Higher Chemistry: Unit 2 – Nature's Chemistry

Part F – Fragrances and Skin Care

Lesson 1 – Fragrances

Learning Outcomes

By the end of this lesson you should know:

1. What are "essential oils"
2. The structure of isoprene and terpene molecules
3. Some physical and chemical properties of terpenes

Success Criteria

You will have been successful in this lesson if you:

1. Read and learn the notes given
2. Watch the links provided
3. Complete questions provided
4. EXTENSION: There is a further reading section to help you gain more depth of understanding for this section. There are also suggested questions for you to try from the blue book of revision questions.

If you have any questions about the content of this lesson, you should ask your class teacher either through your class MS team or via email. The teams will be monitored through the week and someone will get back to you as soon as they can.

Links to Prior Knowledge

You may wish to revise the following to help you understand this lesson:

Higher chemistry – systematic carbon chemistry

You may wish to have a copy of the data booklet handy for this lesson. Download or print a copy of the Higher Chemistry Data Booklet from MS Teams or the SQA website - https://www.sqa.org.uk/sqa/files_ccc/ChemistryDataBooklet_NewH_AH-Sep2016.pdf

Notes - you should either copy, print or save the notes below.

You will receive a paper copy of these notes when we return to school.

Fragrances

WATCH: Click on the link for a 5 minute recorded lesson:

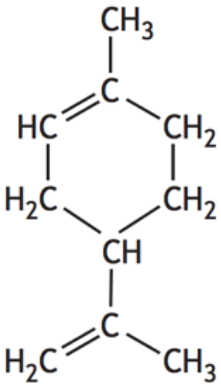
PowerPoint with voice recording from Ms Hastie

Essential oils

Essential oils are concentrated extracts from plants, which have wide variety of often pleasant aromas (smells). *In this context, the word "essential" is related to a plants' essence or odour. ("Essential oils" are not related to "essential amino acids" and also not related to "edible oils" that you learned about earlier in this unit.)*

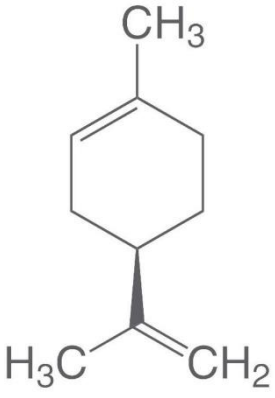
Typical essential oils include lavender oil, peppermint oil and orange oil. Essential oils are widely used in perfumes, cosmetic products, cleaning products and can be used in aromatherapy. They are also found in foods, either naturally or added as flavourings.

Molecules that make up essential oils are **non-water soluble volatile** (this is why they have a smell). Typical compounds include limonene, found in oranges and lemons:



Carbon compounds like this can also be drawn with some carbons and hydrogens removed for simplicity:

These two molecules are the same.
Limonene, $C_{10}H_{16}$



THINK ABOUT:

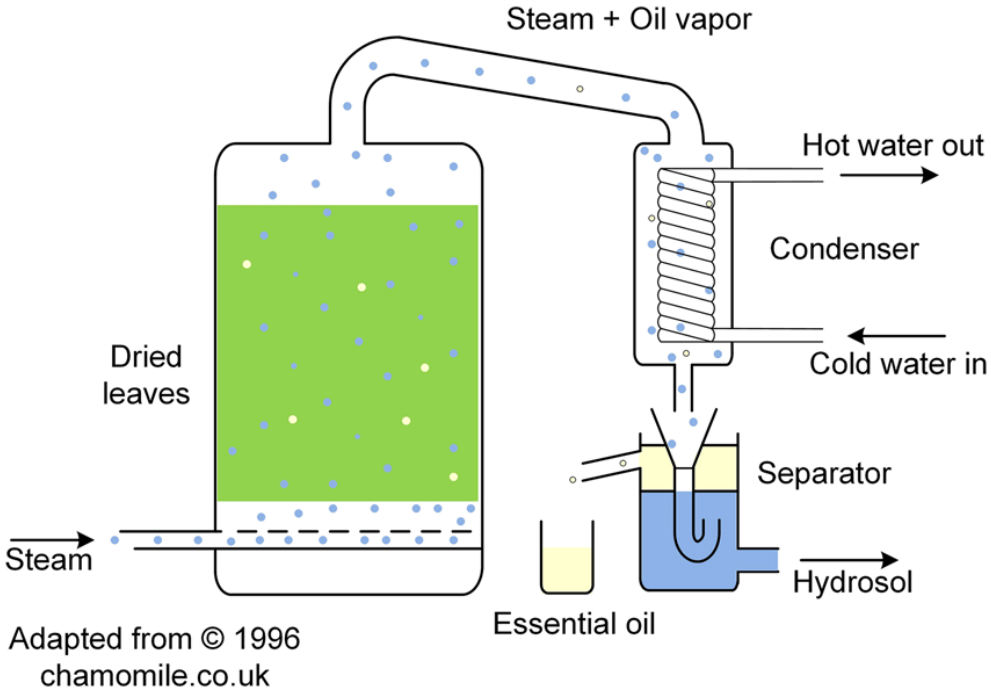
Looking at the structure of limonene, do you think it would be soluble in water? Do you think it would easily evaporate?

