



Alkenes

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First stage

LECTURE:2

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4.1 Introduction

Molecules of the alkene (also called olefins) series of hydrocarbons are characterized by having two adjacent carbon atoms joined to one another by a double bond. The carbon-carbon double bond is unsaturated and hence highly reactive toward a wide variety of reagents.

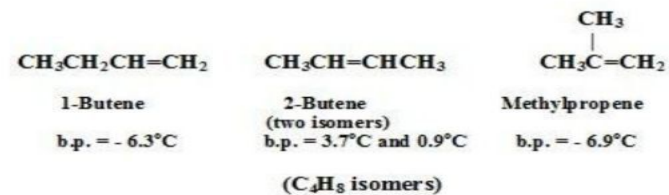
The general formula of alkenes is C_nH_{2n} , where n is the number of carbon atoms. The first nine members of this series are listed in Table 4.1.

Table 4.1 The first nine member of the alkenes

General formula	Structure	Name
C_2H_4	$CH_2 = CH_2$	Ethene
C_3H_6	$CH_2 = CHCH_3$	Propene
C_4H_8	$CH_2 = CHCH_2CH_3$	1-Butene
C_5H_{10}	$CH_2 = CH(CH_2)_2CH_3$	1-Pentene
C_6H_{12}	$CH_2 = CH(CH_2)_3CH_3$	1-Hexene
C_7H_{14}	$CH_2 = CH(CH_2)_4CH_3$	1-Heptene
C_8H_{16}	$CH_2 = CH(CH_2)_5CH_3$	1-Octene
C_9H_{18}	$CH_2 = CH(CH_2)_6CH_3$	1-Nonene
$C_{10}H_{20}$	$CH_2 = CH(CH_2)_7CH_3$	1-Decene

4.2 Isomerism in Alkenes

Isomeric compounds are also possible in the alkenes. For the molecular formula C_4H_8 , there are three different ways of organizing the four carbon atoms and the double bond:



4.3 Nomenclature

Common names are seldom used except for three simple alkene; ethylene, propylene, and isobutylene. Most alkene are named by IUPAC system.

- 1- The longest continuous chain of carbon atoms containing the double bond serves as the parent compound.
- 2- The ending *-ane* of the corresponding alkane hydrocarbon name is replaced by the ending *-ene*.
- 3- The position of the double bond is indicated by the lower number of the numbers of the carbon atoms to which it is attached. The number that represents this position is placed before the parent compound name. Alkyl groups attached to the parent compound are designated as is done for the alkane.

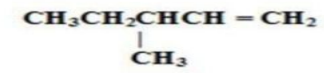
4- If a geometric isomer is designated, the name begins with *cis*- or *trans*-.



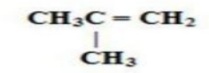
1- Hexene



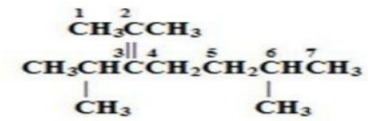
1-Butene



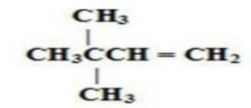
3-Methyl-1-pentene



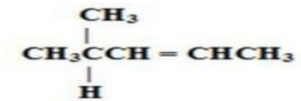
2-Methylpropene



3-Isopropyl-2,6-dimethyl-2-heptene



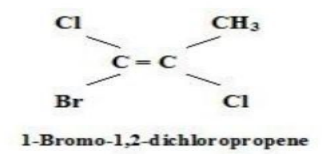
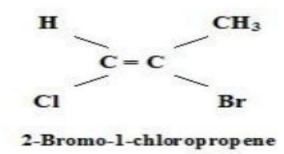
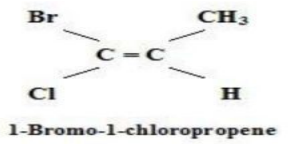
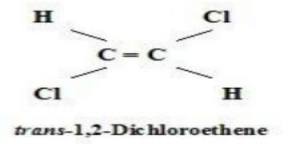
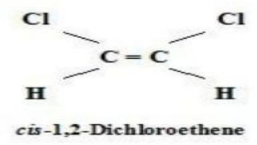
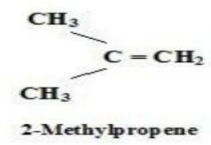
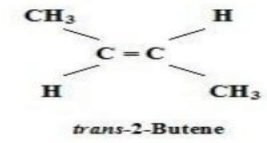
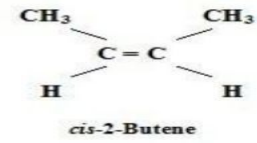
3,3-Dimethyl-1-butene



