The Islamic
University - College
of Pharmacy

Alkenes

By

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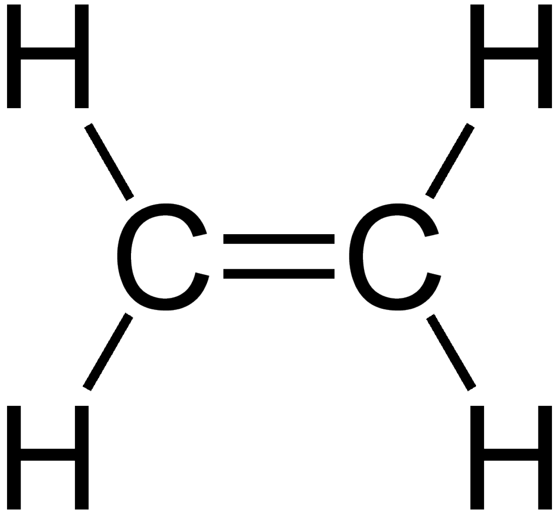
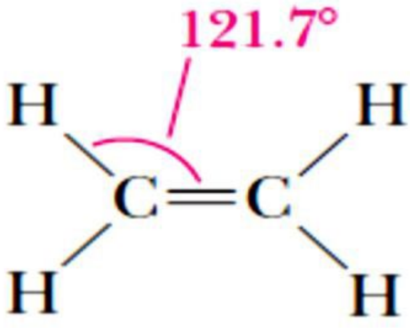


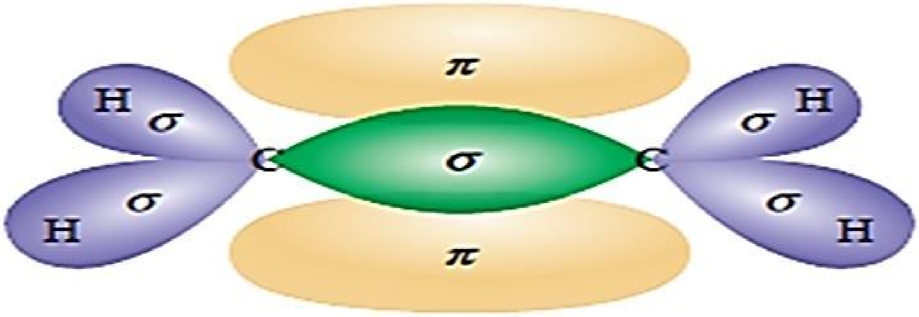
The alkenes were further described as being obtained from alkanes by loss of hydrogen in the cracking process. Since alkenes evidently contain less than the maximum quantity of hydrogen, they arc referred to as **unsaturated** .hydrocarbons

The alkenes (also called **olefins**) contain at least one carbon-carbon double bond. Alkenes have the general formula **C_nH_{2n}**, where n = 2, 3, ... The simplest alkene is **ethylene C_2H_4**, in which both carbon atoms are *sp^2*-hybridized and the double bond is made up of a strong ***sigma* (σ) bond and a weak *pi* (π) bond.**

$$CH_2{=}CH_2$$



Ethylene



Industrial source of Alkenes

Alkenes are obtained in industrial quantities chiefly by the **cracking of petroleum**. The smaller alkenes can be obtained in pure form by **fractional distillation .**

Physical Properties of Alkenes

1.Alkenes are nonpolar compounds.

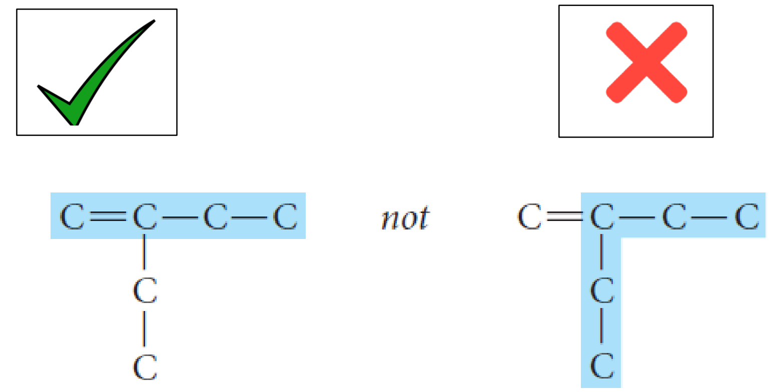
2.Alkenes that are liquid at room temperature have . densities less than 1.0 g>mL.

