

# Current Biofuels

## Activity 1B - Oil extraction

**Learning outcomes:** By the end of the session students should be able to:

- Describe the techniques used to extract oil from plant material.
- Carry out oil extraction from plant material.
- Discuss the ethical, economic and environmental issues associated with producing biofuels from plant material.

**Keywords** Bioenergy, biofuel, biodiesel, renewable, feedstock, yield, biomass, maize, oilseed rape, extraction, phase separation.



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Oil extraction with morta and pestle

## Background

Oil can be extracted by grinding vegetable matter in a mortar and pestle and separating out with water (phase separation). Suitable fruits, nuts or seeds include sweetcorn (where possible fresh) or sunflower seeds, though any plant matter can be used. Sweetcorn and sunflower seeds are recommended as they are easy to obtain, safe and are familiar to students. It should be explained to students that maize (*Zea mays*) is commonly known as corn, and includes popcorn and sweetcorn, as some may not be aware of this. Maize oil is produced in large quantities and is the primary feedstock for biodiesel in the USA. This activity provides opportunity for discussion about the issues raised regarding current biofuels conflicting with food security. The difference in difficulty of grinding the sunflower seeds and sweetcorn can be discussed in relation to energy usage and efficiency. Yield can be compared between sweetcorn and sunflower seeds and the issues involved in choosing suitable feedstocks discussed. Sunflower oil costs are not competitive enough in comparison to palm, coconut or soya oil for it to be a viable alternative. It is recommended that where possible feedstocks used to produce biofuels are used, though it should be noted some feedstocks such as rapeseed prove too difficult to grind.

This is a 'make and take' activity that can be used at public events and provides an ongoing experiment that young people can take away and then observe the separation of the oil over the coming days. Ensure that the oil is separated in a properly sealed Falcon tube (use tape or Parafilm to form a watertight seal).

This activity is based on one developed by the Gatsby Science Enhancement Programme (SEP): Biofuels. 2009. [www.sep.org.uk](http://www.sep.org.uk)

**Age Range:** This activity is suitable for primary and secondary students.

**Duration:** 10-20 minutes.

**Suggested prior knowledge:** This activity does not require any specific prior knowledge but it is recommended that you elicit the existing student knowledge of fuels, properties of liquids - especially oil - and crops.

# Current Biofuels

## What you will need

- Mortars and pestles
- Spoons or spatulas
- Water wash bottles or disposable plastic pipettes
- Boiling tubes or skirted Falcon tubes
- Boiling tube rack or polystyrene tube holder
- Funnel
- Fruits, nuts or seed (preferably sweetcorn or sunflower seeds)

## Optional

- Centrifuge or hand centrifuge
- Centrifuge tubes or microcentrifuge tubes
- Disposable pipettes
- Balance

## Health and Safety

CAUTION: Be aware that some students may have allergies to foodstuffs and ascertain these prior to the activity.

Ensure that the centrifuge tubes are balanced and that the tubes used for centrifugation are sealed.

Follow CLEAPSS® guidance leaflet PS 67-03 and section 13.7 of the laboratory handbook.

## Method

1. Add a small spoonful of vegetable matter to the mortar (if calculating yield accurately, weigh the vegetable matter).
2. Grind the vegetable matter, adding a small amount of water if required.
3. Once completely ground, add more water using a wash bottle (about 20 ml).
4. Transfer the water and ground vegetable matter to a test tube or Falcon tube using a spatula or spoon (a funnel may be helpful if the vegetable matter is finely ground).
5. Wash the mortar and pestle to remove any remaining oils and add the extra water to the tube. Ensure it is about 2/3rds full.
6. Replace the lid, seal, label and leave on a flat surface for 30 minutes to 2 days to observe the oil separation.
7. Alternatively the oil can be separated using a centrifuge.

## Extension activities

The weight of the feedstock and oil could be measured and the yield calculated. Weigh the vegetable matter prior to the extraction. While the oil is separating weigh an empty container such as a microcentrifuge tube. Once the aqueous and oil layers are completely separated, the upper oil layer can be carefully removed with a disposable pipette and added to the weighed container. Calculate the yield:  $(\text{weight of oil} \div \text{weight of vegetable matter}) \times 100 = \% \text{ yield}$ .

# Current Biofuels

Biodiesel can be made from the vegetable oil extracted – see [activity 1D](#) Biodiesel production. The oil can be extracted with a disposable pipette from the surface and used to make biodiesel if there is a sufficient quantity of oil, and providing particulate matter is removed.

Tests for saturated or unsaturated oils can be carried out by GCSE or post-16 students. For further details see CLEAPSS® Guidance PS 67-01 (Testing for unsaturation), 'Unsaturation in fats and oils' from Practical Chemistry [www.practicalchemistry.org/experiments/unsaturation-in-fats-and-oils.227.EX.html](http://www.practicalchemistry.org/experiments/unsaturation-in-fats-and-oils.227.EX.html) or SEP Biofuels activity A5: Saturation of fuels.

If a large volume of oil can be produced prior to the lesson or in preparation for the next lesson, viscosity of the oil produced can be tested – see [activity 1C](#) Oil viscosity.