4-Methyl-2-pentene



Trichloroethene



4.4 Physical Properties of Alkenes

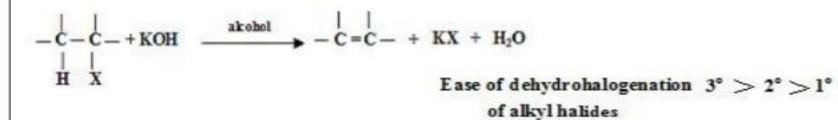
The alkenes possess physical properties that are essentially the same as those of the alkanes. They are insoluble in water, but quite soluble in non-polar solvents like benzene, ether, and chloroform. They are less dense than water. The boiling point rises with increasing carbon number; as with alkane, branching lowers the boiling point.

Like alkanes, alkenes are at most only weakly polar. Since the loosely held π electrons of the double bond are easily pulled or pushed, dipole moments are larger than for alkanes.

4.5 Preparation of Alkenes

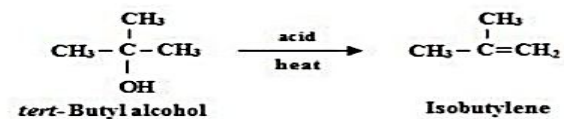
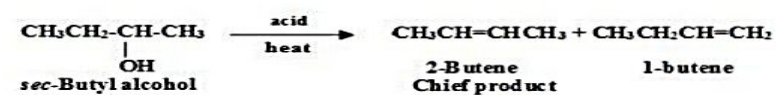
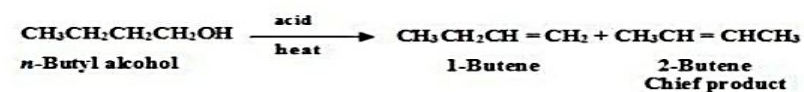
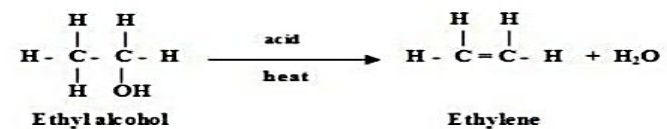
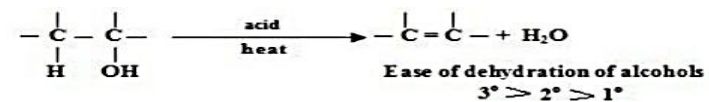
1- Dehydrohalogenation of alkyl halides

Dehydrohalogenation involves loss of the halogen atom and of hydrogen atom from a carbon adjacent to the one losing the halogen (*1,2-elimination*).

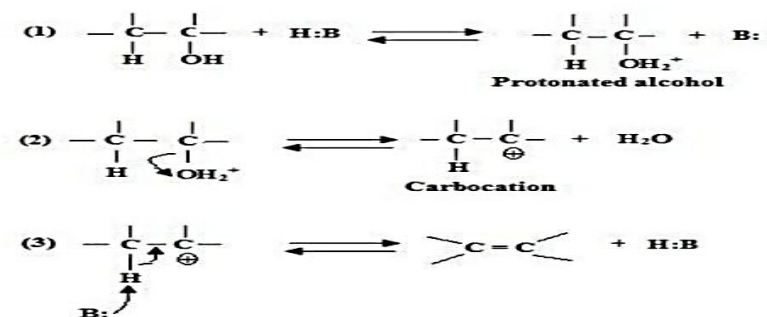


2- Dehydration of alcohols

In the dehydration of alcohols, the H and OH are lost from adjacent carbons (*1,2-elimination*). An acid catalyst is necessary and application of heat.



