Backpacking Stove Fuels

Contact: zenseeker@hotmail.com

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There are a lot of different types of backpacking stoves to choose from. Nothing effects stove design more than the type of fuel it made for. As these fuels differ in several different aspects, each varies greatly price, availability, toxicity, convenience of use, storage requirements, etc.

Since there are a lot of similarities between fuels within a fuel class, backpackers may be able to use a lot of different fuels that may be available to them, depending on where they are in the world. For information on international names fuels check out Mike Buckler's and MSR's list of international fuel names.

The following lists many of the common fuels available to international backpackers. Some are ideal for stove use, while others are far less suited for peak performance and may even be hazardous as noted. Since all stoves are inherently dangerous to use, even when used as designed, one should consider the possible risks of using a fuel not designed for their stove prior to experimenting. The following should only serve as a guide - in other words: use at your own risk.

Stove Fuels

Petroleum Fuels

Great heat to weight ratio. Caustic fuel. Generally burns hot and is unhindered by cold temperatures. See Petrol Stove Fuels for more information.

FYI - These fuels can't be safely used in an alcohol stove (it's already been tried).

Liquefied Gas (Butane, Isobutane, Propane)

Liquefied gas boils/vaporizes at above freezing temperatures and makes stove operation simple and generally has the best heat to weight output. Unfortunately, their boiling point ranges limit

backpacking stove use in the subfreezing temperatures. These tend to be expensive fuels that come packaged in a disposable metal canister. See Canister Stove Fuels for more fuel information.

Alcohol

These are very clean burning fuels that don't create a major health concern or hazard if spilled. They have about half the heat potential per ounce of most petrol fuels and the weight of alcohol fuel will quickly add up if you are cooking many large meals or going on long trips without resupply. See Alcohol Fuel Options for more information.

Chemical Solid Fuels (Esbit, Hexamine, Triox)

These are simple and safe fuels to use and have low toxicity compared to petroleum fuels. They burn slow and don't need a special stove to operate. Often, these are only available through mail order or specialty shops, so can be hard to find if you plan to "shop as you go" thruhiking. There are several solid fuels other than hexamine and trioxane that can be used to heat meals, but many carry along extra hazards such as severe toxicity and explosive potential (e.g. plastic explosive). See Solid Fuels for more information.

Wood

Wood varies in burnability, toxicity and availability. It also provides a special ambiance to being in the outdoors. See Wood Stove Fuels for more information.

Paraffin and other Candle Waxes and Oils (not to be confused with Kerosene) **Not recommended**

Some waxes are worse for your lungs than others and they can vary a small amount in regards to burn time and heat output. This is generally a slow fuel to cook with and can be very sooty. Paraffin and other waxes and oils have a lot of heat potential per gram, but it is difficult to make a practical lightweight stove system with them. See the Candle Stove Fuels for more information.

Sun

The sun has a lot of heat potential, it is a giant nuclear explosion, and some of that heat can be directly used for cooking by concentrating and trapping it. Solar radiation levels differ depending on where you are and when you are there.

Water activated fuels

These do work, but can be hard to find. They are simple and safe to use, if you are using foods packaged for their use. Compared to all other stove fuels, these are heavy to start with, and produce a lot of waste that needs to be carried out.

There are several metals similar to magnesium that release larges

amounts of heat when exposed to water. These metals must be protected from moisture for obvious reasons and shouldn't be handled with bare hands.

Calcium Carbide

This can be hard to find and you'll have to fabricate your own stove if you want to cook with it. This fuel must be kept dry to avoid converting it to acetylene gas and/or turning your pack into a fireball. You'll also need to pack out the byproducts of combustion, which can be quite caustic and heavy. Waste products (CaO and $Ca(OH)_2$) will total between 87.5 and 115.6% (not including any water weight) of the start weight of your calcium carbide.

Make sure that when you purchase your calcium carbide, it is gray in color and hasn't turned into white dust.

Fuel Comparisons

The following data is intended to provide general figures for various fuels. Many of these figures are debatable, but the range of differences are insignificant for backpacking stove performance purposes. For information on international names fuels check out Mike Buckler's and MSR's list of international fuel names.

Fuel	Mol Structure	BP °C	VP 25°C kPa	kcal/gram	Btu/pound
Petrol Liquids:					
Naphtha	C_{5-9}	130-155	20	10.1	18,200
Gasoline	C_{3-12}	14-135	48-103	10.4	18,720
Kerosene	C_{10-18}	200-260	<1	10.3	18,540
Diesel	C_{9-20}	288-338	<1	10.2	18,400
Lamp Oil	C_{10-24}	254-283	<1	10.2*	18,400*
Pressurized Gas:					
Propane	$CH_3CH_2CH_3$	-42.1	9391	11.0	19,782
Butane	$CH_3CH_2CH_2CH_3$	-0.48	2421	10.8	19,512
Isobutane	$CH_3C(CH_3)_2$	-11.8	3481	10.8	19,458
Alcohols:					
Ethanol	CH_3CH_2OH	78.3	7.85 1	6.4	11,570

Methanol	CH_3OH	64.5	16.901	4.7	8419
Isopropanol (100%) 2-Propanol	$CH_3CHOHCH_3$	82.3	6.021	7.2	12,960
Diethyl Glycol	$(HOCH_2CH_2)_2O$	245	0.0011	5.3	9617
Solid fuels:					
Hexamethylenetetramine	$(CH_2)_6N_4$	281	n/a	7.4	13,300
1,3,5-Trioxane	$(CH_2)_3O_3$	115	n/a	4.27*	7,674.7*
Waxes and natural oils:					
Paraffin Wax	C_{19-36}	350-4302	n/a	10.0	18,000
Stearic Acid	$CH_3(CH_2)_{16}CO_2H$	383	n/a	9.6	17,310
Beeswax	C_{24-44}	n/a	n/a	11*	19,000*
Olive Oil	$C_{18+18+16}$	299	n/a	8.9	16,000
Wood/Biomass/EcoFuels:					
Wet Wood	$C_{51\%}H_{6\%}O_{42\%}N_{1\%}$	n/a	n/a	2.22*	4000*
Dry Wood	$C_{51\%}H_{6\%}O_{42\%}N_{1\%}$	n/a	n/a	3.89*	7,000*
Charcoal	C_{Lots}	n/a	n/a	7.83	14,100
Biodiesel	$C_{18-20}H_{33-40}O_2$	182-338*	<1	8.9*	16,000*
Dung (varies)	Animal Poop	n/a	n/a	3.6*	6,500*
Solar Fission:					
Sun	$H_{92.1\%}$ $He_{7.8\%}$	$15x10^6$	n/a	$9x10^{13}$	$2x10^{17}$
Flameless:					
Ration Heater	MgFe	n/a	n/a	10.0*	18,000*
Calcium Carbide:					
Calcium Carbide	CaC_2	n/a	n/a	n/a	n/a
Acetylene	C_2H_2	-84.0	4378	11.5	20,747
CaC_2 ® C_2H_2 ® Heat	C_2H_2 = 40.6% mass CaC_2		n/a	4.7	8,427
Calcium Oxide	CaO - waste	n/a	n/a	n/a	n/a
Calcium Hydroxide	$C_2(OH)_2$ - waste	n/a	n/a	n/a	n/a

Most information derived from the Chemical Hazards Response Information System (C MSDS.
* derived from educated speculation or other sources
1 CRC Handbook of Chemistry and Physics 77th ed
2 North American Combustion Handbook, 2nd ed., North American Mfg. Co., Cleveland

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Petrol Fuel Types

Commercial petrol stoves are designed to work with certain fuels. If you have a multi fuel stove, you may need to modify airflow and/or adjust/replace jets in order to optimize use of various fuels. Larger vaporizer (generator) tubes may also be desirable for heavier and less volatile fuels.

