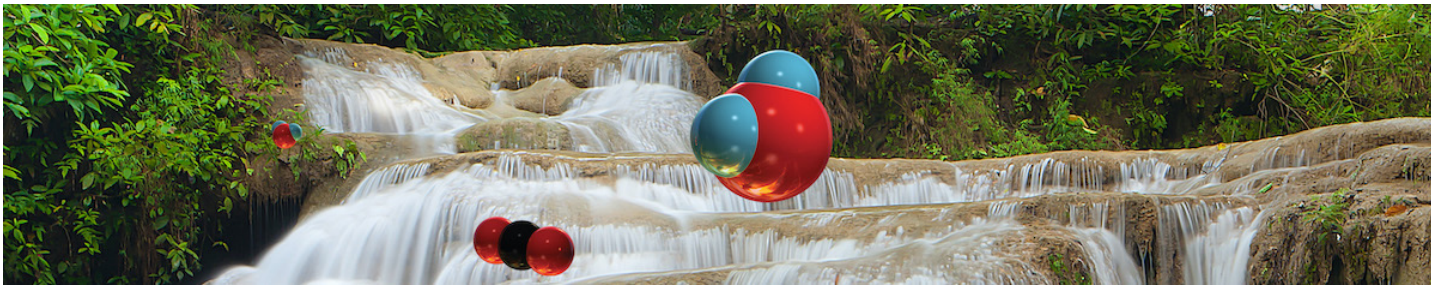
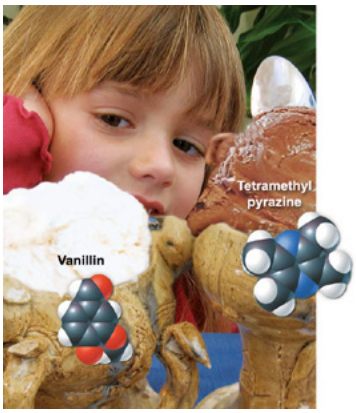


## Chapter 12: Detailed Summary

# Organic Compounds




Carbon atoms are unique in their ability to form bonds with themselves repeatedly. One carbon atom, for example, can bond to another carbon atom, which can bond to another and so on, resulting in a near infinite number of possible structures. The simplest organic compounds are the hydrocarbons, which consist of only carbon and hydrogen. All hydrocarbons are nonpolar and they are generally used as fuels and for the creation of petrochemicals, such as plastic. Hydrocarbons that have the same chemical formula but different chemical structures are called *structural isomers*, where *iso* means "same," and *mer* means "parts."

How the atoms are connected within a molecule is called its *configuration*. Two structural isomers have the same chemical formula, but different configurations. A related term is *conformation*, which is the spatial orientation of a particular configuration. Carbon-carbon single bonds can twist. Thus, a chain of carbon atoms can twist into many different spatial orientations, or "conformations," just as your arm can bend and twist into many different conformations.

Most hydrocarbons are obtained from crude oil, which is a complex mixture of many different kinds of hydrocarbons. The hydrocarbons are isolated by heating the crude oil and passing the vapors through a fractional distillation column. High-boiling-point hydrocarbons, such as tar, condense at the bottom of the column, where it is still quite warm. Low-boiling-point hydrocarbons, such as gasoline, don't condense until reaching the top of the column, where it is cooler.

A hydrocarbon with only single covalent bonds is said to be "saturated". If there are one or more multiple covalent bonds, such as double or triple bonds, then the hydrocarbon is said to be "unsaturated." Saturated hydrocarbons end with –ane, as in butane, $C_4H_{10}$, while unsaturated hydrocarbons end with –ene, as in butene, $C_4H_8$.

The great diversity of organic structures arises not only from the near infinite number of ways that carbon atoms can be linked together but also by the ability of carbon to bond to other atoms, such as oxygen and nitrogen. Nonhydrogen and noncarbon atoms within an organic compound are called *heteroatoms*. Their effects on the chemical and physical properties of the organic compound are great. There are about a dozen or so different structures that heteroatoms generally form. These structures are called *functional groups*. The more common functional groups are presented in Table 12.2.

*Alcohols* are a class of organic compounds that contain the hydroxyl functional group, –OH. Alcohols tend to be soluble in water. Classic examples include methanol, (wood alcohol), ethanol (grain alcohol), and 2-propanol (rubbing alcohol). A related class of compounds are the *phenols*, which contain a hydroxyl group attached to a benzene ring. Alcohols also tend to have relatively high boiling points because the hydroxyl group forms hydrogen bonds, which, as discussed in Chapter 7, are strong dipole–dipole attractions.