Mechanism:

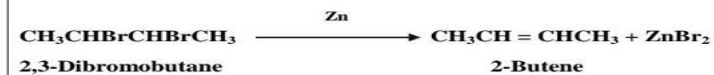


For secondary and tertiary alcohols the above mechanism is generally accepted. Step (1) is a fast acid-base reaction between the alcohol and the catalyzing acid which gives the protonated alcohol and the conjugate base of the acid. In step (2) the protonated alcohol undergoes heterolysis to form the carbocation and water. In step (3) the carbocation loses a proton to the base to yield alkene.

3- Dehalogenation of vicinal dihalides

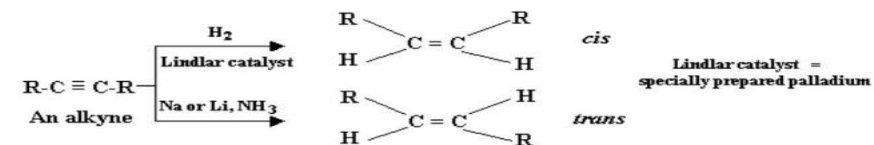
Alkenes can be prepared by elimination of two halide atoms from a vicinal (neighboring) dihalides.





4- Reduction of alkynes

Trans alkene can be obtained by reduction of alkynes with sodium or lithium in liquid ammonia. Cis alkene is obtained by hydrogenation of alkynes with a specially prepared palladium called Lindlar catalyst.



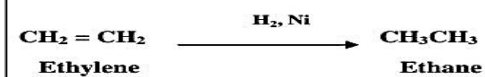
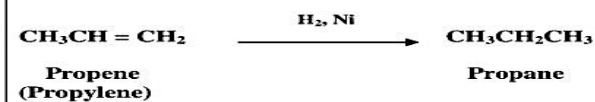
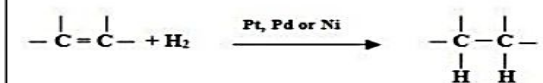
4.6 Reactions of alkenes

The presence of the carbon-carbon double bond confers very considerable chemical activity on the alkenes and consequently they react with a much wider variety of reagents than do the alkanes. The π -bond component of the double bond is weaker than the σ -bond component and the π -electrons are more easily accessible to attacking reagents.

(Addition Reactions)

1- Addition of hydrogen

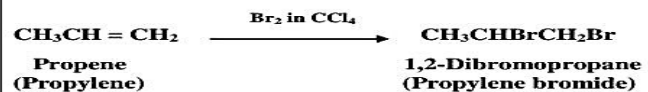
When an alkene is mixed with hydrogen, there is no appreciable reaction, but in the presence of certain metal catalysts such as nickel, platinum or palladium, a fairly rapid reaction occurs leading to the uptake of hydrogen.



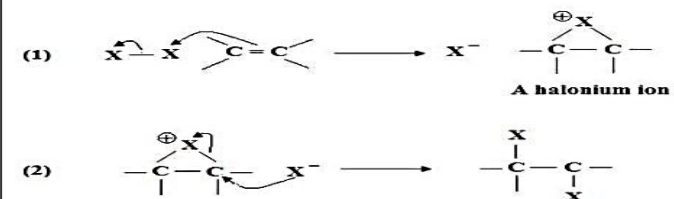
2- Addition of halogen

Chlorine and bromine react readily with alkenes, in the liquid or vapour states, to form dihalogeno addition products, the two halogen atoms are attached to adjacent carbons. Iodine generally fails to react.





Mechanism:



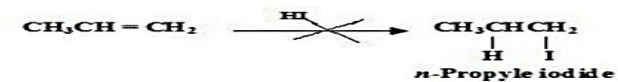
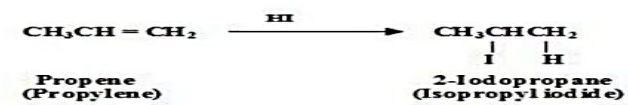
In step (1) a halogen is transferred, without a pair of electrons, from a halogen molecule to the carbon-carbon double bond; there is formed a halide ion and organic cation. In step (2) this cation reacts with a halide ion to yield the addition product.

