Prospects for Obtaining Synthetic Fuel from Biomass and Other Household Waste

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ABSTRACT

The article provides a variety of obtaining synthetic fuel from biological municipal waste. As well as increasing the role of various alcohols in internal combustion engines, dehydration methods for obtaining dimethyl ethers from methanol.

Keywords: Biomass, natural gas, synthetic diesel fuel, ethanol, butanol, water-carbon fuel, dimethyl ether, methyl tert-butyl ether.

Introduction

The term "synthetic fuel" has several different meanings and can refer to different types of fuel. The "International Energy Agency" traditionally defines "synthetic fuel" as any liquid fuel derived from coal or natural gas.US Energy Information Association defines synthetic fuels in its 2006 annual report as fuels derived from coal, natural gas, biomass, or animal feed by chemical conversion into synthetic oil and or synthetic liquid products. Other synthetic fuels are used as additives to conventional fuels to improve the performance of an internal combustion engine (methanol, ethanol etc.) or are used for special applications such as rocket fuel (hydrazine, synching etc.). Numerous definitions of synthetic fuel include fuel made from biomass, as well as from industrial and municipal waste. On the one hand, "synthetic" means that the fuel is produced artificially. Unlike synthetic, conventional fuel is obtained by separating crude oil into separate fractions (distillation, rectification etc.) without chemical modification of the components. However, various chemical processes can also be used in the production of traditional fuels. The concept of "synthetic" can mean, on the other hand, that the fuel was produced by chemical synthesis, that is, by obtaining a compound of a higher level from several lower ones. This definition applies in particular to fuels XTL (raw material in a liquid), in which the raw material first decomposes and turns into synthesis gas, consisting of lower compounds (H_2, CO etc.), from which higher hydrocarbons are then obtained (Fischer-Tropsch synthesis). However, even in the production of conventional fuels, chemical processes may be part of the manufacturing process. For example, hydrocarbons with too long carbon chains by the so-called cracking can be converted into products with a shorter chain.

As a result, it is impossible to make a clear distinction between traditional and synthetic fuels. And although there is no exact definition, the term "synthetic fuel" is usually referred to as XtL fuel. The difference between synthetic and alternative fuels lies in the way they are used: alternative automotive fuel may require more extensive modification of the engine or fuel system, or even the use of an unconventional type of engine (for example, steam). During Second World War Germany to a large extent, up to 30% in some years, met its fuel needs by creating production capacities for the conversion of coal into liquid fuel. Albert Speer, technically, Germany was defeated on 12 May 1944 when due to massive allied bombing 90% of the factories producing synthetic fuel were destroyed. Similarly to this, South Africa's up a company with the same aims Sasol Limited, which at the time of apartheid helped the economy of this state to function successfully, despite international sanctions. ATUSA companies that produce such fuels often receive government subsidies and produce "synthetic fuel" from a mixture of coal with biological waste. Such methods of obtaining government subsidies are criticized by "green", as an example of feature abuse tax system corporations. Synthetic diesel fuel received in Qatar from natural gas has low content sulfur, therefore, it is added to conventional diesel fuel to reduce sulfur levels, which is necessary for marketing diesel fuel in those US states where there are especially high-quality requirements (for example, in California). Synthetic liquid fuels and gas from solid fossil fuels are now produced on a limited scale. Further expansion of synthetic fuel production is constrained by its high cost, which is much higher than the cost of oil-based fuel. Therefore, the search for new economical technical solutions in the field of synthetic fuels is now being intensively conducted. The search is aimed at simplifying known processes, in particular, at reducing the pressure during coal liquefaction from 300–700 atmospheres to 100 atmospheres and lower, increasing the productivity of gas generators for processing coal and oil shale, and also developing new catalysts for the synthesis of methanol and gasoline based on it.