International Names

For information on international names and idiosyncrasies of petrol fuels check out Mike Buckler's and MSR's list of international fuel names.

Petrol Refining

The heart to petroleum refining is the fractional distillation process. Raw petroleum is heated up, and separated into different distillation ranges via a pipestill.

Fraction	Carbon Chains	Boiling Point Range °C	Major Uses
Gaseous hydrocarbons	C_1 - C_4	0-20	Gas fuels for cooking and heating. Methane is used for producing hydrogen for manufacture of ammonia
Naphtha	C_5 - C_7	20-100	Solvents for varnishes, dry cleaning and cracking stock for methane
Gasoline	C_5 - C_{12}	40-175	Fuels for internal combustion engines
Kerosene	C_{12} - C_{18}	175-300	Jet engine fuel and diesel fuel #1
Diesel Fuel or Gas-Oil	C_{18} - C_{24}	300-400	Diesel fuel #2 and cracking stock for gasoline
Lubricating Oil	C_{20} - C_{30}	Non volatile fraction	Lubricants and cracking stock
Paraffin Wax	C_{25} - C_{30}	solids	Candles, packaging, polishing, petroleum jelly, and water proofing
Residue Bitumen	Greater than C_{30}	solids	Asphalt and road surfaces, waterproofing

These distillates are further refined to produce fuels, solvents, and other products that meet specific criteria. These criteria vary depending on manufacturer, destination country, retailer, and targeted use, making it difficult to accurately define attributes such as composition, toxicity, heat output, and performance between various fuels.

Fuels

The following considers a handful of usable fuel categories for petrol camp stoves and is neither all inclusive nor technically complete. The following is given as a brief guideline for backpacking stove use, and nothing more.

NOTE - All petrol fuels are toxic and all are dangerous. Those not listed are possibly even more so dangerous and toxic. Even when well designed petrol stoves and accessories are used in a "safe" manner, they are not risk free. Using fuels in a manner outside of manufacture's recommendations and/or contradictory to common sense can prove deadly.

Naphtha (aka. Coleman Fuel, MSR Fuel, White Gas [North America, Australia, and New Zealand], Shellite, Fuelite, Zippo fuel, Ronsonol fuel, heptane, Blazo, cigarette lighter fluid, some charcoal lighter fluid)

Naphtha is a term relating to a range of hydrocarbons used as solvents or feedstock for petroleum products. For purposes of

categorizing fuels for stoves, "naphtha" is used to include all naphtha and gasoline-like fuels that have been refined to be as aromatic and additive free as practical for stove use. This is a much "cleaner" stove fuel than other petroleum products (except possibly the liquefied gases) so it is less likely to clog stoves. It is also considered by many to be the best fuel for high altitude and extremely cold treks. It evaporates quickly, is quite volatile, burns very hot, and leaves little residue compared to kerosene. Naphtha requires a lot of oxygen to burn and therefore may be a little easier to extinguish than other petroleum fuels. Naphtha is much more explosive than kerosene but is a bit less explosive than gasoline. This fuel category might be slightly less toxic than gasoline but is still very caustic, and releases an unpleasant odor that lingers.

Naphtha is a mix of 5 to 9 carbon alkanes with a boiling range of 104 to 401°F (40 to 205°C). The term "naphtha" has several accepted and obsolete definitions and can even be inclusive of gasoline and kerosene.

Coleman Fuel (Calumet Lantern Fuel)
Coleman fuel contains about 50% naphtha, 50% aliphatic petroleum distillates, 2% xylene, 2% toluene, 0.5% benzene, green dye and rust inhibitors (to help prevent rusting of internal parts and facilitate long shelf life). The carbon number range is C_5 to C_9 with a boiling point range of 100-350° F. Coleman Fuel contains up to 25% n-hexane and up to 15% cyclohexane by weight and it is fully hydrotreated to remove aromatics, (reported to contain less than 0.001% benzene).

Fuelite (Shellite)
Contains >60% Paraffins and naphthenes, N-hexane 13%, <5.0% Aromatic hydrocarbons (3.5% Toluene, 1% Ethylbenzene, <0.5% Benzene, 1% C8 and higher aromatics) and other stuff

White Gas
This is an old term referring to overpriced unleaded gas marketed as lamp and stove fuel back when leaded gas was referred to as Red Gas. True white gas is gasoline without additives, is more volatile than true naphtha and not as safe to use. Some white gas (not made for stove use) even has tetraethyllead added to it.

Environmental gasoline (lawnmower fuel, special bensine, alkylate petrol, Alkylatbensin, Miljöbensin)
This should be "free" from aromatic hydrocarbons and olefins such as benzene and many of the toxic additives in regular unleaded gasoline for your auto.

Unleaded Gasoline (aka petrol, automotive gas, unleaded, benzine) (Not Recommended)

This burns very hot, is extremely explosive, is very caustic, releases a terrible odor that lingers, and its additives and high octane components **release deadly vapors when burned**. It may also prematurely clog your stove when compared to white gas. Avoid if possible and go with the lowest octane available if this is your only choice. The greater the octane the greater the amount of octane-enhancing/antiknock additives.

Additive packages include: octane-enhancing additives (methylcyclopentadienyl manganese tricarbonyl [MMT] in some countries, methyl t-butyl ether [MTBE] in US, etc), anti-oxidants (inhibit gum formation, improve stability), metal deactivators (inhibit gum formation, improve stability) , deposit modifiers (reduce deposits, spark-plug fouling and preignition), surfactants (limit icing, improve vaporization, inhibit deposits, reduce NOx emissions), freezing point depressants (decrease icing), corrosion inhibitors (limit corroding of storage tanks), dyes (product color for safety or regulatory purposes).

Gasoline contains over 500 alkanes, cycloalkanes and other hydrocarbons with 3 to 12 carbons (including Benzene, Butane, Cyclohexane, Ethylbenzene, Heptane, Hexane, Pentane, Toluene, Trimethylbenzene, Xylene) and has a boiling range from 86 to 428°F (30 to 220°C)

Oxygenates
Gasoline uses oxygenates to increase octane and decrease carbon monoxide emissions. What additives are used depends on what part of the world you in and even differs from State to State in the US. Oxygenates include ethanol, MTBE (illegal in many States), tertiary-amyl methyl ether (TAME) and/or ethyl tertiary-butyl ether (ETBE) These additives are often toxic and don't help in stove performance.

Typical Properties of Oxygenates

	Ethanol	MTBE	ETBE	TAME
Chemical formula	CH_3CH_2OH	$CH_3OC(CH_3)_3$	$CH_3CH_2OC(CH_3)_3$	$(CH)_3CCH_2OCH$
Oxygen content, percent by weight	34.73	18.15	15.66	15.66
Octane, (R+M)/2	115	110	111	105
Blending vapor pressure, RVP	18	8	4	1.5

Source: National Petroleum Council, U.S. Petroleum Refining: Meeting Requirements for Cleaner Fuels and Refineries (Washington, DC, August 1993) Appendix L.

Winter Oxygenate Gasoline
In some places, gasoline is oxygenated to reduce carbon monoxide emissions in the winter. Oxygenated gasoline decrease carbon monoxide emissions (particularly older vehicles) by burning leaner in autos engines. According to Chevron, MTBE is used primarily in California and for the East-of-the-Mississippi Reformulated Gasoline (RFG) areas, while ethanol is used in Anchorage, Seattle, Spokane, Vancouver, Portland, Southern Oregon, Salt Lake City, Reno, Las Vegas, Phoenix, Tucson, Albuquerque, and El Paso.

