

Make Your Own Bio Diesel

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Making a difference

Changing your perspective when it comes to using the conventional fuels might prove to be one of the greatest improvements in your life. You have to become aware that the conventional fuels will come to an end one day and you have to be prepared for this.



Therefore, congratulating you on the important decision that you have made, we provide the best solutions and plans for the change that is about to happen. The following lines will inspire you to take the proper steps that will make the difference for your driving experience.

It's time to improve your family life by implementing the necessary and renewable systems of energy. You will also be helping your planet and community when choosing to use the renewable energies. You must not be a rocket science in order to build and use these systems.

The green energy is to be preferred and this is the right moment for you in order to take proper care of your planet. You can use biodiesel in order to heat your beloved home and run your vehicles without having to spend a fortune in order to achieve satisfactory results. This is among the most popular alternatives to the conventional fuels and it's high time you implement it into your own lifestyle.

What are your Options?

There are at least three ways to run a diesel engine on biofuel using vegetable oils, animal fats or both. All three are used with both fresh and used oils.

- Use the oil just as it is - usually called SVO fuel (straight vegetable oil);
- Mix it with kerosene (paraffin) or petroleum diesel fuel, or with biodiesel, or blend it with a solvent, or with gasoline;
- Convert it to biodiesel.

1. Mixing it

Vegetable oil is much more viscous (thicker) than either petro-diesel or biodiesel. The purpose of mixing it or blending it with other fuels is to lower the viscosity to make it thinner so that it flows more freely through the fuel system into the combustion chamber.

If you're mixing veg-oil with petroleum diesel or kerosene (same as #1 diesel) you're still using fossil fuel - cleaner than most, but still not clean enough. Still, for every gallon of vegetable oil you use, that's one gallon of fossil-fuel saved, and that much less climate-changing carbon in the atmosphere.

People use various mixes, ranging from 10% vegetable oil and 90% petro-diesel to 90% vegetable oil and 10% petro-diesel. Some people just use it that way, start up and go, without pre-heating it (which makes veg-oil much thinner), or even use pure vegetable oil without pre-heating it, which would make it much thinner.

You might get away with it with an older Mercedes 5-cylinder IDI diesel, which is a very tough and tolerant motor -- it won't like it but you probably won't kill it. Otherwise, it's not wise.

To do it properly you'll need what amounts to an SVO system with fuel pre-heating anyway, preferably using pure petro-diesel or biodiesel for starts and stops, in which case there's no need for the mixes.

Blends with various solvents and/or with unleaded gasoline are "experimental at best", little or nothing is known about their effects on the combustion characteristics of the fuel or their long-term effects on the engine.

Higher viscosity is not the only problem with using vegetable oil as fuel. Veg-oil has different chemical properties and combustion characteristics from the petroleum diesel fuel for which diesel engines and their fuel systems are designed. Diesel engines are high-tech machines with very precise fuel requirements, especially the more modern, cleaner-burning diesels. They're tough but they'll only take so much abuse.

There's no guarantee of it, but using a blend of up to 20% veg-oil of good quality is said to be safe enough for older diesels, especially in summer. Otherwise using veg-oil fuel needs either a professional SVO solution or biodiesel.

Mixes and blends are generally a poor compromise. But mixes do have an advantage in cold weather. As with biodiesel, some kerosene or winterized petro-diesel fuel mixed with straight vegetable oil lowers the temperature at which it starts to gel.

2. Straight vegetable oil

Straight vegetable oil fuel (SVO) systems can be a clean, effective and economical option. Unlike biodiesel, with SVO you have to modify the engine. The best way is to fit a professional singletank SVO system with replacement injectors and glowplugs optimised for veg-oil, as well as fuel heating.

There are also two-tank SVO systems which pre-heat the oil to make it thinner. You have to start the engine on ordinary petroleum diesel or biodiesel in one tank and then switch to SVO in the other tank when the veg-oil is hot enough, and switch back to petro- or biodiesel before you stop the engine, or you'll coke up the injectors.

3. Biodiesel or SVO?

Biodiesel has some clear advantages over SVO: it works in any diesel, without any conversion or modifications to the engine or the fuel system -- just put it in and go. It also has better cold-weather properties than SVO (but not as good as petro-diesel). Unlike SVO, it's backed by many long-term tests in many countries, including millions of miles on the road.

Biodiesel is a clean, safe, ready-to-use, alternative fuel, whereas it's fair to say that many SVO systems are still experimental and need further development.

On the other hand, biodiesel can be more expensive, depending how much you make, what you make it from and whether you're comparing it with new oil or used oil (and depending on where you live). And unlike SVO, it has to be processed first.

But the large and rapidly growing worldwide band of home brewers don't mind -- they make a supply every week or once a month and soon get used to it. Many have been doing it for years.

Anyway you have to process SVO too, especially WVO (waste vegetable oil, used, cooked), which many people with SVO systems use because it's cheap or free for the taking. With WVO food particles and impurities and water must be removed, and it probably should be deacidified too.

The best way to go - Biodiesel

Converting the oil to biodiesel is probably the best all-round solution of the three options.

You could simply buy your biodiesel. But there's a lot to be said for the GREAT feeling of independence you'll get from making your own fuel!

There are safety issues that we will mention here, but don't worry! Large numbers of ordinary people all over the world are making their own biodiesel, it's been going on for years, and so far there have been NO serious accidents. It's safe if you're careful and sensible.

Start with the **process**, **NOT** with the processor. The processor comes later.

Start with **fresh unused oil**, **NOT** with waste vegetable oil (WVO) that also comes later.

Start by making a test batch of biodiesel in a blender using 1 litre of fresh new oil.

Learn one step at a time. It's all quite simple really, very few biodiesel home brewers are chemists or technicians, there's nothing a layman can't understand, and do, and do it well. But there is a lot to learn.

You'll find everything you need to know right here. We've tried to make it easy for you. You start off with the simplest process that has the best chance of success and move on step by step in a logical progression, adding more advanced features as you go.

The process

Vegetable oils and animal fats are triglycerides, containing glycerine. The biodiesel process turns the oils and fats into esters, separating out the glycerine. The glycerine sinks to the bottom and the biodiesel floats on top and can be syphoned off.

The process is called transesterification, which substitutes alcohol for the glycerine in a chemical reaction, using lye as a catalyst.

Chemicals needed

The alcohol used can be either methanol, which makes methyl esters, or ethanol (ethyl esters). Most methanol comes from fossil fuels (though it can also be made from biomass, such as wood), while most ethanol is plant-based (though it is also made from petroleum) and you can distill it yourself. There is as yet no "backyard" method of producing methanol. But the biodiesel process using ethanol is more difficult than with methanol.

