

# Review: How To Make Biodiesel by Low Impact Living

Contributed by Dougal

If you want to find out what is involved in "homebrewing" biodiesel, or want to learn why that might be of interest to "Downsizers" - then buy this book. But if you already know all that, and are only looking for plans to construct your own processing kit, you will be frustrated that that is the only part of the book that skimps on detail.

Background: Published by Low Impact Living, written by Dan Carter, Jon Halle, Dave Darby and Phillip Hunt.

Biodiesel is liquid stored renewable (solar) energy, that can be used completely interchangeably with petroleum (fossil) diesel fuel - in modern vehicles.

In many European countries, "ordinary" diesel today is actually a blend containing 5% Biodiesel ("B5"). If you can run "Ultra Low Sulphur" Diesel (sometimes called "City" diesel), you can certainly run commercial Biodiesel blends, which are available now, at some UK filling stations.

Even at 5% in the fuel, Biodiesel markedly reduces harmful emissions, and improves lubrication of fuel pumps and injectors. Engines run cleaner, slightly more quietly and should last longer. And the use of the renewable biofuel is substituting for fossil carbon usage.

Biodiesel use offers a fossil carbon-reducing, cleaner air technology for the mass market.

Next year, with the opening of a British plant manufacturing 100,000 Tonnes a year of 100% Biodiesel, the B5 blend should be much more generally available. It remains to be seen if much will appear on the market as "B100", pure Biodiesel.

Because of UK Taxation, processing starting purely from fresh oil is uneconomic, so the raw material is usually Waste Vegetable Oil ("WVO"), which costs little or nothing, and processing it to fuel should prevent any problem of disposal arising now that BSE precautions outlaw its use in animal feeds.

As the book's title suggests, it is possible for enthusiasts to process WVO to make their own 100% Biodiesel, and thus an even greater ecological contribution than running a (commercial) blend, quite apart from the satisfaction of independence from filling stations! Because the vehicle requires no modification whatsoever, it can still run "ordinary diesel" if you should be far from home and need fuel. (Vehicles older than 1996 may have natural rubber joints or seals in the fuel system, which don't like either ULS or Bio diesel fuels.)

Almost the only question marks against "enthusiast homebrewing" concern the equipment required, the risks of the processing, and the rivalry with another biofuel, "straight" vegetable oil ("SVO") - which requires less hazardous processing of the WVO, but is less convenient in use and requires (manufacturer-unapproved) modifications to the vehicle engine.

In other countries, "SVO" would imply fresh new oil but UK Tax on anything used as a Road Fuel makes that uneconomic here, so here I will use "SVO" to refer to cleaned, fuel-quality WVO.

Contents of 'how to make biodiesel': Its slightly bigger than A5 size, and contains over 120 pages. The first 39 pages essentially describe Biodiesel and set out the case for its use, in considerable detail. The next 9 pages discuss engineering differences between different diesel engine designs, and similar factors, that may influence the use or choice of Biodiesel. That is followed by a 10 page "Biodiesel Chemistry Primer".

All this introductory material occupies almost half the book, but there is very little that could usefully be trimmed. Throughout various terms are introduced and explained, so that they can be used later.

The second half begins, perfectly reasonably, with a "Health and Safety" discussion, which leads into the practical sourcing of ingredients. Next comes a 9 page description of a laboratory (or kitchen) scale production of a sample of biodiesel, starting with 2 litres of 'as received' WVO. The practical "meat" of the book should be in the following 12 pages that discuss scaling up the process - to deal with a batch made from 100 litres of filtered and dewatered oil. This section also deals with product purification, storage, by-products, and waste disposal. And possible process variations and enhancements. And Methanol recovery. And the construction of appropriate "kit" for doing the heating, reagent preparation, mixing, separation and washing the stuff by the drumful. Those 12 pages (and the 9 "laboratory" pages) contain all the dirty, practical, production detail that the book offers the would-be homebrewer.