City	Oxy Season	Counties
Albuquerque	Nov 1 - Feb 29	Bernalillo

Anchorage	Nov 1 - Mar 1	Anchorage Borough
El Paso	Oct 1 - Mar 31	El Paso
Las Vegas	Oct 1 - Feb 29	Clark
Phoenix	Oct 1 - Mar 31	Maricopa
Portland	Nov 1 - Feb 29	Clackamas, Multnomah, and Washington
Reno	Oct 1 - Jan 31	Washoe
Salt Lake City	Nov 1 - Feb 29	Utah (Provo)
Seattle	Nov 1 - Feb 29	King, Pierce, and Snohomish
Southern Oregon	Nov 1 - Feb 29	Josephine (Grants Pass), Klamath (Klamath Falls), and Jackson (Medford)
Spokane	Sep 1 - Feb 29	Spokane
Tucson	Oct 1 - Mar 31	Pima
Vancouver	Nov 1 - Feb 29	Clark

According to REI:

> "**NOTE:** Never use oxygenated gasoline in your backpacking stove. Sold in many parts of the U.S. in the winter months, its additives can destroy rubber stove parts and seals."

Reformulated Gasoline
The reformulated gasoline (RFG) program requires reductions in automobile emissions of ozone-forming volatile organic compounds during the summer high-ozone season, and of toxic air pollutants and nitrogen oxides during the entire year in certain areas of the United States. Reformulated gasoline requires a minimum 2.1% oxygen by weight when averaging, which corresponds to approximately 11.7 volume percent MTBE or 5.8 volume percent ethanol. While the sale of Federal reformulated gasoline was mandated for only nine areas in the nation with the most severe ozone pollution, other areas are allowed to voluntarily join the Federal RFG program.

Emissions/Eco Friendly Gasoline
These products are become more popular in heavily polluted areas. Brands such as Blue Planet Earth Friendly Gasoline have lower levels of sulfur, benzene, other volatile organic compounds, toxins, and are MTBE free. These may be the better choice of gasoline for stove use as it should be less likely to clog your stove or cause health problems than regular gasolines.

Leaded Gasoline (Aviation Gasoline, AvGas) (Not Recommended)

If this is the only fuel you can find, consider eating cold meals. In addition to many of the health concerns that come with unleaded

gasoline, these fuels also contain **tetraethyllead $Pb(C_2H_5)_4$** (TEL) which is not only bad for your health but may quickly clog your jets.

Fuel Grade (Octane Rating)	Color	TEL per Gallon
80/87	Red	0.5mL
100LL (low lead)	Blue	1.2 - 2.0mL
100/130	Green	3.0 - 4.0mL
115/145	Purple	4.6mL

Kerosene (aka. paraffin, some charcoal lighter fluid, K-1, high grade diesel fuel, DERV, kerosine, coal oil, Range Oil, kero, Klean-Heat, Deobase)

This is almost as hot as naphtha once it gets burning and can be easier to find than naphtha.. It may prematurely clog your jets, has a very strong odor, leaves an oil residue on everything it comes in contact with and may flavor your food if you don't use a tight lid on your cookware. This fuel is extremely difficult to extinguish and like gasoline, the fumes have an explosive potential (though not nearly as great), and should be stored in a metal container protected from direct sunlight. Kerosene may take longer to prime and requires a separate priming agent if you don't want a lot of soot on and in your stove, jets and pot. You may need to run a narrower jet than used with naphtha for optimal performance.

narrow cut kerosene (Jet A1, K1) is a mix of 10 to 18 carbon alkanes with about 20% aromatics and distils between 350 to518°F (175 to 270°C)

wide cut kerosene (Jet B, JP-4) is cut down to also include some of the gasoline/naphtha range and distils between 212 to 482°F (100 to 250°C)

diesel (#2, Fuel Oil No. 2, Heating Oil No. 2) is a mix of 9 to 20 carbon alkanes and distils between 482 to 716°F (250 to 380°C)

K-1 (low sulfur kerosene) (may have red dye)
This is a low-sulfur kerosene approved for use in nonflue-connected (ventless) kerosene burner appliances and for use in wick-fed illuminating lamps, space heaters, etc. This is the best kerosene choice for stoves. K1 is often referred to as Kero, but Jet A (with toxic additives) is also sometimes sold as Kero.

Odorless Kerosene (Klean-Heat, Deobase, odorless mineral spirits)
This is kerosene that has been "sweetened" with most of its mercaptans (sulfur compound) and aromatics removed. It supposedly burns cleaner, odorless, with less smoke and soot. It may also have a narrower molecule range (C9-C12), higher flashpoint than K-1 (125°F or greater vs. ~100°F) and a much higher price.

K-2 (regular kerosene)
Has a higher sulfur content than K1.

#1 Fuel/Heating/Gas/Burner Oil. (may have red dye) (Not Recommended)
This fuel has high sulfur levels. This fuel is designed for use in conventional pressure and air atomizing domestic oil burner systems such as in domestic and small industrial space heaters and burners. Number 1 Fuel Oil is particularly adapted to vaporizing type burners or where storage conditions require low pour point fuel.

Charcoal lighter fluid
Some of these are a mix of kerosene and naphtha and some are just straight naphtha.

Jet Fuels (Not Recommended)

These fuels are used for powering jet and turbo-prop aircraft. They are are different cuts of kerosene with some additives to improve engine and fuel performance. These include **Tetraethyllead** (TEL, anti-nock/detonation), antioxidants (prevent formation of gum deposits and peroxide compounds), static dissipators (reduce the hazardous effects of static electricity), corrosion inhibitors, lubricants, icing inhibitors, metal de-activators (decrease copper oxidation ability), biocides and thermal stability improvers (prevent deposits in high temp areas).

JET A-1
Jet A1 is a kerosene type fuel with a flash point above 38°C (100°F) and a freeze point maximum of -47°C. It is widely available outside the US.

JET A
Jet A is a similar kerosene type of fuel and is generally only available in the US. It has a higher freeze point maximum (-40°C) than Jet A-1.

JET B
Jet B is a distillate covering the naphtha and kerosene fractions (wide cut kerosene). It is more flammable and explosive than Jet A and is used for very cold climates.

MILITARY
JP-4
Jet B with the addition of corrosion inhibitors and anti-icing additives.

JP-5
JP-5 is a high flash point kerosene making it less likely to explode if hit with small arms fire.

JP-8
Jet A-1 with the addition of corrosion inhibitors and anti-icing additives.

Diesel

Diesel fuel quality varies depending on the manufacture, what time of the year it is and what part of the world you

find it. And depending on composition, it may smoke a lot and clog your stove much faster than with kerosene. How refined your fuel is and the amount of impurities in it will influence whether or not it will work in your stove. This fuel will generally only work well in specifically designed and jetted stoves such as the MSR XGK and Primus Omnifuel. You may need small jets, a large vaporizer tube, a separate priming agent and lots of maintenance to successfully burn diesel.

#1 Diesel Fuel (Kerosene-like, kerosene, Diesel 1-D)
The specifications for No. 1 diesel (minus additives for diesel engines) are so similar to kerosene that many manufactures make a dual purpose product that is sold as both kerosene and diesel #1. This fuel can be ultra low, low, or high sulfur. It has better solvent qualities than #2 and is used in lower temperatures or blended with #2 to improve performance in colder temperatures. Winter diesel blends can have anywhere from 10-50% #1 fuel added to #2.

#2 Diesel Fuel (Diesel 2-D, Home heating oil, No. 2 Gas/Burner oil)
This fuel can be ultra low, low, or high sulfur and is composed of much larger hydrocarbon molecules than diesel #1 (kerosene). This product is approved for use in domestic and small industrial burners.

Commercial Diesel
New low sulfur diesel doesn't lubricate as well as high sulfur diesel and many manufactures have added lubricants and other additives to prolong engine life. If you have a choice, you may want to avoid fuels with additives.

Premium Diesel Fuel (Not Recommended)
"Premium" is an unregulated term used by manufactures/distributors to describe higher quality diesel fuel qualities or fuels enhanced with additives. This may include enhanced cetane number, detergent for system cleanliness, heat content minimum, stability during storage and use, low temperature performance, lubricity, corrosion protection and water handling characteristics. Again, avoid if possible.