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Natural bitumen is an integral part of fossil fuels. Bitumen contains significantly more hydrogen than coal, so the production of liquid fuels from bitumen can be much easier and can cost significantly less than the production of liquid fuels by the Fischer in composition to oil). The Orinoco tar sands (Orinoco oil sands) are deposits of unconventional oil in the form of oil shale in the Orinoco River region of Venezuela, which flows from the Venezuelan-Brazilian border and empties into the Atlantic Ocean. The Orinoco tar sands are considered one of the two largest unconventional oil fields (the other, the Athabasca tar sands, is located in Canada). Isooctane is used as an additive in the production of gasoline to improve its anti-knock properties. Isooctane is used in the production of aviation gasoline, which requires high anti-knock properties. (e.g. Mixture No. 1: 60% B-70, 20% isooctane and 20% neohexane.) In industry, isooctane is obtained by hydrogenation of disobutylene over a catalyst, for example, copper-chromium, or by alkylation of isobutane with isobutylene in the presence of concentrated sulfuric acid, AlCl3, BF3 or other catalysts. method) and very good blending characteristics: when blended with other gasoline, it behaves like a product with an octane number of 90-130 (motor method), depending on the nature of the components with which it is blended See also: Oil as a fuel Liquid (for example, ethanol, methanol, biodiesel), and gaseous (synthesis gas, biogas, hydrogen) biofuels for internal combustion engines (vehicle biofuels) exist mainly as ethanol and biodiesel. In 2014, ethanol accounted for 74% of the transport biofuel market, biodiesel - 23% (mainly in the form of methyl esters of fatty acids), and hydrogenated vegetable oil (HVO) - 3%. These fuels are produced from food raw materials. Ethanol is obtained from sugar cane (61%) and from grain (39%). The main feedstocks for biodiesel production are soybeans and rapeseed. Attempts to commercialize liquid biofuels from sources that do not compete with food production have not yet resulted in statistically significant market results. The rapid growth of biofuel production requires large areas for planting crops. These areas are either cleared by burning forests (resulting in huge carbon dioxide emissions into the atmosphere) or taken away from forage and food crops (resulting in higher food prices). In addition, growing crops requires a lot of energy. For many crops, EROEI (the ratio of energy received to energy expended) is only slightly above one or even below it. So, for corn EROEI is only 1.5. Contrary to popular belief, this is not true for all crops: for example, sugar cane has an EROEI of 8, and palm oil has 9. Every year, about 200 billion tons of plant cellulose-containing biomass is formed on our planet. Cellulose biosynthesis is the largest synthesis in the past, present and at least soon. But in connection with the increasing needs of mankind for resources, it cannot be said for sure that cellulose synthesis will be the largest in the future, for example, in 50 years. For comparison: steel production worldwide in 2009 amounted to 1.3 billion tons, and world oil production in 2006 was 3.8 billion tons per year. According to tentative estimates, the world's proven oil reserves are approximately equal to the timber reserves on our planet, but oil resources are rapidly depleted, while as a result of natural growth, timber reserves are increasing. A significant reserve for increasing the resources of wood raw materials is an increase in the yield of target products from wood. The processing of plant biomass is based mainly on a combination of chemical and biochemical processes. Hydrolysis of vegetable raw materials is the most promising method for the chemical processing of wood, since, in combination with biotechnological processes, it makes it possible to obtain monomers and synthetic resins, fuel for internal combustion engines and a variety of products for technical purposes. The total production of biofuels (bioethanol and biodiesel) in 2005 amounted to about 40 billion litres. In March 2007, Japanese scientists proposed to produce biofuel from seaweed. According to some scientists, the massive use of ethanol engines (not to be confused with biodiesel) will increase the concentration of ozone in the atmosphere, which can lead to an increase in the number of respiratory diseases and asthma. Dimethylfuran is being considered as a potential biofuel that can replace ethanol. Dimethylfuran has a 40% higher energy density than ethanol, so it is comparable to gasoline. It is chemically stable and, unlike ethanol, does not absorb moisture from the atmosphere. In addition, dimethylfuran has a lower evaporation temperature. Methyltetrahydrofuran is a liquid biofuel (diesel) of vegetable origin, which can be used both as a fuel and as an oxygen additive to fuel. This triglyceride is an ester of glycerol and acetic acid. This synthesized chemical compound can be used as a fuel additive as an anti-knock additive, which reduces engine knock when using gasoline, and improves the low-temperature stability and viscosity characteristics of biodiesel. Mycodiesel. In 2008, the fungus A. sarcoids were noted to produce a range of volatile organic compounds, including carbon 6-9 alcohols, ketones, and alkanes. Scientists believe that due to the chemical properties of metabolic products and the ability to grow on cellulose, this species is a potential source of biofuel. The originally tested strain was misidentified as Gliocladium roseum. In 2012, in the hope of understanding the genetic basis of the biochemical processes for the production of volatile organic compounds, the genome of the fungus was sequenced. Some of the metabolic products of A. sarcoids have a high potential for use in the fuel industry.

Table 1. Recently, the role of alcohols as a fuel has been growing (methanol - in fuel cells, ethanol and mixtures with it - in internal combustion engines).

