Chemistry of Alkynes

Learning Outcomes:

Students will be able to:

1. describe that alkynes are more unsaturated than alkenes.
2. describe that terminal alkynes are acidic.
3. describe that alkynes are more energy producing through combustion.
4. describe the preparation of alkynes from dehydrohalogenation of 1,2-dihalides and dehalogenation of tetrahalides.

Introduction:

Alkynes are unsaturated hydrocarbons which contain a carbon-carbon triple bond (C≡C). The general formula of this class of compound is C_nH_{2n-2} in comparison to C_nH_{2n} for alkenes. Therefore, they contain two hydrogen atoms less than the corresponding alkene. The simplest member of this homologous series (putting n=2) has the molecular formula C_2H_2. Hence this series of hydrocarbons are often refered to as *Acetylenes* and could be represented as:

H-C≡C-H **acetylene**

R-C≡C-R **alkynes (acetylenes)**

where R= alkyl or H. The triple bond present in alkynes:

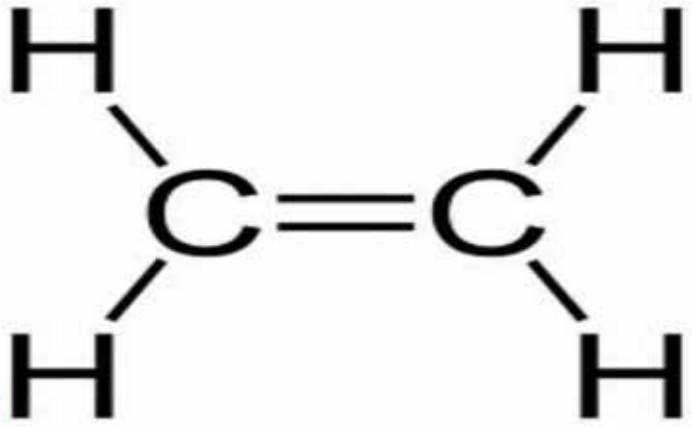
-C≡C- (functional group)

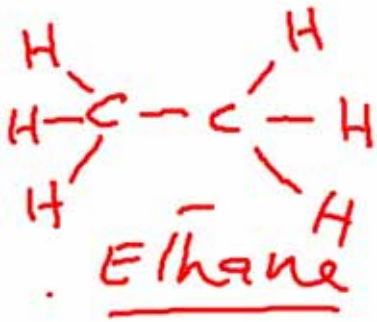
determines their chemical reactivity and constitutes the functional group. This is also named as *acetylenic bond*.

Alkynes are more unsaturated than alkenes:

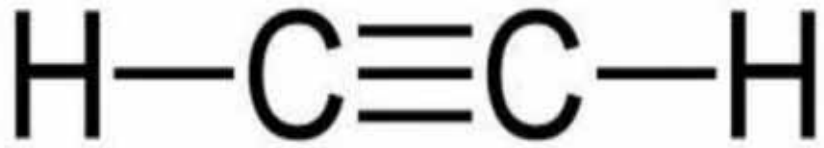
Compounds containing carbon-carbon double bonds or carbon-carbon triple bonds are said to be unsaturated because they do not contain the maximum number of atoms per molecule that the electrons available for bonding would allow. For example methane is a saturated compound due to the presence of four single bonds of carbon with four hydrogens. At the other hand ethylene and acetylene are unsaturated due to the fact that there is a double and a triple bond, between two carbon atoms, respectively.

Ethylene





Acetylene



Acidic nature of Alkynes:

A hydrogen atom attached directly to the carbon of a triple bond can be replaced by metal atoms like Na, Ag and Cu. Such reactions show the acidic nature of 1-alkynes (terminal alkynes). 2-alkynes do not have an acidic hydrogen and, therefore, do not undergo these reactions.

1. Reaction with ammoniacal solution of silver nitrate:

Ethyne and other 1-alkynes react with ammoniacal solution of silver nitrate to give a white precipitate of silver alkynide.

$$H\text{-}C\equiv C\text{-}H + 2AgNO_3 + 2NH_4OH \rightarrow Ag\text{-}C\equiv C\text{-}Ag + 2NH_4NO_3 + 2H_2O$$

Acetylene.

(silver acetylide)

white ppt

Or

$$R\text{-}C\equiv C\text{-}H + AgNO_3 + NH_4OH \rightarrow R\text{-}C\equiv C\text{-}Ag + NH_4NO_3 + H_2O$$

Alkynes

Silver alkynide

Reaction with Ammoniacal Solution of Cuprous Chloride:

When a alkyne reacts with ammoniacal solution of cuprous chloride, it forms a red precipitate of cuprous alkynide.

$$H\text{-}C{\equiv}C\text{-}H + Cu_2Cl_2 + 2NH_4OH \rightarrow \underset{\text{cuprous acetylide red ppt}}{Cu\text{-}C{\equiv}C\text{-}Cu} + 2NH_4Cl + 2H_2O$$

Alkyne:

$$2R\text{-}C\equiv C\text{-}H + Cu_2Cl_2 + 2NH_4OH \rightarrow 2R\text{-}C\equiv C\text{-}Cu + 2NH_4Cl + 2H_2O$$

$$CH_3\text{-}C\equiv C\text{-}H + Cu_2Cl_2 + NH_4OH \longrightarrow CH_3\text{-}C\equiv C\text{-}Cu$$

Combustion of Alkynes:

Alkynes with a low ratio of hydrogen atoms to carbon atoms are highly combustible. Carbon-carbon triple bonds are highly reactive and easily broken or converted to double or single bonds. Triple bonds store large amounts of chemical energy and thus are highly exothermic when broken. The heat released can cause rapid expansion, so care must be taken when working with alkynes such as acetylene.

