[Template:Redirect](/wiki/Template:Redirect" \o "Template:Redirect) [Template:Other uses](/wiki/Template:Other_uses) [Template:Pp-move-indef](/wiki/Template:Pp-move-indef) [Template:Use dmy dates](/wiki/Template:Use_dmy_dates) [Template:Chembox](/wiki/Template:Chembox) **Ethanol** [Template:IPAc-en](/wiki/Template:IPAc-en), also commonly called **alcohol**, **ethyl alcohol**, and **drinking alcohol**, is the principal type of [alcohol](/wiki/Alcohol) found in [alcoholic beverages](/wiki/Alcoholic_beverages), produced by the [fermentation](/wiki/Fermentation) of [sugars](/wiki/Sugar) by [yeasts](/wiki/Yeast). It is a [neurotoxic](/wiki/Neurotoxic),[[1]](#cite_note-1)[[2]](#cite_note-2) [psychoactive drug](/wiki/Psychoactive_drug), and one of the oldest [recreational drugs](/wiki/Recreational_drugs). It can cause [alcohol intoxication](/wiki/Alcohol_intoxication) when consumed in sufficient quantity.

Ethanol is a [volatile](/wiki/Volatility_(chemistry)), [flammable](/wiki/Flammability), colorless liquid with a slight chemical odor. It is used as an [antiseptic](/wiki/Antiseptic), a [solvent](/wiki/Solvent), a [fuel](/wiki/Alcohol_fuel), and due to its low freezing point, the active fluid in many [alcohol thermometers](/wiki/Alcohol_thermometer). The [molecule](/wiki/Molecule) is a simple one, being an [ethyl group](/wiki/Ethyl_group) linked to a [hydroxyl](/wiki/Hydroxyl) group. Its structural formula, [Template:Chem](/wiki/Template:Chem), is often abbreviated as [Template:Chem](/wiki/Template:Chem), [Template:Chem](/wiki/Template:Chem) or *EtOH*.

The stem word "eth-" used in many related compounds originates with the German word for ethanol (*äthyl*).[[3]](#cite_note-3)[Template:TOC limit](/wiki/Template:TOC_limit)

## Contents

* 1 Etymology[[edit](/index.php?title=(none)&action=edit&section=1)]
* 2 Uses[[edit](/index.php?title=(none)&action=edit&section=2)]
  + 2.1 Medical[[edit](/index.php?title=(none)&action=edit&section=3)]
    - 2.1.1 Antiseptic[[edit](/index.php?title=(none)&action=edit&section=4)]
    - 2.1.2 Antitussive[[edit](/index.php?title=(none)&action=edit&section=5)]
    - 2.1.3 Antidote[[edit](/index.php?title=(none)&action=edit&section=6)]
    - 2.1.4 Medicinal solvent[[edit](/index.php?title=(none)&action=edit&section=7)]
  + 2.2 Recreational[[edit](/index.php?title=(none)&action=edit&section=8)]
  + 2.3 Fuel[[edit](/index.php?title=(none)&action=edit&section=9)]
    - 2.3.1 Engine fuel[[edit](/index.php?title=(none)&action=edit&section=10)]
    - 2.3.2 Rocket Fuel[[edit](/index.php?title=(none)&action=edit&section=11)]
    - 2.3.3 Fuel Cells[[edit](/index.php?title=(none)&action=edit&section=12)]
    - 2.3.4 Household heating[[edit](/index.php?title=(none)&action=edit&section=13)]
  + 2.4 Feedstock[[edit](/index.php?title=(none)&action=edit&section=14)]
  + 2.5 Solvent[[edit](/index.php?title=(none)&action=edit&section=15)]
* 3 Adverse effects[[edit](/index.php?title=(none)&action=edit&section=16)]
  + 3.1 Loss of balance[[edit](/index.php?title=(none)&action=edit&section=17)]
  + 3.2 Gastrointestinal diseases{{anchor|Gastrointestinal\_disease}}[[edit](/index.php?title=(none)&action=edit&section=18)]
  + 3.3 Short-term toxic allergy-like responses[[edit](/index.php?title=(none)&action=edit&section=19)]
  + 3.4 Long-term[[edit](/index.php?title=(none)&action=edit&section=20)]
    - 3.4.1 Birth defects[[edit](/index.php?title=(none)&action=edit&section=21)]
    - 3.4.2 Cancer[[edit](/index.php?title=(none)&action=edit&section=22)]
    - 3.4.3 Other effects[[edit](/index.php?title=(none)&action=edit&section=23)]
  + 3.5 Reinforcement disorders[[edit](/index.php?title=(none)&action=edit&section=24)]
    - 3.5.1 Addiction[[edit](/index.php?title=(none)&action=edit&section=25)]
    - 3.5.2 Dependence and withdrawal[[edit](/index.php?title=(none)&action=edit&section=26)]
  + 3.6 Overdose[[edit](/index.php?title=(none)&action=edit&section=27)]
* 4 Interactions[[edit](/index.php?title=(none)&action=edit&section=28)]
  + 4.1 Alcohol and metronidazole[[edit](/index.php?title=(none)&action=edit&section=29)]
* 5 Pharmacology[[edit](/index.php?title=(none)&action=edit&section=30)]
  + 5.1 Pharmacodynamics[[edit](/index.php?title=(none)&action=edit&section=31)]
  + 5.2 Pharmacokinetics[[edit](/index.php?title=(none)&action=edit&section=32)]
    - 5.2.1 Metabolism[[edit](/index.php?title=(none)&action=edit&section=33)]
    - 5.2.2 Alcohol and digestion[[edit](/index.php?title=(none)&action=edit&section=34)]
    - 5.2.3 Magnitude of effects[[edit](/index.php?title=(none)&action=edit&section=35)]
* 6 Physical and chemical properties[[edit](/index.php?title=(none)&action=edit&section=36)]
  + 6.1 Chemical formula[[edit](/index.php?title=(none)&action=edit&section=37)]
  + 6.2 Physical properties[[edit](/index.php?title=(none)&action=edit&section=38)]
  + 6.3 Solvent properties[[edit](/index.php?title=(none)&action=edit&section=39)]
  + 6.4 Flammability[[edit](/index.php?title=(none)&action=edit&section=40)]
* 7 Natural occurrence[[edit](/index.php?title=(none)&action=edit&section=41)]
* 8 Production[[edit](/index.php?title=(none)&action=edit&section=42)]
  + 8.1 Ethylene hydration[[edit](/index.php?title=(none)&action=edit&section=43)]
  + 8.2 Fermentation[[edit](/index.php?title=(none)&action=edit&section=44)]
    - 8.2.1 Cellulose[[edit](/index.php?title=(none)&action=edit&section=45)]
  + 8.3 Testing[[edit](/index.php?title=(none)&action=edit&section=46)]
* 9 Purification[[edit](/index.php?title=(none)&action=edit&section=47)]
  + 9.1 Distillation[[edit](/index.php?title=(none)&action=edit&section=48)]
  + 9.2 Molecular sieves and desiccants[[edit](/index.php?title=(none)&action=edit&section=49)]
  + 9.3 Membranes and reverse osmosis[[edit](/index.php?title=(none)&action=edit&section=50)]
  + 9.4 Other techniques[[edit](/index.php?title=(none)&action=edit&section=51)]
  + 9.5 Grades of ethanol[[edit](/index.php?title=(none)&action=edit&section=52)]
    - 9.5.1 Denatured alcohol[[edit](/index.php?title=(none)&action=edit&section=53)]
    - 9.5.2 Absolute alcohol[[edit](/index.php?title=(none)&action=edit&section=54)]
    - 9.5.3 Rectified spirits[[edit](/index.php?title=(none)&action=edit&section=55)]
* 10 Reactions[[edit](/index.php?title=(none)&action=edit&section=56)]
  + 10.1 Ester formation[[edit](/index.php?title=(none)&action=edit&section=57)]
  + 10.2 Dehydration[[edit](/index.php?title=(none)&action=edit&section=58)]
  + 10.3 Combustion[[edit](/index.php?title=(none)&action=edit&section=59)]
  + 10.4 Acid-base chemistry[[edit](/index.php?title=(none)&action=edit&section=60)]
  + 10.5 Halogenation[[edit](/index.php?title=(none)&action=edit&section=61)]
  + 10.6 Oxidation[[edit](/index.php?title=(none)&action=edit&section=62)]
* 11 History[[edit](/index.php?title=(none)&action=edit&section=63)]
* 12 Society and culture[[edit](/index.php?title=(none)&action=edit&section=64)]
* 13 See also[[edit](/index.php?title=(none)&action=edit&section=65)]
* 14 References[[edit](/index.php?title=(none)&action=edit&section=66)]
* 15 Further reading[[edit](/index.php?title=(none)&action=edit&section=67)]
* 16 External links[[edit](/index.php?title=(none)&action=edit&section=68)]

## Etymology[[edit](/index.php?title=(none)&action=edit&section=1)]

*Ethanol* is the [systematic name](/wiki/Systematic_name) defined by the [International Union of Pure and Applied Chemistry (IUPAC)](/wiki/IUPAC_nomenclature_of_organic_chemistry) for a molecule with two carbon [atoms](/wiki/Atom) (prefix "eth-"), having a single bond between them (suffix "-ane"), and an attached [functional group](/wiki/Functional_group)-OH group (suffix "-ol").[[4]](#cite_note-4) The prefix *ethyl* was coined in 1834 by the German chemist [Justus Liebig](/wiki/Justus_von_Liebig).[[5]](#cite_note-5) *Ethyl* is a contraction of the Ancient Greek αἰθήρ (aithḗr, “upper air”) and the Greek word [*Template:Lang*](/wiki/Template:Lang) (*hyle*, substance).[[6]](#cite_note-6) The name *ethanol* was coined as a result of a resolution that was adopted at the International Conference on Chemical Nomenclature that was held in April 1892 in Geneva, Switzerland.[[7]](#cite_note-7) The term "[alcohol](/wiki/Alcohol)" now refers to a wider class of substances in chemistry nomenclature, but in common parlance it remains the name of ethanol. Ultimately a medieval loan from Arabic [*al-kuḥl*](/wiki/Kohl_(cosmetics)),[[8]](#cite_note-8) use of *alcohol* in this sense is modern, introduced in the mid 18th century. Before that time, Middle Latin *alcohol* referred to "powdered ore of antimony; powdered cosmetic", by the later 17th century "any sublimated substance; [distilled spirit](/wiki/Distilled_beverage)" use for "the spirit of wine" (shortened from a full expression *alcohol of wine*) recorded 1753. The systematic use in chemistry dates to 1850.