Fuel	*Density energy*	*air-fuel mixture*	*Specific energy air-fuel mixtures*	*Specific heat evaporation*	*Octane number (RON)*	*Octane rating (MON)*
Petrol	32 MJ/l	14.6	2.9 MJ/kg air	0.36 MJ/kg	91-99	81-89
Butanol-1	29.2 MJ/l	11.1	3.2 MJ/kg air	0.43 MJ/kg	96	78
ethanol	19.6 MJ/l	9.0	3.0 MJ/kg air	0.92 MJ/kg	107	89
methanol	16 MJ/l	6.4	3.1 MJ/kg air	1.2 MJ/kg	106	92

Ethanol can be used as a fuel, including for rocket engines, and internal combustion engines in its pure form. Limited due to its hygroscopicity (peeling) is used in mixtures with classic petroleum liquid fuels. It is used to produce high-quality fuel and gasoline components - ethyl tert-butyl ether, which is more independent of fossil organic matter than MTBE. The leader in the use of biofuels is Brazil, which provides 40% of its fuel needs with alcohol, thanks to high sugar cane yields and low labour costs. Biofuels do not formally lead to greenhouse gas emissions: only carbon dioxide (CO_2), removed from it during photosynthesis, and water return to the atmosphere. In 2008, the share of ethanol in the world consumption of motor fuel was 5.4%. In the same year, 89% of the world's ethanol production came from the United States and Brazil. Ethanol is a less "energy dense" energy source than gasoline (this only applies to blends with a high ethanol content); the mileage of cars running on E85 (a mixture of 85% ethanol and 15% gasoline; the letter "E" from the English Ethanol) per unit volume of fuel is approximately 75% of the mileage of standard cars. Conventional automotive internal combustion engines cannot run on E85, although they work fine on E10 (some argue that even E15 can be used and E40 (A95-E) is successfully used). On "real" ethanol, only the so-called. machines "Flex-Fuel" (car with a multi-fuel engine). These vehicles can also run on regular gasoline (small addition of ethanol is still required) or on an arbitrary mixture of both. Brazil is a leader in the production and use of bioethanol from sugar cane as a fuel. Gas stations in Brazil offer a choice of either E20 (sometimes E25) under the guise of regular gasoline, or "cool" E100, an ethanol azeotrope (96% $C2H5OH$ and 4% (by weight) water). Taking advantage of the fact that ethanol is cheaper than gasoline, unscrupulous tankers dilute E20 with an azeotrope, so that its concentration can tacitly reach up to 40%. It is possible to convert an ordinary car into Flex-fuel, but it is not economically feasible. Critics of bioethanol production claim that tropical forests are often cut down for cane plantations to produce bioethanol. Although sugarcane plantations are not the primary goal of lumberjacks. Tropical forests are being cut down illegally. Illegal wood producers cut down a section of the forest. After the departure of illegal woodcutters, the site is occupied by farmers for grazing. After 3-4 years, grazing on this site stops, and the site is occupied by farmers for the production of soybeans and other crops. The production of ethanol from corn in the US is 5-6 times less efficient than its production from sugar cane in Brazil. Recently, the production of cellulosic ethanol has begun in the southern states of the United States, for which sweet sorghum is planted. Methanol Small methanol additives can be used in existing vehicle fuels by adding corrosion inhibitors. The so-called European Fuel Quality Directive allows the use of up to 3% methanol with an equal amount of additives in gasoline sold in Europe. Today, China uses more than 1 billion gallons of methanol per year as a vehicle fuel in low-level blends used in existing vehicles, as well as high-level blends in vehicles designed to use methanol as fuel. In addition to the use of methanol as an alternative to gasoline, there is a technology for using methanol to create a coal slurry based on it, which in the United States has the commercial name "methacoal" (methacoal). Such fuel is offered as an alternative to fuel oil, which is widely used for heating buildings (fuel oil). Such a suspension, unlike water-carbon fuel, does not require special boilers and has a higher energy intensity. From an environmental point of view, such fuels have a smaller carbon footprint, than conventional synthetic fuels derived from coal using processes in which some of the coal is burned during the production of liquid fuels. Butyl alcohol Can be used as an additive to conventional fuels. The energy of butanol is close to that of gasoline. Butanol can be used in fuel cells as a feedstock for hydrogen production. Since the 1950s, butanol has been produced primarily from fossil fuels. It can also be obtained by fermentation from plant biomass (until the 1950s, this was the main method for producing butanol), usually from straw, as well as from any other plant waste containing carbohydrates. This process takes place with the participation of the bacteria Clostridium acetobutylicum and makes it possible to obtain butanol with a concentration of up to 7%. Over the past few decades, other bacteria have been discovered that can efficiently produce butanol (eg C. beijerinckii, C. aurantibutyricum and C. butylicum). Research is underway to obtain strains that produce butanol at a higher concentration (more than 9%), which allows the automatic separation of butanol from the aqueous phase during fermentation. Butanol obtained by fermentation of biomass is called biobutanol. In 2007, biobutanol began to be sold in the UK as a gasoline additive. Isopropyl alcohol can be used as an additive to conventional fuels. Isopropyl alcohol is used in large quantities to improve fuel quality as a fuel additive. Because of its miscibility with water, it is used as a fuel additive to improve water solubility and prevent the icing of fuel lines. In the engine carburettor at a temperature of -8 to +13 ° C and relative humidity of 60-100%, icing may occur, which makes it difficult to start and turn off the engine. To eliminate this undesirable phenomenon, it is enough to add 1.5-3% isopropyl alcohol to gasoline.