3 pages supply and interpret Euro, German and HM Customs' different definitions of "biodiesel". There are then 5 pages "examining" different intended scales of production, from moneysaving green self supply to small commercial production. Seriously, I do doubt that many readers would need to be told that a commercial plant could cost between £500,000 and

£2m, but that "it would be less if you designed and specified the plant yourself"!

More to the point, as soon as you start charging anyone anything for the product, it explains that you need an "Integrated Pollution Prevention and Control" license - which is going to be at least £2,500 to issue with £400 for annual renewal thereafter. And then there's Planning Permission, B1 Industrial, not Agricultural. But this is \*only\* if you are selling the product. These vital matters of tax and regulation are covered in 5 pages. As well as explaining Road Fuel Duty, there's a 'heads up' that, strictly speaking, you need a "waste transfer license" costing £160 for two years, to legally collect and take home the waste oil.

After a one page wrap-up, we have 7 pages of useful names, web addresses and phone numbers. There are appendices with product and example chemical hazard specifications - and a 2 page discussion of alternatives such as straight vegetable oil, and emulsions of SVO, for example with kerosene.

Discussion: The basic chemistry is to take an E-shaped molecule (with very long arms) "triglyceride", and by reacting that one very big molecule with three molecules of Methanol, (in the presence of an alkali ("Lye") catalyst), the three arms are chopped off and capped with the methyl groups, which become the methyl ester molecules of "biodiesel". An excess of Methanol is used to drive the reaction towards consuming all the triglyceride. (for chemists - its an equilibrium reaction).

The 'vertical' link piece becomes a molecule of glycerol.

During the oil's cooking life, some of the E-arms will have been broken off, becoming "free fatty acids". These FFAs would corrode the engine if they were not removed before the material goes into the vehicle's fuel tank.

In Biodiesel processing, the FFAs are going to react with some of the alkali, making soap, which has to be removed from the product by washing. Its necessary to measure the acidity and calculate the quantity of alkali required - the book describes this clearly. Notably the authors specify use of Potassium, rather than the more common, cheaper, but more "difficult" and dangerous Sodium, Hydroxide. It seems only about £1 worth is needed for a 100 litre batch.

Equally, for use in an SVO-modified diesel engine, these same acids ought to be removed. Otherwise, although the fuel would still "work", the engine life would be shortened.

WVO needs to be dewatered, whether before Biodiesel processing or as part of cleaning it to make usable SVO. The Biodiesel needs to be dewatered, or dried, again as a final stage to ensure meeting the tax requirements, and the incidental good of the engine.

One difference between SVO and Biodiesel processing is the latter's use of Methanol. Methanol is itself made industrially by reacting Methane with steam. That Methane could come from compost, but is more likely to be petroleum "Natural Gas". Methanol can also be made by fermentation, with complete "biofuel" street cred. But because only (about) 1/20th of the Biodiesel's carbon originates in the Methanol, even B100 made with petrochem Methanol is still 95% fossil-free.

Using Methanol requires excellent ventilation, and the use of sparkless electric motors - because it not only burns, but its vapour can also form explosive mixtures with air. And with Methanol's Boiling Point of 65C, there's going to be a lot of vapour when processing 20 litres of the stuff at around 50C.

On the other hand, filtering WVO of all solids bigger than a few microns (again for engine longevity) is complicated by its viscosity (or "gloopiness"). Biodiesel product is quite runny and more easily filtered.

As a bizarre side issue, SVO itself meets the specification as "Biodiesel" for UK tax, but inexpert processing of the same SVO, despite resulting in an acceptable fuel for unmodified engines, could result in a product that did not meet the official specification for the lower rate of tax on "Biodiesel". Could you make that up?

The processing itself consists of nothing more complex than various filtering, heating, mixing, standing and separating stages. What makes it tricky is that you are likely to be dealing with a large quantity of messy, slippery and potentially corrosive material.

