



Mark Votier/Hulton Archive/Getty Images

**Left:** The crew of a Japanese whaling vessel measures the carcass of a whale during a research mission in the Antarctic in 1993. There is much opposition to this so-called 'scientific whaling' carried out by the Japanese

# Fats, oils and soaps

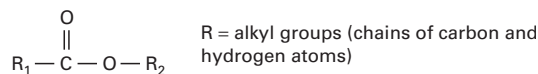
This article investigates a few of the uses of naturally occurring oils. These oils are extracted from animal fats or plant seeds and can be turned into a variety of compounds including soaps, fuel and margarine.

**F**ats and oils extracted from farm animals have been used as lubricants, in cooking, as fuel for oil lamps and in candles for centuries. Another source of animal fat is the whale. Before the Industrial Revolution whale hunting was done on a small scale, but after the development of harpoon guns in the 1870s it increased significantly. Every part of the whale was used – the chins, tongues and meat as food, and the blubber for making oil, margarine and soap. Whale blubber was boiled with sodium hydroxide to produce soap. This process of boiling with sodium hydroxide is called **saponification**.

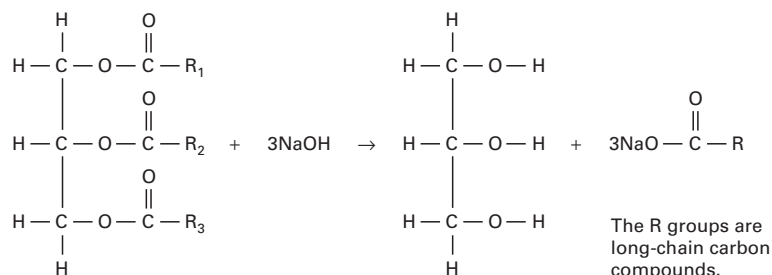
Many nations, including the UK, fished for whales for oil and food, which resulted in several species of whales being driven almost to extinction. Other sources of oil were sought and whaling has now largely stopped. Today, useful oils are extracted from the fruits or seeds of plants – the most popular being sunflower oil, olive oil, soya oil and palm oil.

## Soap

Vegetable and animal oils contain **esters**. These are groups of carbon and oxygen atoms (Figure 1) which can be split using sodium hydroxide to form long-chain hydrocarbons with an organic (carboxylic) acid group at one end (Figure 2). The long chain is hydrophobic ('hates water') and so will dissolve in grease or dirt; the acidic end is hydrophilic ('loves water') and so will attract water molecules. The other product is glycerol (propane-1,2,3-triol). Figure 3 (on page 16) shows how soaps work.



**Figure 1** Ester

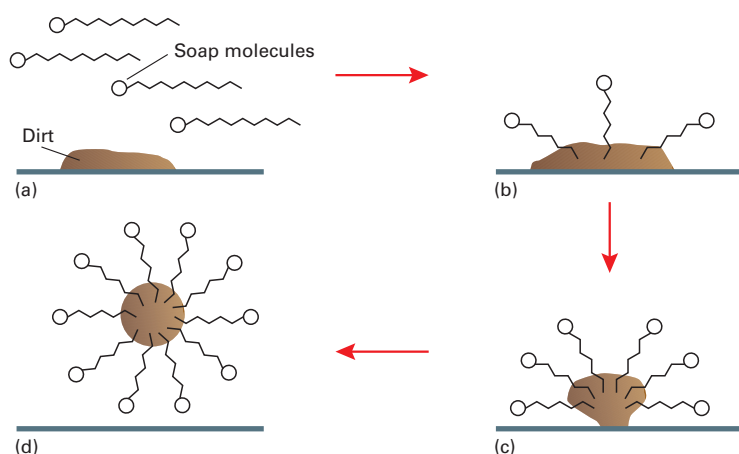


**Figure 2** Using sodium hydroxide to split esters

## GCSE key words

Oil extraction  
Soap action  
Vegetable oils

**Commercial whaling was banned worldwide in 1986. Whaling today is done for scientific purposes, although some countries are keen to resume commercial whaling.**