3.Alkene less dense than water. Like alkanes, alkenes and alkynes are nonpolar and are soluble in each other. they do not dissolve in water. Instead, they form two layers when mixed with water or another polar organic liquid such as ethanol

Nomenclature of Alkenes

The IUPAC System Rules

1. Number the longest carbon chain that contains the double bond in the direction that gives the carbon atoms of the double bond the lower set of numbers.



named as a butene, not as a pentene

2. Use the number of the first carbon of the double bond to show its location.

$$\overset{1}{C}-\overset{2}{C}=\overset{3}{C}-\overset{4}{C}-\overset{5}{C} \quad \textit{not} \quad \overset{5}{C}-\overset{4}{C}=\overset{3}{C}-\overset{2}{C}-\overset{1}{C}$$

$$\overset{1}{CH_2}=\overset{2}{C}H\overset{3}{C}H_2\overset{4}{C}H_3$$

1-butene, *not* 2-butene

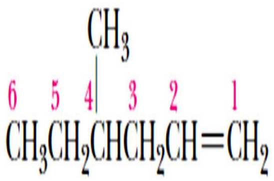
3. Name branched or substituted alkenes in a manner similar to the way we name alkanes

4. Name the main (parent) chain by changing the -an- infix of the parent alkane to -en-

Examples:

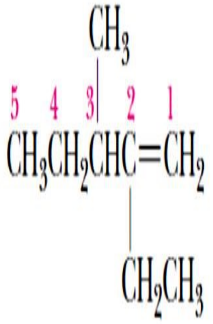
$\overset{6}{C}H_3\overset{5}{C}H_2\overset{4}{C}H_2\overset{3}{C}H_2\overset{2}{C}H=\overset{1}{C}H_2$

1-Hexene



$CH_3CH_2\overset{CH_3}{\overset{|}{C}H}CH_2CH=CH_2$

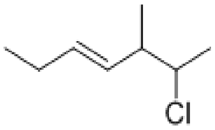
4-Methyl-1-hexene



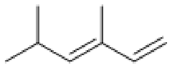
$CH_3CH_2\overset{CH_3}{\overset{|}{C}H}\underset{CH_2CH_3}{\underset{|}{C}}=CH_2$

2-Ethyl-3-methyl-1-pentene

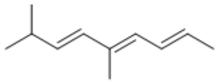
in naming alkenes, the parent chain is the longest chain containing the entire C=C bond, even if a different chain that doesn't contain the C=C bond is longer



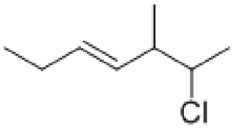
6-chloro-5-methylhept-3-ene



3,5-dimethylhexa-1,3-diene



(2*E*,4*E*,6*E*)-5,8-dimethylnona-2,4,6-triene



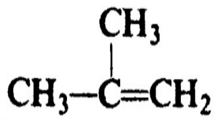
6-chloro-5-methylhept-3-ene

$H_2C{=}CH_2$
Ethene

$CH_3{-}CH{=}CH_2$
Propene

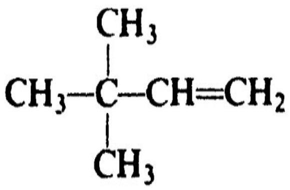
$CH_3CH_2CH{=}CH_2$
1-Butene

$CH_3CH{=}CHCH_3$
2-Butene
(*cis-* or *trans-*)



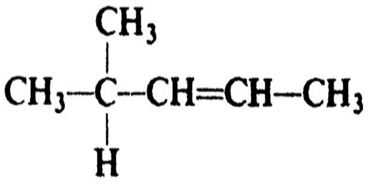
$$CH_3{-}\overset{\displaystyle CH_3}{\overset{|}{C}}{=}CH_2$$

2-Methylpropene



$$CH_3{-}\underset{\displaystyle CH_3}{\underset{|}{\overset{\displaystyle CH_3}{\overset{|}{C}}}}{-}CH{=}CH_2$$