And if you are processing to Biodiesel, there are certainly hazardous chemicals and vapours involved. The work environment demands a \*minimum\* of safety goggles and oil-resistant (nitrile) rubber gloves, with things like eyewash, shower/hose and fire extinguisher ready within reach.

Frustratingly, it is when discussing the detail design, assembly and operation of a "small-scale" (100 litre) processing plant, that the book lapses, whether by accident or design, into generality and avoiding specifics. Sadly, this is the area where many would-be beginning homebrewers are most likely to wish to benefit from the experience of others. It is important to recognise that the book does \*not\* contain any specific "blueprints", or even schematics, for building your own kit.

To quote one example: "The heart of the system is a multifunction pump. It is used to transfer heated oil to the reactor, to mix the reaction, and to evacuate the finished product. This inexpensive water pump has a bronze impeller and a totally enclosed fan-cooled motor, which contributes to safety (no spark risk)."

Unfortunately, that's absolutely \*all\* we are told about this fundamental element. Which "inexpensive water pump"? Who makes it? What model? Would any old central heating pump work? I don't know, and the authors omit to say. But it is "the heart of the system"... Aaargh!

Another example - how long to mix for? In the kitchen-chemistry tutorial, we learn to tell that the reaction has completed by the colour change. Since colour change cannot be seen inside sealed metal vessels and pipework, it needs to be mentioned that to use colour change, either a "sample point" or spyhole is going to be needed. And no estimate whatsoever is given for mixing/reaction time for a 100 litre batch using "this" pump, although we \*are\* told that using a "standard" domestic immersion heater will take over an hour to heat the batch to 50C (incidentally indicating about 3kWh (about 20p?) of electricity for the 100 litres).

I'd like to see the "100 litre" section being \*very\* much larger, with diagrams and complete constructional detail for a basic "reference design" - and then to discuss the ways and means by which it could be improved - even if the book's cover price had to be doubled.

Needless to say the book gives no estimate for the cost of a "100 litre" plant. Much might well be obtained from scrap sources - but an itemisation of how many vessels, valves and heaters are going to be needed, for a basic 'reference' plant, would have given some indication.

The authors do give estimates for the "consumables" costs. Per litre of Biodiesel produced, that's about 1p of Potassium Hydroxide, 6p of Methanol (with 2 or 3p recoverable, if you choose to do that bit), and I estimate perhaps as much as 1p of electricity.

Then there's going to be 27.1p tax to pay per litre that you produce, (but it would be 47.1p if it is out of specification!) So we are looking at between 32p and 55p a litre, plus the cost (if any) of the waste oil.

There will also be odds and ends like filter elements, gloves, and cleaning costs.

But if you are up for scavenging the components, have the space for both processing and secure storage of products and ingredients (and have the time), can handle the metalwork and plumbing (using copper with compression fittings), and are confident you can both be careful with the chemicals, and carefully keep paperwork to satisfy the authorities - then there is a real prospect of cheap, "green" motoring.

When making a "100 litre" batch of Biodiesel, the book tells us that between 8 and 15 litres of crude glycerine will be produced.

This will contain Glycerol, soap from the FFAs, the alkali catalyst and the majority of the excess Methanol (mentioned when discussing the Chemistry above).

Recovering the Methanol for reuse is discussed, and a very simple recipe for making liquid soap is given, as well as a more complex one for hard soap.

Personally, I think there could and should have been more than one paragraph about the alternative of Glycerol purification, and then reverting the (impurity) soap to FFA and recoverable Lye, followed by esterifying the FFAs to additional Biodiesel.

In conclusion: This is an excellent book and a bargain at its modest price of £8.95.

It describes, importantly in a UK context, what you need to know to start tinkering with homebrewing Biodiesel.

But although it gives guidance, it does leave the design, and many real-world details, of building (and operating) a practical 100 litre homebrew batch processor as an exercise for the reader.

Buy the book here