Ethanol from Biomass

Just the Facts

What is ethanol from biomass?

- A domestically produced liquid fuel from renewable, virtually inexhaustible domestic resources.
- A nonfossil transportation fuel contributing no net carbon dioxide to the atmosphere.
- A high-octane fuel that can contribute substantially to the U.S. automotive fuel supply.
- A fuel that can be used as a blend or as a pure fuel, with good efficiency and performance.
- A potentially clean-burning fuel that reduces air pollution problems such as smog and carbon monoxide.

The resource

Today, between 800 million and 850 million gallons of ethanol are produced in the United States annually, principally from corn. However, corn is also valuable as a food and feed crop.

The Department of Energy (DOE) is concentrating its efforts on developing an ethanol feedstock from cellulosic biomass — herbaceous and woody plants, agricultural and forest residues, and municipal solid waste. These cellulosic materials provide an abundant and inexpensive feedstock for ethanol throughout the country.

To ensure that a low-cost energy feedstock is available, DOE researchers at Oak Ridge National Laboratory are examining dedicated energy crops — wood and grass species — that have been genetically altered to require minimum management and produce high yields in several different climatic and soil regions across the United States. With proper management, it is estimated that over 1.7 billion tons of cellulosic biomass could be available each year in the United States. That figure converts to a potential ethanol yield of 170 billion gallons.

The process

Biomass feedstocks have three main components: cellulose, hemicellulose, and lignin. Pretreatment is used to open up the structure of the cellulose and hemicellulose components so they can be broken down (hydrolyzed) into fermentable sugar molecules. Essentially, the hemicellulose is dissolved in pretreatment, and enzymes can then efficiently hydrolyze the cellulose chains.

Scientists involved in DOE-sponsored studies at the National Renewable Energy Laboratory are targeting a procedure known as simultaneous saccharification and fermentation (SSF). The process combines hydrolysis of cellulose and fermentation of the resultant glucose sugar in one vessel to produce high yields of ethanol. Advances in genetic engineering are making fermentations of xylose sugars (formed from the hemicellulose fraction of the biomass) more productive as well. Continued improvements in such key technical areas will make biochemical conversion of biomass to ethanol a more efficient and economical route to alternative fuels production.

The DOE program

Production

The Ethanol from Biomass Program, within DOE's Biofuels Systems Division, is developing technologies with the objective of producing ethanol from biomass at a price competitive with gasoline by 2000.[1]

DOE has already made significant strides in bringing the conversion of biomass to ethanol into the realm of realistic and affordable alternative energy technologies. Over the last decade, the program has succeeded in reducing the predicted cost of biomass-derived ethanol from $3.60 per gallon to $1.27 per gallon.

Utilization

Petroleum imports cost the United States $44 billion in 1987, a hefty portion of the $154 billion balance of payment deficit that year. This issue has been addressed by the Alternative Motor Fuels Act (AMFA) of 1988, which requires that a percentage of government and domestic vehicle fleets be converted to alternative fuels, ethanol among them, by the end of 1993. The purpose of the act is to encourage the development and widespread consumer use of methanol, ethanol, and natural gas as transportation fuels and promote the production of motor vehicles powered by these fuels.

Ethanol use in the United States is centered primarily in the Midwest, where excess corn and grain can be converted into fuel. Many Midwest service stations sell high octane gasoline blends that contain 10% ethanol (gasohol). A near-neat blend (85% ethanol mixed with unleaded gasoline) is also being tested. Ethanol can also be used as a feedstock to produce ethyl-tertiary-butyl ether (ETBE) which may become an important constituent in reformulated gasoline.

Ethanol can be produced from plentiful, native cellulosic feedstocks and provide ample fuel supply to help meet the demands of our transportation sector. Environmental concerns and economic and national security benefits make it clear that ethanol from cellulosic biomass is a transportation fuel of merit.

[1] Currently, gasoline blended with 10% ethanol has a 5.4¢/gal excise tax exemption.

Comparison of Fuel Properties

Fuel Properties	Gasoline	Reformulated Gasoline	#2 Diesel	Ethanol	ETBE
Density, lb/gal	6.20	6.20	7.1-7.5	6.61	6.24
Energy Content, Btu/gal	115,400	115,400	140,000	75,670	93,760
Boiling Temp. (°F)	80-437	80-437	320-640	172	161
Reid Vapor Pressure, psi	9-10.5[a]	7.5- 9[a]	0.03[b]	2.3	4.0
Water Solubility, %	negligible	negligible	negligible	100	.6[d]
Air/Fuel Ratio	14.8	<14.8	≈15.6	9.0	12.1
Flash Point, (°F)	-45	-45	160	55	n/a
Octane Number, (RON+MON)/2[c]	89	89	N/A	111	111
Cetane Number	n/a	n/a	>52	n/a	n/a

[a]summertime formulation

[b]true vapor pressure

[c]Research Octane Number plus Motor Octane Number/2= average octane number

[d] ARCO Chemical Company

The pluses and minuses

With proper crop management, production of ethanol feedstocks can reduce net greenhouse gases from auto emissions. This is because plants require carbon dioxide (CO_2) for growth, so a "carbon cycle" is created when plant-derived fuels are burned in vehicle engines. The CO_2 released in combustion is taken up by plants during the growth process. In addition, use of ethanol fuels can also reduce emissions of carbon monoxide, nitrogen oxides, and unburned hydrocarbons.

Other pluses for ethanol include its relatively low toxicity, its water solubility, and its biodegradability, making the consequences of large fuel spills less environmentally threatening.

On the minus side (and some of these are being addressed by DOE researchers) are the issues of aldehyde emissions, cold start difficulties, low energy density, and corrosive properties.

Appropriate catalytic converters would minimize any detrimental effects from aldehyde emissions. Ethanol contains about two-thirds the energy per volume (or travel range per gallon) as an equal amount of gasoline, but efficiently designed engines could increase the range to 80% that of gasoline. Nonetheless, slightly larger fuel tanks would be needed if vehicles are to travel equal distances on one fill-up of pure ethanol. The range of ethanol blends (gasohol) is statistically indistinguishable from that of regular gasoline. Ethanol's high vaporization temperature is beneficial in reducing emissions but causes starting problems in cold weather climates. Finally, the water solubility of ethanol could precipitate corrosion of many conventional engine components, so appropriate materials need to be used in vehicles using pure ethanol as a fuel. (Corrosive properties are not a factor when using ethanol-gasoline blends.)

For more information

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