Ethanol (or ethyl alcohol, grain alcohol -- EtOH, C₂H₅OH) also goes by various other well-known names, such as whisky, vodka, gin, and so on, but methanol is a poison. Actually they're both poisons. But don't be put off - methanol is not dangerous if you're careful, it's easy to do this safely. Safety is built-in to everything you'll read here.

Methanol is also called methyl alcohol, wood alcohol, wood naphtha, wood spirits, methyl hydrate (or "stove fuel"), carbinol, colonial spirits, Columbian spirits, Manhattan spirits, methylol, methyl hydroxide, hydroxymethane, monohydroxymethane, pyroxylic spirit, or MeOH (CH₃OH or CH₄O) -- all the same thing.

You can usually get **methanol** from bulk liquid fuels distributors; in the US try getting it at race tracks. With a bit of patience, most people in most countries manage to track down a source of methanol for about US\$2-3 per US gallon.

Methanol is also sold in supermarkets and chain stores as "stove fuel" for barbecues and fondues, but check the contents -- not all "stove fuel" is methanol, it could also be "white gas", basically gasoline. It must be pure methanol or it won't work for making biodiesel.

Methylated spirits (denatured ethanol) doesn't work; isopropanol also doesn't work.

The **lye** catalyst can be either potassium hydroxide (KOH) or sodium hydroxide (caustic soda, NaOH). NaOH is often easier to get and it's cheaper to use. KOH is easier to use, and it does a better job. Experienced biodieselers making top-quality fuel usually use KOH,

and so do the commercial producers. (KOH can also provide potash fertiliser as a by-product of the biodiesel process.)

With KOH, the process is the same, but you need to use 1.4 times as much (1.4025).

You can get both KOH and NaOH from soapmakers' suppliers and from chemicals suppliers. NaOH is used as drain-cleaner and you can get it from hardware stores. It has to be pure NaOH. Shake the container to check it hasn't absorbed moisture and coagulated into a useless mass, and make sure to keep it airtight.

CAUTION:

Lye (both NaOH and KOH) is dangerous -- don't get it on your skin or in your eyes, don't breathe any fumes, keep the whole process away from food, and right away from children. Lye reacts with aluminium, tin and zinc. Use HDPE (High-Density Polyethylene), glass, enamel or stainless steel containers for methoxide.

Chemicals for WVO

Isopropanol for titration is available from chemicals suppliers. Some people have used the other kind of Dri-Gas, which is isopropanol, but they found that it's unreliable. Best get 99% pure isopropanol from a chemicals supplier. 70% pure isopropanol is also said to work, but we found it didn't give satisfactory results. Contrary to rumour, "phenol red", sold by pool supply stores and used for checking water, won't work for titrating WVO, its pH range isn't broad enough. Use **phenolphthalein** indicator, specifically 1% phenolphthalein solution (1.0w/v%) with 95% ethanol.

Phenolphthalein lasts about a year. It's sensitive to light, so store it in a cool, dark place. You can get it from chemicals suppliers.

Make your first test batch

Here's what you need:

- 1 litre of new vegetable oil, whatever the supermarket sells as cooking oil
- 200 ml of methanol, 99+% pure
- lye catalyst -- either potassium hydroxide (KOH) or sodium hydroxide (NaOH)
- blender or mini-processor
- scales accurate to 0.1 grams, preferably less -- 0.01 grams is best
- measuring beakers for methanol and oil
- half-litre translucent white HDPE (**#2 plastic**) container with bung and screw-on cap
- 2 funnels to fit the HDPE container
- 2-litre **PET** bottle (water or soft-drinks bottle) for settling
- two 2-litre PET bottles for washing
- duct tape
- thermometer

How to do it?

You need to be quick when measuring out the lye because it very rapidly absorbs water from the atmosphere and water interferes with the biodiesel reaction.

Measure the lye out into a handy-sized lightweight plastic bag on the scales (or even do the whole thing entirely inside a big clear plastic

bag), then close the lid of the container firmly and close the plastic bag, winding it up so there's not much air in it with the lye and no more air can get in. Have exactly the same kind of bag on the other side of the scale to balance the weight, or adjust the scale for the weight of the bag.

How much to use. NaOH must be at least 96% pure, use exactly 3.5 grams. If you're using KOH it depends on the strength. If it's 99% pure (rare) use exactly 4.9 grams (4.90875). If it's 92% pure (more common) use 5.3 grams (5.33). If it's 85% pure (also common) use 5.8 grams (5.775). Any strength of KOH from 85% or stronger will work.

Use the "Methoxide the easy way" method -- it's also the safe way. Here's how to do it.

Measure out 200 ml of methanol and pour it into the half-litre HDPE container via the funnel.

Methanol also absorbs water from the atmosphere so do it quickly and replace the lid of the methanol container tightly. Don't be too frightened of methanol, if you're working at ordinary room temperature and you keep it at arm's length you won't be exposed to dangerous fumes.

Carefully add the lye to the HDPE container via the second funnel. Replace the bung and the screw on the cap tightly.

Shake the container a few times -- swirl it round rather than shaking it up and down. The mixture gets hot from the reaction. If you swirl it thoroughly for a minute or so five or six times over a period of time the lye will completely dissolve in the methanol, forming

sodium methoxide or potassium methoxide. As soon as the liquid is clear with no undissolved particles you can begin the process.

The more you swirl the container the faster the lye will dissolve. With NaOH it can take from overnight to a few hours to as little as half-an-hour with lots of swirling (but don't be impatient, wait for ALL the lye to dissolve). Mixing KOH is much faster, it dissolves in the methanol more easily than NaOH and can be ready for use in 10 minutes.

Using a blender. Use a spare blender you don't need or get a cheap secondhand one -- cheap because it might not last very long, but it will get you going until you build something better.

Check that the blender seals are in good order. Make sure all parts of the blender are clean and dry and that the blender components are tightly fitted.

Pre-heat the oil to 55 deg C (130 deg F) and pour it into the blender. With the blender still switched off, carefully pour the prepared methoxide from the HDPE container into the oil.

Secure the blender lid tightly and switch on. Lower speeds should be enough. Blend for at least 20 minutes.

Using a mini-processor. Follow the instructions [here](#) and improvise where necessary -- there are many ways of building a processor like this. Proceed with processing as above, maintain temperature at 55 deg C (130 deg F), process for one hour.

As soon as the process is completed, pour the mixture from the blender or the mini-processor into the 2-litre PET bottle for settling

and screw on the lid tightly. (As the mixture cools it will contract and you might have to let some more air into the bottle later.)

