

# Alcohol fuel

Although fossil fuels have become the dominant energy resource for the modern world, alcohol has been used as a fuel throughout history. The first four aliphatic alcohols (methanol, ethanol, propanol, and butanol) are of interest as fuels because they can be synthesized chemically or biologically, and they have characteristics which allow them to be used in current engines. One advantage shared by all four alcohols is their high octane rating. This tends to increase fuel efficiency and largely offsets the lower energy density of alcohol fuels (as compared to petrol/gasoline and diesel fuels), thus resulting in comparable "fuel economy" in terms of distance per volume metrics, such as kilometers per liter, or miles per gallon. Biobutanol has the advantage that its energy density is closer to gasoline than the simpler alcohols (while still retaining over 25% higher octane rating); however, biobutanol is currently more difficult to produce than ethanol or methanol. The general chemical formula for alcohol fuel is  $C_n H_{2n+1} OH$ .

Most methanol is produced from natural gas, although it can be produced from biomass using very similar chemical processes. Ethanol is commonly produced from Biological material though fermentation processes. When obtained from biological materials and/or biological processes, they are known as **bioalcohols** (e.g. **bioethanol**). There is no chemical difference between biologically produced and chemically produced alcohols. However, "ethanol" that is derived from petroleum should not be considered safe for consumption as this alcohol contains about 5% methanol and may cause blindness or death. This mixture may also not be purified by simple distillation, as it forms an azeotropic mixture.

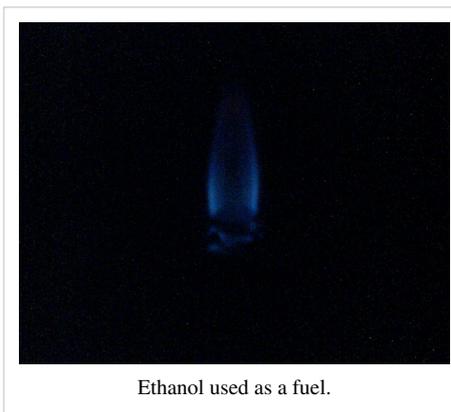
## Methanol and ethanol

*Main articles: Methanol fuel, Ethanol fuel*

Methanol and ethanol can both be derived from fossil fuels, biomass, or perhaps most simply, from carbon dioxide and water. Ethanol has most commonly been produced through fermentation of sugars, and methanol has most commonly been produced from synthesis gas, but there are more modern ways to obtain these fuels. Enzymes can be used instead of fermentation. Methanol is the simpler molecule, and ethanol can be made from methanol. Methanol can be produced industrially from nearly any biomass, including animal waste, or from carbon dioxide and water or steam by first converting the biomass to synthesis gas in a gasifier. It can also be produced in a laboratory using electrolysis or enzymes.<sup>[1]</sup>

As a fuel, methanol and ethanol both have advantages and disadvantages over fuels such as petrol (gasoline) and diesel fuel. In spark ignition engines, both alcohols can run at a much higher exhaust gas recirculation rates and with higher compression ratios. Both alcohols have a high octane rating, with ethanol at 109 RON (Research Octane Number), 90 MON (Motor Octane Number), (which equates to 99.5 AKI) and methanol at 109 RON, 89 MON (which equates to 99 AKI).<sup>[2]</sup> Note that AKI refers to 'Anti-Knock Index' which averages the RON and MON ratings  $(RON+MON)/2$ , and is used on U.S. gas station pumps. Ordinary European petrol is typically 95 RON, 85 MON, equal to 90 AKI. As a compression ignition engine fuel, both alcohols create very little particulates, but their low cetane number means that an ignition improver like glycol must be mixed into the fuel with approx. 5%.

When used in spark ignition engines alcohols have the potential to reduce NO<sub>x</sub>, CO, HC and particulates. A test with E85 fueled Chevrolet Lumina showed that NMHC<sup>[3]</sup> went down by 20-22%, NO<sub>x</sub> by 25-32% and CO by 12-24% compared to reformulated gasoline.<sup>[4]</sup> Toxic emissions of benzene and 1,3 Butadiene also decreased while aldehyde emissions increased (acetaldehyde in particular).