## Uses[[edit](/index.php?title=(none)&action=edit&section=2)]

### Medical[[edit](/index.php?title=(none)&action=edit&section=3)]

#### Antiseptic[[edit](/index.php?title=(none)&action=edit&section=4)]

Ethanol is used in medical wipes and in most common antibacterial [hand sanitizer](/wiki/Hand_sanitizer) gels at a concentration of about 62% v/v as an [antiseptic](/wiki/Antiseptic). Ethanol kills organisms by [denaturing](/wiki/Denaturation_(biochemistry)) their [proteins](/wiki/Protein) and dissolving their [lipids](/wiki/Lipid) and is effective against most [bacteria](/wiki/Bacteria) and [fungi](/wiki/Fungus), and many [viruses](/wiki/Virus). Ethanol is ineffective against bacterial [spores](/wiki/Endospore).[[9]](#cite_note-9)

#### Antitussive[[edit](/index.php?title=(none)&action=edit&section=5)]

Ethanol is widely used, clinically and over the counter, as an [antitussive](/wiki/Antitussive) agent.[[10]](#cite_note-10)

#### Antidote[[edit](/index.php?title=(none)&action=edit&section=6)]

Ethanol may be administered as an [antidote](/wiki/Antidote) to [methanol](/wiki/Methanol)[[11]](#cite_note-11) and [ethylene glycol](/wiki/Ethylene_glycol) poisoning.

#### Medicinal solvent[[edit](/index.php?title=(none)&action=edit&section=7)]

Ethanol, often in high concentrations, is used to dissolve many water-insoluble medications and related compounds. Proprietary liquid preparations of cough and cold remedies, analgesics, and mouth washes may be dissolved in 1 to 25% concentrations of ethanol and may need to be avoided in individuals with adverse reactions to ethanol such as [alcohol-induced respiratory reactions](/wiki/Alcohol-induced_respiratory_reactions).[[12]](#cite_note-12)

### Recreational[[edit](/index.php?title=(none)&action=edit&section=8)]

Ethanol is a central nervous system [depressant](/wiki/Depressant) and has significant psychoactive effects in sublethal doses. Based on its abilities to alter [human consciousness](/wiki/Human_consciousness), ethanol is considered a [psychoactive drug](/wiki/Psychoactive_drug).[[13]](#cite_note-13) The amount of ethanol in the body is typically quantified by [blood alcohol content](/wiki/Blood_alcohol_content) (BAC), which is here taken as weight of ethanol per unit volume of blood. Small doses of ethanol, in general, produce euphoria and relaxation; people experiencing these symptoms tend to become talkative and less inhibited, and may exhibit poor judgment. At higher dosages (BAC > 1 g/L), ethanol acts as a [central nervous system](/wiki/Central_nervous_system) [depressant](/wiki/Depressant), producing at progressively higher dosages, impaired sensory and motor function, slowed cognition, stupefaction, unconsciousness, and possible death. Ethanol is commonly consumed as a recreational drug, especially while socializing, due to its psychoactive effects.

### Fuel[[edit](/index.php?title=(none)&action=edit&section=9)]

#### Engine fuel[[edit](/index.php?title=(none)&action=edit&section=10)]

|  |
| --- |
| +[Energy content](/wiki/Energy_density) of some fuels compared with ethanol:[[14]](#cite_note-14) |
| **Fuel type** | **MJ/L** | **MJ/kg** | [**Research octane number**](/wiki/Octane_rating) |
| [Dry wood (20% moisture)](/wiki/Wood_fuel) |  | ~19.5 |  |
| [Methanol](/wiki/Methanol) | 17.9 | 19.9 | 108.7[[15]](#cite_note-15) |
| [Ethanol](/wiki/Ethanol_fuel) | 21.2[[16]](#cite_note-16) | 26.8[[16]](#cite_note-16) | 108.6[[15]](#cite_note-15) |
| [E85](/wiki/E85) (85% ethanol, 15% gasoline) | 25.2 | 33.2 | 105 |
| [Liquefied natural gas](/wiki/Liquefied_natural_gas) | 25.3 | ~55 |  |
| [Autogas](/wiki/Autogas) ([LPG](/wiki/Liquified_petroleum_gas)) (60% [propane](/wiki/Propane) + 40% [butane](/wiki/Butane)) | 26.8 | 50. |  |
| [Aviation gasoline](/wiki/Aviation_gasoline) (high-octane gasoline, not jet fuel) | 33.5 | 46.8 | 100/130 (lean/rich) |
| [Gasohol](/wiki/Alcohol_fuel) (90% gasoline + 10% ethanol) | 33.7 | 47.1 | 93/94 |
| Regular gasoline/petrol | 34.8 | 44.4[[17]](#cite_note-17) | min. 91 |
| Premium gasoline/petrol |  |  | max. 104 |
| [Diesel](/wiki/Diesel_fuel) | 38.6 | 45.4 | 25 |
| [Charcoal](/wiki/Charcoal), extruded | 50 | 23 |  |

[Template:Main article](/wiki/Template:Main_article)

The largest single use of ethanol is as an engine [fuel](/wiki/Fuel) and [fuel additive](/wiki/Fuel_additive). [Brazil](/wiki/Brazil) in particular relies heavily upon the use of ethanol as an engine fuel, due in part to its role as the globe's leading producer of ethanol.[[18]](#cite_note-18) [Gasoline](/wiki/Gasoline) sold in Brazil contains at least 25% [anhydrous](/wiki/Anhydrous) ethanol. Hydrous ethanol (about 95% ethanol and 5% water) can be used as fuel in more than 90% of new gasoline fueled cars sold in the country. Brazilian ethanol is produced from [sugar cane](/wiki/Sugar_cane) and noted for high [carbon sequestration](/wiki/Carbon_sequestration).[[19]](#cite_note-19) The US uses Gasohol (max 10% ethanol) and E85 (85% ethanol) ethanol/gasoline mixtures. [thumb|upright|](/wiki/File:Ethyl_alcohol_usp_grade.jpg)[USP](/wiki/United_States_Pharmacopeia) grade ethanol for laboratory use. Ethanol has been used as [rocket fuel](/wiki/Rocket_fuel) and is currently in [lightweight](/wiki/Light_aircraft) [rocket-powered racing aircraft](/wiki/Mark-III_X-racer).[[20]](#cite_note-20) Australian law limits the use of pure ethanol from sugarcane waste to 10% in automobiles. Older cars (and vintage cars designed to use a slower burning fuel) should have the engine valves upgraded or replaced.[[21]](#cite_note-21) According to an industry [advocacy group](/wiki/Advocacy_group), ethanol as a fuel reduces harmful [tailpipe emissions](/wiki/Motor_vehicle_emissions) of carbon monoxide, particulate matter, [oxides of nitrogen](/wiki/Oxides_of_nitrogen), and other ozone-forming pollutants.[[22]](#cite_note-22) [Argonne National Laboratory](/wiki/Argonne_National_Laboratory) analyzed greenhouse gas emissions of many different engine and fuel combinations, and found that [biodiesel](/wiki/Biodiesel)/petrodiesel blend ([B20](/wiki/B20_(biodiesel))) showed a reduction of 8%, conventional [E85](/wiki/E85) ethanol blend a reduction of 17% and [cellulosic ethanol](/wiki/Cellulosic_ethanol) 64%, compared with pure gasoline.[[23]](#cite_note-23) Ethanol combustion in an internal combustion engine yields many of the products of incomplete combustion produced by gasoline and significantly larger amounts of [formaldehyde](/wiki/Formaldehyde) and related species such as acetaldehyde.[[24]](#cite_note-24) This leads to a significantly larger photochemical reactivity and more [ground level ozone](/wiki/Ground_level_ozone).[[25]](#cite_note-25) These data have been assembled into [The Clean Fuels Report](/wiki/Clean_Fuels_Report) comparison of fuel emissions[[26]](#cite_note-26) and show that ethanol exhaust generates 2.14 times as much ozone as gasoline exhaust.[Template:Citation needed](/wiki/Template:Citation_needed) When this is added into the custom *Localised Pollution Index (LPI)* of The Clean Fuels Report, the local pollution of ethanol (pollution that contributes to smog) is rated 1.7, where gasoline is 1.0 and higher numbers signify greater pollution.[Template:Citation needed](/wiki/Template:Citation_needed) The [California Air Resources Board](/wiki/California_Air_Resources_Board) formalized this issue in 2008 by recognizing control standards for formaldehydes as an emissions control group, much like the conventional [NOx](/wiki/NOx) and Reactive Organic Gases (ROGs).[[27]](#cite_note-27) World production of ethanol in 2006 was [Template:Convert](/wiki/Template:Convert), with 69% of the world supply coming from Brazil and the United States.[[28]](#cite_note-28) More than 20% of Brazilian cars are able to use 100% ethanol as fuel, which includes ethanol-only engines and [flex-fuel](/wiki/Flexible-fuel_vehicle) engines.[[29]](#cite_note-29) Flex-fuel engines in Brazil are able to work with all ethanol, all gasoline or any mixture of both. In the US flex-fuel vehicles can run on 0% to 85% ethanol (15% gasoline) since higher ethanol blends are not yet allowed or efficient. Brazil supports this population of ethanol-burning automobiles with large national infrastructure that produces ethanol from domestically grown [sugar cane](/wiki/Sugar_cane). [Sugar cane](/wiki/Sugar_cane) not only has a greater concentration of sucrose than corn (by about 30%), but is also much easier to extract. The [bagasse](/wiki/Bagasse) generated by the process is not wasted, but is used in power plants to produce electricity.[Template:Citation needed](/wiki/Template:Citation_needed)

In the United States, the ethanol fuel industry is based largely on [corn](/wiki/Maize). According to the Renewable Fuels Association, as of 30 October 2007, 131 grain ethanol bio-refineries in the United States have the capacity to produce [Template:Convert](/wiki/Template:Convert) of ethanol per year. An additional 72 construction projects underway (in the U.S.) can add [Template:Convert](/wiki/Template:Convert) of new capacity in the next 18 months. Over time, it is believed that a material portion of the ≈[Template:Convert](/wiki/Template:Convert) per year market for gasoline will begin to be replaced with fuel ethanol.[[30]](#cite_note-30) [Sweet sorghum](/wiki/Sweet_sorghum) is another potential source of ethanol, and is suitable for growing in dryland conditions. The [International Crops Research Institute for the Semi-Arid Tropics](/wiki/International_Crops_Research_Institute_for_the_Semi-Arid_Tropics) ([ICRISAT](/wiki/ICRISAT)) is investigating the possibility of growing sorgham as a source of fuel, food, and animal feed in arid parts of [Asia](/wiki/Asia) and [Africa](/wiki/Africa).[[31]](#cite_note-31) [Sweet sorghum](/wiki/Sweet_sorghum) has one-third the water requirement of sugarcane over the same time period. It also requires about 22% less water than corn (also known as maize). The world’s first sweet sorghum ethanol distillery began commercial production in 2007 in Andhra Pradesh, India.[[32]](#cite_note-32) Ethanol's high [miscibility](/wiki/Miscibility) with water makes it unsuitable for shipping through modern [pipelines](/wiki/Pipeline_transport) like liquid hydrocarbons.[[33]](#cite_note-33) Mechanics have seen increased cases of damage to small engines (in particular, the [carburetor](/wiki/Carburetor)) and attribute the damage to the increased water retention by ethanol in fuel.[[34]](#cite_note-34)[Template:Multiple image](/wiki/Template:Multiple_image)

