Chemistry and Industry for Teachers in European Schools

CHEMISTRY CHANGES EVERYTHING

Margarine – from hydrogen and vegetable oil

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Education and Culture

Socrates
Comenius

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CITIES (*Chemistry and Industry for Teachers in European Schools*) is a COMENIUS project that produces educational materials to help teachers to make their chemistry lessons more appealing by seeing the subject in the context of the chemical industry and their daily lives.

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- Czech Chemical Society, Prague, Czech Republic , http://www.csch.cz/
- Jagiellonian University, Kraków, Poland, http://www.chemia.uj.edu.pl/index_en.html
- Hochschule Fresenius, Idstein, Germany, http://www.fh-fresenius.de
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CHEMISTRY CHANGES EVERYTHING


+


Or, to the uninitiated:

"Margarine made from Hydrogen + vegetable oil!"

(if nickel is used in the process!)

- History
- Materials
- Manufacture
- Benefits
- Future

Where and when did all this begin?

In 1869, Emperor Louis Napoleon III was looking for a cheap substitute for butter, possibly for use by armies in the field. The answer was found by French chemist Hippolyte Mège-Mouriés (there are several variants on this spelling.) Mège-Mouriés made his product by gently heating beef suet with milk. Earlier attempts had been made by others but the product did not have an acceptable taste. The inclusion of milk by Mège-Mouriés helped to overcome this problem. He called his invention ' oleomargarine'.

Michel Chevreuil had first extracted margaric acid from certain animal fats over 50 years earlier. He named this substance from its pearly appearance (based on the Greek word 'margaron', meaning pearl.) Mège-Mouriés assumed that his invention contained margaric acid, hence his choice of name 'oleomargarine'. In this respect, he was mistaken; if he had checked for the presence of margaric acid before deciding on this choice of name, the substance we now know as margarine would have had a totally different name.

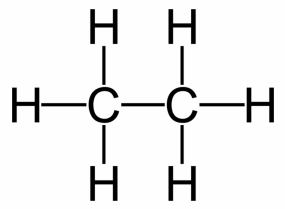
Over the years, a number of different animal fats have been used in the manufacture of margarine. Whale oil was also extensively used for a while. As the 20th century dawned, the use of animal fats was slowly phased out and vegetable oils became the principal starting point for margarine production.

Animal fats contain a high proportion of *satutated* fats, which are usually greasy solids. For this reason, margarine made from animal fats is naturally a greasy solid. Vegetable oils contain a much lower proportion of saturated fats and a higher proportion of

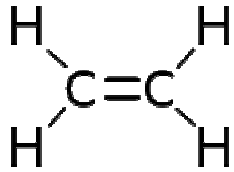
unsaturated fats. For this reason, vegetable oils are not initially ideal for use in margarine production, unless you like to ***brush*** your margarine on to your bread! – it's far too runny!

Is this really chemistry?

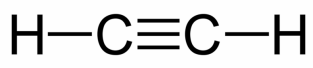
Fats are organic. This word means that they contain molecules made up from chains of carbon atoms, also usually bonded to hydrogen atoms and occasionally other atoms such as oxygen or nitrogen. In these molecules, the carbon atoms must always form four bonds to other atoms. This can be achieved in a number of ways, for example:



four single bonds
on each carbon atom



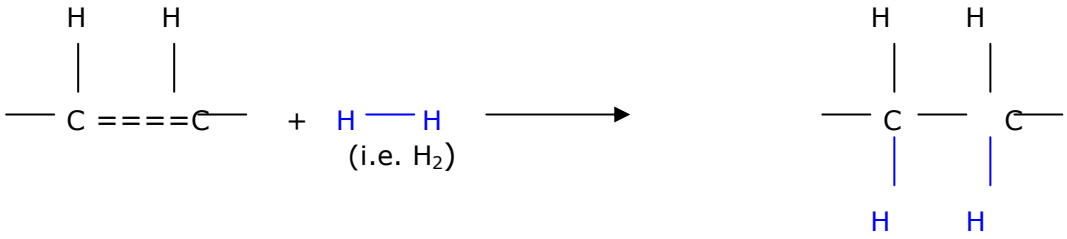
two single bonds
and 1 double bond
on each carbon atom



one triple bond
and one single bond
on each carbon atom

In the first diagram, the carbon atom is bonded to 4 other atoms, the most it can ever bond to. This is classed as ***SATURATED***. In both the 2nd and 3rd diagrams, the carbon atom is bonded to less than 4 other atoms – this is what is meant by ***UNSATURATED***.