HINT: - *Think about the type of bonding and intermolecular forces that are present.*

Property of essential oil compound	Cause
Insoluble in water	Non-polar molecule
Volatile (easily evaporates)	Only weak LDFs between molecules

Extraction of essential oils from plants

Essential oils can be extracted from plant leaves by **steam distillation**.



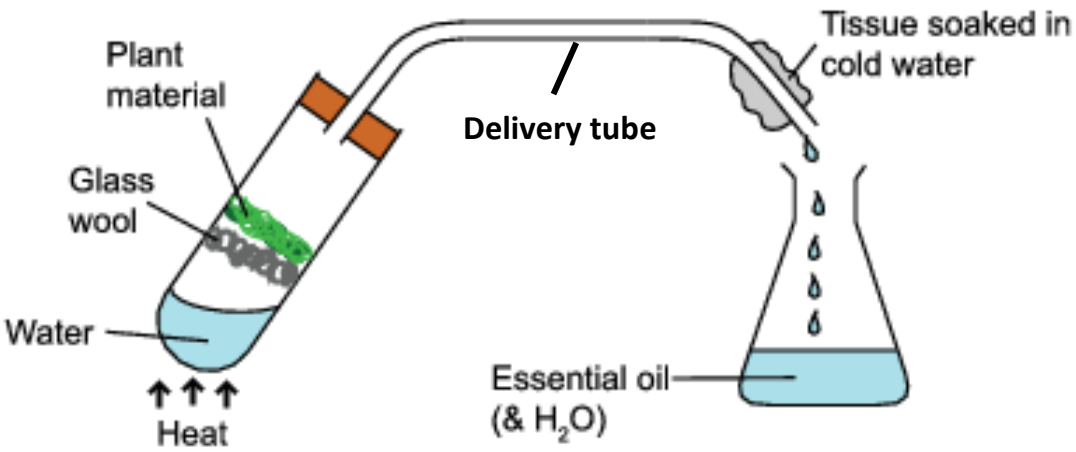
The above apparatus could be used in the lab to extract essential oils. The basic steps are as follows:

1. Water is boiled under a mass of dried plant leaves.
2. As the **steam passes through the leaves**, essential oils vaporise to a gas and are carried with the steam to the condenser
3. The **condenser** creates and area of cold temperature where the gas mixture cools back to liquids
4. The cooled oil appears as a liquid layer on top of the water and can be extracted.

WATCH - (3 mins) YouTube - **Steam distillation of lime**

https://www.youtube.com/watch?v=2Z1Nu7VQ5ak

A simpler version of the experiment is drawn below. Here the condenser has been replaced with a wet tissue - just like in the formation of esters. This makeshift condenser performs the same role – to cool the gas mixture down to liquid form. You can see in the diagram that there is no stopper on the end of the delivery tube, to allow for the condensed liquids fall into the conical flask.



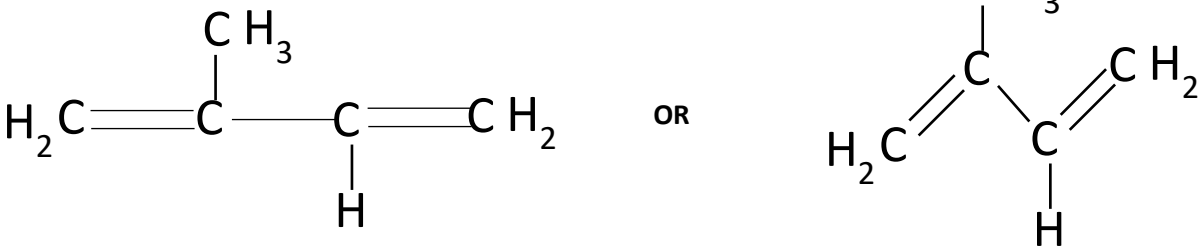
WATCH: (2 mins): YouTube: How to extract limonene from orange peel

https://www.youtube.com/watch?v=o4CBXkfVHDc

Isoprene and Terpenes

Terpenes are a group of compounds which are present in most essential oils. They are unsaturated compounds formed by joining together a number of molecules of **isoprene.**

