Synthesis of Esters

Problem: Produce an ester that smells like bananas using a combinatorial chemistry approach.

Combinatorial chemistry is a technology for producing large numbers of diverse, but related compounds. The pharmaceutical, agrochemical, and biotechnology industries use combinatorial chemistry to reduce the time and cost associated with the discovery of new drugs, pesticides, and peptides. Instead of making one compound at a time and testing it for desirable properties, hundreds of compounds are made and tested at the same time.

In this experiment we are interested in making an ester that smells like bananas. Knowing that esters are made from a carboxylic acid and an alcohol, you could systematically react all the carboxylic acids and alcohols available in our storeroom until you find a pair that produces a banana ester. Or we can begin with four different carboxylic acids and four different alcohols and have the class work together to produce the sixteen different possible esters. Even if this first attempt does not produce the banana ester, you may make other esters of future interest.

Pre-laboratory Assignment

1. Draw the condensed structural formula for these carboxylic acids, which are used in this experiment.

| benzoic acid | salicylic acid | acetic acid | anthranilic acid |

2. Draw the condensed structural formula for these alcohols, which are used in this experiment.

| methanol | ethanol | 1-propanol | 3-methyl-1-butanol |
3. Using condensed structural formulas, write a balanced chemical equation for the reaction of benzoic acid and ethanol.

4. What is the procedure for safely detecting the odor of chemicals?
Procedures

**Caution:** Glacial acetic acid and sulfuric acid are corrosive.

1. Assemble a hot water bath by half filling a 400 mL beaker with tap water and heating it on a hot plate. Maintain a temperature of 80–85 °C

2. In a test tube measure either 0.2 g (solid) or 10 drops (liquid) of your assigned carboxylic acid, 20 drops of your assigned alcohol, and 5 drops of sulfuric acid. Swirl to mix well. Place in hot water bath for 30 minutes. Continue to mix with a stirring rod until the solution is homogeneous (no solid remains).

   **Note:** If you are assigned anthranilic acid use 60 drops of alcohol and 15 drops of sulfuric acid. Add the sulfuric acid very slowly because the reaction is exothermic.

3. Remove the test tube and pour the ester into a small beaker containing about 2 mL of distilled water. Cautiously smell the ester.

4. After all sixteen esters have been synthesized by the class, cautiously smell each one and record your observations in the grid below.

5. Dispose of your ester in the waste beaker. Dispose of your test tube in the broken glass container.

**Experimental Data and Observations**

<table>
<thead>
<tr>
<th></th>
<th>benzoic acid</th>
<th>salicylic acid</th>
<th>acetic acid</th>
<th>anthranilic acid</th>
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</thead>
<tbody>
<tr>
<td>methanol</td>
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<tr>
<td>ethanol</td>
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<tr>
<td>1-propanol</td>
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<tr>
<td>3-methyl-1-butanol</td>
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Post-Laboratory Questions

1. a. Which carboxylic acid and alcohol pair produces an ester with a banana odor?

   b. Draw the condensed structural formula for the banana ester.

2. Draw the condensed structural formula of the ester you synthesized.

3. In an attempt to make an even better banana ester, suggest three new carboxylic acids and three new alcohols to test along side the original pair.