#### Rocket Fuel[[edit](/index.php?title=(none)&action=edit&section=11)]

Ethanol was commonly used as fuel in early [bipropellant](/wiki/Bipropellant) [rocket](/wiki/Rocket) (liquid propelled) vehicles, in conjunction with an [oxidizer](/wiki/Oxidizer) such as liquid oxygen. The German [V-2 rocket](/wiki/V-2_rocket) of [World War II](/wiki/World_War_II), credited with beginning the space age, used ethanol, mixed with 25% of water to reduce the combustion chamber temperature.[[35]](#cite_note-35)[[36]](#cite_note-36) The V-2's design team helped develop U.S. rockets following World War II, including the ethanol-fueled [Redstone rocket](/wiki/Redstone_(rocket)) which launched the first U.S. satellite.[[37]](#cite_note-37) Alcohols fell into general disuse as more efficient rocket fuels were developed.[[36]](#cite_note-36)

#### Fuel Cells[[edit](/index.php?title=(none)&action=edit&section=12)]

Commercial fuel cells operate on reformed natural gas, [hydrogen](/wiki/Hydrogen) or [methanol](/wiki/Methanol). Ethanol is an attractive alternative due to its wide availability, low cost, high purity and low toxicity. There are a wide range of fuel cell concepts that have been trialled including [direct-ethanol fuel cells](/wiki/Direct-ethanol_fuel_cell), auto-thermal reforming systems and thermally integrated systems. The majority of work is being conducted at a research level although there are a number of organizations at the beginning of commercialization of ethanol fuel cells.[[38]](#cite_note-38)

#### Household heating[[edit](/index.php?title=(none)&action=edit&section=13)]

[thumbnail|right|An example of a bio-ethanol fire in the form of a traditional fireplace, using fire-proof ceramic simulated wood logs for effect.](/wiki/File:A_bio-ethanol_fireplace_with_artificial_wood_logs.jpg)

Ethanol fuels flue-less, real flame fireplaces.[[39]](#cite_note-39) Ethanol is kept in a burner containing a wick such as glass wool, a safety shield to reduce the chances of accidents and an extinguisher such as a plate or shutter to cut off oxygen.

It provides almost the same visual benefits of a real flame log or coal fire without the need to vent the fumes via a flue as ethanol produces very little hazardous carbon monoxide, and little or no noticeable scent. It does emit carbon dioxide and requires oxygen. Therefore, external ventilation of the room containing the fire is needed to ensure safe operation.

An additional benefit is that, unlike a flue based fireplace, 100% of the heat energy produced enters the room. This serves to offset some of the heat loss from an external air vent, as well as offset the relatively high cost of the fuel compared to other forms of heating.

### Feedstock[[edit](/index.php?title=(none)&action=edit&section=14)]

[Template:Further](/wiki/Template:Further)

Ethanol is an important industrial ingredient. It has widespread use as a precursor for other organic compounds such as ethyl [halides](/wiki/Halide), ethyl [esters](/wiki/Ester), diethyl ether, acetic acid, and ethyl [amines](/wiki/Amine).

### Solvent[[edit](/index.php?title=(none)&action=edit&section=15)]

Ethanol is [miscible](/wiki/Miscible) with [water](/wiki/Water_(molecule)) and is a good general purpose [solvent](/wiki/Solvent). It is found in [paints](/wiki/Paint), [tinctures](/wiki/Tincture), markers, and personal care products such as mouthwashes, perfumes and deodorants. However, [polysaccharides](/wiki/Polysaccharides) [precipitate](/wiki/Ethanol_precipitation) from aqueous solution in the presence of alcohol, and ethanol precipitation is used for this reason in the purification of [DNA](/wiki/DNA) and [RNA](/wiki/RNA).

## Adverse effects[[edit](/index.php?title=(none)&action=edit&section=16)]

[Template:Main article](/wiki/Template:Main_article)

### Loss of balance[[edit](/index.php?title=(none)&action=edit&section=17)]

When alcohol reaches the brain, it has the ability to delay signals that are sent between nerve cells that control balance, thinking and movement.[[40]](#cite_note-40)

### Gastrointestinal diseases{{anchor|Gastrointestinal\_disease}}[[edit](/index.php?title=(none)&action=edit&section=18)]

[thumb|200px|alt=compare|Diagram of mucosal layer](/wiki/File:Stomach_mucosal_layer_labeled.svg)

Alcohol stimulates gastric juice production, even when food is not present, and as a result, its consumption will stimulate acidic secretions normally intended to digest protein molecules. Consequently, the excess acidity may harm the inner lining of the stomach. The stomach lining is normally protected by a mucosal layer which prevents the stomach from essentially digesting itself. However, in patients who have a [peptic ulcer](/wiki/Peptic_ulcer) disease (PUD), this mucosal layer is broken down. PUD is commonly associated with the bacteria *H. pylori*. *H. pylori* secrete a toxin that weakens the mucosal wall, which as a result lead to acid and protein enzymes penetrating the weakened barrier. Because alcohol stimulates a person's stomach to secrete acid, a person with PUD should avoid drinking alcohol on an empty stomach. Drinking alcohol would cause more acid release which would further damage the already-weakened stomach wall.[[41]](#cite_note-41) Complications of this disease could include a burning pain in the abdomen, bloating and in severe cases, the presence of dark black stools indicate internal bleeding.[[42]](#cite_note-42) A person who drinks alcohol regularly is strongly advised to reduce their intake to prevent PUD aggravation.[[42]](#cite_note-42) Ingestion of alcohol can initiate systemic pro-inflammatory changes through two intestinal routes: (1) altering intestinal microbiota composition (dysbiosis), which increases lipopolysaccharide (LPS) release, and (2) degrading intestinal barrier integrity - thus allowing this (LPS) to enter the circulatory system. The major portion of the blood supply to the liver is provided the portal vein. Therefore, while the liver is continuously fed nutrients from the intestine, it is also exposed to any bacteria and/or bacterial derivatives that breach the intestinal mucosal barrier. Consequently, LPS levels increase in the portal vein, liver and systemic circulation after alcohol intake. Immune cells in the liver respond to LPS with the production of reactive oxygen species (ROS), leukotrienes, chemokines and cytokines. These factors promote tissue inflammation and contribute to organ pathology.[[43]](#cite_note-43)

### Short-term toxic allergy-like responses[[edit](/index.php?title=(none)&action=edit&section=19)]

[Template:Main article](/wiki/Template:Main_article) Ethanol-containing beverages can cause [urticarial](/wiki/Urticarial) skin eruptions, systemic [dermatitis](/wiki/Dermatitis), [alcohol flush reactions](/wiki/Alcohol_flush_reaction), exacerbations of [rhinitis](/wiki/Rhinitis) and, more seriously and commonly, [bronchoconstriction](/wiki/Bronchoconstriction) in patients with a history of [asthma](/wiki/Asthma). These reactions occur within 1–60 minutes of ethanol ingestion and are due to: **1)** genetic abnormalities in the metabolism of ethanol which cause the ethanol metabolite, [acetaldehyde](/wiki/Acetaldehyde), to accumulate in tissues and trigger the release of [histamine](/wiki/Histamine), the evoker of these symptoms; **2)** true [allergy](/wiki/Allergy) reactions to [allergens](/wiki/Allergens) occurring naturally in, or contaminating, alcoholic beverages, particularly wines and beers, and **3)** unknown causes.[[12]](#cite_note-12)

### Long-term[[edit](/index.php?title=(none)&action=edit&section=20)]

[Template:Main article](/wiki/Template:Main_article)

#### Birth defects[[edit](/index.php?title=(none)&action=edit&section=21)]

[Template:See also](/wiki/Template:See_also) Ethanol is classified as a [teratogen](/wiki/Teratogen).[Template:Mcn](/wiki/Template:Mcn) According to the CDC, alcohol consumption by women of child-bearing age who are not using birth control increases the risk of fetal alcohol syndrome. The CDC currently recommends complete abstinence from alcoholic beverages.[[44]](#cite_note-44)

#### Cancer[[edit](/index.php?title=(none)&action=edit&section=22)]

[IARC](/wiki/International_Agency_for_Research_on_Cancer) list ethanol in alcoholic beverages as *Group 1 carcinogens* and arguments "There is sufficient evidence for the [carcinogenicity](/wiki/Alcohol_and_cancer) of [acetaldehyde](/wiki/Acetaldehyde) (the major metabolite of ethanol) in experimental animals.".[[45]](#cite_note-45)

#### Other effects[[edit](/index.php?title=(none)&action=edit&section=23)]

Frequent drinking of alcoholic beverages has been shown to be a major contributing factor in cases of elevated blood levels of [triglycerides](/wiki/Triglyceride).[[46]](#cite_note-46)

### Reinforcement disorders[[edit](/index.php?title=(none)&action=edit&section=24)]

#### Addiction[[edit](/index.php?title=(none)&action=edit&section=25)]

[Template:See also](/wiki/Template:See_also) The reinforcing effects of alcohol consumption are mediated by [acetaldehyde](/wiki/Acetaldehyde) generated by [catalase](/wiki/Catalase) and other oxidizing enzymes such as [cytochrome P-4502E1](/wiki/CYP2E1) in the brain.[[47]](#cite_note-47) Although acetaldehyde has been associated with some of the adverse and toxic effects of ethanol, it appears to play a central role in the activation of the [mesolimbic dopamine system](/wiki/Mesolimbic_pathway).[[48]](#cite_note-48) Ethanol's rewarding and reinforcing (i.e., [addictive](/wiki/Addictive)) properties are mediated through its effects on [dopamine](/wiki/Dopamine) neurons in the [mesolimbic reward pathway](/wiki/Mesolimbic_reward_pathway), which connects the [ventral tegmental area](/wiki/Ventral_tegmental_area) to the [nucleus accumbens](/wiki/Nucleus_accumbens) (NAcc).[[49]](#cite_note-49)[[50]](#cite_note-50) One of ethanol's primary effects is the allosteric inhibition of [NMDA receptors](/wiki/NMDA_receptor) and facilitation of [GABAA receptors](/wiki/GABAA_receptor) (e.g., enhanced GABAA receptor-mediated [chloride](/wiki/Chloride) flux through [allosteric regulation](/wiki/Allosteric_regulation) of the receptor).[[51]](#cite_note-51) At high doses, ethanol inhibits most [ligand gated ion channels](/wiki/Ligand_gated_ion_channel) and [voltage gated ion channels](/wiki/Voltage_gated_ion_channel) in neurons as well.[[51]](#cite_note-51) With acute alcohol consumption, [dopamine](/wiki/Dopamine) is released in the [synapses](/wiki/Chemical_synapse) of the mesolimbic pathway, in turn heightening activation of postsynaptic [D1 receptors](/wiki/Dopamine_receptor_D1).[[49]](#cite_note-49)[[50]](#cite_note-50) The activation of these receptors triggers postsynaptic internal signaling events through [protein kinase A](/wiki/Protein_kinase_A) which ultimately [phosphorylate](/wiki/Phosphorylate) [cAMP response element binding protein](/wiki/CAMP_response_element_binding_protein) (CREB), inducing CREB-mediated changes in [gene expression](/wiki/Gene_expression).[[49]](#cite_note-49)[[50]](#cite_note-50) With chronic alcohol intake, consumption of ethanol similarly induces CREB phosphorylation through the D1 receptor pathway, but it also alters [NMDA receptor](/wiki/NMDA_receptor) function through phosphorylation mechanisms;[[49]](#cite_note-49)[[50]](#cite_note-50) an adaptive [downregulation](/wiki/Downregulation_and_upregulation) of the D1 receptor pathway and CREB function occurs as well.[[49]](#cite_note-49)[[50]](#cite_note-50) Chronic consumption is also associated with an effect on CREB phosphorylation and function via postsynaptic NMDA receptor signaling cascades through a [MAPK/ERK pathway](/wiki/MAPK/ERK_pathway) and [CAMK](/wiki/CAMK)-mediated pathway.[[50]](#cite_note-50) These modifications to CREB function in the mesolimbic pathway [induce expression](/wiki/Inducible_gene) (i.e., increase gene expression) of ΔFosB in the [Template:Abbr](/wiki/Template:Abbr),[[50]](#cite_note-50) where ΔFosB is the "master control protein" that, when overexpressed in the NAcc, is [necessary and sufficient](/wiki/Necessary_and_sufficient) for the development and maintenance of an addictive state (i.e., its overexpression in the nucleus accumbens produces and then directly modulates compulsive alcohol consumption).[[50]](#cite_note-50)[[52]](#cite_note-52)[[53]](#cite_note-53)[[54]](#cite_note-54)

