BRITISH COUNCIL

Science in schools: **Eco-science Biofuels**

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This unit provides opportunities for your students to learn about the importance of sustainable development and the ideas underpinning biodiesel production. They will carry out research about this topic and observe and take part in experiments to turn recycled vegetable fats into oil and potatoes into plastic.

Preparation needed

You will need:

- A set of information cards and worksheets for each group, scissors, envelopes, materials and laboratory equipment to carry out experiments (see instructions below) slides, laptop, projector.

You will need to:

- Photocopy and cut out the card sets and place in envelopes
- Photocopy the worksheets for activity 1 – one copy per group or pair

Age range: 13-16
Science: Chemistry

Curriculum Links: Science - Chemistry, English, Environmental Geography

Objectives:

- To provide students with background knowledge and vocabulary associated with the production and use of biofuels in the UK and Europe.
- To engage in collaborative research practice
- To carry out practical experiments

Skills and attributes: Collaborating, critical thinking, communicating, taking action

Learning Focus: Biofuels and sustainability

Language Functions: Naming, asking and answering questions, discussing

Main Vocabulary

- Oil, biodiesel, solvent, soya, maize, oilseed rape, palm oil, wheat, barley distillation, refined, crops, security, production, carbon dioxide, habitat, ecosystem, biodiversity, plantation, arable, yield, fossil fuel, drought, feedstock, outweigh

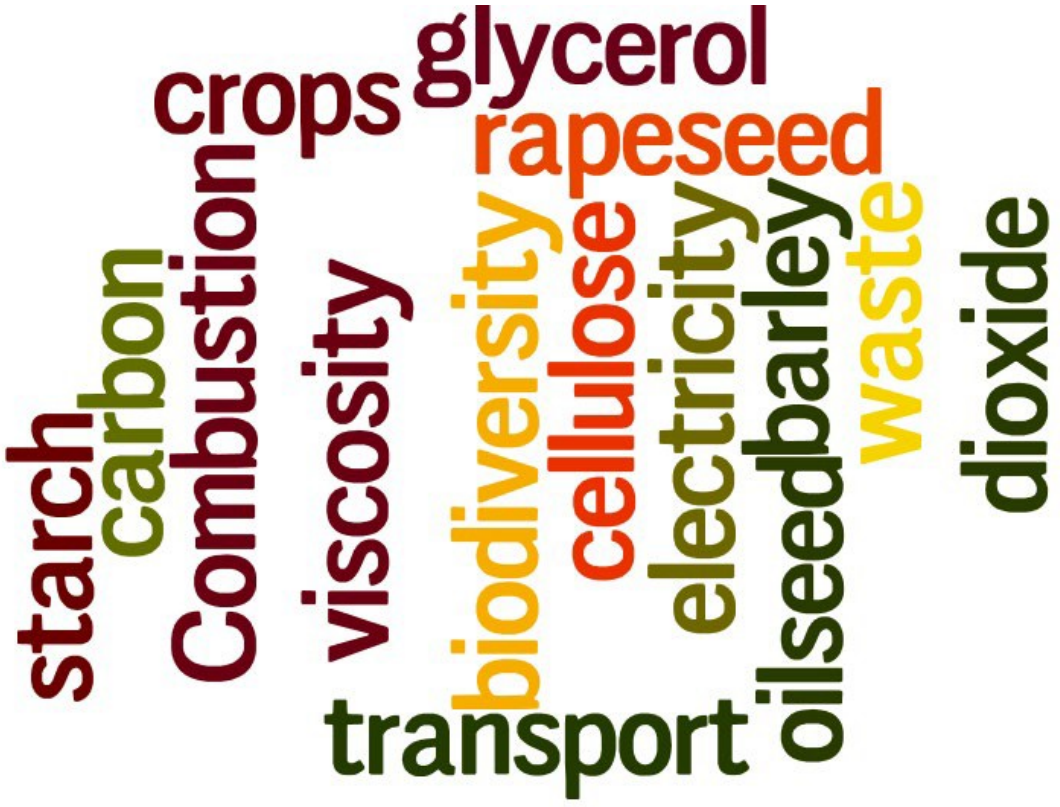
Activities and teaching notes

Introduction

Show your pupils a copy of the image and word cloud on **Activity Sheet 1**.