Ethanol used as a fuel.

Tailpipe emissions of CO<sub>2</sub> also decrease due to the lower carbon-to-hydrogen ratio of these alcohols, and the improved engine efficiency.

Methanol and ethanol contain soluble and insoluble contaminants.<sup>[5]</sup> Halide ions, which are soluble contaminants, such as chloride ions, have a large effect on the corrosivity of alcohol fuels. Halide ions increase corrosion in two ways: they chemically attack passivating oxide films on several metals causing pitting corrosion, and they increase the conductivity of the fuel. Increased electrical conductivity promotes electrical, galvanic and ordinary corrosion in the fuel system. Soluble contaminants such as aluminum hydroxide, itself a product of corrosion by halide ions, clogs the fuel system over time. To prevent corrosion the fuel system must be made of suitable materials, electrical wires must be properly insulated and the fuel level sensor must be of pulse and hold type (or similar). In addition, high quality alcohol should have a low concentration of contaminants and have a suitable corrosion inhibitor added.

Methanol and ethanol are also incompatible with some polymers. The alcohol reacts with the polymers causing swelling, and over time the oxygen breaks down the carbon-carbon bonds in the polymer causing a reduction in tensile strength. For the past few decades though, most cars have been designed to tolerate up to 10% ethanol (E10) without problem. This include both fuel system compatibility and lambda compensation of fuel delivery with fuel injection engines featuring closed loop lambda control. In some engines ethanol may degrade some compositions of plastic or rubber fuel delivery components designed for conventional petrol, and also be unable to lambda compensate the fuel properly.

"FlexFuel" vehicles have upgraded fuel system and engine components which are designed for long life using E85 or M85, and the ECU can adapt to any fuel blend between gasoline and E85 or M85. Typical upgrades include modifications to: fuel tanks, fuel tank electrical wiring, fuel pumps, fuel filters, fuel lines, filler tubes, fuel level sensors, fuel injectors, seals, fuel rails, fuel pressure regulators, valve seats and inlet valves. "Total Flex" Autos destined for the Brazilian market can use E100 (100% Ethanol).

One liter of ethanol contain 21.1 MJ, a liter of methanol 15.8 MJ and a liter of gasoline approximately 32.6 MJ. In other words, for the same energy content as one liter or one gallon of gasoline, one needs 1.6 liters/gallons of ethanol and 2.1 liters/gallons of methanol. The raw energy-per-volume numbers produce misleading fuel consumption numbers however, because alcohol-fueled engines can be made substantially more energy-efficient. A larger percentage of the energy available in a liter of alcohol fuel can be converted to useful work. This difference in efficiency can partially or totally balance out the energy density difference, depending on the particular engines being compared.

Methanol fuel has been proposed as a future biofuel, often as an alternative to the hydrogen economy. Methanol has a long history as a racing fuel. Early Grand Prix Racing used blended mixtures as well as pure methanol. The use of the fuel was primarily used in North America after the war. However, methanol for racing purposes has largely been based on methanol produced from syngas derived from natural gas and therefore this methanol would not be considered a biofuel. Methanol is a possible biofuel, however when the syngas is derived from biomass. In theory, methanol can also be produced from carbon dioxide and hydrogen using nuclear power or any renewable energy source, although this is not likely to be economically viable on an industrial scale (see methanol economy). Compared to bioethanol, the primary advantage of methanol biofuel is its much greater well-to-wheel efficiency. This is particularly relevant in temperate climates where fertilizers are needed to grow sugar or starch crops to make ethanol, whereas methanol can be produced from lignocellulose (woody) biomass.