#4 Diesel (Marine Diesel, Diesel 4-D, Heavy residual fuel oil) (Not Recommended)
This fuel can be very crude and isn't suitable for vaporization/pressurized stoves. Marine diesel varies from country to country and it is possible to get high quality fuel intended for auto use in some ports.

Sulfur Content

Using fuels with less sulfur in automobiles is a recent big environmental theme aimed at decreasing sulfur emissions and problems such as acid rain. Avoiding high sulfur fuels isn't such a bad idea for stove use either, if you are concerned about your health. If you're not

concerned about your health, high sulfur, non-highway use fuels may be cheaper to use and make you feel like a made as the sulfuric acid created by the fumes deepen your voice.

Ultra Low Sulfur Diesel Fuel CARB Diesel Fuel
This was designed to meet the special requirements of the California Air Resources Board Urban Bus Rule. It should contain a maximum of 15 ppm of sulfur.

Low Sulfur Diesel Fuel
Sulfur content is limited to "no greater than 0.05%w." Approved for use in on-road diesel engines.

High Sulfur Diesel Fuel (red dyed, agricultural diesel) (Not Recommended)
Sulfur content is limited to "no greater than 0.50%w." This product is for use in off-highway diesel engines. "Red Diesel" may be much cheaper than the taxed auto diesel in your country.

Lamp oil (aka paraffin, some mineral oils) (Not Recommended)

Lamp oils vary from brand to brand. Some are kerosene labeled as lamp oil while others are more refined, contain heavier (10-24) carbon alkanes and are free from aromatics and other undesirable petroleum products. These fuels are very similar to kerosene but burn cooler, requires more oxygen, are easier to extinguish, have slightly less explosive potential and generally contain fewer toxins. Depending on the makeup of the fuel and the stove you are using, it may not work well and may produce a lot of smoke and soot. It may also require a separate priming agent.

Other Solvents - should never be used!

There are many volatile and flammable solvents that will work in camp stoves. Unfortunately, they also tend to be extremely toxic and should never be used. There are better ways to die.

Biodiesel (veggie diesel, vegetable fuel) (Not Recommended)

A slow burning fuel similar to lamp oil. Releases a French Fry, peanut, fish and chips, etc smell when burned. Biodiesel fuel is one of the safest fuels around as it is relatively nontoxic and not very flammable. Depending on the makeup of the fuel and the stove you are using, it may not work well and produce a lot of smoke and soot. This fuel may only work well in specially designed stoves such as the MSR XGK and Primus Omnifuel. You may need small jets, a large vaporizer tube, a separate priming

agent and lots of maintenance to successfully burn biodiesel.

Rapeseed oil (Canola oil, Colza oil) (Not Recommended)

With proper jets vaporization of fuel, you may be able to get good quality vegetable oil to burn in a stove.

Liquefied Petroleum Gas

Several commercial stoves are able to burn liquefied gas fuels such as butane, isobutane, propane, etc with the addition of an adapter. This fuel burns clean but may not work well at subfreezing temperatures and can be expensive and difficult to find. See Canister Stoves for more information.

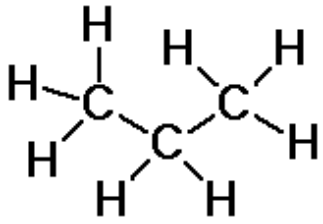
Alcohol Fuels

Burns clean and cool. Poor heat to weight ratio. You may need to use a larger jet to burn this fuel optimally. See Alcohol Fuel Options for more information.

Liquefied Gas Canister Fuel Types

Propane, Butane and Isobutane all have similar heat values and work more or less the same above freezing temperatures. These fuels will not work well bellow their respective boiling points since they won't be able to build up sufficient pressure for stove operation, so the differences in fuel performance by and large relates to fuel's boiling points. The lower the boiling point, the less likely it will fail in the cold.

Propane (LPG, Liquified Propane Gas)

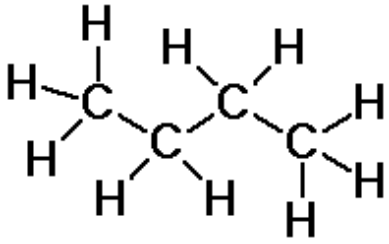


Great hot burning fuel that works at low temperatures and at high altitudes. Due to high pressures of propane (close to five times that of butane at room temperature), propane canisters are made of thick heavy steel. Pure propane is not recommended for stoves designed to run mostly butane and/or isobutane without a pressure regulator.

Propane is generally used for heavy duty stoves, lanterns, heaters and torches.

Boiling point: -43° F (-40°C). Fuel will not vaporizes well below its boiling point.

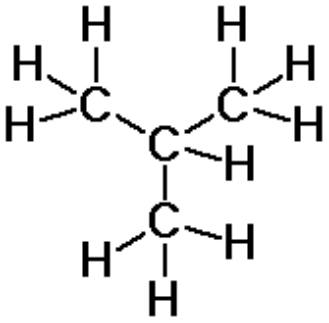
Butane (n-butane)



Works well at high altitudes but burns poorly below 40° F due to poor vaporization at low temperatures. Butane is commonly used in backpacking and portable stoves, lighters, small torches and as a propellant for aerosol cans.

Boiling point: 31° F (0.5°C). Fuel will not vaporizes well below its boiling point.

Isobutane



Isobutane is a structural isomer of butane with a lower boiling point. Manufactures claim that isobutane provides a steady flow without tapering off as the canister empties and is added to butane to increase its performance. Because of the greater vapor pressures of isobutane compared to butane, you may experience much greater flow that may blow itself out if turned up too high or possibly even damage a stove not designed for isobutane.

Boiling point: 11° F (-12°C). Fuel will not vaporizes well below its boiling point.

Fuel Mixes

Isobutane and/or propane are often added to butane to allow stoves and lanterns to operate at subfreezing temperatures. These fuel mixes don't affect the vaporization of butane and each fuel vaporizes separately. This is important because at temperatures below the boiling point of butane, the added fuels will vaporize and be used up first. If your canister isn't warmed by the burning of the more volatile fuels, these fuels will burn off first and leave you with just butane remaining.

Isobutane/Butane Blends

Basically, isobutane may allow you to operate your stove at subfreezing temperatures down to 11° F (-12°C), that is - until the isobutane runs out..

Propane mixes (20-40% Propane) (Butane/Propane, Butane/Isobutane/Propane, Isobutane/Propane, IsoPro, IsoPropane)

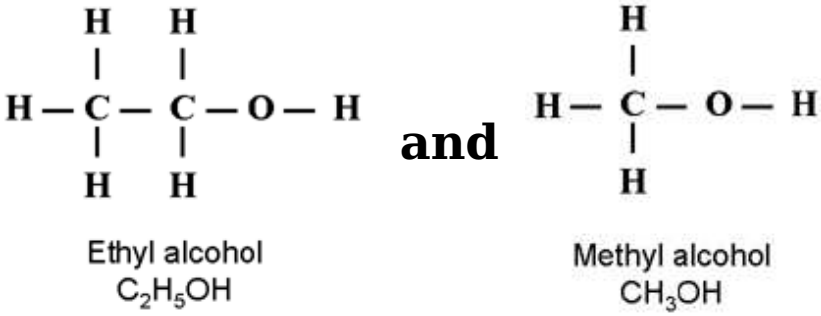
The higher the propane content the longer it will burn at lower temperatures. You may still end up with most of the butane and/or isobutane remaining in the canister if using a stove below 31° F (0.5°C) or 11° F (-12°C) respectively.

Isopropane

The term isopropane suggests that this is structural isomer of propane, but since propane is a three carbon hydrocarbon, a structural isomer doesn't exist. Isopropane is instead a commercial term used to describe isobutane/propane mixes (and sometimes butane/propane mixes). Manufactures claim this combo is great for low temperature use and improves fuel performance by decreasing the tapering off affect of butane alone.

Fuels for Alcohol Stoves

Denatured Alcohol (ethanol with methanol (added as a denaturing agent), methyl ethyl ketone, acetone, water, and possibly other chemicals - aka methylated spirits, shellac thinner, marine stove fuel, liquid fondue fuel, chafing dish fuel)-

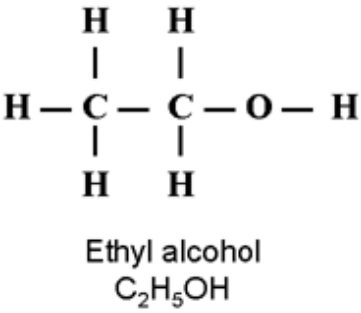


Found in marine shops and in the paint department of most hardware stores. Many brands of this solvent are specifically marketed for use as marine stove fuel and/or chafing fuel.

This form of fuel has anywhere from 1% to 80% methanol and other poisonous chemicals in it. Because of the great variability of contents in denatured alcohol, some brands burn better than others. One trick to test the suitability of a particular brand of denatured is to burn a small amount in a dish and reject it if there is any residue left after it has burned.

Lab grade ethanol may have benzene or other chemicals mixed in with it.

Grain Alcohol (aka pure ethanol, pure grain alcohol, PGA, grain neutral spirits, GNS, rectified spirit, rectified alcohol, medical grade ethanol, ethyl anhydrous, moonshine) -

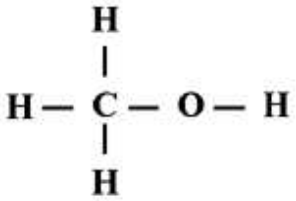


Everclear Grain Alcohol and Golden Grain alcohol from the David Sherman Corporation come in 95% (190 proof) bottles. This fuel works well but is an expensive option and may be illegal or difficult to purchase in many places. It is also non-toxic and can double for medicinal uses.

Grain alcohol can also be made at home in large quantities, though perhaps not legally in your area without special permits or permission (See TTB Forms).

Pure ethanol (aka absolute alcohol or dehydrated alcohol) can also be purchased from chemical supply distributors and as medical grade ethyl alcohol for a very high price. Since production of alcohol greater than 95.4% requires a special dehydration process that includes benzene or glycerine, these fuels can be very toxic.

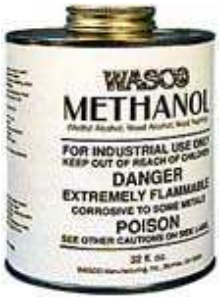
Methyl Alcohol (aka methanol, wood alcohol, methyl hydrate, liquid fondue fuel, camp stove fuel, gas line antifreeze) -



Methyl alcohol
CH_3OH

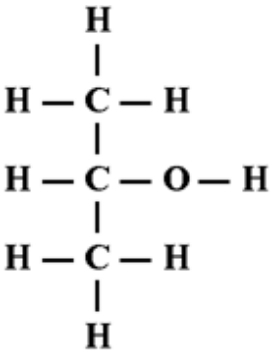
Found in some hardware store paint departments as paint thinner or at gas stations and general stores as gas-line antifreeze such as HEET brand (Yellow is Methanol, Red is Isopropyl).

You may also be able to purchase this for around US$3 per gallon at race shops that sell it as race fuel.



The vaporization pressures of methanol are much higher than ethanol throughout the applicable temperature ranges and the jets in your stove might light up faster when using this fuel. This is also a very poisonous fuel and you should consider the health concerns of this fuel if you decide to use it long term (thru-hikers beware and others may want to avoid storing contaminated stoves in their cook pots or bowls).

Isopropyl Alcohol (Isopropanol, 2-Propanol, rubbing alcohol) **Not recommended** -



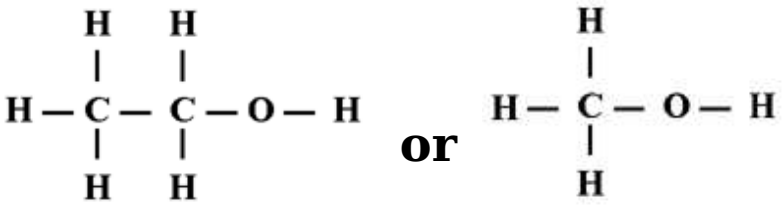
Isopropyl alcohol
C_3H_7OH

Found in drug, food and general stores (HEET in red container). Rubbing alcohol is generally only 70% alcohol and won't work in many stoves. Alcohol with 91% or greater alcohol content will work, but will leave a sooty residue on your pot and brown water in your stove.

The heat potential for this fuel is high, but it doesn't generally burn completely (yellow flame and unburned soot) and is generally mixed with water that isn't burned and hinders fuel efficiency.

If you want to use rubbing alcohol (cheapest easily available fuel on this list) for fuel, you may want to use an open flame stove instead of a jetted stove. If you decided to use a jetted stove, you may need to use larger jets in your stove (#57 drill, pushpin size, ~1.4mm or larger) and try to empty as much left over liquid from your stove as you can after each use (as this will further hinder future fire ups) for it to operate.

Gelled Alcohol (Sterno, Canned Heat, jelled alcohol) -



Ethyl alcohol
C_2H_5OH

or

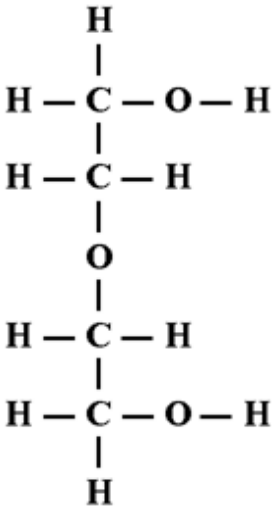
Methyl alcohol
CH_3OH

This is either methanol or ethanol trapped in a network of solid calcium acetate forming a gel. This gel is a little safer to use than liquid alcohol since there is less of a spill hazard. Unfortunately, most gelled alcohol stoves have small top openings and often don't get food hot enough to cook or bring water to a boil.

This fuel usually comes in a resealable can and may be the best choice for young and clumsy campers, since kicking it over is less likely to cause a significant fire hazard as would other liquid and gas stoves. Due to costs and limitations, it is not highly recommended for most long distance backpackers.

See Gelled Alcohol Stoves for more information.

Diethylene Glycol (DEG, 3-oxa-1,5-pentanediol, diglycol, ethylene diglycol, or dihydroxy diethyl ether) **Not recommended** -



Diethylene Glycol
$(HOCH_2CH_2)_2O$

Diethylene glycol is used in many brands of chafing fuels and must

use a wick to burn. It is considered nonflammable by the US Department of Transportation, can be air transported and is therefore much more economical to transport and store. These transportation and storage classifications make it ideal for the retail market and it's safe to assume that any chafing fuel can with a wick uses diethylene glycol until proven otherwise.

This fuel is difficult to light and is extremely poisonous. It is in fact the deadly chemical implicated in the 1937 Elixir Sulfanilamide Incident that killed 107 and was the main motimation for hastening of the enactment of the 1938 Federal Food, Drug, and Cosmetic Act.

This fuel can be used but is not recommended for backpacking stove use due to its toxicity and nonflammable nature.

Wood Properties

Beyond wood, many other biofuels may be burned. You can use agricultural waste, paper products, dried humanimal waste, coal, charcoal, manufactured fire logs, last year's fruitcake, etc.

Firewood Quality
Hard Woods

Species	Heat	Weight*	Ease Of Splitting	Ease Of Starting	Coaling Qualities	Sparks
Alder	Medium-Low	2506	Easy	Fair	Good	Moderate
Apple	High-Medium	4132	Difficult	Difficult	Excellent	Few
Ash , Black	Medium	4132	Easy-Moderate	Fair-Difficult	Good-Excellent	Few
Ash, Green	High	3590	Easy-Moderate	Fair-Difficult	Good-Excellent	Few
Ash, White	High	3,689	Easy-Moderate	Fair-Difficult	Good-Excellent	Few
Species	Heat	Weight*	Ease Of Splitting	Ease Of Starting	Coaling Qualities	Sparks
Aspen, Bigtooth	Low	2439	Easy	Easy	Good	Few
Aspen, Quaking	Low	2373	Easy	Easy	Good	Few
Basswood	Low	2174	Easy	Easy	Poor	Few
Beech	High	3757	Difficult	Difficult	Excellent	Few
Beech, American	High	3793	Difficult	Difficult	Excellent	Few
Species	Heat	Weight*	Ease Of Splitting	Ease Of Starting	Coaling Qualities	Sparks
Beech, Blue	High	3890	Difficult	Difficult	Excellent	Few
Birch, White	Medium	3179	Easy	Easy	Good	Moderate
Birch, Sweet	Medium	4065	Easy	Easy	Good	Moderate
Birch, Gray	Medium	3179	Easy	Easy	Good	Moderate
Birch, Paper	Medium	3260	Easy	Easy	Good	Moderate

Species	Heat	Weight*	Ease Of Splitting	Ease Of Starting	Coaling Qualities	Sparks
Birch, Yellow	High-Medium	3723	Moderate	Easy	Good	Moderate
Birch, Black	High-Medium	3890	Moderate	Easy	Good	Moderate
Buckeye, Horsechestnut	Low	2235	Moderate		Poor	Few
Boxelder	Low	2797	Easy		Poor	Many
Butternut (white walnut)	Low	2440	Easy			
Species	Heat	Weight*	Ease Of Splitting	Ease Of Starting	Coaling Qualities	Sparks
Catalpa	Low	2360	Difficult		Good	Few
Cherry, Black	Medium	2880	Easy	Difficult	Excellent	Few
Cherry	Medium	3184	Easy	Difficult	Excellent	Few
Chestnut	Low	2708	Easy			Many
Coffeetree, Kentucky	High	3112	Moderate		Good	Few
Species	Heat	Weight*	Ease Of Splitting	Ease Of Starting	Coaling Qualities	Sparks
Cottonwood	Low	2102	Easy	Easy	Good	Moderate
Dogwood	High	4331	Difficult	Good	Fair	Few
Elm, American	Medium	3116	Very Difficult	Fair	Good	Very Few
Elm, Rock	Medium	3860	Very Difficult	Fair	Good	Very Few
Elm, Siberian	Medium	3020	Very Difficult	Fair	Good	Very Few
Species	Heat	Weight*	Ease Of Splitting	Ease Of Starting	Coaling Qualities	Sparks
Elm, Slippery	Medium	3251	Very Difficult	Fair	Good	Very Few
Eucalyptus	Very High	4560				
-Swamp yate			Difficult	Poor	Excellent	Few
-Sugar gum			Difficult	Poor	Excellent	Few
-Tasmanian blue gum			Fair	Fair	Good	Few
Species	Heat	Weight*	Ease Of Splitting	Ease Of Starting	Coaling Qualities	Sparks
-River red gum			Difficult	Poor	Excellent	Moderate
-SA blue gum			Difficult	Poor	Excellent	Few
Hackberry	High	3319	Easy		Good	Few
Hazel	High		Moderate	Moderate		
Hawthorn	High		Moderate	Moderate		
Species	Heat	Weight*	Ease Of Splitting	Ease Of Starting	Coaling Qualities	Sparks
Hickory, True	Very High	4,327	Moderate	Fair-Difficult	Excellent	Moderate
Hickory, Mockernut	Very High	4332	Moderate	Fair-Difficult	Excellent	Moderate
Hickory, Pignut	Very High	4332	Moderate	Fair-Difficult	Excellent	Moderate
Hickory, Shagbark	Very High	4333	Moderate	Fair-Difficult	Excellent	Moderate
Hickory, Shellbark	Very High	4195	Moderate	Fair-Difficult	Excellent	Moderate
Species	Heat	Weight*	Ease Of Splitting	Ease Of Starting	Coaling Qualities	Sparks
Holly, American		3387	Difficult			
Honeylocust	High	3832	Easy		Excellent	Few
Hophornbeam, Eastern		4266				
Ironwood (Hornbeam)	Very High	4267	Very Difficult	Very Difficult	Excellent	Few
Laurel, California		3456				
Species	Heat	Weight*	Ease Of Splitting	Ease Of Starting	Coaling Qualities	Sparks
Locust, Black	Very High	4470	Very Difficult	Difficult	Excellent	Very Few
Madrone	High	3925	Difficult	Difficult	Excellent	Very Few
Maple, Bigleaf	High-Medium	2980	Moderate	Fair-Difficult	Excellent	Few

Maple, Silver	High-Medium	2981	Moderate	Fair-Difficult	Excellent	Few
Maple, Black	High-Medium	3523	Moderate	Fair-Difficult	Excellent	Few
Species	Heat	Weight*	Ease Of Splitting	Ease Of Starting	Coaling Qualities	Sparks
Maple, Soft	High-Medium	2924	Moderate	Fair-Difficult	Excellent	Few
Maple, Red	High-Medium	3318	Moderate	Fair-Difficult	Excellent	Few
Maple, Sugar	High	3793	Moderate	Difficult	Excellent	Few
Mesquite	Very High		Very Difficult	Very Difficult	Excellent	Few
Mulberry	Medium	3712	Easy		Excellent	
Species	Heat	Weight*	Ease Of Splitting	Ease Of Starting	Coaling Qualities	Sparks
Oak, Bur	High	3928	Easy	Difficult	Excellent	Few
Oak, Red	High	3680	Moderate	Difficult	Excellent	Few
Oak, White	Very High	4200	Moderate	Difficult	Excellent	Few
Osage Orange	High	4728	Moderate		Excellent	Many
Pecan	High		Moderate		Good	Few
Species	Heat	Weight*	Ease Of Splitting	Ease Of Starting	Coaling Qualities	Sparks
Persimmon		4332	Moderate			
Pine, Lodgepole	Low	2610	Easy	Easy	Fair	Moderate
Poplar, Yellow (Tuliptree)	Low	2708	Easy	Easy	Fair	Moderate
Sweet Gum	Medium	3115	Difficult	Fair	Fair	Few
Sycamore	Medium	3115	Difficult	Very Difficult	Good	Few
Species	Heat	Weight*	Ease Of Splitting	Ease Of Starting	Coaling Qualities	Sparks
Walnut	High-Medium	3454	Moderate	Fair	Good	Few
Willow	Low	2438	Easy	Fair	Poor	Moderate

Soft Woods

Species	Heat	Weight*	Ease Of Splitting	Ease Of Starting	Coaling Qualities	Sparks
Cedar, White	Medium-Low	2100	Easy	Easy	Poor	Moderate
Cedar, Eastern	Medium-Low	2981	Easy	Easy	Poor	Many
Cedar, W. Red	Medium-Low	2100	Easy	Easy	Poor	Many
Cypress	Medium	2844	Easy	Moderate		Few
Fir, Douglas	Medium	3049	Easy	Easy	Fair	Moderate
Species	Heat	Weight*	Ease Of Splitting	Ease Of Starting	Coaling Qualities	Sparks
Fir, Balsam	Low	2236	Easy	Easy	Fair	Moderate
Fir, Grand	Low	2371	Easy	Easy	Fair	Moderate
Fir, White	Low	2104	Easy	Easy	Fair	Moderate
Hemlock, Eastern	Medium-Low	2573	Easy	Easy	Poor	Many
Hemlock, Western	Medium-Low	2847	Easy	Easy	Poor	Many
Species	Heat	Weight*	Ease Of Splitting	Ease Of Starting	Coaling Qualities	Sparks
Juniper	Medium	3150	Medium		Poor	Many
Larch, Western (Tamarack)	High-Medium	3318	Easy-Moderate	Easy-Fair	Fair	Many
Pine, Lodgepole	Low	2576	Easy	Easy	Fair	Moderate
Pine, Ponderosa	Medium-Low	2573	Easy	Easy	Fair	Moderate
Pine, E&W White	Medium-Low	2303	Easy	Easy	Fair	Moderate
Species	Heat	Weight*	Ease Of Splitting	Ease Of Starting	Coaling Qualities	Sparks
Pine, Sugar	Low	2302	Easy	Easy	Fair	Moderate
Pine, Yellow	High-Medium	2610	Easy	Easy	Fair	Moderate
Pinon	High	3000	Easy			Many

Redwood, Old Growth	Medium	2573	Easy	Easy-Fair	Poor	Many
Redwood, Second Growth	Medium	2302	Easy	Easy-Fair	Poor	Many
Species	Heat	Weight*	Ease Of Splitting	Ease Of Starting	Coaling Qualities	Sparks
Spruce, Black	Low	2575	Easy	Easy	Poor	Few
Spruce, Engeiman	Low	2234	Easy	Easy	Poor	Few
Spruce, Norway	Low	2240	Moderate	Easy	Poor	Many
Spruce, Sitka	Low	2506	Easy		Poor	
Yew	High		Difficult	Difficult		

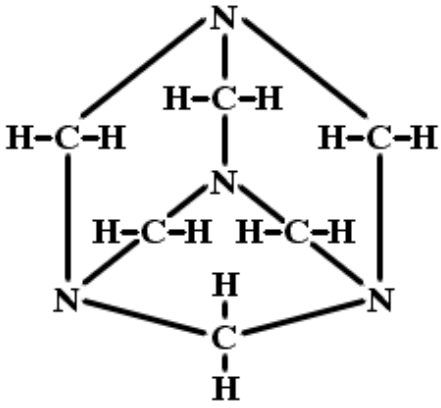
*Weight - pound /cord - seasoned wood.
Cord - stack 4' x 4' x 8' feet high (~85 ft^3, air space removed)
Face cords - 4' x 8' x <4' (~16")

Solid Fuels

Esbit is a great simple fuel that has many benefits for ultralightweight hikers. It's simple to use, doesn't require a heavy stove and is very light. Unfortunately, there are some drawbacks. They coat the bottom of your pot and stove with brown goo, and although said to be nontoxic, the idea of getting it in your pack and pot is less than ideal. The burnt residue does come off easily with a little scrubbing and you can put your pot and stove in separate Ziploc bags to protect the contents of your pack. Esbit and other solid fuels also produce a noticeable odor, despite their manufacturers' claims of being odorless.

Esbit and other solid fuels

Hexamethylenetetramine: aka - Hexamine, Hexy, Hexi, Hexie, Methenamine (Esbit), Hexamethylenetetramine, 3,5,7- Tetraazaadamantane, Ammonioformaldehyde,
Aceto HMT, Aminoform, Ammoform, Cystamin, Cystogen, Esametilentetramina (Italian), Formamine, Formin, Hexaform, Hexamethylenamine, Urotropin, Hexamethyleneamine, Hexamethylenetetraamine, Hexamethylentetramin (German), Hexamethylentetramine, Hexilmethylenamine, HMT, Methamin, Resotropin, Uritone, Urotropine, Esametilentetramina (Italian), 1,3,5,7-Tetraazatricyclo[3.3.1.1(3,7)]decane and $C_6H_{12}N_4$.



Hexamethylenetetramine
$C_6H_{12}N_4$

NOTE: Hexamethylenetetramine releases formaldehyde, ammonia, carbon oxides, hydrogen cyanide and nitrogen oxides when burned. It is also used as a urinary tract infection antiseptic and in explosives.

Hexamine can be purchased from many different manufactures in various shapes and sizes. This fuel is generally advertised as a "safe, clean burning fuel, easy to ignite, smokeless, odorless and non-toxic." All produce an odor, and are not always easy to ignite. You may need to pour a little alcohol on your fuel tab to get it started.

Not all fuel tabs are created equal. Although the many different brands of Hexamine share the same main ingredient, they vary in quality and may use different binding agents. Non-Esbit Hexamine can be found in many stores such as Trailquest, LWgear and military surplus stores (in a white, olive or brown cardboard tube).

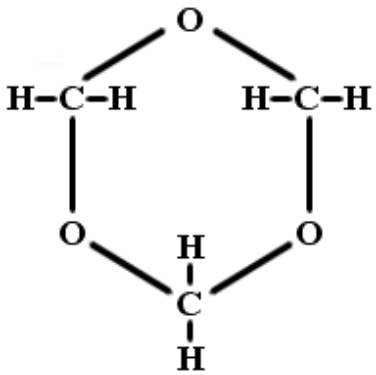
Author's take on the different Hexamethylenetetramine Solid Fuel products:

Esbit	HQ Company Hexamine	StanSport Stove Fuel Item #236	Coghlan's #9565 Fuel Tablets
One tab weighs ~14gm (~0.5oz)	Four tabs weighs ~15gm	One tab weighs ~18gm (~0.6oz)	Two tabs weigh ~13gm (0.47oz)
One tab will get 16oz of water to a good boil with the 2oz Esbit system.	Four tabs will get 16oz of water to a slight boil.		
Esbit burns just about completely, except for the sticky residue left	Tabs leave behind a black skeleton of incompletely burned		

behind on the stand and pot.	material, and you may have to poke it with a stick to expose unburned fuel in order to get it to burn all usable fuel.		
Cost about US$6 for a box of 12 individually wrapped tabs. US$35.71 per kg Produces smoke. Produces odor.	Cost about US$1.30 for a blister pack of 8 (US$7.80 for 48 ~ 12 Esbit tabs). US$43.33 per kg Produces smoke. Produces odor.	Cost about US$3 for a package of 8 tabs (~ 10 Esbit tabs). US$20.83 per kg	Cost about US$4 for a box of 24 individually wrapped tabs (~ 12 Esbit tabs). US$25.64 per kg

Note: According to the Trailquest site, one 1/4oz Coghlan's fuel tab (comparable to half an Esbit in weight) can boil 16oz of water. If this is correct, under ideal conditions the amount of Coghlan's fuel tabs needed would weigh half as much and cost a third of that of Esbit. Sounds too good to be true but worth investigating.

Trioxane: aka - triox, GI fuel tabs, metaformaldehyde, trioxane,1,3,5-trioxacyclohexane, 1,3,5-trioxane, aldeform, formagene, marvosan, s-trioxane, s-trixane, sym-trioxane, triformol, trioxymethylene and $C_3H_6O_3$.



Trioxane
$C_3H_6O_3$

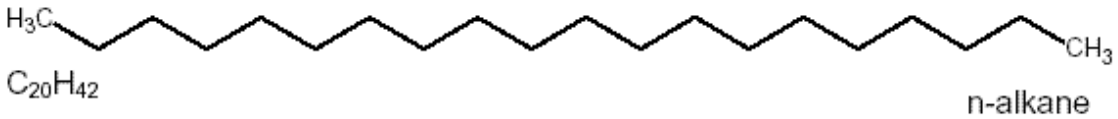
NOTE: These fuel tabs contain metaformaldehyde which is toxic and releases formaldehyde gas (also toxic) when it decomposes. This fuel is toxic despite the many websites that claim theirs are "nontoxic". You shouldn't eat without first washing your hands after handling this fuel and the fumes aren't much fun either.

The US military uses trioxane fuel bars which are cheap (you can buy cases of 750 from many surplus dealers) and are said to have "an almost infinite shelf life." Because of this, they are great for survivalists who want to store large amounts of supplies that are easily procurable and economical (GI surplus is a also a plus with many of these folks). Trioxane has about half the potential heat value per ounce than hexamine but burns a light blue which is more tactically sound than the bright yellow of hexamine.