3,3-Dimethyl-1-butene

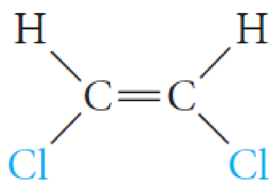


$$CH_3{-}\underset{\displaystyle H}{\underset{|}{\overset{\displaystyle CH_3}{\overset{|}{C}}}}{-}CH{=}CH{-}CH_3$$

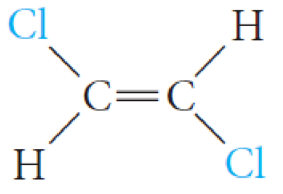
4-Methyl-2-pentene
(*cis- or trans-*)

Cis–Trans Isomerism in Alkenes

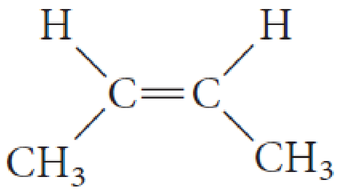
Because rotation at carbon–carbon double bonds is restricted, *cis–trans* isomerism (geometric isomerism) is possible in appropriately substituted alkenes. For example, 1,2-dichloroethene exists in two different forms:



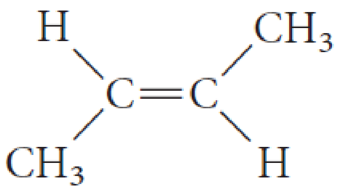
cis-1,2-dichloroethene
bp 60°C, mp −80°C



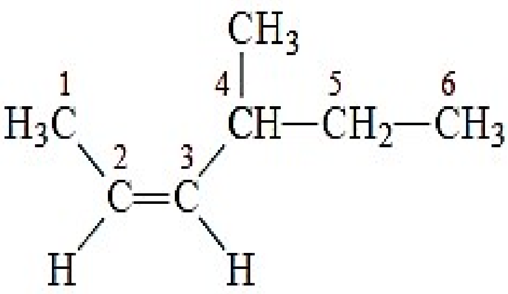
trans-1,2-dichloroethene
bp 47°C, mp −50°C



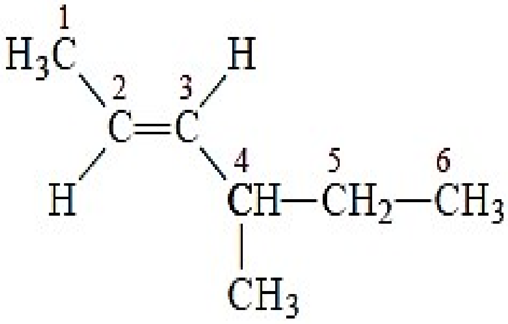
cis-2-butene
bp 3.7°C, mp −139°C



trans-2-butene
bp 0.3°C, mp −106°C



cis-4-methyl-2-hexene

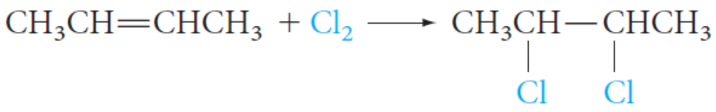


trans-4-methyl-2-hexene

Polar Addition Reactions alkene

a. Addition of Halogens

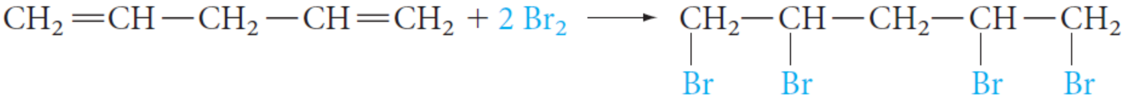
Alkenes readily add chlorine or bromine.



$$CH_3CH{=}CHCH_3 + Cl_2 \longrightarrow CH_3\underset{Cl}{CH}-\underset{Cl}{CH}CH_3$$

2-butene
bp 1–4°C

2,3-dichlorobutane
bp 117–119°C



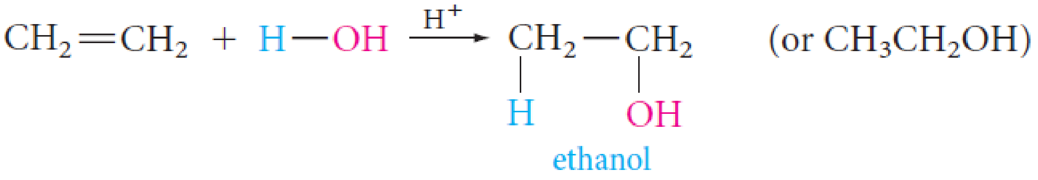
$$CH_2{=}CH-CH_2-CH{=}CH_2 + 2\,Br_2 \longrightarrow \underset{Br}{CH_2}-\underset{Br}{CH}-CH_2-\underset{Br}{CH}-\underset{Br}{CH_2}$$