Allow to settle for 12-24 hours. Darker-coloured glycerine by-product will collect in a distinct layer at the bottom of the bottle, with a clear line of separation from the pale liquid above, which is the biodiesel. The biodiesel varies somewhat in colour according to the oil used (and so does the by-product layer at the bottom) but usually it's pale and yellowish (used-oil biodiesel can be darker and more amber).

The biodiesel might be clear or it might still be cloudy, which is not a problem. It will clear eventually but there's no need to wait. Carefully decant the top layer of biodiesel into a clean jar or PET bottle, taking care not to get any of the glycerine layer mixed up with the biodiesel. If you do, re-settle and try again.

For washing use the two 2-litre PET bottles in succession, with half a litre of tap water added for each of the three or four washes required. Pierce a small 2mm hole in the bottom corner of each of the two bottles and cover the hole securely with duct tape. Pour the biodiesel into one of the wash bottles. Add the half-litre of fresh water.

a. Bubble-washing. Use a small aquarium air-pump and an air-bubbler stone - cut the threaded lid off the wash bottles if necessary to get the stone in. After washing and settling,



drain off the water from the bottom of the bottle by removing the duct tape from the hole. Block it again with your finger when it reaches the biodiesel. Transfer the biodiesel to the second wash bottle, add fresh water and wash again. Clean the first bottle and replace the duct tape. Repeat until finished.

b. Stirring. If you have a small enough paint stirrer and a variable-speed drill, cut the lids off the bottles as above to accommodate the stirrer. Stir until oil and water are well mixed and appear homogenous. Settle for two hours or more, drain as above for bubble-washing, repeat until finished.

If you don't have a stirrer, don't cut the lids off the wash bottles. Add the biodiesel and the water as above. Screw the cap on tightly. Turn the bottle on its side and roll it about with your hands until oil and water are well mixed and homogenous. Settle, drain as above for bubble-washing, repeat until finished.

When it's clear (not colourless but translucent) it's dry and ready to use. It might clear quickly, or it might take a few days or up to a week. If you're in a hurry, heat it gently to 48 deg C (120 deg F) and allow to cool.

Congratulations! You have just made high-quality diesel fuel.

Moving the process further

When you're confident that you can get good results every time, even using oil from different sources, then it's time to scale up the process to provide your fuel needs. Now that you have a feel for the

process and know what to expect, you'll have a much better idea of what sort of processor you want than if you'd started off building the processor (as many do) rather than learning the process first.

However, one-litre test batches are not just something for beginners. It's a basic technique you'll always use. Many experienced biodiesel makers do test batches with each batch of oil. Many not only titrate the oil every time to calculate the right amount of lye to use, they also do "bracket" tests in sequence, followed by wash tests. You learn a lot that way, your fuel gets better, life gets easier.

In fact life is already easier -- people who start off making 40-gallon batches often never learn the accuracy and discipline that comes from making one-litre test batches first. Their fuel quality suffers for it, and when they encounter that inevitable "problem batch", they suffer for it too.

But if you've followed the instructions here carefully, you'll be familiar with all the variables, you'll have good methodology, and you'll be in a much better position to trouble-shoot a problem batch successfully.

Keep a Biodiesel Journal -- make notes, keep records. Get some small glass jars and keep samples of all your batches, clearly labelled and cross-referenced to the notes in your journal. You won't regret it. When scaling up from small test-batches to a full-sized processor, be aware that the process will probably need some adjusting. All the various processing methods use averages and approximations because processors vary so widely.

Removing the water

Water in the oil will interfere with the lye, especially if you use too much lye, and you'll end up with jelly. Test first for water content -- heat half a litre or so of the oil in a saucepan on the stove and monitor the temperature with a thermometer. If there's water in it it will start to "snap, crackle and pop" by 50 deg C (120 deg F) or so. If it's still not crackling by 60 deg C (140 deg F) there's no need to dewater it.

Water in vegetable oil can exist as free water, which will eventually settle to the bottom of a vessel; as suspended droplets, which may settle if the oil is heated, or the droplets are coalesced; and as water in solution with other impurities in the oil. Free water is the easiest to remove. The droplets are removed most efficiently by coalescing and draining. Suspended droplets that cannot be coalesced and water in solution are more problematic.

Boiling off the water is more difficult than it appears on the surface. Colligative properties of solutions (and some mixtures) can make removal of the last traces of water almost impossible.

Water mixed with oil will not boil at the same temperature and pressure as pure water. As water is removed, more heat or lower pressure will be required to remove more water. If the oil contains salts or semi-soluble fatty acids, distillation is even more difficult.

As the percentage of water in the solution decreases (its molar fraction) its vapor pressure will continue to drop. Lowering pressure in the system alone may be insufficient to sustain vaporization when the solution becomes concentrated (the molar

fraction of the solute greatly exceeds that of the solvent). Results will vary depending upon the nature of the water-soluble impurities in the oil. Few solutions are ideal, in terms of Raoult's law, and in used vegetable oil, there is no way to know what solutes are in the oil.

The important thing is how well-used, or overused, the oil is. Titration will tell you that. The higher the titration result, the more water it's likely to contain, and the more difficult it will probably be to remove the water.

Start with heating to 60 deg C and settling and if that doesn't give satisfactory results, try boiling it off, as Mike Pelly recommends. Then try processing small test batches of a litre or less first. If you still have difficulties, try to find better-quality oil.

Washing

Biodiesel must be washed before use to remove soaps, excess methanol, residual lye, free glycerine and other contaminants. Some people (fewer and fewer of them) say washing isn't necessary, arguing that the small amounts of contaminants cause no engine damage.

The methanol in unwashed biodiesel doesn't "make a great fuel anyway". It's also very corrosive. The EU biodiesel standard specifies less than 0.2% methanol content.

Quality biodiesel is well-washed biodiesel. Filtering it is no use, and letting it settle for a few weeks won't help much either. Anyway washing the fuel is easy.

Using biodiesel

You don't have to convert the engine to run it on biodiesel, but you might need to make some adjustments and you should check a few things.

Petroleum diesel leaves a lot of dirt in the tank and the fuel system. Biodiesel is a good solvent – it tends to free the dirt and clean it out. Be sure to check the fuel filters regularly at first. Start off with a new fuel filter.

If a car has been left standing for a long time with petroleum diesel fuel in the tank the inside of the tank may have rusted (water content is a common problem with petro-diesel fuel). Biodiesel will free up the rust, and it could clog the particle filter inside the tank. At worst the car simply stops, starved of fuel. It's not a very common problem, but it happens.

A common warning is that biodiesel, especially 100% biodiesel, will rot any natural or butyl rubber parts in the fuel system, whether fuel lines or injector pump seals, and that they must first be replaced with resistant parts made of Viton. But rubber parts in diesel engine fuel systems have been rare or nonexistent since the early 1980s -- it seldom happens, and when it does happen it's not catastrophic, you have plenty of warning and it's easily fixed.