Saturated fats contain saturated carbon atoms and unsaturated fats contain ***some*** unsaturated carbon atoms as well as some saturated ones i.e. they are ***less*** saturated. When hydrogen gas is reacted with unsaturated molecules, the double or triple bonds break to become single bonds and atoms of hydrogen are added to the carbon atoms:

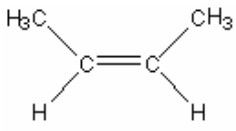


You can see that the product no longer has a double bond between the two carbon atoms and is therefore no longer unsaturated. We sometimes say that the oil has been 'hardened'.

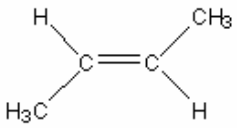
This reaction will not work at room temperature; heating makes little difference to the reaction rate. The introduction of a catalyst, made of metallic nickel, increases the speed of the reaction enormously, making the reaction viable. A temperature of about 150°C and a high pressure works well.

Vegetable oils are made up of molecules containing long chains of carbon atoms, in which there are usually several unsaturated C=C linkages. Careful control of the amount of hydrogen added ensures that not all of the double bonds are hydrogenated. This has health benefits.

Another characteristic of molecules with C=C linkages is that of 'geometric isomerism'. This is when the same groups are attached to the same carbon atoms, but with a different arrangement. This can most easily be illustrated with the molecule of but-2-ene, which has the chemical formula C_4H_8:

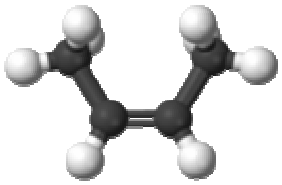


cis form

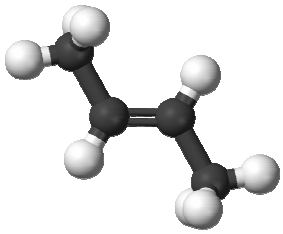


trans form

alternative representation:



cis form



trans form

The presence of the C=C severely restricts rotation about the double bond, effectively preventing the cis-isomer from changing into the trans-isomer; they are therefore two different substances. (In molecules where the carbon atoms are linked by single bonds, rotation is possible, thus excluding this type of isomerism). Although the terms *cis* and *trans* have been in use for many years, there is a growing preference among chemists nowadays to use the terms *E* and *Z.* *E* is the term used instead of *trans* and *Z* is used instead of *cis.* The letters come from German (E=entgegen [opposite] and Z=zusammen [together])

Trans-fats are widely acknowledged to be responsible for increasing the amount of LDL cholesterol (the 'bad' form of cholesterol) in the bloodstream, which is known to increase the risk of coronary heart disease. This is an important consideration when deciding on which type of oil to use in margarine manufacture. LDL represents **L**ow **D**ensity **L**ipoprotein.
These trans fats also reduce the amount of HDL in the bloodstream. HDL is the 'good' form of cholesterol, which is beneficial to good health.

So you want to try something out?

Make your own margarine :

- Pour about 125 ml milk (or water) into a blender or food processor for about 1 minute. Use the highest speed setting. This aerates the milk.
- Slowly add about 250 ml oil* (e.g. coconut or palm oil work best) and continue to blend until a smooth mixture is produced.
- Now add 5 ml liquid lecithin and blend this in. It will help to prevent the oil and milk from separating. Lecithin acts as an emulsifier – it is obtainable from health-food stores. Lecithin is not essential if you do not intend to save the product.
- Now add about 3g granulated sodium chloride (half of a level teaspoon) - you may reduce this quantity if you wish or use a low-sodium equivalent.
- Add a very small amount of yellow food colouring – you could use the juice from a grated carrot or a pinch of turmeric instead. Flavouring may be added at this stage.
- Finally, blend everything together and your margarine is ready to taste. The product may be stored in a refrigerator for up to 3 weeks.
- If lecithin has not been used, you may need to blend the mixture again before use.

*Note: Olive oil or sunflower oil *may* be used instead, but with less success. Cooling may be necessary to achieve a solid product if either of these oils is used.

If you want to be really different, you could use an unusual food colouring e.g. green or blue or even red!

