

Chemistry 1506: Allied Health Chemistry 2

Section 2: Alkenes, Alkynes, and Aromatic Compounds

Hydrocarbons with Multiple Bonds

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Section 2.1 Introduction and Nomenclature of Alkenes

➤ Ethene = (Ethylene), $\text{CH}_2=\text{CH}_2$

➤ IUPAC Rules

- Start numbering from the end that gives the double bond the lowest number.
- Indicate position of double bond(s) by numbers.
- Use the **ene ending**
- Indicated number of double bonds by prefixes (**ene**, **diene**, **triene**, **tetraene**, etc.)

➤ Examples

- Geometric Isomers
 - No free rotation (π -bonds)
 - Experimental observations

- cis isomers vs. trans isomers

- Examples

Section 2.2 π -Bonds

- Bonding: sp^2 hybridization for 3 σ -bonds to the three atoms bonded to each carbon
- p_z orbital for π -bond
- Typical C=C bond distance (i.e., 1.34 Å) and thus shorter than the C-C distance (i.e., 1.54 Å)
- slightly shorter C-H distance than alkanes

Section 2.3 Physical Properties

- Almost identical to Alkanes of same MW
 - Van der Waals forces
- Slightly higher **Mp** and **Bp**
- **Smell** (turpentine like)
- **Density**
- **Solubility**

Section 2.4 Chemical Properties: Addition Reactions

- Addition reaction (generic)
 - π -bonds weaker than σ -bonds

- Hydrogenation: Addition of H_2 or D_2 (Pt catalyst)

- Addition of Cl_2 or Br_2 (X_2)

➤ Addition of HX ((HF) HCl, HBr (HI))

➤ Halide Influences

➤ Markovnikov Addition

➤ Addition of Water (Hydration)

➤ H⁺ Catalyst

➤ Markovnikov

Section 2.5 Addition Polymers

- Definition of Addition **Polymers**
 - No loss of mass
 - Rapid **chain growth**
 - **π -bond opening**
 - “Generic” Synthesis Reaction
 - typical **monomers** are **$\text{CH}_2=\text{CH-R}$**

- Role of **Catalysts**
 - Speed reaction but aren't themselves consumed
 - Highly reactive species

- **Reversibility of Reactions**
 - **Polymerization** under low temperatures/high pressures
 - i.e., **monomer** (liquids or gasses) -> polymer (solids)
 - **Depolymerizations** (unraveling) at high temperatures
 - i.e., polymer -> monomer

- **Molecular Weights and Molecular Weight Distributions**
 - High average Molecular Weights
 - Distributions rather than discrete weights

- **Linear Chains vs. Branched Chains**

➤ Examples

➤ Polyethylene, PE, Synthesis



➤ Poly(vinyl chloride), PVC, Synthesis



➤ Polypropylene, PP, Synthesis



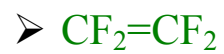
➤ Polystyrene, PS, Synthesis



➤ Poly(methyl methacrylate), PMMA, Synthesis



➤ Teflon Synthesis



➤ Rubber (Polyisoprene) Synthesis



Section 2.6 Alkynes

- Carbon-Carbon Triple Bonds
 - sp hybridized
 - Very Short $C\equiv C$ Bond distance (i.e., 1.20 Å), much shorter than the $C=C$ distance (i.e., 1.34 Å) and the $C-C$ distance (i.e., 1.54 Å)
 - Bonding: 1 σ -bond and 2 π -bonds (p_x and p_y)
 - slightly shorter $C-H$ distance than alkanes or even alkenes
 - Ethyne = Acetylene, $H-C\equiv C-H$

- Physical Properties
 - Almost identical to Alkanes/Alkenes of same MW
 - Van der Waals forces
 - Slightly higher M_p and B_p
 - Density
 - Solubility

- Nomenclature
 - yne ending
 - yne > ene in priority of naming
 - Examples

- Addition of **HX** (most commonly **HCl** and **HBr**)
 - **Markovnikov Addition**

- Addition of **H₂O** (**H⁺** catalyst)
 - **Markovnikov Addition**
 - **Secondary elimination of water from diol**
 - gives **carbonyl group** (aldehyde or ketone)

Section 2.7 Aromatic Hydrocarbons

- Sources
 - Coal Tar
 - Coke production
 - Direct separation
 - Start of industrial chemistry
 - Petroleum
 - multiple processing steps
- Uses
 - Octane enhancers in gasoline
 - Plastics
 - Pigments/Dyes
 - Pharmaceuticals
- Aromatic: Properties, Reactivity, C/H Ratios (cf. Alkane/Alkenes/Alkynes)

➤ **Substitution Reactions** not **Addition Reactions** (i.e., not like alkenes)

➤ **Bonding / Resonance Stabilization**

➤ Nomenclature

➤ IUPAC Names

➤ Halobenzenes (X = F, Cl, Br, I)

➤ Nitrobenzene (Z = NO₂)

➤ Alkylbenzenes (phenylalkanes)

➤ **Common Names (IUPAC)**

➤ **Phenol** (Z = OH)

➤ **Aniline** (Z = NH₂)

➤ **Toluene** (Z = CH₃, **methylbenzene**)

➤ **Benzoic Acid** (Z = CO₂H)

- Multiply Substituted **Arenes**
 - Numbering **Ring Positions**
 - **Ortho, Meta, Para, Ipso**
- As Side Chains (**phenyl groups**)

Section 2.8 Amino Acids having Simple Aromatic Side Chains

➤ Generic AA = $\text{H}_2\text{N}-\text{CHR}-\text{CO}_2\text{H}$

➤ Phenyl Alanine (non-polar)

➤ $\text{R} = \text{CH}_2\text{C}_6\text{H}_5$

➤ PKU

Section 2.9 Aromatic Reactions

➤ Substitution Reactions

➤ Require catalyst

➤ "Generic"

➤ Z^+ Electrophiles

➤ Nitration ($Z = \text{NO}_2$, $\text{HNO}_3/\text{H}_2\text{SO}_4$, TNT)

➤ Sulfonation ($Z = \text{SO}_3\text{H}$, $\text{H}_2\text{SO}_4/\text{SO}_3$)

➤ Halogenation ($X = \text{Cl}$ or Br , Cl_2/Fe or Br_2/Fe)

Section 2.10 Fused Ring Aromatics

- Polycyclic Aromatic Hydrocarbons, PAHs
- Toxicity
- Naphthalene ($C_{10}H_8$)

- Anthracene ($C_{14}H_{10}$)

- Phenanthrene ($C_{14}H_{10}$)

Section 2.11 Heterocyclics (Not covered in detail)

- Replace C-H by **Heteroatom Groups** such as: N, O, S, etc.

- Important in **Biomolecules**

- **Pyridine (C₅H₅N)**

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