Safety issues

Wear proper protective gloves, apron, and eye protection and do not inhale any vapours. Methanol can cause blindness and death, and you don't even have to drink it, it's absorbed through the skin.

Sodium hydroxide can cause severe burns and death. Together these two chemicals form sodium methoxide. This is an extremely caustic chemical.

These are dangerous chemicals -- treat them as such! Gloves should be chemical-proof with cuffs that can be pulled up over long sleeves -- no shorts or sandals. Always have running water handy when working with them. The workspace must be thoroughly ventilated. No children or pets allowed.

Organic vapor cartridge respirators are more or less useless against methanol vapors. Professional advice is not to use organic vapor cartridges for longer than a few hours maximum, or not to use them at all. Only a supplied-air system will do (SCBA -- Self-Contained Breathing Apparatus).

The best advice is not to expose yourself to the fumes in the first place. The main danger is when the methanol is hot -- when it's cold or at "room temperature" it fumes very little if at all and it's easily avoided, just keep it at arm's length whenever you open the container. Don't use "open" reactors -- biodiesel processors should be closed to the atmosphere, with no fumes escaping. All methanol containers should be kept tightly closed anyway to prevent water absorption from the air.

We transfer methanol from its container to the methoxide mixing container by pumping it, with no exposure. This is easily arranged, and an ordinary small aquarium air-pump will do.

When mixed, the methoxide is again pumped into the (closed) biodiesel processor with the aquarium air-pump -- there's no

exposure to fumes, and it's added slowly, which is optimal for the process and also for safety.

So get it in perspective: be careful with these chemicals -- be careful with ALL chemicals -- but there's no need to be frightened of them.

Ethyl esters -- making ethanol biodiesel

Reclaiming excess methanol

Depending on the kind of oil you're using, it takes from 110-160 millilitres of methanol per litre of oil to form the methyl esters molecule. But you also need to use an excess of methanol to push the conversion process towards completion -- the total used is usually 20% and more of the volume of oil used, 200 ml per litre or more.

Much of the excess methanol can be recovered after the process for reuse, simply by boiling it off in a closed container with an outlet leading to a simple condensor.

Methanol boils at 64.7 deg C, 148.5 deg F, though it starts vaporizing well before it reaches boiling point.

Unlike ethanol, methanol does not form an azeotrope with water and relatively pure methanol can be recovered -- pure enough to reuse in the next batch.

The methanol can be recovered at the end of the process, or just from the glycerine by-product layer, since at least 70% of the excess methanol collects in the by-product and it's that much less material to heat.

Recovering the methanol at the end of the process seems convenient because it's already hot, and you can get the methanol back from both the fuel and the glycerine by-product at the same time. But it can push the reaction into reverse, converting the biodiesel back into glycerides.

Removing methanol from the reactor product is a no-no because it reverses the reaction you have just carried out. Without the excess methanol, the ester and the glycerol react to provide an equilibrium mix which is less than desirable. That excess methanol serves a very real purpose in pushing the equilibrium yield up. But once the glycerol is completely separated, the reverse reaction cannot take place and we can get back the excess methanol.

Some people do it before separating it anyway (they often use a vacuum). We'd rather not risk ending up with anything less than good process completion. It's best to recover the methanol separately from the unwashed biodiesel and the glycerine by-product. For the by-product, heat to 65-70 deg C (149-158 deg F).

As the methanol evaporates, leaving an everlower proportion of methanol in the mixture, the boiling point will increase, so you'll have to keep raising the temperature to keep the methanol vaporizing. It goes up to 100 deg C (212 deg F) or more, and then it starts to froth and you have to stop or you'll get frothy brown by-product in your methanol condensate. But the bulk of the methanol should have been recovered by then.

If you have a market for potassium fertiliser and/or industrial-grade glycerine (about 80-90% pure) which makes it worth the cost of the

phosphoric acid you'll need, it's best to separate the by-product into its components first. Adding the phosphoric acid separates the soaps (FFAs) from the glycerin and frees the catalyst, but it won't separate without the methanol. After separation the methanol is left in the glycerine fraction and can be removed then.

It's probably more efficient to use flash evaporators to recover the methanol from either the biodiesel or the separated by-product.

Additional useful information

More about lye

The catalyst used in transesterification of vegetable or animal fats and oils is lye -- either sodium hydroxide (NaOH, caustic soda), or potassium hydroxide (KOH). NaOH might be easier to get and cheaper to use, KOH is easier to use and it mixes with methanol much more easily. KOH does an allround better job than NaOH.

Keep it dry

Lye is hygroscopic -- it absorbs water from the atmosphere. So make sure you get fresh lye, and keep the container tightly sealed.

When weighing it out, don't leave it exposed to the air for any longer than necessary. In humid weather we weigh it out into plastic bags, From a faulty batch of lye (rare) -- the semi-translucent half-pearls are fresh, but the chalky white lump on the right is carbonated.

After only a second or two exposed to the air the fresh half-pearls are already absorbing a sheen of moisture, one on either side of the scale to equalise the extra weight of the bag. As soon as it's weighed

out, close the container, close the bag, and add the lye to the methanol as quickly as possible.

If the weather's really damp, you can do the whole weighing process entirely inside a big clear plastic bag. If you feel it still might be too moist even inside the bag, put some lye in an open container inside the bag to absorb the moisture first.

We buy 85% KOH in 20 kg lots, 44 lb, and transfer it from it's tough airtight clear plastic bag this way:

Everything goes inside a large clear plastic bag -- the sealed bag of KOH, 10 empty 500 g HDPE plastic containers with wide mouths, bungs and tight-fitting lids, a little KOH in another 500 g HDPE container with the lid off to absorb moisture, some tough cord, and a pair of scissors. Then use two knots of cord to seal the large bag closed.

We cut two holes in the side of the large bag and taped a resistant plastic glove into each of them. With your hands in the gloves, it's easy to work efficiently and safely transferring the KOH inside the large bag, with no water present.

When it's done, press all the air out of the KOH bag and tie it closed with two knots of the cord. Make sure all the filled HDPE containers are properly closed. Take your hands out of the gloves, cut the knots closing the big bag, take out all the HDPE bottles, the scissors and the remaining cord. Press all the air out of the big bag, and tie it closed with two knots of cord.

Lye also absorbs carbon dioxide from the atmosphere and becomes carbonated if not stored properly.

Carbonated lye is chalky white, fresh lye is almost translucent. You can still use carbonated lye if it's not too severe, but you'll have to use a bit more. Add about 25%, or better, check it against a titration with fresh lye.