#### Dependence and withdrawal[[edit](/index.php?title=(none)&action=edit&section=26)]

[Template:See also](/wiki/Template:See_also) Discontinuing consumption of alcohol after several years of heavy drinking can also be fatal. Alcohol withdrawal can cause anxiety, autonomic dysfunction, seizures, and hallucinations. [Delirium tremens](/wiki/Delirium_tremens) is a condition that requires people with a long history of heavy drinking to undertake an [alcohol detoxification](/wiki/Alcohol_detoxification) regimen.

### Overdose[[edit](/index.php?title=(none)&action=edit&section=27)]

[Template:See also](/wiki/Template:See_also)

|  |  |  |
| --- | --- | --- |
| **BAC (g/L)** | **BAC  (% v/v)** | **Symptoms**[**[55]**](#cite_note-55) |
| 0.5 | 0.05% | [Euphoria](/wiki/Euphoria), talkativeness, relaxation |
| 1 | 0.1 % | Central nervous system depression, nausea, possible vomiting, impaired motor and sensory function, impaired cognition |
| >1.4 | >0.14% | Decreased blood flow to brain |
| 3 | 0.3% | Stupefaction, possible unconsciousness |
| 4 | 0.4% | Possible death |
| >5.5 | >0.55% | Death |

Death from ethanol consumption is possible when blood alcohol levels reach 0.4%. A blood level of 0.5% or more is commonly fatal. Levels of even less than 0.1% can cause [intoxication](/wiki/Alcohol_intoxication), with unconsciousness often occurring at 0.3–0.4%.[[56]](#cite_note-56) Prolonged heavy consumption of alcohol can cause significant permanent damage to the brain and other organs.

## Interactions[[edit](/index.php?title=(none)&action=edit&section=28)]

Ethanol can intensify the sedation caused by other [central nervous system](/wiki/Central_nervous_system) [depressant](/wiki/Depressant) drugs such as [barbiturates](/wiki/Barbiturate), [benzodiazepines](/wiki/Benzodiazepine), [opioids](/wiki/Opioid), [non-benzodiazepines](/wiki/Non-benzodiazepine) (such as [Zolpidem](/wiki/Zolpidem) and [Zopiclone](/wiki/Zopiclone)), [antipsychotics](/wiki/Antipsychotics), [sedative antihistamines](/wiki/Histamine_antagonist), and [antidepressants](/wiki/Antidepressants).[[56]](#cite_note-56) It interacts with [cocaine](/wiki/Cocaine) in vivo to produce [cocaethylene](/wiki/Cocaethylene), another psychoactive substance.[[57]](#cite_note-57) Ethanol enhances the [bioavailability](/wiki/Bioavailability) of [methylphenidate](/wiki/Methylphenidate) (elevated plasma d-MPH).[[58]](#cite_note-58) In combination with cannabis, ethanol increases plasma THC levels, which suggests that ethanol may increase the absorption of THC.[[59]](#cite_note-59)

### Alcohol and metronidazole[[edit](/index.php?title=(none)&action=edit&section=29)]

One of the most important drug/food interactions that should be noted is between alcohol and [metronidazole](/wiki/Metronidazole).

Metronidazole is an antibacterial agent that kills bacteria by damaging cellular DNA and hence cellular function.[[60]](#cite_note-60) Metronidazole is usually given to people who have diarrhea caused by [*Clostridium difficile*](/wiki/Clostridium_difficile_(bacteria)) bacteria. *C. difficile* is one of the most common microorganisms that cause diarrhea and can lead to complications such as colon inflammation and even more severely, death.

Patients who are taking metronidazole are strongly advised to avoid alcohol, even after 1 hour after the last dose. The reason is that alcohol and metronidazole can lead to side effects such as flushing, headache, nausea, vomiting, abdominal cramps, and sweating.[[61]](#cite_note-61)[[62][62]](#cite_note-62) These symptoms are often called the [disulfiram](/wiki/Disulfiram)-like reaction. The proposed mechanism of action for this interaction is that metronidazole can bind to an enzyme that normally metabolizes alcohol. Binding to this enzyme may impair the liver's ability to process alcohol for proper excretion.[[63]](#cite_note-63)

## Pharmacology[[edit](/index.php?title=(none)&action=edit&section=30)]

### Pharmacodynamics[[edit](/index.php?title=(none)&action=edit&section=31)]

[Template:See also](/wiki/Template:See_also) Ethanol acts in the central nervous system primarily by binding to the GABAA receptor, increasing the effects of the inhibitory [neurotransmitter](/wiki/Neurotransmitter) [GABA](/wiki/GABA) (i.e., it is a [positive allosteric modulator](/wiki/Positive_allosteric_modulator)).[[64]](#cite_note-64) Ethanol is known to possess the following direct [pharmacodynamic](/wiki/Pharmacodynamic) actions (most important actions are bolded):[[65]](#cite_note-65)\* [**GABAA receptor**](/wiki/GABAA_receptor)[**positive allosteric modulator**](/wiki/Positive_allosteric_modulator) (primarily of [δ subunit](/wiki/GABRD)-containing receptors)

* [Glycine receptor](/wiki/Glycine_receptor) positive and negative allosteric modulator
* [**NMDA receptor**](/wiki/NMDA_receptor)[**negative allosteric modulator**](/wiki/Negative_allosteric_modulator)[[66]](#cite_note-66)\* [AMPA receptor](/wiki/AMPA_receptor) negative allosteric modulator[[66]](#cite_note-66)\* [Kainate receptor](/wiki/Kainate_receptor) negative allosteric modulator[[66]](#cite_note-66)\* [nACh receptor](/wiki/Nicotinic_acetylcholine_receptor) positive and negative allosteric modulator
* [5-HT3 receptor](/wiki/5-HT3_receptor) positive allosteric modulator
* [Glycine reuptake inhibitor](/wiki/Glycine_reuptake_inhibitor)[[67]](#cite_note-67)\* [Adenosine reuptake inhibitor](/wiki/Adenosine_reuptake_inhibitor)[[68]](#cite_note-68)\* [L-type calcium channel](/wiki/L-type_calcium_channel) [blocker](/wiki/Channel_blocker)
* [GIRK channel](/wiki/G_protein-coupled_inwardly-rectifying_potassium_channel) [opener](/wiki/Channel_opener)

Some of its actions on [ligand-gated ion channels](/wiki/Ligand-gated_ion_channel), specifically the nACh receptors and the glycine receptor, are [dose-dependent](/wiki/Dose-dependent), with potentiation *or* inhibition occurring dependent on ethanol concentration. This is because ethanol's effects on these channels are a summation of positive and negative allosteric modulatory actions.[[65]](#cite_note-65)

### Pharmacokinetics[[edit](/index.php?title=(none)&action=edit&section=32)]

The removal of ethanol from the human body, through oxidation by [alcohol dehydrogenase](/wiki/Alcohol_dehydrogenase) in the [liver](/wiki/Liver), is limited. Hence, the removal of a large concentration of alcohol from [blood](/wiki/Blood) may follow [zero-order kinetics](/wiki/Zero_order_kinetics). This means that alcohol leaves the body at a constant rate, rather than having an elimination [half-life](/wiki/Biological_half-life).<ref name=pmid5457514>[Template:Cite journal](/wiki/Template:Cite_journal)</ref>

The rate-limiting steps for one substance may be in common with other substances. As a result, the blood alcohol concentration can be used to modify the rate of metabolism of [methanol](/wiki/Methanol) and [ethylene glycol](/wiki/Ethylene_glycol). Methanol itself is not highly toxic, but its metabolites [formaldehyde](/wiki/Formaldehyde) and [formic acid](/wiki/Formic_acid) are; therefore, to reduce the rate of production and concentration of these harmful metabolites, ethanol can be ingested.[[69]](#cite_note-69) [Ethylene glycol](/wiki/Ethylene_glycol) poisoning can be treated in the same way.

Pure ethanol will irritate the skin and eyes.[[70]](#cite_note-70) Nausea, [vomiting](/wiki/Vomiting) and intoxication are symptoms of ingestion. Long-term use by ingestion can result in serious liver damage.[[71]](#cite_note-71)Atmospheric concentrations above one in a thousand are above the European Union [Occupational exposure limits](/wiki/Occupational_exposure_limit).[[71]](#cite_note-71)

#### Metabolism[[edit](/index.php?title=(none)&action=edit&section=33)]

[Template:Main article](/wiki/Template:Main_article) Ethanol within the human body is converted into [acetaldehyde](/wiki/Acetaldehyde) by [alcohol dehydrogenase](/wiki/Alcohol_dehydrogenase) and then into the [acetyl](/wiki/Acetyl) in [acetyl CoA](/wiki/Acetyl_CoA) by [acetaldehyde dehydrogenase](/wiki/Acetaldehyde_dehydrogenase). [Acetyl CoA](/wiki/Acetyl_CoA) is the final product of both carbohydrate and fat metabolism, where the acetyl can be further used to produce energy or for biosynthesis. As such, ethanol can be compared to an energy-bearing macronutrient, yielding approximately 7 kcal per gram consumed.[[72]](#cite_note-72) However, the product of the first step of this breakdown, acetaldehyde,[[73]](#cite_note-73) is more toxic than ethanol. Acetaldehyde is linked to most of the clinical effects of alcohol. It has been shown to increase the risk of developing cirrhosis of the liver[[74]](#cite_note-74) and multiple forms of cancer.

During the metabolism of alcohol via the respective dehydrogenases, NAD ([Nicotinamide adenine dinucleotide](/wiki/Nicotinamide_adenine_dinucleotide)) is converted into reduced NAD. Normally, NAD is used to metabolise fats in the liver, and as such alcohol competes with these fats for the use of NAD. Prolonged exposure to alcohol means that fats accumulate in the liver, leading to the term 'fatty liver'. Continued consumption (such as in [alcoholism](/wiki/Alcoholism)) then leads to cell death in the hepatocytes as the fat stores reduce the function of the cell to the point of death. These cells are then replaced with scar tissue, leading to the condition called [cirrhosis](/wiki/Cirrhosis).