Ethanol is already being used extensively as a fuel additive, and the use of ethanol fuel alone or as part of a mix with gasoline is increasing. Compared to methanol its primary advantage is that it is less corrosive and additionally the fuel is non-toxic, although the fuel will produce some toxic exhaust emissions. From 2007, the Indy Racing League will use ethanol as its exclusive fuel, after 40 years of using methanol.<sup>[6]</sup> Since September 2007 petrol stations in NSW, Australia are mandated to supply all their petrol with 2% Ethanol content<sup>[7]</sup>

Methanol combustion is:  $2\text{CH}_3\text{OH} + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 4\text{H}_2\text{O} + \text{heat}$

Ethanol combustion is:  $\text{C}_2\text{H}_5\text{OH} + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 3\text{H}_2\text{O} + \text{heat}$

## Butanol and Propanol

Propanol and butanol are considerably less toxic and less volatile than methanol. In particular, butanol has a high flash point of 35 °C, which is a benefit for fire safety, but may be a difficulty for starting engines in cold weather. The concept of flash point is however not directly applicable to engines as the compression of the air in the cylinder means that the temperature is several hundred degrees Celsius before ignition takes place.

The fermentation processes to produce propanol and butanol from cellulose are fairly tricky to execute, and the Weizmann organism (*Clostridium acetobutylicum*) currently used to perform these conversions produces an extremely unpleasant smell, and this must be taken into consideration when designing and locating a fermentation plant. This organism also dies when the butanol content of whatever it is fermenting rises to 7%. For comparison, yeast dies when the ethanol content of its feedstock hits 14%. Specialized strains can tolerate even greater ethanol concentrations - so-called turbo yeast can withstand up to 16% ethanol.<sup>[8]</sup> However, if ordinary *Saccharomyces* yeast can be modified to improve its ethanol resistance, scientists may yet one day produce a strain of the Weizmann organism with a butanol resistance higher than the natural boundary of 7%. This would be useful because butanol has a higher energy density than ethanol, and because waste fibre left over from sugar crops used to make ethanol could be made into butanol, raising the alcohol yield of fuel crops without there being a need for more crops to be planted.

Despite these drawbacks, DuPont and British Petroleum have recently announced that they are jointly to build a small scale butanol fuel demonstration plant<sup>[9]</sup> alongside the large bioethanol plant they are jointly developing with Associated British Foods.

Energy Environment International developed a method for producing butanol from biomass, which involves the use of two separate micro-organisms in sequence to minimize production of acetone and ethanol byproducts.<sup>[10]</sup>

The Swiss company Butalco GmbH uses a special technology to modify yeasts in order to produce butanol instead of ethanol. Yeasts as production organisms for butanol have decisive advantages compared to bacteria.<sup>[11]</sup>

Butanol combustion is:  $C_4H_9OH + 6O_2 \rightarrow 4CO_2 + 5H_2O + \text{heat}$

The 3-carbon alcohol, propanol ( $C_3H_7OH$ ), is not often used as a direct fuel source for petrol engines (unlike ethanol, methanol and butanol), with most being directed into use as a solvent. However, it is used as a source of hydrogen in some types of fuel cell; it can generate a higher voltage than methanol, which is the fuel of choice for most alcohol-based fuel cells. However, since propanol is harder to produce than methanol (biologically OR from oil), methanol-utilising fuel cells are preferred over those that utilise propanol.

## By country

### Alcohol in Brazil

Brazil was until recently the largest producer of alcohol fuel in the world, typically fermenting ethanol from sugarcane. The country produces a total of 18 billion liters (4.8 billion gallons) annually, of which 3.5 billion liters are exported, 2 billion of them to the U.S..<sup>[12]</sup> Alcohol cars debuted in the Brazilian market in 1978 and became quite popular because of heavy subsidy, but in the 80's prices rose and gasoline regained the leading market share.

