

Introduction

The term *organic* generally means "something made from the earth" or "not chemically synthesized."

Organic chemistry refers to the study of compounds that contain carbon atoms as the principal element.

The simplest organic compounds are **hydrocarbons** made from C and H atoms

Despite the term *organic* generally meaning "natural," organic compounds **can in fact be chemically synthesized** (first synthesized organic compound was **urea** - found in mammal urine)

Carbon has a **bonding capacity of 4** so each C atom must **always make 4 bonds** within a compound

General Nomenclature

Usual follows order **prefix + root + suffix**

Prefix Indicates *name/multiplying prefix-es/position of branches*

Root Indicates *number of carbons in the parent chain*

Suffix Indicates the parent chain's *functional group*

A Root Name/Branch Prefixes

Number of C atoms / branches	Root prefix	Multiplying prefix
1	<i>meth-</i>	<i>mono-</i>
2	<i>eth-</i>	<i>di-</i>
3	<i>prop-</i>	<i>tri-</i>
4	<i>but-</i>	<i>tetra-</i>
5	<i>pent-</i>	<i>penta-</i>
6	<i>hex-</i>	<i>hexa-</i>
7	<i>hept-</i>	<i>hepta-</i>
8	<i>oct-</i>	<i>octa-</i>

A Root Name/Branch Prefixes (cont)

9	<i>non-</i>	<i>nona-</i>
10	<i>dec-</i>	<i>deca-</i>

Special nomenclature prefixes: See *Importance of Functional Groups, Haloalkyl/Other Functional Groups, and Special Alkyl Branches*

All prefixes are listed in alpha order when writing the name of an organic compound, except for ***cyclo-*** and ***iso-***.

Importance of Functional Groups

Functional Group	Suffix if Highest Precedence	Prefix if Lower Precedence
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RC(=O)OH (carboxylic acid) *-oic acid*² *carboxy-*

RC(=O)OR' (ester) [branch]¹-yl [root]¹-oate *alkoxycarbonyl-*

RC(=O)ON(-R')R" (amide) *-amide* *carbamoyl-*

RC≡N (nitrile) *-nitrile* *cyano-*

RC=O (aldehyde) *-al*³ *oxo-*³

RC(=O)R' (ketone) *-one* *oxo-*

R(OH)R' (alcohol) *-ol* *hydroxy-*

R(N(R')R'')R''' (amine) *-amine* *amino-*

RC=CR' (alkene) *-ene*⁴ Always used as a suffix

RC≡CR' (alkyne) *-yne*⁴ Always used as a suffix

Importance of Functional Groups (cont)

RCCR' (alkane) *-ane* Always used as a suffix

R(X)R' Always used as a prefix See *Haloalkyls/Other Functional Groups*

^[1][branch] and [root] refer to the length of the carbon group's prefix (*meth-*, *eth-*, *prop-*, etc.)

^[2]If the carbon in the RCOOH group is not the parent chain, the highest precedence suffix is *-carboxylic acid*

^[3]If the carbon in the RCO group is not the parent chain, the highest precedence suffix is *-carbaldehyde*, and the alternate prefix is *formyl-*

^[4]If a compound is both an alkene and an alkyne, both *-ene* and *-yne* are used

Haloalkyls/Other Functional Groups

Functional Group	Prefix
R-O-R' (ether) ¹	[branch]-oxy-
R-C-R (cycloalkyls)	<i>cyclo-</i>
R-F	<i>fluoro-</i>
R-Br	<i>bromo-</i>
R-Cl	<i>chloro-</i>
R-I	<i>iodo-</i>
R-NO₂	<i>nitro-</i>
1,2-[branch(es)]²	<i>ortho</i> -[branch(es)]
1,3-[branch(es)]²	<i>meta</i> -[branch(es)]
1,4-[branch(es)]²	<i>para</i> -[branch(es)]

^[1]Ethers take precedence in prefixes over all other prefixes, except the branches attached to the ether group