Acetylene burn in air with a luminous, smoky flame, (forming carbon dioxide and water).

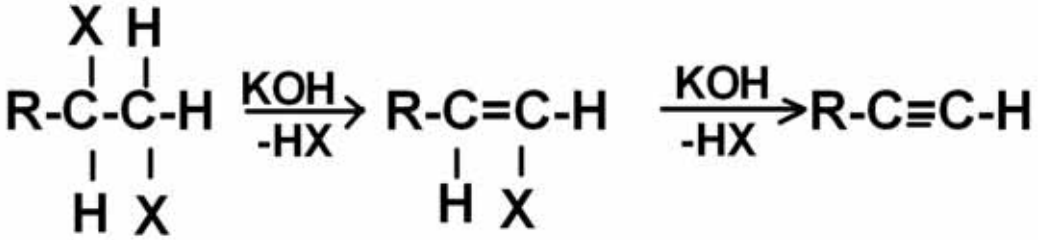
$$2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O + \text{Heat}$$

The Acetylenes are highly dangerously explosives when mixed with air or oxygen.

General Prepration of Alkynes:

1. Dehydrohalogenation of 1,2.dihalides:

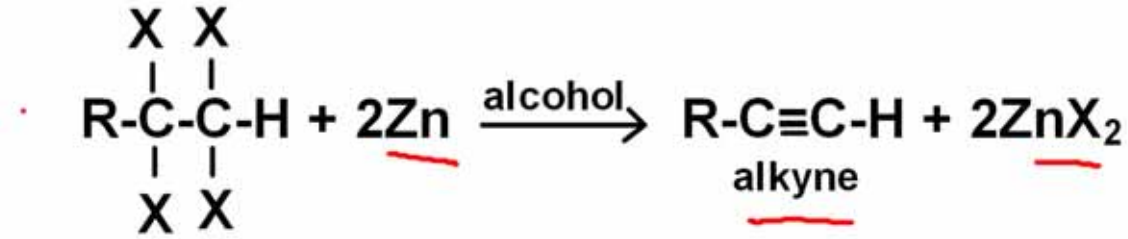
1,2.dihalides (vicinal dihalides) when treated with alcoholic KOH eliminate two molecules of hydrogen halide from adjacent carbons to yield an alkyne.



1,2.dihalide vinyl halide alkyne

2. Dehalogenation of Tetrahalides:

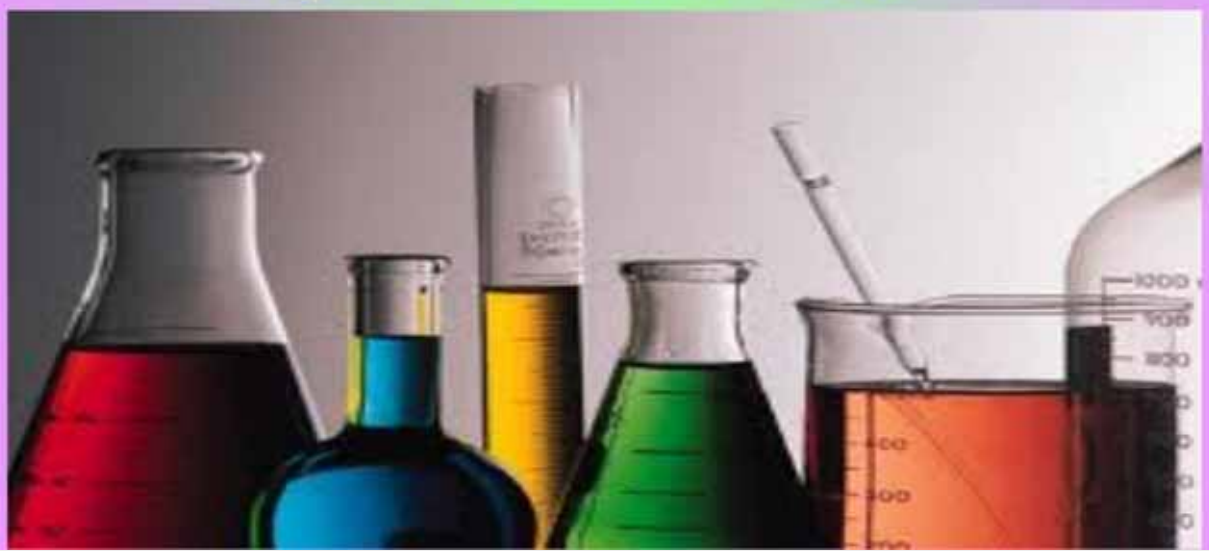
Tetrahalides in which the halogen atoms are attached to adjacent carbon atoms (two on each carbon) when heated with zinc dust in alcohol yields alkynes.



1,1,2,2 tetrahaloalkane

alkyne

Multiple Choice Questions



1. Which of the following is the unsaturated compound?

   A. CH_4
   B. C_2H_4
   C. C_3H_8
   D. C_4H_{10}

2. Which of the following compound possess slightly acidic hydrogen atom?

A. C_3H_8
B. C_3H_6
C. C_3H_4
D. C_2H_4

3. Which of the following compounds is expected to be the major product, when 1,2-dichloro propane is treated with alcoholic KOH?

A. Propane
B. Propene
C. Propyne
D. Acetylene