Saturated and Unsaturated Fats

Plants and animals both store energy in the bonds of chemical substances. The stored energy is used later. The energy stored in plant seeds is used to support rapid growth of the young plant after germination. Animals use the stored energy when food sources are not available.

Organisms store energy as fats and oils, which are mixtures of triglycerides. Triglycerides are esters of long chain carboxylic acids and glycerol. Each molecule of a triglyceride is made from one molecule of glycerol and three molecules of fatty acids.

The formula for a triglyceride may vary because (a) the length of the fatty acid chains may vary from 14 to 24 carbon atoms; (b) a triglyceride may contain as many as three different fatty acids; and (c) the bonding between adjacent carbon atoms may consist of combinations of single and/or double covalent bonds.

The general formula for a triglyceride is shown at the right. In this formula, R, R', and R'' represent fatty acid chains. These groups may be identical to or different from each other.

In a saturated fatty acid, only single bonds are found between carbon atoms. The term saturated indicates that the carbon atoms of the chain contain all the hydrogen atoms that can be attached. Saturated fats contain only saturated fatty acid chains. A fatty acid with one or more double bonds in the chain is said to be unsaturated, that is, more hydrogen atoms can be attached. Unsaturated fats contain one double bond in the fatty acid chain. Polyunsaturated fats contain several double bonds.

Lauric, myristic, palmitic, and stearic fatty acids make up most of the saturated fatty acids found in fats. Oleic acid, linoleic acid, and linolenic acid are the most abundant unsaturated fatty acids found in oils.

The main difference between oils and fats is that oils are liquid at room temperature and fats are solid at room temperature. Oils, such as olive oil or corn oil, usually come from plant sources and contain mainly unsaturated fatty acids. Fats, such as butter and lard, contain an abundance of saturated fatty acids and generally come from animal sources.

Saturated and unsaturated fatty acids have different chemical properties. Halogens can be easily added to fats that contain carbon-carbon double bonds. The reaction may be shown as \( I_2 + R-CH=CH-R' \rightarrow R-CHI-CHI-R' \).

In this activity, iodine solution is used to detect and estimate the degree of unsaturation in fats. The red-brown color of iodine will disappear when an iodine solution is added to an unsaturated fat. The red-brown color of the iodine will be retained when the solution is added to a saturated fat.
Problem
What is the relative amount of saturated and unsaturated fatty acids in sample triglycerides?

Objectives
- **Differentiate** between saturated fats and unsaturated fats.
- **Determine** the relative amount of saturation or unsaturation in samples of triglycerides.

Materials
- test tubes (9)
- test-tube rack
- 10-ml graduated cylinder
- dropper
- glass stirring rod
- coconut oil
- butter
- vegetable shortening
- olive oil
- corn oil
- cottonseed oil
- soybean oil
- linseed oil
- tincture of iodine
- 600-ml beaker
- test-tube holder
- hot plate

Safety Precautions
- Always wear safety goggles, a lab apron, and gloves.
- Dispose of chemical wastes as directed by your teacher.
- Broken glassware can easily puncture or slice skin.
- Tincture of iodine may be a tissue irritant.
- Iodine is toxic.

Pre-Lab
1. Explain how a saturated fat, an unsaturated fat, and a polyunsaturated fat are different.
2. What are two main differences between a fat and an oil?
3. Write an equation to show iodine reacting with an unsaturated hydrocarbon.
4. Read over the entire activity. Form a hypothesis about how a change in color of a halogen can be used to predict the degree of saturation of a fatty acid. Record your hypothesis in the next column.

Procedure
1. Affix labels to nine test tubes. Place your name on each label and number the test tubes 1 through 9.
2. Test tube 1 is a control. Add 1 mL of water to this test tube.
3. As detailed in Data Table 1, add 1 mL of each specified fat or oil to each of the remaining eight test tubes. Heat all tubes in a hot water bath until the solid fats melt.
4. Add 3 drops of tincture of iodine to each test tube.
5. Using a stirring rod, stir the contents of each test tube to evenly distribute the iodine. Clean the stirring rod between each tube.
6. Using a test-tube holder, return the test tubes to the rack and begin observing the color changes at 1-minute intervals for 3 minutes. In Data Table 1, record your observations using this code: 0 = no fading of iodine color; 1 = some fading of iodine color; and 2 = color of iodine completely gone.
7. Determine the degree of unsaturation based on the color changes. Use an arbitrary scale of 1 to 3, where 3 is the most unsaturated.

Hypothesis


Cleanup and Disposal
1. Dispose of chemicals as instructed by your teacher.
2. Return all lab equipment to its proper place.
3. Report any broken or damaged equipment.
4. Wash your hands thoroughly before leaving the lab.
# Data and Observations

<table>
<thead>
<tr>
<th>Test-tube number</th>
<th>Material tested</th>
<th>Color after 1 min (0–2)</th>
<th>Color after 2 min (0–2)</th>
<th>Color after 3 min (0–2)</th>
<th>Degree of unsaturation (1–3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>control</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>olive oil</td>
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<tr>
<td>3</td>
<td>coconut oil</td>
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<tr>
<td>4</td>
<td>corn oil</td>
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<td>5</td>
<td>cottonseed oil</td>
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<td>7</td>
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</tr>
<tr>
<td>9</td>
<td>melted vegetable shortening</td>
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</tr>
</tbody>
</table>

## Analyze and Conclude

1. **Observing and Inferring**  Which fats or oils showed a lesser fading of the iodine color?

2. **Observing and Inferring**  Which fats or oils showed a greater fading of the iodine color?

3. **Observing and Inferring**  What does the different degree of fading of the iodine color indicate about the bond patterns of the substances tested?

4. **Observing and Inferring**  What type of bond pattern results in the greatest degree of color change of the iodine?

5. **Thinking Critically**  What was the function of test tube 1?
6. **Drawing a Conclusion** Do animal fats or vegetable oils generally contain the greater amount of saturated fat?

7. **Drawing a Conclusion** Why were observations made after 1, 2 and 3 minutes, respectively?

8. **Error Analysis** What possible sources of error may account for inaccurate results?

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**Real-World Chemistry**

1. Hydrogenation is the process of adding hydrogen to vegetable oils to make them solid. Explain what happens to the carbon-carbon bonds in the oils when the hydrogen is added.

2. Fats and oils react with oxygen from the air and produce aldehydes and acids that have unpleasant odors and tastes. Where in the fat molecules is the oxidation most likely to take place?