^[2]Applies **only** to benzene ring branches



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B Special Alkyl Branches

Propyl	Butyl
n-propyl (normal)	n-butyl (normal)
isopropyl (y-shape)	isobutyl (y-shape)
	sec-butyl (2 nd C)
	tert-butyl (t-shape)

^ Alkanes

Contain **only single bonds** between C atoms

General chemical formula	C_nH_{2n+2} (n = whole number)
Odour	Odourless
Polarity	Non-polar (only C-H bonds)
Solubility in water	Slightly soluble
Boiling/melting point	Depends on length of parent C chain (more C = \uparrow BP, less C = \downarrow BP)

^ Alkenes

Contain **at least one double bond** between C atoms

General chemical formula	C_nH_{2n} (n = whole number)
Odour	Almost odourless
Polarity	Non-polar (only C-H bonds)
Solubility in water	Slightly soluble
Boiling/melting point	Depends on length of parent C chain (more C = \uparrow BP, less C = \downarrow BP)

^ Alkynes

Contain **at least one triple bond** between C atoms

General chemical formula	C_nH_{2n-2} (n = whole number)
Odour	Almost odourless
Polarity	Non-polar (only C-H bonds)
Solubility in water	Slightly soluble
Boiling/melting point	Depends on length of parent C chain (more C = \uparrow BP, less C = \downarrow BP)

⚙ Cycloalkyl

Alkane/alkene/alkyne where the C atoms are joined in a **ring shape**

General chemical formula	C_2H_{2n} (cycloalkane) C_2H_{2n-2} (cycloalkene) C_2H_{2n-4} (cycloalkyne) (n = whole number)
Odour	Odourless/almost odourless
Polarity	Non-polar (only C-H bonds)
Solubility in water	Slightly soluble
Boiling/melting point	Depends on length of parent C chain (more C = \uparrow BP, less C = \downarrow BP)

Y Alcohols

Any compound that contains a **hydroxyl (R-(OH)-R')** group

General chemical formula	$C_nH_{2n-1}OH$ (n = whole number)
Odour	Slightly pungent
Polarity	Polar (between O-H bonds); longer C chains decrease in polarity
Solubility in water	Very soluble; longer C chains decrease solubility
Boiling/melting point	Depends on length of parent C chain (more C = \uparrow BP, less C = \downarrow BP)

⚡ Aldehydes/Ketones

Any compound that contains a **carbonyl (R-C(=O)-R')** group

Aldehydes have the carbonyl group **at the first and/or last C atom** of the molecule

Ketones have the carbonyl group **in the middle C atom(s)** of the molecule

General chemical formula	$C_nH_{2n}O$ (n = whole number)
Odour	Pungent (aldehyde) Sweet (ketone)
Polarity	Polar (between C=O bonds); longer C chains decrease polarity
Solubility in water	Very soluble; longer C chains decrease solubility



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✂ Aldehydes/Ketones (cont)

Boiling/melting point Very high, increases with length of parent C chain (more C = ↑ BP, less C = ↓ BP)

💧 Carboxylic Acids/Esters

Any compound that contains a **carboxyl (R-C(=O)-O-R')** group

Carboxylic acids have the carboxyl group at the **first and/or last C atom** of the molecule

Esters have the carboxyl group in the **middle C atom(s)** of the molecule

General chemical formula $C_nH_{2n}COOH$ (n = whole number)

Odour Unpleasant (carboxylic acid)
Pleasant (ester)

Polarity Polar (between C=O bonds); longer C chains decrease polarity

Solubility in water Very soluble; longer C chains decrease solubility

Boiling/melting point Very high, increases with length of parent C chain (more C = ↑ BP, less C = ↓ BP)

♥ Ethers

Any compound that contains an **alkoxy (R-O-R')** group

General chemical formula $C_nH_{2n+2}O$ (n = whole number)

Odour Slightly pungent

♥ Ethers (cont)