Using KOH

KOH is not as strong as NaOH -- use 1.4 times as much KOH (actually 1.4025 times). Titration is basically the same.

You can use either KOH solution or NaOH solution for titration.

Unlike NaOH, your KOH probably won't be pure, but as long as you use the same strength of KOH for both the titration solution and the reaction it won't make any difference.

Mix the KOH solution the same as for NaOH: add 1 g of KOH to 1 litre of water.

For each 1 millilitre of solution used in the titration add 1 g of KOH to the basic amount. You can also use the usual 0.1% w/v NaOH solution and convert the end result for KOH, see below.

Instead of the basic 3.5 grams of NaOH per litre of oil, use $3.5 \times 1.4 = 4.9$ grams of KOH (4.90875).

So, if your titration was 3 ml, use $3 + 4.9 = 7.9$ g KOH per litre of oil.

One more complication: KOH is generally not as pure as NaOH. KOH is usually 92%, 90% or 85% pure -- check the label. We use half-pearls assayed at 85%, with good and reliable results. KOH is available at 99% strength, but it's hard to find and it's expensive, and anyway 92% or 85% work just fine.

Adjust the basic lye quantity according to the strength of the KOH: the basic 4.9 grams of KOH at

100% strength would be:

85% KOH -- 5.8 (5.775) grams

90% KOH -- 5.5 (5.454) grams

92% KOH -- 5.3 (5.336) grams

To substitute KOH for the 3.1 grams of NaOH per litre of oil used in the acid-base process:

85% KOH -- 5.1 (5.115) grams

90% KOH -- 4.8 (4.831) grams

92% KOH -- 4.7 (4.726) grams

To convert NaOH quantities for KOH:

For 85% KOH use 165% of the NaOH amount (x 1.65).

For 90% KOH use 155.83% of the NaOH amount (x 1.56).

For 92% KOH use 152.45% of the NaOH amount (x 1.52).

Example: You're using 85% KOH and the titration needed 3 ml of KOH solution to bring the pH to 8.5.

Number of grams of KOH required for the reaction:

Basic amount: 5.8 g KOH (5.775)

Titration result: 3 ml

Add: 3 g KOH

Total: 8.8 g (8.775) of 85% KOH required per litre of WVO.

Using 0.1% NaOH solution for titration and the same WVO as above: the titration result is lower, it only needs 1.8 ml to reach pH8.5.

(Actually 1.82 ml, according to the calculation.)

Basic amount: 3.5 g NaOH

Titration result: 1.8 ml (1.82)

Add: 1.8 g NaOH (1.82)

Total: 5.3 g NaOH (5.32)

Convert for 85% KOH:

$5.3 (5.32) \times 1.65 = 8.8 \text{ g (8.778)}$ of 85% KOH per litre of WVO.

We usually use NaOH solution for titration and convert the result for our 85% KOH, but in practice NaOH solution and KOH solution both work equally well.

One reason for preferring NaOH solution is that it's usually the standard used in describing FFA content of different oils -- 2 ml titration WVO or 5 ml titration WVO invariably refers to ml of 0.1% NaOH solution, unless otherwise specified. In the example above, the WVO would be described as 1.8 ml titration WVO.

KOH dissolves in methanol much faster and more easily than NaOH does, and doesn't "clump" together as NaOH can do. When you use KOH the glycerine by-product is liquid and won't solidify.

KOH is easier to use than NaOH. It's more flexible and adaptable and it gives generally better results.

We seldom use NaOH (except for titration).

How much lye to use?

It requires 3.5 g of NaOH lye or the equivalent of KOH (see above) per litre of oil as catalyst to transesterify new, unused oil.

This makes standard-quality biodiesel within the usual processing parameters of methanol quantity, agitation, processing duration and processing temperature.

Fresh cooking oil contains a standardised amount of Free Fatty Acids (FFAs), which can slow or stop the transesterification process. The lye is alkaline and neutralises the FFA by turning it into soap, which drops out with the glycerine layer, and with 3.5 grams of

NaOH per litre of oil there's enough left over to catalyse the biodiesel reaction.

Used cooking oil (WVO) needs more NaOH than new oil, not to serve as the catalyst but to neutralize the extra FFAs formed in cooking the oil. The hotter and longer it's cooked, the more FFA it contains, and the more lye is needed to neutralise it.

You have to titrate the oil to determine the FFA content and, from that, how much extra lye will be required. Titration measures the pH of the oil, that is, the acid-alkaline level (pH7 is neutral, lower values are increasingly acidic, higher than 7 is increasingly alkaline, or "base"). From this you can calculate how much extra lye will be needed to neutralize the extra FFA.

Too much lye will make extra soap, with very alkaline biodiesel that's difficult to wash, with loss of production, or it can ruin the reaction when the ratio of soap to biodiesel reaches a point where the whole batch turns into "glop soap".

Too little lye will mean some of the oil is left unreacted.

Good-quality oil that hasn't been cooked too much or overheated is quite forgiving, but with poorquality WVO with a high Free Fatty Acid (FFA) content, accurate titration is more important. The higher the FFA level, the more sensitive the reaction, the more precise you have to be with titration and everything else, the more reactive agents you'll need -- and the lower will be the production rate.

Basic titration

For processing used oil, it's essential to titrate the oil to determine the Free Fatty Acid (FFA) content and calculate how much extra lye will be required to neutralise it.

An electronic pH meter is best, but you can also use phenolphthalein solution (from a chemicals supplier).

Dissolve 1 gram of pure sodium hydroxide lye (NaOH) in 1 litre of distilled or de-ionized water (0.1% w/v lye solution) (weight to volume).

In a smaller beaker, dissolve 1 ml of dewatered WVO oil in 10 ml of pure isopropyl alcohol. Warm the beaker gently by standing it in some hot water, stir until all the oil dissolves in the alcohol and the mixture turns clear. If you're using phenolphthalein, add 2 drops of phenolphthalein solution.

Using a graduated syringe, add the 0.1% lye solution drop by drop to the oil-alcohol-phenolphthalein solution, stirring all the time. It might turn a bit cloudy, keep stirring. Keep on carefully adding the lye solution until the solution stays pink (actually magenta) for 15 seconds.

Take the number of millilitres of 0.1% lye solution you used and add 3.5 (the basic amount of lye needed for fresh oil). This is the number of grams of lye you'll need per litre of oil.

With a pH meter or test strips, use the same procedure without adding the phenolphthalein. Add the

0.1% lye solution drop by drop as before until the pH reaches 8.5.

Potassium hydroxide (KOH) can also be used for titration, see **Using KOH**, above.

Better titration

Unless you have a very accurate scale, it's not easy to measure exactly 1 gram of lye. It's much easier to measure 5 g accurately than 1 g, so mix 5 g of lye with 500 millilitres of distilled or de-ionized water to make a stock solution.

