Esters

**Introduction**

**Purpose** To synthesize smells (esters) in the lab using chemicals.

**Discussion**

Esters have the general chemical formula written as: **R-COO-R’.** They are known for their pleasant odors, and are commonly used in fragrances and artificial flavoring in foods (pineapple, cherry, pear, grape, banana, apple). Esters are also found in “essential oils” (An oil is "essential" in the sense that it carries a distinctive scent, or essence, of the plant.) and pheromones. Esters (along with organic acids) are main ingredients in aspirin, soaps, detergents.

* Use the video link and internet for results:

[**http://somup.com/c3VeYpZfMa**](http://somup.com/c3VeYpZfMa) **(3:08)**

**Materials** Hot Plate 2 250 ml Beakers Beaker Tongs Soap

Large Test Tube Test Tube Holder Test Tube Brush Stirring Rod

2 50 ml Beakers 10 ml Graduated Cylinder

**Chemicals** Iso-amyl alcohol n-propyl alcohol Ethyl alcohol Methyl alcohol

Octyl alcohol Benzyl alcohol Acetic acid Butyric acid

## Salicylic acid **Concentrated Sulfuric acid**

Esters are normally added as artificial flavorings to many kinds of foods. Candy and ice cream are two foods containing esters. Esters can be synthesized using an alcohol and an organic acid. We will attempt to produce our own esters, which can naturally be found in bananas, oranges, pears, wintergreen and other familiar foods.

# Procedures

1. Add 100 ml of water to a 250 ml beaker. Place this on a hot plate. Set the hot plate on “High” until the water is almost boiling. Then, turn the hot plate to “Low”. Keep the temperature between 60 – 100 C.
2. Obtain a large test tube and test tube holder (tongs). Have the teacher add 2 ml of an alcohol, 2 ml of an organic acid and 1 ml of sulfuric acid into the large test tube.
3. Place the test tube in the beaker of hot water for several minutes. MAKE SURE THE TEST TUBE IS POINTING TOWARDS THE WINDOW WALL. Keep the test tube holder (tongs) attached. DO NOT ALLOW THE SOLUTION TO BOIL ... IT BECOMES A CANON!
4. After several minutes use a waving motion towards your nose to try and detect a smell. NEVER SMELL DIRECTLY by placing your nose on the test tube. ALWAYS USE A WAVING MOTION to direct odors towards your nose.
5. If there is no smell, place the test tube back in the hot water for more time and try to smell the odor again using a waving motion. You may need to repeat this procedure several times until you smell something.
6. Identify the smell and record this on the calculations and data sheet.
7. Complete the Calculations and Data Sheet.
8. Use the video link and internet to find the appropriate ester (if necessary).

[**http://somup.com/c3VeYpZfMa**](http://somup.com/c3VeYpZfMa) **(3:08)**

# Data Table of Smells

|  |  |  |
| --- | --- | --- |
| Alcohol Used | **Organic Acid Used** | **Observed Smell** |
| Iso-amyl alcohol | Acetic acid |  |
| n-propyl alcohol | Acetic acid |  |
| Ethyl alcohol | Butyric acid |  |
| Methyl alcohol | Butyric acid |  |
| Iso-amyl alcohol | Salicylic acid |  |
| Benzyl alcohol | Acetic acid |  |
| Ethyl alcohol | Acetic acid |  |
| Methyl alcohol | Salicylic acid |  |
| Methyl alcohol | Acetic acid |  |
| Octyl Alcohol | Acetic Acid |  |

# Conclusions and Questions

1. Which of the smells gave the most distinct or noticeable odors? In other words, which “flavors” were easiest to identify?

2. What other industry besides food processing relies on esters?

3. Throughout the lab, you were told to use a waving motion when smelling the odors. Why should you NEVER directly smell an unknown chemical or any chemicals known to be dangerous?

4. What is the general equation for producing Esters. What type of biochemical process is it?

5. Show the specific chemical reaction that took place for the ester you produced. (Give name and formulas for reactants and products)

# ANSWER KEY

# Data Table of Smells

|  |  |  |
| --- | --- | --- |
| Alcohol Used | **Organic Acid Used** | **Observed Smell** |
| Iso-amyl alcohol | Acetic acid | *Banana (slow reaction)* |
| n-propyl alcohol | Acetic acid | *Pear* |
| Ethyl alcohol | Butyric acid | *Pineapple* |
| Methyl alcohol | Butyric acid | *Apple* |
| Iso-amyl alcohol | Salicylic acid | *Rancid fruit (orange color)* |
| Benzyl alcohol | Acetic acid | *Peach* |
| Ethyl alcohol | Acetic acid | *Glue / nail polish* |
| Methyl alcohol | Salicylic acid | *Wintergreen* |
| Methyl alcohol | Acetic acid | *Perfume* |
| Octyl Alcohol | Acetic Acid | *Orange* |

# Conclusions and Questions

1. Which of the smells gave the most distinct or noticeable odors? In other words, which “flavors” were easiest to identify?

*Isoamyl acetate (banana)*

*Isoamyl salicylate (rancid fruit)*

*Methyl salicylate (winter green)*

1. What other industry besides food processing relies on esters?

*perfumes, glues, nail polish, soaps, shampoo*

1. Throughout the lab, you were told to use a waving motion when smelling the odors. Why should you NEVER directly smell an unknown chemical or any chemicals known to be dangerous?

The dangerous chemical may severely damage nasal passages … if one does not know the identity, one should assume it is dangerous to they won’t damage nasal tissues.

1. What is the General Equation for Producing Esters? What type of Biochemical Process is it?

*carboxylic acid + alcohol 🡪 ester + water*

*Dehydration Synthesis*

1. Show the specific chemical reaction that took place for the ester you produced. (Give name and formulas for reactants and products)

*See next page*

**alcohols:**

n-butyl alcohol CH3(CH2)2CH2OH, or, C4H9OH

octyl alcohol CH3(CH2)7OH, or, C8H17OH

amyl alcohol CH3(CH2)4OH, or, C5H11OH

ethanol C2H5OH

methanol CH3OH

**carboxylic acids:**

acetic CH3COOH

butyric CH3CH2CH2COOH

salicylic HOC6H4COOH (*this is a benzene ring with an HO branch and COOH branch*)

The general equation for the “**dehydration synthesis**” reaction is:

carboxylic acid + alcohol 🡪 ester + water

*The -OH functional group is removed from the acid and the -H is removed from the alcohol, forming the ester and a new water molecule.*

The reaction between acetic acid and iso-amyl alcohol to make pineapple:

O CH3 O CH3 H

|| | || | |

CH3-C-**OH**  + CH2CH2CHCH3 🡪 CH3-C-O-CH2CH2CHCH3 + O−H

|

O**H**

The reaction between butyric acid and ethyl alcohol to make banana:

O O H

|| || |

CH3CH2CH2-C-**OH**  + CH2CH2-O**H** 🡪 CH3CH2CH2-C-O-CH2CH2 + O−H

The reaction between salicylic acid and methanol to make wintergreen:

O O H

|| || |

HOC6H4-C-**OH**   + H3C-O**H** 🡪 HOC6H4-C-O-CH3 + O−H