1,4-pentadiene
bp 26.0°C

1,2,4,5-tetrabromopentane
mp 85–86°C

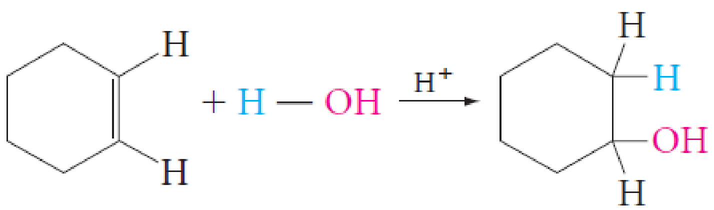
b Addition of Water (Hydration)

If an acid catalyst is present, water adds to alkenes. It adds as H!OH, and the products are alcohols.



$$\mathrm{CH_2{=}CH_2 + H{-}OH \xrightarrow{H^+} \underset{\displaystyle H}{\underset{|}{CH_2}}{-}\underset{\displaystyle OH}{\underset{|}{CH_2}}}\qquad (\text{or } \mathrm{CH_3CH_2OH})$$

ethanol

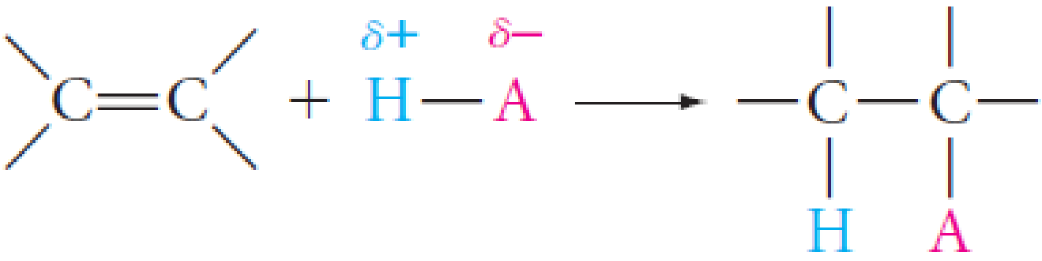


cyclohexene
bp 83.0°C

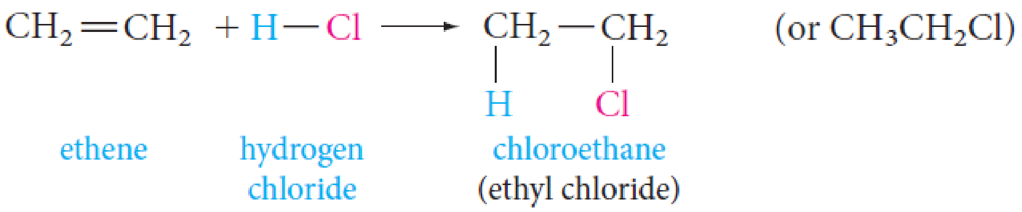
cyclohexanol
bp 161.1°C

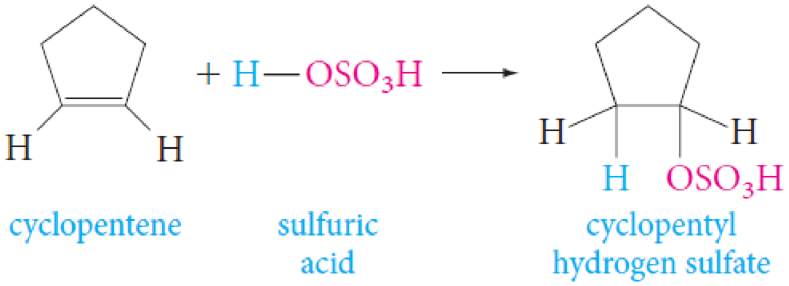
c Addition of Acids

A variety of acids add to the double bond of alkenes. The hydrogen ion (or proton) adds to one carbon of the double bond, and the remainder of the acid becomes connected to the other carbon.