Before titration measure out 5 ml of the stock solution, add 45 ml of distilled or de-ionized water. This makes a 0.1% w/v lye solution. It's also not easy to measure exactly 1 millilitre of oil. Instead of the usual 1 ml of oil and 10 ml of isopropyl alcohol, mix 4 ml of oil in 40 ml of isopropyl alcohol in a glass beaker.

Warm the mixture gently by standing the beaker in hot water, stir until all the oil disperses and it becomes a clear mixture.

Then titrate as usual, measuring millilitres of stock solution used. When it reaches pH8.5 count up the number of millilitres used as usual and divide by 4. This will give a much more precise measurement.

To save on isopropyl alcohol, use 2 ml of oil in 20 ml of isopropyl and divide the results by two – still twice as accurate.

Accurate measurements are highly important

When "newbies" have problems making their first test batches and it doesn't pass the quality tests it's most often because of inaccurate measurements, or they didn't follow the instructions closely enough. Here's some general advice on being more accurate.

Consider Weights

Truly accurate scales are expensive, unless you can pick up a second-hand set in good condition. Even then, it pays to check your scales for accuracy.

A good way of doing this is with new coins. Find out from your bank, or the Central Bank, what the weight is (in grams) of the coins in your country. If you get a full set of new coins you can use them in combination to check the accuracy of a wide range of weights.

With a balance-type scale (two sides with a fulcrum between them), get two full sets of coins, and figure out different combinations to put on each side; you should also be able to use this to achieve smaller gradations than your scale allows: aim to measure a tenth of a gram, 0.1 grams, preferably less -- 0.01 grams is best.

At 0.1-gram accuracy, with a one-litre test batch, measuring the 3.5 grams of NaOH required might give you 3.4 grams or 3.6 grams instead, or anything in between the two. With fresh oil this margin of error or even more won't matter, if you get everything else right you'll have good results.

That margin of error won't matter with test batches of used cooking oil (WVO) either, IF you heed the advice to avoid oils with titration levels higher than about 3 ml of 0.1% NaOH solution for your first test batches.

WVO with higher titration levels and higher levels of Free Fatty Acids will not be so forgiving, there's much less margin for error -- leave them for later when you're more experienced.

Small test-batches of high-FFA oils with titration levels higher than 6 or 7 ml will be easier with scales accurate to 0.01 grams and might need bracket tests as well.

Volumes

If you have a standard millilitre measure that you know is accurate, use it to check all your various measuring flasks, syringes, pipettes, etc. Otherwise, check them against each other. With syringes or pipettes, or whatever you use to add the 1 ml of oil and the 0.1% lye solution to the titration mixture, you should be able to measure 0.1 ml accurately or better.

Smaller syringes are more accurate for titration, 5 ml syringes are a bit big, 2.5 ml will do. We use 1 ml clear plastic syringes, long and narrow, marked in tenths and tenths-of-tenths of 1 ml -- 0.01 ml. The measurement scale is 2-1/4" long (5.5 cm) so it's easy to read. They're cheap, you can get them from hobby shops (you don't need the needles).

Work with good lighting and on a white surface. First draw the syringe plunger back about 1/8" (2 mm) to take in some air. Then insert the end into the oil or NaOH solution and fill the syringe. Hold it up level with your eye, preferably with a well-lit white wall in the background, keep it vertical, and carefully empty a few drops, drop by drop, until the *bottom* of the surface meniscus is level with the 1 ml mark. When emptying the syringe into the titration vessel, don't

empty it completely -- the one millilitre volume ends at the end of the scale, which leaves a little extra in the spout. Empty the syringe only to the end of the scale, with the bottom of the surface meniscus level with the 0 mark.

Use measuring flasks the same way. When filling them hold them vertical, with a well-lit white wall in the background, and with the gradation mark for the quantity you want level with your eye.

Measure from the bottom of the surface meniscus.

Always keep your glassware and other measuring equipment meticulously clean. Barely visible smears of dried caustic residue or other chemicals can upset your results.

pH meters

It's said you can't reliably use an electronic pH meter for titration, nor to check the pH of biodiesel, because biodiesel is not an aqueous solution. Not quite true -- biodiesel is hygroscopic and will always have about 1,200-1,500 ppm water content absorbed from the atmosphere, if from nowhere else. With titration, you're adding water with the 0.1% NaOH solution. And laboratory-standard titration equipment uses electronic pH meters.

We have three pH meters, one of them rather expensive, and we did some comparisons, with constant heat, constant agitation of the titration sample (note the test tube at the right end of the box) phenolphthalein, fresh from a laboratory supplies company in Tokyo, and with various test strips. We used WVO from several sources, and fresh oil as a check. The results were checked with test batches.

In each case, the three pH meters agreed with each other and produced good test-batch results.

Phenolphthalein results were consistently slightly higher, but the test-batch results were still good. The test-strips came a poor third - not as precise as pH meters and phenolphthalein. People do use them with apparent success, but we don't think test strips are precise enough for titration.

Phenolphthalein

Phenolphthalein is often confused with "phenol red" (phenolsulphonophthalein), obtained at pool supply stores and used for checking water. It's not the same thing, and phenol red won't work for titrating WVO, its pH range isn't broad enough. It ranges from about pH 6.6, at which point it's yellow, through orange, to a maximum of pH 8.0, red. It's at its most accurate at pH 7.4. For accurate titration you need to be able to measure pH 8.5.

Phenolphthalein is colourless up to pH 8.3, then it turns pink (magenta), and red at its maximum of pH 10.4. When it just starts turning pink and stays that way for more than 15 seconds, it's measuring pH 8.5.

With good-quality oil with low FFA levels you might just get away with using phenol red for titration, but for higher FFA levels it isn't accurate enough. Use phenolphthalein -- specifically, 1% phenolphthalein solution (1.0w/v%) with 95% ethanol.

Phenolphthalein lasts about a year. It's sensitive to light, store it in a cool, dark place.

High FFA levels

Most people find their used cooking oil generally gives a titration of 2-3 ml, but some used oils can have much higher FFA levels than this -- we've seen horrific titration levels of 9.6 ml. "Horrific" because FFAs are not good for you -- it's a very bad idea to eat food from a restaurant that does that to their cooking oil. Another biodieseler reported titration levels of 16 ml -- black stuff with the consistency of sump oil.

We did succeed in making biodiesel with our 9.6 ml oil. It's not easy to process oil like this with the usual single-stage base process. You're likely to end up with about 50% production half the time, and maybe not a very good product, and glop the rest of the time. If you're really precise with everything you can do it -- we managed to get a consistent 75% production with the single-stage base process, good product, easy wash.