Ask them to work together in pairs, and discuss the questions on the sheet. You may want to give them copies of the science glossary and/or a print or online dictionary such as oxforddictionaries.com

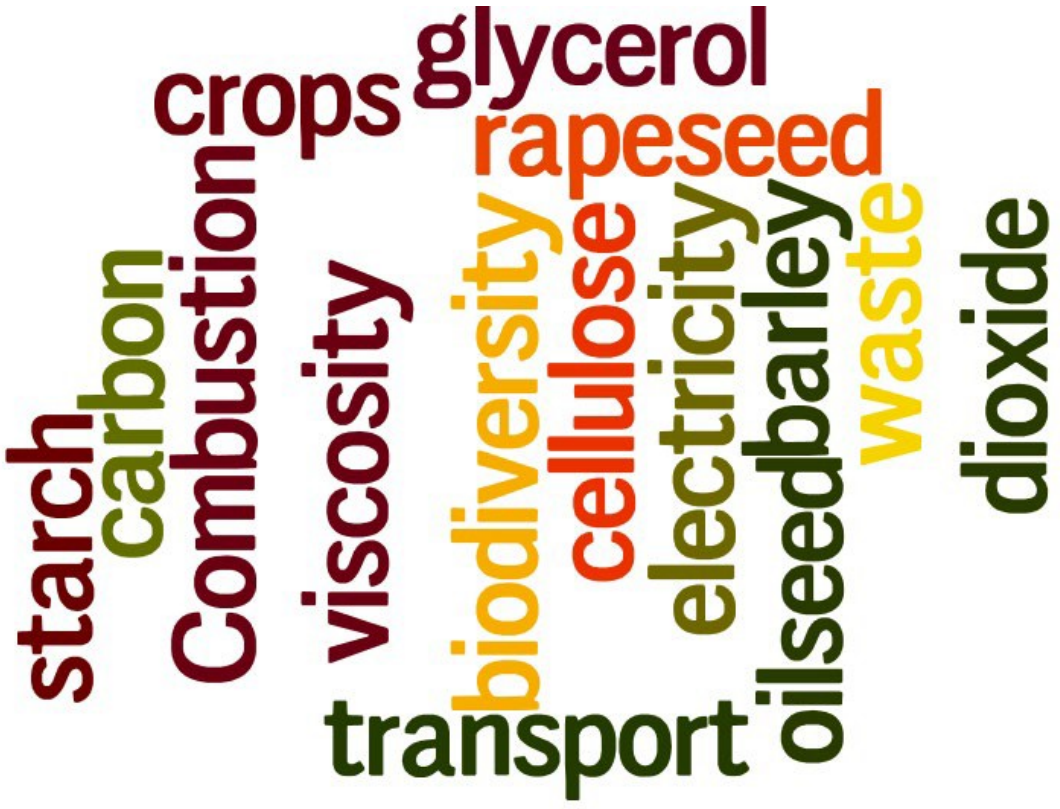
Ask each pair to join another to form a group of four students and share their thoughts and definitions before gathering the class back together to clarify ideas and meanings.



Activity 1

Discussion points:

- What message do you think the artist is trying to convey with this image?
- Which words in the word cloud can you explain?
- Look up the meanings of any words you are unsure of
- What do they think might be the link between the words in the word cloud and the image? Give your reasons.



Background Information

Explain to the class that the link between the two images is the production of biofuels and renewable energy sources. Ask what they currently know about these two topics and what they would like to find out more about. Explain that they will be carrying out their own research to discover more during the session.

Discuss why biofuels are important using the following information or the slideshow.

Biodiesel is a fuel for conventional diesel engine made from plant or animal oils that have been chemically altered to alkyl esters. Diesel engines are compression-ignition engines developed by Rudolph Diesel. They were originally designed to run on peanut oil, not mineral diesel. Diesels have been made which run on milk powder, coa dust and straight vegetable oil. Biodiesel can be made from a very wide range of 'feed stocks'. These can be animal fats and tallows, or vegetabl oils. Algae can even be used. We can also make biodiesel from waste vegetable oil from deep fryers.

