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

Ethers are a class of organic compounds that contain an oxygen between two alkyl groups. They have the formula R-O-R', with R's being the alkyl groups. These compounds are used in dye, perfumes, oils, waxes and industrial use. Ethers are named as alkoxyalkanes. An aliphatic ether is an ether in the molecule of which there are no aryl groups on the ether group, eg:

![Structure of a simple dialkyl ether](image)

An ether molecule may contain aryl groups, nevertheless, be an aliphatic ether. eg:

![Structure of a more complex ether](image)

Naming Ethers

Ethers are compounds having two alkyl or aryl groups bonded to an oxygen atom, as in the formula R1–O–R2. The ether functional group does not have a characteristic IUPAC nomenclature suffix, so it is necessary to designate it as a substituent. To do so the common alkoxy substituents are given names derived from their alkyl component (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>
</tbody>
</table>
The smaller, shorter alkyl group becomes the alkoxy substituent. The larger, longer alkyl group side becomes the alkane base name. Each alkyl group on each side of the oxygen is numbered separately. The numbering priority is given to the carbon closest to the oxygen. The alkoxy side (shorter side) has an "-oxy" ending with its corresponding alkyl group. For example, \((\text{CH}_3\text{CH}_2\text{CH}_2\text{OH})\text{CH}_2\text{CH}_3\text{O}-\text{CH}_2\text{CH}_2\text{CH}_3\) is 1-propoxypentane. If there is cis or trans stereochemistry, the same rule still applies.

Example 18.1.1

Examples of ethers include \(\text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_3\), diethyl ether (sometimes referred to as ether), and \(\text{CH}_3\text{OCH}_2\text{CH}_2\text{OCH}_3\), ethylene glycol dimethyl ether (glyme).

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Common names

Simple ethers are given common names in which the alkyl groups bonded to the oxygen are named in alphabetical order followed by the word "ether". The top left example shows the common name in blue under the IUPAC name. Many simple ethers are symmetrical, in that the two alkyl substituents are the same. These are named as "dialkyl ethers".

Heterocycles

In cyclic ethers (heterocycles), one or more carbons are replaced with oxygen. Often, it's called heteroatoms, when carbon is replaced by an oxygen or any atom other than carbon or hydrogen. In this case, the stem is called the oxacycloalkane, where the prefix "oxa-" is an indicator of the replacement of the carbon by an oxygen in the ring. These compounds are numbered starting at the oxygen and continues around the ring. For example,

If a substituent is an alcohol, the alcohol has higher priority. However, if a substituent is a halide, ether has higher
priority. If there is both an alcohol group and a halide, alcohol has higher priority. The numbering begins with the end that is closest to the higher priority substituent. There are ethers that are contain multiple ether groups that are called **cyclic polyethers** or **crown ethers**. These are also named using the IUPAC system.

Exercise (PageIndex{1})

Name the following ethers:

ETHER PROBS.bmp

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**Answer**

1. diethyl ether
2. 2-ethoxy-2-methyl-propane
3. cis-1-ethoxy-2-methoxycyclopentane
4. 1-ethoxy-1-methylcyclohexane
5. oxirane
6. 2,2-dimethyloxirane

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**Common names of some ethers**

**Edit section**

- anisole

\[
\begin{align*}
\text{methoxybenzene, methyl phenyl ether}
\end{align*}
\]

- oxirane
1,2-epoxyethane, ethylene oxide, dimethylene oxide, oxacyclopropane,

- furan (this compound is aromatic)

- tetrahydrofuran

oxacyclopentane, 1,4-epoxybutane, tetramethylene oxide,

- dioxane

1,4-dioxacyclohexane

**Comparisons of Physical Properties of Alcohols and Ethers**

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 18.1.2).

**Table 18.1.2 Comparison of Boiling Points of Alkanes, Alcohols, and Ethers**

<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>Condensed Structural Formula</td>
<td>Name</td>
<td>Molar Mass</td>
<td>Boiling Point (°C)</td>
<td>Intermolecular Hydrogen Bonding in Pure Liquid?</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>----------------</td>
<td>------------</td>
<td>-------------------</td>
<td>-----------------------------------------------</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).

**Exercises**

**Questions**

**Q18.1.1**

Give the IUPAC name for the following chemical structures.

(a)

(b)

(c)
Q18.1.2

Draw structures of the following.

(a) 3-isopropoxypentane (b) 1-(4-chlorophenoxy)-3-methylbenzene (c) 2-(tert-butoxy)-2-methylpropane

Q18.1.3

Name the following ethers and sulfides.

(a)

(b)

(c)

(d)
Solutions

S18.1.1

(a) oxydicyclopentane  (b) 2-phenyloxirane  (c) 1-cyclohexylethane-1-thiol

S18.1.2

(a)
(a) diisopropylsulfide (b) 1,3-dimethoxybenzene (c) 2-Methyltetrahydro-2H-pyran (d) methyl 3-sulfanylbenzoate (e) methyl(phenyl)sulfide

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