The oil has to be thoroughly dried first -- traces of water make a bigger difference with high FFA levels, because there's more lye for the water to react with. And the reaction itself releases traces of water, especially with high levels of lye. You can also deacidify the oil.

Deacidifying WVO

In commercial oil refining this is done with lye (NaOH), which saponifies the Free Fatty Acids, converting them to soaps which can then be removed, but it usually requires a centrifuge to separate it. This is an easier way, no need for a centrifuge.

Use the titration amount of NaOH -- eg, 9.6 grams per litre of oil for our high-FFA 9.6 ml WVO (see above). Mix the NaOH with 40 ml of water per litre of oil. It gets hot. Use a stainless steel container, mix it outside (by stirring), and take care! This is very corrosive stuff, take full safety precautions, have running water handy.

When the NaOH is fully dissolved add the solution to the oil (room temperature), stir gently by hand until thoroughly mixed. Be gentle! Settle overnight. This leaves soapstock at the bottom. The water stays with the soapstock.

Filter to remove the soapstock -- no need for fine filtering, fine steel mesh will do (like a fine tea strainer). Again, do it gently.

Now process the filtered WVO as usual for fresh oil -- 3.5 grams NaOH per litre of oil, but use 25% methanol, process at 55 deg C (130 deg F), with good and prolonged agitation as usual.

In our tests the product was good, the production rate was 80%.

With high-FFA oil like this, it's a much easier process than the normal single-stage, and it's nice not to have to make such strong methoxide as a straight single-stage process would require with this oil, 13.1 grams of lye per litre oil, or more like 13.6 grams (it needs a bit of excess lye).

It's an alternative -- better than straight single-stage base for oil like this, and while it won't get as high a production rate as the acid-base method, and it uses more catalyst and gives you more coproducts, it's very quick and simple.

This is also useful if you're making ethyl esters biodiesel, using ethanol rather than methanol: the ethyl esters process doesn't work well with oils with more than about 2 ml titration.

As always with a new process, try it first with a small sample, say 1 litre of oil. Be gentle when mixing it -- if you agitate it too much it won't separate easily. If that happens, try heating it, and be more gentle next time.

You can add the soapstock to the glycerine layer after separation and neutralize as usual to separate catalyst, glyc and FFAs.

The soapstock can be used for producing soap, or turned into calcium soap, which is something like Dubbin and has an extremely low water solubility. Useful stuff. Thus an equimolar amount of calcium chloride may be directly added to the soapstock and prompt separation of the calcium soap by precipitation from a relatively pure saline (NaCl) solution will ensue. Calcium soaps are useful industrial ingredients, for instance as demoulding agents.

Mix some calcium chloride in a little water (careful, it gets hot, don't splash) and add it to the soapstock a little at a time, stirring it in, until it separates.

The basic lye quantity -- 3.5 grams?

This is the amount of lye (NaOH, sodium hydroxide) required as catalyst to transesterify 1 litre of fresh, uncooked oil. For used oils, titration determines the amount of lye needed to neutralize the Free Fatty Acid (FFA) content, and this quantity is added to the basic figure of 3.5 grams per litre.

In fact 3.5 grams is an empirical measure -- an average. Different oils have slightly different requirements, and even the same type of oil varies according to how and where it's grown. Other estimates are 3.1 g, 3.4 g, and some people have set it as high as 5 g.

Here is what we've found. For most fresh oils and low-FFA used oils (with titration levels less than 2-3 ml), 3.5 grams works just fine. For high-FFA used oils, use more lye -- up to about 4.5 g instead of 3.5 g. Do small test batches to see what works best.

Different oils also require different amounts of methanol. For oils and fats requiring more methanol -- coconut, palm kernel, as well as tallow, lard, butter -- again, use more lye, up to 4.5 g, even with new oils, and especially when it's used. Once again, do small **test batches** first.

Mixing the methoxide

You can use the easy method with 4-gallon HDPE carboys or similar containers with screw-on caps (preferably with bungs as well). First the methanol, then add the lye gradually. Swirl it about from side to side rather than shaking it up and down.

If you shake it a lot, and often, it can be ready a lot sooner than 24 hours -- in just a few hours or even as little as half an hour, some people say. But DON'T use it until ALL the lye is thoroughly dissolved. If you use a white translucent HDPE container you can see any undissolved lye at the bottom of the container.

KOH -- potassium hydroxide -- dissolves in methanol much faster than NaOH, sodium hydroxide. It can be ready in as little as 10 minutes.

We use HDPE carboys with two screw-on caps and an aquarium air-pump to transfer the mixed methoxide to the reactor vessel via plastic tubing (the braided translucent type), with no exposure at all. Clean, safe and simple. We transfer the methanol from its tank to the carboys the same way.

Stock methoxide solution

Stock methoxide solution is very useful for making test batches, with a series of tests made in a blender using different amounts of lye for each. Rather than measuring tiny amounts of lye for each half-litre (or whatever) test batch, make a stock solution using one litre of methanol and 50 grams of lye. Then you can dilute quantities of the stock solution to whatever strength each test batch requires. If you're making half-litre test batches and using 20% methanol, measure out the methoxide this way:

If titration was, say, 3 ml, you'll need 3 + 3.5 grams of NaOH lye (the basic amount) for the reaction -- that's 6.5 grams per litre of oil. For half a litre of oil, that would be 3.25 grams and 100 ml of methanol at 20%.

It's easy to calculate that 65 ml of the stock methoxide solution will contain 3.25 grams of lye. So measure out 65 ml of the stock, and top it up with 35 ml of pure methanol to make 100 ml (20%).

For a test of 6 grams per litre of oil, you'll need 60 ml of the stock, top it up with 40 ml of pure methanol to make 100 ml. For a 7 grams per litre test, measure out 70 ml of the stock, top up with 30 ml of pure methanol. And so on.

Didn't figure the calculation? For a half-litre test at the rate of 6.5 grams of lye per litre of oil, divide 6.5 by 2 = 3.25 grams. The stock solution is one litre of methanol plus 50 g of lye. To calculate the amount of stock solution needed, multiply 1000 (1000 ml per litre) by 3.25 divided by 50 = 65 ml. For 20% methanol, 20% of 500 ml (half a litre) = 100 ml. 100 ml minus 65 ml = 35, so add 35 ml of pure methanol to the 65 ml of stock to make up 100 ml containing 3.25 grams of lye, equivalent to 6.5 grams of lye per litre of oil with 20% methanol.

Once mixed, methoxide won't last forever, but it's good for a few weeks. Don't make large amounts -- one litre is good for a dozen or more tests. If in any doubt, make up a fresh batch. Include what's left of the old mixture in the methoxide for your next full-sized batch of biodiesel.

