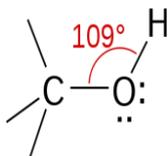


Alcohols

an alcohol is any organic compound in which a hydroxyl group ($-OH$) is bound to a carbon atom of an alkyl or substituted alkyl group.



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Introduction

- In common terms, the word *alcohol* refers to ethanol, the type of alcohol found in alcoholic beverages.
- There are three major subsets of alcohols: *primary* (1°), *secondary* (2°) and *tertiary* (3°), based upon the number of carbon atoms the **C-OH** group's carbon is bonded to.
- The carbon atom is bound to hydrogen atoms and may bind to other carbon atom(s) to form a carbon chain.

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Nomenclature

- In the IUPAC system, the name of the alkane chain loses the terminal "e" and adds "ol", e.g. "methanol" and "ethanol".

Carbons	IUPAC	Structure
1	Methanol	CH_3OH
2	Ethanol	CH_3CH_2OH
3	Propanol	$CH_3CH_2CH_2OH$
4	Butanol	$CH_3(CH_2)_2CH_2OH$
5	Pentanol	$CH_3(CH_2)_3CH_2OH$
6	Hexanol	$CH_3(CH_2)_4CH_2OH$
7	Heptanol	$CH_3(CH_2)_5CH_2OH$
8	Octanol	$CH_3(CH_2)_6CH_2OH$
9	Nonanol	$CH_3(CH_2)_7CH_2OH$
10	Decanol	$CH_3(CH_2)_8CH_2OH$

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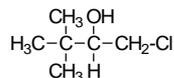
IUPAC rules for alcohols

IUPAC rules that:

- Name the longest carbon chain bearing the $-OH$ group. Drop the last $-e$ from the alkane name and add $-ol$ to obtain the root name.
- Number the longest chain starting at the end nearest the $-OH$ group, and designate a number for the $-OH$ group. (Hydroxyl has greater priority than carbon-carbon multiple bonds).

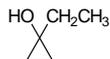
IUPAC rules for alcohols

- Name the remaining substituents and their numbers as for alkanes and alkenes.



1-chloro-3,3-dimethyl-2-butanol

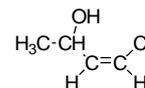
- Cyclic alcohols have the prefix cyclo-, and the hydroxyl group is deemed to be on C-1



1-ethylcyclopropanol

IUPAC rules for alcohols

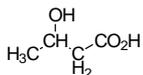
- Alcohols with double or triple bonds are named using the -ol suffix on the alkene or alkyne name. Numbering gives the hydroxyl group the lowest possible number. When numbers are also given for the multiple bond position, the position of the hydroxyl can be written immediately before the -ol prefix.



(Z)-4-chloro-3-buten-2-ol

IUPAC rules for alcohols

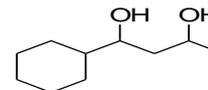
- If the hydroxyl group is only a minor part of the structure, it may be named as a hydroxy-substituent.



3-hydroxybutanoic acid

Nomenclature of Diols (Gcols)

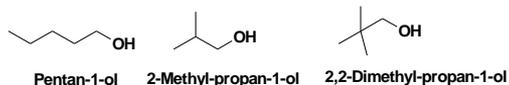
- Diols are compounds with two hydroxyl groups.
- They are named as for alcohols except the suffix -diol is used and two numbers are required to locate the -OH's.



1-cyclohexyl-1,3-butanediol

Primary, secondary & Tertiary alcohols

- A primary alcohol has a hydroxy group attached to carbon bearing 2 hydrogen atoms.

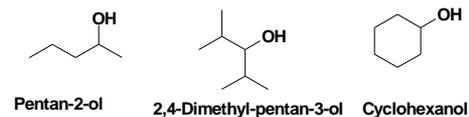


- Notice that the carbon chain containing the primary hydroxyl group can be complex.

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Primary, secondary & Tertiary alcohols

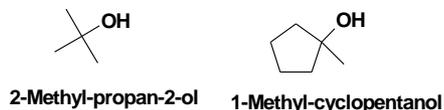
- Secondary alcohols
- The carbon atom contains one hydrogen atom.



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Primary, secondary & Tertiary alcohols

- Tertiary alcohols are those that do not have any hydrogen atom on the carbon atom bearing the hydroxyl group.



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Common names for alcohols

- Take the name of the corresponding alkyl group and add the word "alcohol", e.g. methyl alcohol, ethyl alcohol or *tert*-butyl alcohol.
- Propyl alcohol may be *n*-propyl alcohol or isopropyl alcohol depending on whether the hydroxyl group is bonded to the 1st or 2nd carbon on the propane chain.
- Isopropyl alcohol is also occasionally called *sec*-propyl alcohol.

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Physical properties: Solubility

- The hydroxyl group generally makes the alcohol molecule polar.
- Those groups can form hydrogen bonds to one another and to other compounds.
- This hydrogen bonding means that alcohols can be used as protic solvents.
- Two opposing solubility trends in alcohols are: the tendency of the polar OH to promote solubility in water, and of the carbon chain to resist it.

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Physical properties: Solubility

- Thus, methanol, ethanol, and propanol are miscible in water because the hydroxyl group wins out over the short carbon chain.
- Butanol, with a four-carbon chain, is moderately soluble because of a balance between the two trends.