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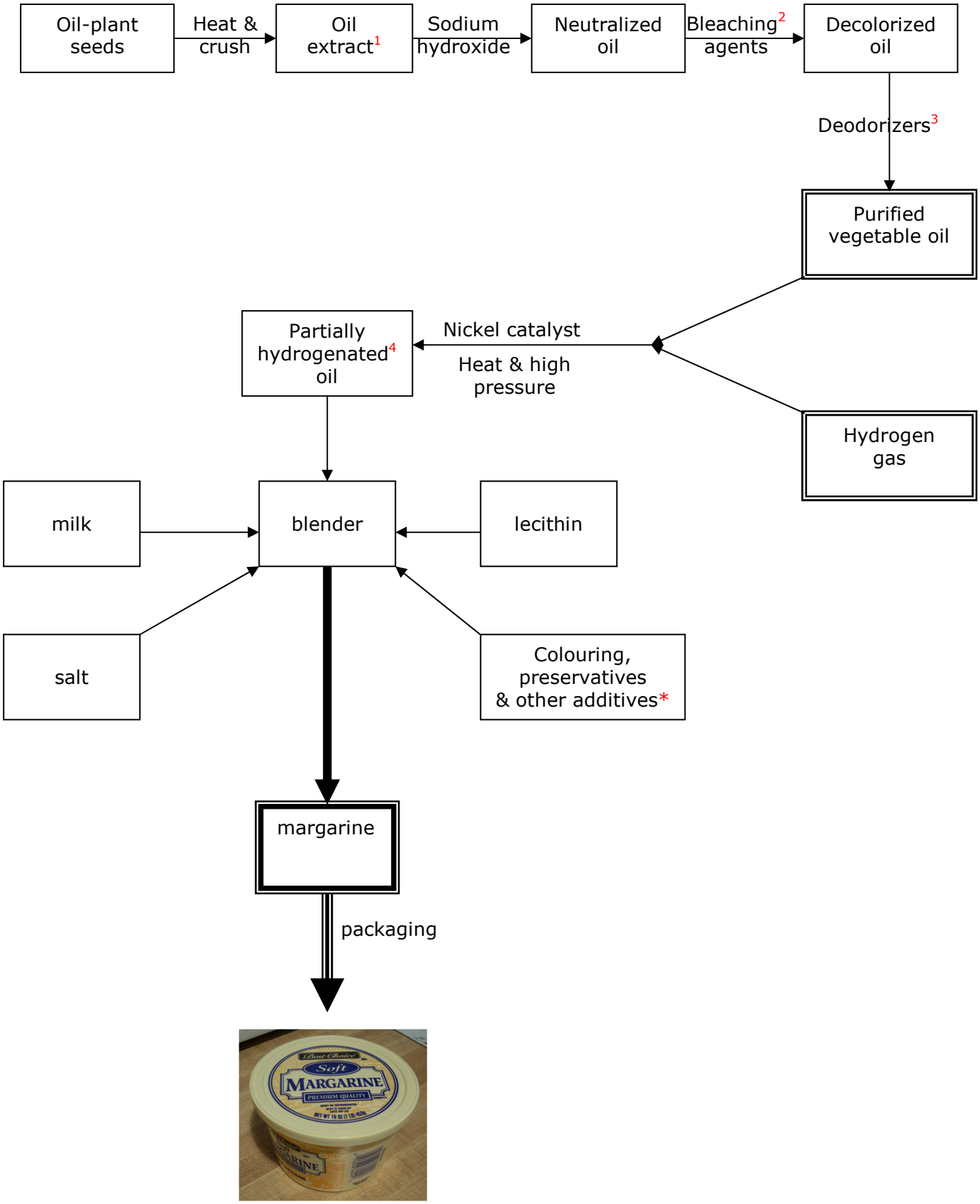
How is margarine produced commercially?



Notes

1 The oil obtained at this stage has unwanted natural acidity, which must be removed. For this reason, it is next treated with sodium hydroxide.

2 & 3 Natural colouring matter and natural aromas are now removed

4 If the oil is completely hydrogenated, it will become too hard and difficult to spread.

* Colouring is added to make the product look more like butter. Preservatives (e.g antioxidants) will extend the life of the margarine. Oils high in omega-3, omega-6 and plant sterols could be added for health reasons.

So, What are the Benefits of margarine? (compared with butter)

- Contains less saturated fat
- Available from various vegetable oil bases
- Available with other additives present (e.g. extra vitamins, omega-3 and omega-6, plant sterols)
- Contains virtually no cholesterol
- Available with a much lower *total* fat content
- Longer shelf-life
- Generally much cheaper

Are there any known risks?

As mentioned earlier, trans fats are known to contribute to coronary problems. Unfortunately, the hydrogenation process results in an increase of trans fats in the product. For this reason, many manufacturers choose very carefully which type of vegetable oil they will use as their starting point; palm oil has been found to be an excellent choice.

Conventional margarine has the same amount of calories per gram as butter, so moderation is advised to help avoid obesity. Butter typically contains about 80% fat (which is animal fat). Modern margarine contains about 55% fat (vegetable fat usually).

Future developments

- Further decreases in the levels of oil used – often replaced by water
- These are more usually referred to as spreads, rather than margarine
- More health-beneficial additives
- New range of flavourings

Are you intrigued by what you have read?

Further information available at:

www.**margarine.org**/RD/index.html

www.**mayoclinic.com**/health/**margarine**/HB00097

www.**madehow.com**/Volume-2/Butter-and-**Margarine**.html

contact the website of margarine manufacturers, e.g. www.**benecol.com**
e.g. www.**olivioproducts.com**

plus numerous other web-based information sites