# Small Scale Demo of Biodiesel Production


***Figure 1** – Biodiesel fuel pump*

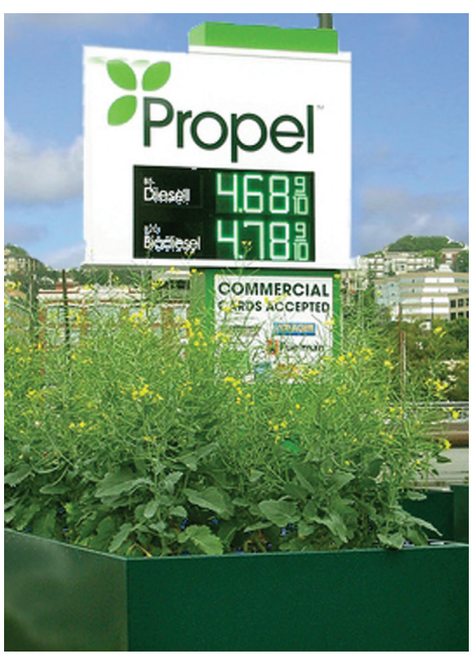


***Figure 2** – Biodiesel can be made from oilseed rape*

Biodiesel is often in the news, sometimes as a cheap green fuel and saviour of the environment, sometimes as the cause of rising world hunger and a reason for the loss of biodiversity. It is also worth mentioning that every so often someone blows themselves up trying to make it at home in a shed or the garage [1].

With Green Chemistry becoming a set of important principles for industry, making biodiesel allows students to engage with the draft learning outcomes in a Curriculum for Excellence.

We have developed a method which allows students to make biodiesel for themselves quickly and simply. By keeping the scale small and doing the reaction quickly, the exposure to risk is much reduced. The biodiesel can be collected by either leaving the mixture to settle overnight, or by separating them using a centrifuge. The overnight method produces a purer product, but the use of a centrifuge means the entire process can be carried out in about half an hour.

There is plenty of scope to scale the process up and there are many areas in the senior school to look further at the reaction. These include enthalpy of combustion, kinetics, thermo-dynamics, titrations and percentage yield.

## Chemicals

- vegetable oil - rapeseed is good as it is high in antioxidant vitamin E.
- potassium methoxide - made from potassium hydroxide and methanol.
- sodium chloride solution, 5%

## Equipment

*Overnight method:*

- eye protection (goggles)
- gloves
- test tubes, 4 per group
- test tube rack, 1 per group
- bungs for test tubes, 2 per group
- beakers, 100 $cm^3$, 3 per group
- syringe, 10 $cm^3$, 1 per group
- Pasteur pipettes - disposable, 3 $cm^3$, 4 per group
- timer/stopclock, 1 per group

*Centrifuge method:*

- centrifuge
- Equipment as above but replace the 4 test tubes per group with: test tube, polypropylene (or polycarbonate) 13 $cm^3$, 1 per group of a size to fit the centrifuge
- test tubes, 3 per group

## The Chemistry

Oils are examples of triglycerides which are esters of three fatty acids (long chain alkyl acids) (which may be the same or different) and glycerol which has three hydroxyl (-OH) groups.

Oils are converted into biodiesel by reacting each triglyceride molecule with three smaller alcohol molecules, usually methanol. Glycerol is also produced. This reaction (called a transesterification reaction) is reversible and can be catalysed by acid or more commonly alkali. An excess of the alcohol is used to drive the equilibrium reaction to the right (the excess can be recovered along with the potassium hydroxide catalyst in the glycerol layer). The overall reaction scheme is shown in Figure 3 below.