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*Ethers* are organic compounds in which an oxygen atom is bonded to two carbon atoms. They tend to be insoluble in water and have relatively low boiling points because they lack the polar hydroxyl group. Diethyl ether was used in the mid-1800s as the world's first general anesthetic, which permitted advances in surgery.

The *amine* functional group consists of a nitrogen bonded to one, two, or three saturated carbons. Amines are alkaline because of the nitrogen's ability to accept a hydrogen ion. A group of naturally occurring complex organic molecules that are alkaline because they contain nitrogen atoms are called *alkaloids*. Many alkaloids, such as caffeine, have biological activity, especially in the nervous system. As explored further in Chapter 14, many pharmaceuticals are developed from alkaloids.

The carbonyl group consists of a carbon atom double-bonded to an oxygen atom. It occurs in the organic compounds known as *ketones*, *alkehydes*, *amides*, *carboxylic acids*, and *esters*. Acetone is a ketone that was once widely used for fingernail polish remover. Many aldehydes, such as vanillin, are fragrant. As described in Chapter 13, amide functional groups link together amino acids to make proteins. Carboxylic acids are acidic because of the stability of the carboxylate ion that forms after donation of a hydrogen ion. An ester is much like an ether, except that it also includes an adjacent carbonyl group.

A polymer is a long organic molecule consisting of repeating molecular units called *monomers*. There are two main classes of synthetic polymers, which include the *addition* polymers and the *condensation* polymers. Many of the molecules that make up living organisms are polymers, including DNA, proteins, and cellulose.

The development of modern plastics began in the mid 1800s with the discovery of *vulcanized rubber*, which found innumerable applications, from tires to rain gear. The first widely used plastic was *Bakelite*, which, developed in the early 1900s, was a thermoset polymer that could be molded into various shapes, such as telephones. Polymers played a key role in the outcome of World War II. After the war, polymers were embraced by society. It wasn't until the environmental awakenings of the 1960s that people came to recognize plastic's negative attributes, such as its being nonbiodegradable. Recycling programs started to gain momentum in the 1980s. Today, polymers are used to make flat and flexible monitors. We have polymers that conduct electricity, replace body parts, and are stronger but much lighter than steel.

## Summary of Terms

**Addition polymer** A polymer formed by the joining together of monomer units with no atoms being lost as the polymer forms.

**Alcohol** An organic molecule that contains a hydroxyl group bonded to a saturated carbon.

**Aldehyde** An organic molecule containing a carbonyl group, the carbon of which is bonded either to one carbon atom and one hydrogen atom or to two hydrogen atoms.

**Alkane** A generic word for a saturated hydrocarbon.

**Alkene** An unsaturated hydrocarbon containing one or more double bonds.

**Alkyne** An unsaturated hydrocarbons containing a triple bond.

**Amide** An organic molecule containing a carbonyl group, the carbon of which is bonded to a nitrogen atom.

**Amine** An organic molecule containing a nitrogen atom bonded to one or more saturated carbon atoms.

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**Aromatic** Said of any organic molecule containing a benzene ring.

**Carbonyl group** A carbon atom double-bonded to an oxygen atom; found in ketones, aldehydes, amides, carboxylic acids, and esters.

**Carboxylic acid** An organic molecule containing a carbonyl group, the carbon of which is bonded to a hydroxyl group.

**Condensation polymer** A polymer formed by the joining together of monomer units accompanied by the loss of small molecules, such as water.

**Configuration** A term used to describe how the atoms within a molecule are connected. For example, two structural isomers will consist of the same number and same kinds of atoms, but in different configurations.

**Conformation** One of a wide range of possible spatial orientations of a particular configuration.

**Ester** An organic molecule containing a carbonyl group, the carbon of which is bonded to one carbon atom and one oxygen atom bonded to another carbon atom.

**Ether** An organic molecule containing an oxygen atom bonded to two carbon atoms.

**Functional group** A specific combination of atoms that behaves as a unit in an organic molecule.

**Heteroatom** Any atom other than carbon or hydrogen in an organic molecule.

**Hydrocarbon** An organic compound containing only carbon and hydrogen atoms.

**Ketone** An organic molecule containing a carbonyl group, the carbon of which is bonded to two carbon atoms.

**Monomers** The small molecular units from which a polymer is formed.

**Organic chemistry** The study of carbon-containing compounds.

**Phenol** An organic molecule in which a hydroxyl group is bonded to a benzene ring.

**Polymer** A long organic molecule made of many repeating units.

**Saturated hydrocarbon** A hydrocarbon containing no multiple covalent bonds, with each carbon atom bonded to four other atoms.

**Structural isomers** Molecules that have the same chemical formula but different chemical structures.

**Unsaturated hydrocarbon** A hydrocarbon containing at least one multiple covalent bond.

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