Polarity Polar (between C-O bonds); longer C chains decrease polarity

Solubility in water Very soluble; longer C chains decrease solubility

Boiling/melting point Depends on length of parent C chain (more C = ↑ BP, less C = ↓ BP)

📄 Amines/Amides

Any compound that contains a **N atom** in a **carboxyl or carbonyl** group

Amines have N atoms in a **carbonyl group(s) (R-C(-N(-R')-R'')-R''')**

Amides have N atoms in a **carboxyl group(s) (R-C(=O)-N(-R')-R'')**

General chemical formula $C_nH_{2n-1}NO$ (n = whole number)

Polarity Polar (between C=O, C-O and C-N bonds); longer C chains decrease polarity

Solubility in water Very soluble; longer C chains decrease solubility

State @ SATP Depends on length of parent C chain (more C = more solid, less C = more gas)

↕ Intermolecular Forces (IMFs)

Forces that occur **between** molecules

Influence the **physical properties** of a substance

Weaker than intramolecular forces (forces *within* molecules)

3 main types:

London Dispersion Forces (LDF) **Very weak** forces that exist in **all atoms/molecules** caused by **temporary charges** due to e^- shifts; become **stronger with more e^-**

Dipole-Dipole Attraction between **opposite charges of polar molecules**; main reason for difference in melting/boiling points

Hydrogen bonding Strong dipole-dipole forces with **H atoms covalently bonded** with an **N, O or F** atom

Strength of forces: (weakest) LDF → Dipole-dipole → H-bonding (strongest)

🔥 Combustion Reactions

All hydrocarbons burn with **oxygen gas** (alkanes/alkenes/alkynes/alcohols)

Combustion of hydrocarbon $C_xH_y + O_2 \rightarrow CO_2 + H_2O$

Combustion of alcohol $C_xH_yOH + O_2 \rightarrow CO_2 + H_2O$



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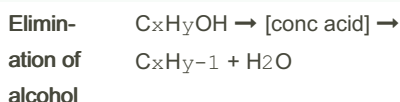
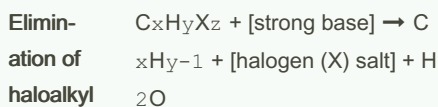
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✦ Elimination Reactions

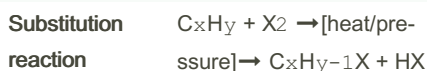
Take away **2 atoms** to form **double bond** or **H₂O**

Also called **condensation/dehydration** reactions



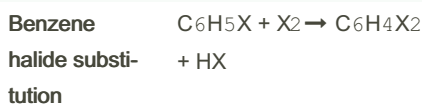
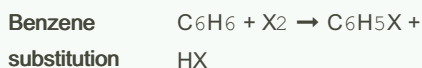
↻ Substitution Reactions

Replace one atom with another



Benzene rings

Benzene does not have true double bonds, so **only substitution reactions** can be performed

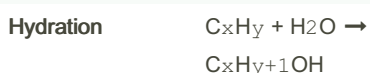
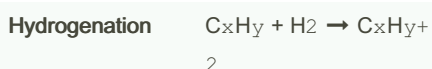
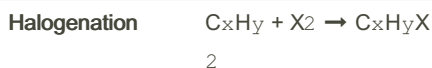
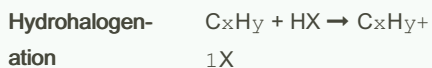


Halogen in benzene halide reactions forms product **meta position only** (1,3-[X]benzene)

⊕ Addition Reactions

Add atoms across double/triple bond

Alkenes/alkynes are **nucleophiles** (they like to give up e⁻)



Markovnikov's Rule: "the rich get richer"

⊕ Addition Reactions (cont)