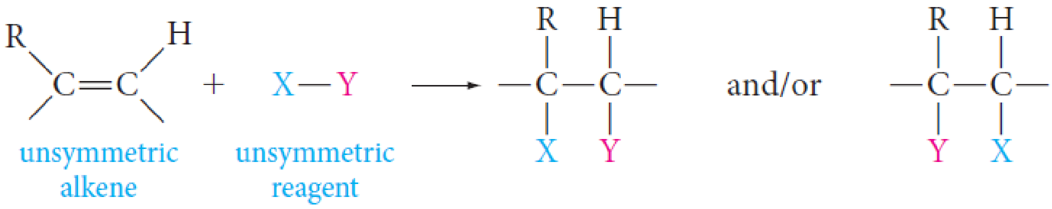


Acids that add in this way are the hydrogen halides (H!F, H!Cl, H!Br, H!I) and sulfuric acid (HOSO3H). Here are two typical examples:

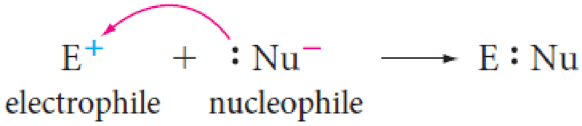


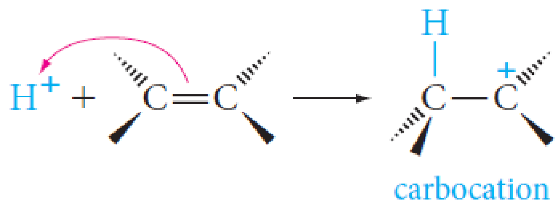


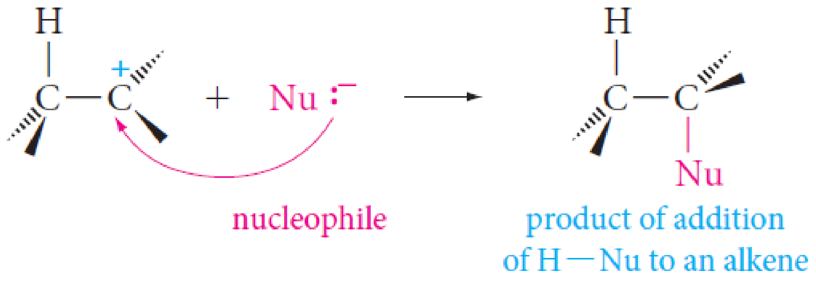
Addition of Unsymmetric Reagents to Unsymmetric Alkenes; Markovnikov’s Rule



Mechanism of Electrophilic Addition to Alkenes

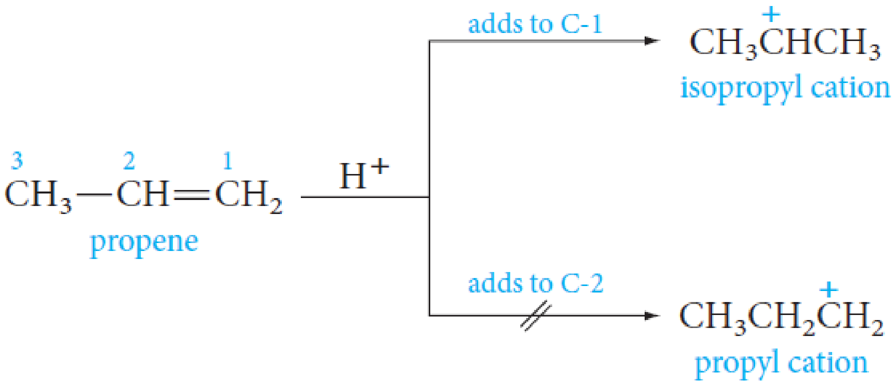






Markovnikov's Rule Explained

To explain Markovnikov's Rule, let us consider a specific example, the addition of HCl to propene. The first step is addition of a proton to the double bond. This can occur in two ways, to give either an isopropyl cation or a propyl cation.



Carbocations can be classified as **tertiary**, **secondary**, or **primary**, depending on whether the positive carbon atom has attached to it three organic groups, two groups, or only one group. From many studies, it has been established that the stability of carbocations decreases in the following order: