

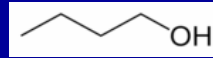
BUTANOL - A POSSIBLE ALTERNATIVE ENERGY SOURCE

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BUTANOL



- An alcohol having 4 carbon atoms
(Density: 0.81g/cm³@20°C; BP:118°C; Viscosity:3 cP@25°C)
- Produced from Biomass as well as fossil fuels
- Better tolerates water contamination and less corrosive than Ethanol.
- More suitable for distribution through existing pipelines for gasoline.
- In blends with gasoline or diesel – less likely separation than Ethanol, if contaminated with water.
- Vapour pressure co-blend synergy in gasoline containing ethanol.

BUTANOL AS FUEL - DEMONSTRATION



July 14 to August 15, 2005 was the first run across the Nation on 100% Butanol. Demonstrating to the public that there is an alcohol made from corn that replaces gas right now if we had it. The sooner we start making *ButylFuel*[™] the sooner you will see it in your tank, go down the road - and stop Global Warming. The '92 Buick Park Avenue got 24 miles per gallon on butanol with no modifications - normally gas is 22 mpg. That is a 9 % increase. In ten states Butanol reduced Hydrocarbons by 95%, Carbon monoxide to 0.01%, Oxides of Nitrogen by 37%, this in a 13 year old car with 60,000 original miles. It runs great up hill and across the deserts.

Butanol is an alcohol that replaces gasoline !

BioButanol[™] is made from anything that grows on the planet

Butanol can be blended in any percentage with gasoline seamlessly with increase in performance

Butanol can be used in Biodiesel applications

PROPERTIES OF GASOLINE AND ALCOHOL FUELS

<u>Fuel</u>	<u>Energy density</u>	<u>Air-fuel ratio</u>	<u>Specific energy</u>	<u>Heat of vaporization</u>	<u>RON</u>	<u>MON</u>
<u>Gasoline</u>	32 MJ/L	14.6	2.9 MJ/kg air	0.36 MJ/kg	91–99	81–89
<u>Butanol</u>	29.2 MJ/L	11.2	3.2 MJ/kg air	0.43 MJ/kg	96	78
<u>Ethanol</u>	19.6 MJ/L	9.0	3.0 MJ/kg air	0.92 MJ/kg	129	102
<u>Methanol</u>	16 MJ/L	6.5	3.1 MJ/kg air	1.2 MJ/kg	136	104

BUTANOL - FUEL PERFORMANCE PARAMETERS

- Energy Content / Density & Fuel Economy : Penalty ~ 10% (Fuel Economy not proportional to change in energy content)
- Octane (RON & MON) : Similar to gasoline but lower than ethanol
- Air-Fuel Ratio : Need to run 'Richer' than gasoline (But closer and can be mixed in higher ratios for use in existing cars w/o modification)
- Specific Energy (MJ / kg air): Butanol -3.2; Ethanol- 3.0; Gasoline-2.9;
- Kinematic Viscosity (@ 20°C) : Butanol – 3.64 cSt; Ethanol – 1.52 cSt; Gasoline - ~ 0.8cSt
- Heat of Vapourization : < half of ethanol (better co-blended synergy with gasoline)
- GHGs Emission : Higher energy density but lower octane number – overall lower combustion efficiency and higher GHGs emission but bio-production more efficient than ethanol

BUTANOL - PRODUCTION

- **CHEMICAL**

- Reaction of syn-gas ($\text{CO} + \text{H}_2$) (From Coal / Petroleum / Biomass) with propylene to Butyraldehyde and Hydrogenation.

- **BIOLOGICAL** ⁽¹⁾

- Anaerobic Bacterial (Clostridium) fermentation (Also produces acetone and small amount of ethanol) called AB or ABE Fermentation process.
- Clostridial Acetone- Butanol fermentation from renewable carbohydrates used to be largest bio-technological process second to Yeast ethanol fermentation and largest ever run under sterile conditions.
- Recent developments in Microbiology, Biochemistry & Genetics can further improve AB producing bacteria as well as substrate preparation (using improved hydrolysis technology), sterilization, fermentation and down stream processing technology

TYPICAL END-PRODUCTS OF AB PROCESS AND COMBUSTION ENERGY OF PRODUCTS

Product	Weight (kg) ^a	Combustion energy (KJ/g)	Net Calorific Value per ton of substrate (MJ/t) ^b
Butanol	207 ± 10	33.1	6,852
Acetone	100 ± 8	28.5	2,850
Ethanol	56 ± 15	26.7	1,495
CO ₂	~ 600	-	-
H ₂	~ 19	119.8	2,276
Total AB			13,273

^a Kilogram of product per ton of starch equivalent

^b Kilojoules of combustion energy (net calorific value) in end product per ton of starch equivalent

BY-PRODUCTS QUANTITIES IN AB FERMENTATION PROCESS

Per Ton of Solvents (ABE)

- CO_2 : 1649 Kgs (97 w%)
- H_2 : 51 Kgs (3 w%)

(85 tons per day gases for 50 tons per day solvents plant)

Plus

30,000 m³ of Biogas per day from fermentation sludge in thermophilic methanogenic fermentation (can be used to provide process heat in sterilization and distillation)

SUGGESTIONS FOR POSSIBLE BUTANOL FUEL

- Butanol-gasoline blends / 100% butanol-testing on engine benches.
- Preliminary approval of engine / vehicle manufacturers.
- Testing of vehicles with butanol-gasoline blends / 100% butanol.
- Consortium of micro-biologists, biotechnologists and chemical engineers to work on bio-butanol-increased production at reduced cost using various agricultural wastes (Presently Market Price per litre is 1.5 times of Ethanol).
- Process technology optimization and costing.
- Overall plan for commercial use in vehicles as alternate fuel

REPORTED STATUS FOR BUTANOL AS FUTURE FUEL

- Forget Ethanol: it's hard to transport and gives bad mileage per gallon. Another alcohol, Butanol, is a much better renewable fuel, says PHILIP NEW, the president of BP Biofuels.
- BP along with University of California, Berkley and DuPont working for Butanol as alternative energy source.
- Other Oil Companies also working in this direction ?
- **Let us work for the near future.**

THANK YOU