#### Alcohol and digestion[[edit](/index.php?title=(none)&action=edit&section=34)]

A part of ethyl alcohol is hydrophobic. This hydrophobic or lipophilic end can diffuse across cells that line the stomach wall. In fact, alcohol is one of the rare substances that can be absorbed in the stomach. Most food substances are absorbed in the small intestine. However, even though alcohol can be absorbed in the stomach, it is mostly absorbed in the small intestine because the small intestine has a large surface area that promotes absorption. Once alcohol is absorbed in the small intestine, it delays the release of stomach contents from emptying into the small intestine. Thus, alcohol can delay the rate of absorption of nutrients.[[75]](#cite_note-75) After absorption, alcohol reaches the liver where it is metabolized.

**Breathalyzers**  
Alcohol that is not processed by the liver goes to the heart. The liver can process only a certain amount of alcohol per unit time. Thus, when a person drinks too much alcohol, more alcohol can reach the heart. In the heart, alcohol reduces the force of heart contractions. Consequently, the heart will pump less blood, lowering overall body blood pressure.[[40]](#cite_note-40) Also, blood that reaches the heart goes to the lungs to replenish blood's oxygen concentration. It is at this stage that a person can breathe out traces of alcohol.[[40]](#cite_note-40) This is the underlying principle of the alcohol breath testing (or breathalyzers) to determine if a driver has been drinking and driving.[[76]](#cite_note-76) From the lungs, blood returns to the heart and will be distributed throughout the body. Interestingly, alcohol increases levels of high-density lipoproteins(HDLs), which carry cholesterol.[[40]](#cite_note-40) Alcohol is known to make blood less likely to clot, reducing risk of heart attack and stroke. This could be the reason that alcohol seems to produce health benefits when consumed in moderate amounts.[[77]](#cite_note-77) Also, alcohol dilates blood vessels. Consequently, a person will feel warmer, and his/her skin flush and appear pink.[[40]](#cite_note-40)

#### Magnitude of effects[[edit](/index.php?title=(none)&action=edit&section=35)]

Some individuals have less effective forms of one or both of the metabolizing enzymes, and can experience more severe symptoms from ethanol consumption than others. However, those having acquired [alcohol tolerance](/wiki/Alcohol_tolerance) have a greater quantity of these enzymes, and metabolize ethanol more rapidly.[[78]](#cite_note-78)

## Physical and chemical properties[[edit](/index.php?title=(none)&action=edit&section=36)]

[Template:Further](/wiki/Template:Further)

### Chemical formula[[edit](/index.php?title=(none)&action=edit&section=37)]

Ethanol is a 2-carbon alcohol. Its [molecular formula](/wiki/Chemical_formula) is CH3CH2OH. An alternative notation is CH3–CH2–OH, which indicates that the carbon of a [methyl group](/wiki/Methyl_group) (CH3–) is attached to the carbon of a [methylene group](/wiki/Methylene_group) (–CH2–), which is attached to the oxygen of a [hydroxyl group (–OH)](/wiki/Hydroxyl). It is a constitutional [isomer](/wiki/Isomer) of [dimethyl ether](/wiki/Dimethyl_ether). Ethanol is sometimes abbreviated as **EtOH**, using the common organic chemistry notation of representing the ethyl group (C2H5-) with **Et**.

### Physical properties[[edit](/index.php?title=(none)&action=edit&section=38)]

[thumb|upright|Ethanol burning with its spectrum depicted](/wiki/File:Spiritusflamme_mit_spektrum.png) Ethanol is a volatile, colorless liquid that has a slight odor. It burns with a smokeless blue flame that is not always visible in normal light.

The physical properties of ethanol stem primarily from the presence of its [hydroxyl](/wiki/Hydroxyl) group and the shortness of its carbon chain. Ethanol's hydroxyl group is able to participate in hydrogen bonding, rendering it more viscous and less volatile than less polar organic compounds of similar molecular weight, such as [propane](/wiki/Propane).

Ethanol is slightly more refractive than water, having a [refractive index](/wiki/Refractive_index) of 1.36242 (at λ=589.3 nm and [Template:Convert](/wiki/Template:Convert)).[[79]](#cite_note-79) The [triple point](/wiki/Triple_point) for ethanol is [Template:Nowrap](/wiki/Template:Nowrap) at a pressure of [Template:Nowrap](/wiki/Template:Nowrap).[[80]](#cite_note-80)

### Solvent properties[[edit](/index.php?title=(none)&action=edit&section=39)]

Ethanol is a versatile solvent, [miscible](/wiki/Miscible) with water and with many organic solvents, including [acetic acid](/wiki/Acetic_acid), [acetone](/wiki/Acetone), [benzene](/wiki/Benzene), [carbon tetrachloride](/wiki/Carbon_tetrachloride), [chloroform](/wiki/Chloroform), [diethyl ether](/wiki/Diethyl_ether), [ethylene glycol](/wiki/Ethylene_glycol), [glycerol](/wiki/Glycerol), [nitromethane](/wiki/Nitromethane), [pyridine](/wiki/Pyridine), and [toluene](/wiki/Toluene).[[79]](#cite_note-79)[[81]](#cite_note-81) It is also miscible with light aliphatic hydrocarbons, such as [pentane](/wiki/Pentane) and [hexane](/wiki/Hexane), and with aliphatic chlorides such as [trichloroethane](/wiki/1,1,1-Trichloroethane) and [tetrachloroethylene](/wiki/Tetrachloroethylene).[[81]](#cite_note-81) Ethanol's miscibility with water contrasts with the immiscibility of longer-chain alcohols (five or more carbon atoms), whose water miscibility decreases sharply as the number of carbons increases.[[82]](#cite_note-82) The miscibility of ethanol with [alkanes](/wiki/Alkane) is limited to alkanes up to [undecane](/wiki/Undecane): mixtures with [dodecane](/wiki/Dodecane) and higher alkanes show a [miscibility gap](/wiki/Miscibility_gap) below a certain temperature (about 13 °C for dodecane[[83]](#cite_note-83)). The miscibility gap tends to get wider with higher alkanes and the temperature for complete miscibility increases.

Ethanol-water mixtures have less volume than the sum of their individual components at the given fractions. Mixing equal volumes of ethanol and water results in only 1.92 volumes of mixture.[[79]](#cite_note-79)[[84]](#cite_note-84) Mixing ethanol and water is [exothermic](/wiki/Exothermic), with up to 777 J/mol[[85]](#cite_note-85) being released at 298 K.

Mixtures of ethanol and water form an [azeotrope](/wiki/Azeotrope) at about 89 mole-% ethanol and 11 mole-% water[[86]](#cite_note-86) or a mixture of 95.6 percent ethanol by mass (or about 97% [alcohol by volume](/wiki/Alcohol_by_volume)) at normal pressure, which boils at 351K (78 °C). This azeotropic composition is strongly temperature- and pressure-dependent and vanishes at temperatures below 303 K.[[87]](#cite_note-87) [thumb|300px|Hydrogen bonding in solid ethanol at −186 °C](/wiki/File:Ethanol-xtal-1976-3D-balls.png) Hydrogen bonding causes pure ethanol to be [hygroscopic](/wiki/Hygroscopic) to the extent that it readily absorbs water from the air. The polar nature of the hydroxyl group causes ethanol to dissolve many ionic compounds, notably [sodium](/wiki/Sodium_hydroxide) and [potassium hydroxides](/wiki/Potassium_hydroxide), [magnesium chloride](/wiki/Magnesium_chloride), [calcium chloride](/wiki/Calcium_chloride), [ammonium chloride](/wiki/Ammonium_chloride), [ammonium bromide](/wiki/Ammonium_bromide), and [sodium bromide](/wiki/Sodium_bromide).[[81]](#cite_note-81) [Sodium](/wiki/Sodium_chloride) and [potassium chlorides](/wiki/Potassium_chloride) are slightly soluble in ethanol.[[81]](#cite_note-81) Because the ethanol molecule also has a nonpolar end, it will also dissolve nonpolar substances, including most [essential oils](/wiki/Essential_oil)[[88]](#cite_note-88) and numerous flavoring, coloring, and medicinal agents.

The addition of even a few percent of ethanol to water sharply reduces the [surface tension](/wiki/Surface_tension) of water. This property partially explains the "[tears of wine](/wiki/Tears_of_wine)" phenomenon. When wine is swirled in a glass, ethanol evaporates quickly from the thin film of wine on the wall of the glass. As the wine's ethanol content decreases, its surface tension increases and the thin film "beads up" and runs down the glass in channels rather than as a smooth sheet.

### Flammability[[edit](/index.php?title=(none)&action=edit&section=40)]

An ethanol-water solution that contains 40% alcohol by weight will catch fire if heated to about [Template:Convert](/wiki/Template:Convert) and if an ignition source is applied to it. This is called its [flash point](/wiki/Flash_point).[[89]](#cite_note-89) The flash point of pure ethanol is [Template:Convert](/wiki/Template:Convert), less than average room temperature.

|  |  |
| --- | --- |
| The flash points of ethanol wt % concentrations[[90]](#cite_note-90) | |
| **wt %** | **Temperature** |
| 10% | [Template:Convert](/wiki/Template:Convert) |
| 20% | [Template:Convert](/wiki/Template:Convert) |
| 30% | [Template:Convert](/wiki/Template:Convert) |
| 40% | [Template:Convert](/wiki/Template:Convert) |
| 50% | [Template:Convert](/wiki/Template:Convert) |
| 60% | [Template:Convert](/wiki/Template:Convert) |
| 70% | [Template:Convert](/wiki/Template:Convert) |
| 80% | [Template:Convert](/wiki/Template:Convert) |
| 90% | [Template:Convert](/wiki/Template:Convert) |
| 96% | [Template:Convert](/wiki/Template:Convert) |

Alcoholic beverages that have a low concentration of ethanol will burn if sufficiently heated and an ignition source (such as an [electric spark](/wiki/Electric_spark) or a match) is applied to them. For example, the flash point of ordinary wine containing 12.5% ethanol is about [Template:Convert](/wiki/Template:Convert).[[91]](#cite_note-91) Dishes using burning alcohol for culinary effects are called [Flambé](/wiki/Flambé).

