name for a family of polyamide polymers. It is a condensation polymer since HCl or H₂O is formed from each extension of the polymer chain. This polymer was discovered at Dupont in 1935. Its usefulness was quickly determined and was commercially used during World War II in clothing and parachutes. Nylon is a thermoplastic and can be molded into shapes or extruded in a fiber. Due to this fact, nylon is very useful being used in athletic apparel, bristles, rugs and carpets, sails, parachutes and much more.

