Biomass based DME

Lab Scale | Bench Scale | Pilot Plant | Demonstration | Production

Biomass based Dimethyl ether, DME

CH_3OCH_3

Dimethyl ether (DME) can be produced from coal, natural gas or biomass and it is used for a variety of purposes including as an aerosol propellant and chemical precursor. DME is an attractive alternative for diesel substitution due to its high cetane number and low tail-pipe emissions. Since it is in gaseous form under normal conditions, it cannot be blended with diesel. BioDME is a so-called second generation, or advanced, biofuel. BioDME production via gasification of black liquor has been successfully demonstrated on pilot scale, including long-time fleet tests in heavy duty vehicles.

Primary area of use

DME is currently used primarily blended with liquefied petroleum gas (LPG) for home heating and cooking (mostly in China), as an aerosol propellant in hairspray and other personal care products, as a refrigerant, and as a feedstock for the production of several chemicals, most commonly dimethyl sulphate. As an aerosol propellant and refrigerant DME does not deplete the ozone layer like the chlorofluorocarbons and freons it replaces. Similar physical properties means that LPG infrastructure can easily be modified to handle DME, enabling wider spread.

DME is also an attractive diesel fuel substitute, due to good combustion characteristics, a high cetane number and a low octane number (see "Properties" info box). DME combusts without creating soot, the main material responsible for PM 2.5 particulate emissions. Further, combustion of DME produces no sulphur oxides at all, and any nitrogen oxides generated are simple to remove in the absence of the particulates.

DME used in conventional compression ignition engines requires a new fuel storage and injection system compared to when using liquid diesel fuels. Typically, DME is pressurized to about 5 bar being in liquid phase at normal temperature. When used as a fuel, DME is in a liquid phase all the way from the tank to the combustion chamber. The injection pump in a DME truck goes up to about 500 bar compared to about 1400 bar for regular diesel engines.

Properties

Chemical formula:	CH_3OCH_3
Molecular mass:	46.07 g/mol
C (%wt)	52
H (%wt)	13
O (%wt)	35
Density at 20°C:	0.67 kg/cm³
Boiling point (°C):	-24.9
Heating value:	28.8 MJ/kg
Cetane number:	55-60

DME is the simplest of the ethers. In ambient conditions it is a colorless, non-toxic, non-corrosive and non-carcinogenic gas. DME does not deplete the ozone layer and it is easy to liquefy and transport.

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This is possible as the DME is easier to atomize resulting in an improved combustion process. DME is not corrosive, although some elastomers may swell in contact with DME. Another benefit is that the noise level of a DME engine is lower than in a conventional diesel engine.

The energy content of DME (LHV, Lower heating value) is 19.3 MJ/litre (28.8 MJ/kg), roughly 70% of the energy content of fossil-derived diesel. Thus, the fuel tank size must be bigger to enable the same driving range as for diesel vehicles. Furthermore, DME has poor lubricity, demanding special additives to avoid excessive wear in engines.

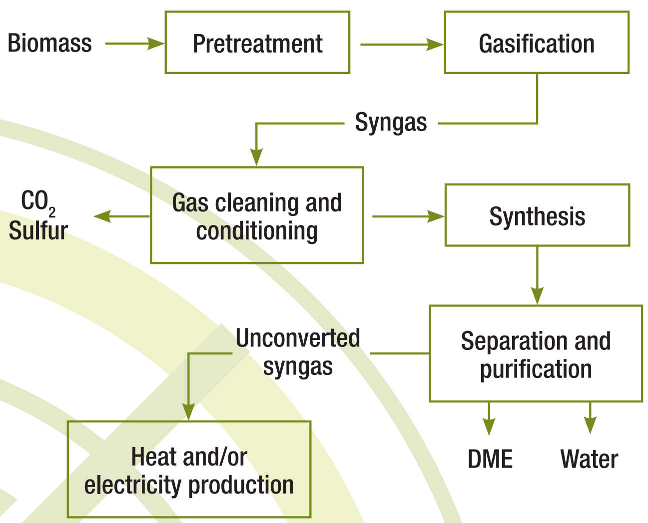
Feedstock and production

DME is currently mainly produced by means of methanol dehydration according to the following reaction:

$$2CH_3OH \text{ (Methanol)} \rightarrow CH_3OCH_3\text{(DME)} + H_2O$$

It is also generated directly from synthesis gas from thermochemical gasification of coal or through natural gas reforming.

Recent developments in gasification technologies provide the opportunity to also use biomass based fuels such as by-products from the paper and pulp industry, forest and agricultural residues, solid municipal waste and other renewable feedstocks. Using thermochemical biomass gasification the feedstock is first converted into a synthesis gas (syngas) stream consisting mainly of CO, CO_2, H_2O and H_2. After cleaning and conditioning of the syngas in order to obtain a gas suitable for the synthesis reactions, DME is synthesised catalytically via methanol. Each of these steps can be carried out in a number of ways and various technologies offer a spectrum of possibilities which may be most suitable for any desired application.



Distribution and storage systems

DME is liquefied at moderate pressures and it can be handled like LPG due to its similar properties. Existing on- and off-shore infrastructure for LPG could therefore be used for transportation, storage, and distribution of DME with minor modifications.

Current production

The current global production of (fossil) DME is approximately 5 million tons per year, with the majority of production in China from coal-derived methanol. Commercial production facilities are also located in Japan, Germany, the Netherlands, Russia, South Korea, Turkey and the United States, with the first large-scale plant in the Americas (in Trinidad and Tobago) scheduled for completion in 2018. China's National Development and Reform Commission forecasts an annual DME production capacity of 20 million tons by the year 2020.

BioDME projects

BioDME production from black liquor, a lignocellulosic by-product from the pulping process, was successfully demonstrated at the LTU Green Fuels (formerly Chemrec) pilot plant in Piteå, Sweden (2011-2016). During the time in operation, about 1,000 tons of DME and methanol was produced in the facility, which has been operating for over 10,000 hours with biofuel production. The produced DME was used for field-testing with ten heavy duty trucks (Volvo Trucks) that were run in commercial traffic using biofuels produced in the pilot plant. Operation in the plant was terminated in 2016.

Currently no other DME projects based on fully renewable feedstocks are ongoing globally.

A schematic overview of the steps in DME production.