However, from 2003 on, alcohol is rapidly rising its market share once again because of new technologies involving flexible-fuel engines,<sup>[13]</sup> called "Flex" by all major car manufacturers (Volkswagen, General Motors, Fiat, etc.). "Flex" engines work with gasoline, alcohol or any mixture of both fuels. As of May 2009, more than 88% of new vehicles sold in Brazil are flex fuel<sup>[14]</sup>

Because of the Brazilian leading production and technology, many countries became very interested in importing alcohol fuel and adopting the "Flex" vehicle concept.<sup>[13]</sup> On March 7 of 2007, US president George W. Bush visited the city of São Paulo to sign agreements with Brazilian president Lula on importing alcohol and its technology as an alternative fuel.<sup>[15]</sup>

## Alcohol in China

China has reported with a 70% methanol use to conventional gasoline an independence from crude oil.

National Committee of Planning and Action Coordination for Clean Automobile had listed key technologies related to alcohol/ether fuel and accelerated industrialization into its main agenda. Alcohol fuels had become part of five main alternative fuels: Two of which were alcohols; methanol and ethanol<sup>[16]</sup>

## Alcohol in Russia

Russia has reduced its dependency on oil by using methanol made from the destructive pyrolysis of eucalyptus wood and fibre. However, this system is less likely to be emulated elsewhere, due to the disadvantages of methanol fuel.

## Alcohol in the United States

*See E85 in the United States*

The United States at the end of 2007 was producing 7 billion gallons (26.9 billion liters) per year.<sup>[17]</sup> E10 or Gasohol is commonly marketed in Delaware and E85 is found in many states, particularly in the Mid West where ethanol from corn is produced locally. Due to government subsidies, many new vehicles are sold each year that can use E85, although the majority are run solely on gasoline due to the limited availability of E85.

Many states and municipalities have mandated that all gasoline fuel be blended with 10 percent alcohol (usually ethanol) during some or all of the year. This is to reduce pollution and allows these areas to comply with federal pollution limits. Because alcohol is partially oxygenated, it produces less overall pollution, including ozone. In some areas (California in particular) the regulations may also require other formulations or added chemicals that reduce pollution, but add complexity to the fuel distribution and increase the cost of the fuel.

## Alcohol in the European Union

| Consumption of Bioethanol (GWh) <sup>[18] [19] [20]</sup> |  |       |       |       |       |
|---|--|-------|-------|-------|-------|
| #   | Country  | 2005  | 2006  | 2007  | 2008  |
| 1   |  France         | 871   | 1,719 | 3,164 | 4,693 |
| 2   |  Germany        | 1,682 | 3,544 | 3,448 | 4,675 |
| 3   |  Sweden         | 1,681 | 1,894 | 2,119 | 2,488 |
| 4   |  Netherlands    | 0     | 179   | 1,023 | 1,512 |
| 5   |  Spain          | 1,314 | 1,332 | 1,512 | 1,454 |
| 6   |  Poland         | 329   | 611   | 837   | 1,382 |
| 7   |  United Kingdom | 502   | 563   | 906   | 1,223 |
| 8   |  Finland        | 0     | 10    | 20    | 858   |
| 9   |  Austria        | 0     | 0     | 199   | 633   |
| 10  |  Hungary        | 28    | 136   | 314   | 454   |
| 11  |  Czech Republic | 0     | 13    | 1     | 378   |
| 12  |  Ireland        | 0     | 13    | 59    | 207   |
| 13  |  Lithuania      | 10    | 64    | 134   | 182   |
| 14  |  Belgium        | 0     | 0     | 0     | 145   |
| 15  |  Slovakia       | 0     | 4     | 140   | 76    |
| 16  |  Bulgaria       | -     | 0     | 0     | 72    |

