2.3: Alkynes - Structures and Names

Learning Objectives

- Describe the general physical and chemical properties of alkynes.
- Name alkynes given formulas and write formulas for alkynes given names.

Alkynes are hydrocarbons with carbon-carbon triple bonds (R–C≡C–R). These compounds are also called *unsaturated* hydrocarbons because they have fewer hydrogen atoms than does an alkane or alkene with the same number of carbon atoms, as is indicated in the following general formulas:

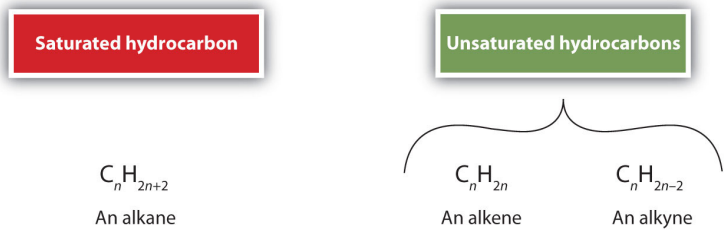


Figure 2.3.1: General molecular formula of saturated and unsaturated hydrocarbons.

Alkynes are similar to alkenes in both physical and chemical properties. The triple bond of an alkyne is shorter and stronger than the double bond of an alkene. The simplest alkyne has the molecular formula C_2H_2 and is known by its common name—acetylene (Figure 2.3.2). Its structure is H–C≡C–H.

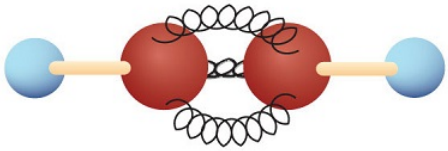


Figure 2.3.2: Ball-and-Spring Model of Acetylene. Acetylene (ethyne) is the simplest member of the alkyne family.

Acetylene is used in oxyacetylene torches for cutting and welding metals. The flame from such a torch can be very hot. Most acetylene, however, is converted to chemical intermediates that are used to make vinyl and acrylic plastics, fibers, resins, and a variety of other products.

Naming Alkynes

The International Union of Pure and Applied Chemistry (IUPAC) names for alkynes parallel those of alkenes, except that the family ending is *-yne* rather than *-ene*. The IUPAC name for acetylene is ethyne. Here are some basic rules for naming alkynes using the IUPAC system:

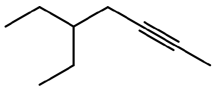


Figure 2.3.3: Skeletal structure of a molecule that will be named as discussing the steps for naming alkynes.

1. The **longest chain of carbon atoms** ***containing both carbon atoms of the triple bond*** is considered the parent chain. It is named using the same stem as the alkane having the same number of carbon atoms but the *-ane* suffix is replaced with *-yne* to identify it as an alkyne. The skeletal structure of alkynes tend to be shown with the geometry of the carbon atoms of the triple bond represented (linear, 180°). *Thus the parent chain is heptyne.*

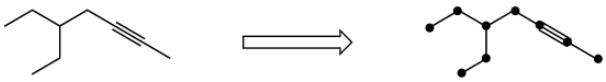
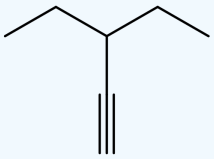
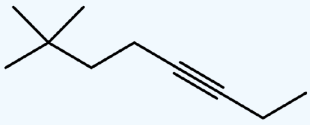


Figure 2.3.3*b*: Illustration of the carbon atoms present in the alkyne. Each dot represents a carbon.

2. If there are four or more carbon atoms in a chain, we must **indicate the position of the triple bond**. The carbons atoms are numbered so that the first of the two that are triple bonded is given the lower of the two possible numbers. Therefore, this representts 2-heptyne (not 5-heptyne).
3. **Substituents are identified (as with other organic compounds) and their location is indicated by a number**. Thus, the structure shown in Figure 2.3.3 is *5-ethyl-2-heptyne*. Note that the numbering of the parent chain is always done in such a way as to give the triple bond the lowest number, even if that causes a substituent to have a higher number. *The triple bond always has priority in numbering.* Also note that cis-trans isomers do not occur in alkynes.

Example 2.3.1

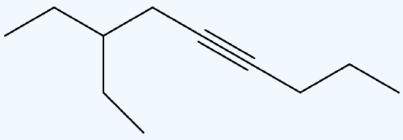
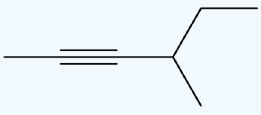
Name each compound.

1. 
2. 

Solution

1. The longest chain containing both carbon of the triple bond has five carbon atoms, so the compound is a *pentyne* (rule 1). To give the first carbon atom of the triple bond the lowest number (rule 2), we number from the bottom of the molecule, so the compound is a 1-pentyne. There is an ethyl group on the third carbon atom (rule 3), so the name of the compound is 3-ethyl-1-pentyne.
2. The longest chain containing both carbon of the triple bond has eight carbon atoms, so the compound is an *octyne* (rule 1). To give the first carbon atom of the triple bond the lowest number (rule 2), we number from right-to-left, so the compound is a 3-octyne. There are two methyl groups and both are attached to the seventh carbon atom (rule 3), so the name of the compound is 7,7-dimethyl-3-octyne.

Exercise 2.3.1

1. Name the following compounds.
   a. 
   b. 
2. Draw the structure for each compound.

a. 4-methyl-2-hexyne
b. 3-octyne
c. 3,4-dimethyl-1-pentyne

Key Takeaway

- Alkynes are hydrocarbons with carbon-carbon triple bonds and properties much like those of alkenes.
- IUPAC nomenclature of alkynes: location and identity of substituents + parent prefix + yne suffix

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