The resulting oil, biodiesel from [activity 1D](#), sugar from [activity 1E](#) and ethanol from [activity 1G](#) can be collected and tested for their combustion energy – see Gatsby SEP:Biofuels activity A7 'How much energy is released when a fuel burns?' or 'Energy values of food' from Practical chemistry [www.practicalchemistry.org/experiments/energy-values-of-food.225.EX.html](http://www.practicalchemistry.org/experiments/energy-values-of-food.225.EX.html)

Oilseed rape (*Brassica napus*) is a member of the *Brassicaceae* family and rapid-cycling *Brassicaceae* are especially amenable to experimentation. Rapid-cycling *Brassicaceae* are used as a model plant for a wide range of studies and can produce seeds in as little as 40 days. This makes the growth of rapid-cycling *Brassicaceae* ideal as a preparatory or follow-up activity with students.

## Suppliers

Sweetcorn, sunflower seeds and other plant material can be obtained from a local supermarket.

Mortars, pestles, test tubes and racks are standard equipment available in secondary school science laboratories otherwise they can be obtained from educational suppliers such as [Philip Harris Education](#), Hyde Buildings, Hyde, Cheshire, SK14 4SH, tel: 0845120 4520 fax: 0800 138 8881. and Rapid [www.rapidonline.com](http://www.rapidonline.com) Severalls Lane, Colchester, Essex, C04 5JS tel: 01206 751166 fax: 01206 751188.

Rapid-cycling *Brassica* kits and seeds are available from Philip Harris Education [www.philipharris.co.uk/secondary/biology/plants-as-organisms/rapid-cycling-brassica-basic-kit/?ev=search](http://www.philipharris.co.uk/secondary/biology/plants-as-organisms/rapid-cycling-brassica-basic-kit/?ev=search) or Blades Biological Limited [www.blades-bio.co.uk](http://www.blades-bio.co.uk) Cowden, Edenbridge, Kent, TN8 7DX, tel:01342 850 242, fax: 01342 850 924.

## Further reading and links

Gatsby Science Enhancement Programme (SEP): Biofuels. 2009. [www.sep.org.uk](http://www.sep.org.uk)

National Non-Food Crops Council (NNFCC), 2007, *Biorefineries: definitions, examples of current activities and suggestions for UK development*. National Non-Food Crops Council position paper. Available online at [www.nnfcc.co.uk/metadot/index.pl?id=3143:isa=DBRow:op=show:dbview\\_id=2457](http://www.nnfcc.co.uk/metadot/index.pl?id=3143:isa=DBRow:op=show:dbview_id=2457)

Exploring knowledge of gene function to combat pod shatter in oilseed rape [www.bbsrc.ac.uk/news/food-security/2011/110615-pr-improved-crops-food-security.aspx](http://www.bbsrc.ac.uk/news/food-security/2011/110615-pr-improved-crops-food-security.aspx) [www.jic.ac.uk/corporate/media-and-public/current-releases/110615CIRCProjects.html](http://www.jic.ac.uk/corporate/media-and-public/current-releases/110615CIRCProjects.html)

Information on the use of the rapid-cycling *Brassica* kits is available from Science and Plants for Schools (SAPS) [www.saps.org.uk/secondary/teaching-resources/126-rapid-cycling-brassica-kits-](http://www.saps.org.uk/secondary/teaching-resources/126-rapid-cycling-brassica-kits-)

Fast plants is a site dedicated to the educational use of rapid-cycling *Brassicaceae* [www.fastplants.org/#menu](http://www.fastplants.org/#menu)

Tompkins, S.P. and Williams, P.H., 1990, *Fast plants for finer science – an introduction to the biology of rapid-cycling Brassica campestris (rapa) L.*, *Journal of Biological Education*, **24** (4), 239-250.

## Current Biofuels

Dissecting the genomes of crop plants to improve breeding potential [www.jic.ac.uk/corporate/media-and-public/current-releases/110731oilseedgenome.html](http://www.jic.ac.uk/corporate/media-and-public/current-releases/110731oilseedgenome.html)

Dissecting the genome of the polyploid crop oilseed rape by transcriptome sequencing [www.nature.com/nbt/journal/v29/n8/full/nbt.1926.html](http://www.nature.com/nbt/journal/v29/n8/full/nbt.1926.html).

Evans, N., Welham, S.J., Antoniw, J.F., Fitt, B.D.L., 2006. Development and Uptake of a Scheme for Predicting Risk of Severe Light Leaf Spot on Oilseed Rape. *Outlooks on Pest Management*, **17**(6), pp. 243-245.



Shattering Rapeseed pods

The fungus forecast: protecting crops from attack.

Mathematical models help UK farmers counter threat to oilseed rape. [www.bbsrc.ac.uk/news/food-security/2010/101207-f-fungus-forecast.aspx](http://www.bbsrc.ac.uk/news/food-security/2010/101207-f-fungus-forecast.aspx)

The Royal Society, January 2008. *Sustainable biofuels: prospects and challenges*, ISBN 978 0 85403 662 2. <http://royalsociety.org/Sustainable-biofuels-prospects-and-challenges/>

Nuffield Council on Bioethics, April 2011, *Biofuels: ethical issues* [www.nuffieldbioethics.org/biofuels-0](http://www.nuffieldbioethics.org/biofuels-0)

### Research groups

Undertaking research to improve oilseed rape yields to address **Food Security**. Professor Lars Ostergaard, Crop genetics, John Innes Centre [www.jic.ac.uk/profile/Lars-Ostergaard.asp](http://www.jic.ac.uk/profile/Lars-Ostergaard.asp)

The Bancroft Research Group, John Innes Centre. [www.jic.ac.uk/staff/ian-bancroft/](http://www.jic.ac.uk/staff/ian-bancroft/)