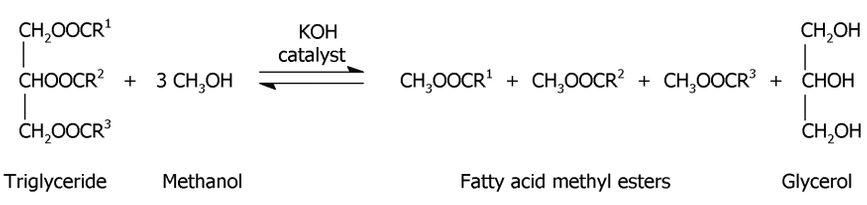


***Figure 3** – The transesterification reaction*

## Experimental method


***Figure 4** – Potassium methoxide is added to the vegetable oil using a pipette.*

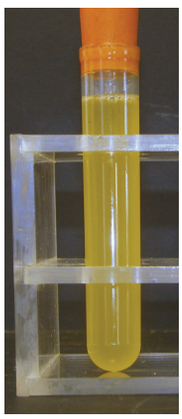

***Figure 5** – Vegetable oil and potassium methoxide after having been shaken vigorously and reacted together.*

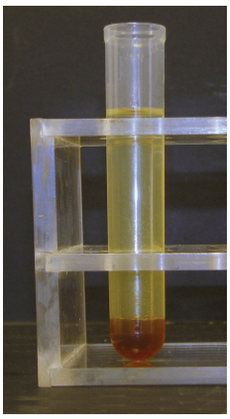

***Figure 6** – Products after separating in the test tube either overnight or by using a centrifuge. The brown layer at the bottom of the test tube is the glycerol layer.*

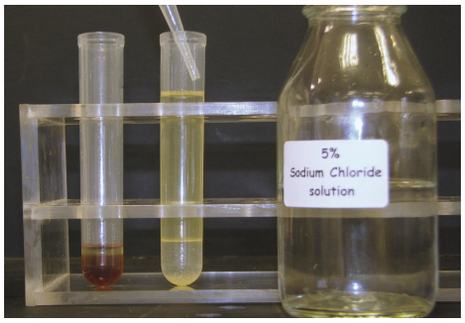


***Figure 7** – The biodiesel layer is separated off and washed to remove impurities.*

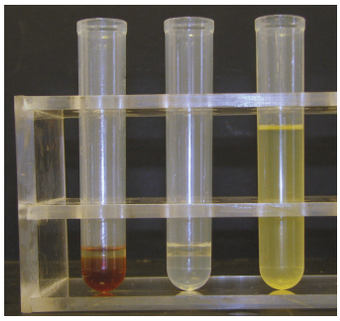

***Figure 8** – Finally the top layer of biodiesel is separated off.*

The products of this reaction are called fatty acid methyl esters (FAMEs). The biodiesel layer is usually washed to remove soaps which can be formed from free fatty acids (FFAs). This is most common for heavily used oils which may already have broken down considerably.

The potassium hydroxide acts as a catalyst in the reaction between the triglyceride and the methanol. In our method, we first produce an intermediate, potassium methoxide, which students then further react with the oil to form the products. The potassium methoxide should be prepared in advance.

A package of teaching and learning materials is now available as a SSERC workshop and will also feature in the 'Bridging the Gap' CPD programme for chemistry teachers. For workshop booking details contact sts@sserc.org.uk

For CPD 2009-10 session check the SSERC website as the courses quickly become oversubscribed.

## References

[1] http://www.theregister.co.uk/2008/07/28/takeaway_biodiesel_fireball_horror/

**Photos credit:** amended from http://www.flickr.com/photos/robseattle/

| Chemical | Main Hazard | Control Measures |
|---|---|---|
| **methanol** | **Toxic** by ingestion, inhalation and skin absorption. Experimental teratogen. Human mutagen. | Use in very well-ventilated area normally but in fume cupboard for large quantities or prolonged working with the compound. Use rubber or plastic gloves and eye protection. Beware repeated exposure. |
| | **Highly flammable** | Keep away from flames and all sources of ignition |
| **potassium hydroxide** | **Strongly corrosive solid** | Wear rubber gloves and eye protection. Use goggles to BS EN 166 1 3. (formerly BS 2092C) |
| **potassium methoxide** | **Toxic** and **Corrosive** | Wear rubber or plastic gloves and eye protection, Use goggles to BS EN 166 1 3. (formerly BS 2092C) |
| **biodiesel** | Possible eye **Irritant** | Use goggles to BS EN 166 1 3. (formerly BS 2092C) |

***Table 1** – Hazards and Control Measures*