3- Addition of hydrogen halides

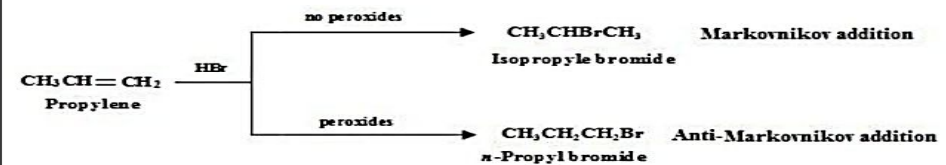
Alkenes react, usually on heating, with hydrogen halides (either gaseous or in concentrated solution) to form an addition product.



The hydrogen attaches itself to the carbon that already holds the greater number of hydrogens. This statement is called *Markovnikov's rule*.

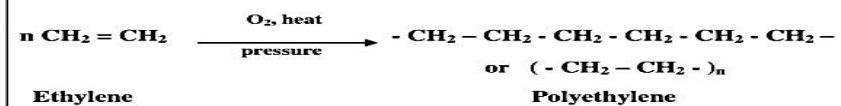


If the reaction takes place in the absence of peroxide, the addition of HBr, to alkenes follows Markovnikov's rule. On the other hand, if the reaction takes place in the presence of peroxide, HBr adds to alkenes in the reverse direction.



7- Polymerization

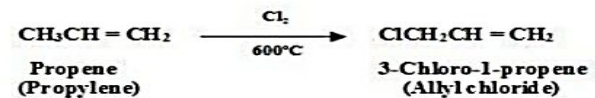
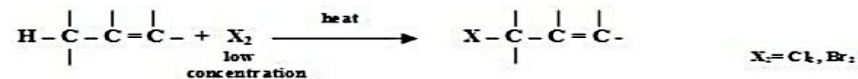
In the presence of a certain catalyst, alkene molecule can add on to each other in a head-to-tail fashion to form long-chain molecules of a very high relative molecular mass.

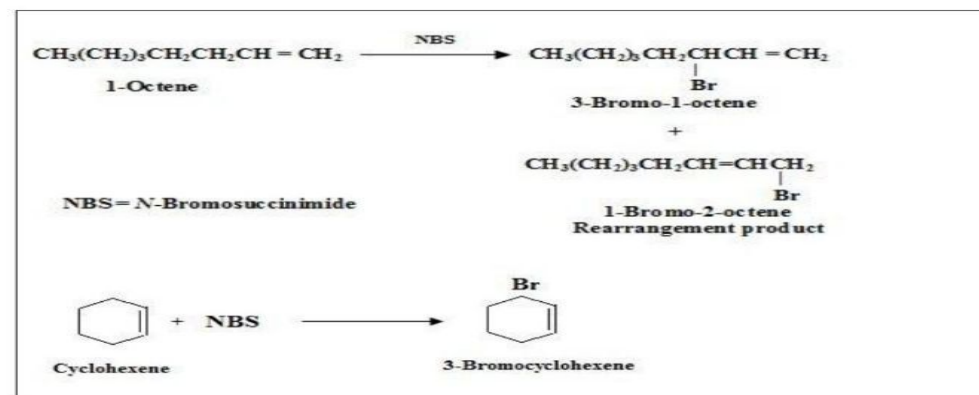


(Substitution Reactions)

Halogenation. Allylic substitution

Alkenes react with halogens, substitution reaction. The reaction carried out as follow:





(Cleavage Reactions)

Ozonolysis

O_3 (ozone) is produced by passage of an electric discharge through oxygen O_2 . If the mixture of gases is bubbled through a solution of an alkene at low temperature, an unstable product known as an ozonide is formed. Ozonides are unstable and are readily hydrolysed to form aldehydes or ketones.