Ethers are colourless, mobile, low-boiling liquids with a characteristic odour. Methyl tertiary butyl ether (MTBE) is currently considered the most promising antiknock agent. In Russia, it is allowed to add it to automotive fuels in an amount of up to 15%. The limitations are caused by the features of operational characteristics: relatively low calorific value and high aggressiveness towards rubbers. According to road test results, unleaded gasoline containing 7-8% MTBE outperform leaded gasoline at all speeds. The addition of 10% MTBE to gasoline increases the octane number by 2.1-5.9 units according to the research method, and 20% - by 4.6-12.6 units, and therefore it is more effective than such well-known additives as alkyl gasoline and methanol. The use of fuel with methyl tert-butyl ether slightly improves the power and economic performance of the engine. MTBE is a colourless transparent liquid with a pungent odour. The boiling point is 54-55°C, the density is 0.74 g/cm^3. The octane number by this method is 115-135 points. World production of MTBE is estimated at tens of millions of tons per year. As potential antiknock agents, it is possible to use ethyl tert-butyl ether, tert-amyl methyl ether, as well as methyl ethers obtained from C6-C7 olefins. World production of MTBE is estimated at tens of millions of tons per year. As potential antiknock agents, it is possible to use ethyl tert-butyl ether, tert-amyl methyl ether, as well as methyl ethers obtained from C6-C7 olefins. World production of MTBE is estimated at tens of millions of tons per year. As potential antiknock agents, it is possible to use ethyl tert-butyl ether, tert-amyl methyl ether, as well as methyl ethers obtained from C6-C7 olefins.

Table 2. Properties of some esters

Ether	*Formula*	*ONRM*	*ONMM*	*ON_{oa}*	*ON_{ip}, °C*
MTBE	$CH_3-O-C(CH_3)_3$	118	110	114	55
ETBE	$C_2H_5-O-C(CH_3)_3$	118	102	110	70
MTAE	$CH_3-O-C(CH_3)_2C_2H_5$	111	98	104.5	87
DIPE	$(CH_3)_2CH-O-CH(CH_3)_2$	110	99	104.5	69

To obtain AI-95 and AI-98 gasoline, MTBE additives or their mixture with tert-butyl alcohol, which is called Feterol - the trade name Octane-115, are usually used. The disadvantage of such oxygen-containing components is the volatilization of ethers in hot weather, which leads to a decrease in the octane number. Solid and gaseous fuels. In some third-world countries, wood and charcoal are still the main fuel available to the population for heating and cooking (about half of the world's population lives this way). This in many cases leads to deforestation, which in turn leads to desertification and soil erosion. One way to reduce the population's dependence on wood sources is to introduce the technology of briquetting agricultural waste or household waste into fuel briquettes. Such briquettes are obtained by pressing the slurry obtained by mixing waste with water on a simple lever press, followed by drying. This technology, however, is very labour-intensive and requires a source of cheap labour. A less primitive option for obtaining briquettes is to use hydraulic pressing machines for this. Some gaseous fuels can be considered options for synthetic fuels, although such a definition can be controversial because engines using such fuels need major modifications. dimethyl ether. Dimethyl ether is obtained by dehydration of methanol at 300–400 °C and 2–3 MPa in the presence of heterogeneous catalysts—aluminosilicates. The degree of conversion of methanol to dimethyl ether is 60%, and to zeolites is almost 100%. Dimethyl ether is an environmentally friendly fuel without sulfur content, and the emission of nitrogen oxides in the exhaust gases is 90% less than that of gasoline. The cetane number of a dimethyl diesel engine is more than 55, while that of a classic oil one is from 38 to 53. The use of dimethyl ether does not require special filters, but it is necessary to remake the power systems (installation of gas-balloon equipment, adjustment of mixture formation) and engine ignition. Without alteration, it is possible to use it on cars with LPG engines with a 30% DME content in the fuel. The combustion heat of DME is about 30 MJ/kg, for classical petroleum fuels, it is about 42 MJ/kg. One of the features of the use of DME is its higher oxidizing power (due to the oxygen content) than that of conventional fuel. In July 2006, the National Development and Reform Commission (NDRC) (China) adopted the standard for the use of dimethyl ether as a fuel. The Chinese government will support the development of dimethyl ether as a possible alternative to diesel fuel. In the next 5 years, China plans to produce 5-10 million tons of dimethyl ether per year. Cars with engines running on dimethyl ether are being developed by KAMAZ, Volvo, Nissan and the Chinese company Shanghai Automotive.

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