Candle Fuel Types

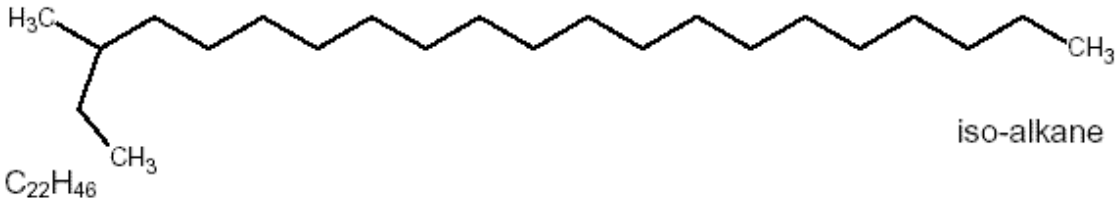
Paraffin Wax

The most common and cheapest wax used in candles today. It is made from petroleum waste and produces smoke and soot. There is big talk these days about cancer caused by inhalation of paraffin candle smoke. Candles made form this wax are ideal for those who shop at the dollar store (or pound store) and don't worry themselves about cancer reports.



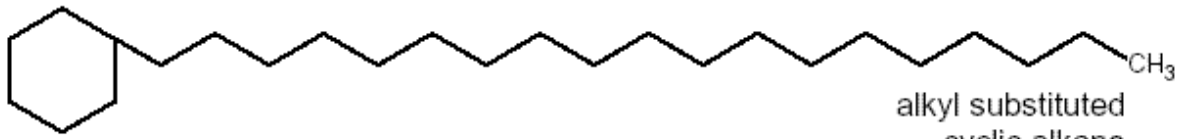
$C_{20}H_{42}$

n-alkane



$C_{22}H_{46}$

iso-alkane

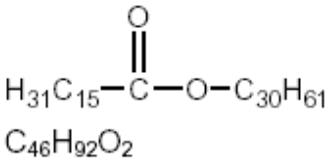


$C_{24}H_{48}$

alkyl substituted
cyclic alkane
(naphthene)

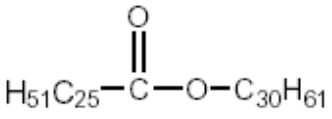
Beeswax

Made by bees and is the cleanest burning wax around. It burns much longer and produces more heat per gram than paraffin wax. Because of the lack of smoke and soot, these waxes are considered safe. It is also more expensive than paraffin per gram but their longer burn times may offset the price difference. Some hunters use honey burners or beeswax candles to attract hungry bears, which could be a plus if you are hunting but not such a desirable feature after a long day of hiking. This is probably the best choice of wax for hikers unless the chance of attracting bears and other critters is undesirable.



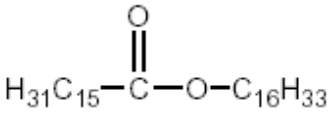
$C_{46}H_{92}O_2$

palmitic acid ester of myricyl alcohol



$C_{56}H_{112}O_2$

hexaeicosan acid ester of myricyl alcohol

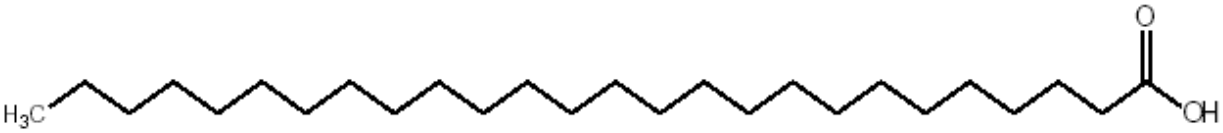


$C_{32}H_{64}O_2$

palmitic acid ester of cetyl alcohol

$C_{30}H_{60}O_2$

melissic acid



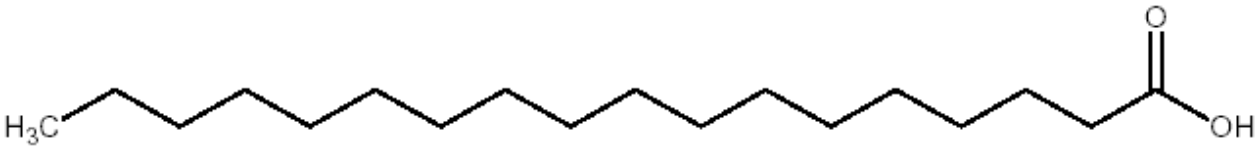
$C_{26}H_{52}O_2$

cerotinic acid

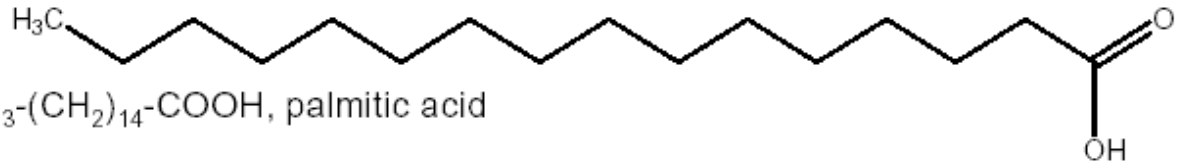
Beeswax composition:
70 % esters of long chain wax alcohols (C_{24}-C_{44}) with carbon acids (C_{16}/C_{18})
13-18 % hydrocarbons (C_{25}-C_{35})
10-15 % free wax acids (C_{24}-C_{32})
1 % free wax alcohols (C_{34}-C_{36})

Stearin

Stearin candles are made up of stearic acid that is often mixed with palmaitic acid. This wax is produced by the saponification (mixing with a strong alkali) of vegetable and/or animal fats. Stearic acid is also used to add firmness to paraffin wax and increases candle burn time.



CH_3-$(CH_2)_{16}$-COOH, stearic acid



CH_3-$(CH_2)_{14}$-COOH, palmitic acid

Gel Wax

This wax is made of white mineral oil, gelliants, and butylated hydroxy toluene. Because of their softness, these waxes must be used in containers with ridged wicks. Ideal for those who like colors, smells and don't have allergies.

Vegetable Waxes

Ideal for vegan extremists.

Soywax

Soywax is made from hydrogenated soybean oil. Not the best candle material around as it may only melt the core of the candle and can be brittle. It does burn cleaner than paraffin (but produces more soot than beeswax), is considered safe to use and doesn't shrink when it cools.

Carnuba wax

A wax exuded by the leaves of the Brazilian Carnauba Palm nuts.

Ceresine

This is made from palm oil and coconut wastes modified with other vegetable waxes. It is a higher quality wax than paraffin.

Bayberry

Made from bayberries. A sweet-smelling wax that burns clean.

Tallow and other Animal Fat Waxes

Tallow is made from suet. Very smoky, sooty and produces an acrid odor when burned. Some of these candles were and can be made to be edible and were used on Captain Scott's final expedition to the South Pole in 1910-11. Ideal for those wanting to go medieval.

Stearic acid

This is produced by the saponification (mixing with a strong alkali) of vegetable or animal fats (also found in chocolate) and is used to add firmness to paraffin wax and increases their burn time.

Spermaceti
Made form the crystallizing oil found in the heads of sperm whales. A one pound candle made form this wax is the standard source of light for one "candle power." Spermaceti wax doesn't produce an acrid odor when burned, is harder than tallow or beeswax, doesn't soften or bend in the summer heat, and produces a pure bright light.

Seal Oil and other animal oils
Oil from blubber can be used with a wick and has been used for centuries in Alaska and Siberia.

Liquid Candle Fuels

Lamp and Candle Fuel

Many brands are straight kerosene, while others are refined into heavier and cleaner hydrocarbons in liquid form (at room temperature).

Vegetable Oils

Oils such as olive oil can be used for lamps, but tend to burn very sooty.

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