## Natural occurrence[[edit](/index.php?title=(none)&action=edit&section=41)]

Ethanol is a byproduct of the [metabolic process](/wiki/Metabolism) of yeast. As such, ethanol will be present in any yeast habitat. Ethanol can commonly be found in overripe fruit.[[92]](#cite_note-92) Ethanol produced by symbiotic yeast can be found in [Bertam Palm](/wiki/Palm_wine) blossoms. Although some animal species such as the [Pentailed Treeshrew](/wiki/Pentailed_Treeshrew) exhibit ethanol-seeking behaviors, most show no interest or avoidance of food sources containing ethanol.[[93]](#cite_note-93) Ethanol is also produced during the germination of many plants as a result of natural [anerobiosis](/wiki/Anerobiosis).[[94]](#cite_note-94) Ethanol has been detected in [outer space](/wiki/Outer_space), forming an icy coating around dust grains in [interstellar clouds](/wiki/Interstellar_cloud).[[95]](#cite_note-95)Minute quantity amounts (average 196 [ppb](/wiki/Parts_per_billion)) of endogenous ethanol and acetaldehyde were found in the exhaled breath of healthy volunteers.[[96]](#cite_note-96) [Auto-brewery syndrome](/wiki/Auto-brewery_syndrome), also known as gut fermentation syndrome, is a rare medical condition in which [intoxicating](/wiki/Alcohol_intoxication) quantities of ethanol are produced through [endogenous](/wiki/Endogenous) [fermentation](/wiki/Fermentation) within the [digestive system](/wiki/Digestive_system).[[97]](#cite_note-97)

## Production[[edit](/index.php?title=(none)&action=edit&section=42)]

[thumb|upright|94% denatured ethanol sold in a bottle for household use](/wiki/File:Ethanol_Flasche.jpg)

Ethanol is produced both as a [petrochemical](/wiki/Petrochemical), through the hydration of ethylene and, via biological processes, by [fermenting](/wiki/Fermentation_(biochemistry)) sugars with [yeast](/wiki/Yeast).[[98]](#cite_note-98) Which process is more economical depends on prevailing prices of petroleum and grain feed stocks.

### Ethylene hydration[[edit](/index.php?title=(none)&action=edit&section=43)]

Ethanol for use as an industrial feedstock or solvent (sometimes referred to as synthetic ethanol) is made from [petrochemical](/wiki/Petrochemical) feed stocks, primarily by the [acid](/wiki/Acid)-[catalyzed](/wiki/Catalysis) hydration of ethylene:

[Template:Chem](/wiki/Template:Chem) + [Template:Chem](/wiki/Template:Chem) → [Template:Chem](/wiki/Template:Chem)

The catalyst is most commonly [phosphoric acid](/wiki/Phosphoric_acid),[[99]](#cite_note-99)[[100]](#cite_note-100) [adsorbed](/wiki/Adsorption) onto a porous support such as [silica gel](/wiki/Silica_gel) or [diatomaceous earth](/wiki/Diatomaceous_earth). This catalyst was first used for large-scale ethanol production by the [Shell Oil Company](/wiki/Shell_Oil_Company) in 1947.[[101]](#cite_note-101) The reaction is carried out in the presence of high pressure steam at [Template:Convert](/wiki/Template:Convert) where a 1.0:0.6 ethylene to steam ratio is maintained.[[102]](#cite_note-102)[[103]](#cite_note-103) In the U.S., this process was used on an industrial scale by [Union Carbide Corporation](/wiki/Union_Carbide) and others, but now only [LyondellBasell](/wiki/LyondellBasell) uses it commercially.

In an older process, first practiced on the industrial scale in 1930 by Union Carbide,[[104]](#cite_note-104) but now almost entirely obsolete, ethylene was hydrated indirectly by reacting it with concentrated [sulfuric acid](/wiki/Sulfuric_acid) to produce [ethyl sulfate](/wiki/Ethyl_sulfate), which was [hydrolyzed](/wiki/Hydrolysis) to yield ethanol and regenerate the sulfuric acid:[[105]](#cite_note-105)

[Template:Chem](/wiki/Template:Chem) + [Template:Chem](/wiki/Template:Chem) → [Template:ChemH](/wiki/Template:Chem)

[Template:ChemTemplate:ChemH](/wiki/Template:Chem) + [Template:Chem](/wiki/Template:Chem) → [Template:ChemTemplate:ChemH](/wiki/Template:Chem) + [Template:Chem](/wiki/Template:Chem)

### Fermentation[[edit](/index.php?title=(none)&action=edit&section=44)]

[Template:Main article](/wiki/Template:Main_article)

[Template:See also](/wiki/Template:See_also)

Ethanol in [alcoholic beverages](/wiki/Alcoholic_beverage) and fuel is produced by fermentation. Certain species of [yeast](/wiki/Yeast) (e.g., [*Saccharomyces cerevisiae*](/wiki/Saccharomyces_cerevisiae)) [metabolizes](/wiki/Metabolism) [sugar](/wiki/Polysaccharide) producing ethanol and carbon dioxide. The chemical equations below summarize the conversion:

[Template:Chem](/wiki/Template:Chem) → 2 [Template:ChemH](/wiki/Template:Chem) + 2 CO2

[Template:Chem](/wiki/Template:Chem) + [Template:Chem](/wiki/Template:Chem) → 4 [Template:ChemH](/wiki/Template:Chem) + 4 CO2

Fermentation is the process of culturing yeast under favorable thermal conditions to produce alcohol. This process is carried out at around [Template:Convert](/wiki/Template:Convert). Toxicity of ethanol to yeast limits the ethanol concentration obtainable by brewing; higher concentrations, therefore, are obtained by [fortification](/wiki/Fortified_wine) or [distillation](/wiki/Distillation). The most ethanol-tolerant yeast strains can survive up to approximately 18% ethanol by volume.

To produce ethanol from starchy materials such as [cereal grains](/wiki/Cereal_grain), the [starch](/wiki/Starch) must first be converted into sugars. In brewing [beer](/wiki/Beer), this has traditionally been accomplished by allowing the grain to germinate, or [malt](/wiki/Malt), which produces the [enzyme](/wiki/Enzyme) [amylase](/wiki/Amylase). When the malted grain is [mashed](/wiki/Mashing), the amylase converts the remaining starches into sugars.

#### Cellulose[[edit](/index.php?title=(none)&action=edit&section=45)]

[Template:Main article](/wiki/Template:Main_article)

Sugars for [ethanol fermentation](/wiki/Ethanol_fermentation) can be obtained from [cellulose](/wiki/Cellulose). Deployment of this technology could turn a number of cellulose-containing agricultural by-products, such as [corncobs](/wiki/Corncob), [straw](/wiki/Straw), and [sawdust](/wiki/Sawdust), into renewable energy resources. Other agricultural residues such as sugar cane bagasse and [energy crops](/wiki/Energy_crop) such as [switchgrass](/wiki/Switchgrass) may also be a sources of fermentable sugars.[[106]](#cite_note-106)

### Testing[[edit](/index.php?title=(none)&action=edit&section=46)]

[thumb|300px|Infrared reflection spectra of liquid ethanol, showing the -OH band centered at ~3300 cm−1 and C-H bands at ~2950 cm−1.](/wiki/File:EthanolMIRInfraredSpectra.PNG)

[thumb|300px|](/wiki/Image:Ethanol_near_IR_spectrum.png)[Near infrared spectrum](/wiki/Near_infrared_spectrum) of liquid ethanol.

Breweries and [biofuel](/wiki/Biofuel) plants employ two methods for measuring ethanol concentration. Infrared ethanol sensors measure the vibrational frequency of dissolved ethanol using the CH band at 2900 cm−1. This method uses a relatively inexpensive solid state sensor that compares the CH band with a reference band to calculate the ethanol content. The calculation makes use of the [Beer-Lambert law](/wiki/Beer-Lambert_law). Alternatively, by measuring the density of the starting material and the density of the product, using a [hydrometer](/wiki/Hydrometer), the change in specific gravity during fermentation indicates the alcohol content. This inexpensive and indirect method has a long history in the beer brewing industry.

## Purification[[edit](/index.php?title=(none)&action=edit&section=47)]

### Distillation[[edit](/index.php?title=(none)&action=edit&section=48)]

Ethylene hydration or brewing produces an ethanol–water mixture. For most industrial and fuel uses, the ethanol must be purified. [Fractional distillation](/wiki/Fractional_distillation) can concentrate ethanol to 95.6% by volume (89.5 mole%). This mixture is an [azeotrope](/wiki/Azeotrope) with a boiling point of [Template:Convert](/wiki/Template:Convert), and *cannot* be further purified by distillation. Addition of an entraining agent, such as [benzene](/wiki/Benzene), [cyclohexane](/wiki/Cyclohexane), or [heptane](/wiki/Heptane), allows a new ternary azeotrope comprising the ethanol, water, and the entraining agent to be formed. This lower-boiling ternary azeotrope is removed preferentially, leading to water-free ethanol.[[100]](#cite_note-100) At pressures less than atmospheric pressure, the composition of the ethanol-water azeotrope shifts to more ethanol-rich mixtures, and at pressures less than 70 [torr](/wiki/Torr) (9.333 kPa), there is no azeotrope, and it is possible to distill absolute ethanol from an ethanol-water mixture. While vacuum distillation of ethanol is not presently economical, pressure-swing distillation is a topic of current research. In this technique, a reduced-pressure distillation first yields an ethanol-water mixture of more than 95.6% ethanol. Then, fractional distillation of this mixture at atmospheric pressure distills off the 95.6% azeotrope, leaving anhydrous ethanol at the bottom.[Template:Citation needed](/wiki/Template:Citation_needed)

### Molecular sieves and desiccants[[edit](/index.php?title=(none)&action=edit&section=49)]

[Template:Refimprove section](/wiki/Template:Refimprove_section) Apart from distillation, ethanol may be dried by addition of a [desiccant](/wiki/Desiccant), such as [molecular sieves](/wiki/Molecular_sieves), [cellulose](/wiki/Cellulose), and [cornmeal](/wiki/Cornmeal). The desiccants can be dried and reused.[[100]](#cite_note-100) [Molecular sieves](/wiki/Molecular_sieve) can be used to selectively absorb the water from the 95.6% ethanol solution. Synthetic [zeolite](/wiki/Zeolite) in pellet form can be used, as well as a variety of plant-derived absorbents, including [cornmeal](/wiki/Cornmeal), [straw](/wiki/Straw), and [sawdust](/wiki/Sawdust). The zeolite bed can be regenerated essentially an unlimited number of times by drying it with a blast of hot [carbon dioxide](/wiki/Carbon_dioxide). Cornmeal and other plant-derived absorbents cannot readily be regenerated, but where ethanol is made from grain, they are often available at low cost. Absolute ethanol produced this way has no residual benzene, and can be used to fortify port and sherry in traditional winery operations.

### Membranes and reverse osmosis[[edit](/index.php?title=(none)&action=edit&section=50)]

Membranes can also be used to separate ethanol and water. Membrane-based separations are not subject to the limitations of the water-ethanol azeotrope because the separations are not based on vapor-liquid equilibria. Membranes are often used in the so-called hybrid membrane distillation process. This process uses a pre-concentration distillation column as first separating step. The further separation is then accomplished with a membrane operated either in vapor permeation or pervaporation mode. Vapor permeation uses a vapor membrane feed and pervaporation uses a liquid membrane feed.