**Figure 3** The action of soaps and detergents  
 (a) Dirt on cloth, detergent molecules in water  
 (b) The hydrocarbon chain of the detergent prefers the dirt rather than the water  
 (c) The dirt is lifted from the cloth as more detergent molecules repel each other  
 (d) The dirt is removed and washed away

### Soap and water

One problem with soap is that it reacts with dissolved calcium and magnesium compounds in **hard water** to make scum rather than a lather. The soap reacts with the calcium and magnesium ions to produce calcium stearate (scum). Hard water containing dissolved calcium is good for bones and teeth.

**Soft water** does not contain these ions and so produces a lather with soap. Soft water is better for use in industry as it does not precipitate out limescale on the inside of pipes. However, soft water contains an excess of sodium ions compared to hard water and these have been linked to heart disease.

### Detergents

Detergents were developed to prevent scum forming with hard water. They contain a long hydrocarbon chain, like soap molecules, but at one end they have a benzene sulphonate group ( $C_6H_4SO_3^- Na^+$ ). This group does not react with calcium or magnesium so does not produce scum in hard water.

A pigment is a coloured compound which is insoluble in water.



The phosphates used in detergents end up in rivers and lakes where they act as a nutrient for algae

If the detergent contains straight chain hydrocarbons it will biodegrade slowly. If the hydrocarbon group is highly branched bacteria have difficulty in breaking it down and it can accumulate in the environment. Detergents with a large amount of branching cannot be sold in the UK.

### Problems with detergents

A typical packet of detergent contains about 20% detergent and between 0 and 30% inorganic phosphates. The phosphates help to remove soluble calcium salts. Unfortunately, the phosphates end up in the sewage system and then in rivers and lakes where they act as a nutrient for certain algae. The algae reproduce and cover the water. Underwater plants cannot photosynthesise due to the lack of light reaching them. These plants die. Bacteria feeding on the decaying plant material use up oxygen in the water. As a result, other aquatic animals die due to lack of oxygen. This process is known as **eutrophication**.

### Oils in paints

For centuries painters have used oils that harden on exposure to air. Some oils — such as linseed oil — contain double carbon-carbon bonds on the hydrocarbon chain part of the molecule. When exposed to light and oxygen, bonds form between double bonds on adjacent molecules. This causes the molecules to link together forming a 'skin'. Oil paints contain coloured pigments mixed with these drying oils — once the paint has been spread on a painting it slowly starts to harden as the cross-linking process occurs.

### Box 1 Soapwort



Soapwort gained its name from the ability of its crushed root to produce suds when rubbed in water. It can be used as a mild detergent for fabrics. Soapwort was once added to beer to create a frothy head. The plant acts as both an antibacterial and an expectorant (it loosens phlegm, making it easier to cough up).

## Oils as fuels

Oils and fats can also be used as fuels. In the UK over 1 million tonnes of rapeseed is produced each year. The oil from rapeseed cannot be used as a fuel on its own – the long carbon chain part of the oil would burn readily, but the propane-1,2,3-triol residues that form during combustion would clog up the engine.

Instead, the oil is boiled with an alkali to break it down and the mixture acidified; this allows the long-chain carboxylic acid products to be isolated (see 'Biofuels' in CATALYST Vol. 17, No. 1). They are reacted with methanol to produce methyl esters [CH<sub>3</sub>OC(O)R]. It is these methyl esters that are used as fuel.

Rape methyl ester is a good diesel substitute which has several environmental advantages over conventional diesel fuel. It does not form sulphur dioxide and emits fewer sooty particles during combustion.