Activity 2

To consolidate their understanding about biodiesel production, ask the class to return to their small groups of four. Cut out the four cards on **Activity sheet 2** and place them in an envelope.

Give each group an envelope. Ask each student to choose a card and read the information on their card, and then work collaboratively together to answer the series of questions on **Activity sheet 3**. For each question they will first need to identify which member of the group is holding the relevant information card with the answer. You could structure this activity as a competition to see which group can complete the task correctly in the quickest time while you observe, help and monitor!

Check the responses with the whole class.

Activity 3: Biofuels Information Cards

Text A Oil and biodiesel
Background
Oil can be extracted from a variety of plants and converted into biodiesel. Most biodiesel is produced from soya, oilseed rape, maize and palm oils. In order to extract the oil the raw material is pressed and then a combination of solvents* and steam distillation is used to improve the quality of the final product. Normal vehicles can function with fuel containing up to 5% biofuels without modification to the engine.

Glossary:
solvents – chemical which can dissolve something
raw material – basic material from which a product is manufactured
refined – material which has been through a process of purification
steam distillation – separation of substances using high temperatures

Text B Oil and biodiesel
in the UK
Oilseed rape and sunflower seeds from Germany and the UK are used in European biodiesel production. Oilseed rape is the third most important crop in the UK after wheat and barley. In 2010 in the UK around 6% of the country's arable land was used for growing oilseed rape which is used in a variety of vegetable and industrial oils and as a biofuel. In order to ensure food security, it is important to manage the conflicting demands of energy and food needs.

Glossary:
food security – food availability, access and use for the global community
wheat – cereal grain
barley – cereal grain
crops – plants grown on a large scale for food and clothing

Text C Oil and biodiesel
Problems
Palm oil comes from Malaysia and Indonesia. Oil palms are more productive than other oil crops but increasing demand for palm oil has caused deforestation and destruction of ecosystems for plantations. This has meant loss of habitat which effects biodiversity, therefore outweighing the benefits of reduced carbon release. There is also concern about the effects on the indigenous peoples of Malaysia and Indonesia and the treatment of workers on palm plantations.

Glossary:
productive – efficient
carbon release – amount of CO2 produced
plantations – man made forest
outweighing – greater or more significant

Text D Oil and biodiesel
Solutions
Future sources of oil for biodiesel production may come from crops which are drought tolerant, growing on non-arable marginal land and produce a yield of up to 40% oil content. Alternatively, research into algal feedstocks may result in the production of sufficient quantities of oil to replace fossil fuel sources and meet demand for biodiesel.

Glossary:
non-arable – not able to cultivate the land
yield – amount produced
feedstocks – there are two types of feedstocks; forest biomass and agricultural biomass
fossil fuel – range of natural volatile materials composed of buried dead organisms, millions of years old e.g. gas and oil
drought – long periods of no water

Activity 3

Use the information on the Biofuel Activity cards to complete the following grid.

1. Where can oil be extracted from?	2. Which are the most important crops in the UK?	3. Where does palm oil come from?	4. Where might the future sources of oil be produced?
5. How is oil extracted from plants?	6. Which countries produce the most plants for biodiesel production in Europe?	7. What are the effects of palm oil plantations on the indigenous people?	8. What is the oil content of future possible biofuel crops?
9. Can any vehicle operate on biofuels?	10. How can we assure the availability of food crops?	11. What is the impact of oil palm production on the environment?	12. How might fossil fuels be replaced in the future?

As an additional activity invite the students to choose a different card and spend a few minutes preparing and then presenting to their group the meanings of the glossary terms on their card or ask them to compile three quiz questions for another group. For example using Text Card A: Why do people use **steam distillation**? Or for Text Card C: Where might you find a palm oil **plantation**?

Activity 3

One way of making biodiesel is to use waste vegetable oil from deep fryers. Normally, straight vegetable oil is too viscous to be used in a modern diesel engine but we can chemically transform the oil to make it thinner using a process called titration so that the fuel is compatible with modern conventional engines.