Isoprene is the basic unit that all terpenes are made from. The systematic name for isoprene is 2-methylbuta-1,3-diene. Molecular formula, C_5H_8. You may see it drawn as:



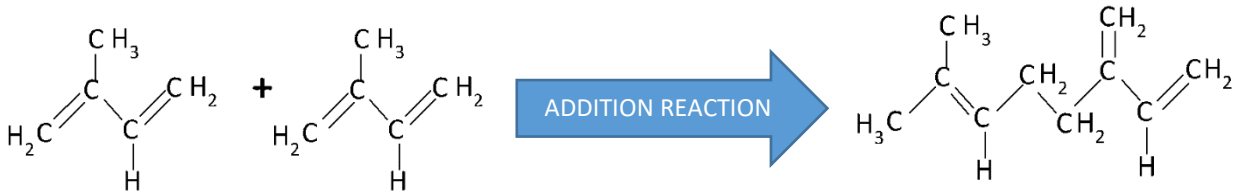
The C=C double bonds in isoprene allow the molecules to undergo addition reactions with other molecules of isoprene to produce terpenes.

You need to be able to draw the structure for isoprene.

Forming Terpenes

A huge variety of **terpenes** are formed by joining isoprene units together. They can be branched chained, cyclic or even contain oxygen atoms.

Example: Myrcene - Two isoprene units join together to form myrcene (a terpene found in parsley and thyme).



2 molecules of isoprene, C_5H_8 myrcene, $C_{10}H_{16}$

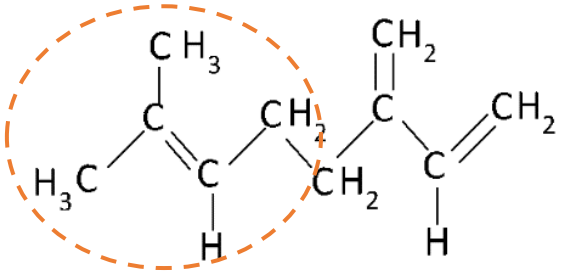
You do not need to memorise the structures of any terpenes, but you may be asked to draw a suggested structure of a terpene made from 2 or 3 isoprene units. More commonly, you will be asked to determine how many isoprene units make up a terpene.

Can you spot the isoprene Unit?

You need to be able to identify an isoprene unit within a terpene molecule.

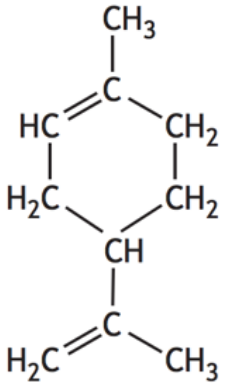
You should look for **the 2-methylbuta-1,3-diene structure**, although because of addition reactions, the double bond positions will have changed or been removed. So look for a chain of 4 carbons, where there is a methyl group branched from carbon number 2 in the chain.

In the molecule below, an **isoprene unit** within the terpene has been circled.



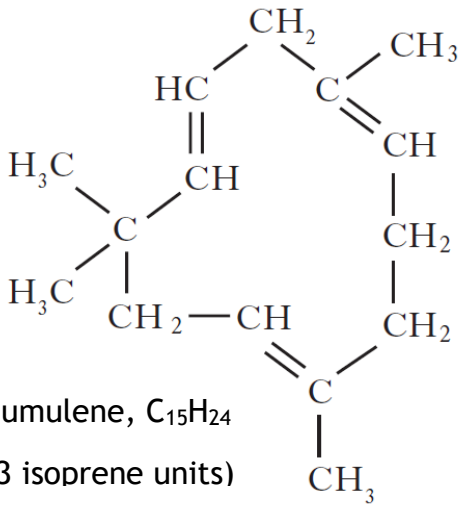
How many Isoprene units?

Isoprene's molecular formula is C_5H_8. The number of carbons in a terpene will be a multiple of 5. The number of hydrogens do not always follow the same pattern, because of further reactions that can occur.