## Margarine

Margarine is used as a substitute for butter. It is made by hardening fish and vegetable oils. The process uses hydrogen in the presence of a nickel catalyst. During this process double bonds in the hydrocarbon chain become saturated, turning it from an alkene into an alkane (Figure 4). This makes the oil become harder. Semi-soft margarines, which are 'high in polyunsaturates', are made by mixing untreated oils with those

### Box 2 Useful websites

- Find out more about whaling at: <http://en.wikipedia.org/wiki/Whaling> and for the current position on whaling look at the section for the *International Whaling Commission*.
- Find out more about the history of soap at: [www.pjonline.com/Editorial/19991218/articles/soap.html](http://www.pjonline.com/Editorial/19991218/articles/soap.html)
- There are more details on soap and detergent manufacture at: [www.cleaning101.com/cleaning/manufact/](http://www.cleaning101.com/cleaning/manufact/)
- These two sites highlight the problems that arise from phosphate use: [www.wwf.org.uk/news/scotland/n\\_0000001573.asp](http://www.wwf.org.uk/news/scotland/n_0000001573.asp) [www.swissinfo.org/eng/swissinfo.html?siteSect=43&sid=5008242](http://www.swissinfo.org/eng/swissinfo.html?siteSect=43&sid=5008242)

Rapeseed is obtained from the yellow-flowered rape crop that can be seen in early summer in the UK countryside.

Fats containing carbon-carbon single bonds are said to be saturated, those containing double bonds are said to be unsaturated.

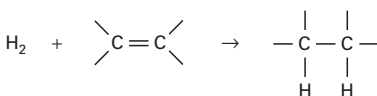


Figure 4 Adding hydrogen to a double bond

that have been partially hardened. Polyunsaturated fats are thought to be less harmful to the heart and arteries than saturated fats.

Margarine is often coloured using carrot extract.

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# Wordmaze

Plants (e.g. sunflowers) can be used as a source of oil, but they can also be used for medical and culinary purposes. Fit the plant names listed below into the grid. The end of one word begins the next. The beginnings and endings are highlighted in yellow. Start with the word 'Sunflower' in the top left, and move round in a clockwise direction. Once you have managed to fit all the words into the grid, rearrange the letters highlighted in green to form the name of a herb which is often used in sweet making.

#### 5-letter words

ELDER  
OLIVE  
BASIL

#### 7-letter words

RAMPION  
ANISEED  
RHUBARB  
RAMSONS

#### 9-letter words

SUNFLOWER  
DIGITALIS  
SANTOLINA  
SAFFLOWER

#### 6-letter words

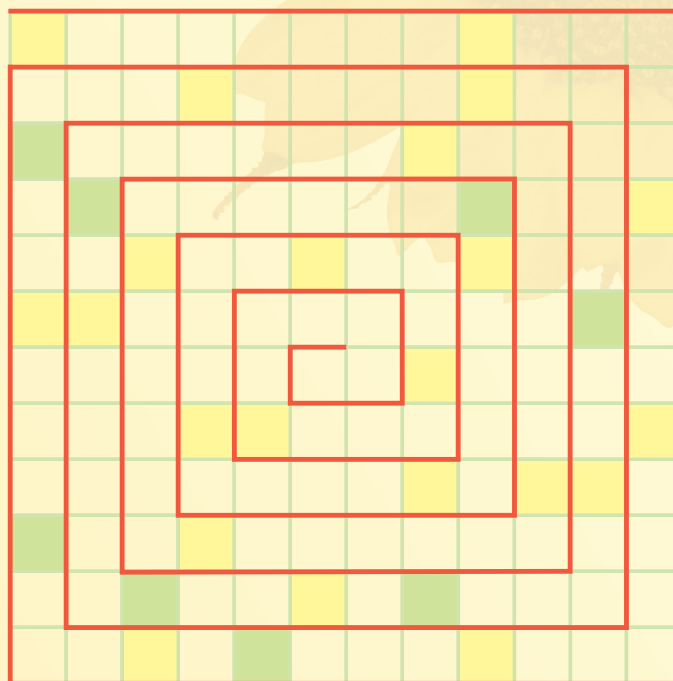
YARROW  
ENDIVE  
SPURGE  
ERYNGO

#### 8-letter words

LAVENDER  
SAMPHIRE  
ROSEMARY  
ANGELICA

#### 10-letter words

ELECAMPANE  
WATERCRESS  
EUCALYPTUS



## Puzzle

Answers on page 19.