### Other techniques[[edit](/index.php?title=(none)&action=edit&section=51)]

A variety of other techniques have been discussed, including the following:[[100]](#cite_note-100)\* [Liquid-liquid extraction](/wiki/Liquid-liquid_extraction) of ethanol from an aqueous solution;

* Extraction of ethanol from grain mash by [supercritical carbon dioxide](/wiki/Supercritical_carbon_dioxide);
* [Pervaporation](/wiki/Pervaporation);
* [Fractional freezing](/wiki/Fractional_freezing) is also used to concentrate fermented alcoholic solutions, such as traditionally made [Applejack (beverage)](/wiki/Applejack_(beverage));
* [Pressure swing adsorption](/wiki/Pressure_swing_adsorption).[[107]](#cite_note-107)

### Grades of ethanol[[edit](/index.php?title=(none)&action=edit&section=52)]

#### Denatured alcohol[[edit](/index.php?title=(none)&action=edit&section=53)]

[Template:Main article](/wiki/Template:Main_article)

Pure ethanol and alcoholic beverages are heavily [taxed](/wiki/Sin_tax) as psychoactive drugs, but ethanol has many uses that do not involve its consumption. To relieve the tax burden on these uses, most jurisdictions waive the tax when an agent has been added to the ethanol to render it unfit to drink. These include [bittering agents](/wiki/Bitterant) such as [denatonium benzoate](/wiki/Denatonium_benzoate) and toxins such as [methanol](/wiki/Methanol), [naphtha](/wiki/Naphtha), and [pyridine](/wiki/Pyridine). Products of this kind are called *denatured alcohol.*[[108]](#cite_note-108)[[109]](#cite_note-109)

#### Absolute alcohol[[edit](/index.php?title=(none)&action=edit&section=54)]

Absolute or anhydrous alcohol refers to ethanol with a low water content. There are various grades with maximum water contents ranging from 1% to a few parts per million (ppm) levels. If [azeotropic distillation](/wiki/Azeotropic_distillation) is used to remove water, it will contain trace amounts of the material separation agent (e.g. benzene).[[110]](#cite_note-110) Absolute alcohol is not intended for human consumption. Absolute ethanol is used as a solvent for laboratory and industrial applications, where water will react with other chemicals, and as fuel alcohol. Spectroscopic ethanol is an absolute ethanol with a low absorbance in [ultraviolet](/wiki/Ultraviolet) and visible light, fit for use as a solvent in [ultraviolet-visible spectroscopy](/wiki/Ultraviolet-visible_spectroscopy).[[111]](#cite_note-111) Pure ethanol is classed as 200 [proof](/wiki/Proof_(alcohol)) in the U.S., equivalent to 175 degrees proof in the UK system.[[112]](#cite_note-112)

#### Rectified spirits[[edit](/index.php?title=(none)&action=edit&section=55)]

Rectified spirit, an azeotropic composition of 96% ethanol containing 4% water, is used instead of anhydrous ethanol for various purposes. Wine spirits are about 94% ethanol (188 [proof](/wiki/Proof_(alcohol))). The impurities are different from those in 95% (190 proof) laboratory ethanol.[[113]](#cite_note-113)

## Reactions[[edit](/index.php?title=(none)&action=edit&section=56)]

[Template:Details](/wiki/Template:Details) Ethanol is classified as a primary alcohol, meaning that the carbon its hydroxyl group attaches to has at least two hydrogen atoms attached to it as well. Many ethanol reactions occur at its [hydroxyl](/wiki/Hydroxyl) group.

### Ester formation[[edit](/index.php?title=(none)&action=edit&section=57)]

In the presence of acid catalysts, ethanol reacts with [carboxylic acids](/wiki/Carboxylic_acid) to produce ethyl [esters](/wiki/Ester) and water:

[RCOOH](/wiki/Carboxylic_acid) + HOCH2CH3 → [RCOOCH2CH3](/wiki/Ester) + H2O

This reaction, which is conducted on large scale industrially, requires the removal of the water from the reaction mixture as it is formed. Esters react in the presence of an acid or base to give back the alcohol and a salt. This reaction is known as [saponification](/wiki/Saponification) because it is used in the preparation of soap. Ethanol can also form esters with inorganic acids. [Diethyl sulfate](/wiki/Diethyl_sulfate) and [triethyl phosphate](/wiki/Triethyl_phosphate) are prepared by treating ethanol with sulfur trioxide and [phosphorus pentoxide](/wiki/Phosphorus_pentoxide) respectively. [Diethyl sulfate](/wiki/Diethyl_sulfate) is a useful ethylating agent in [organic synthesis](/wiki/Organic_synthesis). [Ethyl nitrite](/wiki/Ethyl_nitrite), prepared from the reaction of ethanol with [sodium nitrite](/wiki/Sodium_nitrite) and sulfuric acid, was formerly used as a [diuretic](/wiki/Diuretic).

### Dehydration[[edit](/index.php?title=(none)&action=edit&section=58)]

Strong acid desiccants cause the partial dehydration of ethanol to form [diethyl ether](/wiki/Diethyl_ether) and other byproducts. If the dehydration temperature exceeds around [Template:Convert](/wiki/Template:Convert), full dehydration will occur and [ethylene](/wiki/Ethylene) will be the main product.

2 CH3CH2OH → [CH3CH2OCH2CH3](/wiki/Diethyl_ether) + H2O (ca. 120 °C)

   CH3CH2OH → [H2C=CH2](/wiki/Ethylene) + H2O (above 160 °C)

### Combustion[[edit](/index.php?title=(none)&action=edit&section=59)]

Complete [combustion](/wiki/Combustion) of ethanol forms [carbon dioxide](/wiki/Carbon_dioxide) and [water](/wiki/Water):

C2H5OH (l) + 3 O2 (g) → 2 CO2 (g) + 3 H2O (l); −ΔHc = 1371 kJ/mol[[114]](#cite_note-114) = 29.8 kJ/g = 327 kcal/mol = 7.1 kcal/g

C2H5OH (l) + 3 O2 (g) → 2 CO2 (g) + 3 H2O (g); −ΔHc = 1236 kJ/mol = 26.8 kJ/g = 295.4 kcal/mol = 6.41 kcal/g[[115]](#cite_note-115)

Specific heat = 2.44 kJ/(kg·K)

### Acid-base chemistry[[edit](/index.php?title=(none)&action=edit&section=60)]

Ethanol is a neutral molecule and the [pH](/wiki/PH) of a solution of ethanol in water is nearly 7.00. Ethanol can be quantitatively converted to its [conjugate base](/wiki/Conjugate_base), the [ethoxide](/wiki/Alkoxide) ion (CH3CH2O−), by reaction with an [alkali metal](/wiki/Alkali_metal) such as [sodium](/wiki/Sodium):[[82]](#cite_note-82):2 CH3CH2OH + 2 Na → 2 CH3CH2ONa + H2 or a very strong base such as [sodium hydride](/wiki/Sodium_hydride):

CH3CH2OH + NaH → CH3CH2ONa + H2

The acidity of water and ethanol are nearly the same, as indicated by their [pKa](/wiki/Acid_dissociation_constant) of 15.7 and 16 respectively. Thus, sodium ethoxide and [sodium hydroxide](/wiki/Sodium_hydroxide) exist in an equilibrium that is closely balanced:

CH3CH2OH + NaOH [Template:Eqm](/wiki/Template:Eqm) CH3CH2ONa + H2O

### Halogenation[[edit](/index.php?title=(none)&action=edit&section=61)]

Ethanol is not used industrially as a precursor to ethyl halides, but the reactions are illustrative. Ethanol reacts with [hydrogen halides](/wiki/Hydrogen_halide) to produce [ethyl halides](/wiki/Haloalkane) such as [ethyl chloride](/wiki/Ethyl_chloride) and [ethyl bromide](/wiki/Ethyl_bromide) via an [SN2 reaction](/wiki/SN2_reaction):

CH3CH2OH + [HCl](/wiki/Hydrogen_chloride) → CH3CH2Cl + H2O

These reactions require a catalyst such as [zinc chloride](/wiki/Zinc_chloride).[[105]](#cite_note-105)HBr requires [refluxing](/wiki/Refluxing) with a [sulfuric acid](/wiki/Sulfuric_acid) catalyst.[[105]](#cite_note-105) Ethyl halides can, in principle, also be produced by treating ethanol with more specialized [halogenating agents](/wiki/Halogenation), such as [thionyl chloride](/wiki/Thionyl_chloride) or [phosphorus tribromide](/wiki/Phosphorus_tribromide).[[82]](#cite_note-82)[[105]](#cite_note-105):CH3CH2OH + SOCl2 → CH3CH2Cl + SO2 + HCl

Upon treatment with halogens in the presence of base, ethanol gives the corresponding [haloform](/wiki/Haloform) (CHX3, where X = Cl, Br, I). This conversion is called the [haloform reaction](/wiki/Haloform_reaction).[[116]](#cite_note-116) " An intermediate in the reaction with chlorine is the [aldehyde](/wiki/Aldehyde) called [chloral](/wiki/Chloral), which forms [chloral hydrate](/wiki/Chloral_hydrate) upon reaction with water:<ref name=Ull>Reinhard Jira, Erwin Kopp, Blaine C. McKusick, Gerhard Röderer, Axel Bosch and Gerald Fleischmann "Chloroacetaldehydes" in Ullmann's Encyclopedia of Industrial Chemistry, 2007, Wiley-VCH, Weinheim. [Template:DOI](/wiki/Template:DOI)</ref>

4 Cl2 + CH3CH2OH → CCl3CHO + 5 HCl

CCl3CHO + H2O → CCl3C(OH)2H

### Oxidation[[edit](/index.php?title=(none)&action=edit&section=62)]

Ethanol can be oxidized to [acetaldehyde](/wiki/Acetaldehyde) and further oxidized to [acetic acid](/wiki/Acetic_acid), depending on the reagents and conditions.[[105]](#cite_note-105) This oxidation is of no importance industrially, but in the human body, these oxidation reactions are catalyzed by the [enzyme](/wiki/Enzyme) [liver alcohol dehydrogenase](/wiki/Liver_alcohol_dehydrogenase). The oxidation product of ethanol, acetic acid, is a nutrient for humans, being a precursor to [acetyl CoA](/wiki/Acetyl_CoA), where the acetyl group can be spent as energy or used for biosynthesis.