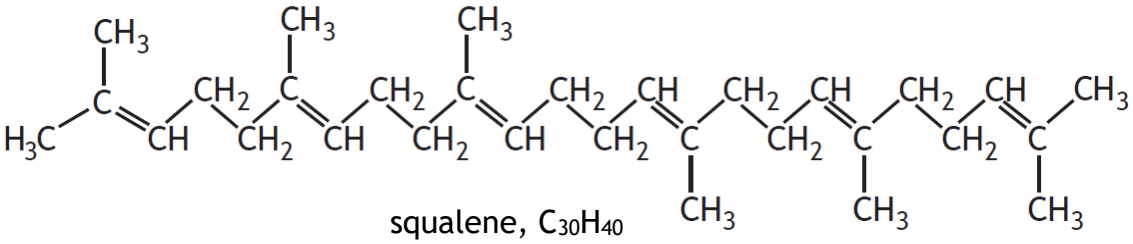
limonene, $C_{10}H_{16}$

(2 isoprene units)



humulene, $C_{15}H_{24}$

(3 isoprene units)



squalene, $C_{30}H_{40}$

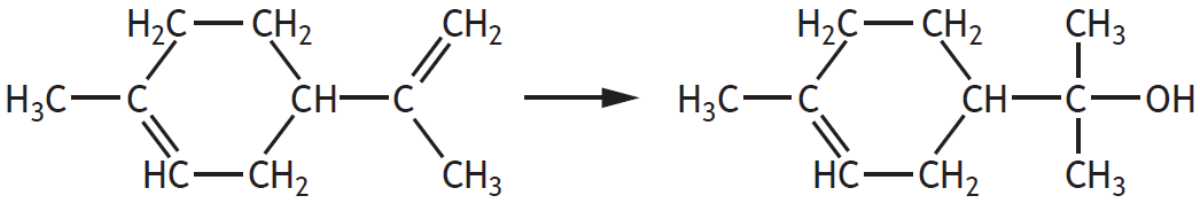
(6 isoprene units)

TASK:

1. Draw out one of the structures above.
2. Circle or highlight an isoprene unit within the molecule.

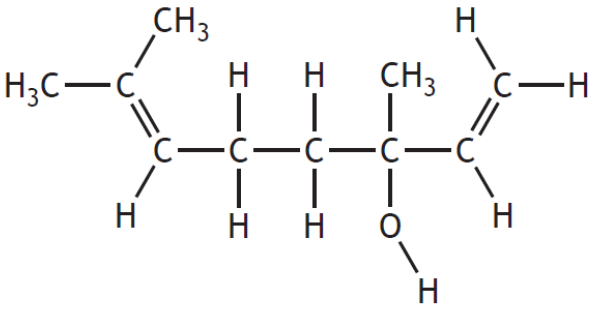
Further Reactions of Terpenes

Terpene can undergo hydration reactions (addition of water) to make a wider variety of molecules.



limonene terpineol

Other terpenes that contain oxygen include linalool, an essential oil found in lavender.



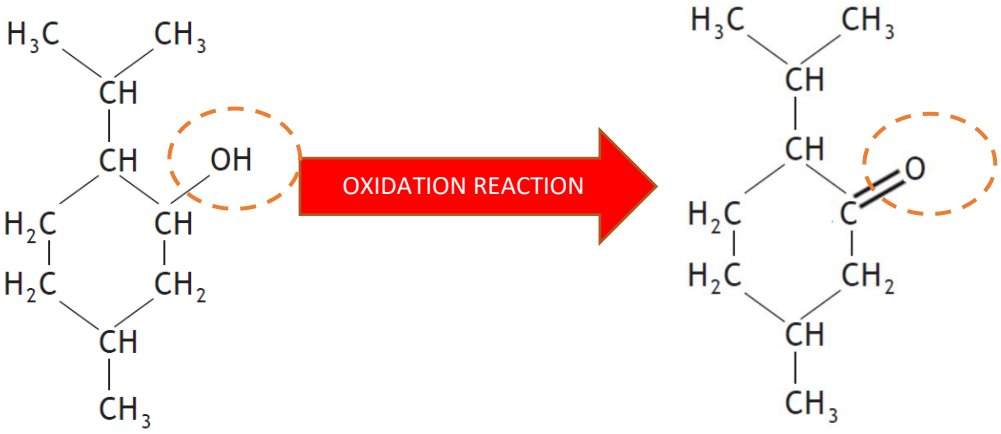
Linalool

THINK ABOUT:

- **How many isoprene units are added together to make linalool?**

Oxidation of Terpenes

Terpenes can be **oxidised** within plants to produce some of the compounds responsible for the distinctive **aromas of spices.**



menthol (secondary alcohol) menthone (ketone)

Note the **hydroxyl** group in menthol changes to a **carbonyl** group in menthone.

Peppermint oil contains both menthol and the oxidation product menthone.

DO YOU KNOW YOUR HERBS & SPICES?