Carry out the 'Titration' experiment and use the following diagram to demonstrate this process to your students, which can allow fat to be turned into fuel.

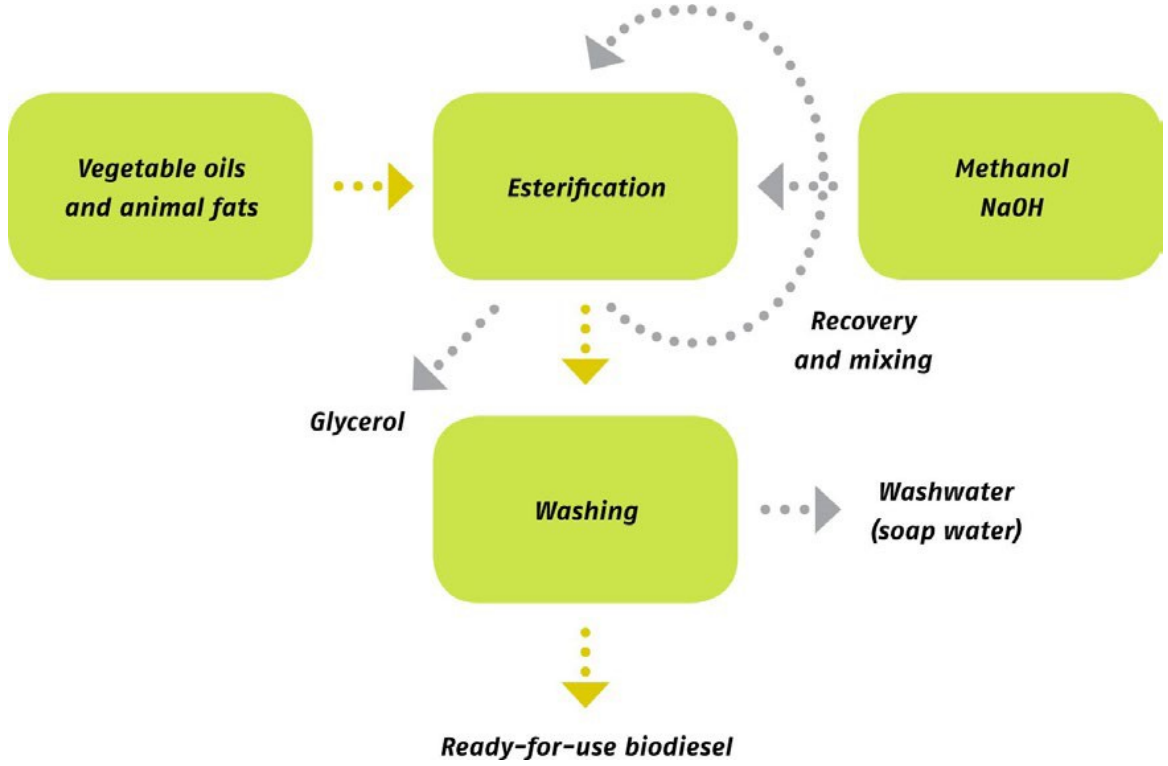
Follow these instructions to carry out the Titration Experiment

1. Add 10ml of isopropyl alcohol to a beaker
2. Add a few drops of indicator and stir
3. Add 0.5ml of KOH solution to the solution
4. Continue to add the KOH, 0.5ml at a time, until the red colour persists after stirring. The isopropyl alcohol is now pH neutral
5. Add 1ml of the waste oil to the solution and stir. The red colour will disappear as the oil has made solution acidic.
6. Continue adding KOH, 0.5ml at a time, until the red colour persists. Record how much KOH you put into the solution.
7. The amount of KOH (ml) it takes to neutralise 1ml of oil equates to the number of grams of KOH it takes to neutralise a litre.

After watching the demonstration ask your students to work in pairs to complete the text on Activity Sheet and put the Titration instructions in the correct sequence.

Fat to fuel

Triglycerides + Methanol = Methyl Esters + Glycerol



Activity 4

Pure vegetable oil is too .....to be used in a modern diesel engine. We have to chemically .....the oil to make it ..... This process is called ..... After this process the..... can be used in modern.....engines.

