

ALKENES, ALKYNES and AROMATIC COMPOUNDS
Chapter 13

13.1 Introduction

An ALKENE is a hydrocarbon with a double C bond that looks like C=C

An ALKYNE is a hydrocarbon with a triple C bond that looks like C≡C

Alkenes and alkynes are unsaturated because they have a C-C multiple bonds...the “un” coming from the fact that there are fewer Hydrogens on these molecules, and additional atoms could potentially be added by breaking the double bond (which frees up space for the C to attach to something else.)

13.2 Naming Alkenes and Alkynes

Step 1: Name the parent compound by finding the longest chain or carbons that INCLUDES the multiple bond.

It will be an -ene or an -yne

Step 2: If there is more than one multiple bond, then 2 = *diene*, 3 = *triene*

Step 3: Number the C atoms in the main chain.

Begin at the end nearest the multiple bond

If bond is in the middle, begin at C nearest first branching point.

If a cycloalkane, begin the numbering at the point that gives the sub the lowest #

Step 4: Write the full name

Be mindful of alphabetical order (di & tri don't count, iso does count)

Give # of first multiple bond. This goes at the end

If multiple multiple-bonds, use *diene*, *triene*

Simple alkenes are made in vast quantities in the petroleum industry by a process called “thermal cracking”, whereby alkanes are heated to high temperatures to “crack” them apart. The pieces reunite or rearrange into lower-molecular-weight molecules such as ethylene and propene.

A few alkenes and alkynes have common names:

IUPAC	COMMON

Ex: 3-Propyl-2-Hexene

13.3 Structure of Alkenes, Cis-Trans Isomerism

Some basic shapes: Methane is tetrahedral
Ethylene is flat
Acetylene is straight

Constitutional Isomers = double bonds occur at different positions along the chain. (Ex: 1-butene and 2-butene)

In a *cis* isomer configuration, the groups with the highest molecular weight are on the same side of the double bond. In a *trans* isomer configuration, the groups attach on opposite sides of the double bond.

These cis-trans isomers have the same formula and connections between atoms, but have DIFFERENT 3-D structures because of the way that groups attach to different sides of the double bond.

Cis-trans isomerism occurs in an alkene whenever each double-bond carbon is bonded to two DIFFERENT substituent groups. If one carbon has two identical attachments, cis-trans isomerism is not possible.

Flipping one side
top to bottom
doesn't change it.

Flipping one side
top to bottom
DOES change it

When a molecule is *-cis* to one and *-trans* for another, go with the biggest molecular weight! Ex: Trans-3-methyl-2-pentene

13.4 Properties of Alkenes and Alkynes

- nonpolar
- soluble in nonpolar organic solvents
- less dense than water
- flammable
- nontoxic
- alkenes capable of cis-trans isomerism when each double-bond carbon atom has different substituents (alkanes are not)
- chemically reactive at the multiple bond (alkanes are not)

13.5 Types of Organic Reactions

The four types of general organic reactions are: *additions, eliminations, substitutions and rearrangements.*

Addition rxns: X-Y adds to the multiple bond of an unsaturated reactant to yield a saturated product with only single bonds. (hydrogenation of margarine)

Elimination rxns: Saturated reactant yields an unsaturated product by losing groups from 2 adjacent carbons. The catalyst for this is an acid catalyst such as HCl, HBr or H₂SO₄.

Substitution rxns: Atom or group is replaced by another

Rearrangement rxns: Molecule undergoes bond reorganization to yield an isomer. Not discussed much in our book.

13.6 Reactions of Alkenes and Alkynes

Most of the reactions of carbon-carbon multiple bonds are ADDITION REACTIONS. Alkenes and alkynes react similarly, but alkenes are more common.

The addition of a H_2 to Alkenes and Alkynes is HYDROGENATION. Alkenes and alkynes react with hydrogen in the presence of a metal catalyst such as palladium to yield an alkane product. This process is used commercially to convert unsaturated vegetable oils (which have a lot of double bonds) to saturated fats like margarine.

The addition of HALOGENS (Cl_2 and Br_2) to Alkenes is HALOGENATION. The alkenes react with the halogens to give 1,2 dihaloalkane addition products.

The addition of HBr and HCl to Alkenes is a HYDROHALOGENATION RXN. The alkenes react with HBr to yield *alkyl bromide*, and with HCl to yield *alkyl chlorides*.

Markovnikov's Rule comes into play when HBr and HCl add to an alkene in which one of the double-bound carbons has more hydrogens than the other. The rule states "*In the addition of HX to an alkene, the H attaches to the carbon that already has the most H, and the X attaches to the carbon that has fewer H.*"

The addition of water to alkenes is HYDRATION. If an alkene and pure water are just mixed together, nothing happens. But if the right experimental conditions are used (like a strong acid catalyst) then hydration occurs and it yields an alcohol (R – OH). Markovnikov's rule comes into play with hydration reactions.

Chirality

If you have a carbon atom with FOUR different (non-identical) substituents around it, then this carbon is the "chiral center." This molecule has a non-superimposable mirror image (in other words, they are enantiomers.) The subs can include H, alkanes, halogens and whole functional groups. FYI: the body is effective at using things that are chiral!

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