Learning Objectives

• Describe the structural difference between an alcohol and an ether that affects physical characteristics and reactivity of each.
• Name simple ethers.
• Describe the structure and uses of some ethers.

With the general formula \( \text{ROR'} \), an ether may be considered a derivative of water in which both hydrogen atoms are replaced by alkyl or aryl groups. It may also be considered a derivative of an alcohol (ROH) in which the hydrogen atom of the OH group is been replaced by a second alkyl or aryl group:

\[
\text{HOH} \xrightarrow{\text{replace both}} \text{ROR'} \xleftarrow{\text{replace H: atom}} \text{ROH}
\]

Simple ethers have simple common names, formed from the names of the groups attached to oxygen atom, followed by the generic name ether. For example, \( \text{CH}_3\text{OCH}_2\text{CH}_3 \) is methyl propyl ether. If both groups are the same, the group name should be preceded by the prefix di-, as in dimethyl ether \( \text{CH}_3\text{OCH}_3 \) and diethyl ether \( \text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_3 \).

Ether molecules have no hydrogen atom on the oxygen atom (that is, no OH group). Therefore there is no intermolecular hydrogen bonding between ether molecules, and ethers therefore have quite low boiling points for a given molar mass. Indeed, ethers have boiling points about the same as those of alkanes of comparable molar mass and much lower than those of the corresponding alcohols (Table \( \PageIndex{1} \)).

<table>
<thead>
<tr>
<th>Condensed Structural Formula</th>
<th>Name</th>
<th>Molar Mass</th>
<th>Boiling Point (°C)</th>
<th>Intermolecular Hydrogen Bonding in Pure Liquid?</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{CH}_3\text{CH}_2\text{CH}_3 )</td>
<td>propane</td>
<td>44</td>
<td>–42</td>
<td>no</td>
</tr>
<tr>
<td>( \text{CH}_3\text{OCH}_3 )</td>
<td>dimethyl ether</td>
<td>46</td>
<td>–25</td>
<td>no</td>
</tr>
<tr>
<td>( \text{CH}_3\text{CH}_2\text{OH} )</td>
<td>ethyl alcohol</td>
<td>46</td>
<td>78</td>
<td>yes</td>
</tr>
<tr>
<td>( \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3 )</td>
<td>pentane</td>
<td>72</td>
<td>36</td>
<td>no</td>
</tr>
<tr>
<td>( \text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_3 )</td>
<td>diethyl ether</td>
<td>74</td>
<td>35</td>
<td>no</td>
</tr>
<tr>
<td>( \text{CH}_3\text{CH}_2\text{CH}_2\text{OH} )</td>
<td>butyl alcohol</td>
<td>74</td>
<td>117</td>
<td>yes</td>
</tr>
</tbody>
</table>

Ether molecules do have an oxygen atom, however, and engage in hydrogen bonding with water molecules. Consequently, an ether has about the same solubility in water as the alcohol that is isomeric with it. For example, dimethyl ether and ethanol (both having the molecular formula \( \text{C}_2\text{H}_6\text{O} \)) are completely soluble in water, whereas diethyl ether and 1-butanol (both \( \text{C}_4\text{H}_{10}\text{O} \)) are barely soluble in water (8 g/100 mL of water).
Example \(\PageIndex{1}\)

What is the common name for each ether?

a. \(\text{CH}_3\text{CH}_2\text{CH}_2\text{OCH}_2\text{CH}_2\text{CH}_3\)

\[
\text{CH}_3 \overset{\text{OCH}_2}{\text{CH}_3}
\]

b. 

SOLUTION

a. The carbon groups on either side of the oxygen atom are propyl (\(\text{CH}_3\text{CH}_2\text{CH}_2\)) groups, so the compound is dipropyl ether.

b. The three-carbon group is attached by the middle carbon atom, so it is an isopropyl group. The one-carbon group is a methyl group. The compound is isopropyl methyl ether.

Exercise \(\PageIndex{1}\)

What is the common name for each ether?

a. \(\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OCH}_2\text{CH}_2\text{CH}_2\text{CH}_3\)

b. 

To Your Health: Ethers as General Anesthetics

A *general anesthetic* acts on the brain to produce unconsciousness and a general insensitivity to feeling or pain. Diethyl ether (\(\text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_3\)) was the first general anesthetic to be used.

William Morton, a Boston dentist, introduced diethyl ether into surgical practice in 1846. This painting shows an operation in Boston in 1846 in which diethyl ether was used as an anesthetic. Inhalation of ether vapor produces unconsciousness by depressing the activity of the central nervous system. Source: Painting of William Morton by Ernest
Board.

Diethyl ether is relatively safe because there is a fairly wide gap between the dose that produces an effective level of anesthesia and the lethal dose. However, because it is highly flammable and has the added disadvantage of causing nausea, it has been replaced by newer inhalant anesthetics, including the fluorine-containing compounds halothane, enflurane, and isoflurane. Unfortunately, the safety of these compounds for operating room personnel has been questioned. For example, female operating room workers exposed to halothane suffer a higher rate of miscarriages than women in the general population.

These three modern, inhalant, halogen-containing, anesthetic compounds are less flammable than diethyl ether.

Summary

To give ethers common names, simply name the groups attached to the oxygen atom, followed by the generic name ether. If both groups are the same, the group name should be preceded by the prefix di-. Ether molecules have no OH group and thus no intermolecular hydrogen bonding. Ethers therefore have quite low boiling points for a given molar mass. Ether molecules have an oxygen atom and can engage in hydrogen bonding with water molecules. An ether molecule has about the same solubility in water as the alcohol that is isomeric with it.

Concept Review Exercises

1. Why does diethyl ether (CH₃CH₂OCH₂CH₃) have a much lower boiling point than 1-butanol (CH₃CH₂CH₂CH₂OH)?

2. Which is more soluble in water—ethyl methyl ether (CH₃CH₂OCH₃) or 1-butanol (CH₃CH₂CH₂CH₂OH)? Explain.

Answers

1. Diethyl ether has no intermolecular hydrogen bonding because there is no OH group; 1-butanol has an OH and engages in intermolecular hydrogen bonding.

2. Ethyl methyl ether (three carbon atoms, one oxygen atom) is more soluble in water than 1-butanol (four carbon atoms, one oxygen atom), even though both can engage in hydrogen bonding with water.
Exercises

1. How can ethanol give two different products when heated with sulfuric acid? Name these products.

2. Which of these ethers is isomeric with ethanol—CH₃CH₂OCH₂CH₃, CH₃OCH₂CH₃, or CH₃OCH₃?

3. Name each compound.
   a. CH₃OCH₂CH₂CH₃
      ![Structure of CH₃OCH₂CH₂CH₃]
   b.

4. Name each compound.
   a. CH₃CH₂CH₂CH₂OCH₃
   b. CH₃CH₂OCH₂CH₂CH₃

5. Draw the structure for each compound.
   a. methyl ethyl ether
   b. tert-butyl ethyl ether

6. Draw the structure for each compound.
   a. diisopropyl ether
   b. cyclopropyl propyl ether

Answers

1. Intramolecular (both the H and the OH come from the same molecule) dehydration gives ethylene; intermolecular (the H comes from one molecule and the OH comes from another molecule) dehydration gives diethyl ether.

3. a. methyl propyl ether
   b. ethyl isopropyl ether

5. a. CH₃OCH₂CH₃
b.