Objectives

After completing this section, you should be able to

1. write two acceptable names for a simple dialkyl ether, given its Kekulé, shorthand or condensed structure.
2. name a complicated ether by the IUPAC system, given its Kekulé, shorthand or condensed structure.
3. draw the Kekulé, condensed or shorthand structure of an ether, given an acceptable name.
4. explain why the boiling point of an ether is generally higher than that of an alkane of similar molecular mass.

Structure of Ethers

Aliphatic ethers have no aryl groups directly attached to the ether oxygen.

\[
\text{H}_3\text{C}-\text{O-CH}_2\text{CH}_3
\]  
\[
\text{H}_3\text{CCH}_2\text{C}-\text{O-CH}_2\text{CH}_3
\]

Examples of Aliphatic Ethers

Aromatic ethers have at least one aryl ring directly attached to the ether oxygen. In aryl ethers, the lone pair electrons on oxygen are conjugated with the aromatic ring which significantly changes the properties of the ether.

\[
\text{O-CH}_2\text{CH}_3
\]  
\[
\text{O-CH}_2\text{CH}_3
\]

Example of Aromatic Ethers

The sp\(^3\) hybridization of oxygen gives ethers roughly the same geometry as alcohols and water. The R-O-R' bond angle is close to what is expected in a tetrahedral geometry. The bond angle of dimethyl ether is 112° which is larger than the H-O-H bond angle in water (104.5°) due to the steric repulsion of the methyl groups.
The presence of an electronegative oxygen atom gives ethers a small dipole moment.

\[ \mu = 1.3 \text{ D} \]

Comparisons of Physical Properties of Alcohols and Ethers

Ethers, unlike alcohols, have no hydrogen atom on the oxygen atom (that is, no OH group). Therefore, there is no intermolecular hydrogen bonding between ether molecules, which makes their boiling points much lower than an alcohol with similar mass. Despite the presence of a small dipole moment, ethers have boiling points that are about the same as alkanes of comparable molar mass. (Table 18.1.2).

<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>CH₃CH₂CH₃</td>
<td>propane</td>
<td>44</td>
<td>-42</td>
<td>no</td>
</tr>
<tr>
<td>CH₃OCH₃</td>
<td>dimethyl ether</td>
<td>46</td>
<td>-25</td>
<td>no</td>
</tr>
<tr>
<td>CH₃CH₂OH</td>
<td>ethyl alcohol</td>
<td>46</td>
<td>78</td>
<td>yes</td>
</tr>
<tr>
<td>CH₃CH₂CH₂CH₂CH₃</td>
<td>pentane</td>
<td>72</td>
<td>36</td>
<td>no</td>
</tr>
<tr>
<td>CH₃CH₂OCH₂CH₃</td>
<td>diethyl ether</td>
<td>74</td>
<td>35</td>
<td>no</td>
</tr>
<tr>
<td>CH₃CH₂CH₂CH₂OH</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 C₂H₆O) are completely soluble in water, whereas diethyl ether and 1-butanol (both C₄H₁₀O) are barely soluble in water (8 g/100 mL of water).

**Peroxide Formation**

Many ethers can react with oxygen to form explosive peroxide compounds in a free radical process called autoxidation. For this reason ethers should not be stored for long periods of time and should not be stored in glass bottles. The danger is particularly acute when ether solutions are distilled to near dryness. The hydroperoxides can become more concentrated during a distillation because they tend to have a slightly higher boiling point than the corresponding ether. Before performing an ether distillation great care should be taken to test for the presence of peroxides.

![Reaction](image)

**Naming Ethers**

When no other functional group is present, simple ethers are often given common functional class names. Both alkyl groups attached to the oxygen atom are named as substituents (in alphabetical order) and then the word *ether* is added. The common names for alkyl substituents discussed in Section 3.3 are often used.

Example

<table>
<thead>
<tr>
<th>Methyl tert-butyl ether</th>
<th>Diethyl ether</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Methyl tert-butyl ether" /></td>
<td><img src="image" alt="Diethyl ether" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Diisopropyl ether</th>
<th>Cyclohexyl cyclopentyl ether</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Diisopropyl ether" /></td>
<td><img src="image" alt="Cyclohexyl cyclopentyl ether" /></td>
</tr>
</tbody>
</table>

IUPAC nomenclature for ethers should be used for complicated ethers, compounds with more than one ether linkage, and compounds where other functional groups are present with an ether. In these cases, an RO group of the ether is named as an alkoxy substituent.

Common alkoxy substituents are given names derived from their alkyl component. The suffix -yl is replaced with -oxy.
(Table 18.1.1):

<table>
<thead>
<tr>
<th>Alkyl Group</th>
<th>Name</th>
<th>Alkoxy Group</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH₃–</td>
<td>Methyl</td>
<td>CH₃O–</td>
<td>Methoxy</td>
</tr>
<tr>
<td>CH₃CH₂–</td>
<td>Ethyl</td>
<td>CH₃CH₂O–</td>
<td>Ethoxy</td>
</tr>
<tr>
<td>(CH₃)₂CH–</td>
<td>Isopropyl</td>
<td>(CH₃)₂CHO–</td>
<td>Isopropoxy</td>
</tr>
<tr>
<td>(CH₃)₃C–</td>
<td>tert-Butyl</td>
<td>(CH₃)₃CO–</td>
<td>tert-Butoxy</td>
</tr>
<tr>
<td>C₆H₅–</td>
<td>Phenyl</td>
<td>C₆H₅O–</td>
<td>Phenoxy</td>
</tr>
</tbody>
</table>

Example \[\PageIndex{2}\])

Propoxybenzene  1-Isopropoxy cyclopentene  

2-Methoxy hexane  Cis-1,3-Dimethoxy cyclohexane

Cyclic Ethers

In cyclic ethers are a type of heterocycle with one or more oxygens located in the ring. Many cyclic ethers have common names and are often used as solvents due to their inert nature. These ring structures are often found in biological molecules such as sugars and DNA. The rings are numbered so that an oxygen gets position 1.
Example (PageIndex{3})

\[
\begin{align*}
\text{2-Methoxytetrahydrofuran} & \quad \text{3-Methyltetrahydropyran}
\end{align*}
\]

Exercise (PageIndex{1})

Please name the following ethers:

a)

b)
g) 4-Butoxycyclohexene

Contributors and Attributions

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