The link below will take you to a poster that shows the chemical make up of lots of common herbs and spices. Many of the structure are terpene- based compounds.

https://edu.rsc.org/download?ac=14971

WATCH: (3 mins): YouTube: Edible Experiments: earth's perfume

https://www.youtube.com/watch?v=bEtG3Luqx5s&feature=emb_logo

SUMMARY

Fragrances (2019)

1. Essential oils are concentrated extracts of the volatile, non-water soluble aroma compounds from plants.
2. They are mixtures of many different compounds.
3. They are widely used in perfumes, cosmetic products, cleaning products and as flavourings in foods.
4. Terpenes are key components in most essential oils.
5. They are unsaturated compounds formed by joining together isoprene (2-methylbuta-1,3-diene) units.
6. Terpenes can be oxidised within plants to produce some of the compounds responsible for the distinctive aromas of spices.
7. Given the structural formula for a terpene-based molecule:
    - an isoprene unit can be identified within the molecule
    - the number of isoprene units joined together within the molecule can be stated

Learning Outcomes

You should now know:

4. What are "essential oils"

5. The structure of isoprene and terpene molecules

6. Some physical and chemical properties of terpenes

Further Reading

To learn more about proteins, try the following online resources:

BBC Bitesize: https://www.bbc.co.uk/bitesize/guides/zchnn39/revision/1

Read page 1 & 2 and **TRY THE END TOPIC TEST**

Scholar: Log in through GLOW

Higher Chemistry → Nature's chemistry → 10. Fragrances

Read through the exercises and **TRY THE END TOPIC TEST**

Evans2 chem web: https://www.evans2chemweb.co.uk/login/index.php#

Username: snhs password: giffnock

Select any teacher → revision material → CfE Higher → Unit 2: Nature's Chemistry → Fragrances

Check your understanding – Answers the questions below in you class jotter

2.18 Fragrances; Isoprene and Terpenes

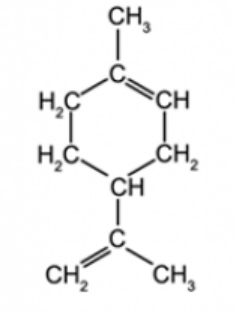
1. Many household products contain essential oils that are extracted from plants.

a) What is an essential oil?
b) What type of solvent should be used to dissolve an essential oil?

2. Isoprene is the basic building block of many essential oils. Isoprene has the systematic name 2-methyl-1,3-butadiene.

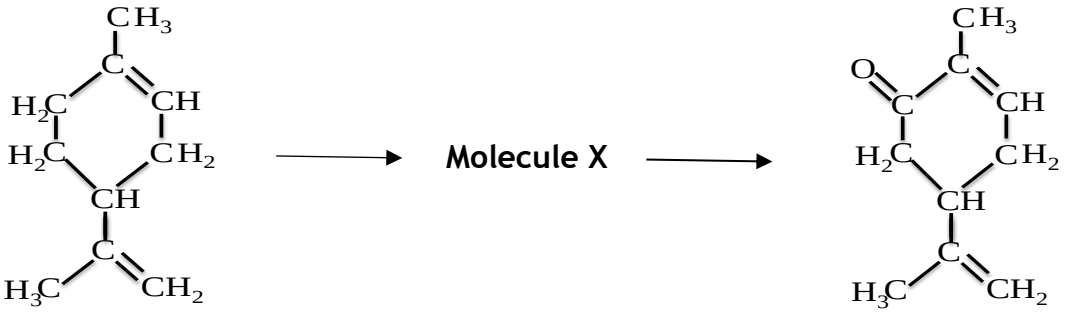
a) Draw the full structural formula of isoprene.
b) What is the molecular formula of isoprene?

3. The terpene shown is a natural oil found in lemons:



a) What is a terpene?
b) Write the molecular formula of the above molecule?
c) How many isoprene units joined together to produce the terpene?
d) Terpenes are volatile molecules:
i. Define the term, volatile.
ii. Why is the above molecule volatile?

4. Limonene can be converted to carvone as shown below:



Limonene **Carvone**

a) What is the molecular formula of carvone?
b) Why does carvone's name end in *one*?
c) Carvone is produced by oxidation of molecule X. Draw the full structural formula of X?

ANSWERS TO EXERCISES WILL BE POSTED ON WEDNESDAY FOR YOU TO CHECK YOUR WORK

EXTENSION WORK

Use the online learning link above if you would like to extend your knowledge of soaps. For more practise questions for proteins, use your Revision Questions for Higher Chemistry "Blue book"

Everyday chemistry page 62 Q1-6