|   |   |              |               |               |               |
|---|---|--------------|---------------|---------------|---------------|
| 17  |  Denmark               | 0            | 42            | 60            | 50            |
| 18  |  Slovenia              | 0            | 2             | 9             | 28            |
| 19  |  Estonia               | 0            | 0             | 0             | 17            |
| 20  |  Latvia                | 5            | 12            | 0             | 0             |
| 21  |  Luxembourg            | 0            | 0             | 14            | 11            |
| 22  |  Portugal              | 0            | 0             | 0             | 0             |
| 23  |  Italy                 | 59           | 0             | 0             | 0             |
| 24  |  Greece                | 0            | 0             | 0             | 0             |
| 25  |  Romania               | -            | 0             | 0             | 0             |
| 26  |  Malta                 | 0            | 0             | 0             | 0             |
| 27  |  Cyprus                | 0            | 0             | 0             | 0             |
| 27  |  <b>European Union</b> | <b>6,481</b> | <b>10,138</b> | <b>13,962</b> | <b>20,538</b> |
| 1 toe = 11,63 MWh, 0 = no data<br>Alcohol consumption does not specify the traffic fuel use<br>The 2008 data is not confirmed yet |   |              |               |               |               |

## Alcohol in Japan

The first alcohol fuel in Japan started from **GAIAX** in 1999. GAIAX was developed in South Korea, and imported by Japan. The principal ingredient was a methanol.

Because GAIAX was not gasoline, it was a tax-free object of the gas tax of Japan. However, the use of GAIAX came to be considered to be an act of smuggling from Japanese Government and the petroleum industry in Japan as a result. The retailer of GAIAX was done to evade the tax evasion criticism by independently paying the diesel fuel tax in the legal system regulations either.

The fire accident from the vehicle where GAIAX was refueled began to be reported in around 2000 when the tax evasion discussion ended almost. The car industry in Japan criticized GAIAX, saying that "A fire broke out because high density alcohol had made them corrode the fuel pipe". And, GAIAX was named "**High density alcoholic fuel**", and the campaign from the market to exclude it was executed for a long term. Finally, the Ministry of Economy, Trade and Industry also joined this campaign.<sup>[21]</sup>

The gasoline quality method was revised by the pretext from the reason on safety in 2003. This was a content that prohibited the manufacturing sales of "High density alcoholic fuel", and a substantial GAIAX sales ban. The thing that the fuel manufacturer provided by revising this law prohibits gasoline from adding of the alcohol of 3% or more. This law revision is grounds not to be able to sell the fuel alcohol more than the E3 fuel in Japan.

GAIAX was excluded from the market by such details. The consumer came also to acknowledge that the fuel alcohol was dangerous widely by a negative campaign of the industrial-government complex cooperation.

However, Japan sarcastically invited the result of leaving from the tendency to making of a worldwide vehicle fuel alcohol as a result. The petroleum industry in Japan is advancing the research and development of a fuel alcohol that differs from GAIAX and is original now. However, the above-mentioned law used to exclude GAIAX becomes a trouble on the market of their fuel alcohol. Moreover, the prospect of marketing doesn't stand because disgust to "High density alcoholic fuel" of the consumer in Japan strongly remains by a longtime campaign, too at all.