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Physical properties: Solubility

- Alcohols of five or more carbons (Pentanol and higher) are effectively insoluble in water because of the hydrocarbon chain's dominance.
- All simple alcohols are miscible in organic solvents.

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Physical properties: boiling points of selected Alcohols

Carbons	IUPAC	Structure	Boiling point °C
1	Methanol	CH_3OH	65
2	Ethanol	$\text{CH}_3\text{CH}_2\text{OH}$	78
3	Propanol	$\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$	97
4	Butanol	$\text{CH}_3(\text{CH}_2)_2\text{CH}_2\text{OH}$	117
5	Pentanol	$\text{CH}_3(\text{CH}_2)_3\text{CH}_2\text{OH}$	138
6	Hexanol	$\text{CH}_3(\text{CH}_2)_4\text{CH}_2\text{OH}$	157

- Alcohols tend to have higher boiling points than comparable hydrocarbons due to hydrogen bonding

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Applications

- Alcohols can be used as a
 - beverage (ethanol only). Ethanol in the form of alcoholic beverages has been consumed by humans since pre-historic times.
 - as fuel and for many scientific, medical, and industrial utilities.
 - A 50% v/v solution of ethylene glycol in water is commonly used as an antifreeze.

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- Some alcohols, mainly ethanol and methanol, can be used as an alcohol fuel.
- Alcohols have applications in industry and science as reagents or solvents.
- Because of its low toxicity and ability to dissolve non-polar substances, ethanol can be used as a solvent in medical drugs, perfumes, and vegetable essences such as vanilla.

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- Ethanol can be used as an antiseptic to disinfect the skin before injections are given, often along with iodine.
- Ethanol-based soaps are becoming common in restaurants and are convenient because they do not require drying due to the volatility of the compound.

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- Alcohol is also used as a preservative for specimens.
- Alcohol gels have become common as hand sanitizers.

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Production of Industrial Ethanol

- Industrially alcohols are produced in several ways:
 - By fermentation using glucose produced from sugar from the hydrolysis of starch, in the presence of yeast and temperature of less than 37°C to produce ethanol. For instance the conversion of invertase to glucose and fructose or the conversion of glucose to zymase and ethanol.

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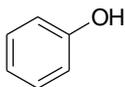
Production of Industrial Ethanol

- By direct hydration using ethylene (ethylene hydration or other alkenes from cracking of fractions of distilled crude oil. It usually uses a catalyst of phosphoric acid under high temperature and pressure of 50-120 atm.
- Methanol is produced from synthesis gas, where carbon monoxide and 2 equivalents of hydrogen gas are combined to produce methanol using a copper, zinc oxide and aluminium oxide catalyst at 250°C and a pressure of 50-100 atm.

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Phenol

- **Phenol**, also known as **carbolic acid**, is a toxic, white crystalline solid with a sweet tarry odor, commonly referred to as a "hospital smell". Its chemical formula is C_6H_5OH and its structure is that of a hydroxyl group (-OH) bonded to a phenyl ring; it is thus an aromatic compound.



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Phenol

- The word *phenol* is also used to refer to any compound that contains a six-membered aromatic ring, bonded directly to a hydroxyl group (-OH). In effect, phenols are a class of organic compounds of which the phenol discussed here is the simplest member.

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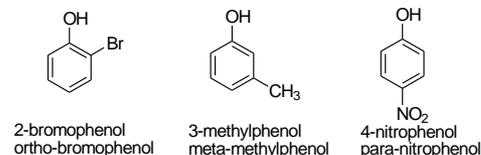
Properties of Phenol

- Phenol has a limited solubility in water (8.3 g/100 ml).
- It is slightly acidic. This means that a solution of phenol can turn blue litmus paper red.

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Nomenclature of Phenols

- A phenol always involves a benzene (type) ring, and often the terms ortho, meta and para (meaning 1,2 disubstituted, 1,3 disubstituted and 1,4 disubstituted respectively) are used. These terms are non-IUPAC though.



Uses of Phenol

- Phenol has antiseptic properties, and was used by Joseph Lister (1827-1912) in his pioneering technique of antiseptic surgery, though the skin irritation caused by continual exposure to phenol eventually led to the substitution of aseptic (germ-free) techniques in surgery.

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Uses of Phenol: Historical

- It is also used in the production of drugs (it is the starting material in the industrial production of aspirin), herbicides, and synthetic resins (Bakelite, one of the first synthetic resins to be manufactured, is a polymer of phenol with formaldehyde).

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Uses of Phenol: Current

- It is used in cosmetic surgery to remove layers of dead skin. It is also used in phenolization, a surgical procedure used to treat an ingrown nail, in which it is applied to the toe to prevent regrowth of nails.
- 5% Phenol is sometimes injected near a sensory nerve in order to temporarily (up to a year) stop it transmitting impulses in some intractable cases of chronic neuropathic pain.

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Uses of Phenol: Current

- Phenol is also used in the preparation of cosmetics including sunscreens, hair dyes, and skin lightening preparations.
- Compounds containing phenol moieties can be used to prevent ultraviolet light-induced damage to hair and skin due to the UV-absorbing properties of the aromatic ring of the phenol.

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