Viscosity testing

Viscosity levels are a comparative indicator of biodiesel quality. Unfortunately, and despite claims to the contrary, that's all they are, a comparative indicator: this batch is better than that batch. Even at the laboratory or industrial level, viscosity testing alone cannot tell you if the process has gone far enough before reaching equilibrium and that there are not unacceptably high levels of harmful unreacted and partly reacted materials in your fuel.

Unconverted monoglycerides (MGs) and diglycerides (DGs) are fuel contaminants that can cause injector coking and engine damage. MGs and DGs are very similar in viscosity to biodiesel and stay in

solution with it after an incomplete reaction, they can't be washed out. The allowed maximums are low: less than 1% for DGs and less than half that for MGs. Viscosity tests might get you within 5% accuracy, not nearly close enough for a useful quality check.

The same goes for density -- specific gravity measures (SG). Even both viscosity and density together can't assure you that the reaction has gone far enough towards completion. About the only sure way to know that is with a Gas Chromatograph or expensive laboratory tests which few biodieselers can afford. Short of a GC the best indicator of a completed reaction is the wash -- easy washing and a crystal-clear product.

Nonetheless, viscosity can be a useful indicator, especially with test batches. You can check viscosity with a 100 ml pipette and a stopwatch -- time exactly how long it takes 100 ml of your fuel to empty from the pipette. Or use a viscosity meter. Excess methanol in the fuel will render the results meaningless, so you must wash the biodiesel first. Measure some petro-diesel for a comparison. Remember that viscosity is sensitive to temperature -- try it at two or three different temperatures.

Kinematic viscosity is measured in "Stokes". You cannot measure it at home without a viscosimeter. There is a comparative way, though. Take a liquid with a known viscosity value (petroleum heating oil, look the value up in an engineering manual) and let a known volume flow through an upside-down plastic water bottle with a drinking straw glued in a hole in the screw top. Stop the time with a stopwatch.

Do the same with your biodiesel (same volume) and compare the results. Generally a smaller diameter straw will produce more accurate results. If the time of your sample is 1.5 the time of your control sample (petroleum oil), this means its viscosity is roughly 1.6-ish that of the control sample. You can use two straws, the second one to let air in for a smooth flow of oil. Measure specific gravity (SG) by weighing a specific volume of the fuel. Remember that volume is also sensitive to temperature. A litre should weigh about 880 g at 15.5 deg C.

How the process works

What is meant by "completion" and "equilibrium"?

First, vegetable or animal fats and oils are triglycerides (TGs), composed of three chains of fatty acids bound by a glycerine molecule (see diagram in next section below).

Triglycerides are esters. Esters are acids, such as fatty acids, combined with an alcohol, and glycerine (glycerol) is a heavy alcohol.

The transesterification process converts triglyceride esters into alkyl esters (biodiesel) by means of a catalyst (lye) and an alcohol reagent, usually methanol, which yields methyl esters biodiesel – the methanol replaces the glycerine.

In transesterification the triglyceride molecule is broken into three separate methyl ester molecules plus glycerine as a by-product. The lye catalyst breaks the bond holding the fatty acid chains to the glycerine, the glycerine falls away, the fatty acid chains then bond with the methanol.

It happens in three stages (this has nothing to do with the single-stage or two-stage processes). First, one fatty acid chain is broken off the triglyceride molecule and bonds with methanol to form a methyl ester molecule, leaving a diglyceride molecule (DG) -- two chains of fatty acids bound by glycerine.

Then a fatty acid chain is broken off the diglyceride molecule and bonded with methanol to form another methyl ester molecule, leaving a monoglyceride molecule (MG). Finally the monoglycerides are converted to methyl esters -- completion.

The problem is that the process can run out of reagent or catalyst before it gets that far, or agitation, temperature or processing time may be inadequate.

The result is some unconverted or partly converted material remaining in the biodiesel. Well, so what if the process isn't completed? SVO (straight vegetable oil) is a good fuel anyway, so what's it matter if some of it is unreacted? But it's not just unreacted material that's the problem so much as the partlyreacted stuff. Diglycerides and monoglycerides are bad things to put in your diesel. Diglycerides don't burn well and lead to coking problems, monoglycerides can lead to corrosion and other problems -- bad fuel.

So, either don't process it at all and use SVO (which can have its own problems), or process it PROPERLY.

In fact the process never reaches 100% completion, it always reaches equilibrium first, so there will always be some unreacted glycerides left. The various national biodiesel standards stipulate just how much is allowable, and it's not very much: diglycerides range from less than 0.4% to less than 0.1% by mass, monoglycerides less than 0.8% by mass.

The first part of the process happens rapidly, which is why some people think it only needs a few shakes and that's it. Not so. If it takes X minutes to convert half the TGs to DGs, it takes almost as long, another X minutes, to convert half the remaining TGs, then a further X minutes for the remaining half, and so on. So the process goes more and more slowly, and never quite arrives -- there's always half left.

Finally comes a point when the remaining half is insignificant, and, indeed, within the limitations set by the various quality standards. But it's very easy to fall short of that point and end up with nasties in your beautiful clean eco-friendly nice-smelling home-brewed fuel, and in your motor.

You CAN make high-quality biodiesel, all it takes is a little care. On analysis, biodiesel made by homebrewers with no qualifications and no special equipment using the methods detailed at this website has proved the equal of professionally made commercial fuel or better. Professional mechanics checking their motors have been amazed by the lack of wear and corrosion. You can do it too.

For beginners, start off with good practices: follow the instructions carefully, be meticulous with your titration, make sure your measurements are as accurate as you can make them. Learn as much as you can. You'll soon get a feel for it, and then, once you're familiar with the process in all its aspects, you'll be able to decide what's best for you in your situation, with your source of oil, on your budget, and just where you can relax a little and take calculated shortcuts, based on your own experience.

NOTE: It's a common misconception that biodiesel has lower viscosity than SVO or WVO because the transesterification process shortens the carbon chain length of the fatty acid molecules in the oil.

This is not so. The biodiesel molecule is indeed smaller and less complex. Transesterification converts the triple-chain triglyceride vegetable oil molecule to three single-chain methyl ester molecules, but the chain lengths of the fatty acids themselves remain the same. The fatty acid composition of biodiesel depends on the feedstock and is not changed by transesterification.

Conclusion

It may seem like a lot of difficult information to process, but just take it slow, read it a few times and you'll eventually make it. Just by taking the time to read this book, you have made a big step towards a cleaner, cheaper and more efficient way of providing fuel for your necessities.

We want to thank you for putting your trust in our efforts and we will make sure you get all the assistance and guiding to make your life a lot better with the help of our green projects.