## References

- [1] ENZYMATIC CONVERSION OF CARBON DIOXIDE TO METHANOL [http://www.anl.gov/PCS/acsfuel/preprint%20archive/Files/47\\_1\\_Orlando\\_03-02\\_0072.pdf](http://www.anl.gov/PCS/acsfuel/preprint%20archive/Files/47_1_Orlando_03-02_0072.pdf)
- [2] Owen, K., Coley, C.S. Weaver, "Automotive Fuels Reference Book", SAE International, ISBN 978-1-56091-589-8
- [3] Non-Methane HydroCarbons [http://www.atmosphere.mpg.de/enid/EN\\_\\_Compounds/NMHC\\_5rg.html](http://www.atmosphere.mpg.de/enid/EN__Compounds/NMHC_5rg.html)
- [4] Kelly, K.J., Bailey, B.K., Coburn, T.C., Clark, W., Lissiuk, P. "Federal Test Procedure Emissions Test Results from Ethanol Variable-Fuel Vehicle Chevrolet Lumina", SAE Technical Paper 961092
- [5] Brinkman, N., Halsall, R., Jorgensen, S.W., & Kirwan, J.E., "The Development Of Improved Fuel Specifications for Methanol (M85) and Ethanol (Ed85)", SAE Technical Paper 940764
- [6] "Tech: ethanol" (<http://www.indycar.com/tech/ethanol.php>). Indycar.com. . Retrieved 22 May 2007.
- [7] "NSW to mandate ethanol in petrol" (<http://www.smh.com.au/news/NATIONAL/NSW-to-mandate-ethanol-in-petrol/2007/05/11/1178390531377.html>). Sydney Morning Herald. 2007-05-11. . Retrieved 5 October 2007.
- [8] "Make your own Fuel" ([http://running\\_on\\_alcohol.tripod.com/](http://running_on_alcohol.tripod.com/)). Tripod.com. . Retrieved 22 May 2007.
- [9] "BP, ABF and DuPont Unveil \$400 Million Investment in UK Biofuels" (<http://www.bp.com/genericarticle.do?categoryId=2012968&contentId=7034350>). BP. . Retrieved 3 August 2007.
- [10] "Butanol Works in your Car Today" (<http://www.butanol.com>). Environmental Energy, inc. . Retrieved 22 May 2007.
- [11] Home (<http://www.butalco.com>)
- [12] **(Portuguese)** "Lula diz que taxa dos EUA sobre etanol não tem sentido" ([http://br.invertia.com/noticias/noticia.aspx?idNoticia=200703051055\\_ABR\\_30409713](http://br.invertia.com/noticias/noticia.aspx?idNoticia=200703051055_ABR_30409713)). Invertia. 2007-03-05. . Retrieved 2007-05-22.
- [13] "The rise, fall and rise of Brazil's biofuel" (<http://news.bbc.co.uk/1/hi/business/4581955.stm>). BBC News. 2006-01-24. . Retrieved 2007-05-22.
- [14] **(Portuguese)** Venda "de carros flex sobe em maio para 210,4 mil unidades" ([http://economia.terra.com.br/noticias/noticia.aspx?idNoticia=200906041737\\_RTR\\_1244137077nN04224621](http://economia.terra.com.br/noticias/noticia.aspx?idNoticia=200906041737_RTR_1244137077nN04224621)). Invertia. 2009-06-04. Venda. Retrieved 2009-12-16.
- [15] (<http://www.foodfirst.org/node/1654>)
- [16] (<http://www.eri.ucr.edu/ISAFXVCD/ISAFXVPP/AIEFC.pdf>)
- [17] Ethanol Fact Book ([http://www.ethanol.org/pdf/contentmgmt/2007\\_Ethanol\\_Fact\\_Book.pdf](http://www.ethanol.org/pdf/contentmgmt/2007_Ethanol_Fact_Book.pdf))
- [18] Biofuels barometer 2007 - EurObserv'ER (<http://www.eurobserv-er.org/pdf/baro179.asp>) Systèmes solaires Le journal des énergies renouvelables n° 179, p. 63-75, 5/2007
- [19] Biofuels barometer 2008 - EurObserv'ER (<http://www.eurobserv-er.org/pdf/baro185.asp>) Systèmes solaires Le journal des énergies renouvelables n° 185, p. 49-66, 6/2008
- [20] Biofuels barometer (<http://www.eurobserv-er.org/pdf/baro192.asp>) Eurobserv'er – July 2009, no 192 p.54-77: Obs. The year 2008 data is preliminary info and not confirmed yet.
- [21] 「高濃度アルコール含有燃料は、車の安全にNO！環境にNO！」 (<http://www.enecho.meti.go.jp/topics/nennryouhp/index.html>) 産業省・資源エネルギー庁HP

## External links

- World Bank, Biofuels: The Promise and the Risks. World Development Report 2008: Agriculture for Development (<http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/EXTWDRS/EXTWDR2008/0,,contentMDK:21501336~pagePK:64167689~piPK:64167673~theSitePK:2795143,00.html>)
- Alcohol Stoves (<http://zenstoves.net/Stoves.htm>)
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