

Objectives for Chapter 13 – Alkynes

I. Introduction to Alkynes

Classifying Alkynes

1. Explain the difference between alkynes and unsaturated compounds with carbon-carbon triple bonds.
2. Identify internal and terminal alkynes.

Hybridization and bond formation

1. Give the hybridization of the carbons in a C \equiv C.
2. Explain how the sigma and two pi bonds are formed in a C \equiv C.
3. Explain how carbon-carbon single, double, and triple bonds compare in length.

Geometry

1. Give the geometry of C \equiv C bonds, and correctly draw alkynes to show this geometry.
2. State how many C's a ring must have in order to contain a C \equiv C and be stable at room temperature.

Stereochemistry

1. Explain why the carbons in a C \equiv C can't be stereocenters, but alkynes can still be chiral.

Molecular formula

1. Explain how to write the molecular formula for an alkyne, and give the formula for an alkyne or cyclic alkyne with a given number of carbons.

Stabilization

1. State whether terminal or internal alkynes are more stable, and why.

Reactivity

1. State the two locations in which an alkyne can react.
2. Show how an alkyne will react with a strong base, a strong acid, or an electrophile.

II. Natural Uses and Occurrences of Alkynes

1. State whether alkynes are common in nature, and give some types of naturally occurring or useful compounds that contain C \equiv C's.

2. Explain how acetylene is used, how it is created, and some safety issues involved in its handling.

III. Physical Properties of Alkynes

1. Give the physical properties of alkynes, including polarity, water solubility, flammability, and odor.

IV. Spectroscopy of Alkynes

1. Give the two IR bands which are characteristic of alkynes.
2. Explain how the IR of terminal and internal alkynes are different, and why.
3. Compare the IR spectra of alkynes with those of alkenes and nitriles.
4. Explain why NMR is not a very useful way of identifying alkynes.

V. Nomenclature of Alkynes

Common names

1. Give common names for simple alkynes, and draw correct structures when given common names.

Systematic (IUPAC) Names

1. List the steps for naming an alkyne.
2. Explain what the priorities are for choosing the principle chain of an alkyne.
3. Explain how to form the name of the principle chain of an alkyne with one C---C, two C---C's, or one C---C and one C=C.
4. Explain the priorities for numbering the principle chain of an alkyne.
5. Explain how to form the name of a substituent containing a C---C, and how to number it.
6. Give correct names for alkynes with one or two C---C's, or one C---C and one C=C.
7. Draw structures for alkynes with correct geometry when give the name.

VI. Acid/base Properties of Alkynes; Synthesis by Substitution

1. Explain why alkynes are weak acids, but not as weak as alkanes or alkenes.
2. Give the pK_a of alkynes, what the conjugate base is called.

3. Explain why bases must have conjugate acid pKa's higher than 26 in order to effectively deprotonate an alkyne, and state what bases are commonly used.
4. Explain what will happen to acetylide ions if they come in contact with acids of pKa less than 26.
5. Explain how acetylide ions react with alkyl halides, and why S_N2 reactions are more useful than E2 reactions.
6. Identify the alkyl halides that would be needed to synthesize a given alkyne from acetylene.
7. Write a reaction or series of reactions that would be needed to synthesize a terminal or internal alkyne from acetylene.
8. Identify alkynes that could not be effectively synthesized using this method.

VII. Synthesis of Alkynes by Elimination

1. Explain the difference between making an alkyne using substitution or elimination.
2. Explain why a stronger base is needed to form an alkyne than to form an alkene.
3. Explain why a second step of water is necessary when forming a terminal alkyne.
4. Show how this reaction could be used in conjunction with addition of X₂ to an alkene to convert an alkene to an alkyne in two steps.

VIII. Reduction to form cis and trans Alkenes and Alkanes

1. Explain how to convert an alkyne to an alkane, a cis alkene, or a trans alkene.
2. For each of these reactions, draw products if given starting material and reagents, or draw starting materials and reagents if given a product, or use the reaction in combination with others to synthesize a product.
3. Explain how reduction to alkanes can be used to show that terminal alkynes are higher in energy than internal alkynes.
4. Explain how the formation of cis alkenes demonstrates the higher reactivity of alkynes.
5. Explain the advantage of the second two reactions over using E2 reactions to synthesize alkenes.

IX. Addition of HX and X₂ to Alkynes

1. Give the product(s) that will form when a given alkyne is reacted with 1 or 2 equivalents of HX or X₂.

2. When given a product, write the starting material and reagents needed to form this product.
3. Give the regioselectivity of the addition of HX to terminal alkynes.
4. Give the stereochemistry of the alkene that results from the addition of 1 equivalent of X_2 to an alkyne.
5. Explain how the regioselectivity of addition of HBr will change in the presence of organic peroxides.

X. Hydration of Alkynes

1. Give the reagents needed for both hydration reactions of alkynes.
2. Draw the tautomerized product that forms after hydration has occurred.
3. Give the regioselectivity for both reactions.
4. Explain how the reagents for hydroboration-oxidation need to be altered when using a terminal alkyne.
5. Give products of these reactions when given starting materials and reagents.
6. Give starting materials and reagents needed to synthesize ketones or aldehydes using these reactions without forming other products.

XI. Oxidation of Alkynes

1. Give products that would form when alkynes are reacted with potassium permanganate, hydroxide and water, or ozone and water.
2. Give starting materials and reagents needed to synthesize diketones or carboxylic acids using these reactions.