Jumbled instructions
Can you put the instructions for the titration experiment in the correct order?

Number	Instruction
	Add a few drops of indicator and stir.
	Continue to add the KOH, 0.5ml at a time, until the red colour persists after stirring. The isopropyl alcohol is now pH neutral.
	Continue adding KOH, 0.5ml at a time, until the red colour persists. Record how much KOH you put into solution.
	Add 0.5ml of KOH solution to the solution.
	Add 1ml of the waste oil to the solution and stir. The red colour will disappear as the oil has made the solution acidic.
1	Add 10ml of isopropyl alcohol to a beaker.
	The amount of KOH (ml) it takes to neutralise 1ml of oil equates to the number of grams of KOH it takes to neutralise a litre.

Activity 4: Answers

Pure vegetable oil is too viscous to be used in a modern diesel engine. We have to chemically transform the oil to make it thinner. This process is called trans-esterification. After this process the fuel can be used in modern conventional engines.

Jumbled instructions
Can you put the instructions for the titration experiment in the correct order?

Number	Instruction
2	Add a few drops of indicator and stir.
4	Continue to add the KOH, 0.5ml at a time, until the red colour persists after stirring. The isopropyl alcohol is now pH neutral.
6	Continue adding KOH, 0.5ml at a time, until the red colour persists. Record how much KOH you put into solution.
3	Add 0.5ml of KOH solution to the solution.
5	Add 1ml of the waste oil to the solution and stir. The red colour will disappear as the oil has made the solution acidic.
1	Add 10ml of isopropyl alcohol to a beaker.
7	The amount of KOH (ml) it takes to neutralise 1ml of oil equates to the number of grams of KOH it takes to neutralise a litre.

Additional Activities

Making plastic from potatoes

You could also invite your students to carry out another Eco science experiment by turning everyday potatoes into plastic.

Introduction

Ask your class to think of 10 objects that they use everyday that are made from plastic.

Background Information

Explain that plastic is a common term for a wide variety of synthetic or semi-synthetic materials suitable for use in manufacture as it malleable and inexpensive. Plastics are usually made up of polymers and often created from non-renewable petroleum products. They also account for 35% of all litter.

Bio plastic is a from of plastic made from renewable plant - based sources, such as vegetable oil or corn starch rather than fossil fuels. However there are associated problems with this such as large-scale mono cropping and the destruction of large areas of rainforest.

If Bio plastic is produced on a smaller scale, planted with biodiversity in mind and produced using renewable energy, it really is a sustainable option. One example of this is making plastic from locally grown potatoes, which your students can experiment with.

Step 1 – Extracting starch

Explain that potato starch is made from two carbohydrate polymers, amylose and amylopectin. Amylopectin needs to be broken down in order for the starch to be plasticised. In order to achieve this give your students the following instructions to carry out:

Extracting starch:

- Grate about 100g of clean potato. Add 100cl-distilled water to the potato and grind in a pestle and mortar

- Strain the liquid off, and repeat adding 100ml distilled water, grinding and straining twice more. Leave to settle for 5 minutes. Strain the water off, leaving the starch behind.

Turning potato to plastic

1. Put 25cm^3 water into a beaker and add 2.5g starch and 3cm^3 hydrochloric acid and 2cm^3 pure glycerol.
2. Bring to the boil for 15 minutes, ensuring it doesn't boil dry
3. Use indicator paper and sodium hydroxide to neutralise the solution (probably about 3cm^3).
4. Add a few drops of colouring to the mixture and mix in.
5. Pour the mixture out, and mould into your preferred shape. Leave to dry out. This will take a while...
6. Once your mixture has dried out, attach a magnet to the back with some superglue to create a fridge magnet!

Partner School Activities

If you are working with a partner school you could:

- Ask students to find out more about the manufacture and use of biofuels in their own country and discuss the similarities and differences with students from your partner school.
- Produce a presentation or teach a lesson to another class about the importance of sustainable development and the production of biofuels or bio plastic
- Exchange photographs and blogs about their experiments. Were they all successful?

Further information can be found at:

- http://zerocarbonbritain.org
- The Centre for Alternative Technology at: http://www.cat.org.uk/index.html