

10.2: Families of Organic Molecules - Functional Groups

Learning Objectives



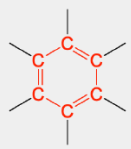
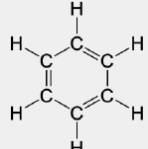


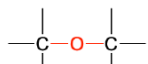
- Identify and describe functional groups in organic molecules.

Organic molecules can be classified into *families* based on structural similarities. Within a family, molecules have similar physical behavior and often have predictable chemical reactivity. The structural components differentiating different organic families involve specific arrangements of atoms or bonds, called **functional groups**. If you understand the behavior of a particular functional group, you can describe the general properties of that class of compounds.

The simplest organic compounds are in the **alkane** family and contain only carbon–carbon and carbon–hydrogen *single* bonds but do not have any specific functional group. Hydrocarbons containing at least one carbon–carbon double bond, (denoted C=C), are in the **alkene** family. **Alkynes** have at least one carbon–carbon triple bond (C≡C). Both carbon–carbon double bonds and triple bonds chemically react in specific ways that differ from reactions of alkanes and each other, making these specific functional groups.

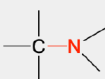



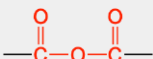
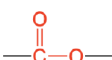
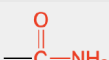

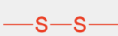

In the next few chapters, we will learn more about additional functional groups that are made up of atoms or groups of atoms attached to hydrocarbons. Being able to recognize different functional groups will help to understand and describe common medications and biomolecules such as amino acids, carbohydrates, and fats. Table 10.2.1 and Figure 10.2.1 below list several of the functional groups to become familiar with as you learn about organic chemistry.

Table 10.2.1 : Organic Families and Functional Groups

Family Name	Functional Structure	Group	Simple Example Structure	Simple Example Name	Name Suffix
alkane	none		CH ₃ CH ₂ CH ₃	propane	-ane
alkene			H ₂ C=CH ₂	ethene (ethylene)	-ene
alkyne			HC≡CH	ethyne (acetylene)	-yne
aromatic				benzene	none
alkyl halide	 (X = F, Cl, Br, I)		CH ₃ CH ₂ Cl	chloroethane	none
alcohol			CH ₃ CH ₂ OH	ethanol	-ol
ether			CH ₃ CH ₂ -O-CH ₂ CH ₃	diethyl ether	none*

Atoms and bonds in red indicate the functional group. Bonds not specified are attached to R groups (carbons and hydrogens).

*Ethers do not have a suffix in their common name; all ethers end with the word *ether*.

Family Name	Functional Structure	Group	Simple Example Structure	Simple Example Name	Name Suffix
amine			$\text{CH}_3\text{CH}_2\text{NH}_2$	ethylamine	<i>-amine</i>
aldehyde			$\text{H}_3\text{C}-\overset{\text{O}}{\parallel}{\text{C}}-\text{H}$	ethanal	<i>-al</i>
ketone			$\text{H}_3\text{C}-\overset{\text{O}}{\parallel}{\text{C}}-\text{CH}_3$	propanone (acetone)	<i>-one</i>
carboxylic acid			$\text{H}_3\text{C}-\overset{\text{O}}{\parallel}{\text{C}}-\text{OH}$	ethanoic acid (acetic acid)	<i>-oic acid</i>
anhydride			$\text{H}_3\text{C}-\overset{\text{O}}{\parallel}{\text{C}}-\text{O}-\overset{\text{O}}{\parallel}{\text{C}}-\text{CH}_3$	acetic anhydride	none
ester			$\text{H}_3\text{C}-\overset{\text{O}}{\parallel}{\text{C}}-\text{O}-\text{CH}_3$	methyl ethanoate (methyl acetate)	<i>-ate</i>
amide			$\text{H}_3\text{C}-\overset{\text{O}}{\parallel}{\text{C}}-\text{NH}_2$	acetamide	<i>-amide</i>
thiol			$\text{CH}_3\text{CH}_2\text{SH}$	ethanethiol	<i>-thiol</i>
disulfide			$\text{CH}_3\text{S}-\text{SCH}_3$	dimethyl disulfide	none
sulfide			$\text{CH}_3\text{CH}_2\text{SCH}_3$	ethyl methyl sulfide	none

Atoms and bonds in red indicate the functional group. Bonds not specified are attached to R groups (carbons and hydrogens).

*Ethers do not have a suffix in their common name; all ethers end with the word *ether*.

FUNCTIONAL GROUPS IN ORGANIC CHEMISTRY

Functional groups are the characteristic groups in organic molecules that give them their reactivity. In the formulae below, R represents the rest of the molecule and X represents any halogen atom.

● Hydrocarbons ● Halogen-containing groups ● Oxygen-containing groups ● Nitrogen-containing groups ● Sulfur-containing groups ● Phosphorus-containing groups

ALKANE Naming: -ane e.g. ethane	ALKENE Naming: -ene e.g. ethene	ALKYNE Naming: -yne e.g. ethyne	ARENE Naming: -yl benzene e.g. ethyl benzene	HALOALKANE Naming: halo- e.g. chloroethane	ALCOHOL Naming: -ol e.g. ethanol	ALDEHYDE Naming: -al e.g. ethanal	KETONE Naming: -one e.g. propanone	CARBOXYLIC ACID Naming: -oic acid e.g. ethanoic acid	ACID ANHYDRIDE Naming: -oic anhydride e.g. ethanoic anhydride
ACYL HALIDE Naming: -oyl halide e.g. ethanoyl chloride	ESTER Naming: -yl -oate e.g. ethyl ethanoate	ETHER Naming: -oxy -ane e.g. methoxyethane	EPOXIDE Naming: -ene oxide e.g. ethene oxide	AMINE Naming: -amine e.g. ethanamine	AMIDE Naming: -amide e.g. ethanamide	NITRATE Naming: -yl nitrate e.g. ethyl nitrate	NITRITE Naming: -yl nitrite e.g. ethyl nitrite	NITRILE Naming: -nitrile e.g. ethanenitrile	NITRO Naming: nitro- e.g. nitromethane
NITROSO Naming: nitroso- e.g. nitrosoethane	IMINE Naming: -imine e.g. ethanimine	IMIDE Naming: -imide e.g. succinimide	AZIDE Naming: -yl azide e.g. phenylazide	CYANATE Naming: -yl cyanate e.g. methyl cyanate	ISOCYANATE Naming: -yl isocyanate e.g. methyl isocyanate	AZO COMPOUND Naming: azo- e.g. azoethane	THIOL Naming: -thiol e.g. methanethiol	SULFIDE Naming: sulfide e.g. dimethyl sulfide	DISULFIDE Naming: disulfide e.g. dimethyl disulfide
SULFOXIDE Naming: sulfoxide e.g. dimethyl sulfoxide	SULFONE Naming: sulfone e.g. dimethyl sulfone	SULFINIC ACID Naming: -sulfinic acid e.g. benzenesulfinic acid	SULFONIC ACID Naming: -sulfonic acid e.g. benzenesulfonic acid	SULFONATE ESTER Naming: -yl sulfonate e.g. methylmethanesulfonate	THIOCYANATE Naming: thiocyanate e.g. ethyl thiocyanate	ISOTHIOCYANATE Naming: isothiocyanate e.g. ethyl isothiocyanate	THIAL Naming: -thial e.g. ethanethial	THIOKETONE Naming: -thione e.g. propanethione	PHOSPHINE Naming: phosphine e.g. methylphosphane



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Figure 10.2.1: Functional groups in organic chemistry. (CC BY-NC-ND, CompoundChem.com).

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