## History[[edit](/index.php?title=(none)&action=edit&section=63)]

[Template:Details](/wiki/Template:Details)

The [fermentation](/wiki/Ethanol_fermentation) of sugar into ethanol is one of the earliest [biotechnologies](/wiki/Biotechnology) employed by humans. The intoxicating effects of ethanol consumption have been known since ancient times. Ethanol has been used by humans since prehistory as the intoxicating ingredient of [alcoholic beverages](/wiki/Alcoholic_beverage). Dried residue on 9,000-year-old pottery found in China suggests that [Neolithic](/wiki/Neolithic) people consumed alcoholic beverages.[[117]](#cite_note-117) Although [distillation](/wiki/Distillation) was well known by the early Greeks and Arabs, the first recorded production of alcohol from distilled wine was by the [School of Salerno](/wiki/Schola_Medica_Salernitana) alchemists in the 12th century.[[118]](#cite_note-118) The first to mention absolute alcohol, in contrast with alcohol-water mixtures, was [Raymond Lull](/wiki/Ramon_Llull).[[118]](#cite_note-118) In 1796, German-Russian chemist Johann Tobias Lowitz obtained pure ethanol by mixing partially purified ethanol (the alcohol-water azeotrope) with an excess of anhydrous alkali and then distilling the mixture over low heat.[[119]](#cite_note-119) French chemist [Antoine Lavoisier](/wiki/Antoine_Lavoisier) described ethanol as a compound of carbon, hydrogen, and oxygen, and in 1807 [Nicolas-Théodore de Saussure](/wiki/Nicolas-Théodore_de_Saussure) determined ethanol's chemical formula.[[120]](#cite_note-120)[[121]](#cite_note-121) Fifty years later, [Archibald Scott Couper](/wiki/Archibald_Scott_Couper) published the structural formula of ethanol. It was one of the first structural formulas determined.[[122]](#cite_note-122) Ethanol was first prepared synthetically in 1825 by [Michael Faraday](/wiki/Michael_Faraday). He found that sulfuric acid could absorb large volumes of [coal gas](/wiki/Coal_gas).[[123]](#cite_note-123) He gave the resulting solution to Henry Hennell, a British chemist, who found in 1826 that it contained "sulphovinic acid" ([ethyl hydrogen sulfate](/wiki/Ethyl_sulfate)).[[124]](#cite_note-124) In 1828, Hennell and the French chemist [Georges-Simon Serullas](/wiki/Georges-Simon_Serullas) independently discovered that sulphovinic acid could be decomposed into ethanol.[[125]](#cite_note-125)[[126]](#cite_note-126) Thus, in 1825 Faraday had unwittingly discovered that ethanol could be produced from [ethylene](/wiki/Ethylene) (a component of coal gas) by [acid-catalyzed](/wiki/Acid_catalysis) hydration, a process similar to current industrial ethanol synthesis.[[127]](#cite_note-127) Ethanol was used as lamp fuel in the United States as early as 1840, but a tax levied on industrial alcohol during the [Civil War](/wiki/American_Civil_War) made this use uneconomical. The tax was repealed in 1906.[[128]](#cite_note-128) Use as an automotive fuel dates back to 1908, with the [Ford Model T](/wiki/Ford_Model_T) able to run on [petrol](/wiki/Petrol) (gasoline) or ethanol.[[129]](#cite_note-129) It fuels some [spirit lamps](/wiki/Spirit_lamps).

Ethanol intended for industrial use is often produced from [ethylene](/wiki/Ethylene).[[130]](#cite_note-130) Ethanol has widespread use as a solvent of substances intended for human contact or consumption, including scents, flavorings, colorings, and medicines. In chemistry, it is both a solvent and a feedstock for the synthesis of other products. It has a long history as a fuel for heat and light, and more recently as a fuel for [internal combustion engines](/wiki/Internal_combustion_engine).

## Society and culture[[edit](/index.php?title=(none)&action=edit&section=64)]

[Template:Details](/wiki/Template:Details)

A 2002 study found 41% of people fatally injured in traffic accidents were in alcohol related crashes.[[131]](#cite_note-131) The risk of a fatal [car accident](/wiki/Car_accident) increases exponentially with the level of alcohol in the driver's blood.[[132]](#cite_note-132) Most [drunk driving](/wiki/Drunk_driving) laws governing the acceptable levels in the blood while driving or operating heavy machinery set typical upper limits of legal [blood alcohol content](/wiki/Blood_alcohol_content) (BAC) at 0.08%.[[133]](#cite_note-133)

## See also[[edit](/index.php?title=(none)&action=edit&section=65)]

[Template:Portal](/wiki/Template:Portal) [Template:Div col](/wiki/Template:Div_col)

* [1-Propanol](/wiki/1-Propanol)
* [2,2,2-Trichloroethanol](/wiki/2,2,2-Trichloroethanol)
* [Breathalyzer](/wiki/Breathalyzer)
* [Butanol fuel](/wiki/Butanol_fuel)
* [Ethanol (data page)](/wiki/Ethanol_(data_page))
* [Cellulosic ethanol commercialization](/wiki/Cellulosic_ethanol_commercialization)
* [Ethenol](/wiki/Vinyl_alcohol)
* [Ethynol](/wiki/Ethynol)
* [Isopropyl alcohol](/wiki/Isopropyl_alcohol)
* [Rubbing alcohol](/wiki/Rubbing_alcohol)
* [Timeline of alcohol fuel](/wiki/Timeline_of_alcohol_fuel)
* [Ethanol induced non-lamellar phases in phospholipids](/wiki/Ethanol_induced_non-lamellar_phases_in_phospholipids)

[Template:Div col end](/wiki/Template:Div_col_end)

## References[[edit](/index.php?title=(none)&action=edit&section=66)]

[Template:Reflist](/wiki/Template:Reflist)

## Further reading[[edit](/index.php?title=(none)&action=edit&section=67)]

* The [National Institute on Alcohol Abuse and Alcoholism](/wiki/National_Institute_on_Alcohol_Abuse_and_Alcoholism) maintains a database of alcohol-related health effects. [ETOH Archival Database (1972–2003)](http://etoh.niaaa.nih.gov/Archive.htm) Alcohol and Alcohol Problems Science Database.
* Boyce, John M., and Pittet Didier. (2003). ["Hand Hygiene in Healthcare Settings"](http://cdc.gov/handhygiene/). [Centers for Disease Control](/wiki/Centers_for_Disease_Control), [Atlanta](/wiki/Atlanta,_Georgia), [Georgia](/wiki/Georgia_(U.S._state)), United States.
* [Template:Cite conference](/wiki/Template:Cite_conference)
* [Sci-toys website explanation of US denatured alcohol designations](http://sci-toys.com/ingredients/alcohol.html)
* Smith, M.G., and M. Snyder. (2005). "Ethanol-induced virulence of *Acinetobacter baumannii*". *American Society for Microbiology meeting*. *Volume 1* 5 – 9 June. Atlanta.

## External links[[edit](/index.php?title=(none)&action=edit&section=68)]

[Template:Wiktionary](/wiki/Template:Wiktionary) [Template:Commons](/wiki/Template:Commons)

* [Alcohol (Ethanol)](http://www.periodicvideos.com/videos/mv_alcohol.htm) at [*The Periodic Table of Videos*](/wiki/The_Periodic_Table_of_Videos) (University of Nottingham)
* [International Labour Organization](http://www.inchem.org/documents/icsc/icsc/eics0044.htm) ethanol safety information
* [National Pollutant Inventory – Ethanol Fact Sheet](http://www.npi.gov.au/substances/ethanol/index.html)
* [CDC – NIOSH Pocket Guide to Chemical Hazards – Ethyl Alcohol](http://www.cdc.gov/niosh/npg/npgd0262.html)
* [National Institute of Standards and Technology](http://webbook.nist.gov/cgi/cbook.cgi?Name=ethanol&Units=SI) chemical data on ethanol
* [ChEBI – biology related](http://www.ebi.ac.uk/chebi/searchId.do?chebiId=CHEBI:16236)
* [Chicago Board of Trade](http://www.cmegroup.com/company/cbot.html) news and market data on ethanol futures
* Calculation of [vapor pressure](http://ddbonline.ddbst.de/AntoineCalculation/AntoineCalculationCGI.exe?component=Ethanol), [liquid density](http://ddbonline.ddbst.de/DIPPR105DensityCalculation/DIPPR105CalculationCGI.exe?component=Ethanol), [dynamic liquid viscosity](http://ddbonline.ddbst.de/VogelCalculation/VogelCalculationCGI.exe?component=Ethanol), [surface tension](http://ddbonline.ddbst.de/DIPPR106SFTCalculation/DIPPR106SFTCalculationCGI.exe?component=Ethanol) of ethanol
* [Ethanol History](http://www.ethanolhistory.com/) A look into the history of ethanol
* [ChemSub Online: Ethyl alcohol](http://chemsub.online.fr/name/ethyl_alcohol.html)
* [Industrial ethanol production process flow diagram using ethylene and sulphuric acid](http://www.inclusive-science-engineering.com/industrial-alcohol-production-from-ethylene-and-sulphuric-acid/industrial-ethyl-alcohol-production-from-ethylene-and-sulphuric-acid/)

[Template:Alcohols](/wiki/Template:Alcohols) [Template:Motor fuel](/wiki/Template:Motor_fuel) [Template:Molecules detected in outer space](/wiki/Template:Molecules_detected_in_outer_space) [Template:Antiseptics and disinfectants](/wiki/Template:Antiseptics_and_disinfectants) [Template:Psychoactive substance use](/wiki/Template:Psychoactive_substance_use) [Template:Alcohol and health](/wiki/Template:Alcohol_and_health) [Template:Other therapeutic products](/wiki/Template:Other_therapeutic_products) [Template:Alcoholic beverages](/wiki/Template:Alcoholic_beverages) [Template:Hidden begin](/wiki/Template:Hidden_begin) [Template:Cholinergics](/wiki/Template:Cholinergics) [Template:GABAAergics](/wiki/Template:GABAAergics) [Template:Glutamatergics](/wiki/Template:Glutamatergics) [Template:Serotonergics](/wiki/Template:Serotonergics) [Template:Hidden end](/wiki/Template:Hidden_end) [Template:Drug use](/wiki/Template:Drug_use)

[Template:Authority control](/wiki/Template:Authority_control)

[Category:Alcohol solvents](/wiki/Category:Alcohol_solvents) [Category:Anatomical preservation](/wiki/Category:Anatomical_preservation) [Category:Anesthesia](/wiki/Category:Anesthesia) [Category:Anxiolytics](/wiki/Category:Anxiolytics) [Category:Disinfectants](/wiki/Category:Disinfectants) [Category:Ethanol](/wiki/Category:Ethanol) [Category:5-HT3 agonists](/wiki/Category:5-HT3_agonists) [Category:GABAA receptor positive allosteric modulators](/wiki/Category:GABAA_receptor_positive_allosteric_modulators) [Category:Glycine receptor agonists](/wiki/Category:Glycine_receptor_agonists) [Category:Glycine reuptake inhibitors](/wiki/Category:Glycine_reuptake_inhibitors) [Category:Household chemicals](/wiki/Category:Household_chemicals) [Category:Human metabolites](/wiki/Category:Human_metabolites) [Category:AMPA receptor antagonists](/wiki/Category:AMPA_receptor_antagonists) [Category:Kainate receptor antagonists](/wiki/Category:Kainate_receptor_antagonists) [Category:NMDA receptor antagonists](/wiki/Category:NMDA_receptor_antagonists) [Category:Oxygenates](/wiki/Category:Oxygenates) [Category:Primary alcohols](/wiki/Category:Primary_alcohols) [Category:Rocket fuels](/wiki/Category:Rocket_fuels) [Category:Sedatives](/wiki/Category:Sedatives) [Category:Teratogens](/wiki/Category:Teratogens) [Category:IARC Group 1 carcinogens](/wiki/Category:IARC_Group_1_carcinogens) [Category:Commodity chemicals](/wiki/Category:Commodity_chemicals) [Category:Cholinergics](/wiki/Category:Cholinergics) [Category:Alkanols](/wiki/Category:Alkanols) [Category:Antidotes](/wiki/Category:Antidotes)