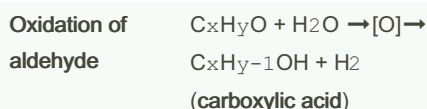
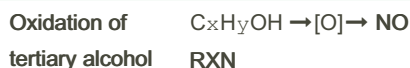
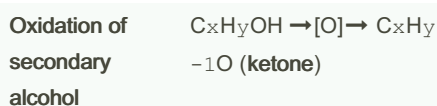
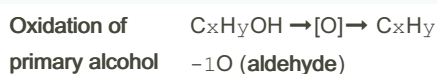
The H atom of water/hydrogen gas/hydrogen halide **will always bond** with the C atom that **already had more H atoms** bonded to it in an addition reaction

⚡ Redox Reactions

Oxidation

C atoms will form **more bonds to O atoms**

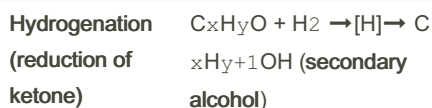
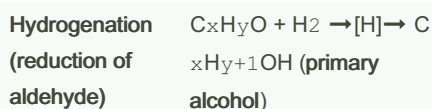
Occurs when an organic compound reacts with an **oxidizing agent** (usually $KMnO_4/K_2Cr_2O_7$)



Reduction

C atoms will form **fewer bonds to O atoms**

Occurs when an organic compound reacts with an **reducing agent** (usually $H_2/LiAlH_4$)

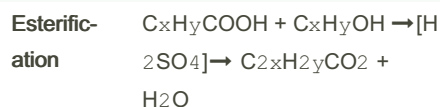


↔ Esterification/Hydrolysis of Esters

Esterification

Condensation reaction (forms H₂O)

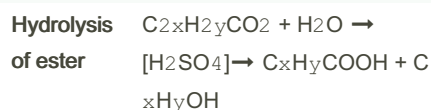
Catalyzed by **concentrated H₂SO₄** and **high heat**



Hydrolysis of Esters

Reverse reaction to esterification

Hydro = water, *lysis* = break

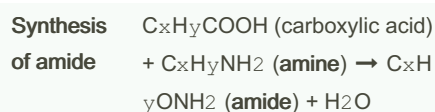


Remember: Ester is a party girl; she drank some alcohol and did some acid

↔ Synthesis/Hydrolysis of Amides

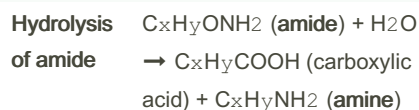
Synthesis of Amides

Condensation reaction (forms H₂O)



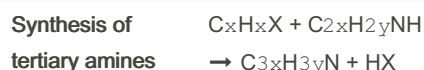
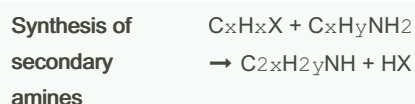
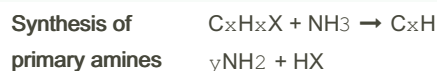
Hydrolysis of Amides

Reverse reaction to synthesis



↔ Synthesis of Amines

Amines can be made from **haloalkyls** using **ammonia** as a starting reactant



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🔗 Polymers

Large molecules that are composed of **many repeated subunits** called **monomers**

Created through **polymerization**

Examples include **plastics**, **DNA**, and **proteins**

Unique physical properties - **chemically unreactive**, **flexible/mouldable/stretchable**

Polymerization (addition - chain reaction of alkene)
 $C_xH_y + C_xH_y + C_xH_y + \dots \rightarrow [C_xH_y]_n$

Polymerization (condensation with alcohol - polyester)
 $HOC_xH_yOH + HOOC_xH_yCOOH + \dots \rightarrow [O_2C_xH_yO_2]_n$

Polymerization (condensation with alcohol - polyamide)
 $H_2NC_xH_yNH_2 + HOOC_xH_yCOOH + \dots \rightarrow [NOCC_xH_yO_2C_xH_yON]_n$

Polymerization (condensation) need the reacting functional group(s) to be on **both sides of the monomer(s)** to be able to complete the chain reaction (-**dioic acid**, -**diol**, -**diamine**)



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